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End-of-waste criteria for biodegradable waste subjected to biological treatment (compost & digestate): Technical proposals

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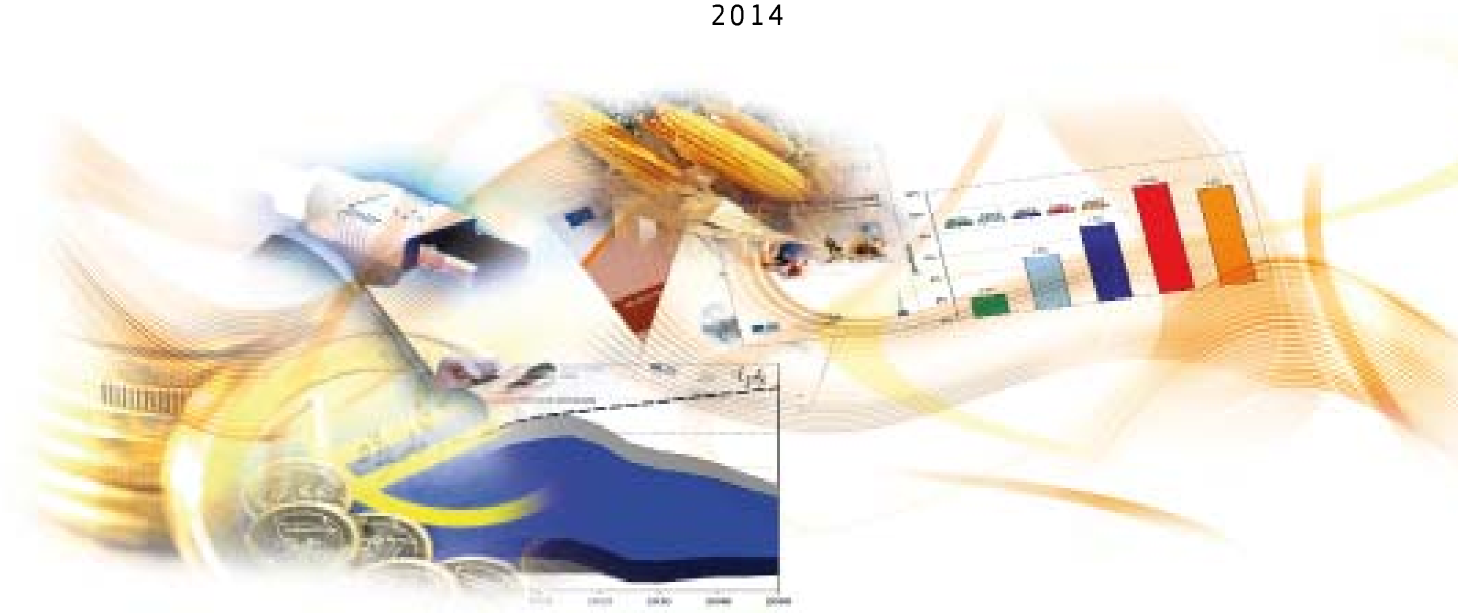

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End-of-waste criteria for biodegradable waste subjected to biological treatment (compost & digestate):

Technical proposals

Final Report

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1 Introduction

1.1 Background

The Waste Framework Directive (2008/98/EC, in the following referred to as 'the Directive' or WFD) among other amendments introduces a new procedure for defining end-of-waste (EoW) criteria, which are criteria that a given waste stream has to fulfil in order to cease to be waste.

Waste streams that are candidates for this procedure must have undergone a recovery operation, and comply with a set of specific criteria. These criteria are yet to be defined for each specific waste stream, but the general conditions that a waste material has to follow are defined by Article 6 of the WFD in the following terms:

'certain specified waste shall cease to be waste [within the meaning of point (1) of Article 3] when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions:

a) The substance or object is commonly used for a specific purpose;
b) A market or demand exists for such a substance or object;
c) The substance or object fulfils the technical requirements for the specific purpose referred to in (a) and meets the existing legislation and standards applicable to products; and
d) The use of the substance or object will not lead to overall adverse environmental or human health impacts.'

Moreover, Articles 6(2) and 39(2) of the Directive specify the political process of decision-making for the criteria on each end-of-waste stream, which in this case is a Comitology procedure[1] with Council and Parliament scrutiny, the output taking the form of a Regulation. As input to decision-making in Comitology, the European Commission is to prepare proposals for end-of-waste criteria for a number of specific waste streams, including biodegradable waste.

A methodology guideline[2] to develop end-of-waste criteria has been elaborated by the Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) as part of the so-called 'End-of-Waste Criteria report'. The European Commission is now working on preparing proposals for end-of-waste criteria for specific waste streams according to the legal conditions and following the JRC methodology guidelines. As part of this work, and for each candidate waste stream, the IPTS will prepare studies with technical information that will support each of the proposals for end-of-waste criteria. Besides describing the criteria, these studies will include all the background information necessary for ensuring conformity with the conditions of Article 6 of the Directive.

For each waste stream, the background studies will be developed based on the contributions of experts from Member States and from interested stakeholders, by means of a technical working group. The working groups are composed of experts from Member States administration, industry, NGOs and academia. Experts of these groups are expected to contribute with data, information or comments to written documents and through participation in expert workshops

[1] The progress of the Comitology processes on the WFD can be followed at: http://ec.europa.eu/transparency/regcomitology/index_en.htm

[2] End-of-waste documents from the JRC-IPTS are available from http://susproc.jrc.ec.europa.eu/activities/waste/. See in particular the operational procedure guidelines of Figure 5 in the "End-of-Waste Criteria" report.

organised by the IPTS. Individual experts may be asked to assist to the workshops on a case by case basis.

The communication procedure is as follows: for each waste stream IPTS takes initiative and submits background documents with questions to the technical working group. Open questions are discussed with the experts at the workshops, and if needed to clarify individual elements, by personal communication. IPTS collects the necessary information from the experts, as appropriate before and/or and after the workshops, and synthesises this information in draft documents. At the end of the process for each waste stream, these documents result in technical proposals on end-of-waste, and are submitted to DG Environment for further use in the preparation of proposals of Commission Regulations.

In the political decision process, Member States (Comitology in the Technical Adaptation Committee under the Waste Framework Directive, followed by scrutiny from both Parliament and Council) will discuss each of the Regulation proposals and if approved, these will enter into force.

1.2 Objectives

The objective of this study was to provide the full background information and a possible technical proposal on end-of-waste criteria for biodegradable waste subject to biological treatment.

This document follows the work of the Technical Working Group, including several written consultations, three expert workshops held at the IPTS in Seville (March and October 2011 and February 2013) and following completion of the JRC Sampling and Analysis Campaign. As such, this study presents a picture of the possibilities for recovering biodegradable waste though composting and/or digestion, including the areas of information that need to be documented for defining end-of-waste criteria.

The document may be used as a basis for further discussions within the Commission and/or with external stakeholders.

1.3 Working scope definition

In the Communication from the Commission on future steps in bio-waste management in the European Union (COM(2010) 235)[3], the European Commission states that compost and digestate from bio-waste are under-used materials. Furthermore, it is mentioned that the ***end-of-waste procedure under the Waste Framework Directive could be the most efficient way of setting standards for compost and digestate*** that enable their free circulation on the internal market and to allow using them without further monitoring and control of the soils on which they are used.
Moreover, according to the Commission Staff working document[4] accompanying the same Communication on future steps in bio-waste management in the EU, there are different categories of waste suited for some form of biological treatment: bio-waste and biodegradable waste.

[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0235:FIN:EN:PDF
[4] http://ec.europa.eu/environment/waste/compost/pdf/sec_bio-waste.pdf

*"**Bio-waste**"* is defined in the Waste Framework Directive (WFD) as "*biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants*". It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste (natural textiles, paper or processed wood).

*"**Biodegradable waste**"* is a broader concept defined in the Landfill Directive as any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard.

The total yearly production of bio-waste in the EU amounts to 118 to 138 Mt of which around 88 Mt originate from municipal waste and between 30 to 50 Mt from industrial sources such as food processing[5]. In the EU, bio-waste usually constitutes between 30% and 40% - but can range from 18% up to 60% - of municipal solid waste (MSW). The bio-waste part of MSW comprises two major streams: green waste from parks, gardens etc. and kitchen waste. The former usually includes 50-60% water and more wood (lignocellulose), the latter contains no wood and up to 80% water.

Different forms of (biological) treatment exist for bio-waste and biodegradable waste, but composting and digestion represent the vast majority of the processes used. In this respect, the working scope of this study has been limited to compost and digestate, in particular from biodegradable waste.

Compost and digestate are defined in this study as follows:

- ***Compost***: compost is the solid particulate material which has been sanitised and stabilised by a biological treatment process of which the last step is an aerobic composting step. Composting is a process of controlled decomposition of biodegradable materials under managed conditions, which are predominantly aerobic and which allow the development of temperatures suitable for thermophilic bacteria as a result of biologically produced heat.

- ***Digestate***: digestate is the semisolid or liquid product that has been sanitised and stabilised by a biological treatment process of which the last step is an anaerobic digestion step. It can be presented as whole digestate or separated in a liquor phase and a semisolid phase. Anaerobic digestion is a process of controlled decomposition of biodegradable materials under managed conditions, predominantly anaerobic and at temperatures suitable for mesophilic or thermophilic bacteria.

It should be noted that mere aerobic storage or maturation of anaerobically digested materials is not considered to be a composting step. Furthermore, the study is restricted to materials that may cease to be waste after an operation consisting of composting or anaerobic digestion of biodegradable materials. It does not consider any material that constitutes by definition a product or by-product.

Whenever this study refers to compost or digestate from Mechanical Biological Treatment (MBT), it considers by default materials produced by installations that are designed to produce

[5] Based on municipal waste data from EUROSTAT, source : Eunomia (2009)

compost or digestate of sufficient quality to be used on soils. Any other target destination, such as a stabilised landfillable or combustible material, will be specified explicitly in this document. The widespread confusion around the different technologies covered by the label Mechanical Biological Treatment is discussed in section 2.2

Moreover, the current study targets ***material recycling*** of the substance derived from composting or digestion of biodegradable waste. This study does not consider the use of biodegradable materials or their derived products as a fuel or for other forms of energy recovery, which has been covered by a parallel JRC-IPTS study.

Finally, biodegradable *materials that have not been subject to composting or anaerobic digestion* are explicitly excluded from this study. These include untreated manure, raw sewage sludge or residues of crops that are ploughed in on farmland, but also textiles that are being reused. Different reasons can be cited:

- the material has no waste status (e.g. untreated manure);
- the material may lack hygienic safety and/or biological stability (e.g. untreated manure and raw sewage sludge);
- the intended use of a material is not that of a fertiliser, soil improver or constituent of growing medium and hence the proposed end-of-waste criteria from these study are not considered to be relevant for the material (e.g. recycled textile).

1.4 Structure of this document

As a general remark, it should be pointed out that this document is partially based on information provided in the case-study on compost presented in Chapter 2 of the final report on End-of-Waste Criteria (IPTS, 2008). It has been complemented with data from new research and input provided by stakeholders during and following the three workshops held in Seville in the period 2010-2013, especially for the items dealing with digestate.

This document consists of three differentiated main chapters, which follow the lower part of the conceptual illustration in Figure 1. The first part of the study (Chapter 2) corresponds to the second row of Figure 1 and presents an overview of compost and digestate, its composition, the types and sources of compost and digestate, its processing, grading and recycling. The chapter contains information on the fulfilment of the four conditions set out in Article 6 of the Waste Framework Directive, namely the existence of a market demand and a specific use for compost and digestate, the identification of health and environmental impacts that may result from a change of status, the conditions for conformity with standards and quality requirements, and the legislative framework of compost and digestate inside and outside waste legislation.

The second part of the study (Chapter 3) provides a discussion on pollutants in compost and digestate. It includes the results of a sampling and analysis campaign organised by the JRC on inorganic and organic pollutants of a series of compost and digestate samples that were initial candidates for receiving end-of-waste status. Moreover, the results from this campaign have been complemented by an extensive review of existing data from literature or provided by stakeholder experts, for an overall discussion.

The third part of the study (Chapter 4), referring to the bottom row in Figure 1, gravitates on a proposal of a set of end-of-waste criteria, and includes the main conclusions of the discussions and consultations held with the expert group during and following the three workshops held in Seville.

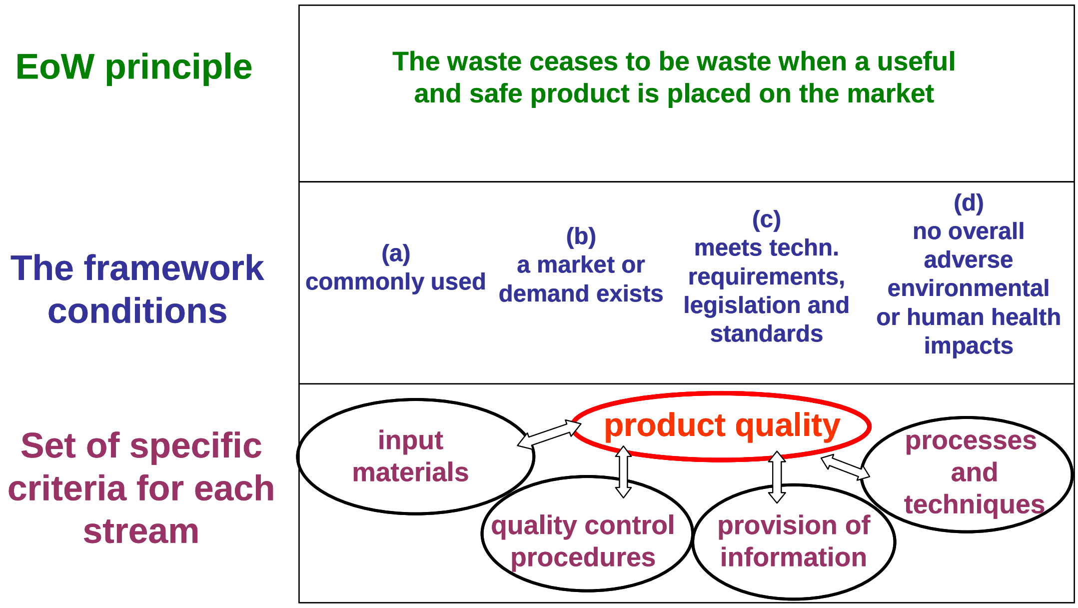

Figure 1: Conceptual illustration of the principle, framework conditions and elements of end-of-waste (EoW) criteria.

Chapter 5 describes the identified potential impacts of the implementation of end-of-waste criteria.

1.5 Overview of major changes to consecutive documents

This Final Report follows three Working Documents and a Draft Final Report. It reflects the outcome of a process involving several stakeholder meetings, written consultations and an extensive sampling and analysis campaign. Several proposals were changed in the course of time, following the acquisition of new data and detailed expert information.

The major milestones in the process can be summarized as follows:

- 2007-2008: pilot study performed by JRC-IPTS on possible end-of-waste criteria for Compost;
- November 2010: creation of a Technical Working Group (TWG) for "Biodegradable waste subject to biological treatment";
- November 2010-February 2011: organisation of site visits to composting and digestion plants, first TWG consultation and issuing of the 1st Working Document;
- March 2011: First Workshop on end-of-waste criteria for biodegradable waste (IPTS, Seville);
- May 2011: launch of an EU-wide JRC Sampling and Analysis Campaign for compost and digestate;
- October 2011: completion of TWG consultation on 1st Working Document and first analyses from sampling campaign followed by issuing of the 2nd Working Document;
- 24-25 October 2011: Second Workshop on end-of-waste criteria for biodegradable waste (IPTS, Seville);
- March 2012: organisation of additional site visits to composting and digestion plants;

- August 2012: completion of TWG consultation on 2nd Working Document and all analyses from sampling campaign followed by issuing of the 3rd Working Document for consultation;
- February 2013: completion of TWG consultation on 3rd Working Document followed by distribution of a Background Paper. Organisation of Third Workshop on end-of-waste criteria for biodegradable waste (IPTS, Seville) followed by additional input of scientific and technical data by TWG experts;
- July 2013: issuing of the Draft Final Report for consultation;
- November 2013: completion of TWG consultation on the Draft Final report followed by issuing of the Final Report.

Detailed overviews of the proposed end-of-waste criteria from the 2nd and 3rd Working Document are presented in "Annex 19: Proposed end-of-waste criteria from 2nd Working Document" and "Annex 20: Proposed end-of-waste criteria from 3rd Working Document". The main changes in the consecutive documents are listed below:

1st Working Document

- The First Working Document was based on the IPTS pilot study of 2006-2007, but also introduced digestate as a candidate material for end-of-waste criteria on biodegradable waste subject to biological treatment.

2nd Working Document

- A new chapter was introduced, describing the methodology and preliminary results from the JRC Sampling and Analysis Campaign on compost and digestate.
- Based on the preliminary results from the sampling and analysis campaign, suggesting higher pollutant concentrations in MBT materials and sewage sludge based compost/digestate, compared to materials derived from source separated inputs, it was proposed to provisionally exclude MBT and sludge materials from eligibility of end-of-waste status.

3rd Working Document

- The full results of the JRC Sampling and Analysis Campaign on compost and digestate were included.
- Based on the full results from the sampling and analysis campaign, it was proposed to allow a broad range of input materials, including mixed municipal solid waste and sewage sludge, to be used provided strict output quality criteria were respected. These included concentration limits for four classes of organic pollutants.
- It was proposed to remove the stability criterion from the quality criteria, based on the suggestion by several experts that its use can be regulated by market mechanisms, rather than by imposing a binding parameter. Furthermore, the lack of an EU-wide recognized standard was seen as an additional hurdle for proposing such a criterion.

The Draft Final Report and Final Report

- The full results of the JRC Sampling and Analysis Campaign on compost and digestate quality are critically discussed against new extensive scientific data from literature and TWG experts.
- Based on feedback from many experts regarding possible negative impacts to national markets from a wide scope with strict quality parameters for EU end-of-waste criteria, it has been proposed to adapt the scope. More specifically, it has been proposed to restrict

the scope of EU-wide end-of-waste criteria to materials derived from source separated input materials, thus allowing national end-of-waste or equivalent systems for non-scope materials to continue operating.

- Following new information on soil micronutrient needs as well as possible risks associated to high micronutrient dosing, a proposal for a substantial increase in possible limit values for Cu and Zn has been made, while keeping other quality parameter limit values constant.
- It has been proposed to reintroduce a mandatory stability criterion to protect the market against insufficiently treated materials which may cause adverse environmental impacts during storage, transportation and application. The newly formulated proposal takes into account the national specificities of existing systems.
- Important cost reduction proposals have been made by proposing changes to the requirements for external sampling and routine measurements of organic pollutants.
- In view of the difficulties in establishing a commonly agreed positive list of eligible input materials for compost/digestate production and given the major TWG preference for a scope based on input materials exclusively from source separation, it has been proposed to replace the positive list by a detailed scope description. Such a description provides the basis for competent authorities to decide on the eligibility of candidate input materials. In addition, such an approach provides a fast update mechanism for possible new input materials entering the market.

2 Background information on compost and digestate

2.1 Types of biodegradable waste

Biodegradable fractions of municipal solid waste (MSW)

MSW comprises wastes from private households and similar wastes from other establishments that municipalities collect together with household waste. While the exact composition of MSW varies considerably from municipality to municipality and across Member States, it always contains an important portion of biological material. Depending on the country, kitchen waste and ‘green’ waste from gardens and parks make up 30–50 % of the total mass of MSW. Together they are sometimes called putrescible wastes or ‘bio-wastes’. The term ‘bio-waste’, however, is not always used in the same way and sometimes refers to kitchen waste only and excludes green waste[6]. Kitchen waste consists largely of food waste. On average, the amounts of kitchen and green wastes are about the same but there are important local variations, for instance, between rural and urban areas. Also the paper fraction in MSW consists, to a large degree, of processed biological material, and so does a part of the textile waste (from non-synthetic fibres).

Other biodegradable wastes

Other biodegradable wastes that may be composted on their own or together with the biodegradable fraction of MSW include mainly the following items:

- commercial food waste, not collected as part of the MSW, including:
    - waste from markets
    - catering waste;

- forestry residues, including:
    - bark
    - wood residues;

- waste from agriculture, including:
    - animal husbandry excrements (solid and liquid manure)
    - straw residues
    - sugar beet and potato haulm
    - residues of growing of beans, peas, flax and vegetables
    - spent mushroom compost

- wastes from the food and beverage industry, including:
    - breweries and malt houses
    - wineries
    - fruit and vegetable production industry
    - potato industry including starch

6 In the Waste Framework Directive, bio-waste is defined as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants

- residues of beet sugar production
- slaughterhouse residues
- meat production
- whey;

- sewage sludge (derived from biological treatment of municipal wastewater)

Practically all biological wastes are biodegradable in the presence of oxygen (aerobic conditions) and most biological materials are biodegradable also without oxygen (anaerobic conditions). A relevant exception is lignin (in woody materials) which does not readily degrade anaerobically. However, pretreatment by thermal hydrolysis can increase the anaerobic digestibility of lignin. The speed of the degradation depends on the environment in which it takes place. Moisture, temperature, pH and the physical structure of the materials are some of the key parameters. Burning or incineration is the other main option for decomposing biological material.

2.2 Treatment options

Biodegradable wastes can undergo a series of treatment operations. The major processes are listed below. Frequently, combinations of the listed treatment options are implemented as well. The current section does not consider treatment options for which bio-waste should legally be considered as a by-product, such as the processing into animal feed.

<u>Landfill</u>

In the past, landfilling mixed MSW without pretreatment or separating out the biological fraction was common practice in most Member States. This option is today considered bad practice because it is associated with environmental and safety risks related to a.o. landfill gas with a high greenhouse gas potential (methane), leachate and space usage.

Through the Landfill Directive[7], the European Union has laid down strict requirements for landfills to prevent and reduce the negative effects on the environment as far as possible. Amongst other things, the Landfill Directive requires that waste must be treated before being landfilled and that the biodegradable waste going to landfills must be reduced gradually to 35 % of the levels of the total amount of biodegradable municipal waste produced in 1995.

<u>Incineration and other thermal treatments</u>

The combustion of waste in incinerators allows diminution of the waste for material recovery (e.g. metals) or disposal in landfills to an inorganic ash residue. The organic carbon and hydrogen are oxidised to CO_2 and H_2O which are discharged to the atmosphere in the flue gas.

Large-scale mass burn incineration is the most common form of incineration today. It means that waste is combusted with little or no sorting or other pretreatment. However, due to the low calorific value and high water content of many biodegradable wastes (with the exception of paper and wood), exclusion of biodegradable materials by source separation is generally preferred for incineration. In most present-day incinerators, the energy is recovered to produce electricity and/or heat. The calorific values of individual types of waste vary considerably, from

[7] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

about 1.8 to 4 GJ/tonne for food waste to over 35 GJ/tonne for some plastics (Smith et al., 2001). Waste is generally blended to reach an average of 9-12 GJ/tonne so that combustion occurs without pilot fuels, as their use is discouraged by the R1 formula.

An alternative option to mass burn incineration is to preprocess the waste to produce refuse derived fuels (RDF). Processing the waste allows the removal of several streams of recyclable materials, including biodegradable wastes, which receive separate treatment. The combustible residue has a higher calorific value than mixed waste, and may then be burned directly or co-incinerated, for example in cement kilns.

Newly emerging technologies involve pyrolysis and gasification to first break down the organic matter in the waste into a mixture of gaseous and/or liquid products that are then used as secondary fuels. However, these technologies are still in a development stage.

The Waste Incineration Directive from 2000[8], which will be repealed with effect from 7 January 2014 and has been merged into the Industrial Emissions Directive[9], aims to prevent or to reduce negative effects on the environment caused by the incineration and co-incineration of waste. In particular, the conditions laid down in the directive should reduce pollution caused by emissions into the air, soil, surface water and groundwater, and thus lessen the risks which these pose to human health. This is to be achieved through the application of operational conditions, technical requirements, and emission limit values for waste incineration and co-incineration plants within the Community.

Mechanical biological treatment (MBT) and mechanical biological stabilisation (MBS)

In plants for mechanical separation and biological treatment, the mixed MSW undergoes a mechanical sorting of the waste into a biodegradable material containing fraction and a non-biodegradable material containing fraction. The latter fraction may be further split, especially to sort out and recycle metals or other recyclables. The remainder of the non-biodegradable containing material fraction is either landfilled or incinerated.

The biodegradable material containing fraction is then composted or anaerobically digested, according to the methods described below. By composting and digestion, the volume of the material and its further degradability are reduced (stabilisation).

It is important to note that, depending on the final purpose of the biodegradable fraction, mechanical biological treatment installations are designed differently. Mechanical biological treatment either aims

- at a stabilized landfillable or combustible fraction with a minimum of unstable biodegradable material, NOT destined for agriculture, in which case the wording compost/digestate is not used[10];

or

- at a composted/digested organic fraction that can be recycled in e.g. agriculture with an acceptable maximum level of pollutants and physical impurities (only allowed in certain

8 Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (OJ L 332, 28.12.2000, p. 91).

9 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ L 334, 17.12.2010, p. 17)

10 In this case, the output material is sometimes referred to as compost-like output (CLO)

Member States), often denominated as MBT compost/digestate or (mixed) MSW compost/digestate.

The former technology may be referred to as Mechanical Biological Stabilisation (MBS), whereas the latter technology is also called Mixed Waste Composting/Digestion or Sorting+Composting/Digestion (S+C/D).

When landfilled, the biologically stabilised residual waste has a much reduced capacity for producing landfill gas and leachate, and it can provide a very compact material. It can also be used to cover or restore land on landfills. When used in agriculture or horticulture, quality demands are higher and the material needs to respect several limit values on pollutants.

In practice, it appears that the two technologies discussed above tend to be confused. There might be several reasons for this, including:

- MBT/MBS plants can be *operated in different ways*, even if the final destination of the biodegradable material containing fraction is the same.

  For example, in Italy the wet organic fraction of the mixed household waste is separated from the dry fraction and then composted in MBT installations, before being sent to landfill. In other installations, also aiming at producing a stabilized material for landfilling, this separation step may be less pronounced and the biodegradable fraction will still contain a large amount of non-biodegradables that enter the composting step.

- *Initial low market acceptance* of the stabilized material for use on agricultural land *triggered different reactions*. It has led to either changed outlets for the produced stabilized materials or to changes in legislation and upgrading of technology and waste collection practices.

  The majority of Member States report a historical market rejection of the separated organic fraction obtained from MBT for use as compost on (agricultural) land. Up to the 80's or 90's of the last century, most of the MBT output was characterized by a high content of heavy metals and visually noticeable physical impurities, which often led to public repulsion. In some cases, this has led to a ban of such material in agriculture and to a shift of the outlets for MBT stabilized materials to landfilling/incineration, often with a parallel establishment of a separate collection and composting/digestion system for organic waste (e.g. Germany). In other cases, this has led to stricter legal requirements for the material, the introduction of a partial source separation of MSW, such as the separate collection of glass and WEEE, and an upgrading of the MBT installations (e.g. France).

Further on in this document, the output of Mechanical Biological Stabilisation (MBS) installations destined for landfilling/incineration is excluded from the discussions on possible end-of-waste status, as its primary aim is clearly not to produce a compost or digestate of sufficient quality to be used on soils, but to discard waste in a way that minimizes greenhouse gas emissions and other undesired effects from disposing of untreated organic wastes.

Composting

Composting is the aerobic degradation of waste to produce compost. It has a long history in many parts of Europe. Originally it was used in the form of simple processes on a small scale for farm and back yard composting. In the last two decades, composting has received renewed and widened interest as a means of addressing current waste management challenges, in particular for reducing the amount of wastes going to landfills and the associated CH_4 emissions from the degradation of organic materials in landfills. The production of compost is also seen as an opportunity for providing a material that can be used as a component in growing media or as an organic fertiliser or soil improver. These and other uses of compost are discussed in more detail in Section 2.4 below.

Most installations producing composts for use as growing media or soil improvers rely on source-separated biological fractions of MSW (kitchen waste and/or garden and park waste). The rationale for this is to keep the levels of compost contamination with undesirable materials, such as glass or plastic, and other substances, such as heavy metals and organic pollutants, as low as possible. Recently, technologies have been under development with the aim of achieving high compost purities from the organic fraction of mixed MSW by means of enhanced material separation before and throughout the composting process. The other main types of compost are compost produced from bark, manure and from sewage sludge (together with bulking material).

The size of composting plants ranges from treatment capacities of less than 1 000 tonnes to more than 100 000 tonnes/year. The process technologies of composting are very diverse. Distinctive features of different composting technologies are:

- open or closed composting;
- with or without forced aeration;
- different process techniques like windrow, container, box channel or tunnel composting.

Open-air windrow composting is the simplest technique. Generally, these plants work without forced aeration and waste gas collecting. Techniques with forced air systems are mostly associated with the collecting and treatment of waste gas. Combined scrubber and biofilter systems are a typical form of waste gas treatment. Different types of mechanical separation techniques are usually applied before, during or after the composting processes to sort out undesirable components from the material.

Depending on the composting technique applied and the 'maturity' of the compost product, the duration of the composting process ranges from a little more than a week to several months.

An important part of the composting takes place by the action of thermophilic micro-organisms at a temperature of up to 70 °C and sometimes even more. If temperatures are maintained for a sufficiently long time, pathogenic micro-organisms are killed off along with the weed seed, and the material can be considered hygienically safe.

Anaerobic digestion

Alternative to, or in combination with, aerobic composting, biodegradable waste can also be decomposed in a controlled process in the absence of oxygen. The process runs in airtight

vessels, usually for several weeks, and produces methane-rich biogas (45-80% methane content). The biogas is burnt to generate electricity and/or heat. A part of the energy may be used to heat the process and keep it at the required temperature (30–60 °C). Alternatively, the biogas may be upgraded to methane and injected into the gas grid or used as a vehicle fuel.
The biogas produced will be stored before being either refined further into methane for vehicle fuel or for injection into the gas grid or burned in a combined heat and power engine to produce electricity and heat, or burned in a gas boiler to produce heat for local use.
In some cases, biogas yields of a material may be low but anaerobic digestion offers other advantages. This is especially the case for manure. Apart from reducing greenhouse gas emissions, major environmental benefits associated with using digestate as a biofertiliser in place of untreated manures include reduced odours, improved veterinary safety, plant pathogen reduction and the reduction of weed seeds (Lukehurst et al., 2010).
The anaerobic digestion process also produces a sludge-like or liquid residue, termed 'digestate', which may be used on farmland as liquid organic fertiliser. In some plants the digestate is dewatered, resulting in a separated liquor and a separated semisolid fraction. Alternatively, the digestate may be subject to aerobic composting. The liquid from the process is recycled back into the process to a large extent, and the excess, if any, can be used as a liquid fertiliser if the quality allows this.

Anaerobic digestion is applied to the biodegradable fractions of MSW, agricultural wastes (excrements, litter, straw, beet and potato leaves), food industry wastes (residues from brewing, grape pressing, sugar production, slaughterhouse by-products and meat processing residues, waste water from milk processing) and sewage sludge.

Anaerobic digestion applied to MSW can use source-separated biodegradable waste as the input or mechanically separated organic fractions of MSW (see section on MBT). The process can also imply the treatment of several streams at once, e.g. as co-digestion with agricultural residues.

<u>Fermentation</u>

Apart from secondary fuel production from gasification products and biogas production through anaerobic digestion, certain biodegradable wastes may be used for biofuel production through fermentation. Whereas first generation biofuels were based on energy crops such as maize, secondary generation biofuels can be based on waste material from food crops, often containing high amounts of lignocellulose The production of biofuels from these waste materials hence generally involves a step to make the material fermentable, e.g. by steam cracking of the lignocellulose parts, followed by a fermentation step yielding alcoholic fuels.

2.3 Developments in the treatment of biodegradable waste

The Landfill Directive[11] requires that the biodegradable waste going to landfills is reduced to

- 75 % by 16 July 2006;
- 50 % by 16 July 2009;
- 35 % by 16 July 2016;

[11] Article 5(2) of Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

compared to the total amount of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data are available.
Member States that landfilled more than 80 % of their municipal waste in 1995 were allowed to postpone each of the targets by a maximum of four years.

The Landfill Directive requires Member States to set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills. On 30 March 2005, the European Commission reported on the national strategies it had received from Denmark, Germany, Greece, France, Italy, Luxembourg, the Netherlands, Austria, Portugal and Sweden as well as on the regional plans for England, Wales, Scotland, Northern Ireland, Gibraltar, the Flemish Region and the Walloon Region. The report shows that there are large differences in the roles given to composting in the different national and regional strategies. The following three examples illustrate the diversity of the national strategies.

Austria has introduced a legal obligation to collect biodegradable waste separately, which may then be used to produce compost. As a consequence, the amount of separately collected biodegradable waste increased from a few thousand tonnes in 1989 to approximately 530 ktonne in 2003 (in 1995, the amount of biodegradable municipal waste produced in Austria was 2 675 ktonne). In 1999, the first Renewable Energy Act for electricity came into force, including provisions for digestion of bio- waste. According to information from the European Biogas Association for 2009, 472 ktonne of bio-waste was digested and 947 ktonne was composted. The first policy initiatives were complemented by the entry into force of an Ordinance on Composting in 2001, which regulates the quality requirements for composts from waste, the type and origin of the input materials and the conditions for their placing on the markets. Austria has already achieved the last reduction target as stated in the Landfill Directive.

Denmark has also already achieved the last target, but with a completely different strategy. An Order regarding waste issued in 2000 requires all Danish municipalities to send waste that is suitable for incineration to incineration. In recent years, only very small amounts of biodegradable municipal waste have therefore been landfilled, corresponding to far less than 10 % of the total amount of biodegradable municipal waste produced in 1995.

Italy is an example of a country that has opted for a mixed strategy. The country already fulfilled the target for 2006. In 2002, 8300 ktonne of biodegradable waste was diverted from landfills through:

- separate collection (3 800 ktonne);
- mechanical biological treatment (5 600 ktonne of unsorted waste with an estimated biodegradable fraction of 3 100 ktonne);
- incineration (2 700 ktonne of waste, of which about 1 500 ktonne was biodegradable).

Eurostat data for 2011 showed that on average 15% of the municipal waste in the EU-27 was treated by composting or digestion. Belgium, Luxemburg, the Netherlands and Austria composted/digested at least 20% of their municipal waste. The Eurostat dataset also suggested that composting/digestion of municipal waste is still relatively limited in Ireland, Greece and Portugal, as well as in most of the EU-12 countries, with less than 10% of the municipal waste being composted/digested. Nonetheless, composting/digestion figures of 17% for Poland and 10% for Estonia were recorded.

However, not all Member States report similar amounts of municipal waste production per capita. Hence, the largest *per capita* municipal waste composting/digestion figures were encountered in Austria (179 kg/person), the Netherlands (142 kg/person), Luxemburg (135 kg/person) and Germany (103 kg/person).
Figure 2 displays the evolution of municipal waste treatment options in the EU-27 until 2011, indicating that composting/digestion grew steadily during the last decade, from about 50 kg/capita in 2001 to 70 kg/capita in 2011.

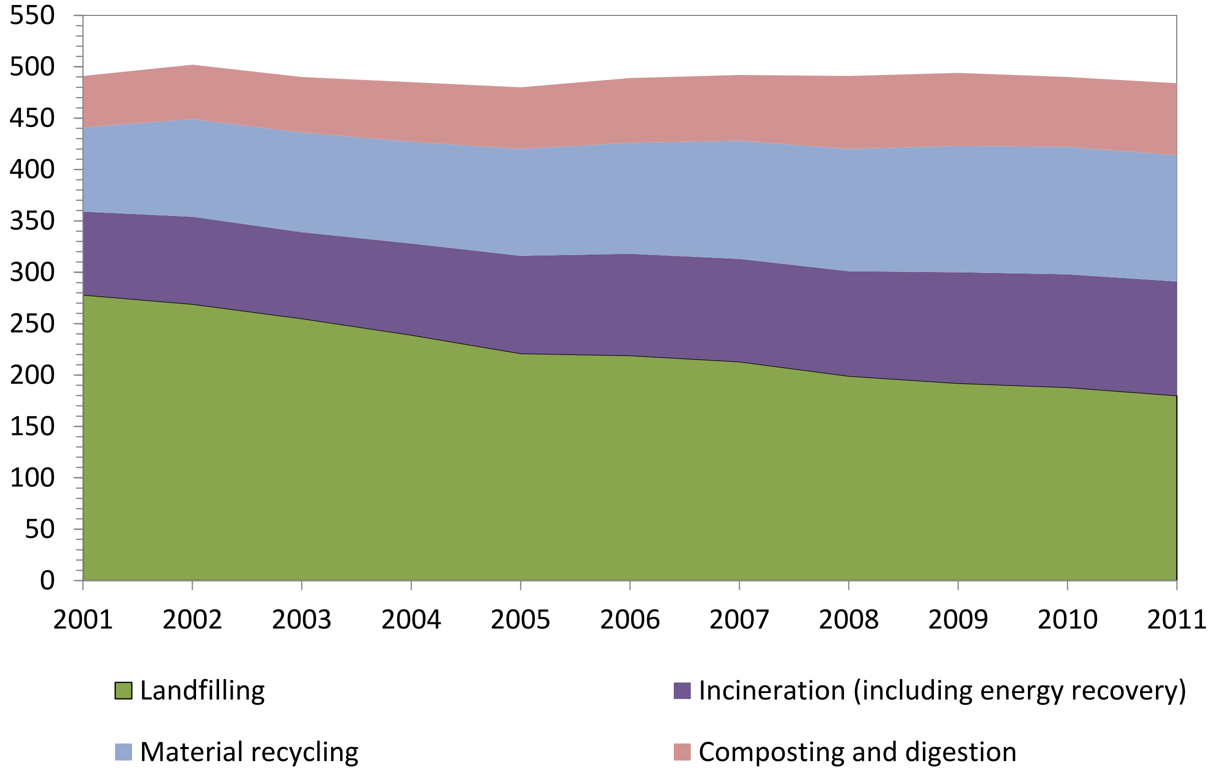

Figure 2: Treatment of municipal waste in the EU-27 from 2001 until 2011 (in kg/capita) (Source: Eurostat)

A brief characterisation of biodegradable waste management (excluding sewage sludge management) in 25 EU Member States is presented in "Annex 1: Biodegradable waste management".

From the stakeholder consultation following the workshops in 2011, additional information was received on trends and facts with regard to the treatment of biodegradable waste in various Member States of the EU.

- In *Finland*, landfilling is the most common treatment for municipal solid waste. Separate collection of bio-waste started in the 90`s and it is generally only mandatory for bigger housing units. Single family houses are normally not included in the separate collection system but they are encouraged to home composting. Composting of separately collected bio-waste was first performed in open windrows. Several composting plants have been built at the end of the 90`s and the beginning of this century. Often bio-waste was treated together with sewage sludge in the composting plant. Many of the plants suffered from technical problems, because the composting systems coming from central Europe were not adapted sufficiently to the Finnish bio-waste, which is mainly kitchen waste. During the last years the interest for anaerobic digestion increased in parallel with a discussion on renewable energy and an electricity tariff support. There is no complete information about the use of composts and digestate in Finland. Most of the composting and anaerobic digestion plants in Finland treat sewage sludge and green waste to some extent as well. According to the reports of regional authorities circa 190 ktonne was composted and 42 ktonne treated in AD-plants 2008. The total capacity of installed anaerobic digestion plants for biodegradable waste in Finland is about 50 ktonne.

- While the compost sector is relatively well developed in *Ireland*, the development of an anaerobic digestion industry has been slower to gain traction, which is due to the nature of proposed facilities (i.e. on farm), uncertainties in respect of subsidies available (e.g. for renewables) and requirements of Animal By-Products legislation where material from off site, other farm slurries or separately collected bio-waste from the local authorities, is proposed to be treated.

- In *Spain*, in 2008, 34 plants produced 60.5 ktonne of compost from source separated bio-waste, whereas 66 plants produced 493.5 ktonne of compost from mixed waste and 15 plants produced 56.1 ktonne of compost from mixed waste after digestion. All digestate from biodegradable municipal solid waste is post-composted.

- In *Sweden*, in the decade preceding the year 2009, landfilling nearly faded out completely, whereas biological treatment of biodegradable waste increased steadily. In 2009, 536 ktonne of biodegradable waste was treated by anaerobic digestion and 631 ktonne by composting.

- In *Italy*, in 2008, about 7 Mtonne of biodegradable waste was separately collected and recycled. About 7.5 Mtonne of municipal solid waste was treated in mechanical biological treatment plants, although the output was disposed in landfills after treatment. In fact no other uses are allowed for the stabilized wastes in Italy. About 4.1 Mtonne of municipal solid waste was incinerated for energy production. A share of this waste was biodegradable. Composting plants (290 plants in total) received about 3.4 Mtonne of source segregated biodegradable waste in Italy in 2008. The Italian anaerobic digestion sector was considerably smaller than the composting sector in 2008. About 24.5 ktonne of digestate were produced from selected and mixed biodegradable waste sources, 52.6 ktonne of digestate were produced from selected biodegradable sources only and 6 ktonne of digestate were produced from waste from the agro-industrial sector.

- In *Belgium*, in the Flemish region, in 2009, 881 ktonne of bio-waste was treated in anaerobic digestion plants, 776 ktonne was composted and 341 ktonne was biothermally dried. In Wallonia, biodegradable waste is either biologically treated (mainly through composting, a in a lesser extent through anaerobic digestion), or is incinerated with energy recovery. At present, in the Brussels Region, the major part of organic waste goes to incineration.

- In *Slovenia*, in 2009, 32.4 ktonne of organic waste was collected, 19.2 ktonne from catering and 13.1 ktonne from households. In 2007, 2.9 ktonne of organic kitchen waste was composted and 2.8 ktonne was anaerobically digested.

- In the *UK*, according to preliminary results from the draft Annual Survey of the UK Organics Recycling Industry 2009, the organics recycling industry was composed of 281 permitted composting plants, 17 anaerobic digestion plants, 9 MBT plants and two TAD (thermal aerobic digestion) plants. Collectively, it was estimated that they recycled 5.2 Mtonne of waste. Approximately 2733 registered exempt composting sites were also identified, composting an estimated 900 ktonne of waste. Permitted aerobic composting was therefore the predominant treatment method, accounting for 90% of all sites and 90% of the waste. This composition is broadly in line with findings in previous surveys in which composting dominated; however, it is anticipated that the 17 AD plants represents the emergence of this sector, largely in response to government drivers and the promotion of anaerobic digestion nationally. Municipal waste remained the principal waste stream (just over 80%), with wastes from parks and gardens accounting for 53% overall. This probably reflects the targets placed on local authorities to recycle and divert biodegradable municipal waste from landfill, which has resulted in a comprehensive network of recycling schemes in place across all four nations of the UK.

- The *Netherlands* expect the vegetable fruit and garden waste digestion capacity to grow from the current 200 ktonne/year to 1000 ktonne/year in 2015. As digestate is not recognized as fertilizer, it is all post-composted. In the NL the primary purpose of anaerobic digestion is considered to be the production of biogas for energy purposes (upgrading to natural gas quality or production of electricity/heat) and not producing a fertilizer.

- In *Bulgaria*, the first composting plants for green waste and source separated biodegradable waste have been established in 2013. Anaerobic digestion of bio-waste is not in place yet but has been planned. MBT installations will be aimed at waste stabilisation for landfilling or low grade applications under the waste regime. Bulgaria has also launched a 2012-2014 project under its Operational Programme for developing a comprehensive legislative framework and strategy for the implementation of a national Bio-waste Management System. It includes binding targets for separate collection of bio-waste and end-of-waste criteria for compost and digestate.

- In *Estonia*, 47 composting installations existed in 2010, with a total annual production capacity of 200 ktonne compost. Anaerobic digestion is applied in large wastewater treatment plants for sewage sludge treatment, as well as on farm sites for manure treatment.

- In *Romania*, there is currently very limited bio-waste collection, while separate collection is non-existent. With the implementation of the Sectorial Operational Programme for Environment (2008-2015), 20 composting facilities with a planned capacity of 200 ktonne/year should be installed, as well as 17 MBT installations with a planned capacity of 1300 ktonne/year. Compost will be produced from separately collected garden and park waste, but not from bio-waste. The MBT installations are aimed at waste stabilisation.

- As of 2013, construction has been planned for 10 mechanical-biological treatment (MBT) plants in *Lithuania*. Moreover, 22 sewage sludge treatment plants are currently being installed (12 digestion – bio-drying; 1 bio-drying; 9 composting plants). A number of 34 green waste composting sites have been constructed, and plans exist for construction of 19 more. Furthermore, it has been planned to install 157 899 composting boxes for individual households.

- According to EFAR, circa 25% of the sewage sludge production is co-composted with green waste in *France*. The NF U44-095 standard applicable since May 2002 has established product criteria for sewage sludge, allowing the development of a well-structured market for this type of soil improver.

- According to the European Compost Network (ECN), in 2009, there were about 2500 sites in *Europe* for composting of source segregated materials, 40% of which only treat garden waste, with an annual capacity of 27 Mtonne and an estimated annual capacity increase of 0.5 to 1 Mtonne. Additionally, there were 800 small agricultural co-composting plants, mainly in Germany and Austria. According to the ECN, such plants offer large potential for the rural areas of the eastern Member States. Furthermore, 195 large anaerobic digestion sites were operational in 2010, with 5.9 Mtonne annual capacity for organic waste, with a current capacity doubling every 5 years. Additionally, 7500 agricultural digestion and co-digestion sites for agricultural residues, energy crops and organic waste were present in Europe in 2010. The totally produced volume of digestate is estimated at 56 million m^3 for 2010, whereas the electric capacity for electricity production from biogas is 2.5 GW. Finally, according to ECN data, there were about 280 plants in Europe for the mechanical biological treatment of mixed waste (by composting or digestion), with an annual capacity of 18 Mtonne and mainly aimed at producing a stabilised fraction for landfilling. These plants are situated largely in Italy, Germany, Austria, France and Spain.

2.4 Compost and digestate applications

For compost, there are two main uses as a product: as a soil improver/organic fertiliser and as a component of growing media. Digestate is mainly used as an organic fertiliser with lesser soil improvement potential, except for the separated fibre fraction.

2.4.1 Compost as a soil improver/organic fertiliser

Compost is considered a multifunctional soil improver. It is therefore used in agriculture and horticulture as well as to produce topsoil for landscaping or land restoration. The application of compost usually improves the physical, biological and chemical properties of soil. Repeated application of compost leads to an increase in soil organic matter, it often helps to reduce erosion, it increases the water retention capacity and pH buffer capacity, and it improves the physical structure of soil (aggregate stability, density, pore size). Composts may also improve the biological activity of the soil.

Compost is often considered an organic fertiliser, although the fertiliser function of compost (supply of nutrients) is, in many cases, less pronounced than the general soil improvement function. According to Kluge et al. (2008) the supply of plant-available nitrogen by compost is rather low, especially in the short term, and only repeated applications over long periods may have a measurable effect. However, the phosphate and potassium demand of agricultural soils can, in many cases, largely be covered by adequate compost application. Compost also supplies calcium, magnesium, sulphur and micronutrients and have a neutralizing value for the soil.

The effects of compost also depend on the local soil conditions and agricultural practices, and many aspects are still not well understood.

The quality parameters that characterise the usefulness of compost in agricultural applications include:

- organic matter content;
- nutrient content (N, P, K, Mg, Ca);
- dry matter;
- particle size;
- bulk density;
- pH.

2.4.2 Compost as component of growing media

The second main use of compost is as a component of growing media.

Growing media are materials, other than soil in situ, in which plants are grown. About 60 % of growing media are used in hobby applications (potting soil), and the rest in professional applications (greenhouses, container cultures). The total volume of growing media consumed in the EU is estimated to be about 20–30 million m^3 annually. Worldwide, peat-based growing media cover some 85–90 % of the market. The market share of compost as a growing medium constituent is below 5 %. Growing media are usually blends with materials mixed according to the required end product characteristics (SV&A, 2005).

The Waste and Resources Action Programme (WRAP) together with the Growing Media Association have issued guidelines for the specification of composted green materials used as a growing medium component based on the BSI PAS 100 specifications for composted materials (WRAP, 2011b). The guidelines introduce additional requirements to those of BSI PAS 100, e.g. concerning heavy metal limits.

According to these guidelines, any growing media shall:

- have a structure which physically supports plants and provides air to their roots and reserves of water and nutrients;
- be easy to use with no unpleasant smell;
- be stable and not degrade significantly in storage;
- contain no materials, contaminants, weeds or pathogens that adversely affect the user, equipment or plant growth;
- be fit for the purpose and grow plants to the standard expected by the consumer in accordance with the vendor’s description and claims.

Specifically for compost, the guidelines identify the fundamental requirements of a composted green material supplied as a component of a growing medium. It shall:

- be produced only from green waste inputs;
- be sanitised, mature and stable;
- be free of all ‘sharps’ (macroscopic inorganic contaminants, such as glass fragments, nails and needles);

- contain no materials, contaminants, weeds, pathogens or potentially toxic elements that adversely affect the user, equipment or plant growth (beyond certain specified limits);
- be dark in colour and have an earthy smell;
- be free-flowing and friable and be neither wet and sticky nor dry and dusty;
- be low in density and electrical conductivity.

According to the WRAP guidelines, such composts 'would normally be suitable for use as a growing medium constituent at a maximum rate of 33 % by volume in combination with peat and/or other suitable low nutrient substrate(s) such as bark, processed wood, forestry co-products or coir.' Higher rates usually affect plant growth negatively because of the compost's naturally high conductivity.

According to ORBIT/ECN (2008), the proportion of compost in growing media depends very much on the composting process and final compost quality. The main criteria are maturation and degree of humification, concentration of mineral nitrogen components, salt content and structural stability (porosity, bulk density, aggregation) and purpose for use. In growing media for hobby gardening 40–50 % (by volume) compost can be used; in growing media for professional use 20–30 % (by volume) compost can be used. In the German quality assurance system for compost (RAL, 2007) specific criteria are laid down for compost in potting soils (growing media). Two types of compost suitable as mixing compound for growing media with different mixing volumes are described regarding stability level, nutrient and salt content.

It is important to note that compost produced with a high proportion of cooked kitchen waste is usually only suitable in lower portions as growing media component because it tends to have a higher salinity and nutrient content.

2.4.3 Digestate applications

Digestate is generally used for its fertilizing properties, given its highly available fractions of N, P and K, yet it also holds certain soil improving properties.

Stakeholders provided multiple examples of digestate applications in the various Member States.

- In *Germany*, the majority of the digestate is used without further treatment and only about 10% of the plants treating waste produce compost from the output of the digestion process. The liquid phase is separated after digestion and the separated fibre is generally post-composted. Only 6% of the quality assured digestate (BGK label) is produced as solid digestate in Germany. Liquid digestate (94% of whole digestate) is used directly as fertiliser in agriculture.

- In the *Netherlands*, digestate from separately collected organic waste from households always undergoes aerobic post-treatment (composting) and the resulting material is sold as fertilizer or component in growing media. It is also noted that digestate from mixed waste, even after composting, does not meet the requirements for use as fertilizer and is partially incinerated and partially land-filled, the latter route being politically discouraged.

- In *Spain*, in general digestate or separated fibre from digestate is composted, the separate liquor is treated as wastewater or it is recycled into the process. The resulting compost is mainly sold to agriculture. Besides, digestate from the co-digestion of manure with other biodegradable waste is used directly in agriculture.

- In *Sweden*, in 2009, 97% of the digestate produced from anaerobic treatment plants was used in agriculture, mostly as whole digestate. Three of sixteen plants do separate the digestate. One of them uses the separated fibre and the liquor phase in agriculture, the other two plants compost the separated fibre.

- In *Italy*, anaerobic digestion plants that treat agricultural biomass apply the digestate directly in agriculture. For anaerobic digestion plants that treat organic wastes, the resulting digestate is considered a waste and the digestate can be aerobically post-treated to produce compost according to the national fertilizer regulations or disposed.

- In *Belgium*, only professional users are allowed to apply liquid digestates, as it is assumed that these materials are not suitable for application by private users, because of a lack of stability, which implies a need for certain measures for storage and no possibility of packaging in small bags. Moreover, special equipment is necessary to be able to apply the digestate (like for liquid manure). The same remarks apply to the separated liquor, containing fewer nutrients and less organic matter. The other fraction, the dewatered digestate, is more concentrated in organic matter and nutrients, but is still unstable and thus not suitable for private use. Often, the dewatered digestate is (bio)thermally dried so as to obtain a dried digestate, containing a higher concentration of nutrients and organic matter on a fresh matter basis. These end products have both fertilizing and soil improving properties. In Belgium, the product is considered to be stable at a dry matter content of at least 80 % and can then be named ‘dried’ digestate. It is possible to press the dried digestate into granules in order to obtain a product easy to apply in the desired dose. In function of the market demand, some producers are aiming at a dry matter content of less than 80 %. In that case, the product is named ‘partially dried’ digestate (40-80 % dry matter). Until now, the use of these products has been restricted to professional users in Belgium. No authorizations for private use have been delivered yet. In the future, the Belgian authorities could deliver such authorizations, only for dried (stable) digestates, based on a case by case evaluation and under strict conditions, such as requirements for input materials, process monitoring, the quality of the end product as well as sustainable application of the end product.

    - In Flanders, in total 150 415 tonnes of products were produced from digestion in 2009 (whole digestate, separated liquor, separated fibre, effluent after biological treatment of liquid fraction, concentrate after filtration of liquid fraction digestate, thermally dried digestate, biothermally dried bio-waste mixed with manure, biothermally dried organic soil improver). These products are mainly exported (56%). The second most important market is agriculture and horticulture (19%). The products are mainly applied on arable land. The liquid fractions are mainly used in agriculture, the solid fraction (separated fibre) is often transported towards manure processing plants (for biothermal drying) and export outside the Flemish Region.

    - In Wallonia, only one plant out of the 4 AD operating plants separates the digestate into a fibre and a liquor fraction.

- In *Slovenia*, there are currently 11 anaerobic digestion plants, of which 7 only treat agricultural biomass. Digestate is spread on agricultural land, whereby restrictions apply on the amount of nitrogen according to the Decree concerning the protection of waters against pollution caused by nitrates from agricultural sources (Official Gazette of the Republic of Slovenia, no. 113/09). The other 4 anaerobic digestion plants treat mainly catering waste, slurry and silage (corn) and the digestate (mainly liquid) is also spread in agriculture when it meets the requirements of the Decree on the treatment of biodegradable waste (waste legislation).

- According to the *UK* Organics Recycling Group, whole digestate may be suitable for use as biofertiliser, soil conditioner and, if sufficiently low in dry solids content, as foliar feed for plants. Separated liquor may be suitable for use as biofertiliser, soil conditioner and, if sufficiently low in dry solids content, as foliar feed for plants. Separated fibre may be suitable for use as biofertiliser, soil conditioner and mulch. In 2013, there were 111 anaerobic digestion facilities not related to wastewater treatment works, comprising 46 farm-fed installations (manures, slurries, crops), 47 food-waste fed installations and 18 industry fed installations (distilleries, dairies). The UK has developed an AD Quality Protocol, which defines end-of-waste for digestate. As of 2013, twelve plants are producing digestate certified to the Publicly Available Specification PAS 110 and the AD Quality Protocol.

- According to the European Compost Network, the following trends are noted with regard to digestate use:
  - Wet fermentation of bio-waste biogas plants:
    - In Central/Western Europe: the output is separated into a liquid and solid fraction whereby the solid fraction is post-composted and the excess liquid fraction that is not recycled to the process is mostly applied to agricultural land
    - In Scandinavia: the complete digestion residue is applied on agricultural land
  - Wet fermentation of energy crops, manure and industrial / commercial waste (food industries, restaurants, former foodstuff etc.): the complete digestion residue is applied on agricultural land
  - Dry fermentation: the solid digestion residue is generally post-composted together with bio-/green waste
  - Approximately less than 3% of the digestates are further treated to specific products e.g. for pellets or as constituents for growing media or manufactured soils.

- According to the European Biogas Association, new products like dried or pelletized digestates are increasingly released into the European market. With full upgrading by ultrafiltration and reverse osmosis, highly concentrated fertiliser and a purified aqueous stream of drinking water quality can be produced. These developments are rather new. Today, still more than 95% of the produced digestate in Europe is used directly in the agricultural sector as a liquid fertilizer.

In conclusion, it can be stated that digestate is often used in agriculture, either as a whole digestate fraction or following separation in a solid and liquid fraction. The solid fraction may undergo additional treatments such as post-composting or drying. The liquid fraction, when not used on agricultural land, may undergo a treatment similar to wastewater to produce a clean water fraction.

2.5 Economic and market aspects

This section characterises the compost and digestate market in the EU in terms of current compost and digestate supply and use, imports and exports, production costs, prices, and the agronomic value of compost and digestate. It also presents a market outlook for both materials.

2.5.1 Compost supply

ORBIT/ECN (2008) estimated that the yearly production of compost in the EU in 2005 was more than 13 million tonnes (compost from the biodegradable fraction of MSW and sewage sludge). When extrapolating from the partially updated data received following the stakeholder survey in December 2010, it is expected that compost production grew slightly from 2005 to 2008.

Only a few countries make up most of the compost production from MSW in the EU. In absolute amounts, Germany is the biggest compost producer with about 4.4 million tonnes annual production, followed by France, the United Kingdom, the Netherlands and Italy, according to the ORBIT/ECN (2008) study. On a per capita basis, compost production is highest in the Netherlands, followed by Austria, France and Germany. Of these countries, Germany, the United Kingdom, the Netherlands and Austria rely mainly on source-separated biodegradable fractions of MSW for compost production. In France and Spain, compost is also produced in considerable quantities from mixed MSW with a growing market share of MBT compost in France. France, Spain and Italy also produce sizeable amounts of sewage sludge compost. In the 12 new Member States, compost production plays a very small role. Table 1 presents compost production data country by country.

Based on sewage sludge production data from 2002 until 2007, Milieu (2009) calculated an annual EU-27 sewage sludge production of 10 Mtonne, of which 39% on average is used in agriculture. These data seem to be confirmed by Eurostat data for 2008. Although the Eurostat data only provide breakdown figures of use for 14 Member States, it can be derived that 37 % of the sewage sludge was used in agriculture in 2008 and around 17% was composted. Composting figures in individual Member States ranged from 0 to 86%. At least 10 Member States reported sewage sludge compost production. Germany and France appear to have the largest sewage sludge composting sectors, based on the Eurostat data. In general, sewage sludge makes up one to two thirds of the sewage sludge compost input materials, the other inputs being green waste and bio-waste.

Apart from MSW and sewage sludge, compost can also be produced from wastes from agriculture, forestry, and the food and drink industries. Reliable data on the quantities of composts produced from these sources is generally lacking.

Table 1: Compost produced in the EU (tonnes/year). Source: ORBIT/ECN (2008) and stakeholder survey December 2010

	Year	**Total**	**Bio-waste (except green waste) compost**	%	**Green waste compost**	**%**	**Sewage sludge compost**	**%**	**Mixed waste compost**	**%**	**Other composts**	**%**
AT	2005	**634,400**	218,400	34	380,000	60	32,000	5	4,000	1		0
BE/Flanders	2009	**344,856**	115,150	33	229,706	67	0	0	0	0		0
BE/Wallonia	2008	**152,954**	11,892	8	120,129	79	20,933	14	0	0		0
BG		**0**	0		0		0		0			
CY		**0**	0		0		0		0			
CZ	2006	**77,600**	4,000	5	21,600	28	52,000	67	0	0		0
DE	2008	**4,384,400**	2,048,600	47	1,599,000	36	627,600	14	0	0	109,200	2
DK	2008	**374,530**	17,600	5	315,600	84	41,330	11	0	0		0
EE		**0**	0		0		0		0			
ES	2008	**610,148**	53,969	9	6,549	1		0	549,630	90		0
FI	2005	**180,000**	150,000	83		0	30,000	17		0		0
FR	2005	**2,490,000**	170,000	7	920,000	37	800,000	32	600,000	24		0
EL	2005	**8,840**	0	0	840	10	0	0	8,000	90		0
HU	2005	**50,800**	20,000	39	30,800	61	0	0	0	0		0
IE	2006	**100,500**	25,000	25	34,000	34	17,000	17	24,500	24		0
IT	2008	**1,004,952**	802,340	80	176,804	18		0		0	25,808	3
LT		**0**	0		0		0		0			
LU	2005	**20,677**	20,677	100	0	0	0	0	0	0		0
LV		**0**	0		0		0		0			
MT		**0**	0		0		0		0			
NL	2008	**1,603,464**	595,464	37	1,000,000	62	8,000	0	0	0		0
PL		**0**	0		0		0		0			
PT	2005	**29,501**	2,086	7	1,730	6	2,500	8	23,185	79		0
RO		**0**	0		0		0		0			
SE	2008	**199,700**	71,700	36	116,000	58	0	0	12,000	6		0
SI		**0**	0		0		0		0			
SK	2005	**32,938**	1,836	6	27,102	82	4,000	12	0	0		0
UK	2005/06	**2,036,000**	316,000	16	1,660,000	82	15,000	1	45,000	2		0
EU-27		**14,358,104**	**4,651,864**	**32**	**6,654,554**	**46**	**1,650,363**	**11**	**1,266,315**	**9**	**135,008**	**1**
Bio and green waste compost					**11,306,418**	**79**						

2.5.2 Compost use

The suitable uses of compost depend on source material type, compost class and quality. Application areas like agriculture just require standard quality. Landscaping and, even more so, the growing media sector need an upgraded and more specialised product. Here, further requirements of the customers have to be met and it is up to the marketing strategy of the compost plant to decide whether to enter into this market segment.

Compost producers often face difficulties in marketing because they lack understanding of the potential use sectors such as the landscaping and horticultural sectors (e.g. knowledge of plant growing and the related technical language). Declaration, advertisement and marketing are not always of a standard comparable with competing products.

Table 2 provides an overview of compost use in the main compost producing countries in the EU.

Table 2: Compost use distribution (%) in major compost producing countries (Source: ORBIT/ECN, 2008)

	AT 2003	BE/ Fl 2009 (1)	DE 2005	ES (2) 2006	FI 2005	FR (3) 2005	HU 2005	IE 2006	IT 2003	NL bio-waste 2005	NL (2) green waste 2005	PL (3) 2005	SE 2005	UK 2005	Weighted Mean EU(4)
Agriculture	40.0	11	53.4	88.0	20.0	71.0	55.0	37.0	51.0	74.8	44.4	—	—	30.0	50.9
Horticulture & green house production	10.0		3.9	8.0	—	25.0	15.0	3.0	—	—	15.5	—	5.0	13.0	10.6
Landscaping	15.0	38	15.9	4.0	20.0	—	10.0	6.0	6.0	3.6	12.3	—	20.0	14.0	10.4
Blends	15.0	44	13.6	—	10.0	—	—	16.0		15.0	5.1	—		2.0	6.3
Soil mixing companies	2.0		—	—	—	—	—	—	—	—	9.4	—	10.0	—	1.6
Wholesalers	—		—	—	—	—	—	—	—	—	5.2	—	15.0	—	0.9
Hobby gardening	15.0		11.9	—	—	4.0	5.0	—	27.0	1.1	2.3	—	10.0	25.0	12.9
Land restoration and landfill cover	2.0		—	—	50.0	—	15.0	38	2.0	—	—	100.0	40.0	16.0	4.9
Export	1.0	6	—	—	—	—	—	—	—	5.5	5.0	—	—	—	1.0
Others	—	2	1.3	—	—	—	—	—	—	—	0.8	—	—	—	0.5

(1) Data for Wallonia reported in different classification: Agriculture 56.6%; Private 4.4%; Potting compost 13.1%; Green areas 2.1%; Rehabilitation 4.1%; Storage on-site 5.6%; Landfill 2.7%; Other elimination 2.6%; Exported 8.9%. (2) Green waste compost. ; (3) Mainly mixed waste compost; (4) Weighted by data from Table 1

An important factor determining compost use is the national environmental and fertilising policy. The manure policy in Belgium, for instance, makes it very difficult to sell compost to farmers. The excess of manure encountered in Flanders compared to the agricultural surface available implies that the limits of organic nitrogen levels are rapidly reached through manure spreading and that only 11 % of the compost goes to agriculture. This situation is not encountered in Wallonia, such that up to 57% of the compost produced goes to agricultural soils in that region. In the Netherlands, however, with the same animal husbandry and nutrient situation, most of the kitchen/bio-waste compost is used in agriculture (75 %).

In Europe, more than 50 % of the compost goes to mass markets which require standard quantities. Twenty to thirty per cent of the market volumes are used in higher specialised market areas which require an upgrade and mixing of the compost in order to meet the specific requirements of the customers.

In recent years, the use distribution in countries with developed markets (such as Flanders in Belgium, Germany and the Netherlands) was relatively stable. Changes in the fertiliser legislation in the Netherlands have, however, led to a reduced share of agricultural use after 2005.

2.5.3 Compost imports and exports

According to ORBIT/ECN (2008), the main compost exporting countries in the EU are probably Belgium and the Netherlands. On average, they exported 4.5 % of their annual production in 2005 and 2006. The main reason for exports in these cases was a low national demand because of strong competition of other cheap organic material (mainly manure). However, the Netherlands informed that competition with manure is no longer an issue for Dutch agriculture according to the feedback received following the stakeholder survey.

Generally, compost plants supply their product within 50 km of the plant. This corresponds to the distance a large lorry of 25 tonnes capacity can make within an hour for the cost of EUR 50–60. These transport costs and the other marketing expenses are still covered by prices of around EUR 5/tonne (EUR 125/lorry load). All plants close to borders (less than 50 km distance) contacted by ORBIT/ECN underlined the importance of this local market and expressed their appreciation of the end-of-waste provisions which could potentially help them to overcome the constraints of selling their compost over the border. Nonetheless, ORBIT/ECN also mentioned cases in Germany where compost is being transported over a distance of 200 km.

ORBIT/ECN reports not having detected a ‘real import demand’ for compost. The low value per weight of compost does not cover the cost of the transport to the areas where the main needs exist, such as the Mediterranean countries.

The main continuous import and export activities and potentials are related to the growing media sector. Using compost in various products based on green waste are a common business especially for the large international companies producing and dealing with peat, soil and bark. However, growing media products containing compost as one of the components are generally not considered subject to waste legislation.

2.5.4 Production costs and compost prices

The costs of composting depend on local conditions and the quality of the material to be composted. Eunomia (2002) reviewed the information from various sources regarding the cost of composting source-separated biological waste, and made a cost estimate of EUR 35–60/tonne of waste for larger ‘best practice’ plants in closed systems, although higher costs had also been reported in some cases. The cost of low-tech windrow composting may be less than EUR 20/tonne of waste. There are also some cost differences between countries following the general tendencies of producer prices. Gate fees charged for green waste tend to be smaller than for kitchen waste or for mixed kitchen and green waste.

The price of bulk compost for use as an organic fertiliser or a soil improver is much lower than the ‘production costs’, i.e. the costs of treating biological wastes in a composting plant. The prices achieved for composts for agricultural use in central Europe are rarely higher than EUR 5/tonne of compost and, in most cases, lower. Often, the compost is actually given away to farmers free of charge. A typical scenario in Germany is that the compost producer offers the transport, the compost and the spreading of the compost on the field as a service to the farmers (usually through subcontractors) and charges about EUR 1–2/tonne for everything.

Compost sales to agriculture become very difficult when there is a fierce competition with manure. This is the case in Flanders and the Netherlands, where, on account of the huge animal husbandry, a surplus in manure arises and up to EUR 30/tonne of manure is paid to the users. This and a restrictive application regulation make it difficult to sell compost for agricultural uses in those countries (ORBIT/ECN, 2008).

A French compost market study for ADEME (2006) reports the following price ranges for compost use in agriculture (grandes cultures):

- compost from green waste: EUR 0 (in most cases) to EUR 10–12/tonne (including the cost for transport and spreading)
- compost from mixed MSW: EUR 0 (most frequently) to EUR 2–3/tonne (including spreading).

The combined separation-composting plant for MSW at Launay Lantic (France) sells most of the compost produced to artichoke or cauliflower growers at a price of EUR 2.34/tonne (personal communication).

In Austria, decentralised composting plays an important role and often farmers run small and simple windrow composting facilities in which they treat source-separated biological waste from nearby municipalities. The farmers use the compost on their own farmland, and if their farmland is of a suitable size, there is no need for these compost producers to sell or give away the compost. For the highest quality compost, which is suitable for organic farming, prices of a little more than EUR 10/m^3 have been found. An example of the gate fee charged by a ‘farmer-composter’ in Austria is EUR 48/tonne bio-waste from separate collection.

In 2001, the average sales price for compost made from pure garden and park waste in Denmark were reported to be about EUR 8–9/tonne (Hogg et al., 2002).

According to ORBIT/ECN (2008), soil manufacturing companies and blenders are interested in getting cheap raw material and are therefore not willing to pay high prices, so sales prices range from EUR 2.40 to EUR 3.20/tonne.

The Italian Composting Association indicates average sales prices for compost in Italy at 3 to 10 Euro/tonne.

Landscaping and horticulture require medium efforts in product development and marketing, which reflect the price of EUR 6–15/tonne. Hobby gardening prices are on a similar level.

Relatively high prices from EUR 90 to EUR 300/tonne follow from situations where the compost is sold in small bags, e.g. as blends, to hobby gardeners or to wholesalers. Bulk deliveries to wholesalers, however, only lead to about EUR 7/tonne. However, in most cases such prices are only obtained for a minor fraction of the total compost production of a plant (typically 1% or less). As such, the sales of compost to private end-users serves more in raising awareness on the need for good recycling of biodegradable materials.

An interesting approach to generate higher revenues from compost is applied in certain compost plants in Germany. An external company provides the marketing tools, such as billboards, information folders etc. The local plant operator prepares the mixtures according to prescriptions and pays the marketing company based on the amount of compost products sold in bulk or bagged. In order to encourage citizens to respect source separation guidelines for bio-waste collection and to create trust in the manufactured compost products that they purchase, references are made to regional affiliations on the compost bags. In this way, the consumers understand that the compost bought is the output of their proper collection and sorting efforts.
Using this marketing approach, plants do not only guarantee good compost quality, but they are also able to combine high turnover to private customers with high revenues. In this way, they can sell around 30% of the compost production to private end-users and generate prices of up to 20 Euro/m^3 for compost and even higher prices for compost blends. A requirement for such a strategy is that the compost plant is situated in areas with a considerable number of garden owners.

Figure 3: Billboard outside composting plant (Weiterstadt, Germany) indicating prices of locally produced compost and compost based goods

Unless sizeable proportions of the compost produced can be sold to outlets other than agriculture for higher prices, the financial feasibility of the composting plants essentially depends on the gate fees charged for the treatment of the wastes used as input or on subsidies. According to ORBIT, this is true for all European countries. Ninety-five per cent of the plants rely on the gate fee. Only very few companies have developed their local market so well that compost sales contribute substantially to their economic feasibility. In most cases, only a relatively moderate pressure exists for entering into the revenue-oriented high price markets, which requires additional efforts and competence in market and product development and marketing.

The low value per tonne of compost soil improvers and fertilisers is a strong limitation to the distances over which the transport of compost for agricultural uses makes economic sense. Transportation over more than 100 km for agricultural uses will only be feasible if there are specific areas where agriculture has an exceptionally strong demand for organic fertilisers that cannot be satisfied from local sources or if the waste management sector 'cross-subsidises' the transport cost (negative prices of the compost before transport). The latter is likely to occur if the alternative treatments for biological waste, such as landfill or incineration, are more expensive than composting.

2.5.5 Agronomic value of compost

In general, prices for industrial fertilisers are known to be very volatile and hence may substantially fluctuate in time. This is important to consider when estimating the agronomic value of possible substitute products, such as compost.

ORBIT/ECN (2008) estimated the agronomic value of compost based on the fertiliser prices published on 10 April 2007 by the Chamber of Agriculture of North Rhine-Westphalia. For example, fresh compost produced from kitchen and garden wastes, rich in nutrients and well structured, and declared as organic NPK fertiliser 1.40 (N)–0.60 (P_2O_5)–1.02 (K_2O) had a nutrient value of EUR 8.49/tonne fresh matter. The fertiliser value of well-structured compost with lower nutrient contents (organic PK fertiliser EUR 0.43/kg P_2O_5–EUR 0.22/kg K_2O) was calculated to be EUR 3.93/tonne fresh matter. The nitrogen content was calculated on the basis of the available contents. The contents of phosphorus and potassium were calculated at 100 % on recommendation of agricultural consultants.

In addition to the nutrient value, ORBIT/ECN also calculated the humus value for an average compost application (ca. 2 800 kg humus-C/hectare incorporated within a three-year crop rotation). Taking the substituted supply costs of humus via 'green manuring' with *Phacelia* or *Sinapis arvensis* and/or straw sale as the reference, the humus value of compost was calculated to be EUR 3.28/tonne fresh matter.

According to April 2011 data from the German Compost Quality Assurance Organisation (BGK), the fertiliser value for compost was 11.26 Euro/ tonne fresh matter (with 8.3 kg N/tonne fresh matter, 3.8 kg P_2O_5/ tonne fresh matter, 6.8 kg K_2O/ tonne fresh matter and 25.1 kg CaO/ tonne fresh matter). When including the organic matter, the monetary value of compost was calculated at 22.82 Euro/ tonne fresh matter by BGK.

Comparing the figures of agronomic value above with actual compost prices for agricultural use, it appears that compost prices have substantial potential for increase.

2.5.6 Market outlook for compost

In this section, the theoretical potential of compost production from the source-segregated biodegradable fractions of MSW is estimated and compared to the theoretical compost use potential. Also, the amounts of alternative materials, which can be used instead of compost, are estimated.

<u>Compost production potential</u>

According to Eurostat[12], 524 kg of municipal waste was generated per person in 2008, of which about 88 kg or 17% was composted. In absolute figures, this implies 44.5 million tonnes of MSW being composted. These figures hardly changed from the 2007 data.

Based on ORBIT/ECN study (2008), about 29.5 % or 23.6 million tonnes of the estimated total recoverable potential of the 80 million tonnes organic waste fractions was separated *at the sourc*e and treated predominantly through composting. This corresponds to an average per capita bio-waste and green waste collection rate of about 50 kg/year.

Experience in certain countries showed that a collection rate of up to 180 kg/capita/year of source-separated organic waste suitable for biological treatment can realistically be achieved (for example in the Netherlands or Austria). A reasonable and realistically achievable European average rate might be 150 kg/capita/year (ORBIT/ECN 2008). Using this as a reference, it would imply a potential of separate bio-waste and green waste collection in the EU of about 80 Mtonne/year. If all this were used for compost production, 35–40 Mtonne of compost could be produced per year. Table 3 shows estimates of current amounts of separately collected wastes as well as of the maximum potentials for the 27 Member States of the EU.

Furthermore, the potential for the production of compost from sewage sludge was estimated to be from 5 to 10 Mtonne/year. The potential for the production of compost from other organic materials cannot reasonably be quantified, because of the very heterogeneous properties even within one sub-waste stream (e.g. market wastes). The suitability of treating those materials in an aerobic composting process depends on the composition, degradability, water or nutrient content (C/N ratio). Composting is not always the first choice. Most of the food and vegetable residues, for instance, are very wet which makes them more suitable for anaerobic digestion. For bark and wood, energy generation might sometimes be the preferred option.

[12] Eurostat news release 43/2010 http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-19032010-AP/EN/8-19032010-AP-EN.PDF

Table 3: Potential and actual amounts of bio-waste and green waste collected for composting in the EU-27 (1 000 tonnes) (Source: ORBIT/ECN, 2008).

		Potential quantities			Separately collected today (without home composting) (3)			Separately collected (% of total potential)
	Total MSW (1)	Bio-waste	Green waste	Total (2)	Bio-waste	Green waste	Total	
AT	3 419	750	950	1 700	546	950	1 496	88
BE	4 847	n.d.	n.d.	2 573	n.d.	n.d.	885	34
BG*	3 593	n.d.	n.d.	1 164	0	0	0	0
CY*	554	n.d.	n.d.	112	0	0	0	0
CZ	3 979	1 354	180	1 534	10	123	133	9
DE	37 266	8 000	8 000	16 000	4 084	4 254	8 338	52
DK	3 988	433	750	1 183	38	737	775	66
EE	556	195	130	325	0	0	0	0
ES*	25 694	n.d.	n.d.	6 456	n.d.	n.d.	308	5
FI*	2 451	n.d.	n.d.	785	350	100	450	57
FR*	46 000	n.d.	n.d.	9 378	300	2 400	2 700	29
EL*	4 854	n.d.	n.d.	1 662	0	2	2	0
HU*	4 446	n.d.	n.d.	1 515	n.d.	n.d.	127	8
IE*	3 041	n.d.	n.d.	616	52	71	123	20
IT	31 687	n.d.	n.d.	8 700	2 050	380	2 430	28
LT*	1 295	n.d.	n.d.	514	0	0	0	0
LU*	321	n.d.	n.d.	68	n.d.	n.d.	52	76
LV*	715	n.d.	n.d.	346	0	0	0	0
MT*	246	n.d.	n.d.	60	0	0	0	0
NL*	10 900	n.d.	n.d.	2 446	1 656	1 700	3 356	137 (4)
PL*	9 353	n.d.	n.d.	5 726	n.d.	n.d.	70	1
PT	4 696	n.d.	n.d.	1 579	24	10	34	2
RO*	8 274	n.d.	n.d.	3 249	0	0	0	0
SE*	4 343	n.d.	n.d.	1 352	125	250	375	28
SI*	845	n.d.	n.d.	300	0	0	0	0
SK*	1 558	n.d.	n.d.	808	5	68	73	9
UK*	35 075	n.d.	n.d.	9 009	n.d.	n.d.	1 872	21
EU-27	257 947			80 101			23 598	29.5

(1) Source: Eurostat website (http://epp.eurostat.ec.europa.eu).
(2) In most cases individual estimations by national experts were missing. For all Member States marked with an asterisk (*) the realistic potential of bio-waste and green waste collection is based on the assumption of 150 kg/capita/year.
(3) The estimation of currently collected bio-waste and green waste was provided by national experts contacted during the elaboration of this study (see acknowledgments). The reference year was 2005.
(4) The Netherlands with 200 kg/capita/year bio and green waste collection has already exceeded the mean potential estimated with 150 kg/capita/year. This leads to 137 % collected against potential.

Compost use potential

ORBIT/ECN (2008) suggests a simple calculation to illustrate that the theoretical potential for compost use, in agriculture alone, is much higher than the theoretical compost production potential from bio-waste and green waste. The calculation is reproduced in Table 4. Similar conclusions were obtained by calculations of this type at the level of individual Member States.

Furthermore, there are specific compost market studies for Germany, Ireland, Spain, France and the United Kingdom (most of them reviewed by ORBIT/ECN) that all conclude that there is sufficient potential for use of high-quality compost.

Table 4: Comparison of compost production and agricultural use potentials in the EU (Source: ORBIT/ECN, 2008).

Present situation in EU	Amount
Amount of collected bio and green waste	23 600 000 tonnes
Amount of compost produced in the EU-27	11 800 000 tonnes
Arable land for plant production in the EU-27	123 391 000 ha [13]
A typical application rate of 10 tonnes compost/ha/year needs	1 180 000 ha
Portion of the total arable land needed to absorb the compost	1.5 %
Theoretical compost production potential (maximum)	Amount
Potential for collected bio and green waste	80 000 000 tonnes
Potential amount of compost produced in the EU-27	40 000 000 tonnes
Arable land for plant production in the EU-27	123 391 000 ha
A typical application rate of 10 tonnes compost/ha/year needs	4 000 000 ha
Portion of the total arable land needed to absorb the compost	3.2 %

<u>Substitute materials for compost</u>

As soil improvers, agricultural residues — first of all straw and manure — can create a similar benefit to compost by fertilising the soil and delivering organic matter. According to ORBIT/ECN (2008), the effect on humus reproduction is, however, much higher of compost than of these materials. In the EU, there are from 1.5 to 2 billion tonnes of agricultural residues per year.

Plant nutrients contained in compost can substitute, to some extent, mineral fertilisers. In Germany for example, the substitution potential for phosphate is 28 000 tonnes, which corresponds to 10 % of the phosphate of the mineral fertilisers applied in Germany. These potentials are 9 % (43 000 tonnes) in the case of potassium and 8 % (175 000 tonnes) in the case of lime fertilisers.

Compost also competes with the land spreading of sewage sludge. Some 4 Mtonne (dry matter) treated sludge from municipal waste water treatment was used in agriculture in 2006 in the EU-27.

In growing media, compost can partly substitute peat and bark. Bog peat is still the overall predominant growing medium constituent in the EU. This is also true for Member States

[13] Source: Eurostat. Statistik kurz gefasst. Landwirtschaft und Fischerei 86/2007. Europäische Gemeinschaften 2007.

without domestic peat production. Peat-free growing media are highly esteemed by some stakeholder and user groups but still play a relatively minor role in the industrial production of growing media. For technical reasons, bark, coir and compost can only partly serve as substitutes for peat.

In 2005, 0.95 million m^3 compost and 2.05 million m^3 bark (including wooden materials) were used in growing media (ORBIT/ECN, 2008).

2.5.7 Digestate supply

Comparisons of digestate and compost supply are often complicated due to the different units used for reporting, such as dry weight, wet weight or fresh matter. The data below therefore indicate all values as they are reported. Furthermore, some data may not be fully available, such as on digestate from sewage sludge.

The total amount of digestate produced in Europe is estimated at 56 Mtonne fresh matter/year[14]. However, it should be noted that not all of the digestate produced is derived from biodegradable waste only. In view of the high prices paid for electricity produced from biogas (up to 0.3 Euro/kWh), digestion plants frequently rely on energy crops as input material for biogas production.

In the EU-27, *Germany* is the major producer of digestate, with about 36.5 Mtonne digestate produced annually. The majority of digestate is a residue from the biogas production from energy crops, which is financially stimulated through the revenues from green electricity production. Digestate produced from bio-waste amounts to only a small fraction of the total digestate produced, with 2.84 Mtonne fresh matter/year (2008 data). In the German quality assurance system for digestate (RAL GZ 245/246) of BGK 2.5 million tonnes fresh matter of digestate are quality assured. A number of 84 digestion plants treat bio-waste and 15 digestion plants treat only renewable energy crops under the BGK QAS. The main input materials are: renewable energy crops (24%), bio-waste from households through biobin (22%), manure (20%), food waste (14%), fats (10%), former foodstuff (7%) and diverse bio-waste (3%). About 93% of the input streams used in anaerobic digestion plants treating waste, based on the German waste statistics, consists of following waste streams: wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing (30.99%), waste from the production of food of animal origin (21.02%), waste from the production of food of plant origin (14.21%), municipal sewage sludge (3.14%), commercial food waste (6.84%), green waste (2.75%), biobin waste from households (14.23%). According to the European Biogas Association, 27 million tonnes of manure are fed into anaerobic digesters in Germany for the production of biogas, and there is a potential to increase this number to 150 million tonnes. Furthermore it is stated that Germany produces 75% of all biogas in Europe. Sewage sludge is not allowed in Germany as input material as in German legislation, the Sewage sludge ordinance takes precedence.

In *Sweden* 389 ktonne fresh matter/year digestate was produced in 2008 (with an average dry matter content of 10%). The input material for anaerobic digestion consisted of source separated biodegradable fractions of municipal solid waste (17%), commercial food waste (18%), manure (24%), slaughterhouse residues (29%) and other biodegradable wastes (12%).

[14] E-mail comunication with the European Compost Network (1 February 2011)

In *The Netherlands*, in 2010, ten plants had a license to digest separately collected organic waste from households. These ten plants had a combined licensed capacity of 1000 ktonne/year. Four of these ten installations really digested waste in 2010. Together they treated 174 ktonne, consisting of 154 ktonne separately collected organic waste from households and 20 ktonne of comparable organic waste from businesses. All digestate is post-composted. The total production of manure in 2010 in the NL was about 70 000 ktonne. In 2010, at least 842 ktonne of manure was fermented in The Netherlands. The study producing this figure had a response rate of approximately 70% so in reality anaerobic digestion of manure will involve approximately 1200 ktonne.

In the *Czech Republic*, digestate production from agricultural bio-waste amounted to 80 ktonne digestate in 2008.

In *Denmark*, the yearly amounts of waste treated by anaerobic digestion are 13 ktonne of source separated municipal waste, 282.6 ktonne of industry waste, 39 ktonne of sewage sludge and 1320 ktonne of manure. According to the Danish EPA, there is potential for further treatment of 724 ktonnne/year of municipal waste.

In *Italy*, in 2008, the amount of digestate produced from source segregated bio-waste was 52.6 ktonne (fresh matter). The CIC (Italian Consortium for composting) estimates for the year 2010 a production of 400 ktonne fresh matter. Digestate from biodegradable source separated wastes is used to produce compost with the requirement of the fertilizer national law (product). In addition to this, digestate is also produced from various wastes and from agricultural materials, for which the treatment capacity is about 10 times higher (521 plants with an estimated total input capacity of 6 to 8 Mtonne/year). This digestate is generally used directly in the farms where it is produced.

In Flanders (*Belgium*), in 2010, around 800 ktonne fresh matter of digestate was produced, with the large majority ending up as mushroom substrate or biothermally dried compost for export. 100 ktonne of source separated vegetable fruit and garden waste were digested in mono-digestion, whereas 749 ktonne of organic biological waste were co-digested with 415 ktonne of manure and 149 ktonne of agricultural residues or energy crops.

In *Luxembourg*, 177 ktonne of digestate was produced from biodegradable waste (12%), manure (64%) and energy crops (24%) in 2009.

In *Spain*, in 2008, 504 ktonne of digestate from sewage sludge was produced in 185 plants.

In the *UK*, estimated quantities of whole digestate manufactured in 2009 were 124 ktonne. The quantities reported for separated fibre and separated liquor for the same year were only respectively 380 and 80 tonnes. Almost similar proportions of municipal (25.4 ktonne) and non-municipal wastes (23.1 ktonne) were digested (52% and 48%, respectively), which was in sharp contrast to the composting sector where the ratio was 80% and 20%, respectively. This implies a reduced reliance on wastes supplied by local authorities, and a more diversified business model, sourcing wastes from the commercial and industrial sector. Within the municipal waste category, the majority comprised biodegradable kitchen and canteen wastes (EWC code 20 01 08; 56%; 14 ktonne), although mixed municipal wastes (20 03 01) comprised 25% (6 ktonne). The latter were only accepted at a single site in Scotland. Waste from markets (20 03 02) made up 11% (2.76 ktonne), whilst edible oils and fats (20 01 26) were 5% (1.3

ktonne). Wastes from non-municipal sources were split between wastes from agricultural, horticultural, hunting, fishing and aquaculture primary production, food preparation and processing) at 40% (9.2 ktonne) and wastes from waste treatment facilities, offsite waste water treatment plants and the water industry at 60% (13.9 ktonne). The latter comprised just less than 14 ktonne of “digestate from anaerobic treatment of animal and vegetable waste” (19 06 06) at one AD plant. Since 2009, the UK AD sector has increased significantly from 17 to 78 plants (WRAP, 2012).

According to the Austrian Compost and Biogas Association, *Austria* had 132 biogas plants, treating biodegradable waste with an installed capacity of 470 000 tonne per year, in 2011.

Based on data from EFAR, 70%, 17% and 90% of the total sewage sludge production is digested in parts of the UK (England and Wales), France and Germany, respectively.

Further data on digestion facilities for bio-waste (source separated organics) and municipal solid waste is provided in a study by De Baere and Mattheeuws (2010). They made an inventory of the existing plants, contracted installations and plants under construction in several EU member states (Table 5).

Table 5: Installed capacity of anaerobic digestion plants for bio-waste and municipal solid waste (Source: De Baere and Mattheeuws, 2010)

	Total capacity (tonnes/year)	**Average capacity (tonnes/year)**	**Number**
AT	84,500	12,071	7
BE	173,700	34,740	5
DE	1,732,805	23,104	75
DK	31,000	40,500	1
ES	1,495,000	59,563	25
FI	15,000	15,000	1
FR	862,000	66,308	13
IT	397,500	36,136	11
LU	23,000	11,500	2
MT	45,000*	45,000*	1
NL	476,500	59,563	8
PL	52,000	13,000	4
PT	85,000	21,250	4
SE	40,000	10,000	4
UK	202,500	40,500	5
Total	**5,715,505**		**166**

*According to information from the Maltese Environmental Protection Officer, the value is 35000

Following criteria were taken into account in the study by De Baere and Mattheeuws:

- At least 10% of organic solid waste from household origin needs to be treated in the plant, with a minimum capacity of 3 ktonne per year.
- The capacity taken into consideration is the designed capacity for the plant, unless specified differently by the supplier/operator. For bio-waste, the total capacity of the

bio-waste plant was used while for mixed and residual waste plants, the actual capacity going into the digesters was used.

- Plants were not eliminated if their operation ceased.
- The plants taken into consideration have to be at least under construction or contracted and situated in Europe.

According to the same study by De Baere and Mattheeuws (2010), the capacity of AD plants in Europe currently nearly doubles every 5 years.

2.5.8 Digestate use

Europe-wide, the majority of the digestate is recycled in agriculture (80-97%). It is estimated that the overall ratio of digestate to compost use on farmland is about 1/10 in countries with a well-developed compost market.

In *Germany*, nearly all digestate is used in agriculture. In *Sweden*, 96% of the digestate goes to agriculture.

In the *UK*, in 2009 all of the reported whole digestate, liquor and fibre was applied to agricultural land. The main type of agricultural crop to which whole digestate was applied was grassland (52%), whilst 43% was applied to cereals / combinable crops. The relatively small quantities of fibre and liquor were applied predominantly to cereals and other combinable crops.

In *Slovenia*, when the digestate produced from bio-waste meets the requirements of the Decree on the treatment of biodegradable waste of quality Class I, it can be spread on agricultural land without restrictions. When the digestate meets the requirements of quality Class II, it can be used on agricultural land with the permit of the competent authority and in horticulture and landscaping without restrictions. The quality classes are the same for compost and digestate.

Although the official statistical figures for Germany indicate that 110 ktonne of digestate are composted, the European Biogas Association states that in practice 250 ktonne of digestate are post-composted, but the anomaly stems from the fact that the resulting material is not always being declared as compost, which should be the correct denomination.

2.5.9 Digestate imports and exports

Very few Member States mentioned current exports or imports of digestate. *Sweden* and the *Czech Republic* explicitly mentioned not importing or exporting digestate.

Import or export of digestate is more likely to happen in smaller countries with a large digestate production and reduced uptake possibilities in the own market. As such, digestate is exported from the Flemish Region towards a.o. France, after it is treated in manure treatment plants with ABPR recognition (1069/2009), or when sanitised in the digestion plant. This is mainly the solid fraction of digestate (20-25% dry matter), digestate after biothermal drying (40-45% dry matter) or thermally dried digestate (65-85% dry matter). No liquid digestate is exported, except as incubation material to set up new anaerobic digestion plants abroad. There is very few import of digestate because of manure legislation in Flanders hampering the input of extra nutrients into agriculture. A negligible part of digestate is exported from Wallonia (due to the fact that some fields from the producer are located in another country), and no import occurs.

2.5.10 Digestate production costs, gate fees and digestate prices

According to the European Biogas Association, production costs range from 10 to 30 Euro per tonne for bio-waste treatment through anaerobic digestion, *excluding* investment costs. The figure depends on the technology used and the quality and purity of the input materials. Gate fees also largely vary on local conditions and regulations and especially on the energy content of the feedstock. For certain lipid derived materials with high gas potential, anaerobic digestion operators are even willing to pay for the waste.

The sales price for digestate is generally slightly lower than for compost. Positive prices are seldom encountered and the digestion plants commonly pay intermediate companies or farmers for the landspreading of digestate. Furthermore, digestate is rarely sold at cost covering prices, with an average maximum price of 3 to 5 Euro/tonne for whole digestate. In the best cases, solid and post-composted digestates can be sold for up to 10 Euro per tonne. Noteworthy, however, is that dry pelletized digestates can reach prices of up to 150-250 Euro per tonne in the agricultural market. Additionally, digestates in all forms can reach higher prices when sold for private consumer use.

According to the European Biogas Association, several thousands of tonnes of dried digestate produced from energy crops and manure are already available in the market and sold to fertiliser factories as well as transported across the borders. Prices range from 5 - 30 € per tonne dried digestate, depending on the feedstock, content of nutrients and quality[15]. Wet digestates are sold at prices of 0 to 8 Euro/tonne, whereas composted digestates generally generate prices of 0 to 50 Euro per tonne. The wide price span is explained by different demands in different EU regions, whereby regions with a high manure supply are characterised by lower digestate prices.

Treatment costs for composting and digestion in *Germany* are reported to be between 30 and 80 Euro per tonne. Additional composting following digestion adds an additional cost up to 30 Euro per tonne.

In the *Czech Republic*, there are only a few waste anaerobic digestion plants. Plant owners are facing serious difficulties to receive sufficient input of source separated bio-waste, due to cheap landfilling, low enforcement of bio-waste diversion targets from landfills and catering waste shredders, which are very common in every catering facility even if they are not legally operated. Furthermore, anaerobic digestion plants usually have to pay 1 to 5 Euro/ tonne wet material for post-composting of digestate. The gate fee for waste treatment is very low to keep competition with landfilling and avoid direct shredding of biodegradable waste into the wastewater. Gate fees are hence at 0-15 Euro/tonne, compared to 30-40 Euro/tonne for landfilling.

In *Spain*, in Catalonia, production costs for digestate from source separated bio-waste are estimated at between 60 and 90 Euro/tonne of bio-waste.

Gate fees in *Belgium* are reported at 20 Euro/tonne for manure and 15.6 Euro/tonne for other organic biological waste (Flanders). Anaerobic digestion plants in Wallonia are driven by the

[15] According to a personal communication with a producer of dried digestate in Belgium, prices of dried digestate fluctuate in line with market prices for industrial fertilizers.

objective of either treating organic wastes or producing energy at low costs (subsidies for green energy production) and therefore it is reported that there are no gate fees for digestion plants.

In the *Netherlands*, gate fees for anaerobic digestion of vegetable fruit and garden waste are at 40-50 Euro/tonne input material.

In *Slovenia*, digestate is given away free of charge to farmers.
In the *UK*, gate fees for anaerobic digestion (£36-64 per tonne input) are generally in line with those of in vessel composting sites (£29-82 per tonne input) and somehow higher than open air windrow composting (£6-51 per tonne input) according to a WRAP study[16]. The income from sale of digestate was found to be low, with a pecuniary value of only £3 (approximately 3.5 Euro) per tonne. The financial value of anaerobic digestate is estimated at £7 (approximately 8 Euro) per tonne. Although most digestate is currently going to agriculture, it could offer a cost effective alternative to expensive commercial fertilisers for the UK's landscape and regeneration sectors. Furthermore, gate fees are expected to fall in the future, because of increased revenue from the production of electricity.

2.5.11 Agronomic value of digestate

According to the European Compost Network [17], the nutrient value for solid digestion products was about 11.7 Euro/tonne fresh matter and for liquid digestion products 6.7 Euro/tonne fresh matter. These data were valid for 2007 and went up by about 50% from 2005, due to the rising prices for mineral fertilisers. They are largely comparable with the nutrient values of compost.

According to the *German* Quality Assurance Organisation of Compost (BGK), the fertiliser value for digestate (with 5.2 kg N/m^3 fresh matter, 1.6 kg P_2O_5/m^3 fresh matter, 2.3 kg K_2O/m^3 fresh matter and 2.2 kg CaO/m^3 fresh matter) was 6.38 Euro/m^3 fresh matter in April 2011. When including organic matter, the monetary value of digestate is calculated at 7.23 Euro/m^3 fresh matter.

Based on ammonia nitrogen content and phosphorous, digestate with 4% dry matter content is estimated to have an economic value of 4.5 Euro/ton digestate in *Sweden*.

2.5.12 Market outlook for digestate

Despite the low sales price for digestate, several Member States clearly experience an increasing trend for digestion and a shift from composting to digestion or to combined composting and digestion. This evolution is explained by the fact that municipalities are able to negotiate lower gate fees to bio-waste operators thanks to increased competition in the bio-waste treatment sector. Hence bio-waste operators are forced to generate revenue through other options, such as through the sale of electricity from biogas production.

In Member States with emerging treatment facilities for biodegradable waste and a large history of landfilling, the market development seems to be less smooth. In the *Czech Republic*, gate fees for landfilling of 30-40 Euro/tonne include 20 Euro/tonne landfill tax that directly goes to the receiving municipality. Because of the latter policy, municipalities tend to largely support landfilling, as it provides a certain income, at the expense of anaerobic digestion. As a

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[16] http://www.wrap.org.uk/sites/files/wrap/Gate%20Fees%20Report%202011.pdf
[17] http://www.compost.it/biblio/2010_beacon_conference_perugia/2nd_day/5.c%20-%20Barth.pdf

result, waste anaerobic digestion plants are orienting themselves towards industrial materials such as glycerine from biodiesel production, with a high biogas yield.

Finally, high value products, such as biothermally dried digestate sells at prices that compete with industrially made fertilizers and could hence increase the revenues for digestion plants.

2.6 Standards and technical specifications

This section deals with standards and technical specifications for compost and digestate. It should be noted, however, that standards and legislative aspects are commonly interwoven, as certain member states recognize the efforts of voluntary quality assurance schemes through legislation. Hence, this section and the next section on legislative aspects may contain closely related information.

2.6.1 Compost categories

Compost classifications are very diverse across Member States. The categories are usually defined by compost, fertiliser or soil protection legislation or by voluntary standards. The criteria typically applied for classification are the input materials used, the compost product quality (contents of hazardous substances, nutrients, impurities), and the uses for which the compost is fit. In this report, the categories defined according to input materials are called ‘compost types’ and the categories defined according to product quality are called ‘compost classes’. The ORBIT/ECN (2008) study suggested a terminology for the most relevant compost categories, depicted in Table 6. More detailed descriptions of existing compost categories can be found in ORBIT/ECN (2008).

Table 6: Classification of compost (Based on ORBIT/ECN, 2008).

Input material The compost type is defined by the type, origin and characteristics of the source materials used for the production of the compost.	
Bio-waste compost	Compost from kitchen and garden waste (from source-separated waste collection). This is the material commonly collected in the commingled collection scheme for food and garden waste (brown bin, ‘biobin’ system).
Green waste compost	Compost produced from garden and park waste.
VFG compost	Compost from vegetable, fruit and garden waste. This type of compost has been established in Belgium (Flanders) and the Netherlands based on the collection scheme for organic household waste where the collection of meat is excluded (BE) or included (NL).
Biomix compost	Bio-waste, green waste, sewage sludge (quite a common system in Italy where sewage sludge is co-composted with source-separated bio and green waste).
Bark compost	Compost produced from bark; usually not mixed with other organic residues but with additives as a nitrogen source.
Manure compost	Compost from solid stable manure or from dewatered (separated) slurry.
Sewage sludge compost	Compost produced from dewatered municipal sewage sludge together with bulking material.

Mixed waste compost	Compost produced from mixed municipal solid waste (only partial or no source separation of the organic waste fraction), which has undergone mechanical separation and biological treatment (MBT).
Product quality Compost classes demand certain quality levels as regards the concentration of contaminants (e.g. heavy metals) and macroscopic impurities.	
Heavy metal classes	Compost classes are distinguished by limit values for heavy metals.
Impurity classes	Limits for the contents of macroscopic impurities like plastics, metals and glass. A two-class class system has been suggested, which should distinguish between composts for food production/pasture land and non-food areas.
Others	Distinction between composts may be based on
Uses The use types classify composts for certain areas of application based on defined quality parameters. In some cases, this is linked to product quality classes.	
Compost for organic farming	For the use of bio-waste from source-separated organic household waste, limit values for heavy metals have to be respected (Commission Regulation (EC) No 889/2008). There are no such quality criteria for other compost types like green waste compost. Any compost produced from municipal sewage sludge is forbidden in organic farming.
Compost for food production	Restriction of certain heavy metal or impurities related *compost classes* (e.g. Class 2 or B) for use in agricultural or horticultural food and feedstuff production.
Substrate compost for growing media and potting soils	Compost providing specific performance characteristics such as particle size, salt content, stability, plant response, nutrient availability, etc., in order to be successfully used as a constituent in growing media and potting soils.
Mulch compost	Compost of a generally coarse structure (higher portions of wood chips with a maximum particle size up to ca 35 mm) and with fewer demands regarding maturity.
Mature compost	Fully humified compost generally utilised and recommended in all — also sensitive — applications. Identification is done by methods testing the plant response or measuring the biological activity of the compost (e.g. oxygen consumption, CO_2 evolution, self-heating test).
Fresh compost	Partly degraded material that is still in a decomposition process but thermally sanitised (thermophilic phase). It is used for soil improvement and fertilisation on agricultural land. Identification is done by methods testing the plant response or measuring the biological activity of the compost (e.g. oxygen consumption, CO_2 evolution, self-heating test).

2.6.2 Quality assurance systems

About 700 composting plants in the EU operate under a formal quality assurance system. Quality assurance typically comprises the following elements:

- raw material/feedstock type and quality;
- limits for hazardous substances;
- hygiene requirements (sanitisation);
- quality criteria for the valuables (e.g. organic matter);
- external monitoring of the product and the production;
- in-house control at the site for all batches (temperature, pH, salt);
- quality label or a certificate for the product;
- annual external quality certification of the site and its successful operations;
- product specifications for different application areas;
- recommendations for use and application information.

In some cases, quality assurance is purely voluntary, on private initiative, but more often it is required or promoted by legislation or regulatory authorities. Sometimes there are exemptions from certain legal compliance obligations if the compost is quality certified. "Annex 8: Compost quality assurance schemes" provides detailed descriptions of the existing compost-specific quality assurance schemes in the EU.

In 2010, the European Compost Network (ECN) has launched a European quality assurance scheme and produced an accompanying quality manual.
The ECN-QAS presents an independent quality assurance scheme and includes fundamental requirements for national quality assurance organisations (NQAO) for compost and basic requirements for a European compost standard in the first instance. Besides a positive list for suitable input materials and requirements for process quality also quality criteria for compost are laid down in the scheme.

The European quality assurance scheme includes the following elements:

- The requirements for conformity assessment of national quality assurance organisations (NQAO) to the ECN-QAS.
- Regular assessment of the production in the plants by the national quality assurance organisation (NQAO) by means of process requirements.
- Regular sample taking and analysis of the final product from independent, acknowledged labs and additionally the evaluation of the results by the national quality assurance organisation (NQAO).
- Documentation by the national quality assurance organisation (NQAO) with information about the quality properties of the product, legal requirements, the necessary compost declaration and information about use and application rates according to good practice.
- Awarding of the ECN-QAS Conformity Label to national quality assurance organisations (NQAO).
- Awarding of a quality label for composting plants and compost products by a conformity assessed national quality assurance organisation (NQAO) in respect to ECN-QAS.

The ECN-QAS Quality Manual provides all information and recommendations on all checks that the applicant and the corresponding body (National Quality Assurance Organisation) have to carry out during the utilisation period of the Conformity Label and Quality Label for compost. The Quality Manual includes the requirements for the conformity assessment of national quality assurance organisations and for composting plants.

The Quality Manual is divided in three main parts:

- Part A: *The European Quality Assurance Scheme* describes the general target and structure of the European Quality Assurance Scheme (ECN-QAS).
- Part B: *Quality Assurance Organisations of the ECN-QAS Quality Manual* specifies the ECN requirements to be met by a national quality assurance organisation (NQAO) for composting plants, which are preconditions for the described recognition procedure of an organisation performing quality assurance according to the European Quality Assurance Scheme of ECN e.V.
- Part C: *European Quality Assurance Scheme for Compost of the ECN-QAS Quality Manual* specifies requirements for the operational process management of composting, the selection of input materials and the compost quality. It includes specifications for sampling and testing. It also specifies requirements for product certification and declaration to ensure that the compost products are consistently fit for their intended uses. These essential elements have to be implemented into the quality assurance scheme of the national quality assurance organisation (NQAO).

2.6.3 Standardisation of sampling and analysis

Today, compost sampling and analysis is carried out following national legal provisions and often national analytical methods and standards, which are not always comparable. However, the European Commission earlier gave a mandate to CEN for the development of horizontal standards in the field of sludge, bio-waste and soil (Mandate M/330). The mandate considers standards on sampling and analytical methods for hygienic and biological parameters as well as inorganic and organic parameters. The main advantages of Horizontal standards are:

a. Comparability of analytical results between different materials is ensured
b. Results can be assessed in a uniform way
c. The development of methodologies for monitoring programs is facilitated
d. Costs are decreased by establishing one analysis to cover various legal areas

Consequently, the CEN Technical Board (BT) created a Task Force for 'Horizontal Standards in the fields of sludge, bio-waste and soil' (CEN/BT TF 151). On most sampling and analytical topics, the final consultation and validation of the draft standards took place in autumn 2007 according to the dedicated website for the project (http://www.ecn.nl/horizontal). The work of the former TF 151 is now being continued by a technical project committee, CEN TC 400. This committee has now the task to fulfil the requirements of mandate 330. Until the end of 2012 approximately 30 European standards and Technical Specifications were published (see also "Annex 12: Compost and digestate sampling and testing methods"). In principle these methods should be valid for both compost and digestate. However, in some cases additional method validation or revalidation programs were established to demonstrate the applicability of the standardized methods for the mentioned matrices and additional matrices as well, or to transfer Technical Specifications (TS) in regular Standards (EN).

Until horizontal standards elaborated under the guidance of CEN TC 400 are formally adopted, testing and sampling may also be carried out in accordance with test methods developed by Technical Committee CEN 223 'Soil improvers and growing media'.

2.6.4 Standards and specifications for digestate

Standards and specifications for digestate have been elaborated in a number of EU-27 member states. In Germany a quality assurance system exists for digestate which is carried by "GüteGemeinschaft Gärprodukt e.V. (GGG)", a member of the "Bundesgütegemeinschaft Kompost e.V. (BGK)." Also in Belgium, Sweden, and the UK voluntary quality assurance systems exist for digestate. In each system, the quality is assured by checking the observation of the national regulations (animal by-product, bio-waste and fertiliser regulations), prescribing positive lists for the feedstock and monitoring the controlling of the process to prove the compliance with the hygienic requirements. This includes measuring and documenting temperature and pH-value in the reactor and hygienisation unit, hydraulic retention time as well as organic and volumetric loading rate. Types and amounts of substrates and additives have to be documented and certain actions are taken to avoid re-contamination and process disturbances. The feedstock has to be clean and source separated. The operation is controlled by plant visits of independent quality managers. The products are regularly (4 -12 times/year) controlled by independent sample takers and by declaration in analysis reports. Additionally, recommendations are given for the correct application according to the fertiliser regulation.

The European Compost Network has provided a summary of the different aspects of quality assurance systems for digestate in different European countries, which are listed in Table 7.

- In the *UK*, digestate can obtain end-of-waste status. The Anaerobic Digestate Quality Protocol was launched in September 2009 and is developed by WRAP (Waste & Resources Action Programme) and the Environment Agency in consultation with industry and other regulatory stakeholders. It is applicable in England, Wales and Northern Ireland. The protocol sets out end-of-waste criteria for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste, not including sewage sludge. Manure is allowed as an input material. Quality outputs from anaerobic digestion include the whole digestate, the separated fibre fraction and the separated liquor. To be Quality Protocol compliant for this material, digestate producers will need to be certified against the BSI PAS110 certification scheme[18], which is managed by the Environment Agency. The PAS is a fast track precursor to a potential future British standard.
    - Producers and users are not obliged to comply with the Quality Protocol. If they do not, the quality outputs from anaerobic digestion will normally be considered to be waste and waste management controls will apply to their handling, transport and application.
    - Input materials may include non-waste biodegradable materials; input materials that fall under the ABPR must be treated according to the conditions set out in this regulation.
    - It must be demonstrated that the quality digestate is destined for use in one of the designated market sectors (agriculture, forestry and soil/field-grown horticulture + land restoration where only separated fibre can be used).
    - Test parameters, upper limit values and declaration parameters for validation for PAS 110 are listed in "Annex 13: UK PAS 110".

[18] PAS 110:2010 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials

- The Biofertiliser Certification Scheme (BCS) is currently the only quality assurance scheme in the UK for quality digestates derived from source-segregated biodegradable input materials. Information about this scheme can be found on the following web site: http://www.biofertiliser.org.uk/. A detailed description is given in "Annex 17: UK Biofertiliser Scheme".

- In *Sweden*, there is a voluntary certification system in place for anaerobic digestate, the SPCR 120[19]. This SPCR is a quality assurance system for both the process and the quality of the end product, digestate. The requirements for the final digestate product according to this QAS are listed in "Annex 14: Swedish SPCR 120". However, as in the case of compost guided by SPCR 152 QAS, digestate complying with the SPCR 120 quality label continues to have a waste status. Substrates for certificated digestate should be clean, source separated and easily biodegradable. Sewage sludge is not included in the input materials list, but manure is allowed.

- In *Germany*, the Bundesgütesgemeinschaft Kompost (BGK) is the carrier of the quality label for compost, digestate products and composted sewage sludge. BGK is recognised by RAL, the German Institute for Quality Assurance and Certification, as being the organisation to handle monitoring and controlling of all quality labels in Germany. According to the input materials used, there are two product groups for digestate and two corresponding labels: RAL GZ 245 for digestion products derived from bio-waste and RAL GZ 246 for digestion products from renewable energy crops. The allowable input materials are marked on a positive list (Annex 1 of the German Bio-waste Ordinance) and should be source separated. Sewage sludge is not included in the input materials list, but manure is allowed. "Annex 15: German RAL GZ 245" lists the quality criteria for digestate products from bio-waste. The RAL GZ 245 is a voluntary scheme, yet the efforts of participants are rewarded by the authorities by exempting member plants from some control requirements which are subject to the waste legislation. By means of that procedure quality assured digestate have a "quasi" product status in Germany. Both for digestate products from bio-waste and digestate products from renewable energy crops, two labels can be authorised for liquid (dry matter content <15%) and solid digestate products (dry matter content >15%). The minimum quality criteria for digestate products include valuable ingredients, potentially toxic elements, physical contaminants and the degree of fermentation. The quality criteria for digestate products from renewable energy crops differ only in the case of hygienic requirements. The thermophilic or mesophilic treatment with a temperature of > 37 °C for a dwell time of 20 days is sufficient. Authorisation to use the RAL quality label for digestate products is granted in accordance with the quality and testing regulations, laid down in the BGK-Methodbook for analysing organic fertiliser, soil improver and growing media. Sampling and investigations should be done by an approved external monitoring body.

- In *Ireland*, the Market Development Programme for Waste Resources 2007-2011 has a considerable focus on organics with several deliverables, including the establishment of an industry-based compost standard, the development of a Quality Assurance Scheme so as to support the establishment of a National Compost Quality Standard and the establishment of crop trials so as to demonstrate the farming community the benefits of

[19] http://www.avfallsverige.se/fileadmin/uploads/Rapporter/Biologisk/English_summary_of_SPCR_120.pdf

using compost and digestate within variable agricultural applications. The work to develop a national compost standard was overseen by the National Standards authority of Ireland (NSAI) and has been completed in July 2011 by the publication of the voluntary Irish Standard 441:2011.

- In *Spain*, at national level there are no standards or technical specifications for digestate from biodegradable waste, but digested sewage sludge has to fulfil the quality standards established in the sewage sludge legislation (RD 1310/1990) for its use in agriculture and digested bio-waste has to be composted and is subject to the same quality standards as compost (RD 506/2013).

- For the sale of finished biological treatment products such as compost and digestate, different rules apply in *Belgium*, such as at European level, but also at federal and regional levels. At European level, these products are subject to Animal By-products Regulation (EC) 1069/2009 and Commission Regulation (EC) 1013/2006. At the federal level, the Royal Decree of 07/01/1998 on the marketing of fertilizers, soil improvers and growing substrates is in force, while at the regional level, the Manure Decree and VLAREA apply in Flanders, and the Sustainable Nitrate Management Plan (from the Water Code) as well as the Waste Decree apply in Wallonia. For digestates and derived materials containing sludges from waste water treatment, the restrictions mentioned in article 7 of the Sludge Directive 86/278/EEC apply.
    - From the point of view that the production of compost should go hand in hand with the reasoned use of compost and digestate, the Flemish Public Waste Agency supported the initiation of VLACO, the Flemish Compost Association, an independent non-profit membership organisation bringing together the stakeholders with activities related to prevention, collection and treatment of bio-waste (OVAM, compost producers, municipalities and inter-municipalities). The two main work domains of VLACO are compost quality assurance and compost marketing. Since its start-up in 1992, VLACO has considered quality as a key issue. VLACO is working according to the principles of independent certification. This procedure is imposed by Decree in the Flemish legislation VLAREA on 13.09.2009. General Regulations are established, so that all conditions be made clear and the companies involved have clearly identified the certification requirements they must meet. A description of the quality assurance system is given in "Annex 16: Belgian VLACO QAS". Regarding sampling, in Flanders, Vlaco assembles information about the quality of the end product by own sample takings. The treatment plants are visited numerous times per year for sampling and analysis. The minimum required number of samples taken by the producer is calculated from the fraction of bio-waste and secondary materials in the input of the treatment plant on an annual basis using the following formula:

      number of analyses per year = 1 + X/10000
      where X= fraction bio-waste and secondary materials (tonnes)

      For a plant treating 50 000 tonnes per year this means at least 6 analyses per year. The number is always rounded up. The analyses packages are considered by the quality assurance organisation on a case by case basis. If several product types are produced, the formula above has to be used to calculate the necessary

number of analyses for each product type, where the partition of input is made per product type. The dates of sampling must be equally divided during the year.
  - In Wallonia, quality assurance systems (ISO 14001-EMAS) corresponding to Regulation EC 761/2011 is actually required for digestion and composting plants and is specified in the environmental permit of the plant. A traceability system for the fields where compost and digestate have been applied should be imposed. There are also maximum concentration levels for heavy metals and organic contaminants.
    In Wallonia, analysis is required at a frequency of 1 per 1000 tonnes of fresh matter. Sampling must be carried out by a registered laboratory in order to ensure proper representativeness of the material characteristics
- In *Slovenia*, no quality assurance system has been set up for digestate. The quality standards are the same for compost and digestate (Class I or II).

Table 7: Comparison of digestate quality assurance systems in Europe (Source: European Compost Network)

Country	AT	BE (FL)	CH	DE	SE	UK
General information						
QA organisation	ARGE	VLACO	VKS-ASIC	BGK	AVFALL Sverige	REA
Applicable standard	Austrian Fertiliser Ordinance BGBl. II Nr. 162/2010	General Regulations for end products of biological treatment of bio-waste	Quality guideline for compost and digestate 2010	1) RAL GZ 245 for bio-wastes 2) RAL GZ 246 for renewable energy crops	SPCR 120	PAS 110:2010
Types of digestate		1 type	2 types	2 types		3 types
	whole	whole			whole	whole
			liquid	liquid		separated liquor
			solid	solid		separated fibre
Input materials						
Input material definition	Positive list of source segregated materials and manure listed in BGBl. II Nr. 162/2010	No input list Conformity of input materials with limit values of VLAREA	Positive list of source segregated materials	Input list of source segregated materials	Input list of source segregated materials	Input materials shall be source segregated bio-wastes materials or other bio-degradable materials (e.g. crops, crop residues, etc.)
Requirement for input materials		Conformity with VLAREA				Written supply agreement
Process requirements & ABPR aspects						
General	ABPR or	ABPR	Minimum	≥ 50 °C,	Requirements	ABPR with no

Country	AT	BE (FL)	CH	DE	SE	UK
process requirements	validated process		hydraulic dwell time 24 h ≥ 53 °C Catering waste ≥ 70 °C 1 h 12 mm	approved minimum hydraulic retention time or ≥ 70°C 1h 12 mm	for different plant categories e.g. Cat. B/C: ≥ 55 °C 6 h Minimum hydraulic dwell time 7 days	further requirement or national ABPR for catering wastes only: ≥ 70°C 1h 60 mm or ≥ 57 °C 5h 50 mm followed by storage for an average of 18 days
Proof of sanitation		x	x	x	x	x
Salmonella				Absent in 50 g fresh matter	Absent in 25 g fresh matter	Absent in 25 g fresh matter
Germinable weeds and sprouting		≤ 1 seed/l		≤ 2 seeds/l	≤ 2 seeds/l only for solid digestate	
E. Coli		Max 1000 CFU /g fresh matter	Max 1000 CFU /g fresh matter	Max 1000 CFU /g fresh matter with one exception in 5 trials of 5000 CFU/g	Max 1000 CFU /g fresh matter	Max 1000 CFU /g fresh matter
Enterococci		x	x	x	x	x
Physical contaminants						
Impurities	≤ 0.5 % d.m. (glass, plastics and metals > 2mm)	≤ 0.5 % d.m. (glass, plastics and metals > 2mm)	≤ 0,5 % d.m. (glass, plastics and metals > 2mm)	≤ 0.5 % d.m. (glass, plastics and metals > 2mm)	≤ 0.5 % d.m. (glass, plastics and metals > 2mm)	≤ 0.5 % d.m. (glass, plastics and metals > 2mm)
Visible impurities				>25 cm2/l fresh matter		
Stones > 5mm		< 2 % d.m.		< 10 % d.m.		< 8 % d.m.
Stability/maturity/fermentation degree						
Oxygen consumption		≤ 50 mmol O_2/kg organic matter/h				
Organic acids				≤ 1.500 mg/l		
Volatile Fatty Acids						0.43 g COD/g VS
Residual Biogas Potential						0.25 l/g VS
Organic matter and dry matter requirements						
Organic matter content	≥ 50 % d.m.			≥ 30 mass-% for solid dig.	≥ 20 mass.-%	
Dry matter						< 15 % of its mass should be dry matter for whole and liquid

Country	AT	BE (FL)	CH	DE	SE	UK
						digestate
Heavy metal limits (mg/kg d.m.)						
As		150	-	-	-	-
Cd		6	1	1.5	1	1.5
Cr		250	70	100	100	100
Cu		375	100/150 (in case >50% pig manure)	100 Exception from limit value possible if tolerated by local authority	600	200
Hg		5	1	1	1	1
Ni		50	30	50	50	50
Pb		300	120	150	100	200
Zn		900	400/600 (in case >50% pig manure)	400 Exception from limit value possible if tolerated by local authority	800	400
Declaration parameters						
Product type	x	x	x	x	x	x
Weight or volume	x	x	x	x	x	x
Bulk density				x		
Organic matter	x	x	x	x	x	x
pH Value	x	x	x	x	x	x
Salt content			x	x		
Nutrients total (N, P_2O_5, K_2O, MgO, S)	x (S, MgO)	x (S)	x + Ca (S)	x (S)	x + Ca	x (only total N, P and K)
Soluble Nitrogen (NH_4-N, NO_3-N)			x	x		Only NH_4-N
Micro nutrients				(x)		
Water soluble sodium chloride						x

2.7 Legislative aspects

2.7.1 Introduction

This section looks at the legal frameworks that have been put in place to ensure the usefulness of compost and digestate and to manage the environmental impacts and risks of compost and digestate production and use.

The previous sections have argued that the use of compost and digestate as a soil improver or organic fertiliser can improve the chemical, physical and biological properties of soil and lead to better agronomic performance as well as to positive environmental impacts. The use of compost as a component of growing media can reduce the dependence on peat to some extent. Diverting biodegradable waste from landfills to produce compost or digestate reduces the climate change impacts of waste management.

At the same time there are certain environmental and health risks associated with the production and use of compost and digestate.

Regulators are thus faced with the challenge to optimise the benefits of recycling organic matter and nutrients through composting, and to avoid unnecessary barriers. At the same time the health and environmental impacts and risks need to be managed to ensure adequate levels of safety and environmental protection.

The analysis below pays particular attention to those aspects that are linked to the question of whether composts are a waste or not. It looks at the current national approaches in determining the waste status of compost; systems of compost registration or certification; compost categories; regulation placed on and standards of input materials, product quality and compost use; health protection; quality assurance schemes; standardisation of compost testing.

Legislative aspects for digestate are discussed near the end of the section.

The section finishes by a discussion on collection requirements for waste destined for production of compost and digestate.

2.7.2 Current approaches to determining the waste status of compost

Today, Member States follow different approaches when determining the status of compost, i.e. whether it is considered a waste or not. In some cases, there are explicit and detailed rules set by legislation under waste law. In other cases, it is mainly up to the discretion of the regulatory authorities to decide. In a third group of countries, there is an implicit assumption that compost ceases to be waste when registered as a product (e.g. as fertiliser).

End-of-waste defined by national regulations under waste law or other national environmental regulations

In some Member States, there is legislation under waste law that explicitly defines the conditions under which compost ceases to be waste. Examples are the Austrian Compost Ordinance ([20]) and the German Bio-waste Ordinance ([21]).

The conditions included in the Austrian Ordinance for compost to be considered as a product and not a waste includes:

- a positive list of wastes from which the compost may be produced;
- specifications of the product quality (heavy metal threshold values);
- temperature-time profile during composting to achieve hygienic safety;
- labelling provisions;
- quality control provisions on the input materials and the product;
- external quality control provisions;
- mandatory record keeping (for five years) of batch-wise information on input materials and products, including details of who receives the compost;
- obligations for registering and notifying the authorities;
- analytical methods.

The German Ordinance explicitly states that compost is considered waste until it has been applied to soil (in the case of agricultural use). However, the waste law-based regulatory controls are reduced considerably if a quality assurance system is applied. End-of-waste is not explicitly defined by German regulations when using compost for the production of growing media.

In France, the product quality requirements for compost from source separated materials or mixed MSW are defined by the French standard NF U44-051. When the compost includes sewage sludge, French standard NF U44-095 applies. These standards have been made statutory by the French government under the fertiliser regulation. The standards include limits for concentrations of heavy metals and some organic compounds as well as microbiological and agronomic parameters. Compost that complies with the requirements of the standard is considered a product, not a waste.

In Italy compost is registered as a product under its fertilizer regulation. In addition, Italy has a national end-of-waste system under waste law. Such national end-of-waste regulation is represented by the "DM 5 febbraio 1998" decree, which regulates the procedure for the authorization of certain recovery operations of non-hazardous waste and establishes the conditions under which biodegradable waste can cease to be waste. The decree is linked to the fertilizer regulation in the sense that it refers to it when establishing the criteria for the output quality of the composting process. Whilst the Italian fertilizer regulation determines which input materials can be used for compost production apart from establishing compost output

[20] Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über Qualitätsanforderungen an Komposte aus Abfällen (Kompostverordung). BGBl. II — Ausgegeben am 14 August 2001 — No 292.

[21] Verordnung über die Verwertung von Bioabfällen auf landwirtschaftlich, forstwirtschaftlich und gärtnerisch genutzten Boeden. BGBl. I 1998 S. 2955, BGBl. I 2001 S. 1488.

quality criteria, the Italian decree “DM 5 febbraio 1998” also establishes requirements for the recovery process.

End-of-waste determined by regulatory authorities, possibly on the basis of acknowledged protocols and standards

This is the case, for example, in the United Kingdom (England, Wales and Northern Ireland).

In England, Wales and Northern Ireland, compost must be sold/supplied in accordance with the Environmental Permitting Regulations rules for the storing and spreading of compost on land. There are no explicit quality criteria, but on the registration form and from the evidence (test results for the waste) sent to the regulator, the ‘agricultural benefit’ or ‘ecological improvement’ must be justified. The regulator then makes an evaluation taking account of the characteristics of the soil/land that is intended to receive the waste, the intended application rate and any other relevant issues.

The Quality Compost Protocol (QCP) represents the thinking of the Environment Agency for England, Wales and Northern Ireland as the reference for defining the point at which compost may become a product. It sets the criteria for production of quality compost from source-segregated biodegradable waste. Quality compost will normally be regarded as having ceased to be a waste when dispatched to the customer.

De facto end-of-waste when registered as fertiliser

In many countries, compost has to be registered under fertiliser regulations (e.g. as an organic fertiliser or as a soil improver) before it can be used in agriculture. It is then implicitly assumed that registered compost is a product and has ceased to be waste. This situation can be found in the Czech Republic, Greece, Spain, Latvia, Hungary, the Netherlands, Poland, Portugal, Slovenia and Finland.

Finally, there is a group of countries where compost production is not common, compost-specific regulations do not exist and the waste status of compost is not yet an issue.

More details on how the waste status of compost is determined today in each Member State are presented in "Annex 2: Waste and product approaches for compost".

2.7.3 Systems of compost registration or certification

Usually it is required by the corresponding regulation that compost must be registered or certified before it can be used or placed on the market. Sometimes, but not always, such registration or certification implies end-of-waste.

In practice, there are three main legal bases under which compost is certified or registered:

- fertiliser legislation, with and without specific compost provisions;
- waste legislation, with specific compost or bio-waste ordinances or under general waste treatment licensing procedures;
- soil protection legislation, with minimum requirements for waste derived materials, sludge and compost to be spread on land.

Standards or voluntary agreements based on criteria which are implemented by quality assurance schemes are another category, however, without direct legal status.

Following ORBIT/ECN (2008), one may distinguish various typical compost registration or certification schemes.

1. Simple registration systems without third-party verification

The main criterion of registration is final compost quality and product declaration (e.g. as an organic fertiliser or an organic soil improver). Sampling is done directly by the compost producer. External quality control is not systematic. Inspections by regulatory authorities are possible but typically not frequent. Usually, once registered, the compost can be traded as a product without further waste regulatory controls, even if formal end-of-waste is not established explicitly. According to ORBIT, this scheme can be found in the Czech Republic, Ireland, Spain (certain regions), France, Latvia, Hungary and Poland.

2. Simple registration systems with third-party verification

Testing of compost quality is carried out by an external laboratory that is acknowledged by the authorities. The laboratory may also certify compliance with a wider set of legal requirements concerning the documentation, the process management and the input materials used. This system can be found in Spain (certain regions), Denmark and Slovakia.

3. Third-party product certification under specific compost legislation

This means full-scale product certification schemes, such as under the Austrian Compost Ordinance. Such schemes include the following elements:

- the compost producer is responsible for the compliance with all requirements for input materials, process management and documentation, external quality approval and product declaration;
- the compost producer must have a contract with an authorised laboratory;
- sampling is done by the authorised laboratory or a contracted partner of the laboratory;
- the authorised laboratory and/or a quality assurance organisation (QAO) inspect and approve the required documentation and the required quality and process management in compliance with all legislative provisions;
- based on the analytical and the on-site inspection report, the authorised laboratory or the QAO awards a product and plant operation certificate including (in most cases) the permission for the use of a quality label;
- in some cases, the compost then obtains the product status from the moment a compost batch is declared compliant according to the certificate provided by the external laboratory or QAO;
- based on the certified product labelling and declaration including recommendations for proper use in the foreseen applications and market sectors, the correct application in line with all further soil and environment related rules is entirely the responsibility of the user.

Schemes of this type exist in Belgium (Flanders), Germany, Luxembourg, the Netherlands, Austria and Sweden. Membership of a quality assurance organisation is, in most cases, voluntary, although often promoted by authorities or legal incentives. In Belgium (Flanders), the entire external certification and quality assurance system is executed by a semi-public organisation and it is obligatory for all compost producers to participate. In the United Kingdom, the Quality Protocol (QCP) issued by the Environment Agency and the Waste & Resources and Action Programme (WRAP and Environment Agency, 2007) has established a comprehensive quality assurance scheme which requires extensive documentation and record keeping from the compost producer. The QCP also contains requirements for accreditation and auditing by the sector.

2.7.4 Regulations and standards on input materials

Most national regulations dealing with compost include restrictions on the input materials that may be used for compost production. In most cases, there are 'positive lists' of the allowed types of input materials. Materials not included on the list are forbidden as inputs. The most sensitive questions regarding input materials are whether municipal sewage sludge is allowed and in what form the biological fractions of MSW may be used as an input (whether there is a requirement for source segregation or not).

Most positive lists follow the classification of the European Waste Catalogue, and in some cases, include some additional specifications or requirements. If the waste list is directly binding, the system is rather rigid. This has been addressed, for example, in the case of Belgium, by allowing case-by-case decisions to be made by the competent authorities, based on a more generic positive list.

Usually, national regulations require that composting plants are run with a consistent control of the input material (compliance check upon receiving the waste), which includes documentation to ensure traceability and allows inspection by the competent authorities.

2.7.5 Regulations and standards on product quality

Compost-related national regulations as well as compost quality certification schemes usually include minimum product quality requirements for ensuring the usefulness of compost and for achieving the desired levels of health and environment protection. Minimum product quality requirements typically demand that composts should:

- have a minimum organic matter content, to ensure basic usefulness and to prevent dilution with inorganic materials, as well as sufficient stability/maturity;
- not contain certain pathogens (such as salmonellae) that pose health risks;
- contain only a limited amount of macroscopic impurities (as a basic requirement for usefulness and to limit the risks of injuries);
- only have limited concentrations of pollutants (mainly regarding heavy metals and sometimes also certain types of organic pollutants).

Further requirements are often included as specifications for certain uses and application areas. For instance, there are a number of compost standards and specifications for using compost in growing media and potting soil or for use in landscaping. Examples are the RHP quality mark for compost substrate components for horticulture and consumer use, or the RAL Quality label for compost with requirements for compost for potting soils/growing media (RAL, 2007) (see also Section 2.4.2).

In addition to requiring that limit values for the mentioned parameters are met, it is usually also required that the values for these parameters and further properties, such as salinity or electric conductivity, are declared (without the need for complying with limits). The purpose is to inform the potential users of the compost about the material properties.

Legal limits on heavy metal concentrations are in place everywhere that compost plays a role today. Limits are usually set at a national level and differ from country to country. In some countries, limits have been set for a number of different compost classes. At the EU level, a set of heavy metal concentration limits exists as part of the EU eco-label criteria for soil improvers and growing media. Another set of limits applies to the use of certain composts in organic agriculture. "Annex 3: Heavy metal limits for compost/digestate" provides an overview of the heavy metal concentration limits for compost in the EU.

In most places, limits also exist for macroscopic impurities. Sometimes a maximum concentration is set for the sum of plastics, metals and glass particles with a particle size of > 2 to 5 mm or there may be more complex regulations with separate limits for different types of impurities and considering more than one particle size (e.g. 2 and 20 mm fraction for plastic constituents).

"Annex 4: Impurities limits for compost" shows examples of the impurity limits included in national regulations and standards.

Apart from the wide-spread product quality requirements discussed above, some Member States have introduced specific product quality requirements such as a minimum dry matter content, absence of specific weed seeds or plant parasites, etc.

The rules for compliance testing (number of tests, protocols for sampling, analysis) are also different across Member States. Efforts to produce European harmonised standards are ongoing (see also Section 2.6.3.).

2.7.6 Health-related requirements

Provisions for the exclusion of potential pathogenic micro-organisms are established on two levels:

- direct methods by setting minimum requirements for pathogenic indicator organisms in the final product;
- indirect methods by the documentation and recording of the process showing compliance with required process parameters (HACCP concepts, temperature regime, black and white zone separation, hygienisation/sanitisation in closed reactors, etc.).

"Annex 5: Hygienisation provisions for compost" gives an overview of national regulations with respect to indirect and direct methods as well as of the requirements of the EU Eco-labels on soil improvers and growing media and of the Animal By-products Regulations. It also shows the requirements and limit values for germinating weeds and plant propagules.

At the European level, a key reference is the Animal By-products Regulation (ABPR)[22], which provides detailed hygienisation rules for composting and biogas plants which treat animal by-products.

The ABPR restricts the types of animal by-products that may be transformed in a biogas or composting plant. Materials that are allowed under certain conditions include amongst others:

- manure and digestive tract content;
- animal parts fit for human consumption (not intended for human consumption because of commercial reasons);
- animal parts rejected as unfit for human consumption (without any signs of transmissible diseases) and derived from carcasses fit for human consumption;
- blood, hides and skins, hooves, feathers, wool, horns, hair and fur (without any signs of diseases communicable through them);
- former foodstuffs and waste from the food industry containing animal products;
- raw milk;
- shells, hatchery by-products and cracked egg by-products;
- fish or other sea animals (except sea mammals);
- fresh fish by-products derived from the food industry.

The hygienisation requirements are laid down in the Implementing Regulation (EU) 142/2011[23]), which entered into force on 4 March 2011 and which was amended by Regulation (EU) 294/2013. Amongst other requirements, this states that Category 3 materials (which include, for example, catering waste) used as raw material in a composting plant must comply with the following minimum requirements:

- maximum particle size before entering the composting reactor: 12 mm;
- minimum temperature in all material in the reactor: 70 °C;
- minimum time in the reactor at 70 °C (all material): 60 minutes.

As an alternative to the time-temperature regime of 70 °C for one hour at a particle size of 12 mm, the possibility of a process validation system to be conducted by Member States was introduced. The authorisation of other standardised process parameters is bound to the applicant's demonstration that such parameters ensure the minimising of biological risks. It should be noted that end-products from materials transformed according to national transformation parameters may only be placed on the market within the Member State where the transformation parameters have been authorized (EU Regulation, 142/2011, Annex V, Chapter III, Section 2).

The ABPR also requires control of the final product. This is divided into two measures:

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22 Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

23 Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive.

- representative sampling during or immediately after processing in order to monitor the proper functioning of the hygienisation process, and
- representative sampling during or on withdrawal from storage in order to approve the overall hygiene status of the product.

Escherichia coli or *Enterococci* are used as indicators for the hygienisation process. The hygiene status of the product is tested with *Salmonella*, which must be absent in 5 samples of 25 g of the product. It is up to the competent authority to decide on sampling schemes (i.e. considering the total throughput and the maximum time span between two sampling dates).
There are possible exceptions for catering waste[24], which may be processed in accordance with national law unless the Commission determines harmonised measures.
According to Article 32 of Regulation (EC) No 1069/2009, organic fertilisers (compost and residua of biogas production) shall be under strict control until final use of such material.

In summary, it can be stated that compost and digestate containing animal by-products will always be subject to the specific provisions of Regulation (EC) No 1069/2009 with regard to hygienisation, transport, use, etc. No national or EU wide end-of-waste regulations established for such materials can overrule or annul Regulation (EC) No 1069/2009.

2.7.7 Regulations of compost use

The regulations and standards for compost use vary considerably across countries. There are countries where compost use is subject to a complex network of regulations on national and/or provincial level (Germany, the Netherlands, Austria) and then there are countries where compost can be used without any legal directions (Greece, Portugal, Slovenia).

Use rules include direct regulations like dosage restrictions (admitted quantity of compost per hectare) and indirect rules such as good agricultural practice (GAP) protocols and cross-compliance requirements in agricultural application. The latter refer mainly to fertilising, which should be executed in a way that considers the nutrients in soil and in compost as well as the uptake by the plant and to manage organic matter with the target to keep soils in a proper condition.

The main restrictions in EU countries usually concern the permissible quantity of compost (tonnes dry matter) at a maximum heavy metal content (compost class) which can be spread annually, or over two to five years. "Annex 6: Compost use regulation" provides an overview of the restrictions in place.

The following systems of application rules can be distinguished:

- direct load limitation (grams of substance per hectare and year), in most cases calculated on a basis of 2 to 10 years;
- restrictions of the admissible dosage of dry matter compost per hectare and year;
- restrictions according to a maximum nutrient supply (phosphorus and/or nitrogen) to the agricultural crops.

[24] Catering waste means all waste food including used cooking oil originating in restaurants, catering facilities and kitchens, including central kitchens and household kitchens.

The restrictions are usually intended to regulate continuous applications, as in agriculture. In most other applications, e.g. landscaping, compost is applied only once or infrequently. Here, larger amounts (e.g. 200 tonnes dry matter in 10 years) are used to achieve the desired application effects.

In some cases, the factor which limits application rates is not only the heavy metals but the nutrient contents, especially phosphorus and nitrogen.

The ranges of restrictions for the amounts of compost (on a dry matter basis per hectare) or plant nutrients to be applied can be summarised as follows:

• quantity of compost (*)	agriculture/regular	3 (pasture)–15 (arable) tonnes/ha/year
	non-food/regular	6.6–15 tonnes/ha/year
	non-food/once	100–400 tonnes/ha
• quantity of N	agriculture/regular	150–250 kg/ha/year
• quantity of P_2O_5	agriculture/regular	22–80 kg/ha/year
	set aside land	20 kg/ha/year

(ha = hectare)

(*) In most cases quantity differentiation depends on quality class obtained.

More details, country by country, are provided in "Annex 6: Compost use regulation".

In many cases, the need to comply with the EU Nitrates Directive or national water protection legislation has led to maximum application regimes for nitrogen or forbidding the application of compost during the winter season. This is justified by the fact that there is no nutrient uptake in winter time, so there is a risk that all nutrients are washed out as runoff to the water bodies.

Finally, it becomes more and more common to consider the application of compost in fertiliser management systems. Germany for example refers to the need to follow ‘best fertilising expert practise’, whilst in the Netherlands there is a system of three application standards per hectare and year (total N from fertilisers, total P from fertilisers and total N from animal manure).

2.7.8 Legislative aspects for digestate

Most member states generally regulate the quality and application of digestate and other bio-wastes through waste laws (e.g. DK) or fertiliser legislation (e.g NL), which are similar or identical to the data described above for composts.

In the UK, digestate can receive end-of-waste status through the Quality Protocol. Also the Czech Republic provides product status for digestate via national regulation: biodegradable waste treatment decree (341/2008 Sb.) or fertilizer law (156/1998 Sb.).

On a European level, the Animal By-Products Regulation also applies to anaerobic digestion facilities.

- *England, Wales and Northern Ireland* have adopted the ‘Quality Protocol for the production and use of quality outputs from the anaerobic digestion of source-separated biodegradable waste’ (AD QP). This document defines the full recovery for digestates, namely the point at which digestates cease to be waste and can be used as a product, without the need for waste management controls. More information is provided in "Annex 18: AD Quality Protocol". Moreover, the UK regulators have issued a regulatory position that means that digested manures and slurries can be spread without the need for environmental permitting.

- In *Germany* there is no specific legislation only for digestate. Legal requirements for digestate are included in waste legislation as well as in the legislation on fertilisers. Waste legislation regulates “bio-waste”, which is not identical to the European definition, as it includes a number of biodegradable waste streams apart from kitchen and green waste suited for later use on soil. These waste streams are listed in the Ordinance on the Utilisation of Bio-wastes on Land used for Agricultural, Silvicultural and Horticultural Purposes. The ordinance applies to any treatment, treatment meaning any controlled degradation of bio-waste under aerobic conditions (composting) or anaerobic conditions (fermentation) or any other measures for sanitisation suitable for the biodegradable waste listed in the bio-waste ordinance. All quality requirements, i.e. limit values for pollutants or standards for pathogen reduction, for bio-waste apply. Detailed specifications concerning specific waste streams or treatment methods can be found in the ordinance as well. Voluntary quality assurance systems are structured along the same lines and from the legal point of view are valid for compost and digestate irrespective of the fact whether digestate has been composted following anaerobic treatment or is liquid or solid. Next to the obligatory legal parameters a Quality Assurance (QA) system can of course include additional parameters for specific outputs, i.e. the BGK RAL QA system includes the “degree of digestion” in the form of organic acids that must be lower than 1500 mg/l for liquid digestate but not for compost. Furthermore, additives are regulated in the Fertilizer Ordinance and used only in low concentrations in anaerobic digestion. The aim is to stabilize and optimize the anaerobic process or avoid the formation of hydrogen sulphide. Non-composted digestate is used frequently as a fertiliser in Germany and in addition to waste legislation must fulfil the requirements of legislation on the use of fertilisers.

- The *Netherlands* have no specific end-of-waste legislation for bio-waste or digestate. However, within the Dutch Fertiliser Act there are provisions for different types of bio-waste which can be allowed as a fertiliser on agricultural land. The effect is similar to having an end-of-waste status. A distinction is made between compost, sewage sludge and other bio-waste from the food/feed/fuel -process industry. For each group of these fertilizers only one class of quality criteria is available in the Fertilizer act. Furthermore, there is no specific registration system in place for digestate. Regulating the input side is generally not used. It is for the operator to ensure that his product meets the quality criteria on the output side. In general, for separately collected bio-waste this is no problem, but the Dutch experience with digestate from mixed waste is that such material cannot meet the output criteria. The Dutch Ministry of Environment and Infrastructure also mentions that an associated problem is the fact that mixed waste may contain all sorts of pollutants, which can and will in practice not all be monitored. According to this body, this increases the risk that also the end product contains unknown (non-monitored) pollutants in concentrations likely to endanger the environment or human health. They argue that for separately collected material this risk is not significant. For the use of digestate on soils, the same requirements apply as for compost from aerobic treatment of biodegradable waste.

- In *Spain*, no specific legislation regarding digestate from biodegradable waste exists. However various parts of existing legislation are also applicable to digestate: digested sludge is subject to legislation on sewage sludge and digested source-separated bio-waste or digested organic matter from mixed municipal waste (usually composted) is subject to legislation on compost. In Catalonia there is also a technical instruction according to which sewage sludge that is not suitable for direct application in agriculture is also prohibited as input material in co-digestion plants to be co-digested with manures or slurries, an analysis of digestate and soil is required prior to the agricultural spreading of digestate when this digestate comes from co-digestion plants and digestate from bio-waste has to be composted and can be used in agriculture but digestate from mixed municipal waste has to be stabilised and cannot be used in agriculture.

- In *Estonia*, if the inputs for anaerobic digestion are manure and slurry, the quality and use does not fall under the Jäätmeseaduse (Waste Act) regulation, but under the Väetiseseaduse (Fertilizer Act) and Veeseaduse (Water Act) regulation. In the case of sewage sludge, the quality standards are currently based on the Water Act only through the regulation of sewage sludge.

- In *Slovenia*, at present, digestate is covered by the Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/2008). The Annex 1 to this Decree provides a list of bio-waste suitable for biological treatment. In case of production of compost or digestate, the producer has to put in place the necessary controls on the incoming bio-waste to ensure that there is no intentional dilution of polluting substances.

- In *Austria*, the same positive list of input materials applicable for compost also applies for the treatment in biogas plants if the material is suitable for digestion. The list is based on the principle of separate collection and the use of clean and traceable organic sources. Furthermore, Austria has a Guideline on the use of digestate on agricultural land.

2.7.9 Collection requirements for waste destined for production of compost and digestate

At present, composting and digestion operations mainly differ on the input materials and technologies used in different Member States. Whereas some Member States allow the use of compost/digestate produced from comingled input (mixed municipal waste) or sewage sludge for agricultural purposes, others are opposed to it.

Community legislation and European Commission documents on separate collection of bio-waste aimed at producing compost or digestate provide following information:

- The 2008 **Waste Framework Directive (2008/98/EC)**, in Article 22, states that "*Member States shall take measures, as appropriate, and in accordance with Articles 4 and 13, to encourage the separate collection of bio-waste with a view to the composting and digestion of bio-waste"*.
- The 2010 **Communication from the Commission on Future steps in bio-waste management in the European Union (COM(2010)235 Final)** states the following: *"Composting and anaerobic digestion offer the most promising environmental and*

economic results for bio-waste that cannot be prevented. An important pre-condition is a good quality of the input to these processes. This would in the majority of cases be best achieved by separate collection."

- The 2012 **Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste**[25] states that *"co-mingled collection of more than one single waste stream may be accepted as meeting the requirement for separate collection, but the benchmark of 'high-quality recycling' of separately collected single waste streams has to be examined; if subsequent separation can achieve high-quality recycling similar to that achieved with separate collection, then co-mingling would be in line with Article 11 WFD and the principles of the waste hierarchy"*. And although the Guidance document subsequently states that *"practically, this usually excludes co-mingled collection of bio-waste and other 'wet' waste fractions with dry fractions such as e.g. paper"*, it also states that *"the wording of Article 22 WFD leaves the introduction of separate bio-waste collection to Member States' discretion but obliges Member States to concretely encourage separate collection"*.

The above documents indicate that the advantages of separate collection in view of producing high quality composts and digestates from bio-waste are clearly recognized at Community level, whereas Member States can ultimately decide on the options to provide high quality input materials for composting and digestion of bio-waste, without the exclusion of any technology.

Finally, no specific Community legislation seems in place that regulates the input material collection requirements for compost and digestate from other biodegradable wastes such as sewage sludge.

2.8 Environmental and health issues

2.8.1 Environmental and health issues of compost

2.8.1.1 Introduction

Quite independently of the composting technique applied and the nature of the input materials, composting has a series of potential environmental interventions and health issues associated to it. They are presented in this section and include greenhouse gas and other air emissions, water emissions (leachate), soil related effects, hygiene issues and the risk of injuries, and positive environmental effects of compost use. Finally, conclusions are made with the regard to the main issues.

The fact that the potential environmental and health impacts of composting are discussed in a comprehensive manner should not be misinterpreted as an indication per se of compost being good or bad for the environment. The purpose of this chapter is simply to provide the information base for understanding the potential environmental and health impacts and risks that need to be managed. Such a comprehensive analysis is required for any material that is a potential candidate for end-of-waste criteria.

[25] http://ec.europa.eu/environment/waste/framework/pdf/guidance_doc.pdf

2.8.1.2 Air emissions

Gaseous emissions from the composting process include carbon dioxide (CO_2), water vapour, and, in smaller quantities ammonia, (NH_3), volatile organic compounds (VOCs), bioaerosols (fungi, bacteria, actinomycetes, endotoxins, mycotoxins) and particulates. Usually there will also be nitrous oxide (N_2O) and methane (CH_4) emissions, as it is often not possible to guarantee that all material will be kept under aerobic conditions at all times. Depending on the input materials, composting may release odour emissions, which can potentially be strong.

In closed composting systems, biofilters are often used to treat the waste gas to reduce the emissions of odours, some VOCs, ammonia, aerosols and particulates. On the other hand, certain emissions may also be increased by biofilters, in particular N_2O.

According to ADEME (2005) and DEFRA (2004), there is a lack of generally representative quantitative air emission data.

The DEFRA study carried out a 'Review of environmental and health effects of waste management: municipal solid waste'. It was based on a substantial sample of the available literature and data. The study systematically assessed the reliability of all the data, taking into account, for instance, the number of waste management facilities from which data were available, if an extrapolation to the full sector at a national level was possible, and whether the information came from peer reviewed literature, was endorsed by governmental bodies, or came from 'grey' literature. The study report as such underwent an external review by the Royal Society. The study concluded that the available data were not sufficient to quantify air emissions from composting, mechanical biological treatment (MBT) or anaerobic treatment.

The ADEME report, which systematically establishes emissions data for biological treatments based on a reliability assessment of data found in literature, comes to similar conclusions, and confirms that there is a general lack of representative air emissions data (and, in the case of compost, especially VOCs). It also notes a general lack of data on emissions during the storage of the biological material.

In recent years, several new investigations on gaseous emissions from composting, covering various composting techniques, have, nevertheless, been carried out and used to characterise the state of the art of composting (Amlinger et al., 2005; Cuhls and Mähl, 2008).

The CH_4 and N_2O emissions are important for the climate change impacts of composting (see Section 2.8.1.3 on greenhouse gas emissions) while the CO_2 emissions are considered climate-neutral because they originate mainly from short-cycle biomass (see also next section on greenhouse gas emissions).

The other emissions are relevant mainly for potential occupational and local population health impacts or may be perceived to be a nuisance. They make it necessary to take suitable measures to protect plant workers and residents in the surrounding areas.

Workers at a composting facility may be exposed to, and inhale, large quantities of bioaerosols if not protected by technical or operational means (Wouters et al., 2006). It needs to be considered that there are certain individuals, for example asthmatics and the immuno-compromised, that are especially susceptible to potential adverse health effects after exposure to bioaerosols.

2.8.1.3 Greenhouse gas emissions

The fate of the organic carbon contained in the waste is one of the key factors that determine the relevance of compost production and use for climate change, i.e. the extent to which the carbon is immobilised or degraded and emitted as gas, and the proportions of CO_2 and CH_4 in the gas emissions. A second important factor is N_2O emissions during composting. Other greenhouse emissions are, in most cases, of much less relevance (including those originating from process energy or transport).

According to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, CO_2 from organic waste handling and decay should not be included in greenhouse gas inventories. The reason is that organic material derived from biomass sources which are regrown on an annual basis is the primary source of CO_2 released from such waste. These CO_2 emissions are not treated as net emissions from waste according to the IPCC guidelines (if biomass raw materials are not being produced sustainably, the net CO_2 release should be calculated and reported under agriculture, land use change or forestry).

However, consideration needs to be given to the fact that if organic waste or materials obtained from biomass remain at least partly un-degraded for longer times, this effectively removes carbon from the atmosphere. This is the case, for example, when compost that has been spread on agricultural land is only slowly mineralised and increases the soil organic matter, or when organic material in landfills decays only over many years.

Composting, as an aerobic biological degradation process, degrades the carbon of the input materials mainly into CO_2. The percentage of the carbon content that is converted depends partly on the nature of the input material. In the case of kitchen waste, composting converts about two thirds of the carbon content of the input material into CO_2. This means that about 0.9 kg CO_2 is generated per kg dry matter of the bio-waste input. In the case of green waste, this value is much lower at about 0.17 kg CO_2/kg dry matter (ADEME, 2005). Data from the European Compost Network indicate a CO_2 release of 0.35 to 1.2 kg CO_2/kg dry matter. It is noticed that the CO_2 released is neutral to climate change as it has been taken up from the atmosphere during the lifetime of the organisms.

After the composting process is finished and when compost is used, for example, as a soil improver, the remaining organic matter in the compost is then relatively stable and further degradation is rather slow. This depends on the physical, chemical and biological environment in which the compost is used. The further release of carbon to the atmosphere is therefore only gradual. Relatively little is known about the rates of transformation, which vary depending on climate and soil type. It has been estimated that, on average, some 13 % of the organic carbon supplied by the application of compost remains in the soil after 50 years (Eunomia, 2002; Annex p. 95). Assuming that the composting process had reduced the original organic carbon content by 50 % (for example of a mixture of green waste and kitchen waste), this means that about 6.5 % is still not degraded after 50 years. Furthermore, if compost use enhances biomass production, this may bind further carbon from the atmosphere in addition to the direct carbon input by the compost.

If compost displaces other fertilisers, this may lead to greenhouse gas emissions being saved by the avoidance of fertiliser production. If it displaces peat as a soil improver or in growing media, then this avoids the long-cycle carbon emissions emanating from the degradation of peat under aerobic conditions. According to a report from the Dutch Waste Management

Association (Vereniging Afvalbedrijven, 2010), transport of vegetable, garden and fruit waste causes about 0.010 kg CO_2-equivalents emissions per kg input material, compared to savings of 0.113 kg CO_2-equivalents per tonne input material by use of the resulting compost in a mixed use scenario (agriculture, greenhouses, growing media and other peat and fertilizer replacements).

In theory, composting as an aerobic process should not generate CH_4. In practice, however, and depending on the type of composting process and its management, the oxygen supply and the aerobic conditions during the biological degradation are not perfect. The lack of oxygen may then lead to anaerobic processes and to emissions of CH_4. The proportion of the carbon content of the input material that is transformed into CH_4 emissions varies widely, depending on the type of input materials and the processes, but can be from 0.01 % to 2.4 % of the original carbon according to ADEME (2005). A typical value found for CH_4 emissions from household waste composting would be 0.04 kg CO_2-eq/kg of dry matter of the input material. The European Compost Network suggests greenhouse gas emissions for CH_4 and N_2O to be in the range of 0.03 to 0.07 kg CO_2-eq/kg fresh matter or 0.09 to 0.2 kg CO_2-eq/kg dry matter, based on Amlinger et al. (2008) (obtained from data of different type of composting and different types of input materials). According to ECN, if compost is well matured then even in piles of matured compost CH_4 emissions will be close to zero, whereas half rotted and active stocked material would produce still considerable greenhouse gas emissions. Therefore, in principle, at least in case of mature compost, if incorporated to soil at usual amounts of 0.4 to 0.5 % of a 20 cm soil layer the likelihood of producing higher CH_4 emissions than naturally emitted by the soil is extremely low.

Sometimes organic waste composting is preceded intentionally by a phase of initial anaerobic degradation to reduce odours, for example. If the generated gas is not captured adequately, this will lead to CH_4 emissions to the atmosphere. The CH_4 emissions of such intentional anaerobic pretreatment seem potentially important but have not yet been investigated.

It is quite likely that the application of compost onto agricultural land is neutral in terms of CH_4 emissions; however, this has not yet been scientifically confirmed. There is a lack of literature and measured data on how the use of compost on agricultural land influences the flows of CH_4 between the soil and the atmosphere (ADEME, 2005).

N_2O is generated directly by the composting processes (quantities are strongly influenced by the C/N ratio) but also in biofilters, which are sometimes used to clean the composting exhaust gas stream from other components (see for example Cuhls and Mähl, 2008). For the composting of bio-waste, the N_2O emissions have been found to be in the range 0.002–0.05 kg CO_2-eq./kg of input dry matter (typical value: 0.02 kg CO_2-eq.). For household waste, the range is 0.005 to 0.125 kg CO_2-eq./kg of input dry matter (typical value 0.1 kg CO_2-eq.) (ADEME, 2005). The European Compost Network has also reported numbers within this range.

The use of compost as an organic fertiliser may, to some extent, reduce the N_2O emissions associated with the use of mineral nitrogen fertilisers. However, this effect has not been quantified reliably so far.

Generally, the figures on greenhouse gas emissions other than CO_2 (i.e. CH_4 and N_2O) are based on a limited number of measurements, which are not fully representative.

According to information from the European Compost Network, emissions generated during composting contribute for 0.01 to 0.06% to the national greenhouse gas inventories for the EU.

2.8.1.4 Leachate

Some composting systems recirculate leachate, whilst others treat the liquid residue if required or discharge it directly into the sewerage system. Often composting requires a net input of water because of evaporation during the composting process. In well-managed composting processes impacts on the environment can be assumed to be negligible. However, there is no consolidated information on the amounts and compositions of leachate released that considers the variety of composting plants in operation.

2.8.1.5 Soil-related issues

The application of compost to soil changes the soil's chemical, physical and biological properties. The parameters affected include: contents and availability of plant nutrients, soil organic matter, pH, ion exchange capacity, chelating ability, buffering capacity, density, structure, water management, biodiversity and biological activity. Composts become part of the soil humus and have long-term effects on soil properties. The ways in which compost can affect soil are very complex and far from being fully understood; however, it is widely accepted that compost will have a positive long-term effect on soil fertility if the quality of the compost used is assured and good agricultural practice is followed.

At the same time, the use of compost on soil as an organic fertiliser or soil improver has diverse environmental implications. If composts are applied to land, the chemical content of the composts is transferred to the soil. For potential negative effects, heavy metals and organic pollutants especially need to be considered.

The contents of heavy metals in composts are generally well studied and controlled in compost applications. They are determined by the materials entering the composting process as inputs. Apart from a natural enrichment of heavy metals due to water and organic matter losses, the composting process itself has little impact on the heavy metal content. Chapter 3 extensively discusses heavy metal contents of composts and digestate materials, based on expert data, literature sources and data from the JRC Sampling and Analysis Campaign. It follows that some composting/digestion technologies or input materials might lead to a lower likelihood of meeting certain limit values than others. Nonetheless, in all compost and digestate categories, it is possible to encounter very low quality materials as well as high quality materials. This illustrates that the use of a certain technology in itself does not constitute a sufficient guarantee or insurmountable hurdle for compost quality and that monitoring of input materials, processes and product quality is of utmost importance.

Heavy metals may be directly toxic to plants or passed through the food chain to humans. The fate of the heavy metals in soil is very site specific and depends on a number of factors such as the nature of the crop and the type and pH of the soil. Repeated applications of compost to soil may lead to an accumulation of heavy metals, for which the long-term impact may be unknown. However, a more recent review of existing scientific literature (Smith, 2009) states that only positive effects of compost application on the microbial status and fertility of soil have been reported. Nonetheless, there are important local variations concerning the accumulation of heavy metals (background concentrations are generally increasing), their leachability into groundwater, and the uptake of heavy metals by plants and consequences once in the food chain. Some metals such as zinc, copper and nickel are vital trace elements for plant growth as long as their quantity is not too high.

Relatively little is still known about the contents, fate and effects of organic pollutants in compost. Organic pollutants may be introduced into the compost through the input materials and, to some extent, may also be generated during the composting processes. At the same time, there is also degradation of organic pollutants. Persistent organic pollutants (POPs), however, are hardly removed by composting. It has been shown, for example, that some poly-aromatic hydrocarbons (PAHs) are hardly degraded during composting and are ecotoxicologically relevant when transferred with compost to soil (Kupper et al., 2006). Kluge et al. (2008) ran experiments with quality assured composts in Germany, showing that regular applications did not lead to an accumulation of organic pollutants in soil (including PCB ([26]), PCDD/F ([27]) and PAH) (Kluge et al. 2008). However, Umlauf et al. (2011) reported on a long-term experiment of soil treated with mineral fertilizer, farmyard manure, sewage sludge and compost on a test plot in Meckenheim (Germany). Samples taken after nearly 40 years of application showed that fertilization with sewage sludge and compost of different sources had led to a substantial accumulation of PCDD/Fs and PCBs in the soils, even though the soil concentration levels of these organic pollutants remained in all cases well below German guidelines for arable land.

With regard to physical impurities, sometimes confusingly denoted as "inert", little is known on their long term effects on the soil apart from the visual contamination. Metal particles may undergo redox processes and dissolve and plastics may decompose with release of the additives. Glass is supposed to decompose extremely slowly but metals such as lead and cadmium can leach from glass. All physical impurities are likely to be reduced in size by natural weathering and physical land treatment operations. Through ingestion by soil fauna, the ensuing micro-particles may end up in the food chain

Generally, there is some uncertainty about the exact nature and size of the impacts and risks when compost is spread on soil, notably due to the variable quality of the input materials used for compost production. As a consequence, there may be a high variability in the qualities of the different compost batches produced at the same site and even more so between different compost plants. Finally, much is still unknown about what actually happens to compost and its constituents once spread on soil.

The limitations of current knowledge are also reflected in the opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE; adopted on 8 January 2004) on the report ‘Heavy Metals and Organic Compounds from Wastes Used as Organic Fertilisers’ (Amlinger et al., 2004). This study was commissioned by the Directorate-General for the Environment in the framework of its background work related to possible legislative proposals concerning the biological treatment of biodegradable waste. The CSTEE concluded that the study did not provide sufficient scientific bases for the Commission to be able to propose the appropriate threshold levels for pollutants in compost. To date, there appears to be no other studies or research results that could easily provide a strictly scientific basis at a European level. The major issue remains the determination of safe levels of heavy metals in soils with regard to human toxicity and ecotoxicity.

[26] Polychlorinated biphenyls.
[27] Polychlorinated dibenzodioxins and dibenzofurans.

2.8.1.6 Hygiene issues and the risk of injuries

From a hygienic point of view, the application of compost is associated with risks unless the compost production is controlled appropriately. The reason is that the biological wastes used to produce compost may contain different types of pathogens, which may be bacteria, viruses, fungi, parasites and prions (at least theoretically). Compost may also contain weeds and viable plant propagules, which may encourage weed growth when spread on the land. The presence of pathogens in the input material depends on the origin, storage and pretreatment. If the composting process does not provide the required conditions to reduce or even eliminate the pathogens during the composting process, these pathogens may still be present in the compost, and, in the worst case, some of them may even have multiplied during composting. After application to land, the pathogens may then infect animals, plants or humans and pose serious health and plant disease control problems. Particular care needs to be taken in the case of grazing animals and in the production of salads, vegetables and fruits that grow close to the ground and may be consumed raw.

The main measures for controlling the contamination of compost with pathogens are to sort out especially risky material from the compost feedstock and to ensure that all of the material in the compost process is subject to temperature-time profiles that kill off the pathogens (sanitation) or reduce the population to an extent where it is considered to be below a specific hazard threshold.

Macroscopic impurities of compost (especially plastic, glass and metal objects) not only reduce the aesthetic value of land, they also bring the risk of accidents, such as worker injuries when handling compost containing glass fragments.

When compost is used as a component in growing media, direct health and safety aspects are of special importance because of the often quite intense contact workers have with the material. Macroscopic glass fragments, for example, must not be present.

2.8.1.7 Positive environmental effects

The use of compost as an organic fertiliser can, to some extent, replace the use of mineral fertilisers. This is clearer for potassium and phosphate than for nitrogen because the nitrogen contained in the organic matter of compost only slowly becomes available to plants. If compost is used to reduce the need for mineral fertiliser, some of the environmental stresses of fertiliser production can be avoided. These include greenhouse gas emissions (N_2O and energy-related emissions), and impacts of phosphate extraction. The use of compost over longer periods of time and a lower use of mineral fertilisers also reduces nitrate leaching.

The humus produced from compost increases soil organic matter and stores some of the biomass carbon contained in compost in soil for longer periods of time. This carbon can be considered sequestered from the atmosphere, which acts against global warming.

Other potential positive environmental effects that have been attributed to compost include:

- reduced soil erosion;
- compost of a good quality may help to control plant diseases and thus reduce the need for applying pesticides;

- water retention is improved, reducing the need for irrigation and reducing the risk of flooding;
- the improved soil structure reduces the need to work the soil with agricultural machinery and the related use of fuel.

When compost can be used instead of peat in growing media, there is also a lower global warming potential, mainly because peat degrades relatively quickly under the release of 'long cycle' CO_2 when exposed to oxygen. Replacing peat also contributes to the protection of the biodiversity and landscape value of peatlands and bogs.

2.8.1.8 Conclusions with regard to managing potential environmental and health effects for compost

There are three main groups of environmental and health issues related to composting that need to be managed.

1. Climate change

Choices about how to manage and treat the putrescible fraction of MSW have a substantial influence on the net greenhouse emissions caused in the EU. The Landfill Directive addresses this by requiring that biological wastes be diverted from landfills. In principle, composting is a valid recovery route that allows such diversion (the environmentally best treatment option needs to be assessed in each specific case; for this purpose, life cycle guidelines for the management of the organic fraction of municipal waste have been prepared by the JRC for DG Environment and are currently in a final draft value stage. The most critical factors for a high performance of composting with respect to greenhouse gas emissions is the minimisation of methane and N_2O emissions during the composting process, pretreatment and storage.

2. Local health and environmental impacts and risks at, and close to, the composting facility

Odour, gas emissions, leachate, and pathogens in bioaerosols are released from composting processes and may affect the local environment and the health and well-being of workers and residents. Plant permits for composting facilities address these issues more and more appropriately and some Member States have issued guidelines on state-of-the-art composting techniques that help address these aspects. Composting plants with a capacity of more than 75 tonnes per day are covered in the Industrial Emissions Directive[28], as well as anaerobic digestion plants with a capacity of at least 100 tonnes per day.

3. Soil, environment and health protection when using compost, especially when applying compost to land

This aspect is highly complex because it requires managing the trade-off of the benefits of compost application on land with the environmental and health risks associated with releasing a material derived from waste that potentially contains many chemical compounds (including heavy metals and potentially organic pollutants) and biological agents on soils. Whether the benefits outweigh the risks depends on the quality of the compost and the local conditions under which it is applied. The complexity is aggravated by the fact that there are important

[28] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ L 334 17.12.2010, p. 17)

knowledge gaps regarding soil properties and functions and the interactions with compost and its components. Nevertheless, it is widely accepted that the use of quality assured compost with relatively low pollutant contents following good agricultural practices allows achieving long term benefits to the soil-plant system that outweigh the risks and potential negative impacts.

Member States where the use of compost plays a substantial role have usually put regulations in place to ensure a positive trade-off, considering the specific situations of the countries. Depending on the countries or regions, the use of compost is regulated by soil protection, fertiliser or waste legislation or combinations thereof. If the introduction of European end-of-waste criteria changes the waste status of compost in a Member State, then this may affect the system of rules applying to the use of compost on land. This will then impact on the corresponding levels of soil, health and environmental protection.

2.8.2 Environmental and health effects of digestate

2.8.2.1 Introduction

Data regarding environmental and health effects of anaerobic digestion and digestate production are rather limited, compared with the data available on composting. The basic difference between composting and anaerobic digestion is the presence, respectively absence of oxygen in the process, which generates different emissions. Whereas these emissions are mainly composed of CO_2 in composting, CH_4 is the main gas formed during anaerobic digestion. Hence, it is important to note that any leaks from the digestion process should be avoided because the greenhouse gas potential of methane is more than 20 times larger than that of carbon dioxide. Gaseous emissions are thus the major point of possible concern for anaerobic digestion installations.

2.8.2.2 Gaseous emissions from digestion operation

Enviros Consulting performed a study in 2004 for the UK Office of the Deputy Prime Minister (Enviros Consulting, 2004) to investigate the necessary planning considerations and impact of newly built MSW management installations. For anaerobic digestion, the following issues were listed (among others): published data on air emissions from anaerobic digestion facilities are extremely limited, and the derivation of emission estimates that has been achieved is based upon a single study. From that data, the preliminary conclusion is that the emissions from anaerobic digestion are low compared with those for other waste disposal options. As the anaerobic digestion process itself is enclosed, emissions to air should be well controlled. However, as biogas is under positive pressure in the tank, some fugitive emissions may arise.

There is also the potential for bioaerosols to be released from the anaerobic digestion process, mainly from feedstock reception and the eventual aeration of the digestate during application. The separated dewatered fraction of the digestate should be stored properly in order to avoid methane emission (Lukehurst et al., 2010).

In 2010, the Netherlands introduced emission factors for calculations within the framework of the National Inventory Report. The factors relate to fruit, vegetable and garden waste separately collected from households. The emission factors have been drafted following a study that showed large spreads on emission factors from several National Inventory Reports of various countries. The emission factors for digestion are 1100 g CH_4/tonne input material, 2.3 g NH_3 /tonne input material, 46 g N_2O /tonne input material, 180 g NO_x /tonne input material and 10.7

g SO_2 /tonne input material. This compares to the emission factors for composting, which are 750 g CH_4 /tonne input material, 200 g NH_3/tonne input material and 96 g N_2O /tonne input material.

At the same time, the European Biogas Association states that anaerobic digestion offers the advantage of reducing emissions by avoiding emissions from open storage of e.g. manure or landfilling of unstable organic matter.

Based on the feedback received from Belgium, in a digestion plant with a QAS system, the removal of digestate is rather performed in a semi-continuous way, so that only some biogas is released into the environment. Even if the maximum fermentation is not reached at that moment, a removal of digestate does not lead immediately to methane production. When the digestate is cooled down, the digestion process will be cut off (similar to the storage of manure in a manure pit). Also when the separated fibre fraction or dewatered digestate is aerated, there will be no further methane release, but CO_2 will be formed instead of CH_4, which in terms of emissions has less impact on the environment.

Finally, according to a study from the German Environment Ministry (Bundesministerium, 2008) anaerobic digestion offers clear greenhouse gas savings when performed properly, despite small emissions that may occur at the plant.

2.8.2.3 Other emissions from digestion operation

- *Dust/Odour*

  One of the main perceived planning issues associated with anaerobic digestion has been the potential for generation of odour. Odours from any mixed waste or putrescible waste facility have the potential to represent a nuisance issue, particularly when waste is allowed to decompose in uncontrolled anaerobic conditions, due to poor storage for example. However, as the anaerobic digestion process is largely enclosed and controlled, the potential for odour is greatly reduced. Dust can sometimes be generated when waste is loaded and unloaded, and when waste is transported onto manoeuvring areas on vehicle wheels. Digestate may be injected in land in order to reduce ammonia and odour emissions (Lukehurst et al., 2010). Furthermore, according to Lukehurst et al. (2010), the anaerobic digestion process induces a reduction of volatile fatty acids, hence reducing odour nuisance typical for many slurries and especially manure.

- *Noise/Vibration*

  The noise and vibration associated with anaerobic digestion will be similar to that associated with other waste treatment plants. The process operations are not inherently noisy, although vehicle manoeuvring, loading and unloading, as well as engines and pumps, are potential sources of noise.

- *Water Resources*

  Waste water can be formed if the liquid digestate from a separation step cannot be used as fertiliser e.g. because of too high concentrations of heavy metals. This waste water may be disposed of to the sewer system, but if the level of contaminants breaches the level imposed by the water companies, on-site treatment may be necessary.

2.8.2.4 Emissions and leaching from digestate use

Lukehurst et al. (2010) note that when digestate is applied to a field surface, some ammonia volatilization will take place after application. As a result, the utilisation percentage will decrease. As a consequence it is important to minimise the surface area of digestate that is exposed to air after application so as to minimise ammonia volatilisation. This can be achieved by different methods of spreading, and/or by immediate incorporation in the topsoil. The expected utilisation percentage of nitrogen is greater for digestate than for slurry; for spring applications rather than applications in summer; and for injection rather than trailing-shoe.

Further according to Lukehurst et al. (2010), the application of digestate or any crop fertiliser at times of the year when there is little plant uptake (e.g. autumn and winter) can result in nutrient leaching and runoff into ground and surface waters (e.g. of N and P). Digestate must therefore be stored until the correct time for application. Field trials undertaken over two years as part of the Canadian Government's Technology Assessment Programme showed no significant increase in N leaching from digestate (compared with that from raw cow slurry) following spring application. In contrast, autumn application of digestate almost doubled the amount of N leached into the drainage waters compared with raw slurry. The potential for nutrient leaching is higher on sandy soils with poor water retention capacity. However, in all cases this problem can be minimised by avoiding the application of digestate (or any fertilisers) in periods with low plant uptake or high rainfall. It is therefore essential to know the fertiliser composition of digestate as well as the best method for accurate application to growing crops. Digestate and other fertiliser applications should be matched with crop nutrient requirements to minimize leaching and runoff.

According to a WRAP study, emissions from fugitive methane and aerobic degradation as well as nitrous oxide (N_2O) emissions are considered to be similar for wastes and residues applied to land (WRAP, 2009a).

2.8.2.5 Hygiene issues related to anaerobic digestion

In general, anaerobic digestion provides a hygienisation of the input material. Lukehurst et al. (2010) mentions following advantages of anaerobic digestion:

- very effective lowering of the pathogen load, such as gastrointestinal worm eggs, bacteria and viruses[29];
- plant pathogen reduction and spore destruction;
- weed seed reduction.

However, according to the German Environment Ministry, plant pathogens like the Tobacco Mosaic Virus may not be reliably reduced by an anaerobic digestion process. From a precautionary point of view the use of digestate in certain crops such as tobacco or tomato and similar susceptible plants that are used to be grown in green houses is not appropriate.

2.8.2.6 Conclusions with regard to environmental impacts of anaerobic digestion

A consortium by Enviros Consulting, the University of Birmingham and DEFRA published a "Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste

[29] According to studies ordered by the Flemish OVAM, lowering of the pathogen load is obtained by thermophilic digestion, but not by mesophilic digestion

and Similar Wastes" (DEFRA, 2011). Figure 4 presents the environmental effects for several MSW management options. It follows from the study that anaerobic digestion, if well performed, does not constitute any major environmental burden and even provides benefits to flora/fauna and soils.

Activity	Noise	Odour	Dust	Flora/ fauna	Soils	Water quality/ flow	Air quality	Climate	Building damage
Materials recycling facility	x	x	x	x	x	xx	xx	–	–
Composting	xx	xxx	xx	✓	x ✓	xx	xxx	x	–
Mechanical biological treatment	xx	xxx	xx	–	–	xx	xx	x	x
Anaerobic digestion	xx	xx	x	x ✓	x ✓	xx	xx	x	x
Gasification/ pyrolysis	xx	xx	xx	–	–	–	xx	x	x
Incineration with pre-sorting	xx	xx	xxx	xx	xx	xx	xxx	x	x
Incineration	xx	xx	xxx	xxx	xxx	xxx	xxx	x	x
Landfill	xxx	xxx	xx	xxx ✓	xxx	xxx	xxx	xxxx	x
Waste transfer stations	xx	xxx	x	–	–	xx	x	✓	–

Category	Meaning
✓	Direct or indirect benefit
–	No effect
x	Unlikely to be significant
xx	Potentially significant impact in some cases, but can be controlled
xxx	Impact can normally be controlled, but an issue at sites if design, engineering or operation falls below best practice
xxxx	An issue at all sites

Figure 4: Summary of key environmental issues for several MSW management options (DEFRA, 2011)

Regarding possible health impacts, the data did not indicate any major health risk from MSW management in general or from anaerobic digestion in particular.

As indicated in Figure 4, anaerobic digestion provides several major beneficial environmental effects. Lukehurst et al. (2010) list the positive effects of anaerobic digestion:

- biogas produced through anaerobic digestion is a source of renewable energy;
- digestate is a highly valuable biofertiliser that can partially replace mineral fertilisers;
- digestion reduces greenhouse gas emissions from open manure stores;
- digestion provides a highly efficient method for resource recycling.

3 Pollutant occurrence in compost and digestate

3.1 Introduction

From the start of this study, extensive discussions were held about the **eligibility of certain compost/digestate materials** for EU end-of-waste status. More specifically, the TWG experts were clearly divided about the eligibility of compost/digestate materials based on sewage sludge and the organic fraction originating from mechanical biological treatment (MBT) of mixed municipal waste.

Whereas several experts supported their opinions with technical data, the TWG discussions did not converge to a common point of view. The **criticisms** voiced on the presented data, whether originating from scientific literature or provided directly by experts, included:

- the sampling and measurement methods may differ from one study to the other and therefore data cannot be fully compared (e.g. physical impurities analysis by optical selection or bleach method);
- measurement data may be outdated and not be relevant for state-of-the-art technology (e.g. for installations in their start-up phase);
- measurement data only concern a particular type of compost or digestate or a particular area (e.g. one Member State);
- datasets are too small (e.g. less than 10 samples);
- the number of measured parameters may be limited and therefore data may not provide a complete picture of the quality of a certain material (e.g. data only available on heavy metals but not on organic pollutants).

Moreover, existing information sources displayed a large **discrepancy between the available data on inorganic and organic pollutants** in various types of compost and digestate. A number of causes may explain the lack of scientific data on organic pollutants. Certain experts suggested that organic pollutants would be of little concern in compost/digestate due to the nature of the used input materials, especially for source separated bio-waste and green waste, which is sometimes reflected in national legislation not requiring the routine measurement of such pollutants. Other experts suggested that chemical analytical developments in trace level detection of organic pollutants, combined with a raising awareness on their possible effects make that organic pollutants constitute a relatively recent discussion topic. This clearly contrasts with the longstanding knowledge around heavy metals and physical impurities.

As a result of the TWG discussions, it emerged that reliable and state-of-the-art scientific data on the levels of organic and inorganic pollutants in different types of compost and digestate were needed to support the decision-making process for end-of-waste criteria. Therefore, TWG experts agreed that available and relevant scientific data should be reviewed and complemented by independent recent data generated through a pan-European collaborative screening exercise. Such a screening, consisting of measuring a large series of compost and digestate samples in the best possible standardized way, was therefore carried out in May-December 2011 by the JRC with the collaboration of the TWG network.

The methodology and results of this JRC Sampling and Analysis Campaign (JSAC) are presented in this chapter. The data are then discussed against a review of relevant scientific data retrieved from literature or provided by experts.

3.2 Objectives of the JRC Sampling and Analysis Campaign (JSAC)

The two objectives of the collaborative screening exercise, further denoted as **JRC Sampling and Analysis Campaign (JSAC)**, were:

1. Generate, within a limited timeframe, a large amount of analytical data, through uniform sample treatment and analysis, for a number of compost and digestate types, to allow a general overview and estimation of possible variability of pollutant levels within and between different compost/digestate materials and technologies.
2. Guarantee maximal objectivity and avoid bias upon sampling by independent, unannounced control sampling performed by a single team composed of EC JRC staff only, at selected plants participating in the collaborative screening exercise.

The Technical Working Group agreed that the results from this collaborative screening exercise, together with relevant existing data, had to be used to support the establishment of end-of-waste criteria such as e.g. product quality, input materials or quality assurance. Hence, they form an important basis for the proposed end-of-waste criteria in this document.

3.3 Organisation of the JSAC

The Institute for Environment and Sustainability (JRC-IES) in Ispra (Italy) had already been making provisions for a FATE-COMES study on composts and bio-waste materials, following previous successful pan-European measurement campaigns such as FATE-EUMORE (surface water), FATE-GROWS (groundwater) and FATE-SEES (sewage sludge and effluents). Their study formed the basis for the current collaborative screening exercise.

The JSAC, organized within the FATE-COMES framework, featured around 120 samples[30] eligible for measurement, georeferenced and distributed over the following categories:
(a) Compost produced from separately collected organic waste from households and similar commercial institutions, including garden and park waste
(b) Compost produced from garden and park waste only (green compost)
(c) Sewage sludge compost produced from sewage sludge and other separately collected organic waste (e.g. garden and park waste, straw, etc.)
(d) Municipal Solid Waste compost generated by Mechanical Biological Treatment aimed at producing compost (derived from non-hazardous household waste and similar commercial waste where no separate collection of household bio-waste is in place)
(e) Digestates from source separated bio-wastes from households and similar commercial institutions (liquid and solid fraction)
(f) Digestates from manure and source separated bio-wastes from households and similar commercial institutions (liquid and solid fraction)
(g) Digestates from manure and energy crops (liquid and solid fraction)
(h) Digestate derived from Mechanical Biological Treatment of Municipal Solid Waste, aimed at producing digestate for use in agriculture (derived from non-hazardous household waste and similar commercial waste)
(i) Other, minor categories. These include bark compost or stabilized waste generated by MBS processes[31]. Hence *this category does not constitute compost or digestate aimed*

[30] Initially, some 160 samples had been committed, but not all samples were used for reasons that include late delivery, unclear material type, low content, etc.

at receiving end-of-waste status, but only serves as illustration of pollutant levels in materials from related industrial and waste treatment processes.

It should be noted that the criterion for classification as digestate or compost also depended on the final form of the material. Hence any post-composted digestate was to be classified as compost.

For the first study objective, allowing a broad screening of different materials and technologies, samples were taken by the compost/digestate producers, in sample containers provided by the JRC-IES, and shipped back to JRC-IES for analysis.

For the second study objective, the JRC selected a number of compost/digestate producing plants from the list of participating producers, in order to visit these unannounced (last week of June 2011). The JRC team took their own samples for measurement by JRC-IES. Nineteen different samples were taken during the sampling campaign, in Italy, France, Belgium, The Netherlands and Germany.

3.3.1 Targeted measurement parameters

The FATE-COMES study targeted the measurement of a wide range of parameters, as listed in Table 8.

Table 8: Targeted parameters for measurement on compost and digestate samples within the FATE-COMES project

Compound class	***Method principle***
Perflurorinated surfactants (including PFOS, PFOA)	LC MS
Heavy metals (including Ag, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, Pb, Sb, Se, Ti, Tl, V, Zn)	ICP-OES
Mercury	CV AAS
PCBs	GC-MS
PCDD/Fs	GC-MS
PAHs	GC-MS
Siloxanes	LC-MS
Polycyclic Musks	LC-MS
Nonylphenol and -ethoxylates	LC-MS
PBDE	LC-MS
Pesticides	LC-MS
Veterinary drugs, pharmaceuticals	Various
Estrogene activitiy (bio-asssay)	CALUX

The various compounds were measured by JRC laboratories and selected partner laboratories. The laboratories followed their validated in-house methods. JRC-IES labs were ISO 9001 certified. Partner laboratories were accredited laboratories under ISO 17025. Where possible, so-called Horizontal standards of CEN TC 400 were used or at least the provisional prEN standards. Final results were received in July 2012.

[31] See also section 2.2 Treatment options for the difference in MBT technologies depending on the aim of the installation

The parameters were selected following earlier assessment of their relevance with regard to possible environmental and human health impacts.

The current report does not aspire to provide a full detailed overview of the results from the JRC Sampling and Analysis Campaign, but rather focuses on summarizing key data that are needed to establish end-of-waste criteria. Therefore, some of the above mentioned parameters will not be discussed further in this document. The JRC Institute for Environment and Sustainability has published a detailed report on the study (IES, 2013) and informed individual participants on the analytical results of their samples.

3.3.2 Sampling methods

In order to reduce the organizational and financial efforts for participating plants, there was no obligation to perform independent sampling by external accredited sample takers and plants were allowed to perform the sampling themselves. Where possible, JRC recommended using EN 12579 for solid samples and EN ISO 5667-13- 1997 "Water quality -Sampling - Part 13: Guidance on sampling of sludges from sewage and water-treatment works" for liquid samples. Alternatively, plants could use their usual sampling method.

Furthermore, by participating in the campaign, plants agreed to receive a possible visit from the JRC team for the collection of independent samples. The JRC team employed the same sampling method as described above in these cases.

3.3.3 Sampling protocol

The European Compost Network had prepared a sampling protocol, which was a modified version of the Sampling Record described in their Quality Assurance Scheme and which was distributed by the JRC to the participating plants. Plant owners were requested to fill out the sampling protocol and categorize the samples according to their best judgment. No specific detail was requested on the input material composition.

3.4 Sample distribution

In total, compost/digestate producers from 15 EU Member States, as well as Switzerland, participated in the exercise. As could be expected, countries with a well-established compost/digestate production were the largest source of samples. France was the largest contributor of samples (35 samples), whereas only two samples were received from the EU-12 (CZ and MT). In order to avoid bias by overrepresentation of certain technologies or regions, further plants were no longer admitted to participation in the screening exercise at some point in time. This was especially the case for certain candidate participants from France.

Regarding the sample types, the number of usable compost samples (88) was higher than the number of usable digestate samples (25) received. Some samples had to be omitted for a number of reasons, including late arrival and doubts on the specified content.
The figures below represent the distribution of usable samples according to country of origin (Figure 5) and sample type (Figure 6).

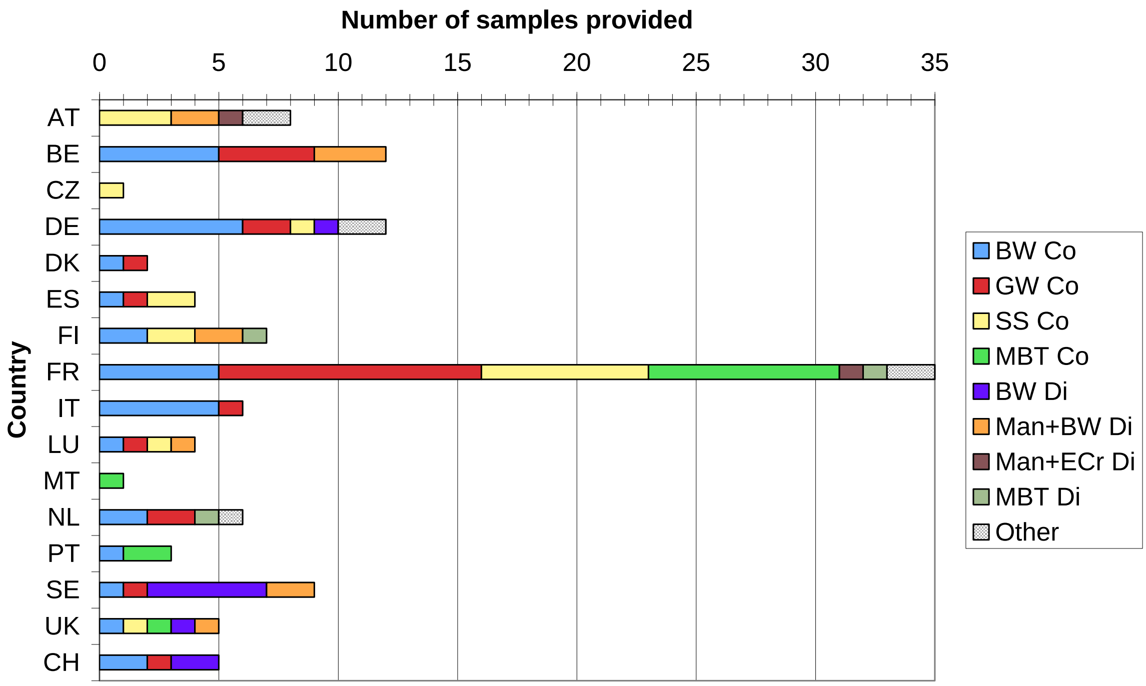

Figure 5: Distribution of samples according to participating country (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

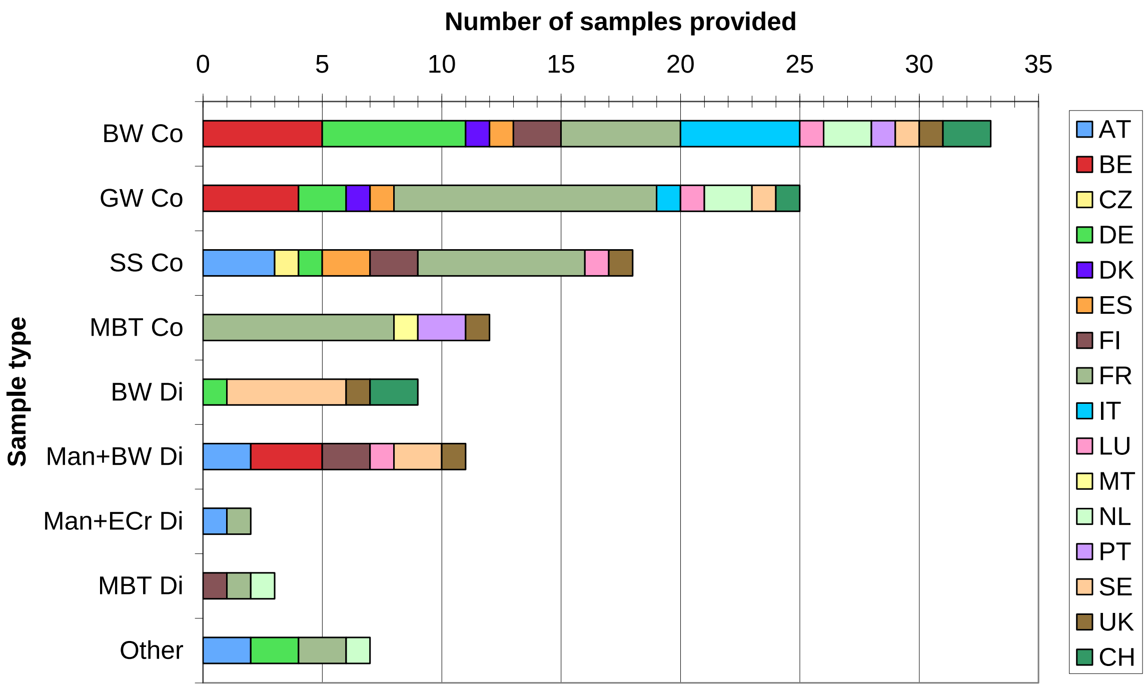

Figure 6: Distribution of samples according to sample type (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

3.5 Analytical results and discussion

3.5.1 Introduction

As indicated above, the analytical results have been collected through joined efforts from the JRC-IES and partner laboratories.
All data are expressed on dry matter (d.m.) basis unless indicated otherwise.
In view of respecting the anonymity of the participating plants, this report has omitted the exact geographical location and description of the participating plants.

3.5.2 Representativeness of the received samples

In a first instance, analytical results from samples collected by the plants and collected by the JRC team were compared, for 5 different types of compost and digestate materials.

Based on 75 measurement values for organic and inorganic compounds, a Pearson correlation coefficient of 97.4% was obtained. Furthermore, a T-test at 95% confidence level did not indicate a significant difference between the data originating from the JRC samples and the plant samples. This indicates that no specific bias linked to sampling could be found.

3.5.3 Heavy metals

The results of the heavy metal analyses from the JSAC are depicted in Figure 7. The figure displays the results as cumulative graphs scaled from 0 to 100% of the total sample population for a material type, with every concentration data point representing an actual sample measurement. This representation helps visualizing the spread on the data and allows checking how many samples of a compost/digestate type surpass a certain threshold concentration.

Some samples, especially digestates, could not be analysed for various reasons. In order to have a minimum number of valuable samples for evaluation and discussion, the results of source separated bio-waste, manure and energy crop digestates have been grouped. For the category of MBT digestate only two samples were available, hence these have mere illustrative value and will not be discussed.

The graphs also contain red bars, indicating the proposed EU end-of-waste limit values, based on the 2008 IPTS pilot study on compost/digestate (IPTS, 2008) and TWG discussions from this study.

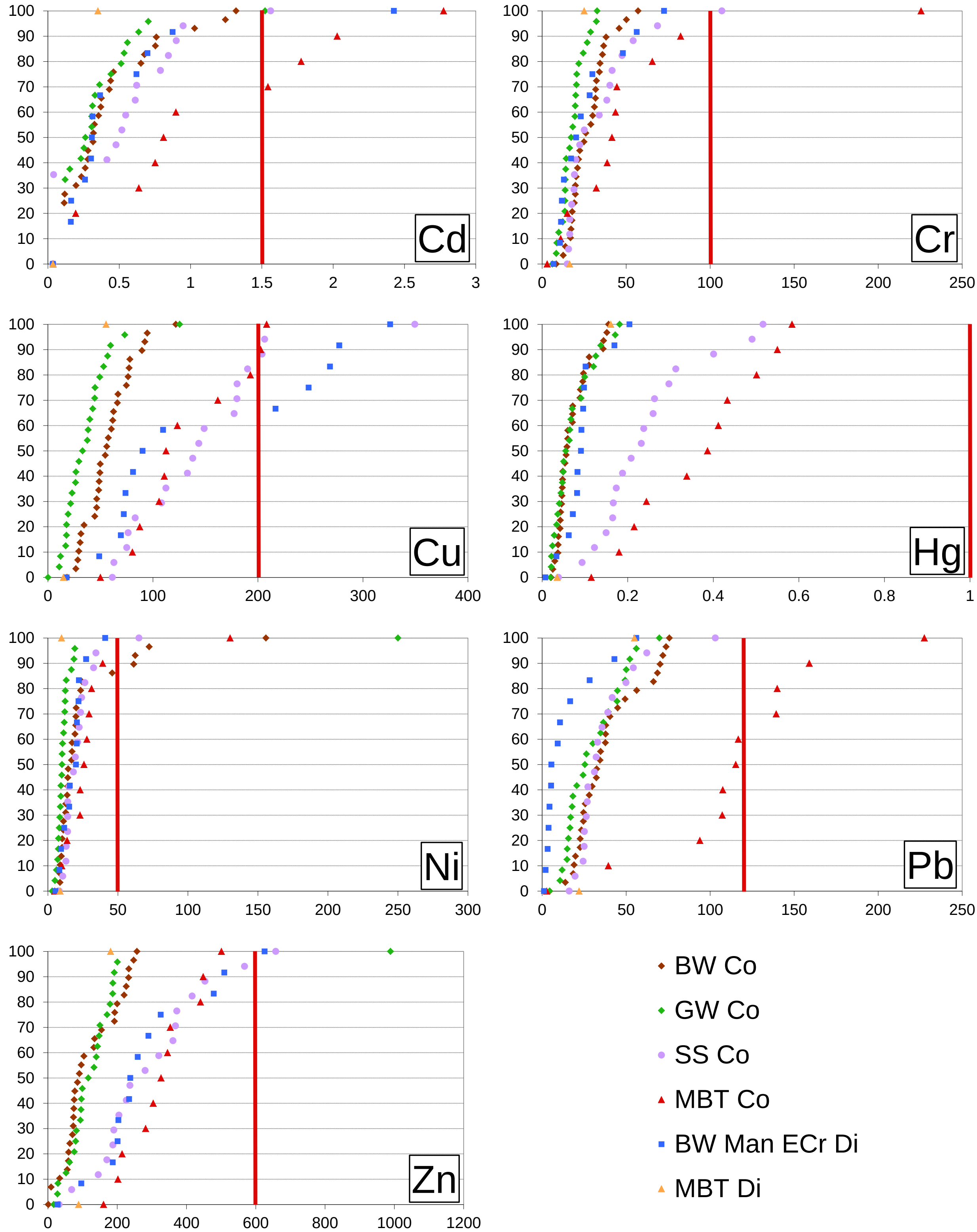

Figure 7: Heavy metals in compost and digestate samples collected by JRC and sent by plants. The horizontal axis represents the concentration (mg/kg d.m.) and the vertical axis the cumulative percentage of samples. The red bar represents the proposed maximum values for EU EoW product quality criteria (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

From the subplots in Figure 7, the following can be concluded:

- **Cd**: many samples meet the proposed 1.5 mg/kg dry matter limit value, except 1 green waste compost sample, 1 sewage sludge compost sample, 4 MBT compost samples and 1 digestate sample. MBT compost displays the generally highest Cd levels;
- **Cr**: nearly all samples meet the proposed limit of 100 mg/kg dry matter, except one sewage sludge compost sample and 1 MBT compost sample. MBT compost displays the generally highest Cr levels;
- **Cu**: compost from source separated bio-waste or green waste generally meets the proposed limit value of 200 mg/kg dry matter, with most of the materials having a concentration below 100 mg/kg. Sewage sludge compost, MBT compost and digestate display generally higher Cu concentrations, with respectively 3, 2 and 5 samples failing to meet the proposed limit value. Although the very limited overall number of digestate samples does not allow making any firm analysis, it was noted that Cu exceedings of the proposed limit values were recorded for digestates with manure (3 samples) and without manure (2 samples). So the presence of manure seems not the only possible factor to explain high Cu concentrations in digestate;
- **Hg**: all samples meet the proposed limit of 1 mg/kg dry matter. Sewage sludge compost and MBT compost clearly display generally higher Hg concentrations than compost and digestate from source separation;
- **Ni**: most samples meet the proposed 50 mg/kg dry matter limit value, except 4 separately collected bio-waste compost samples, 1 green waste compost sample, 1 sewage sludge compost sample and 1 MBT compost sample. Although certain Italian regions are known for high natural soil nickel background concentrations from wearing of ultramafic rock (Lado et al., 2008; Poggio et al., 2009), only one of the 4 concerned bio-waste samples exceeding the Ni limit value appeared to originate from Italy, indicating that other types of contamination may have played a role in the bio-waste compost samples;
- **Pb**: MBT compost samples show generally higher Pb concentrations than the other materials, with 4 samples failing to meet the proposed limit of 120 mg/kg dry matter. All other material types meet the proposed limit. Digestate samples generally display the lowest Pb levels;
- **Zn**: composts from source separated bio-waste or green waste generally display the lowest Zn concentrations, with only one green waste compost sample failing the limit. Sewage sludge compost, MBT compost and digestate display generally higher Zn concentrations, with 1 MBT compost and 1digestate sample failing the proposed limit value.

In the category "other" materials, consisting of only 7 samples, exceedings of the proposed limits for end-of-waste were noted for Cd (1 sample), Cr (1 sample), Cu (3 samples), Hg (1 sample), Ni (2 samples), Pb (3 samples), Zn (1 sample). In this category, the 3 samples of stabilized waste destined for landfilling exceeded the proposed limits for at least 3 metals, clearly indicating the high possibility of contamination of these materials.

The percentage of samples in each category that met *each of the 7* proposed heavy metal limits ranged from 36% for MBT compost, over 72% for sewage sludge compost, 62% for the grouped digestate category, 87% for source separated bio-waste and green waste compost to 88% for source separated green waste compost. The two MBT digestate samples also met the proposed criteria. It should be stressed that given the relatively small sample size in every category, these figures have little statistical value. Nonetheless, they indicate that some technologies and/or input materials tend to achieve the proposed limit values more easily than others. Moreover, for every material type, it was possible to encounter both samples that meet and that don't meet the proposed criteria.

Furthermore, it can be derived from the above dataset that:

- in general, compost from source separated collection of bio-waste and green waste display the lowest overall heavy metal concentrations, except for Pb. **Composts** produced **from source separated collection of green waste nearly always meet the proposed limit values** for individual heavy metals (with sporadic exceedings), but **several bio-waste composts exceeded the proposed Ni limits**. At the same time, the exceeding values also demonstrate that analysis of the output material is necessary to avoid possible problems related to e.g. contaminated input materials;
- **sewage sludge compost** generally meets the proposed limit values for Cd, Cr, Hg, Ni, Pb and Zn (with sporadic exceedings) but tends to have **problems in meeting the proposed Cu limits**;
- **MBT compost** generally meets the proposed limit values for Cu, Cr, Hg, Ni and Zn (with some sporadic exceedings) but tends to have **problems in meeting the proposed limit values for Cd and Pb**;
- **digestate** generally meets the proposed limit values for Cd, Cr, Hg, Ni, Pb and Zn (with sporadic exceedings), displaying the generally lowest Pb levels of all materials, but tends to have **problems in meeting the proposed Cu limits**;
- there are not enough samples to make a sound judgement on MBT digestate, but the 2 samples analysed met all proposed limit values;
- "Other" samples can hardly meet the proposed limit values and show large exceedings.

Benchmark against existing data

In order to check the relevance of the JSAC data, it is useful to benchmark them against other data sources, preferably with large sample numbers and acquired over a certain period to compensate for possible seasonal variations. At the same time, data should be taken from recent years, in order to ensure representativity and comparability with the JSAC. Therefore, it was preferred to use data provided by stakeholders, rather than from scientific literature, which tend to be older. For instance, Smith (2009) contains an extensive literature review on heavy metal concentrations in different kinds of composts, but all data refer to the period 1981-2007 and hence may not be representative for the state-of-the-art composting and digestion technology in Europe.

An overview of measurement data from more than 14000 samples from different locations through the EU and different compost/digestate types is given in Table 9. The table aims to reflect only the most recently available datasets, in order to be representative for the current composting and digestion sectors.

Where available, median values and 90-percentile data were extracted immediately from a given dataset. Alternatively, the average value was reported and/or the 90-percentile value was calculated assuming a normal distribution and taking into account the average and standard deviation in the dataset[32].

[32] Calculated 90-percentile value= average+1.281*standard deviation

Table 9: Overview of compost/digestate heavy metal concentrations (mg/kg) from various European databases. Data are ranked per material type according to the number of samples N in the population. Cell colour filters: RED = proposed EU EoW limit exceeded, ORANGE= 90% of proposed EU EoW limit exceeded, GREEN= value below 50% of proposed EU EoW limit (green filter only applied on 90-percentile data) (NN= no information available; Co=compost; Di=digestate; BW=source separated bio-waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

						Median/Average								90 Percentile (From distribution/Calculated)							
Material type	Quality label received?	Data source	Year(s)	MS	Number of samples	Median or Average?	Cd	Cr	Cu	Hg	Ni	Pb	Zn	From Distribution or Calculated?	Cd	Cr	Cu	Hg	Ni	Pb	Zn
"Raw": analytical results from materials that have NOT received a quality label																					
BW Co	No	Ineris	2009-2011	FR	161	A	0.6	26	66	0.19	17	57	230	C	0.9	39	107	0.38	25	92	332
BW Co	No	Cré (IMD)	2000-2006	IE	82	M	0.5	27	64	0.08	19	45	173	D	0.8	65	100	0.30	39	100	266
BW Co	No	ADEME	2007-2008	FR	15	M	0.8	23	57	0.16	15	75	191	D	0.9	38	137	0.45	24	99	255
BW + GW Co	No	DWMA	1994-2009	NL	1728	M	0.4	20	35	0.08	10	56	175	D	0.6	27	55	0.15	13	79	217
BW + GW Co	No	REA	2009-2012	UK	1437	M	0.5	19	58	0.14	13	95	206	D	0.9	37	99	0.24	22	164	282
BW + GW Co	No	ARGE	2010-2012	AT	164	M	0.4	26	44	0.13	18	25	155	D	0.8	40	88	0.28	27	41	324
BW + GW Co	No	MS ES	2008-2012	ES	135	M	0.2	22	89	0.20	15	43	243	D	0.6	57	169	0.60	31	83	359
BW + GW Co	No	VLACO	2008-2010	BE	114	M	1.0	31	49	0.10	15	64	238	D	1.3	46	59	0.20	18	103	317
BW + GW Co	NN	MS PT	2011-2012	PT	10	A	1.7	20	105	0.24	15	17	372	C	2.2	34	111	0.30	18	21	404
GW Co	No	VLACO	2008-2010	BE	237	M	1.0	25	34	0.20	11	49	168	D	1.2	30	41	0.20	14	54	187
GW Co	No	ADEME	2007-2008	FR	45	M	0.5	19	49	0.18	12	59	136	D	0.7	23	60	0.47	14	88	196
GW Co	No	Cré (IMD)	2000-2006	IE	38	M	0.5	40	61	0.10	32	74	182	D	1.0	57	82	0.15	38	114	253
SS Co	No	EFAR	2011	FR	605	M	0.9	35	184	0.59	22	46	421	D	1.7	56	315	1.14	32	94	663
SS Co	No	ADEME	2007-2008	FR	20	M	1.0	25	162	0.63	17	74	361	D	1.4	44	335	1.03	33	154	627
MBT Co	No	Ineris	2009-2011	FR	247	A	1.1	43	128	0.51	26	93	356	C	1.9	64	196	0.93	37	136	497
MBT Co	No	MS ES	2011-2012	ES	12	M	1.0	63	202	0.45	45	118	416	D	1.3	192	449	1.06	129	210	609
BW Di (separated liquor)	No	REA	2010-2011	UK	28	M	0.4	6	41	0.04	12	5	145	D	1.5	18	208	0.20	18	16	459
BW Di (separated liquor)	No	WRAP	2009-2012	UK	15	M	0.0	3	35	0.05	9	7	106	D	0.5	13	63	0.05	13	15	203
BW Di (solid)	No	REA	2010-2011	UK	33	M	0.2	15	39	0.01	8	8	189	D	0.7	38	107	0.14	14	20	565
BW Di (solid)	No	WRAP	2009-2012	UK	24	M	0.2	16	63	0.05	9	12	286	D	0.7	37	274	0.24	14	47	696
BW Di (whole)	No	REA	2010-2011	UK	24	M	0.6	7	38	0.05	10	4	124	D	2.4	19	129	0.20	30	19	301
BW Di (whole)	No	WRAP	2009-2012	UK	51	M	0.4	7	37	0.05	10	4	127	D	1.8	17	156	0.05	23	10	338
BW+Man+Ecr Di (Whole)	No	VLACO	2011-2012	BE	211	M	0.5	18	91	0.10	12	10	340	D	0.8	34	214	0.30	20	15	582
BW+Man+Ecr Di (Dried)	No	VLACO	2011-2012	BE	64	M	0.5	23	100	0.10	13	10	368	D	0.7	57	223	0.30	27	15	652
BW+Man+Ecr Di (Solid)	No	VLACO	2011-2012	BE	55	M	0.5	15	85	0.10	9	10	290	D	1.5	33	238	0.30	17	11	688
BW+Man+Ecr Di (Whole)	No	ARGE	2007-2011	AT	11	M	0.2	14	75	0.10	9	5	427	D	0.4	26	123	0.15	12	10	580
"Label awarded": analytical results from materials that received a quality label																					
BW Co	RAL GZ 251	BGK/ECN	2012	DE	1734	M	0.4	23	45	0.10	14	33	174	D	0.6	37	70	0.17	24	57	250
BW Co	CIC Label	CIC	2006-2012	IT	1530	A	0.4	NN	94	0.23	20	48	217	D	0.8	NN	135	0.50	33	79	312
BW + GW Co ("Mature")	RAL-GZ 251	BGK/ECN	2008	DE	1817	M	0.4	22	42	0.11	13	35	165	D	0.7	36	75	0.20	25	62	250
BW + GW Co ("Fresh")	RAL-GZ 251	BGK/ECN	2008	DE	832	M	0.4	23	48	0.10	14	36	175	D	0.7	37	78	0.17	25	55	246
BW + GW Co	NF U 44-051	CompostPlus	2006-2010	FR	36	M	0.5	22	58	0.08	15	36	172	D	0.6	41	86	0.19	24	66	236
GW Co	RAL GZ 251	BGK/ECN	2012	DE	1061	M	0.4	20	32	0.10	12	29	143	D	0.7	36	50	0.16	24	51	213
GW Co	CIC Label	CIC	2006-2012	IT	251	A	0.4	NN	78	0.20	30	45	173	D	0.7	NN	110	0.50	76	71	221
GW Co	PAS 100	AFOR	2008	UK	100	M	0.6	18	51	0.15	13	94	180	D	0.9	34	73	0.42	24	148	241
SS Co	Soil Improver	CIC	2006-2012	IT	98	A	0.6	NN	124	0.35	30	46	312	D	1.0	NN	166	1.00	44	64	464
BW Di (Liquid)	RAL-GZ 245	BGK/ECN	2012	DE	783	M	0.4	15	64	0.07	13	5	274	D	0.7	32	130	0.19	27	32	546
BW Di (Liquid)	RAL-GZ 245	BGK/ECN	2010	DE	575	M	0.4	13	68	0.09	11	5	290	C	0.8	32	151	0.25	28	36	475
BW Di (Solid)	RAL-GZ 245	BGK/ECN	2012	DE	62	M	0.3	17	36	0.07	13	24	186	D	0.9	40	63	0.15	29	48	285
BW Di (Solid)	RAL-GZ 245	BGK/ECN	2010	DE	44	M	0.4	16	53	0.11	12	22	214	C	0.8	33	73	0.30	24	44	299
BW Di	SPCR 120	JTI	2010-2012	SE	15	M	0.3	11	44	0.04	9	3	213	D	0.5	18	68	0.09	22	9	260
BW+Man Di	SPCR 120	JTI	2010-2012	SE	11	M	0.3	7	111	0.03	7	2	324	D	0.4	16	183	0.06	13	6	465
Man+Ecr Di (Liquid)	RAL-GZ 246	BGK/ECN	2012	DE	85	M	0.4	6	90	0.05	8	3	347	D	0.7	12	172	0.11	12	7	633
Man+Ecr Di (Solid)	RAL-GZ 246	BGK/ECN	2012	DE	33	M	0.2	2	16	0.05	3	3	121	D	0.3	7	87	0.06	8	3	636

The table contains "Raw" data from more than 5500 samples that did not necessarily receive a quality label. This means that the measurements may have exceeded the metal limits of a national quality system and do not only represent materials that meet certain quality requirements. These data include a few results from general surveys or studies. However, most of the data concern materials applying for a quality label, but before being awarded the label.

The latter category includes for instance analytical data from plants operating under a quality system, but whose materials may have exceeded the applicable limit values, in which case corrective actions were taken. Therefore, these data can serve to understand how feasible the proposed end-of-waste metal limits are for a certain compost/digestate type.

In addition, data are listed for more than 9000 samples that passed some form of quality based preselection ("Label awarded"). Obviously, these data are less useful to assess how feasible the proposed end-of-waste heavy metal limits are, as materials exceeding certain heavy metal concentrations do not appear in the dataset. Nevertheless, these data may be useful for other purposes, e.g. to compare the overall metal levels in fresh versus mature composts or liquid versus solid digestates.

The following can be derived from the extended database compilation:

- **Bio-waste and greenwaste compost** from materials derived from **source separate selection** display the same tendency as in the JRC data. All proposed heavy metal limit values are generally met at the 90-percentile level. Nonetheless, the extensive REA data for the UK indicate that for all heavy metals more than 99% of the materials respect the proposed limit value, except for Pb where 27.5 % of the samples fail the proposed EU end-of-waste Pb limit. The somewhat older data from the Irish Metal Database also indicate relatively high Pb values for green waste compost. Certain TWG experts have suggested that these cases are due to historical pollution from the extended use of leaded fuels. The high 90-percentile value for Ni from the Italian database could be attributed to all samples from one plant, suggesting the likely regional pedogenic cause for high Ni levels in certain Italian composts. The extensive Dutch DWMA database shows that 97.4% of the more than 1700 samples measured in the period 1994-2009 would meet the proposed limit values for all 7 heavy metals. The Spanish database also shows that more than 90% of the samples would meet the proposed limit values for all 7 heavy metals.
- **Sewage sludge compost** data from the extensive EFAR database display the same tendency as the JRC data regarding the higher median concentrations of heavy metals Cu, Hg and Zn compared to bio-waste and green waste composts from source separate collection. Moreover, more than 13% of the samples would fail the criteria for Cd, Hg and Zn and more than 39% for Cu. In total, only slightly more than half of the 605 samples (52.2%) would meet all proposed 7 heavy metal limits. These results are worse than the findings from the JRC campaign, where 72% met all metal limits, although it should be stated that only 18 sewage sludge samples were measured in the JSAC. Yet, the previously conducted JRC FATE-SEES screening study on sewage sludge (IES, 2012) also indicated particularly high median sludge concentration values for Cd, Cu, Hg and Zn (0.9, 240, 0.4 and 655 mg/kg d.m., respectively), which may help explain the high presence of these metals in sludge derived compost materials. The Italian sludge compost data show that sewage sludge composts can meet most requirements if a strict preselection takes place. In Italy, only around 10% of the total sewage sludge produced is used for composting and sewage sludge is added to a maximum of 35% of the input materials mix.
- The results for **MBT compost** from the JSAC seem to converge with the external data. The large French Ineris database (247 samples) shows that Cr, Ni and Zn limits are generally met. However, 8.0%, 12.4 % and 19.4% of the samples exceed the Cu, Cd and Pb limits, respectively, in line with the findings from the current JRC study. From the Spanish MBT data it was derived that none of the samples would meet all criteria,

although it should be emphasized that the size of the Spanish dataset is much smaller than the Ineris dataset (only 12 samples). Nevertheless, based on MBT compost data over the last decade (2003-2012), it was noticed that only 2 out of 48 Spanish samples met all proposed limits for heavy metals.

- "Raw" **bio-waste digestate** data are less abundant compared to compost data. Hence, digestate data should be interpreted with extreme care, given the limited sample numbers. Nonetheless, the limited datasets of REA and WRAP for bio-waste digestates in the UK seem to suggest that median heavy metal concentrations are similar or lower than for composts. Nonetheless, in some but certainly not all cases problems are noted with Cd, Cu and Zn at 90-percentile level.
- The VLACO **digestate** data indicate that for digestate containing **manure**, Zn and especially Cu limits may be difficult to meet, in line with the JRC findings.
- The BGK/ECN data for **fresh and mature composts show a remarkable high similarity** in median and 90-percentile values for all heavy metals. A robust judgment to what extent the maturity level influences the concentration level of metals cannot be concluded since there is no clear information available from this database about the actual difference in the extent of decomposition (mineralisation) that occurred in the so-called "fresh" samples relative to the "matured" ones. Some TWG experts had suggested that maturation of composts would systematically drive up the heavy metal content value expressed on dry weight, due to loss of organic matter. The present data analysis does at least not seem to support this hypothesis.
- The different median values from VLACO and BGK/ECN digestate databases indicate that the **metal concentrations**, when expressed on dry matter base, are **relatively independent of the physical form of digestate**. The median liquid and median solid BGK data are very similar, and the same goes for the three different forms of VLACO digestate, whole, solid or dried. Although the UK databases from REA and WRAP contain fewer samples than the BGK/ECN and VLACO datasets, they seem to confirm the above observations.
- Based on data from the same source for different material types, it can be derived that the **quality of a material does not so much depend on the geographical area as well as on the technology used**. This becomes clear when comparing for instance the Ineris and Spanish data for source separated composts on the one hand and MBT composts on the other hand.

Conclusion

In conclusion, the JSAC data appear to consolidate findings from existing data sources. Furthermore, the proposed end-of-waste limit values seem feasible targets from a technological point of view, when carefully selecting the input materials. Some composting/digestion technologies or input materials might lead to a lower likelihood of meeting the proposed limit values than others. Nonetheless, in all categories samples were encountered that met the proposed limit values and other samples were encountered that exceeded the proposed limit values.

3.5.4 Physical impurities

For organisational reasons, only a limited number of samples (16 compost samples) could be analysed for physical impurities. The method used was the bleach method as defined in the Horizontal standards. The results are depicted in Figure 8.

Figure 8 also contains a red bar, indicating the proposed EU end-of-waste limit value, based on the 2008 IPTS pilot study on compost/digestate (IPTS, 2008) and TWG discussions from this study.

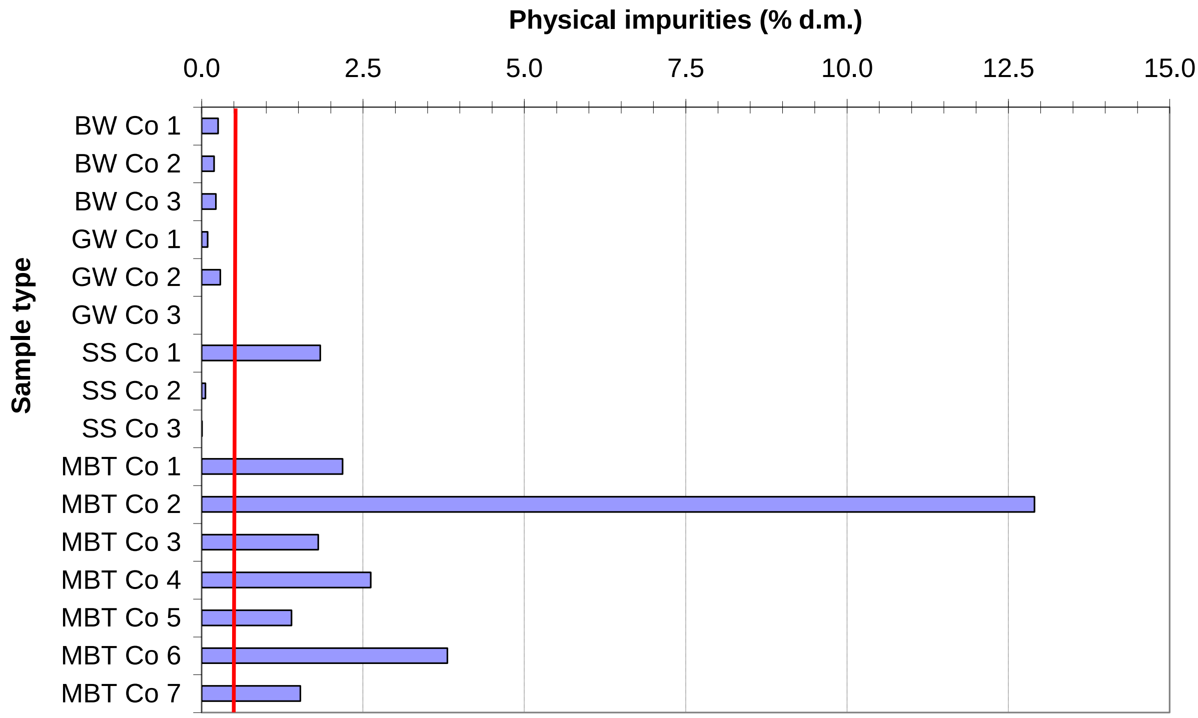

Figure 8: Physical impurities (glass, metal and plastic > 2mm) in compost samples collected by JRC and sent by plants. The red bar represents the proposed maximum value for EU EoW product quality criteria (Co=compost; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment)

From the data obtained, it is clear that all compost samples derived from source separated bio-waste and green waste, as well as two out of three sewage sludge compost samples, easily met the proposed limit value of 0.5 %. However, none of the MBT based compost samples reached the proposed limit value. The MBT samples also show a large variation in quality for this parameter.

Benchmark against existing data

With only 16 samples, the data set for this parameter is very limited. However, the external databases presented for the heavy metals often contain information on physical impurities as well. These are presented in Table 10.

Table 10: Overview of compost/digestate impurities concentrations (% d.m.) from various European databases. Data are ranked as in Table 9. Known exceedings of the proposed limit are either presented as absolute numbers or as a percentage. Cell colour filters: RED = proposed EU EoW limit exceeded, ORANGE= 90% of proposed EU EoW limit exceeded, GREEN= value below 50% of proposed EU EoW limit (green filter only applied on 90-percentile data) (NN= no information available; Co=compost; Di=digestate; BW=source separated bio-waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

					Impurities > 2 mm					
Material type	Quality label received?	Data source	Year(s)	MS	Number of samples	Median or Average ?	M/A	From Distribution or Calculated?	90-percentile	Exceedings >0.5% d.m. limit?
"Raw": analytical results from materials that have NOT received a quality label										
BW Co	No	Ineris	2009-2011	FR	135	M	0.30	D	0.76	25.9%
BW Co	No	Cré (IMD)	2000-2006	IE	99	M	0.00	D	0.30	≥1
BW Co	No	ADEME	2007-2008	FR	15	M	0.11	D	0.46	2
BW + GW Co	No	DWMA	1994-2009	NL	976	M	0.13	D	0.40	5.9%
BW + GW Co	No	REA	2009-2012	UK						
BW + GW Co	No	ARGE	2010-2012	AT	164	M	0.00	D	0.16	0.0%
BW + GW Co	No	MS ES	2008-2012	ES	50	M	0.20	D	1.09	10
BW + GW Co	No	VLACO	2008-2010	BE	114	M	0.20	D	0.30	≥1
BW + GW Co	NN	MS PT	2011-2012	PT	12	M	0.76	D	1.43	5
GW Co	No	VLACO	2008-2010	BE	237	M	0.10	D	0.10	≥1
GW Co	No	ADEME	2007-2008	FR	45	M	0.17	D	0.83	5
GW Co	No	Cré (IMD)	2000-2006	IE	42	M	0.00	D	0.06	0
SS Co	No	EFAR	2011	FR	161	M	0.10	D	0.59	11.8%
SS Co	No	ADEME	2007-2008	FR	20	M	0.12	D	1.05	4
MBT Co	No	Ineris	2009-2011	FR	293	M	1.30	D	2.40	91.5%
MBT Co	No	MS ES	2011-2012	ES	11	M	2.04	D	7.51	9
BW+Man+Ecr Di (Whole)	No	VLACO	2011-2012	BE	211	M	0.00	D	0.00	0.0%
BW+Man+Ecr Di (Dried)	No	VLACO	2011-2012	BE	64	M	0.00	D	0.10	0
BW+Man+Ecr Di (Solid)	No	VLACO	2011-2012	BE	55	M	0.00	D	0.00	≥1
"Label awarded": analytical results from materials that received a quality label										
BW Co	RAL GZ 251	BGK/ECN	2012	DE	1734	M	0.09	D	0.38	NN
BW Co	CIC Label	CIC	2006-2012	IT	686	A	0.17	D	0.45	7.0%
BW + GW Co ("Mature")	RAL-GZ 251	BGK/ECN	2008	DE	1817	M	0.05	D	0.27	NN
BW + GW Co ("Fresh")	RAL-GZ 251	BGK/ECN	2008	DE	832	M	0.10	D	0.40	NN
BW + GW Co	NF U 44-051	CompostPlus	2006-2010	FR	25	M	0.30	D	0.55	3
GW Co	RAL GZ 251	BGK/ECN	2012	DE	1061	M	0.02	D	0.14	NN
GW Co	CIC Label	CIC	2006-2012	IT	98	A	0.07	D	0.24	4
GW Co	PAS 100	AFOR	2008	UK	94	M	0.00	D	0.17	0
BW Di (Liquid)	RAL-GZ 245	BGK/ECN	2012	DE	783	M	0.00	D	0.04	NN
BW Di (Liquid)	RAL-GZ 245	BGK/ECN	2010	DE	575	M	0.00	C	0.23	NN
BW Di (Solid)	RAL-GZ 245	BGK/ECN	2012	DE	62	M	0.01	D	0.20	NN
BW Di (Solid)	RAL-GZ 245	BGK/ECN	2010	DE	44	M	0.03	C	0.87	≥2
Man+Ecr Di (Liquid)	RAL-GZ 246	BGK/ECN	2012	DE	85	M	0.00	D	0.01	NN
Man+Ecr Di (Solid)	RAL-GZ 246	BGK/ECN	2012	DE	33	M	0.00	D	0.01	NN

It should be noted that the impurities content values presented in Table 10 need to be assessed with care for following reasons:

- different methods are in use for the determination (e.g. bleach destruction method or optical sieving method);
- different impurities are being determined in the different analysis frameworks: glass, metals, plastics, plastic films, stones, etc.;
- data on different impurities fractions do not always correspond exactly to sizes >2mm, but in some cases to sizes >5mm. In order to establish Table 10, those data were used that best reflect all the impurities above 2 mm, excluding stones;
- some datasets have a very limited number of samples. Therefore, exceeding numbers have only been reported as a percentage value where the sample size is sufficiently large (>100 samples).

From Table 10, the following can be derived:

- **Bio-waste and greenwaste compost** from materials derived from **source separate selection** generally meet the proposed limit values at 90-percentile level. Levels in France, Spain and Portugal are rather elevated compared to those in Italy, the Netherlands and Belgium. Although the reason for the higher levels in the former Member States is not fully clear, it may be due to a combination of measurement method (e.g. bleach determination in France), higher national limits and a beginning industry of compost production from source separated materials (e.g. Spain with most of the source separated materials' compost production located in Catalonia). The difference between the Dutch and the French data on physical impurities in compost from source separated materials is noteworthy. Although the data cannot be exactly compared due to different measurement methodologies, it may be striking at first glance that only 6 % of the Dutch samples would fail the proposed physical impurities limit, whereas 26% of the French samples would fail the proposed limit. A possible explanation may be that composting/digestion installations are designed and operated in a way to meet existing national legislation and that stricter legislation will lead to lower impurities levels.
- Data on **sewage sludge compost** are scarce and restricted to France but suggest that a large majority of the samples (> 80 %) meets the proposed limit values.
- Both the extensive French data and limited Spanish data indicate that a large majority of **MBT composts** is *not* able to meet the proposed limit values. More than 90% of the samples fail the proposed criteria. Although the measurement method may partially explain this figure (e.g. bleach determination in France), it is believed that a combination of consumer attitude and technology are the main responsible factors. As such, it is noted that large fractions of the physical impurities in French MBT compost consist of glass. This suggests that glass enters the mixed MSW chain rather than being recycled through the available glass and WEEE[33] collection systems, and that the ensuing mechanical separation of the mixed MSW has not been able to remove all of this glass. It also appeared that huge differences existed between the physical impurities levels of different MBT installations. When studying the Ineris data at plant level, there appeared to be 3 MBT plants out of 15 that met the proposed 0.5% limit value in more than 30% of the cases, whereas the other MBT plants were hardly able to meet the proposed limit value. However, it could not be determined whether the better performance in some installations could be attributed to a better quality of the input

([33]) WEEE=waste electric and electronic equipment (relevant to glass from e.g. displays and lighting equipment) materials or to more efficient impurities removal technologies in certain MBT installations, or to a combination of both factors.

- For **digestate** from source separated input materials, physical impurities hardly pose a problem, with most of these materials having very low 90-percentile levels.
- A comparison between the BGK/ECN data for **fresh and mature composts** shows that the final sieving of the compost product may have an influence on the impurity levels. Fresh compost under the BGK system is mostly delivered with a screen size of 0-30 mm whereas mature compost is delivered with a screen size of 0-15 (12) mm.

Conclusion

In conclusion, the JSAC data appear to provide the same picture as derived from external sources, despite other methodologies used. As for the heavy metals parameter, it can be seen that some compost/digestate materials, such as MBT compost, experience severe difficulties in meeting the proposed limit values for physical impurities. Other compost/digestate materials, such as those derived from source separated inputs, tend to meet the proposed limit values more easily. When combining the JSAC data with external data, it appears that for all types of compost and digestates certain samples can be encountered that meet the proposed limit values and other samples can be encountered that exceed the proposed limit values, although the physical impurities levels in compost from source separated materials are in general distinctly lower than in MBT derived materials.

3.5.5 Organic pollutants

3.5.5.1 Introduction

Neither in the 2008 pilot study on possible end-of-waste criteria for compost (IPTS, 2008), nor in the initial stages of this study, proposals had been made for limit concentrations for organic pollutants. Hence, contrary to the case of heavy metals and physical impurities, a clear reference point was lacking for discussion of the analytical results from the JSAC and literature data. At the same time, a concern about possibly elevated concentrations of organic pollutants in certain compost/digestate materials was one of the reasons to launch the JRC Sampling and Analysis Campaign.

Possible limit values may be derived from a number of approaches, including risk assessments and techno-economic evaluations. Nonetheless, it is reasonable to assume that limit values encountered in legislation are based on a multitude of criteria and take into account market conditions as well as possible adverse environmental and human health effects. Therefore, the discussions in this section will be oriented towards limit values encountered in relevant existing legislation.

EU legislation with specific organic pollutant limit values for composts and digestates currently does not exist. In a broader context, Council Regulation (EC) No 1195/2006 of 18 July 2006 amending Annex IV to Regulation (EC) No 850/2004 (POPs Regulation) prescribes general maximum concentration limit values in waste for PCBs (50 mg/kg) and PCDD/F (15µg/kg). If these limits are exceeded, the waste must be treated in such a way as to ensure that the POP content is destroyed or irreversibly transformed.

At Member State level, substantial national and regional legislation can be found that is directly or indirectly destined at regulating organic pollutant limits in compost and digestate. Table 11 gives an overview of legally binding limits and guide values for organic pollutants in compost/digestate and similar materials in different European countries.

Table 11 only lists specific organic pollutant legislation for compost and/or digestate or comparable materials intended for use on (agricultural) land. As mentioned above, it is important to note that some Member States have specific legislation for compost/digestate, which does not require the measurement of organic pollutants, provided that the compost/digestate fulfills certain conditions. This is the case in e.g. Austria and Germany where no organic pollutant limits exist for compost and digestate from source separated materials listed on a positive list.

Table 11: Overview of organic pollutant limit values for compost/digestate and similar materials in EU + CH (source: data provided by stakeholders, Amlinger et al., 2004 and Brändli et al. 2007a,b)

	AT (a)	BE (Fl) (b)	BE (Wal; digestate) (c)	DE (d)	DK (e)	FR (compost) (f)	LU (g)	SI (h)	CH (i)
PAH (mg/kg dm)	**6** (sum for 6 congeners **)	Individual limits for 10 congeners	**5** (PAH_{16})		**3** (sum for 11 congeners***)	Individual limits for 3 congeners	**10*** (PAH_{16})	**3**	**4*** (PAH_{16})
PCB (mg/kg dm)	**0.2** (PCB_6)	**0.8** (PCB_7)	**0.15** (PCB_7)	****	**0.08*** (PCB_7)	**0.8** (PCB_7; only for sewage sludge compost)	**0.1*** (PCB_6)	**0.4** (1st class) **1** (2nd class) (PCB_6)	
PCDD/F (ng I-TEQ /kg dm)	**20**		**100**	****			**20***		**20***
PFC (mg/kg dm)	**0.1**			**0.1**					
AOX (mg/kg dm)	**500**		**250**						
LAS (mg/kg dm)			**1500***		**1300**				
NPE (mg/kg dm)			**25***		**10**				
DEHP (mg/kg dm)			**50***		**50**				

a) Düngemittelverordnung; b) VLAREA Regulation c) AGW du 14/06/2001 favorisant la valorisation de certains déchets d) Düngemittelverordnung e) Slambekendtgørelsen f) NF U44-051 and NF U44-095 g) Guidance value h) Official Gazette of the Republic of Slovenia, no. 62/08 i) Guidance value from ChemRRV 814.81

*= guide value; **=sum of benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, fluoranthene and indeno[1,2,3-cd]pyrene; ***=sum of acenaphthene, phenanthrene, fluorene, fluoranthene, pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[ghi]perylene and indeno[1,2,3-cd]pyrene; **** Maximum sum of PCDD/F and dl-PCB: 30 ng WHO-TEQ/kg dm, in some cases additional restrictions for PCDD/F only of maximum 5 ng WHO-TEQ/kg dm; PAH_{16}= sum of US EPA 16 priority listed polycyclic aromatic hydrocarbons; PCB_6= sum of PCBs 28, 52, 101, 138, 153 and 180; PCB_7= sum of PCBs 28, 52, 101, 118, 138, 153 and 180; PCDD/F= sum of 17 polychlorinated dibenzo-p-dioxins/furans expressed in International Toxicity Equivalents; PFC= perfluorinated compounds (sum of PFOS and PFOA); AOX= adsorbable organic halogens; LAS linear alkylbenzene sulphonates, NPE= nonylphenol and –ethoxylates; DEHP= di(2-ethylhexyl)phtalates

Other Member States, such as the Netherlands have certain exemption rules from measurement of organic pollutants for composts and digestates from source separated materials listed on a positive list.

In several Member States, other legislation may also affect the allowable concentrations of organic pollutants in compost/digestate, such as sewage sludge legislation (e.g. for sewage sludge composts). As such, the German Sewage Sludge Regulation prescribes limits for sewage sludge products, including sewage sludge based composts: 0.2 mg/kg dm for every of the PCB_6 congeners and 100 ng I-TEQ/kg dm for the 17 PCDD/F. Austria also has a different set of limits for MBT compost that cannot be used in traditional agriculture but only for landfill covering and biofilter applications: 1 mg/kg dm for PCB_6, 50 ng I-TEQ/ kg dm for PCDD/F and 6 mg/ kg dm for PAH_6.

It should be noted that other limits exist for certain organic molecules in compost/digestate, which are often specific for a certain Member State or region, and therefore these have been excluded from the comparative table above. For example, the region of Flanders has compost/digestate limits for 40 organic compounds, including 10 PAHs.

The French compost norm NF U44-051 sets limit values for 3 PAH compounds: fluoranthene (4 mg/kg dm), benzo[b]fluoranthene (2.5 mg/kg dm) and benzo[a]pyrene (1.5 mg/kg dm). The French sludge compost norm NF U44-095 also provides an additional limit of 0.8 mg/kg dm for PCBs.

The Netherlands have a slightly different system, in which the maximum permissible organic pollutant concentration is not expressed on dry matter basis, but on the so-called relevant beneficial component (P, N, K, neutralizing value or organic matter). Therefore, a comparison with the values in the above table cannot be made.

Finally, several Member States are in the process of setting compost/digestate organic pollutant limit values or revising them. The Czech Republic has certain limit values for compost and digestate for other uses than agriculture (e.g. children playgrounds), but not yet for agricultural use. Italy has a proposal for limit values for compost/digestate materials, but it has not been approved yet.

3.5.5.2 Polycyclic aromatic hydrocarbons (PAH)

Polycyclic aromatic hydrocarbons (PAH) originate from combustion processes and are of concern because of their carcinogenic and mutagenic character.

PAH compounds are known to be biodegradable, but biodegradation rates may differ widely, depending on the compound and the environmental conditions, with half-lives reported from days to several years (Shuttleworth and Cerniglia, 1995). Furthermore, biodegradation or transformation does not always equal full mineralisation. Meyer and Steinhart (2001) reported that metabolites from PAH breakdown may be very persistent and Lundstedt et al. (2007) indicated that PAHs may be transformed into other toxic compounds such as oxy-PAHs.

Most limit or guide values in legislation refer to a subset or the full set of the 16 principal PAH compounds on the US EPA's priority pollutants list: naphthalene, acenaphtylene, acenaphtene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene.

In this JSAC study, 12 of the 16 US EPA PAH compounds were measured on the received compost and digestate samples (phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene). The PAH compounds that were not measured are naphthalene, acenaphtylene, acenaphtene and fluorene. The latter compounds are very volatile and therefore might have been lost through lyophilisation of the samples. Based on the raw data available from Brändli et al. (2007a), PAH_{16} and PAH_{12} are very well correlated (R^2=0.983 for 72 samples) and the ratio between PAH_{16} and PAH_{12} is 1.073. Hence it can be assumed that the actual PAH_{16} values will be about 7.3 % higher than the measured PAH_{12} values from the present study. This correction factor has been used to calculate the PAH_{16} values displayed in Figure 9.

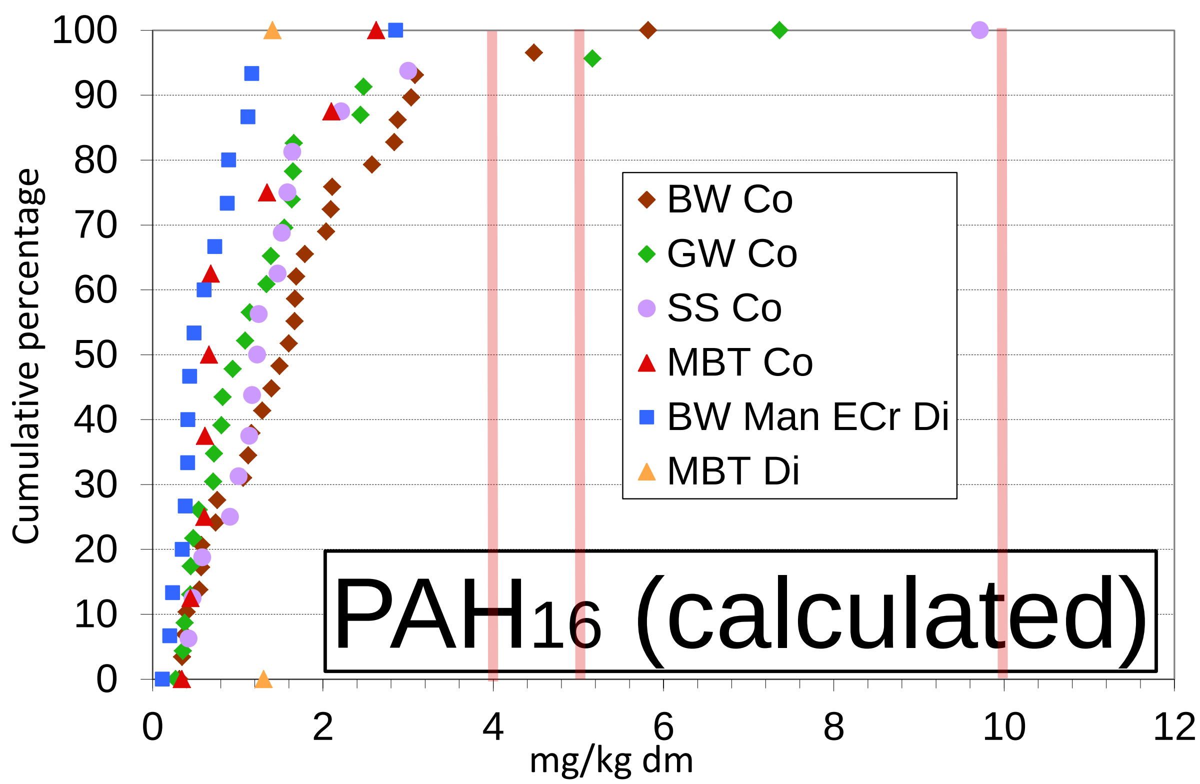

Figure 9: Calculated PAH_{16} in compost and digestate samples collected by JRC and sent by plants. Data are based on measured PAH_{12} values and extrapolated using the 1.073 PAH_{16}/PAH_{12} ratio derived from Brändli et al. (2007a). The horizontal axis represents the concentration (mg/kg d.m.) and the vertical axis the cumulative percentage of samples. The semi-transparent red bars represent existing limit values in different European countries for similar materials (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

Some trends can well be discerned. It is seen that the digestate samples contain the lowest amounts of PAH_{16}, followed by MBT compost, whereas bio-waste compost, green waste compost and sewage sludge compost display higher overall PAH_{16} concentrations. The latter three categories also contain a number of samples with concentrations above existing national limit or guidance values for similar materials.

For the sake of completeness, it should be mentioned that 5 samples from the category "Other" were measured and that one of them exceeded 20 mg PAH/kg d.m., indicating the contamination potential of any ill-defined material.

Benchmark against existing data

The data above are confirmed by a number of studies:

- Brändli et al. (2007a) found that more than 25% of 69 Swiss compost and digestate samples derived from source separate collection had PAH concentrations larger than the Swiss guide value for compost of 4 mg/kg with median levels around 3 mg/kg and 90-percentile levels around 7 mg/kg. According to their study, PAH compounds are believed to be mainly of pyrogenic nature, originating from traffic (asphalt and vehicle exhaust) as well as diffuse sources. In a follow-up study investigating the fate of PAHs in full-scale plants (Brändli et al., 2007c), they demonstrated that levels of low-molecular weight PAHs declined during composting, whereas high-molecular weight compounds were stable and that PAH concentrations did not seem to vary during digestion.
- Schmutz and Bono (2012), reported on a recent survey of Swiss compost from source separate collection in which 25 % of the 26 samples showed PAH levels above the Swiss guidance value of 4 mg/kg dm. It appeared that the presence of high PAH levels was linked to green waste collected from street side plants and street maintenance.
- When combining literature data from Brändli et al. (2007a), Schmutz and Bono (2012), WRAP (2011), BLfU (2007), Kuch et al. (2007) and Prasad and Foster (2009), a set of 172 samples for compost and digestate from source separated input materials is obtained. These data show that more than 38% of the samples exhibited a concentration of >3 mg PAH_{16}/kg d.m. and 10% of the samples even exhibited a concentration of >6 mg PAH_{16}/kg d.m. The highest value encountered was 20.8 mg/kg d.m.
- The French Ineris (2012) study investigated 125 source separated biobin compost samples and 133 MBT compost samples for 3 PAHs: fluoranthene, benzo[b]fluoranthene and benzo[a]pyrene. For all three compounds, lower average concentrations were found in the MBT samples (fluoranthene: 0.29 mg/kg, benzo[b]fluoranthene: 0.12 mg/kg and benzo[a]pyrene: 0.09 mg/kg) than in the biobin compost samples (fluoranthene: 0.46 mg/kg, benzo[b]fluoranthene: 0.22 mg/kg and benzo[a]pyrene: 0.17 mg/kg). It was suggested that a possible explanation could be the presence of green waste and ashes in the biobin.
- VLACO provided PAH_{10} data for Belgian (Flemish) composts and digestates produced from 2008 onwards. Composts were made of either separately collected green or VFG waste, whereas digestates were made of a mixture of bio-waste, manure and energy crops. Based on the correlation between these PAH_{10} and the US EPA PAH_{16} from Brändli et al. (2007a), PAH_{16} values can be calculated by multiplying the PAH_{10} value by a factor of 1.284 (R^2=0.98 between PAH_{10} and PAH_{16} for 72 samples). Median calculated values for PAH_{16} were 2.53 mg/kg d.m. for green waste compost (62 samples), 3.29 mg/kg d.m. for VFG waste compost (22 samples), 0.26 mg/kg d.m. for whole digestate (150 samples), 0.18 mg/kg d.m. for the solid fraction of digestate (69

samples) and 0.18 mg/kg d.m. for dried digestate (68 samples). 90-percentile calculated values for PAH_{16} were 5.08 mg/kg d.m. for green waste compost (62 samples), 4.75 mg/kg d.m. for VFG waste compost (22 samples), 1.30 mg/kg d.m. for whole digestate (150 samples), 1.49 mg/kg d.m. for the solid fraction of digestate (69 samples) and 1.55 mg/kg d.m. for dried digestate (68 samples). 95-percentile calculated values for PAH_{16} even amounted to 6.86 mg/kg d.m. for green waste compost These data show that overall PAH concentrations are moderate, but that especially for compost PAH loadings can be elevated, with PAH_{16} concentrations sometimes exceeding existing national limit or guidance values for similar materials.

- Luxembourg provided PAH data for composts from 6 sites over the time-frame 2005-2011 (total of 38 measurement results). Some of the data constituted PAH_{16} measurements, whereas others constituted PAH_6 (fluoranthene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[g,h,i]perylene and indeno[1,2,3,c,d]pyrene). Based on the correlation between the PAH_6 and the US EPA PAH_{16} from Brändli et al. (2007a), PAH_{16} values can be estimated by multiplying the PAH_6 value by a factor of 2.1 (R^2=0.83 between PAH_6 and PAH_{16} for 72 samples). The hence obtained list of PAH_{16} concentrations showed a median value of 6.13 mg/kg and a 90-percentile value of 12.0 mg/kg, which appears high compared to the JSAC and literature data. A direct explanation was not available for these observations. However, it was noted that for the last recorded year (2011), PAH_{16} concentrations were generally lower.
- EFAR provided 2011 data for 3 PAH (fluoranthene, benzo[b]fluoranthene and benzo[a]pyrene) concentrations in French sewage sludge compost (483 samples). Based on the correlation between these PAH_3 and the US EPA PAH_{16} from Brändli et al. (2007a), PAH_{16} values can be estimated by multiplying the PAH_3 value by a factor of 3.01 (R^2=0.90 between PAH_3 and PAH_{16} for 72 samples). The hence estimated PAH_{16} concentrations showed a median value of 1.60 mg/kg and a 90-percentile value of 3.64 mg/kg, which is in very much line with the findings of the JSAC.
- The previously conducted JRC FATE-SEES screening study on sewage sludge (IES, 2012) indicated relatively high median and 90-percentile sludge concentration values for PAH_{16} of 4.4 and 12.9 mg/kg d.m., respectively (extrapolated from PAH_{12} data on 32 samples). Hence, it is likely to assume that sewage sludge provides a considerable contribution to the presence of PAH in sludge derived compost/digestate materials.

Conclusion

The data from the JSAC and literature suggest that all types of composts and digestates contain PAH compounds, generally between trace amount levels and a few mg/kg d.m. Exceedings of existing national PAH limit or guidance values for similar materials appear to occur and generally represent a few percent to more than a quarter of the sample population, depending on the reference limit value and the type of material.

3.5.5.3 Dioxins and dioxin-like compounds

Polychlorinated dibenzodioxins (PCDD), polychlorinated dibenzofurans (PCDF) and polychlorinated biphenyls (PCB) have been banned or limited by the Stockholm Convention on Persistent Organic Pollutants. The toxicity of PCB is related to that of dioxins and comprises carcinogenic effects, endocrine disruptive effects and neurotoxicity.

Data on long-term accumulation of dioxin(like) compounds from compost/digestate or similar materials are scarce. Umlauf et al. (2011) reported on a long-term experiment of soil treated with mineral fertilizer, farmyard manure, sewage sludge and compost on a test plot in Meckenheim (Germany). The experiment started in 1962 and samples were taken in 2001. The dose of sewage sludge and compost applied was very elevated, namely 4 times higher than laid down in the German Sewage sludge ordinance and Bio-waste ordinance. Moreover, the compost originally consisted of household waste and sewage sludge and only since 1991 its content had been restricted to source separated bio-waste. The authors also mentioned that average PCB and PCDD/F concentrations in sewage sludge and other bio-wastes had decreased substantially in the last decades. The measurement results showed that PCDD/F levels were in all cases at least 4 times below German guidelines for arable land. Yet it was noticed that the plots treated with compost and sludge had a 2- to 3-fold higher PCDD/F concentration than the plots treated with mineral fertilizer or manure. The same observations were made for dioxin-like PCBs. Initial follow-up work indicated stable PCDD/F levels and a slight decrease of dioxin-like PCBs over time. These long-term data demonstrate the accumulation potential of PCDD/F and PCBs in the soil. Moreover, they show that a decade after switching to compost exclusively derived from source separated materials, the PCDD/F and PCB levels were still the most elevated in the compost treated plot, suggesting the high persistence of these pollutants in arable soils.

General biological screening

In a first instance, dioxin-like effects were measured in the JSAC by means of a biological assay with the biological response expressed as TCDD equivalent (Figure 10). It is important to note that the measurements were carried out using the so-called CALUX test (Chemically Activated LUciferase gene eXpression), an in vitro test that measures dioxin-like effects (Vondrácek et al., 2001). The bioassay test gives a dioxin toxicity response that is induced through the binding of dioxins and dioxin-like compounds to the aryl hydrocarbon receptor. However, the bioassay test is not specific and therefore will also yield dioxin-like toxicity response for non-dioxin compounds such as PCBs and PAHs (Takigami et al., 2010).
Therefore, the results from these tests cannot be used to judge on the intrinsic toxicity of samples, related to dioxins or other compounds, but can only provide a comparison of dioxin toxicity between different samples. Nevertheless, as a diagnostic tool it helps in discerning dioxin-like toxicity effects exhibited by different samples. Hence, it serves as a screening tool to target those samples that are worth further investigation.

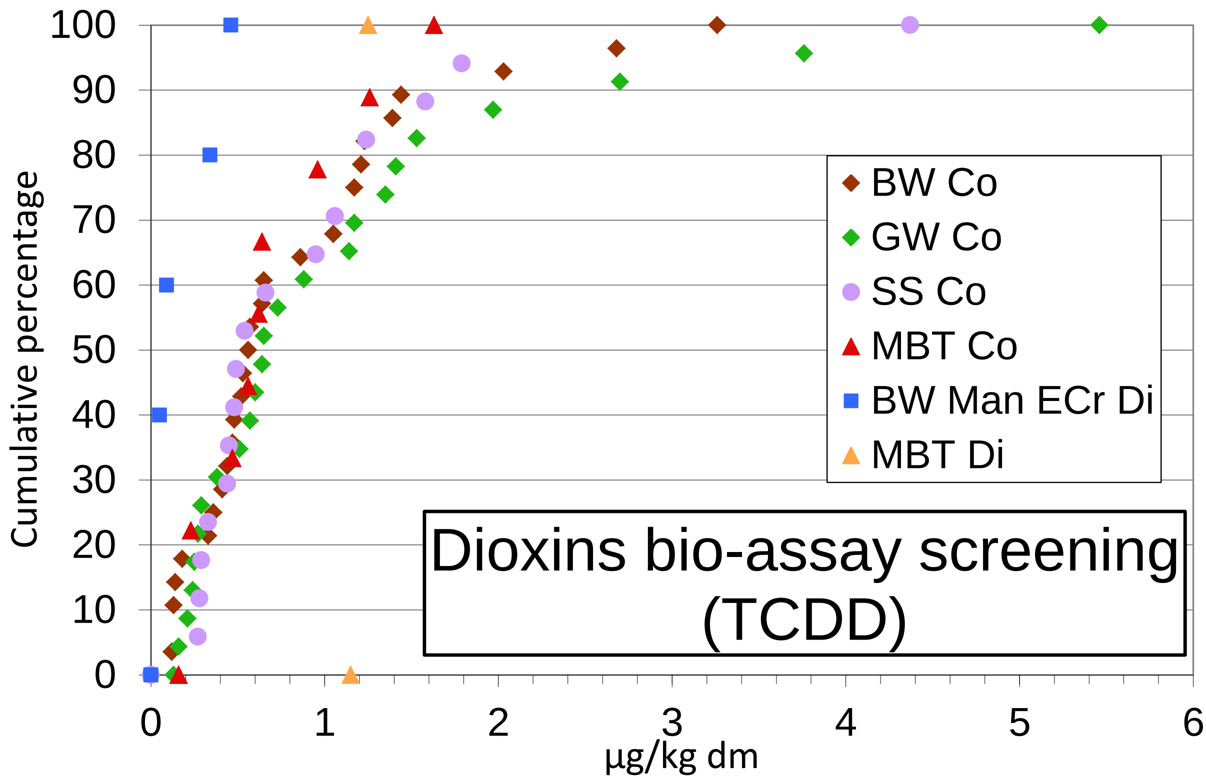

Figure 10: Dioxin effects as measured by CALUX bio-assay (expressed in TCDD toxicity equivalents) in compost and digestate samples collected by JRC and sent by plants. The horizontal axis represents the concentration (µg/kg d.m.) and the vertical axis the cumulative percentage of samples (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

It can be noticed that a similar trend is noticed for the bio-assay dioxin response as for the PAH_{16} measurements displayed in Figure 9. It is seen that the digestate samples give the lowest overall TCDD response, followed by MBT compost. Bio-waste compost, green waste compost and sewage sludge compost samples display the highest overall PAH_{16} concentration values. Nevertheless, it must be added that no direct correlation could be established between the PAH_{16} concentration of a given sample and its bio-assay dioxin response, indicating that other compounds present may be responsible for the response as well.

PCB chemical analysis

Following the results obtained from these measurements, samples in each category exhibiting high TEQ values were subject to further chemical analysis on PCBs and PCDD/Fs. In total, 18 compost and digestate samples were selected. The results of the subsequent PCB and PCDD/F measurements are given in Figure 11 and Figure 12.

The **PCB analysis** results (Figure 11) indicate that none of the compost or digestate samples exceed any of the existing national limit or guide values. The compost and digestate samples exhibit generally low PCB levels and no clear distinctions can be made between the categories.

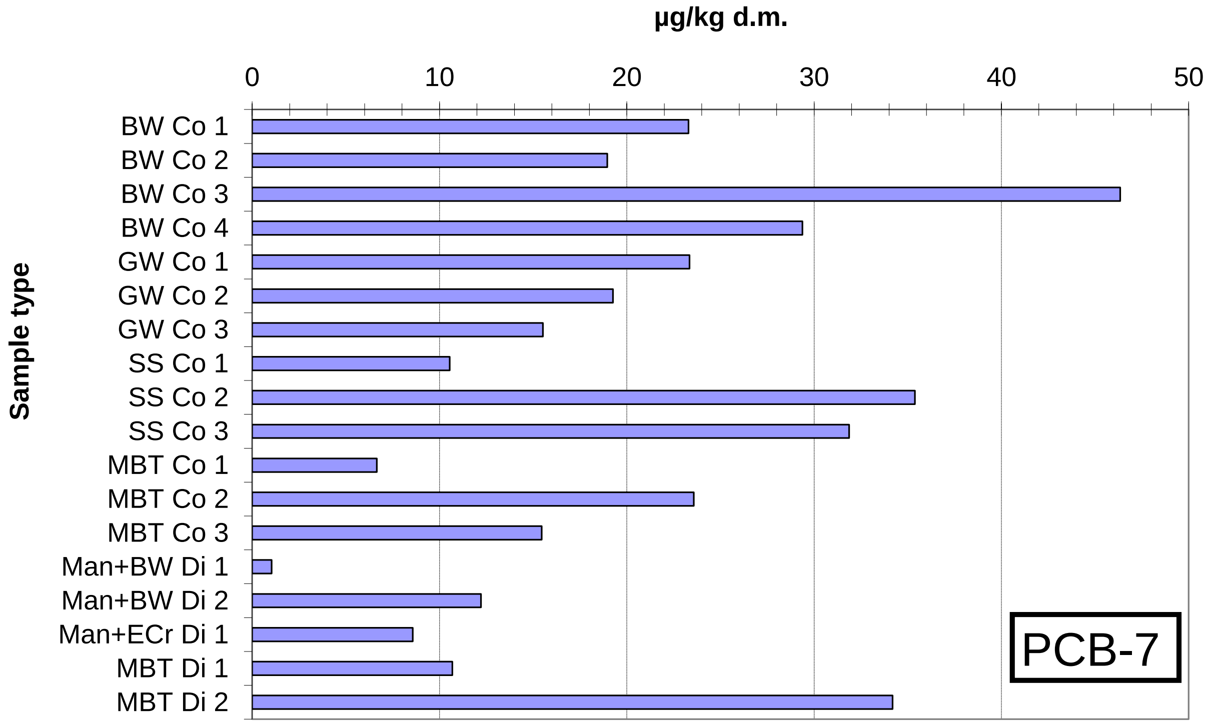

Figure 11: Sum of 7 PCB (PCBs 28, 52, 101, 118, 138, 153 and 180) compounds in compost and digestate samples collected by JRC and sent by plants. The red bars represent existing limit values in different European countries (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

PCDD/F chemical analysis

The **PCDD/F analysis** results (Figure 12) are given as both lower and upper bound values[34], with actual values situated between these two limits. The results generally indicate low to medium toxicity equivalents for all samples, with no upper bound value exceeding the strictest existing national limit of 20 ng I-TEQ/ kg dm. Again, no clear distinctions can be made between categories, especially when taking into account both the lower and upper bound levels.

[34] In the case of measurement results below the detection limit, the lower bound value is calculated assuming a zero concentration value, whereas the upper bound value is calculated assuming the detection limit as concentration value. The detection limit may vary per sample as the instrument settings are adjusted to allow measurement of all compounds.

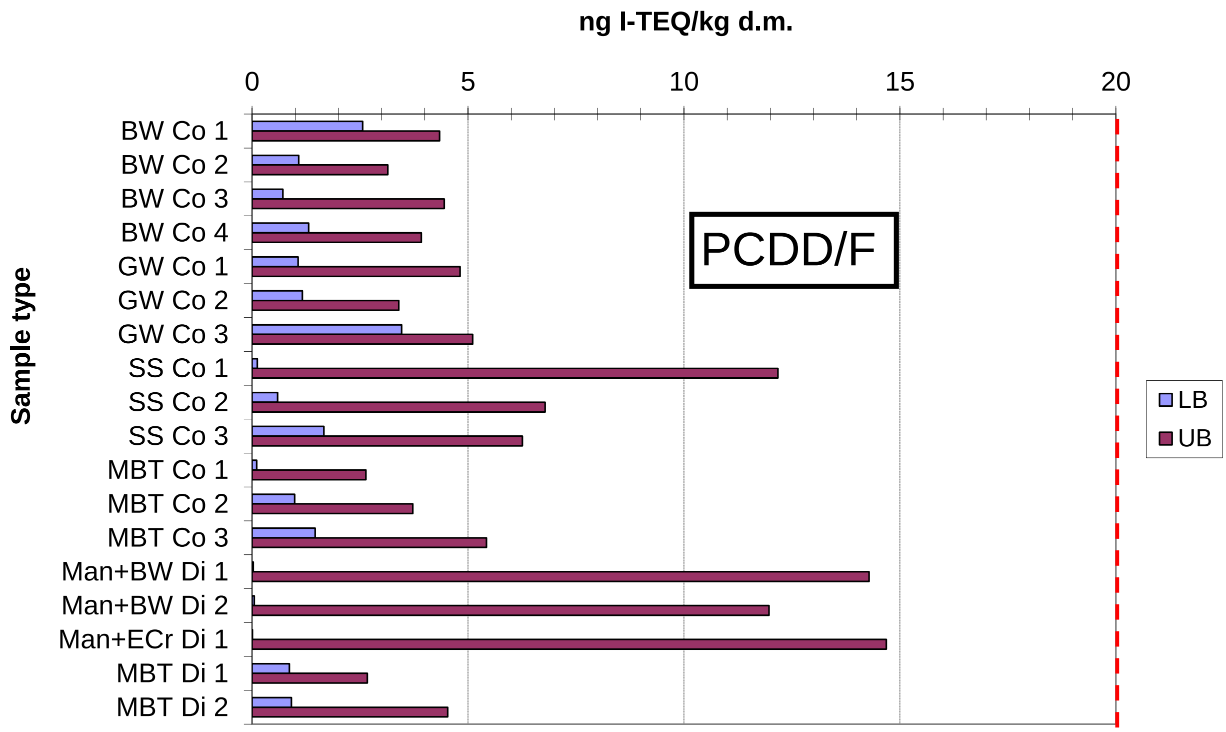

Figure 12: International toxicity equivalents (I-TEQ) of 17 PCDD/F compounds in compost and digestate samples collected by JRC and sent by plants. Data represent lower bound (LB) and upper bound (UB) values. The red bar represents an existing limit value in different European countries (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

For the sake of completeness, it should be mentioned that one of two analyzed samples from the category "Other" displayed a PCB value of more than 100 µg/kg d.m., more than double the concentration of any other compost/digestate sample. The PCDD/F concentrations of the two measured "Other" samples did not differ from those of the compost/digestate samples.

Benchmark against existing data

The data presented above on PCB and PCDD/F seem to be confirmed by a number of scientific studies:

- The studies by Brändli et al. (2007a and b) for composts and digestates from source separation displayed data in line with the JSAC findings. Based on the individual data provided on 68 samples, it was seen that PCB-7 values ranged from 8.8 to 101.4 µg/kg dry matter. The median PCB-7 value was 27.3 µg/kg dry matter and the 90-percentile value 46.4 µg/kg d.m. For PCDD/F, the range was 0.5 to 21.0 ng I-TEQ/kg dry matter, with a median value of 3.2 ng I-TEQ/kg dry matter and a 90-percentile value of 9.9 ng I-TEQ/kg dry matter in 18 samples. No correlation between PCB and PCDD/F could be found (R^2 =0.0013).
- An extensive literature review by Brändli et al. (2005) on compost from source separated materials, with data from 1990 to 2003, showed 90-percentile levels of PCB-6 for green waste compost around 70 µg/kg dry matter (based on 55 samples) and 90

percentile levels of PCB-6 for biobin waste compost just above 100 µg/kg dry matter (based on 124 samples). The data also showed 90-percentile levels of PCDD/F for green waste compost slightly above 20 ng I-TEQ/kg dry matter (based on 61 samples) and 90-percentile levels of PCDD/F for biobin waste compost around 18 ng I-TEQ/kg dry matter (based on 124 samples).

- When combining PCB literature data from Brändli et al. (2007a), Schmutz and Bono (2012), WRAP (2011), BLfU (2007), Kuch et al. (2007) and Prasad and Foster (2009), a set of 168 samples for compost and digestate from source separated input materials is obtained. These data show that 3 samples exhibited a concentration of >100 µg PCB/kg d.m. but none of the samples exhibited a concentration above 200 µg PCB/kg d.m.
- When combining PCDD/F literature data from Brändli et al. (2007b), WRAP (2011) and BLfU (2007), a set of 57 samples for compost and digestate from source separated input materials is obtained. Analysis of the data revealed that 3 samples exhibited a concentration of >15 ng I-TEQ/kg dry matter and 2 samples exhibited a concentration of >30 ng I-TEQ/kg dry matter.
- VLACO provided PCB-7 data for Belgian (Flemish) composts and digestates produced from 2008 onwards. Composts were made of either green waste or VFG waste, whereas digestates were made of a mixture of bio-waste, manure and energy crops. Median values for PCB were 4 µg/kg d.m. for green waste compost (62 samples), 14 µg/kg d.m. for VFG waste compost (22 samples), 0 µg/kg d.m. for whole digestate (150 samples), 0 µg/kg d.m. for the solid fraction of digestate (69 samples) and 0 µg/kg d.m. for dried digestate (68 samples). 90-percentile values for PCB were 25 µg/kg d.m. for green waste compost (62 samples), 40 µg/kg d.m. for VFG waste compost (22 samples), 16 µg/kg d.m. for whole digestate (150 samples), 1 µg/kg d.m. for the solid fraction of digestate (69 samples) and 10 µg/kg d.m. for dried digestate (68 samples).
- EFAR provided 2011 data for PCB-7 concentrations in French sewage sludge compost (453 samples). In many cases the quantification limit was rather high, namely 105 µg/kg, and more than two thirds of all samples displayed concentrations below this limit. The 90-percentile concentration for PCB-7 was 133 µg/kg d.m. For 4.6% of the samples, the PCB-7 concentration exceeded 200 µg/kg d.m.
- Ineris provided 2007-2012 data on PCBs in French source separated bio-waste composts (27 samples), showing that all PCB-7 data were below 105 µg/kg d.m (or below quantification limits). In addition, 2009-2012 data were provided for MBT composts (55 samples), either originating from direct composting or anaerobic digestion followed by composting. The maximum measured concentration of PCB-7 was always below 105 µg/kg d.m. (or below quantification limits), except for two samples (164 and 632 µg/kg d.m.).
- WRAP (2006) studied PCB levels in 8 samples of compost made from low grade waste wood and found an average concentration of 4.4 mg PCB/kg with levels up to 10 mg/kg (10 000 µg/kg). Although it was unclear which PCB compounds had been specifically analyzed in this study, these very high PCB levels indicate that ill-defined or contaminated input materials may have a detrimental effect on compost quality.

<u>*Conclusion*</u>

The data from the JSAC and literature suggest that all types of composts and digestates contain PCB and PCDD/F compounds, at least at trace level. In general, concentration ranges appear well below existing national limit or guidance values for similar materials. Exceedings of existing national limit or guidance values occasionally occur and generally represent zero to a few percent of the sample population, depending on the applicable reference limit value and the type of material.

3.5.5.4 Perfluorinated compounds (fluorosurfactants, PFC)

Perfluorinated compounds or fluorosurfactants are used in many industrial processes and as stain repellents. They include the fluorosurfactants perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and perfluorononanoic acid (PFNA). Their toxicity mechanisms include carcinogenic and endocrine dirsruptive effects. In 2009, PFOS and related derivatives were listed under the Stockholm Convention due to their demonstrated toxicity.

The Danish EPA carried out a recent study on the potential risk related to sewage sludge application on Danish soils (Jensen, 2012). It was concluded that for brominated flame retardants, musk substances, pharmaceuticals and polychlorinated biphenyls it was very unlikely that these would pose a significant risk to soil dwelling organisms and the soil quality in general. However, it could not be excluded that the PFOS levels observed in Danish sludge may pose a long term risk to soil ecosystems.
Austria and Germany have established a limit value of 100 µg PFT /kg d.m. (sum of PFOA and PFOS) for fertilisers.

Analytical results from the JSAC on the sum of PFOS and PFOA are depicted in Figure 13.

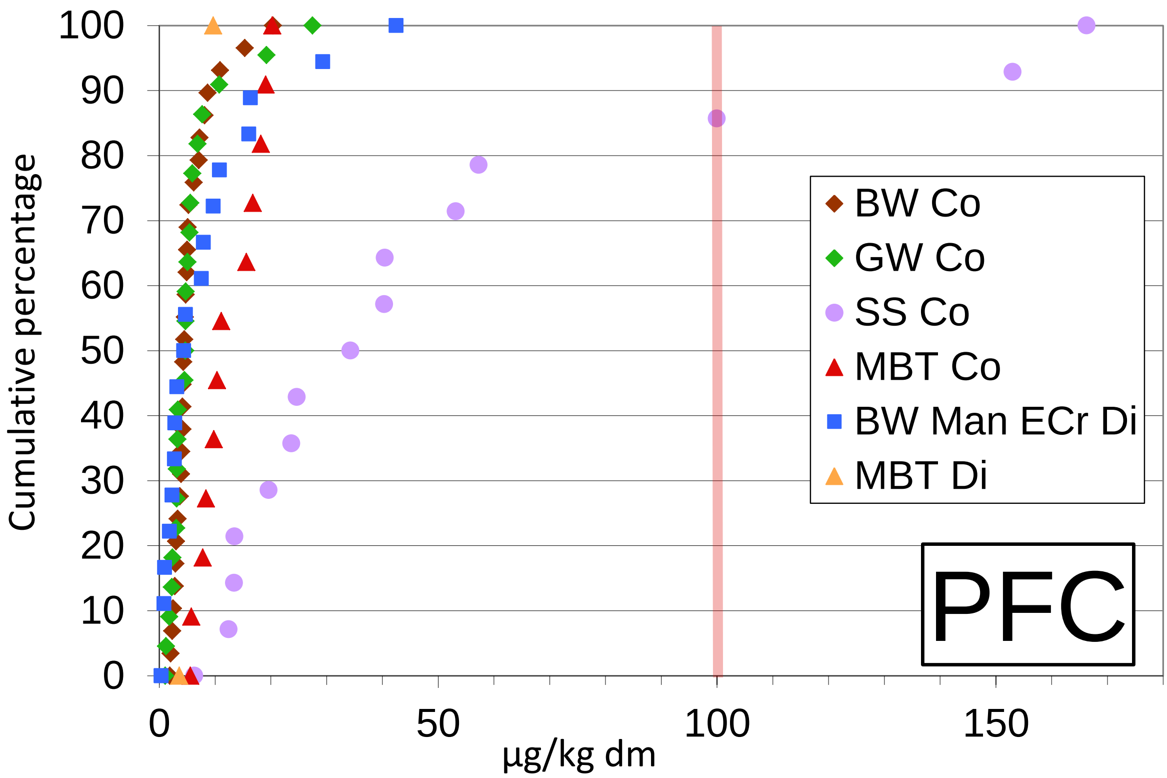

Figure 13: Pefluorinated compounds (sum of PFOA and PFOS) in compost and digestate samples collected by JRC and sent by plants. The horizontal axis represents the concentration (µg/kg d.m.) and the vertical axis the cumulative percentage of samples. The semi-transparent red bars represent existing limit values in different European countries for similar materials (Co=compost; Di=digestate; BW=source separated bio-waste & green waste; GW= source separated green waste; SS=sewage sludge; MBT=mechanical biological treatment; Man=manure; ECr=energy crops)

The data indicate that bio-waste and green waste composts display the lowest PFC concentrations, followed by digestate and MBT compost. Sewage sludge composts clearly display overall higher PFC concentrations, with several samples exceeding the 100 µg/kg d.m. limit applicable in Austria and Germany for fertilisers.

For the sake of completeness, it should be mentioned that the PFC concentrations of seven measured samples from the category "Other" did not clearly differ from those measured on the compost/digestate samples.

Benchmark against existing data

Up to date literature data on perfluorinated compounds in compost and digestate appears to be very scarce.

- Brändli et al (2007b) found combined concentrations of PFOA and PFOS substances from 1.8 to 24.6 µg/kg dry matter in 18 digestate and compost samples from source separate collection.
- When combining PFC literature data from Brändli et al. (2007b), WRAP (2011) and BLfU (2007), a set of 66 samples for compost and digestate from source separated input materials is obtained. These data show that none of the samples exceeded 50 µg PFC/kg dry matter.

Conclusion

The data from the JSAC and literature suggest that all types of composts and digestates contain PFC compounds. The scarcely available data show that most composts and digestates only contain trace levels well below any existing national limit or guidance value. However, the JSAC measurements suggest that sewage sludge compost materials may have generally higher overall PFC concentrations, which may exceed the currently existing national limit or guidance values for similar materials.

3.5.5.5 Others

In the sampling campaign, other compounds were analysed. However, for most of these either low measurement values were registered or no benchmarking legislation or guidance values exist for compost/digestate or similar products (e.g. biofertilisers). An overview and concise discussion is given below:

- **Nonylphenol**: a screening was done on 28 samples from the JSAC throughout all categories on this surfactant precursor. The highest concentration of nonylphenol encountered in one sample (a green waste compost sample) was 10.4 mg/kg, and the second highest concentration was 3.9 mg/kg. The largest value is well below the Belgian guidance limit value for compost/digestate of 25 mg/kg and just over the Danish limit value of 10 mg/kg. An EU risk assessment study (IHCP, 2002) reports an EC10 (reproduction) value of 3.44 mg/kg in soil for earthworms, but also mentions that the half-life for biodegradation is 20-30 days and for full mineralisation 100-300 days. Given the low concentrations encountered and the relatively rapid biodegradation, it may be assumed that this compound is likely of very low concern for compost/digestate quality.

- **PBDE** (polybrominated diphenyl ethers): This group of flame retardants is known for its persistent nature. The consortium ESWI performed a study to provide to the European Commission necessary scientific information in order to amend the POP Regulation in view of setting limit values for newly listed substances (ESWI, 2011). The report also proposes critical levels in waste prone to direct application to soil. One of these proposals is a limit of 50 mg/kg (50 000 µg/kg) for PBDE congener groups and 500 µg/kg for PentaBDE. In the current JRC Sampling and Analysis campaign, a total of 34 samples over all categories were selected and used to produce a pool sample for every category. This yielded 9 pool samples made up of 1 to 5 individual subsamples. In none of the pool samples, values of more than 1 mg/kg d.m. of PBDE and 40 µg/kg PentaBDE were encountered. Even when taking into account the extreme possibility that the PBDE signal would have been derived from one subsample in each pool sample, this indicates that the maximum concentration would be 5 mg/kg for the total PBDE and 200 µg/kg for PentaBDE in one subsample, which is still far below the proposed limit values in the ESWI study. Therefore, it can be stated that these compounds are likely to be of very low concern for compost/digestate quality.

- **Polycyclic musks**: a screening on these fragrance compounds was done on 100 samples from the JRC Sampling and Analysis campaign throughout all categories. The highest concentration encountered in any sample was 6.8 mg/kg for galaxolide (HHCB) and 0.95 mg/kg for tonalide (AHTN). No legal limits were found for those compounds in compost/digestate or similar materials at Member State level. There has been a proposal in Germany in 2006 to establish a limit of 10 or 15 mg/kg for these compounds in sewage sludge, but this has not been adopted in the end (Bundesministerium, 2006). In any case, the current study shows that the encountered concentrations are well below these suggested limit values. Furthermore, following an earlier impact assessment study, it was concluded by the European Chemical Bureau that neither HHCB nor AHTN are considered PBT[35] substances (IHCP, 2008a,b) and rapidly degrade in the environment. Therefore, it can be stated that these compounds are likely to be of very low concern for compost/digestate quality.

- **Pesticides**: a screening was done on 54 samples from the JRC Sampling and Analysis campaign throughout all categories for several pesticides. They include herbicides such as 2,4-D, one of the most widely used compounds in crop protection (Eurostat, 2007), as well as Dichlorprop, Mecoprop, MCPA, 2,4,5-T and Bentazone. These herbicide compounds are complemented by the widely applied insecticide Imidacloprid. The sum of the concentration values for these 7 pesticides was in all cases lower than 50.1 µg/kg. No specific legislation exists in Member States for these compounds in composts or digestates, but for illustrative purposes it can be mentioned that Austria has a limit value of 500 µg/kg for the sum of 10 organochlorine pesticides. Although the pesticides in this study only represent a small fraction of all pesticides available on the market, the measurement data suggest that pesticides are likely to be of very low concern for compost/digestate quality.

- **Chlorophenols**: a screening was done on 29 samples from the JRC Sampling and Analysis campaign throughout all categories for 2,4,6-trichlorophenol, pentachlorophenol, 2-chlorophenol, 2,4-dichlorophenol, 2,4,5-trichlorophenol and

[35] PBT= Persistency/Bioaccumulation/Toxicity

2,3,4,6-tetrachlorophenol. The highest concentration encountered was 0.08 mg/kg, much lower than the individual limit values proposed for the new VLAREA legislation for soil improvers and fertilisers, based on a recent study by VITO in Belgium[36]. The results are also in line with the report by Amlinger et al. (2004) that stated that chlorophenols are highly biodegradable.

- For **LAS, AOX and DEHP**, no measurements were performed. However, few Member States currently have legislation on these compounds and it was indicated in the study by Amlinger et al. (2004) that most of these compounds are highly degradable.

- For **pharmaceutical** compounds, the absence of existing guidance values or legal limits, did not allow any firm conclusions. However, a risk assessment study provided by the Danish EPA on sewage sludge did not indicate an unacceptable risk of pharmaceuticals present in sewage sludge on soil dwelling species (Jensen, 2012).

3.6 Conclusions and recommendations

The results from the JRC Sampling and Analysis Campaign presented in this chapter provide many new insights. The JSAC data, complemented with state-of-the-art scientific data from other sources, constitute a very valuable tool in supporting the establishment of end-of-waste criteria for compost and digestate.

Overall, the results from JSAC, together with recent scientific literature data and databases provided by stakeholder experts indicate that:

- Any ill-defined product ("Other"), such as stabilized mixed waste destined for landfill, may yield very unpredictable and high pollutant concentrations.
- No single technology provides an absolute barrier against the presence of inorganic or organic pollutants, making regular testing of certain pollutants recommended for all types of materials.
- The use of source separated bio-waste and green waste materials tends to lead to better results for heavy metal concentrations than when mixed municipal waste or sewage sludge is used as input material.
- MBT composts tend to have very high overall physical impurities levels and the existing data show that a large majority of the MBT composts would fail the proposed end-of-waste physical impurities criteria.
- On average, all materials (except "Other") show comparable concentration levels for PAH, PCB, PCDD/F and PFC, with the sole exception of sewage sludge compost that tends to have higher PFC levels. Exceedings of existing national limit and guidance values appeared to occur most frequently for the PAH compound class. Exceedings of existing national limit and guidance values of PFC were limited to sewage sludge derived materials, where they appeared quite probable. Other organic pollutants showed very low concentration levels in all the materials studied and/or are currently not widely considered as compounds of concern in Member States' national legislations.

[36] Personal communication by Belgian MS delegate: proposed limit values for chlorophenols ranging from 0.3 to 6 mg/kg for different chlorophenol compounds.

However, it is important to note the following limitations of the JSAC:

- Participation in the JSAC was done on a voluntary basis, and therefore it cannot be excluded that other composting/digestion installations produce materials with a clearly different quality than those sampled within the JSAC framework.
- Due to the set-up and time limitations of the JSAC, temporal variations could not be considered, although the data seem to be confirmed by external studies that cover longer periods and therefore take into account seasonal variations and possible spikes of contamination. Moreover, Brändli et al (2005) reported that the highest concentrations of persistent organic pollutants were observed in summer compost samples. So given that most JSAC samples were acquired during the 2011 summer period, there appears no particular reason to assume that the JSAC organic pollutant measurements would systematically underrepresent actual POP concentrations in compost and digestate.
- Due to its limited size, the JSAC dataset generally provides trend information rather than elucidating statistically significant differences between different compost/digestate types.

In summary, following conclusions and recommendations regarding end-of-waste criteria for compost/digestate can be derived from the extensive scientific data presented in this chapter:

- End-of-waste product quality requirements should provide an additional safeguard against undesired pollutants that cannot be avoided or removed solely through input material selection and process conditions and which could cause adverse environmental or human health impacts.
- When establishing end-of-waste criteria, it should be considered to include testing requirements and limit values for heavy metals and physical impurities for all compost/digestate categories, as no technology or input material type provides a full safeguard against the presence of heavy metals.
- When establishing end-of-waste criteria, it should be considered to include testing requirements and limit values for certain organic pollutants, especially for PAH (for all possible compost/digestate materials) and PFC (only if sewage sludge derived materials were to be allowed), as no technology or input material type provides a full safeguard against the presence of organic pollutants.

4 Proposed Scope and End-of-waste criteria

This Chapter details the outcome of the discussions held within the Technical Working Group regarding possible end-of-waste criteria for compost and digestate and formulates a proposal for such criteria taking into account the varying expert opinions.

From an early stage in this study, it became clear that any proposed set of EU-wide end-of-waste criteria is inherently linked to the precise definition of the **scope** of the materials that would be subject to such criteria. Therefore, this Chapter begins with an analysis of the different scope options that were proposed in the course of the project, followed by a final proposal for a scope definition.

In the second part of this Chapter, an overview is given of the possible benefits of EU end-of-waste criteria, as well as the conditions that need to be respected for possible end-of-waste status. This part ends with a detailed discussion of the various elements of a possible **set of end-of-waste criteria** for compost and digestate.

4.1 Scope options and proposed definition

4.1.1 Introduction

Any proposal of a set of EU-wide end-of-waste criteria should be accompanied by a precise definition of the scope of the materials that would be subject to such criteria. For example, the type of pollutants to be routinely monitored in compost/digestate as part of the quality criteria should not only depend on their possible adverse environmental impacts but also on the probability of occurrence in the input materials.

During the study, several options for the definition of the scope have been suggested by the expert stakeholders and were the subject of intense debate. An overview of these scope options is given below, together with a discussion of their main advantages, drawbacks and less distinct features, based on the expert feedback.

4.1.2 Option 1: Broad scope with strict output material quality criteria

This scope proposal is based on an approach in which the output material criteria are predominant, with a relatively tolerant stance towards the used input materials for the composting/digestion process.

It enables the use of a large series of input materials, provided these are on a positive list of allowed materials and provided the output material meets strict quality criteria. In this proposal, compost/digestate materials derived from sewage sludge and mixed MSW may be eligible for end-of-waste, but certain highly polluted input materials are banned.

<u>*Advantages*</u>

- *Level playing field*. The same standards apply across the EU for all compost and digestate materials derived from biodegradable waste, offering simplicity and clarity to producers and consumers of compost/digestate, as well as the derived materials such as food crops.

- *Technology neutral*. This option provides the most neutral stance towards all existing and future composting/digestion technological systems operating on the market, as it judges mainly on the product quality. At the same time it stimulates competition and technological innovation, especially for technologies that currently experience difficulties in meeting the product quality criteria.
- *Legal certainty*. By setting strict product quality criteria, authorities and industries can make informed decisions on possible composting/digestion options, facilitating long-term investment planning.

<u>Drawbacks</u>

- *Subsidiarity principle at risk*. The proposed scope tends to neglect the specificities of national markets by forcing them to accept a broad range of materials, including materials that were previously not allowed.
- *Sudden and large disruptions of existing markets*. A majority of the MBT and sewage sludge based materials currently being produced across the EU would not be able to meet the strict quality standards. Nonetheless, many of these materials currently enjoy national product(like) status. Hence, the introduction of EU legislation with strict standards would result in large amounts of material suddenly shifting from a product status to a waste status, with sudden and important financial impacts for the concerned authorities and producers of these materials. Nevertheless, this scope option would in principle allow authorities and producers to adapt their collection systems and installations in order to improve the quality of the output material in order to meet the quality criteria and therefore allow them to recover from the temporary impacts.
- *Possibly decreased consumer confidence*. Many experts argued that an introduction on the EU market of materials previously not allowed in certain Member States (e.g. MBT compost) would result in decreased consumer confidence and rejection by the consumer of all compost/digestate types.
- *Likely compliance cost increase*. If a vast spectrum of input materials is allowed, it becomes necessary to screen for many pollutants whose presence is likely in any of these input materials. This in turn may lead to an increase of the costs for analytical measurements related to product quality compliance testing. The ultimate changes in analytical costs will depend on the existing elements of the testing programs that are already in place at national level and of the pollutant concentration level of the material.
- *Difficulties with positive list*. The TWG expert discussions indicated that for many types of input materials, different views existed about their eligibility for inclusion on the positive list of allowed materials. Hence, it would be very difficult to establish a positive list that is agreed upon by all experts, even if the focus in this approach is on the output material quality and a more tolerant stance towards input materials can be taken. Moreover, updating the positive list would be a complicated and time-consuming process that may hamper the rapid evolutions on the market.

<u>Neutral</u>

- *Indirectly encourages separate collection of bio-waste*. By imposing strict product quality criteria, which are readily achievable for most systems based on source separate collection of input materials, this scope proposal indirectly stimulates Member States' measures to encourage separate collection of bio-waste with a view to composting and digestion, as required by Article 22(a) of the Waste Framework Directive.

This proposal was outlined in Working Document 1 and 3. A detailed overview of the proposed end-of-waste criteria from the 3rd Working Document is given in "Annex 20: Proposed end-of-waste criteria from 3rd Working Document".

4.1.3 Option 2: Broad scope explicitly prohibiting certain input materials

This scope proposal is based on an approach in which input material criteria are seen as the key tool to ensure the quality of the output material. It acknowledges the advantages of separate collection of biodegradable waste with the aim to produce valuable compost/digestate materials, as set out in recitals 28 and 35 and articles 10, 11 and 22 of the Waste Framework Directive, by excluding certain compost/digestate types from end-of-waste status *both at national and EU level*.

It enables the use of a number of input materials, provided these are on a positive list of allowed materials. The output material must also meet several quality criteria, although these will generally be less extensive than in Option 1. At the same time, it explicitly excludes several materials from receiving end-of-waste status at EU or national level, regardless of their quality. In this proposal, compost/digestate materials derived from sewage sludge and mixed MSW are *not* considered to be eligible for end-of-waste status, neither at national, nor at Community level. Furthermore, certain highly polluted input materials are banned.

<u>Advantages</u>

- *Encourages separate collection of bio-waste*. This scope proposal stimulates Member States' measures to encourage separate collection of bio-waste with a view to composting and digestion, as required by Article 22(a) of the Waste Framework Directive.
- *Possibly reinforced consumer confidence*. Several experts argued that by reducing the eligible input materials to those for which the output material has a proven track record of quality in many Member States will help in establishing consumer confidence for compost/digestate. This is especially the case for emerging markets, many of which are developing in the EU-12 Member States, where consumers are little acquainted with compost and digestate materials from biodegradable waste.

<u>Drawbacks</u>

- *Subsidiarity principle at risk*. The proposed scope tends to neglect the specificities of certain national markets and technologies by explicitly excluding certain materials from end-of-waste status even if they are currently enjoying product(like) status at national level.
- *Sudden, large and possibly irreversible disruptions of existing markets*. A majority of the MBT and sewage sludge based materials currently being produced across the EU would suddenly be excluded from end-of-waste status, regardless of their current status at national level. This would have important, sudden and possibly irreversible impacts for the concerned authorities and producers of these materials, as the only remaining option would be to handle these materials under the waste regime.
- *Not technology neutral*. Preventing MBT and/or sewage sludge based compost/digestate materials from receiving end-of-waste status at any level, national and EU, regardless of their product quality, was perceived by certain experts as discriminatory. Excluding these materials from the product market will most probably constitute a considerable barrier against further investment and innovation for these technologies.

- *No level playing field*. Different rules apply to different kinds of compost/digestate types, therefore abolishing the level playing field.
- *Severe difficulties with positive list*. The TWG expert discussions indicated that for many types of input materials, different views existed about their eligibility for inclusion on the positive list of allowed materials. In view of the important consequences for materials being excluded from the positive list, it would be very difficult to establish a positive list that is agreed upon by all experts. Moreover, updating the positive list could be a complicated and time-consuming process that may hamper the rapid evolutions on the market.

<u>*Neutral*</u>

- *Restricted compliance cost.* If only a limited number of input materials are allowed, the number of possible pollutants to screen for remains relatively low. This limits the costs for analytical measurements related to product quality compliance testing. Nonetheless, certain costs may be incurred due to the introduction of an EU-wide end-of-waste system. The changes in analytical costs will depend on the existing elements of the testing programs that are already in place at national level and of the pollutant concentration level of the material.
- *Partial legal certainty*. By limiting the allowable input materials and technologies, authorities and industries can make informed decisions on possible composting/digestion options, facilitating long-term investment planning. However, existing systems that become excluded from end-of-waste status through the introduction of new EU legislation may experience legal difficulties through the sudden and irreversible change from product to waste status.

This proposal was outlined in Working Document 2. A detailed overview of the proposed end-of-waste criteria from the 2nd Working Document is given in "Annex 19: Proposed end-of-waste criteria from 2nd Working Document".

4.1.4 Option 3: Narrow scope excluding certain input materials

This scope proposal is a variation on Option 2. It is based on an approach in which input material criteria are seen as the key tool to ensure the quality of the output material. It acknowledges the advantages of separate collection of biodegradable waste with the aim to produce valuable compost/digestate materials, as set out in recitals 28 and 35 and articles 10, 11 and 22 of the Waste Framework Directive, by excluding certain compost/digestate types from end-of-waste status at *EU level*. However, contrary to Option 2, it does not immediately exclude other compost/digestate types, such as MBT and sewage sludge based materials, from receiving *national* end-of-waste or similar product status.

This option provides Member States with the possibility and time to adapt their national compost and digestate production chains. Authorities and industries may then decide to replace certain technologies on the long term or to invest in technological improvements with the aim to request future eligibility for currently excluded compost/digestate materials within the EU end-of-waste framework. In the latter case, it will be necessary to demonstrate the improved and constant output quality of certain technologies, with the bulk of the produced materials meeting the envisaged EU output quality requirements, and to provide thorough scientific evidence on the safe use of the materials, especially with regard to the fate of the pollutant compounds and their possible breakdown products. Future decisions on the possible end-of-waste status of current non-scope materials may therefore depend on proven technological advancements in the coming years, or conversely, the lack thereof.

Advantages

- *Subsidiarity principle respected.* The proposed scope acknowledges the specificities of certain national markets and technologies, while providing a Community framework for compost and digestate produced from source separated input materials.
- *Limited sudden disruptions of existing markets*. A majority of the MBT and/or sewage sludge based materials currently being produced across the EU would retain their current status within the national legal framework and technology changes could be implemented gradually. Moreover, markets for compost/digestate from source separate collection are likely to benefit on the long run from the recognition provided by the EU-wide end-of-waste status.
- *Positive list can be avoided.* By limiting the scope for EU end-of-waste materials, while concurrently allowing national systems to be maintained, the establishment of a single EU positive list of allowed input materials for end-of-waste compost/digestate production becomes less crucial. Moreover, in absence of a commonly agreed EU positive list, the update mechanism is clearly facilitated. Future new candidate materials can be introduced in the EU end-of-waste compost/digestate market after examination and confirmation by the competent national authorities that a material falls under the scope for EU end-of-waste compost/digestate.
- *Encourages separate collection of bio-waste*. By limiting EU wide end-of-waste status to materials from source separate collection, this scope proposal stimulates Member States' measures to encourage separate collection of bio-waste with a view to composting and digestion, as required by Article 22(a) of the Waste Framework Directive.
- *Possibly reinforced consumer confidence*. Several experts argued that by reducing the eligible input materials to those for which the output material has a proven quality track record in many Member States will help in boosting consumer confidence for compost/digestate. This is especially relevant for emerging markets, many of which are developing in the EU-12 Member States, where consumers are little acquainted with compost and digestate materials from biodegradable waste.

Drawbacks

- *No full level playing field*. Different rules apply to different kinds of compost/digestate types for this scope option, yet product status is not exclusively attributed to materials from source separate collection. Hence, the level playing field is not fully established, but a high level of competition is still ensured.

Neutral

- *Restricted compliance cost.* If only a limited number of input materials are allowed, the number of possible pollutants to screen for remains relatively low. This limits the costs for analytical measurements related to product quality compliance testing. Nonetheless, certain costs may be incurred due to the introduction of an EU-wide end-of-waste system. The changes in analytical costs will depend on the existing elements of the testing programs that are already in place at national level and of the pollutant concentration level of the material.
- *Partial legal certainty*. Systems based on separate collection will benefit from clear legal certainty in this approach. However, by allowing EU-wide and national product

systems to co-exist, authorities and industries may lack a clear view on possible future composting/digestion options. This may hamper long-term investment decisions in technologies that are currently excluded from EU-wide end-of-waste status.

- *Partially technology neutral*. This option allows different composting/digestion technological systems to operate on the market, albeit at different levels. At the same time it stimulates competition and technological innovation, especially for technologies that currently experience difficulties in meeting the proposed EU product quality criteria such as sewage sludge composting and MBT.

4.1.5 Proposed scope definition

A summary overview of the different discussed scope options and their likely impacts, based on expert feedback, is given in Table 12.

It should be **stressed that the above proposed scope options are obviously not exhaustive**. New scope options may be developed by adapting elements of the different options and by proposing modifications to lessen the possible negative impacts while preserving or improving the positive impacts. Moreover, Table 12 mainly lists the individual impacts of every option, but **no weighing factors** have been attributed to each impact. Hence, preference for a given option may depend as well on the overall weighted appreciation of each option. Moreover, several experts had different opinions on the individual impacts, with some experts estimating certain impacts to be more negative while others estimated certain impacts to be more positive.

Table 12: Summary overview of likely impacts from different possible scope options (++ = very positive, + =positive,0 =neutral, - =negative, -- = very negative)

	Option 1: Broad scope with strict output quality criteria	Option 2: Broad scope explicitly prohibiting certain input materials	Option 3: Narrow scope excluding certain input materials
Limiting compliance cost	-	0	0
Promoting consumer confidence	-	++	+
Facilitating listing and updating of allowable input materials	-	--	++
Encouraging separate collection	+	++	+
Providing legal certainty	++	0	0
Ensuring a level playing field	++	--	-
Avoiding disruption of existing markets	-	--	+
Respecting subsidiarity	-	--	++
Being technology neutral	++	--	0

Certain experts also suggested other impacts that could not be retained because they did not reflect any techno-economic aspects of end-of-waste criteria, but were related to e.g. general waste management policy.

Both options 1 and 2 failed to receive extensive support from the Technical Working Group. Each option had its distinct proponents. Nevertheless, stakeholders from the markets that were likely to suffer most from the negative impacts associated to a certain option clearly voiced their objections. In this respect, it should be noted that some experts advocated leaving the development of end-of-waste systems at the decision of the individual Member States, claiming a likely overall negative impact to local markets from possible EU end-of-waste criteria.
Option 3, as presented in the Background Paper and discussed at the Third Workshop in Seville (26 February 2013), received relatively widespread support from the TWG as an acceptable compromise solution, with less explicit objections being formulated.

Given the overall preference for Option 3, it has been retained in this document as a basis to formulate a set of proposed end-of-waste criteria.

More specifically, it is proposed to define the scope for possible EU legislation on end-of-waste criteria for compost and digestate as follows:

The ***scope*** *<u>includes</u> hygienised and stabilized compost and digestate materials obtained through a biological waste treatment process using input materials exclusively originating from:*

a) the separate collection of bio-waste and/or;
b) manure and/or;
c) living or dead organisms or parts thereof, provided the latter are unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, by extraction with water, by steam distillation or by heating solely to remove water, or which are extracted from air by any means and/or;
d) processed living or dead organisms or parts thereof other than c), as well as biodegradable packaging materials, provided all such materials are certified biodegradable according to EN 13432, EN 14995 or equivalent and 90% biodegradability in 6 months has been demonstrated in a single or combined composting and/or anaerobic digestion process and/or;
e) any material listed in points a), b), c) and/or d) that has previously been composted and/or digested;

Input materials must not be contaminated.

'Bio-waste' is defined according to Article 3(4) of the Waste Framework Directive 2008/98/EC as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants.

'Contaminated' is defined as having a level of chemical, biological or physical contamination that may cause difficulties in meeting the end-of-

waste output product quality requirements or that may result in other adverse environmental or human health impacts from the normal use of the output compost/digestate material.

'Manure' is defined according to Article 3(20) of the Animal By-Products Regulation (EC) 1069/2009 as any excrement and/or urine of farmed animals other than farmed fish, with or without litter.

'Separate collection' is defined according to Article 3(11) of the Waste Framework Directive 2008/98/EC as the collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment.

The scope <u>*excludes*</u> *compost and digestate materials partially or completely derived from*
a) the organic fraction of mixed municipal household waste separated through mechanical, physicochemical, biological and/or manual treatment and/or;
b) sewage sludge and/or;
c) sludges derived from the paper industry and/or;
d) sludges derived from materials other than those included in the scope and/or;
e) animal by-product category 1 materials according to ABP Regulation (EC) No 1069/2009 and/or;
f) animal by-product category 2 and/or 3 materials for which composting and/or digestion is not allowed according to ABP Regulation (EC) No 1069/2009 and implementing Regulation (EU) 142/2011.

Compost or digestate materials partially or completely derived from contaminated input materials, regardless of their origin, are also excluded from the scope.

Examples of materials falling under this proposed scope definition are provided in this Chapter, in section 4.5 "Requirements on input materials".

The scope definition should set a clear framework to determine eligible materials and exclude non-eligible materials for EU end-of-waste status. The rationale behind this definition is elaborated below.

During TWG expert discussions of the possible scope for EU end-of-waste criteria, a **definition of eligible scope materials** has initially been based on a number of well-defined material streams for which readily available legal definitions exist such as bio-waste and manure. These have been listed as items a) and b) in the scope definition.

However, as indicated in Section 1.3, these definitions do not include possibly valuable input materials for compost and digestate, such as garden and park waste. Hence, a clear description for such materials proved necessary. In principle, it could be stated that any non-contaminated biological material that would undergo natural decomposition by aerobic or anaerobic biodegradation processes in a relatively short time-frame of a few months, thereby disintegrating into naturally occurring compounds and giving back valuable transformation materials and nutrients to the soil, should be eligible for composting and/or digestion. Although seemingly straightforward, using a definition based on 'biodegradability' may not be the most appropriate. Not all biological materials will fully disintegrate in a time frame of weeks or months, e.g. woody materials. Nevertheless, humus complexes derived from these materials are deemed to be valuable for soils. A better approach may be to describe such eligible materials as *'naturally occurring biological materials'*. An exact definition for the latter material group does not seem to exist. Yet, the "Guidance for Annex V, Exemptions from the obligation to register" document on REACH[37] may be used as a starting point for establishing a workable definition. Exemptions from the obligation to register under REACH are foreseen for certain 'naturally occurring substances'. This group of substances is characterised via the definitions given in Articles 3(39) and 3(40): *according to Article 3(39), 'substances which occur in nature' means 'a naturally occurring substance as such, unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, by extraction with water, by steam distillation or by heating solely to remove water, or which is extracted from air by any means'*. Clearly, such a definition includes naturally occurring biological materials. Nonetheless, it also includes inorganic materials such as ores or organic materials such as oil and coal. The latter materials, clearly non-biodegradable, should not be considered eligible input materials for composting/digestion. Fortuitously, the same Guidance document provides information on general exemptions for biological materials, given that these are not considered substances under REACH. The Guidance documents states: "*It should be noted that whole living or unprocessed dead organisms (e.g. yeast (...), freeze-dried bacteria) or parts thereof (e.g. body parts, blood, branches, leaves, flowers etc.) are not considered as substances, mixtures or articles in the sense of REACH and are therefore outside of the scope of REACH. The latter would also be the case if these have undergone digestion or decomposition resulting in waste as defined in Directive 2008/98/EC, even if, under certain circumstances, these might be seen as non-waste recovered materials*." Hence by combining the definitions under REACH of exempted *naturally occurring* substances and non-substance *biological materials*, a useful definition for eligible input materials other than bio-waste or manure may be established. This definition has been used in the scope definition above under item c).

At the same time, in many cases 'processed' biological materials may still provide a valuable source of input materials for composting or anaerobic digestion processes. This may also be the case for biodegradable packaging materials. Nonetheless, it should also be stressed that 'bio-based' materials are not always biologically degradable anymore, e.g. because they underwent a chemical modification that negatively affected their biodegradation properties as in the case of certain bioplastics. It should be clear that such materials should be prevented from entering the composting/digestion chain. The same restrictions should apply to materials that have been treated to prevent biodegradation (e.g. treated wood) or that form a mix of well biodegradable materials with non-biodegradable materials. Therefore, only those processed materials of biological origin or packaging materials that are readily biodegradable, i.e. disintegrating into naturally occurring compounds, are proposed to be eligible for the scope of EU-wide end-of-waste materials, according to expert feedback. The existing definition of "*Biodegradable*" from the Landfill Directive 1999/31/EC, namely "*any waste that is capable of undergoing anaerobic or aerobic decomposition*" may not be fully appropriate in this context. In landfills, even very slowly biodegradable wastes will ultimately decompose. These wastes may include certain

[37] http://echa.europa.eu/documents/10162/13632/annex_v_en.pdf

industrially manufactured materials that slowly decompose through the action of specifically adapted micro-organisms, such as standard plastics. For composting and anaerobic digestion, only materials should be allowed that undergo a high level of biodegradation within the normal processing time period. European standard EN 13432 on requirements for packaging recoverable through composting and biodegradation provides a first step to a more targeted approach. It stipulates that at least 90% of the organic material is converted into CO_2 within 6 months in an aerobic process. However, it only requires 50% degradation after 2 months under anaerobic conditions, assuming that the anaerobic digestion will be followed by an aerobic stabilization phase. Yet, the latter assumption is not always valid in practice as anaerobic digestion can yield a stabilized material for which post-composting is not necessary. Hence, requirements on the level of biodegradation should be independent of the chosen technology for treatment, whether it concerns composting or digestion. Moreover, it should be ensured that all processed biological materials or packaging materials reach high levels of biodegradation in the composting/digestion process they enter. Therefore, a uniform requirement of 90% biodegradation may be advisable, whether attained through a typical single composting or anaerobic digestion process or a combination of both processes. This has been the rationale for the definition in the scope of material group d).

Finally, as was agreed by the majority of expert stakeholders, previously composted or digested materials derived from eligible input materials should be eligible input materials themselves. This has been ensured in the definition in the scope of material group e). Note that restrictions apply for compost/digestate materials that were refused end-of-waste status for exceeding certain pollutant limits (see section 4.5 Requirements on input materials).

Other materials may have varying levels of possible contamination, either because they have been mixed with other waste (e.g. organic fraction of mixed MSW) or because they have been used for certain industrial processes (e.g. sewage sludge and other industrial sludges). Given the diverging views from TWG experts on the usefulness and eligibility of these materials, it is proposed to exclude these at present from use for production of compost/digestate materials eligible for EU end-of-waste status.

As a final point, it should be clear that any **contaminated** input material should be banned from use in composting/digestion operations with the aim to obtain end-of-waste compost/digestate material. For instance, it should be clear that input materials with heavy metal concentrations well above those of the product quality criteria are likely to lead to exceedings of the product limits, when used in considerable amounts. At the same time, it is important to stress that no single material will be strictly free of contamination. As such, despite effective controls from waste collectors, biobins collected from households may contain an occasional wrong item (e.g. a plastic flower pot) and even organically farmed crops will always contain traces of heavy metals or organic pollutants. Therefore, a possible definition of contamination should acknowledge that input materials are acceptable as long as their contamination remains below a certain level. Moreover, such a level should be in relation to the risk associated to a contamination. For example, when expressed per kg dry matter, higher levels of physical impurities can be tolerated than for dioxins. On the other hand, whenever contamination of input materials can realistically be avoided or minimized by readily available and wide-spread technological solutions, these should be applied. Hence, packed expired foods from supermarkets should be mechanically or manually removed from their packaging prior to entering the composting/digestion operation, to minimize the physical impurities content.

An interesting definition for "*Contaminated*" is provided in Article 10 of the proposed Soil Framework Directive (COM(2006) 232). The proposal reads "…*sites in their national territory where there is a confirmed presence, caused by man, of dangerous substances of such a level that Member States consider they pose a significant risk to human health or the environment, hereinafter "contaminated sites"*". The latter proposal includes very useful elements, such as the reference to a threshold concentration level and to the associated risks of pollutants. Unfortunately, the latter definition cannot be applied directly for compost/digestate. Firstly, presence of contamination is not always confirmed but can merely be assumed or suspected from the provenance of the input material. Secondly, contamination is not always caused by man but may have natural causes, as in the case of high geological background concentrations of heavy metals or organic pollutants caused by natural combustion processes (e.g. forest fires). Nonetheless, even such naturally caused contaminations may be undesired in the production of quality compost/digestate materials. Moreover, the proposed Soil Framework Directive has not been adopted to date, complicating any direct reference to it. Therefore, a new specific possible definition for "contaminated" has been proposed for the scope of the current compost/digestate end-of-waste framework, which takes into account the elements discussed above. It states that 'Contaminated' is defined as having a level of chemical, biological or physical contamination that may cause difficulties in meeting the end-of-waste output product quality requirements or that may result in other adverse environmental or human health impacts from the normal use of the output compost/digestate material.

4.2 Background considerations on end-of-waste criteria

4.2.1 Introduction

End-of-waste criteria for a material should be such that the recycled material has waste status if – and only if – regulatory controls under waste legislation are needed to protect the environment and human health.

Criteria have to be developed in compliance with the legal conditions set out in Article 6 of the WFD, be operational, not lead to new disproportionate burdens and undesirable side-effects, and consider that the collection and treatment of biodegradable waste into e.g. compost or digestate is a well-functioning practice today. Criteria have to be ambitious in providing benefits to as many flows as possible, but must also ensure protection of the environment and human health through strictness. The criteria must address with priority the main and largest represented flows in the EU fulfilling the conditions of the WFD. Criteria cannot fail to target these priority flows by trying to encompass all existing biodegradable waste flows, and all national and regional singularities.

Through end-of-waste, the intention is to promote more recycling and use of waste materials as resources, reduce consumption of natural resources and reduce the amount of waste sent for disposal. A material which satisfies a set of end-of-waste criteria can then be freely traded as a non-waste material and thereby its beneficial use promoted. Potential users of the material should be able to have increased confidence on the quality standards of the material and this may also help to alleviate any user prejudice against the material simply because it is classified as waste.

This chapter suggests how the end-of-waste criteria for compost and digestate could be defined so that they fulfil the conditions and purposes specified in Article 6 of the WFD. It first identifies and discusses the different reasons why the end-of-waste criteria for compost and digestate would be beneficial, then it goes through the four conditions of Article 6 and analyses what they mean for the specific case of compost and to a lesser extent for digestate. Finally, a scope and a set of end-of-waste criteria on compost and digestate and accompanying measures are proposed accordingly.

4.2.2 Rationale for end-of-waste criteria

The purpose of having end-of-waste criteria is to facilitate recycling and to obtain environmental and economic benefits. This section discusses how, i.e. through which mechanisms, end-of-waste criteria may achieve this in the case of compost and digestate.

4.2.2.1 Improve harmonisation and legal certainty in the internal market

There are environmental and economic benefits to be gained as the end-of-waste criteria improve the harmonisation and legal certainty in the internal market.

There is currently no harmonised way in the EU for determining whether a compost or digestate material is a waste or a 'normal' product. Member States deal with the question rather differently. In some cases, specific legislation may be in place for composts or digestates, whereas in other cases other laws are applicable such as fertiliser legislation. There is a group of Member States where there are types of composts or digestates that are explicitly recognised as non-waste even if they are produced from input materials that are waste. However, across these Member States, the standards that composts and digestates must meet in order to qualify as normal products differ considerably. Then there are other Member States where composts or digestates made from waste are always considered waste, regardless of the quality of the material. In the remaining Member States there are no explicit general rules and the classification of compost/digestate as waste or not is left to case-by-case decisions or to interpretive protocols that are applicable to certain parts of the Member State.

The lack of harmonisation creates legal uncertainty for waste management decisions and for the different actors dealing with the material, including the producers and users of compost/digestate or haulage contractors. The uncertainty arises especially when trade between Member States is involved. However, there are also differences in interpreting the waste status of compost and digestate between different regions within certain Member States.

One identified consequence is that both compost/digestate producers and users tend to restrict themselves to the national (or regional) market because they want to avoid the administrative and judicial costs or risks of an unclear waste status of the material. This means that composts/digestates do not always reach the place where they could, in principle, be used best, i.e. economically and delivering the highest benefits with the proportionally lowest environmental and health risks. It may also mean that less compost/digestate is produced. In fact, the volumes of compost and digestate traded between Member States are smaller today than they could theoretically be and it is likely that with clear rules about when compost and digestate cease to be waste, the supply and demand of these materials would be balanced better.

The legal uncertainty regarding the waste status of compost/digestate also affects the investment decisions on new treatment capacities for the management of biological wastes. Such uncertainty evidently comes at a cost when it hinders the development of the composting and digestion sector in situations where, in reality, the conditions would exist for compost or digestate to cease to be waste. This is relevant not only for the situation in certain Member States, but especially also at the European level. For example, the possibility of exporting compost/digestate is an important factor for the feasibility of a composting/digestion plant in border regions. When uncertainties regarding the status of the waste reduce the export possibilities, then this may easily lead to opting for another waste treatment option even if a need and environmentally suitable absorption capacity for the compost or digestate exists across the border[38]. Harmonised end-of-waste criteria would promote investing in compost and digestate production in such situations.

Furthermore, harmonisation of end-of-waste criteria at EU level would facilitate other Community legislative initiatives. Fertilisers Regulation EC 2003/2003 is currently being revised, also with the aim to extent its scope[39]. A new legislative document would clearly benefit from a clear and uniform definition of end-of-waste materials, in view of granting

[38] Due to the relatively high costs of transporting the compost/digestate, the feasibility of a composting/digestion plant critically depends on the existence of sufficient market capacity for its use within a radius of not more than 50–100 km around the plant. If national borders within the EU work as barriers to compost/digestate use, then composting/digestion facilities close to borders have an obvious ‘geometric’ handicap that works to the detriment of allowing an environmentally optimised waste management and compost/digestate use.

[39] For status and further information, see http://ec.europa.eu/enterprise/sectors/chemicals/documents/specific-chemicals/fertilisers/

fertiliser product status to former waste materials of biological origin subjected to biological treatment.

The lack of harmonisation also means that there is no system that ensures that the control of compost and digestate flows across national borders is proportionate to the related environmental risks. Harmonised end-of-waste criteria could improve the management of environmental risks under waste shipment rules by excluding low risk compost and digestate from waste shipment controls, while making explicit that compost or digestate with higher risks for the environment have to be considered waste. This would avoid unnecessary costs and barriers in end-of-waste compost and digestate and ensure the necessary controls (prior written notification and consent of shipment) in waste compost and digestate.

Generally, end-of-waste criteria would have the benefit of making more explicit when compost and digestate have to be considered waste. This would consolidate the application of waste law derived controls to non-compliant compost and strengthen environmental and health protection.

4.2.2.2 Avoid waste status if unnecessary

There are several economic benefits to be reaped when the end-of-waste criteria prevent compost or digestate being considered as waste when such a status is not necessary.

A direct economic benefit is that compliance costs are avoided. According to certain Member State legislation, users of compost or digestate may need a permit for usage from the waste management authorities. Compost or digestate not requiring a permit or an exemption under waste law can be used at lower costs. The UK's Quality Protocol for compost, for example, allows the use of compliant compost in England and Wales without having to pay an exemption fee related to waste status. The avoided costs were estimated at more than GBP 2/tonne of compost (The Composting Association, 2006)[40].

Another economic benefit can be obtained by avoiding potential users undervaluing compost or digestate simply because it is unnecessarily labelled as waste. It has been reported that farmers are hesitant to use compost as a soil improver if it is presented to them as a waste material because the waste status makes them perceive compost as of low value, or even causing adverse impacts to agriculture. In such cases, the waste status works as a stigma. Compost that is not considered waste has a higher perceived value than otherwise identical waste compost. In fact, it is likely that the agronomic value of compost is higher than the price paid for it when it is waste[41]. If higher prices are paid for end-of-waste compost, then a part of the benefits obtained by the user is transferred back to compost producers and possibly, through reduced gate fees, further to municipalities so that e.g. the costs of waste management are reduced, or improvements in collection can be made.

A correctly perceived value of compost and digestate and reduced costs of compost use are important factors to strengthen the demand for compost and digestate and in this way improve the feasibility of the compost route of managing biodegradable wastes.

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40 In Germany, composts do not cease to be waste *before they have been used*, but quality certified composts are exempted from the most onerous obligations that a full waste status would imply for the users. Also this reduces compliance costs for the use of compost.

41 For instance, it was a reason for including end-of-waste criteria in the Austrian Compost Ordinance to avoid that the value of compost is unduly underestimated because of unnecessary waste status.

Examples such as Austria and the United Kingdom show that Member States can effectively avoid the waste status of certain composts and digestates already within the current European framework, but these rules are only valid within each of these Member States. There would, however, be additional benefits of the European end-of-waste criteria by accelerating and consolidating the establishment of compliant compost and digestate as a freely traded product throughout the EU.

4.2.2.3 Promote product standardisation and quality assurance

Harmonising the end-of-waste criteria is also an opportunity to introduce widely recognised product standards for compost and digestate and to promote quality assurance.

A high level of environmental protection can be achieved only if there is reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. To manage compost and digestate so that environmental impacts and risks are kept low, it must be possible for compost/digestate users and regulatory authorities to interpret the declared product properties in the right way and to trust in conformity. Therefore, standardisation of product parameters, sampling and testing is needed as well as quality assurance.

End-of-waste criteria that demand the use of harmonised standards could be a decisive factor for promoting the widespread use of harmonised standards throughout the EU. Harmonised standards for compost/digestate property parameters, sampling and testing are, to a large extent, already available to be used today, even if they are not yet fully adopted as European standards.

Where compost and digestate production and use are already well-established today, quality assurance is a common practice. While quality assurance can also be developed by industry alone, as a purely voluntary initiative, most of the successful compost quality assurance and certification schemes have benefited, however, from some sort of quasi-statutory support by regulations in Member States. By demanding quality assurance, the end-of-waste criteria would promote quality assurance throughout the EU.

4.2.2.4 Promote higher compost and digestate quality

The end-of-waste criteria can promote higher compost and digestate quality standards by including certain product quality requirements. Such requirements comprise limit values for hazardous components (maximum concentrations allowed) and for properties adding value to the product (e.g. minimum organic matter content). It is evident that high quality in this sense is important for a good overall cost-benefit balance of compost use. If only high-quality composts benefit from the cost reducing and demand enhancing effects of end-of-waste, they will become preferable as an option compared to lower quality composts not only for compost users but also for operators of compost plants and in strategic waste management decisions.

4.2.3 Conditions for end-of-waste criteria

This section discusses, one by one, what the conditions of end-of-waste criteria as defined in Article 6 of the WFD mean in the case of compost and digestate and how end-of-waste criteria need to be formulated so that compost or digestate only qualify when all four conditions are met.

4.2.3.1 The substance has undergone a recovery operation

Compost and digestate are materials that are the result of a recovery operation according to Article 3 (15) and Annex II R3 of the Waste Framework Directive. The recovery in this case constitutes a material recovery, as the organic matter of the input biodegradable waste is recovered and transformed into a material with more desirable properties with regard to nutrient value, soil amendment potential, sanitation, etc.

4.2.3.2 The substance or object is commonly used for specific purposes

There are a number of specific purposes for which compost and digestate are commonly used. The main use for compost and digestate is as a soil improver or an organic fertiliser in agriculture. Compost is also incorporated as a component in growing media for use in horticulture, landscaping and hobby gardening. Product specifications for using compost or digestate for these purposes exist on national levels and, to some extent, also at European level (eco-label criteria on soil improvers and growing media). Some compost is also used for land restoration and as a landfill cover. The use of compost for these purposes is common in several Member States of the EU. Digestate is almost completely applied in agriculture. The main compost and digestate producing countries are also the main compost and digestate users. The nine Member States with the biggest compost production produce about 95 % of all compost in the EU, whereas Germany is by far the largest digestate producer of the EU accounting for nearly two thirds of all digestate produced. Depending on the purpose and the specific situation, the use of compost and digestate is regulated at least in those Member States where such use is common. For use on soil, and particularly in agriculture, there are usually restrictions on the amounts of compost and digestate that may be used, often depending on the heavy metal and nutrient contents of the material.

4.2.3.3 A market or demand exists for such a substance or object

Theoretically, there is a strong need for compost in the EU, especially as a soil improver to work against the loss of organic matter from soil (erosion). The demand for digestate mainly originates from its merits as an organic fertiliser. In practice today, the market for compost and digestate is well established only in the part of the EU where compost/digestate production and use is concentrated (see Section 4.2.3.2), and is not coincident with the regions of most erosion or nutrient depletion. In other parts of the EU, the market is being developed in a proactive manner, typically with government support. Finally, there are a number of countries in which compost or digestate does not yet play any significant role.

Where compost and digestate are being produced, the market tends to be supply-driven and prices for compost and digestate are sometimes close to or at zero. Even if globally there is more than sufficient use for the compost and digestate produced, there may be local imbalances of supply and demand.

Removing the waste status from compost/digestate that can be safely used for a specific purpose is likely to strengthen the demand for such material and help avoid local oversupply. To prevent the ultimate disposal of compost and digestate, the end-of-waste criteria must be demanding in terms of usefulness, ensuring a high value when used for a specific purpose. The stricter the quality requirements in the end-of-waste criteria, the higher the price will likely be for compost and digestate that meet them.

A compost or digestate should not cease to be waste if, in most places, it does not comply with the applicable regulations and standards on the relevant specific compost/digestate uses, because hardly any demand for the compost/digestate would exist in such a case.

Experience in countries where compost/digestate is commonly used today has shown that the compost/digestate market works well when the quality of compost/digestate supplied is high and reliable and the demand is proactively developed.

4.2.3.4 The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products

When compost or digestate is placed on the market, there must be at least one purpose for which it can be used without requiring any further treatment. It will be up to the undertaking that places the compost or digestate on the market to declare fitness for such use, referring to the applicable legislation and standards. Market surveillance by Member State authorities will also play a role.

Although specific Community legislation applies across the EU (Sewage Sludge Directive 86/278/EC, Fertilisers Regulation EC 2003/2003, Plant Health Directive 2000/29/EC, etc.), the existing legislation and standards for using certain types of compost or digestate for the different purposes vary between countries. It is reasonable that the specific conditions and rules for the application of compost and digestate to soils (such as how much compost and of what quality may be used on certain types of soil) are regulated at the level of Member States. Diversity in soil properties, climates, land use practices, etc., throughout the EU is very high and there is a need for regulations to be adapted to the specific conditions.

Furthermore, there does not seem to be a scientifically sound and generally acceptable way to derive comprehensive, Europe-wide technical requirements for the use of compost and digestate on land, which is the main outlet for these materials. This implies that the conditions and rules for compost/digestate use cannot directly be part of the European end-of-waste criteria for compost and digestate[42]. The declaration of fitness for use will therefore have to be adjusted to the national legislation and standards that are applicable in the place where the compost or digestate will be used.

Only for some technical requirements that are of a general nature for all typical purposes of compost or digestate use may minimum requirements be included directly in the end-of-waste criteria at EU level. The purpose of such minimum requirements would be to generally exclude composts/digestates from end-of-waste for which there is not use at all, except, maybe, in small niche applications.

In any case, there is a need for harmonised technical standardisation of compost and digestate quality parameters, sampling and testing across the EU, to avoid an artificial fragmentation of compost or digestate markets that is not justified by the real use requirements. The end-of-waste criteria should, therefore, be based on common standardised quality parameters, as well as common standardised testing and sampling. As a complementary measure, it would be

[42] Concerning the use of compost in products such as growing media, EU-wide rules may be justified because growing media are products traded freely on the internal market. This would primarily be a question of regulating growing media, and would affect the end-of-waste criteria for compost only indirectly.

important that Member States use the same harmonised standards in the relevant legislation on compost and digestate use.

4.2.3.5 The use of the substance or object will not lead to overall adverse environmental or human health impacts

There are various aspects to consider for avoiding overall adverse environmental or human health impacts.

1. Compost or digestate use should not exert any stress on soil that may compromise the multifunctional soil functions. Therefore, the transfer to soil of hazardous substances through compost/digestate application needs to be limited. This is primarily a question of rules on the use of compost/ digestate, which, as argued before, are best formulated at national/regional levels. Composts/digestates should cease to be waste only if they comply with the environmental and health regulations on compost use that apply to the purpose for which they are placed on the market (see also condition c). As complementary measures to the end-of-waste criteria, it would be important that Member States, who have not already regulated the use of composts/digestates, put such rules in place.

2. Compost/digestate should not pose any health risks because of macroscopic impurities such as plastics, metals or glass, which may cause cuts or could be ingested by animals or humans that come into contact with crops and soils treated with compost/digestate. This can best be controlled by careful monitoring of the quality of input materials and by including limits on such impurities as a quality requirement in the end-of-waste criteria.

3. The end-of-waste criteria should not lead to a relaxation of the strictness of quality for compost/digestate. This could happen if the end-of-waste criteria included concentration limits for hazardous substances that are less strict than the standards that determine the quality of compost/digestate produced today. One may think that in this way more compost/digestate could benefit from the advantages of end-of-waste, which would promote recycling. However, if the thresholds are less strict, then the overall adverse environmental impacts can only be avoided by using less compost, which would work against the aim of promoting recycling.

   As part of the product quality requirements, maximum limits for a number of substances will have to be introduced, striking a balance between ensuring environmental and health protection, and providing the advantages of end-of-waste to as much compost and digestate flows as possible.

4. Lifting the waste status should not create any regulatory void that would impair the management of environmental and health risks. The introduction of harmonised end-of-waste criteria will require the authorities in Member States to reconsider the waste status of composts and digestates. This will, in some cases, mean that certain composts/digestates that used to be considered waste can be considered non-waste. Such a change would mean that the legal and administrative controls available under waste law do not apply any longer. If in a given Member State the legislative measures for control of compost/digestate use are independent from the status of

compost/digestate as waste, they will not be affected by a change to end-of-waste. Conversely, if such measures are part of, or linked to waste law, they would be affected by a change to end-of-waste, for instance:

- Permits for the application of compost/digestate on land and for other compost uses such as the preparation of growing media including compost;
- Inspection of compost/digestate users, collectors or transporters by the competent waste authorities;
- Obligation of compost/digestate users to keep records of the quantity, nature and origin of compost;
- Prior written notification and consent of shipment;
- Registration by the authorities of transporters, dealers and brokers of waste.

The logic of the end-of-waste criteria requires that only compost or digestate for which waste law- based controls are not needed should qualify, either because the inherent risks and impacts of the materials are sufficiently low, or because there are other regulatory controls to deal with them independently of the status as waste. The use of the compost/digestate under different conditions should be possible without any danger to the environment and to health.

The inherent risks of the material are determined by the content of impurities and pollutants (hazardous substances) as well as the hygienic properties of the compost or digestate. The end-of-waste criteria can limit the environmental and health risks by including certain product quality requirements regarding pollutants and impurities, restrictions on the input materials used to produce the compost/digestate, and process requirements to eliminate pathogens from the material.

As stated above, composts/digestates should cease to be waste only if they are placed on the market for a purpose for which adequate rules on the use of compost/digestate apply. As complementary measures, such rules should be established where they do not yet exist. In several Member States, there are already soil protection and/or fertiliser laws that regulate the use of compost/digestate independently of the waste status. Often reference is made to good agricultural practices, or application recommendations for compost/digestate are provided. Compost or digestate should not cease to be waste if it does not meet the product quality requirements for the main use purposes or in most places. This should be considered when determining the product quality requirements (e.g. concentration limits on hazardous substances) for the end-of-waste criteria.

Private quality assurance schemes play an important role in risk management in a number of countries, and sometimes are made quasi-compulsory (statutory) by reference in the relevant legal (waste or other law) instruments.

Finally, there is also the possibility of introducing new complementary control instruments especially designed for non-waste compost or digestate. As an example, new requirements for ensuring the traceability of compost and digestate might be established independently of the waste laws in certain markets where this is desirable. The key question for any new controls introduced together with end-of-waste criteria is if these specific controls are better suited to deal with the compost/digestate-specific risks than the general controls linked to the status as a waste, considering that disproportionate new burdens need to be avoided. The inclusion of additional administrative measures for end-of-waste compost/digestate which waste compost/digestate does not require may deter the uptake of end-of-waste by producers.

4.3 Outline of end-of-waste criteria

Following the JRC methodology guidelines[43], it has been found that the following complementary elements should be combined in a set of end-of-waste criteria:

1. Product quality requirements
2. Requirements on input materials
3. Requirements on treatment processes and techniques
4. Requirements on the provision of information
5. Requirements on quality assurance procedures

The array of possible end-of-waste criteria that could be part of a proposal are presented individually below, with explanations that were partially derived from discussions held with the technical working group in the 2008 case study on compost (IPTS, 2008).

The possible criteria presented below have been discussed with the technical working group, and have been adjusted and refined using the written inputs and the discussions held during the three workshops in Seville.

4.4 Product quality requirements for compost and digestate

Product quality criteria are needed to check:

(1) for elements that can result in direct environmental and health risks, and
(2) that the product is suitable for direct use (on land, for production of growing media, etc).

Product quality requires that compost or digestate is an adequate alternative to primary raw-materials and that substances or properties limiting or jeopardizing its usefulness have been effectively separated or eliminated. This refers to the usefulness both in the short term (one season, one year) and in a long-term perspective that considers several years and the progressive potential accumulation of harmful elements in soil. Hence, when establishing measurement requirements and limit values for pollutants, both the likelihood of encountering elevated contents of a given pollutant and the persistence of that pollutant should be taken into account.

Direct quality criteria on compost/digestate could include the following parameters:

(1) Quantitative minimum limits of elements providing a soil improvement/fertilising function, such as organic matter content, or nutrient (N, P, K, Mg) content.
(2) Quantitative maximum limits on elements potentially toxic to human health or ecotoxic, such as heavy metals, or persistent organic pollutants.

[43] End-of-waste documents from the JRC-IPTS are available from http://susproc.jrc.ec.europa.eu/activities/waste/. See in particular the operational procedure guidelines of Figure 5 in the "End-of-Waste Criteria" report.

(3) Quantitative maximum limits on macroscopic foreign materials (e.g. glass, plastics, metals)
(4) Limited content of pathogens (if appropriate through quantitative maximum limits)
(5) Limited presence of viable weeds (if appropriate through quantitative maximum limits)
(6) Minimum stability (if appropriate through quantitative maximum limits)

When the mentioned parameters need to be quantified, the criteria should include requirements on how each of the parameters has to be tested. These testing requirements can be generic, allowing a degree of freedom within a framework of minima, or if found appropriate, be specific and refer to e.g. existing testing standards.

The different requirements that could be part of the product quality criteria were first identified for compost in the pilot study (IPTS, 2008). They were maintained as a base for this document following the support received from the Technical Working Group during the various stakeholder consultations and the discussions at the three workshops in Seville. It was also agreed that they can straightforwardly be extended to digestate. The requirements are recalled below:

Criteria	Explanations	Reasons
<u>Product quality requirements:</u> (1) minimum organic matter content (2) minimum stability (3) no content of pathogens to an extent that poses health risks (measured by the absence of certain indicator organisms such as salmonellae) (4) limited content of viable weeds and plant propagules (5) limited content of macroscopic impurities (6) limited content of heavy metals and persistent organic compounds	One set of product quality requirements shall be developed and be valid for most uses, as it is not the role of the EU end-of-waste criteria to regulate specific uses. The criteria shall ensure that the quality of compost/digestate is high, as reflected in the existence of a market and a demand for the material, which shall be fit for most uses. Rules on compost/digestate use for very specific purposes and in specific geographical areas may demand even stricter product quality requirements than those included in the end-of-waste criteria, on the grounds of environmental protection, e.g. organic farming, or use on soil above water extraction aquifers.	The product quality requirements serve to exclude composts/digestates from end-of-waste that: ○ have a low quality and therefore a too weak market demand ○ do not fulfil the technical requirements for the most important use purposes, or that in a dominating part of the compost/digestate market do not meet the existing legislation and standards applicable to products ○ are likely to have an overall adverse environmental or human health impact. More specifically: A minimum level of organic matter content is needed to ensure value, basic usefulness, as well as to prevent dilution with inorganic materials. A minimum stability is needed to avoid methane and odour emissions during uncontrolled anaerobic conditions after sales (e.g. during storage). Limitation of macroscopic impurities is needed to ensure

Criteria	Explanations	Reasons
	The development of stricter requirements for such specific uses is not within the scope of end-of-waste criteria.	usefulness and to limit the risks of injuries. Limitation of pollutant concentrations is needed: o to ensure that the material's inherent risks are sufficiently low so that the environmental impacts in the case of misuse are within acceptable limits o to exclude end-of-waste composts/digestates that cannot be used lawfully for the main purposes in a dominant part of the compost/digestate market o to promote higher compost/digestate quality and as a signal against relaxing quality targets for compost/digestate production.

The proposal for the actual limits of the parameters to be regulated in the product quality requirements, in the table below, is based on the compost pilot study (IPTS, 2008) with the rationale for setting the values detailed in "Annex 11: Initial proposal product quality requirements compost" and following the stakeholder consultations and workshop discussions and the JRC Sampling and Analysis Campaign (JSAC). Furthermore, information was used from relevant national practices and legislation as well as related activities at EU level, such as the on-going revisions of the Sewage Sludge Directive and the Fertilisers Regulation. The necessary adaptations for digestate have been implemented as well.

The views from the TWG stakeholders on **organic matter**, **pathogens** and **weed seeds** generally tended to converge. Nonetheless, some stakeholders advocated to relax criteria or increase strictness (e.g. no weed seeds allowed) or to add certain criteria (e.g. requirement for analysing other pathogen test organisms). Some of these proposals would be relevant for certain applications of compost/digestate (e.g. use in potting soil), but not to all (e.g. used in farming). Other proposals appeared to be related to existing practices in certain Member States. For example, certain stakeholders demanded much higher organic matter contents and a limit based on wet weight, rather than on dry matter. They argued that composts are often used as organic amendments and have to meet agricultural demands. However, several experts argued that such requests can better be dealt with through other mechanisms, such as market specifications or national legislation on use of different types of composts/digestates. In their view, product labelling is a better approach to deal with such possible issues (see section 4.4 "Requirements on the provision of information").

On the issue of including a **stability** criterion, the opinions from the Technical Working Group experts remained divided during the consequent discussions and consultations. Several arguments pro and contra such a criterion were conveyed.

In favour of a stability requirement, following arguments were brought forward:

- a stability requirement can help prevent the introduction of materials that have hardly undergone any treatment (e.g. so-called "shred-and-spread" compost);
- greenhouse gas emissions may occur during transport and storage of all compost and digestate materials. According to BGK (2010), 14% of the emissions associated to compost production and use take place during application and 2% during storage. The study also mentions that the risk for spontaneous anaerobic digestion of the product during storage is higher for very fresh, less stable composts compared to mature, more stable composts. Therefore, several experts argued that unstable materials should be used under controlled conditions, outside the end-of-waste framework;

Against a stability requirement, or against a too strict requirement, following arguments were used:

- at present, there is no EU-wide standard available for determination of stability in compost or digestate and Member States use diverse standards and systems;
- different markets may require different stability values for compost and/or digestate, therefore the stability criterion may better be handled through market mechanisms.

Many Member States already regulate compost stability, whether by imposing certain methods and associated limit values or by requiring a declaration. Most methods are based on a self-heating test or a respirometric index. Studies on the evaluation of the different systems used for stability measurement indicate that the different approaches are actually highly correlated, at least for compost stability. A WRAP study (WRAP, 2009b) suggested that there is no clear superiority of any given method. Nonetheless, EN standards exist for oxygen uptake rate and self-heating tests (EN 16087-1 and EN 16087-2) and hence these should be preferable over national standards or commercial measurement tools to provide a level playing field.
For digestate stability, it appears that fewer measurement methods are being used at present. Most of them are based on organic acids testing or assessment of remaining biodegradability through an aerobic respirometric test or anaerobic biogas formation potential.
Hence, many experts advocated recognizing a number of test methods and limits that are widely in use at present. Moreover, several experts called on the compost and digestate producers, together with competent Member States authorities, to collaborate towards the development of a standardized measurement method and limit value for stability, one for compost and one for digestate, in view of possible future revisions of the end-of-waste criteria.

Another parameter that has been debated intensively within the TWG is the allowable level of **macroscopic physical impurities**. Not only may the presence of metals, glass fragments or plastics cause direct potential risks to users of composts/digestates, their accumulation on soils may also pose a risk for internal injuries to grazing animals and lead to degradation and a decrease of land value. In addition, many macroscopic physical impurities are not inert, as some stakeholders suggested, but may slowly leach or fragment into micro-particles harmful to soil fauna. Furthermore, they are the only directly visible pollutants in the product and therefore play an important role in establishing or, conversely, undermining consumer confidence in end-of-waste materials. Therefore, they might have a large impact on the demand, condition b) in Article 6 of the WFD. Nonetheless, some stakeholders have argued that physical impurities only lead to a perception of lower quality, but do not pose any specific real human health or environmental problem. Certain stakeholders even suggested that end-users such as farmers are not particularly concerned by the physical impurities levels in compost. Finally, most stakeholders stressed the importance of using a uniform measurement and reporting method for

physical impurities. The bleach destruction method, in which all organic matter is destroyed, was preferred by certain stakeholders for its completeness of measurement, yet was criticized by others for its use of corrosive chemicals and higher price (around 75 Euro per sample for the bleach method compared to 50 Euro average price for dry sieving). Other methods based on wet or dry sieving received support for their easiness of use, and their already widespread application in many Member States, even if their accuracy may be slightly lower due to possible confusion of physical impurities with other materials during the manual separation.
The proposed limit value of 0.5% dry matter for plastic, glass and metal materials larger than 2 mm received large support and was in line with many national limits. Nonetheless, both requests to increase and decrease this limit were expressed by distinct stakeholders. Moreover, some stakeholders suggested imposing distinct limits for plastics, metal and/or glass. The data on physical impurities from the various available databases, as discussed in Chapter 3, suggest that the proposed limit may be more challenging in countries where the current limit is higher and/or where separate collection of bio-waste is still in its infancy. A comparison of the large Dutch VFG compost database with a recent French Ineris study indicated that 94% of the Dutch compost samples would meet the proposed 0.5% dry matter limit, compared to only 74% of the French biobin compost samples originating from separate collection. A possible explanation for this observed discrepancy could be that tighter standards on physical impurities in the Netherlands, compared to France, may have led towards actual overall lower physical impurities contents.
A suggestion was also made to introduce a requirement on the absence of sharps, to avoid any injuries upon manipulating the compost. Introducing the latter requirement may be hampered by the fact that a standard measurement method does not exist at present, and that this could lead to liability issues between producers and buyers of compost.

Regarding **heavy metal** concentrations, stakeholders have advocated a number of alternative approaches for setting limit values. These ranged from using the strictest values existing in a Member State to setting very lenient values based on a risk assessment of metal uptake by crops. Whereas such approaches all hold certain merits, their value is limited by the fact that they generally tend to focus on one specific end-of-waste condition, and are less relevant with regard to other conditions. For example, introducing more lenient limits for heavy metal values may still guarantee acceptable human health impacts, but risks to neglect ecological impacts or can even lead to a collapse of the compost market due to a declined consumer confidence. Conversely, setting stricter heavy metal limit values can provide a strong barrier against soil pollution in sensitive areas provided reasonable quantities of compost/digestate are applied. Yet, at the same time, such strict limits may reduce the amounts of compost/digestate that can reach end-of-waste status and hence slow down market development and recycling rates in the EU, whereas the same soil protection goals could be realized by national regulations on the application of compost/digestate in such sensitive areas.
From the examples above, it is clear that setting heavy metal limit values **should take into account all four end-of-waste conditions** and should be based on available data regarding use, markets, existing standards and legislation as well as possible environmental and human health effects. Therefore, the heavy metal limit values proposed in this document are a.o. based on the earlier multi-factor study by Amlinger et al. (2004), as well as on national legislation, which is generally based on a multicriteria evaluation of compost and digestate use. Furthermore, the study of Monteiro et al. (2010) on the environmental impact of Cu and Zn from animal nutrition proved very useful for interpreting soil and water pollution risks from Cu/Zn fertilization. Moreover, extensive data from the JSAC and Chapter 3 were used to evaluate the metal concentration ranges of compost/digestate materials currently being offered on the

European market. The available data were used for intensive workshop discussions and stakeholder consultations. As a result, a considerable increase for Cu and Zn limits was proposed during the Third Workshop (100 to 200 ppm for Cu and 400 to 600 ppm for Zn), whereas it was proposed to maintain the other heavy metal limit values from the initial pilot study (IPTS, 2008).

Nonetheless, following arguments have been quoted by some stakeholders to ***advocate even less strict*** heavy metal limit values:

- **Cu and Zn are desired as micronutrients for plants**. Based on a typical recommended maximum use of compost of 7 to 10 tonne dry matter/ha/year, a Cu limit of 200 ppm and Zn limit of 600 ppm will lead to a maximal annual loading of 1.4 to 2 kg Cu and 4.2 to 6 kg Zn per hectare. These values are well in line with recommended fertilizing practices for normal soils. According to fertilizing guidelines issued by the Austrian ministry (Lebensministerium, 2006), recommended doses for soils with a medium micronutrient fertilizing need are 1 to 3 kg Cu/ha and 5 to 7 kg Zn/ha. Only for Cu/Zn deficient soils or special cultures, higher Cu or Zn doses are needed. On the other hand, recommended maximum compost doses for hobbygardening and private use are often many times higher than for agricultural use, ranging from 5 to 45 l/m^2, corresponding to about 20 to 180 tonne dry matter/ha[44]. In this case, associated Cu and Zn loads to the soil may exceed several times the desirable amounts of these micronutrients. For digestate, effective soil loadings of Cu and Zn may be somewhat lower due to nitrogen limiting the allowable digestate application rates. In any case, the main function of compost or digestate is not to meet high trace element demands for Cu/Zn depleted soils but to act as a soil improver and/or general fertilizer. Moreover, Monteiro et al. (2010) demonstrated that run-off and drainage of Cu/Zn to water bodies may be of concern in sensitive areas where Cu/Zn doses are above those discussed here. Finally, further increasing Cu and Zn concentration limit values in compost and digestate could result in Cu/Zn contaminated materials entering the compost and digestate chain (e.g. non-biodegradable plastic bags, painted wood, etc.). For the sake of completeness, it should also be noted that heavy metals other than Cu/Zn do not have any beneficial effect at elevated concentrations. Hence the micronutrient argument is certainly not valid for advocating an increase of possible limits for other metals than Cu and Zn.
- **Some input streams contain high concentration levels of Cu and Zn** (e.g. manure from piglet rearing, vine material treated with $CuSO_4$, etc), which will unavoidably lead to high levels of Cu/Zn in the compost/digestate material. The JRC Sampling and Analysis Campaign has demonstrated that the proposed limits for heavy metal limit values are feasible values. Chapter 3 showed that more than 85% of the JSAC compost samples from separate collection of bio-waste and green waste met all heavy metal limits proposed. These data were confirmed by literature data on compost and digestate, showing that 90-percentile heavy metal values were below or only slightly above the proposed limit values. Moreover, most of the input materials with high Cu/Zn contents, such as piglet manure, generally do not enter the composting/digestion process as a single stream and hence their high metal content could be partially compensated through careful selection of other input materials with lower metal concentrations.

[44] See http://www.vlaco.be/compostcalculator, http://www.kompost.de/fileadmin/docs/shop/Sonderdrucke/KuR_Kompost_Sonderd_web.pdf and http://www.ages.at/fileadmin/redakteure/lwt-bgp/Download_Broschueren/Kompost_2010.pdf

Moreover, Cu and Zn levels in manure could be reduced by reducing dissipation at the farm (e.g. by avoiding contamination from hoofbaths). Furthermore, an imbalance between the supply of Cu/Zn and the uptake by animals seems one of the major reasons explaining high excretion of Cu/Zn to manure. Farmers may be able to tackle this issue by ensuring that Cu and Zn levels supplied through the feedstuff meet the actual dietary requirements of the animals. In addition, farmers may use feedstuff in which Cu and Zn have been formulated in a way as to ensure a better uptake by the animal. Hence, such relatively simple optimization measures could contribute to further increasing the amount of manure derived materials that meet the proposed end-of-waste metal limit values. Finally, the Expert Group for Technical Advice on Organic Production expressed its opinion that, although it recommended the formal inclusion of copper as an eligible pesticide in order to legalize a traditional practice in organic farming, it supported the explicit reduction of copper use (EGTOP, 2011).

- **Limit values should be derived from a risk assessment.** Several stakeholders suggested that setting metal limit values should be based on a risk assessment and suggested limit increases based on information from existing risk assessment studies. As indicated above, other experts argued that such an approach tends to ignore the other end-of-waste conditions. For instance, markets or demand may collapse due to reduced consumer confidence if limit values are substantially raised or the product quality may conflict with existing standards or legislation for the use of these materials.
- **Certain regions in Europe have high background concentrations of certain heavy metals**, either due to historical pollution (e.g. by industrial activity) or due to natural phenomena (e.g. mineralogical composition of the soil). However, several experts have suggested that other solutions might be more appropriate for these local issues than increasing the EU-wide end-of-waste limit values for certain heavy metals. They argue that the overall quality of end-of-waste compost/digestate produced in the EU may worsen due to a relaxing of the limit values in favour of some specific regions.
- Some stakeholders argued **that end-of-waste criteria should not limit the metal concentrations as it is the total metal load to the soil that is important**, i.e. the concentration times the compost/digestate amount applied. Control of the applied compost/digestate quantity, however, falls outside the competence of Community end-of-waste legislation. Moreover, application control is a typical feature of waste legislation and is often considered as a burden that could be partially tackled through end-of-waste status. Therefore, limit values need to be set that ensure a basic and robust level of environmental and human health protection without the need of application control for a material receiving product status.
- **Limits should be expressed in a different way than on dry matter basis**. Some experts advocated making heavy metal limit values dependent on other parameters, such as the amount of fresh matter or organic matter. For instance, they argued that in the case of digestate the liquid phase contains little dry matter but a large amount of dissolved heavy metals, which will result in high metal concentrations when expressed on dry matter. Yet the data in Table 9 (Chapter 3) showed that median and 90-percentile values expressed in mg/kg dry matter were very much in line for the different phases of a digestate. Furthermore, the same table shows that median and 90-percentile values of heavy metals were very similar for fresh compost, with higher organic matter contents, compared to mature composts, with lower organic matter content. In conclusion, the available data presented in Chapter 3 seem to support the proposal of expressing limit values as function of dry matter in all cases.

- **Strict EU end-of-waste criteria limits might be used to set challenging metal limits for end-of-waste criteria at national level for non-scope materials**, more specifically sewage sludge and MBT composts/digestates. Yet other experts argue that such a move, if it would occur, may provide an incentive for MBT installations and sewage sludge compost/digestate producers to upgrade their technology and carefully select input materials. In addition, it may help stimulate authorities to further push separate collection of fractions such as glass and WEEE. Examples from state-of-the-art MBT installations in France and sewage sludge compost production in Italy, as discussed in Chapter 3, show that the currently proposed heavy metal limit values can in some cases be achieved by these technologies. Nevertheless, several TWG experts suggested that more efforts would be needed to raise their overall quality performance level, which might come at the detriment of yield. In addition, the Waste Framework Directive (WFD) clearly stimulates the separate collection of bio-waste and other waste through articles 11 and 22. The 2012 Guidance on the interpretation of key provisions of the WFD states that "co-mingled collection of more than one single waste stream may be accepted as meeting the requirement for separate collection, but the benchmark of 'high-quality recycling' of separately collected single waste streams has to be examined; if subsequent separation can achieve high-quality recycling similar to that achieved with separate collection, then co-mingling would be in line with Article 11 WFD and the principles of the waste hierarchy". This indicates that the bar for the required quality level should be set by what can be achieved through separate collection and that other technologies should aim to demonstrate equivalent performances.

In addition, following arguments have been quoted by expert TWG stakeholders to ***advocate stricter*** heavy metal limit values:

- Composts and digestate with relatively high organic matter content will **undergo a continued decomposition of the organic matter, leading to a further increase of the metal concentrations in the soil**, according to certain experts. As discussed above, the very similar heavy metal concentration data registered for fresh composts and mature composts, discussed in Table 9 (Chapter 3) do not seem to support this argument.
- **Plants may mix input streams with a high metal loading with other streams**, in an attempt to just meet the limit values. However, the current limit values are considered as safe limits and therefore dilution is not deemed to be an issue. Furthermore, plants mixing different streams with the purpose to meet the pollutant requirements jeopardize the compliance of the output material with the end-of-waste criteria and therefore might suffer economic losses due to increased measurement frequencies and decreased possible sales of end-of-waste compost/digestate.
- The results from the JSAC and other data sources show that when input materials are carefully selected and the composting/digestion process is well performed, **levels of pollution well below currently proposed limit values can be attained without major problems**. According to a large majority of TWG experts, correct source separation of input materials may be the simplest and most cost effective way in ensuring the production of high quality compost/digestate materials. However, whereas this goes without saying in well established markets with a long history of source separate collection, it may be more difficult to realize in starting markets. In practice, it may take some time for authorities and households to implement good source separation practices. Therefore, setting too strict limit values from the beginning risks throttling the development of emerging markets.

The requirement for measuring **organic pollutants** was the subject of intensive debate during the three workshops and TWG stakeholder consultations. Due to the lack of sufficient reliable scientific data that would either prove the ubiquitous presence or the absence of certain organic pollutants in distinct types of compost or digestate, initial TWG discussions were partially based on outdated figures and perceived quality. It was therefore agreed to organize the JRC Sampling and Analysis Campaign (JSAC). The results of this campaign, together with data provided by stakeholders and retrieved from literature sources, were used for extensive discussions at the Third Workshop in Seville (26 February 2013).
Several arguments were put forward by the experts, both against and in favour of the monitoring of organic pollutants.

Following arguments were used ***against*** a mandatory measurement of organic pollutants:

- **Cost of measurements**. Several stakeholders provided cost data showing that measurement costs for heavy metals in compost/digestate were on average 129 Euro for a full metal set (range of 42 to 230 Euro), 149 Euro for PAH_{16} (range of 85 to 245 Euro), 201 Euro for PCB (range of 85 to 480 Euro), 481 Euro for PCDD/F (range of 300 to 741 Euro) and 150 Euro for PFC (only one data source). This shows that PCDD/F measurements are clearly the most expensive, followed by PCB, whereas PAH and PFC measurements only seem slightly more expensive than heavy metal measurements. For comparison, prices provided for the full suite of measurements for quality assured composts/digestates were generally situated between 350 and 550 Euro[45]. Hence, adding the full set of 4 organic compound groups would roughly result in a tripling of the current analytical costs, whereas including only a PAH measurement would lead to an increase of the current measurement costs with about a third. Moreover, if only one PAH measurement would be required for every fifth sample, the average analytical cost for end-of-waste materials would only increase by 7%. In addition, other stakeholders have argued that cost increases would not be linear. As such, data were provided that showed that packages of different analytical parameters were generally more economical, e.g. 190 Euro for a full set of 8 heavy metals, PAH_{16} and PCB_7, compared to 91 Euro for the metals alone, for a same laboratory. Moreover, it is believed that a price increase from implementing mandatory organic pollutants measurements would be partially offset by a price decrease on the long term thanks to EU-wide standardization of the measurements and ensuing increased competition between laboratories.
- **Relevance of compounds for certain waste streams**. Before the JRC Sampling and Analysis Campaign was organised, several experts claimed that organic pollutant loading was a problem limited to certain compost and digestate streams such as sewage sludge and MBT materials. The results of the JSAC combined with stakeholder and literature sources, as discussed in Chapter 3, indicated that organic pollutants may occur in any type of compost or digestate, albeit in different concentration ranges depending on the input material and technology used. Whereas the JSAC data suggest that occurrences of heavy PFC loadings are generally restricted to sewage sludge materials, it could not be shown that PAH, PCB or PCDD/F loadings would be substantially higher in other materials than those derived from source separation. The results from

[45] One exception is the UK were the total analytical cost for digestate under PAS 110 is estimated at 850 Euro, mainly due to the costs related to stability testing. At the time of this study, the UK was investigating whether the method for measuring digestate stability could be simplified. At the low end of the spectrum, EFAR indicated that the full cost for measurement of heavy metals, PAH and agronomical parameters amounts only to 120 Euro per sample, according to information from accredited laboratories contracted by their members.

Chapter 3 furthermore suggested that the PAH compound class is the most likely to be encountered at concentrations above existing national limit and guidance values, with exceedings being recorded for up to a quarter of the sample population. PCB and PCDD/F compound classes displayed more sporadic exceedings of existing national reference limits, in the range of zero to a few percent of the sample population.

- Introducing mandatory organic pollutant measurements **may not be justified by the environmental risk associated to these compounds**. Several stakeholders pointed to the (partial) biodegradability of organic pollutants, limiting or slowing down their long-term accumulation in soils. Furthermore, certain experts claimed that no single study has suggested unacceptable environmental or human health impacts from long-term compost and digestate use. However, other experts pointed out that the same argument may be used in favour of the inclusion of MBT and sewage sludge materials, as well as for materials with higher contents of other pollutant types such as heavy metals. This demonstrates that a mere risk based approach is not recommended as it tends to ignore the other end-of-waste conditions such as market impacts from lacking consumer confidence. Moreover, it has been discussed in Chapter 3 that even if (partial) biodegradation of several organic pollutants occurs, little is known about the fate of the breakdown products. In addition, it should be mentioned that certain experts in favour of organic pollutant measurements were not in favour of measuring all 16 US EPA PAH compounds, arguing that not all congeners exhibit similar levels of intrinsic toxicity. The French quality assurance system (NF U44-051 and NF U44-095) was referred to in this discussion, where only 3 PAH compounds are currently subject to mandatory measurement in compost. However, other experts suggested that the 16 US EPA PAH congeners are considered to be an internationally recognised set of reference compounds and that the price difference between measuring 3 or 16 PAH compounds is minimal due to the fixed costs for sample preparation and measurement.
- **Difficulties in setting specific limit values**. Chapter 3 provides an overview of limit values and guidance values for organic pollutants in different European countries for compost/digestate or similar materials (Table 11). The data show that limit values indeed differ from country to country to some extent. This may be explained by the slightly different approaches that countries have applied in establishing limit values as well as by the uncertainties that are inherent to risk assessments. However, most limit values are of the same order of magnitude for a given parameter and hence a limit value that is proposed within the existing range of legal limits and guidance values should be close to all national limits.

In favour of a mandatory organic pollutant measurement, following arguments were used:

- **Possible synergetic effects** of organic pollutant mixes. Certain experts argued that the toxicity of certain compounds can be affected by the presence of other compounds. Therefore, even when individual concentrations of organic pollutants are below a threshold level to cause known adverse environmental or human health effects, it is difficult to exclude synergetic effects from the pollutant mix. This argument had also been used by many experts to advocate the exclusion of sewage sludge and MBT materials from eligibility of EU end-of-waste status. They claimed that these materials may contain more pronounced traces of organic pollutants than those derived from source separation, leading to a possibly overall higher toxicity. Figure 10 in Chapter 3 illustrates the possible synergetic effects from different pollutants by displaying dioxin-like effects as perceived by a bio-assay in which cells are exposed to compost and digestate materials. The response of this test could not be linked to the concentration of a certain class of compounds but cell reactions seemed to be triggered by various compound types. Nor did the test results suggest a markedly higher toxicity response for a certain compost/digestate type. Hence, some experts had suggested using such a biological assay test, rather than a series of chemical analyses, for determining organic pollution limits for compost and digestate. However, the complex structure of compost and digestate may influence the toxicity of the pollutants present in its matrix. Hence, despite the cost advantages that such a broad-spectrum biological assay test could offer in theory, further research will be needed to develop a robust standardized test method that enables a straightforward interpretation. Therefore, any currently proposed end-of-waste concentration limit values for pollutants should be rather conservative according to several experts.

- **Building consumer confidence from quality products**. Throughout the various workshop discussions and stakeholder consultations, many stakeholders had stressed the importance of building and safeguarding consumer confidence in compost/digestate products. Concerns about consumer confidence had been a major argument used to exclude materials with low (perceived) quality from eligibility for EU end-of-waste status. Several experts cited historical incidents where substandard compost materials had negatively affected the image of the whole compost market, resulting in a strenuous image recovery operation that took several years. Most experts also agreed that the hard-earned consumer confidence in quality products should not be jeopardized, but opinions differed between stakeholders on the necessary actions. Certain stakeholders argued that restricting input materials to those derived from source separation should be a sufficient measure to guarantee product quality and protect consumer confidence. However, other stakeholders acknowledged that JSAC and literature data confirmed that organic pollutants in compost and digestate may exceed existing limit concentrations for a considerable fraction of the sample population. Based on these findings, they advocated safeguarding consumer confidence in EU end-of-waste compost/digestate materials by ensuring that only quality products receive end-of-waste status, through regular monitoring and elaboration of a database on organic pollutants in compost and digestate.
- **Supporting and protecting emerging markets**. Many compost and digestate markets are still in their infancy, especially in EU-12 Member States. Hardly any literature data on compost/digestate quality exists for these markets and they were heavily underrepresented in the JSAC as well. These markets will be confronted with challenges in helping consumers shift their attitudes towards waste handling as to ensure a correct source separation. Feedback from the mandatory measurements of heavy metals and physical impurities will help in steering these efforts, but should be complemented by organic pollutant data, according to certain experts. Moreover, as elsewhere in the EU, some geographical areas may be affected by severe historical pollution with organic chemicals and it should be avoided that such pollution is unknowingly spread by the use of compost or digestate from these areas.
- **Fraud combatting**. All experts agreed that it should be avoided that the compost/digestate route is used as a cheap but illegal way for disposing of contaminated waste streams. Although input material controls are in place in the proposed end-of-waste criteria, it may be difficult to differentiate polluted waste streams from unpolluted ones by mere visual inspection. For instance, it may be difficult for plant operators to visually detect any difference between polluted roadside green waste and ordinary park or garden green waste. Several experts suggested that a minimal monitoring system should be in place to discourage any deliberate fraud attempts.

Apart from the TWG expert discussions, existing legislation and practices in Member States can constitute a valuable starting point for selecting compounds, determining limit values and setting measurement frequencies for organic pollutants.
Table 11 in the previous chapter provided an overview of existing legislation on organic pollutants for composts, digestates and similar materials in various Member States. Such legislation is generally elaborated from a substantial knowledge base of in-depth studies, historical pollution cases, accumulation calculations, risk assessments, etc. Table 11 indicates the recurrence of the compounds PAH, PCB and PCDD/F in many a national legal text on compost, digestate or similar fertiliser materials. In addition, it should be noted that the on-going revision of the Sewage Sludge Directive (86/278/EEC), based on extensive consultation[46], has focussed on several limits for PCBs, PAHs and PCDD/Fs. Finally, actual limit values for PCBs, PAHs and PCDD/Fs in fertilisers have been proposed by the Working Group on the Revision of the European Fertiliser Regulation (EC No 2003/2003) (DG ENTR, 2012). The repetition of PAH, PCB and PCDD/F in the examples above is in line with the observations from Amlinger et al. (2004), where it was reported that from the large number of potentially hazardous compounds the chlorinated pesticides, the PCBs, PAHs and PCDD/Fs are considered to be ecologically relevant due to their high stability and toxicity.
Regarding measurement frequencies for organic pollutants, practices clearly differ in Member States. Whereas organic pollutant measurements are done on a routine basis for all compost/digestate products in some Member States (e.g. Belgium, France), occasional or systematic spot monitoring programs have been carried out in other Member States (e.g. Germany, UK) and others have no monitoring mechanism at all in place. Member States where routine measurements are part of a quality system sometimes impose a lower analysis frequency for organic pollutants than for other parameters such as heavy metals. This is for instance the case in France where a mandatory measurement is in place for 3 PAH compounds for all types of compost, including these from source separated input materials. PAH are analysed by at least 2 measurements per year for plants with a compost production of more than 7000 tonne/year, whereas heavy metals need to be measured at least 4 times per year in such plants, according to norm NF U44-051.
Financing of organic pollutant analyses also depends on the system, with spot monitoring systems often being financed by government means and routine measurements being financed directly by the producers or the compost/digestate sector.

Finally, most experts seemed to agree on the following:

- extensive data from literature and other databases, such as it is available for heavy metals, appears to lack for organic pollutants in compost and digestate;
- polluted materials should be barred from entering the end-of-waste compost/digestate chain;
- any organic pollutant measurement cost incurred should be kept low and in relation to the expected benefit, such as increased consumer confidence or environmental and human health protection;
- only compounds should be targeted for which it is realistic that they might exceed relevant limit values;
- any measurement should be done in a standardized way across the EU.

Therefore, despite the diverging views that still existed within the TWG after the discussions, it is proposed to focus the mandatory monitoring on the compound family for which the available

[46] For more information, see http://ec.europa.eu/environment/waste/sludge/pdf/part_iii_report.pdf

data suggested the highest likelihood of occurrence at concentrations above existing national limit levels, namely PAHs. These compounds carry the lowest analytical cost of all organic pollutants and the analysis cost may be even further reduced when offered as part of an analysis package. Therefore, a mandatory PAH_{16} measurement is proposed, with a substantial reduction in measurement frequency after the recognition year in case measured concentration levels remain below a proposed limit.

The results from these mandatory PAH_{16} measurements could help establish a EU-wide knowledge base on organic pollutants in compost and digestate. Furthermore, it is recommended that the PAH_{16} data are complemented by other information on organic pollutants in compost and digestate. Hence, producers of end-of-waste compost and digestate, together with competent local authorities, are encouraged to **organize spot monitoring programs** for organic pollutants with following characteristics:

- measurement of PCB, PCDD/F and other relevant organic pollutant compounds;
- based on independent and random sampling;
- repeated in time as to include new producers and to follow evolutions;
- using Horizontal standards where available or, if not, widespread and internationally recognized standard methods;
- taking appropriate actions where guidance values of 0.2 mg/kg d.m. for PCB-7 and 30 ng I-TEQ/ kg d.m for PCDD/F are exceeded.

The hence acquired knowledge base may be used in the future to redefine analytical needs for organic pollutants in the framework of end-of-waste compost and digestate production.

<u>Other product quality requirements</u> were proposed by certain stakeholders as well. These included minimum N/P/K values, dry matter content, C/N ratios, plant response, plastic film content, etc. However, experts argued that several of these parameters only had a tradition of use in certain Member States and that there was little demand to expand these to the framework of EU-wide end-of-waste criteria. In some cases, these parameters could be linked to use in certain specific market sectors (e.g. horticulture). In other cases, it was argued that these parameters could be better managed by market mechanisms or national legislation on use and therefore some of these should only be declared, rather than subject to limits. See also section "4.7 Requirements on the provision of information" for a list of parameters whose mandatory declaration has been proposed.

<u>Compost product quality criteria</u>

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and based on the results from the JRC Sampling and Analysis Campaign, taking into account external data and considering the different stakeholder views discussed above, following minimum quality requirements for **compost could be proposed:**

- A minimum organic matter content. A minimum value of 15% on dry weight was greatly supported, as the initially proposed value of 20 % from the First Working Document was estimated to be too high by several experts. A minimum concentration of 15% is necessary as a protection threshold against organic manufactured mineral soils, which may contain high quantities of clayey materials. At the same time, it allows for materials with low natural organic matter such as green compost or very mature compost.

- Stability. For compost stability, materials are allowed that display a Rottegrad III, IV or V (self-heating test temperature rise of max. 30 degrees C above ambient temperature) or a respirometric index result of maximum 25 mmol O_2/kg organic matter/h. The methods to be used should be EN standards 16087-1 and 16087-2. If a Member State already has an official method in place that differs from the two methods above, together with an associated limit value, the Member State competent authorities may complement or replace the two methods described above with its existing method and associated limit value as an eligible alternative. Materials being produced in one Member State and used or put on the market in a different Member State shall meet the requirements of both Member States for the stability criterion unless the receiving Member State recognizes the method of the producing Member State.
- Pathogens: *E. Coli* and *Salmonella* were indicated as the most important pathogen indicator organisms. There was large support for the criteria 1000 CFU/g fresh mass for *E. Coli* and no *Salmonella* spp. in 25g of sample, which exist already in many national specifications. Most stakeholders supported the idea of having a pathogen criterion parallel to a criterion of a time-temperature profile.
- Viable weed seeds and plant propagules: there was large support for the criterion of maximum 2 viable weed seeds per litre of compost.
- Macroscopic impurities: here it was proposed to modify the original proposal of impurities (0.5% on dry matter base) into a more clear formulation of glass, metal and plastics. Stones should not be seen as a man-made contamination and do not pose an environmental or health risk, and it appears to be more appropriate to regulate their content through market mechanisms. Large support was received for 0.5% on dry matter base for glass, metal and plastics > 2mm.
- Heavy metal values. As outlined above, there were both requests for increasing and lowering heavy metal limit values from the initial proposal in the First Working Document. Based on the above discussions, it is concluded that earlier proposals for heavy metal limit values should remain as developed in the previous working documents, except for Cu and Zn, where the allowable concentrations could be increased.
- Organic pollutants: following the above discussion, a limit of 6 mg/kg dry matter is proposed for PAH_{16}, in line with existing national legislation.

<u>Digestate product quality criteria</u>

During the TWG stakeholder consultation, less feedback was received regarding digestate product quality requirements. However, those stakeholders providing input on digestate generally had a positive attitude towards setting end-of-waste quality criteria for digestate, supporting existing standards such as the UK PAS 110, Swedish SPCR 120 or German RAL GZ 245, or proposing similar quality requirements. Nonetheless, some stakeholders were not in favour of setting end-of-waste criteria for digestate for a number of reasons quoted, such as a lack of demand for digestate, a lack of stability, a low market value, etc.

Some stakeholders advocated the establishment of a separate set of product quality criteria for digestate to highlight the difference in nature and use between compost and digestate. Among stakeholders suggesting a separate set of criteria for digestate, opinions varied whether these should be as close as possible to those of compost or clearly different from those of compost. Those in favour of keeping a very similar set of requirements often suggested that keeping the same requirements for digestate as for compost would avoid that input streams that exhibit a somewhat higher contamination would be transferred from one treatment option to another. Those in favour of a clearly different set of criteria for digestate suggested that this would allow alleviating certain problems typical of anaerobic digestion, such as the often high Cu and Zn levels encountered in digestate.

Following the discussions at the three workshops, the various written consultations of the TWG and based on the results from the JRC Sampling and Analysis Campaign, taking into account external data and considering the different stakeholder views discussed above, following minimum quality requirements for **digestate could be proposed:**

- Minimum organic matter content. Generally, digestates are less likely to contain large amounts of inorganic material due to the nature of the input materials used and there is little tendency of mixing digestate with inorganic materials prior to use. In order to be in line with the requirements for compost, a value of at least 15% on dry weight is proposed.
- Stability. For digestate stability, materials are allowed that display a stability value that meets one of the currently existing limit values (respirometric index result of maximum 50 mmol O_2/kg organic matter/h measured according to EN 16087-1, organic acids content of max 1500 mg/l or residual biogas potential of maximum 0.25 l/ g volatile solids). Alternatively, the competent authorities of a Member State may complement or replace the three latter methods and associated limit values with a new method and associated limit value that provide equivalent stability guarantees, as an eligible alternative. Materials being produced in one Member State and used or put on the market in a different Member State shall meet the requirements of both Member States for the stability criterion unless the receiving Member State recognizes the method of the producing Member State.
- Pathogen control: Here the same values as for compost are clearly supported: 1000 CFU/g fresh mass for *E. Coli* and no *Salmonella* spp. in 25g of sample. Some suggestions were made to test for Plasmodiophora brassicae, tomato seeds and Salmonella Senftenberg W_{775}, but these were not generally supported.
- Viable weed seeds and plant propagules: Here as well wide support was received for the criterion of maximum 2 viable weed seeds per litre of digestate.
- Macroscopic impurities: here it was also proposed to modify the original proposal of impurities (0.5% on dry matter base) into a more clear formulation of glass, metal and plastics. Large support was received for 0.5% on dry matter base for glass, metal and plastics > 2mm. Moreover, digestates from liquid digestion systems are less likely to contain high contents of physical impurities as these must be removed in the pretreatment steps to avoid physical damage to the digester system.
- Heavy metal values: the same reasoning as for compost is valid for digestate to retain the earlier proposed limit values, except for Cu and Zn, where the allowable concentrations could be increased.
- Organic pollutants: the same reasoning as for compost is valid for digestate to propose limit values for PAH_{16}.

In conclusion, this leads to following set of proposed criteria **for compost and digestate**

Parameter	**Value**	**Comments**
(1) Minimum organic matter content:	15% on dry matter weight	The minimum organic matter content of the final product, after the composting/digestion phase and

		prior to any mixing with other materials. This is intended to prevent dilution of compost/digestate with mineral components (e.g. sand, soil).
(2) minimum stability	***<u>Compost</u>***: Unless an eligible alternative method has been specified by the competent authorities, the producer must demonstrate to meet at least one of the following two stability criteria for compost: -Respirometric index of maximum 25 mmol O_2/kg organic matter/h, measured according to standard EN 16087-1. -Minimum Rottegrad III, IV or V (self-heating test temperature rise of maximum 30 °C above ambient temperature), measured according to standard EN 16087-2. If a Member State already has an official method in place that differs from the two methods above, together with an associated limit value, the Member State competent authorities may complement or replace the two methods described above with its existing method	A minimum stability should avoid unwanted emissions during transport and storage and prevent materials from entering the market without proper treatment. Materials being produced in one Member State and used or put on the market in a different Member State shall meet the requirements of both Member States for the stability criterion unless the receiving Member State recognizes the method of the producing Member State.

	and associated limit value as an eligible alternative. ***Digestate***: Unless an eligible alternative method has been specified by the competent authorities, the producer must demonstrate to meet at least one of the following three stability criteria for digestate: -Respirometric index of maximum 50 mmol O_2/kg organic matter/h, measured according to standard EN 16087-1. -Organic acids content of maximum 1500 mg/l -Residual biogas potential of maximum 0.25 l/ g volatile solids. As an eligible alternative, the competent authorities of a Member State may complement or replace the three methods described above with another method and associated limit value providing equivalent stability guarantees.	
(3) no content of	No *Salmonella* sp.	Measurement of this parameter should be

pathogens	in 25 g sample 1000 CFU/g fresh mass for *E. Coli*	complemented by a requirement on processing, e.g. a temperature-time profile.
(4) limited content of viable weeds and plant propagules	2 viable weed seeds per litre of compost/digestate	Measurement of this parameter should be complemented by a requirement on processing, e.g. a temperature-time profile.
(5) limited content of macroscopic impurities	0.5% on dry matter weight for glass, metal and plastics > 2mm to be determined by the dry sieving method	There is a need to distinguish between natural impurities such as stones and manmade impurities.
(6) limited content of heavy metals and organic pollutants:	mg/kg (dry weight)	In the final product, just after the composting/digestion phase and prior to any mixing with other materials
Cd	1.5	
Cr	100	
Cu	200	
Hg	1	
Ni	50	
Pb	120	
Zn	600	
PAH_{16} (sum of naphthalene, acenaphtylene, acenaphtene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene)	6	

Requirements on product testing for compost and digestate

Following the different discussions at workshops and during the TWG stakeholder consultation, many calls were made to set a **minimum sampling frequency**, in order to guarantee common standards across Member States. Furthermore, it was generally supported that the measurement frequency should be established depending on the size of the compost or digestate producing plant. At the same time, there was wide support for a **minimization of the**

burden incurred by frequent sampling and analysis, by allowing for a reduction in measurement frequency for those parameters that repeatedly are far below the limit values.

Different arguments were used during the discussions. A majority of the TWG was in favour of some form of independent sampling. However, some experts questioned whether all sampling needed to be contracted by professional external independent samplers. They proposed that producers should be allowed to partially carry out sampling themselves, provided plant personnel is available that has received the proper training for correct sampling. The major reason given for this was the cost for external sample taking, which was on average around 200 Euro per sample (price range of 20 to 550 Euro reported by experts). This cost is considerably higher than the cost for internal sampling by trained plant staff, which is estimated at around 50 Euro per sample, covering training and labour costs, as well as shipping fees.

Other stakeholders opposed the idea of abandoning independent sampling for reasons of consumer confidence and possible fraud combatting. They also indicated that not all plants may have the necessary trained staff to correctly carry out sample taking and that independent sampling is needed in case of customer complaints about the quality of the received compost/digestate. Some stakeholders proposed to reduce the sampling frequency over time, as function of the historical quality output, whereas other stakeholders were in favour of keeping a constant measurement frequency after the recognition year.

Other suggestions made by experts were related to the introduction of different measurement frequencies for some parameters than for others. As such, the measurement frequency could be reduced for e.g. organic pollutants after initial assessment in case the compost/digestate displays low organic pollutant levels. In this context, proposals have been discussed at the Third Workshop to reduce the monitoring frequency for PAH_{16} measurements after the recognition year and as long as the measurement values prove to be below the limit value. Expert opinions on such a reduction varied widely, with some advocating an identical measurement frequency for organic pollutants as for other parameters at all time, whereas others were in favour of completely abolishing organic pollutant measurements, either from the very beginning or after the recognition year.

Different mechanisms were also proposed by the various experts for relaxing sampling and measurement requirements for plants after the recognition year. Some experts proposed that *all individual* measurement results from the recognition year should have to respect a reference value (e.g. 80 % of the limit value) in order to benefit from subsequent reductions in sampling and analysis, whereas other experts suggested that the *average* measured parameter values should respect a reference value (e.g. average value below 50% of limit value). Other experts suggested to merely reduce measurement frequencies for those parameters that were consistently complying with certain requirements. However, other experts pointed out that it is very difficult to determine a sensible reference value other than the limit value. Moreover, some experts suggested that selective and partial measurement reductions could lead to a situation where certain plants can benefit from reduced analyses for some parameters, even if they regularly fail other product quality requirements. They argued that only those plants should benefit from reduced measurements whose outputs feature a constant overall quality.

Following the discussions, and despite diverging expert opinions, following proposal could be made that provides a reasonable limitation to sampling cost, while aiming to safeguard the necessary consumer confidence:

- the default sampling and analysis frequency is given by the formula: *number of analyses per year = amount of annual input material (in tonnes)/10000 tonne + 1*;

- a minimum measurement frequency is proposed for the recognition year: 4 samples or more (except for the smallest plants), as well as for the following years: 2 samples or more (except for the smallest plants);
- the smallest plants should be able to benefit from reduced sampling requirements: one sample for every 1000 tonnes input material, rounded to the next integer, is required in the recognition year for plants up to 3000 tonne annual input and only one yearly measurement is required for plants with an annual input up to 1000 tonne in subsequent years;
- all mandatory measurement frequencies are capped at 12 measurements per year;
- PAH_{16} measurements are subject to a separate, reduced mandatory measurement frequency. After the recognition year, this measurement frequency is also decreased, ensuring a spot monitoring for the smallest plants. The frequency is given as follows:

Recognition year	
Annual input (tonne)	**Samples / year**
≤ 3000	1
3001-10000	2
10001-20000	3
20001- 40000	4
40001- 60000	5
60001- 80000	6
80001-100000	7
100001-120000	8
120001-140000	9
140001-160000	10
160001-180000	11
> 180000	12

Following years	
Annual input (tonne)	**Samples / year**
≤ 10000	0.2 (once per 5 years)
10001-25000	0.5 (once per 2 years)
25001-50000	1
50001-100000	2
100001-150000	3
150001-200000	4
200001-250000	5
250001-300000	6
300001-350000	7
350001-400000	8
400001-450000	9
450001-500000	10
500001-550000	11
> 550000	12

- all sampling and analysing needed to meet the minimum sampling and analysis frequency requirements must be carried out by independent external samplers and laboratories;
- it is recommended to have 100% external and independent sampling in subsequent years. Nonetheless, provided all analysis results in a given year respect the specified limit values, the producer may benefit from a modification to the default sampling requirements in the following years, unless opposed by the competent authorities. This modification may be maintained as long as all of the measurements during a year respect the limit values. Under this modification, only half of the default total annual minimum required samples, rounded up to the next integer, must be acquired by external independent samplers, the remaining samples may be collected by properly trained plant personnel. In this case, the producer shall keep the necessary records to be able to demonstrate at all times that internal sampling does not lead to a bias in the analytical results compared to external sampling. In any case, all samples taken for PAH_{16} measurements need to be taken by external independent samplers.

Table 13 provides a summary overview of the proposed minimum requirements on sampling and analysis frequency, together with the estimated associated costs. Cost estimations have been made based on data provided by several expert stakeholders on costs for mandatory sampling and measurement of parameters under the proposed EU end-of-waste framework.

These costs and their ranges have been discussed above and typical cost values have been used for the calculations.

The composting and digestion landscape widely differs across the EU. Commonly, installations with an annual input capacity below 10 ktonne are dedicated to local green waste composting whereas anaerobic digestion plants generally have a larger input capacity. Very few composting or anaerobic digestion plants have a capacity larger than 120 ktonne annual input. Nonetheless, the average annual input capacity for composting and digestion installations in several Member States is situated between 10 and 50 ktonne, according to expert info. The data in Table 13 indicate that for installations in this capacity range, the cost for sampling and analysis ranges from 0.07 to 0.31 Euro per tonne, which is only a small fraction of the gate fees that are generally being charged. Moreover, for these plants, the cost for organic pollutant measurement is reduced to 30-150 Euro per year, or 0.003-0.015 Euro per tonne input after the recognition year.

In addition to this, it should be stated that the calculated prices presented in Table 13 are based on rather conservative assumptions regarding the cost for organic pollutant (PAH_{16}) measurements. The full actual average market price for a PAH_{16} measurement was assumed, rather than a more realistic reduced price increment as part of a measurement package. It should be noted as well that the calculations did not take into account the possible price effects from increased competition thanks to standardized methods across the EU, but neither from the needed investments for laboratories to shift to Horizontal standards. These effects will most probably contrast but it is difficult to predict their overall effect.

Moreover, it should be clear that the proposed reduction in external sampling and organic pollutant analysis in this document, compared to the Third Working Document proposal[47], ensures important cost savings for plants. Assuming an analytical cost of 980 Euro for the 4 organic compound sets (PAH, PCB, PCDD/F and PFC), the unit cost per tonne would have been between 0.10 and 0.65 Euro per tonne for installations of 10 to 50 ktonne annual input, according to the proposal from the 3rd Working Document. Hence, the current proposal amounts to a reduction of sampling and analysis costs for these plants of more than 50% in the recognition year and cost reductions of 27 to 48% in subsequent years, compared to the proposal from the Third Working Document. For relatively small plants (<10 ktonne annual input), the relative cost reductions of the new proposal are even more outspoken, namely 51% in the recognition year, and 48 to 70% in subsequent years.

In summary, the cost estimations discussed above clearly indicate that the sampling and analysis cost associated to the proposed EU end-of-waste framework appears very reasonable compared to typical overall operating costs for most plants and that the additional cost induced by measurement of PAH_{16} represents only a minimal fraction of the typical operating cost of most medium-sized to large plants.

[47] The Third Working Document proposal included the mandatory measurement of 4 organic pollutant families (PAH, PCB, PCDD/F and PFC) at identical frequency like the other measurements in the recognition year and for one cumulative sample in subsequent years. Furthermore, 100% external sampling was required at all times. The minimum sampling frequency was calculated according to the default formula, with individual minimum and maximum values for the first and subsequent years. For details, see "Annex 20: Proposed end-of-waste criteria from 3rd Working Document".

Table 13: Overview of minimum sampling frequency and associated estimated costs for sampling and analysis, calculated according to the proposed EU end-of-waste framework assuming an external sampling cost of 200 Euro, an internal sampling cost of 50 Euro, an analytical cost excluding PAH_{16} of 450 Euro and a PAH_{16} analytical cost of 150 Euro (prices without VAT).

	Sampling and analysis frequency (number/year)										Cost			
	Recognition year					Following years					Recognition year		Following years	
	Sampling			Analyses		Sampling			Analyses					
Annual Input (tonne)	Total	External	Internal	All but PAH	PAH	Total	External	Internal	All but PAH	PAH	Total (Euro)	Unit cost (Euro/tonne)	Total (Euro)	Unit cost (Euro/tonne)
<500	1	1	0	1	1	1	1	0	1	0.2	800		680	
500	1	1	0	1	1	1	1	0	1	0.2	800	1.60	680	1.36
1000	1	1	0	1	1	1	1	0	1	0.2	800	0.80	680	0.68
1500	2	2	0	2	1	2	1	1	2	0.2	1450	0.97	1180	0.79
2000	2	2	0	2	1	2	1	1	2	0.2	1450	0.73	1180	0.59
2500	3	3	0	3	1	2	1	1	2	0.2	2100	0.84	1180	0.47
3000	3	3	0	3	1	2	1	1	2	0.2	2100	0.70	1180	0.39
3500	4	4	0	4	2	2	1	1	2	0.2	2900	0.83	1180	0.34
4000	4	4	0	4	2	2	1	1	2	0.2	2900	0.73	1180	0.30
4500	4	4	0	4	2	2	1	1	2	0.2	2900	0.64	1180	0.26
5000	4	4	0	4	2	2	1	1	2	0.2	2900	0.58	1180	0.24
7500	4	4	0	4	2	2	1	1	2	0.2	2900	0.39	1180	0.16
10000	4	4	0	4	2	2	1	1	2	0.2	2900	0.29	1180	0.12
15000	4	4	0	4	3	3	2	1	3	0.5	3050	0.20	1875	0.13
20000	4	4	0	4	3	3	2	1	3	0.5	3050	0.15	1875	0.09
25000	4	4	0	4	4	4	2	2	4	0.5	3200	0.13	2375	0.10
30000	4	4	0	4	4	4	2	2	4	1	3200	0.11	2450	0.08
40000	5	5	0	5	4	5	3	2	5	1	3850	0.10	3100	0.08
50000	6	6	0	6	5	6	3	3	6	1	4650	0.09	3600	0.07
60000	7	7	0	7	5	7	4	3	7	2	5300	0.09	4400	0.07
70000	8	8	0	8	6	8	4	4	8	2	6100	0.09	4900	0.07
80000	9	9	0	9	6	9	5	4	9	2	6750	0.08	5550	0.07
90000	10	10	0	10	7	10	5	5	10	2	7550	0.08	6050	0.07
100000	11	11	0	11	7	11	6	5	11	2	8200	0.08	6700	0.07
110000	12	12	0	12	8	12	6	6	12	3	9000	0.08	7350	0.07
120000	12	12	0	12	8	12	6	6	12	3	9000	0.08	7350	0.06
>120000	12	12	0	12	9-12	12	6	6	12	3-12	≤9600		≤8700	

Nonetheless, **for very small plants**, product quality measurement costs may constitute an insurmountable barrier to joining the end-of-waste system. This group typically comprises small scale community composting systems that work on a voluntary basis or with limited financial means and do not charge gate fees. In this context, some experts had suggested to further relax or lift requirements on mandatory measurements for these small plants, in order to allow them to operate within the end-of-waste framework. However, other experts signalled that such relaxations could undermine the trustworthiness of the proposed end-of-waste system and jeopardize the level playing field. Moreover, opponents of relaxed requirements for very small plants indicated that Member States already have the necessary means at their disposal to recognize the valuable contributions of these plants to the recycling chain, outside of the end-of-waste framework (see also section 5.2.4 "Overall assessment").

Finally, **changes to the input streams** could possibly lead to a surge in inorganic or organic contaminants. Stakeholder experts were in favour of adapting the analytical needs to important changes in input material or to likely quality variations in input materials, although opinions varied on what precise change should lead to an adaptation. Given the proposed limitation of the scope to input materials from source separation, it was argued by a majority of stakeholders that only a major change should lead to changes in measurement frequency. Such major changes may be linked to a change of supplier or the introduction of a new type of input material. Natural seasonal variations of input materials, e.g. those occurring in municipal recycling parks for household green waste, were not considered to be major changes by most experts. Furthermore, changes in intake or production volume were not considered major changes neither, as long as there is no change in the used input materials.
Therefore, it could be proposed that only in the case of an important change of 20% or more in the composition of input materials, the measurement frequency should be adapted and reset to the measurement frequency of the recognition year, while still allowing the plant to produce end-of-waste material.

Most experts agreed on applying the principle of probabilistic sampling. Nonetheless, several experts suggested to either provide guidance on how such a system should be interpreted or to clearly define the **conditions for passing/failing** the product quality requirements. Other experts advocated the use of existing practices under national quality assurance systems for compost/digestate. Based on expert feedback, it was understood that many Member States have already systems in place that describe how to act in case of disrespecting a certain limit value. Such systems generally have many common elements, such as the possibility to repeat measurements on the original sample or the possibility to measure a new sample from the same batch or production entity. Hence, following cascade system could be proposed:

> When all measurement results respect their corresponding parameter limit values, a material shall be deemed to have met the output quality criteria.
>
> If this is not the case for one or several measurement results, the plant operator may proceed as follows:
>
> 1. Wherever a certain parameter is unlikely to undergo important changes due to sample storage[48], the operator may order one or several repeated measurements of the same sample for the parameter(s) that failed to respect the limit value, starting from the sample pretreatment procedure (e.g. drying, acid digestion, etc.) for each new measurement. For the calculation of the 95% confidence interval, all measurements shall be given equivalent weighing, including the original one, and a normal distribution shall be assumed. Outliers may be removed from the measurement results according to the procedures described in ISO 5725-2. The 95% confidence interval obtained shall respect the corresponding limit value.

---

[48] Parameters such as organic matter content, weed seeds, physical impurities, heavy metals and PAH are not likely to undergo important changes during correct storage of a compost/digestate sample. However, stability and pathogen content may change considerably because of biological processes taking place in the stored compost/digestate sample. As a consequence, repeated measurement of the original sample should be avoided for the latter two parameters and a new sample should be taken.

2. If procedure 1 fails, or if the operator prefers to do so immediately, one or more additional samples from the same batch or production entity as the original sample may be obtained through independent external sampling and measured externally for the parameter(s) that failed to respect the limit value. For the calculation of the 95% confidence interval, all samples shall be given equivalent weighing, including the original one, and a normal distribution shall be assumed. Outliers may be removed from the measurement results according to the procedures described in ISO 5725-2. The 95% confidence interval obtained shall respect the corresponding limit value.

The 95% confidence interval is calculated as: $mean \pm 1.96 * \frac{standard\ deviation}{\sqrt{number\ of\ measurements}}$

"*The 95% confidence interval obtained shall respect the corresponding limit value*" means that the upper boundary of the confidence interval is below the corresponding limit in case of a maximum limit (e.g. heavy metals) or that the lower boundary of the confidence interval is above the corresponding limit in case of a minimum limit (e.g. organic matter content).

There is no limit to the number of repeated measurements or additional samples that can be taken. Additional measurements are likely to narrow the confidence interval but it should be noted that extensive repeated measurements and/or resampling might increase the analytical costs considerably.

If both procedure 1 and 2 fail, the concerned batch and subsequently produced batches that have not been investigated through independent sampling and analyses and having successfully met all end-of-waste criteria shall be discarded as waste. Moreover, the producer shall take corrective actions to avoid future exceedings of limit values. Furthermore, the measurement frequency for the specific type of compost or digestate (with respect to feedstock composition and production process) and for all output product quality parameters will be reset to the recognition year. End-of-waste status for materials can only be granted again after successfully meeting *all* output quality criteria for a new batch that has been produced after implementing the corrective measures. Note that materials that have been discarded as waste may remain valid input materials for new composting/digestion processes as long as the exceedings were not related to heavy metals and/or PAH.

It is also important to note that a reset to the recognition year is only due when the failure is related to any measurement from the mandatory product quality monitoring programme, of which the minimum sampling and analysis frequency has been outlined above. When a producer suspects that there has been a problem with e.g. the input materials or time/temperature profiles, he may decide to perform separate, individual measurements on e.g. heavy metals or E. Coli and discard/reprocess a batch if it turns out that there have been indeed exceedings. In such case, it is clear that the producer did not intend to request end-of-waste status for a non-compliant material and that he merely ran the additional measurements to check the possible consequences of presumed or known problems. Such early problem detection would prove that the plant's quality management system is working well. Therefore, in such case, there would be no ground for increased quality control by resetting the mandatory product quality measurement frequency of the plant to that of the recognition year.

Moreover, the procedure implies that only those streams that fail the quality criteria at some point should be subject to a reset of the measurement frequency. Hence, if a plant has different lines of production for end-of-waste materials, e.g. green waste compost and bio-waste digestate, different measurement frequencies could be in place for these different streams, depending on the quality requirements compliance history of the distinct compost/digestate materials.

Regarding the **testing methods** to be used, there was large support from the TWG for using EU-wide harmonized standards, especially those developed in the CEN **Horizontal** Project (CEN TC 400), which were established in view of a wide range of materials, or when not available, those from CEN TC 223 on soil improvers. In case relevant Horizontal or CEN TC 223 standards would not be available, several experts suggested using widely recognised and internationally applied standards and methods, e.g. those from the Quality Assurance Quality Manual of the European Compost Network. Nonetheless, some stakeholders requested the recognition, albeit temporarily, of national standards, to avoid too sudden changes in common practice and high adaptation costs for producers. Certain stakeholders requested proficiency testing of national standards against Horizontal standards. However, other stakeholders were clearly opposed against the continued use of national standards in case of availability of Horizontal standards, as this might lead to continued discussions on mutual recognition of measurement data and would contradict with the rationale of the Horizontal project. Moreover, ring test data presented by experts indicated a very high variability in obtained measurement results whenever national standards were used to measure the same parameter on a sub-sample of the same compost (Decelle and Martel, 2011). Some stakeholders also questioned the validity of Horizontal standards and claimed that they would generally exhibit inferior reproducibility characteristics. However, publicly available validation data from project Horizontal[49] for different material matrices did not seem to confirm these allegations, but on the contrary demonstrated good overall between-lab variability results.

Following the discussions at the three workshops in Seville and taking into account the different stakeholder views discussed above, following minimum product testing requirements **for compost and digestate could be proposed:**

Criteria	Explanations	Reasons
<u>Requirements on product testing</u> (sampling and analysis): Compost and digestate producers must demonstrate by <u>external independent sampling and analysis</u> that there is a sufficiently high probability that any consignment of compost/digestate delivered to a customer complies with the minimum quality requirements and is at least as good as the properties declared.	The criteria imply that the 95% confidence interval for a parameter value in a population needs to respect the end-of-waste product quality requirement limits. For instance, in the case of heavy metal and organic pollutant concentrations, the probability that the mean value of the concentration in a sample exceeds the legal limit should be less	A high level of environmental protection can be achieved only if there is reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. To manage compost/digestate so that

[49] http://horizontal.ecn.nl/validation/performance-data/

Criteria	Explanations	Reasons
The details of the sampling programme may be adjusted to the concrete situation of each compost/digestate plant. However, the producer will have to demonstrate compliance with the following requirements: • **The compliance testing has to be carried out within an <u>external, independent quality assurance</u> framework by laboratories that are <u>accredited</u> for that purpose (through an accreditation standard and accreditation organisation accepted at EU level or equivalent recognition by the Member State competent authority).** • **The CEN TC 400 Horizontal standards for sampling and analysis have to be applied as far as available. Otherwise, relevant CEN TC 223 standards should be used. In the case of absence of Horizontal (CEN TC 400) and CEN TC 223 test methods, other internationally recognised test methods may be used, unless the competent authorities of a Member State prescribe a certain standard. See "Annex 12: Compost and digestate sampling and testing methods" for a list of standards and sampling and testing methods.** • **Probabilistic sampling should be chosen as the sampling approach and appropriate statistical**	than 5%. Usually, it will be impractical to sample from the total population and a subset of the overall population that can be considered typical of the whole population will have to be defined as part of the quality assurance process. Typically, the population will correspond to all the compost/digestate sold from a composting plant throughout a year or shorter periods of time. The scale of sampling needs to be chosen depending on the sales/dispatch structure of a composting/digestion plant. The scale should correspond to the minimum quantity of material below which variations are judged to be unimportant. Confidence intervals tend to narrow when more measurements are made. When typical parameter measurement results are very good, namely far from the corresponding limit value, the width of the confidence interval will be less decisive in meeting the quality requirements and hence the measurement frequency can be kept relatively low. However, when typical parameter measurement results are close to the corresponding limit value, it might be necessary to increase the measurement frequency in	environmental impacts and risks are kept low, it must be possible for compost/digestate users and regulatory authorities to interpret the declared product properties in the right way and to trust in conformity. Therefore, standardisation of product parameters, sampling and testing is needed as well as quality assurance.

Criteria	Explanations	Reasons
methods used in the evaluation of the testing. **The *default* minimum sampling and analysis frequency is calculated according to the formula:** ***number of analyses per year = amount of annual input material (in tonnes)/10000 tonne + 1*** **with a maximum of 12 analyses per year. Any non-integer value should be rounded up to the next integer. The frequency therefore being at least 2, and limited at 12. Only one yearly sample measurement is required for plants with an annual input up to 1000 tonne. This minimum annual number of samples must be acquired by external independent samplers trained by and recognised by an accredited laboratory, or by a Quality Assurance Organisation or by the Member State competent authorities. All collected samples shall be measured by accredited external independent laboratories.** **The minimum sampling and analysis frequency in the *first year* (recognition year) for all product quality parameters should be at least 4 (one sample every season), unless the plant treats up to 3000 tonnes of input material per year in which case one sample for every 1000 tonnes input material, rounded to the next integer, is required. For plants with an annual input of more than 20000 tonne, the sampling and analysis frequency in the**	order to ensure that the confidence interval respects the product quality requirement limits. Therefore, the costs of a testing programme of compost/digestate with very good quality can be kept lower than for compost/digestate materials with parameter values closer to the limits. When a new compost/digestate plant is licensed there is usually an initial phase of intensive testing to achieve a basic characterisation (for example one year) of the compost/digestate qualities achieved. If this proves satisfactory, the further testing requirements are then usually reduced.	

Criteria	Explanations	Reasons
first year is calculated according to the default formula. This minimum annual number of samples must be acquired by external independent samplers trained by and recognised by an accredited laboratory, or by a Quality Assurance Organisation or by the Member State competent authorities. All collected samples shall be measured by accredited external independent laboratories. **<u>Provided all analysis results in a given year respect the specified limit values</u> from the end-of-waste product quality criteria, the producer may <u>benefit from a modification to the default sampling requirements</u> in the following year, unless opposed by the competent authorities. This modification may be maintained as long as all measurement results during a year respect the limit values and is described as follows:** **<u>Only half</u> of the total default annual minimum required samples, rounded up to the next integer, must be <u>acquired by external independent samplers trained by and recognised by an accredited laboratory, or by a Quality Assurance Organisation or by the Member State competent authorities</u>. The remaining samples may be collected by properly trained plant personnel. In this case, the producer must be able to demonstrate at all times that**		

<table>
<tr><th>Criteria</th><th>Explanations</th><th>Reasons</th></tr>
<tr><td>
internal sampling does not lead to a bias in the analytical results compared to external sampling, by keeping the necessary records. All collected samples shall be measured by accredited external independent laboratories.

The minimum <u>measurement frequency for PAH$_{16}$</u> is lower than for the other parameters and given by:
<table>
<tr><th colspan="2">Recognition year</th></tr>
<tr><th>Annual input (tonne)</th><th>Samples / year</th></tr>
<tr><td>≤ 3000</td><td>1</td></tr>
<tr><td>3001 - 10000</td><td>2</td></tr>
<tr><td>10001 - 20000</td><td>3</td></tr>
<tr><td>20001 - 40000</td><td>4</td></tr>
<tr><td>40001 - 60000</td><td>5</td></tr>
<tr><td>60001 - 80000</td><td>6</td></tr>
<tr><td>80001 - 100000</td><td>7</td></tr>
<tr><td>100001-120000</td><td>8</td></tr>
<tr><td>120001-140000</td><td>9</td></tr>
<tr><td>140001-160000</td><td>10</td></tr>
<tr><td>160001-180000</td><td>11</td></tr>
<tr><td>> 180000</td><td>12</td></tr>
</table>
<table>
<tr><th colspan="2">Following years</th></tr>
<tr><th>Annual input (tonne)</th><th>Samples / year</th></tr>
<tr><td>≤ 10000</td><td>0.2 (once per 5 years)</td></tr>
<tr><td>10001- 25000</td><td>0.5 (once per 2 years)</td></tr>
<tr><td>25001 - 50000</td><td>1</td></tr>
<tr><td>50001 - 100000</td><td>2</td></tr>
<tr><td>100001-150000</td><td>3</td></tr>
<tr><td>150001-200000</td><td>4</td></tr>
<tr><td>200001-250000</td><td>5</td></tr>
<tr><td>250001-300000</td><td>6</td></tr>
<tr><td>300001-350000</td><td>7</td></tr>
<tr><td>350001-400000</td><td>8</td></tr>
<tr><td>400001-450000</td><td>9</td></tr>
<tr><td>450001-500000</td><td>10</td></tr>
<tr><td>500001-550000</td><td>11</td></tr>
<tr><td>> 550000</td><td>12</td></tr>
</table>

There is a maximum of 12 analyses per year. All samples taken for PAH$_{16}$ measurements need to be taken by external
</td><td></td><td></td></tr>
</table>

Criteria	Explanations	Reasons
independent samplers trained by and recognised by an accredited laboratory, or by a Quality Assurance Organisation or by the Member State competent authorities. All collected samples shall be measured by accredited external independent laboratories.		
In case of <u>important changes (> 20%) regarding the source or composition of the input material</u>, the measurement frequency for inorganic and organic pollutants is reset to the measurement frequency of the first year.	The measurement frequency for inorganic and organic pollutants must be adapted to possible changes in the input material. Seasonal variations on the composition of the input material are accounted for through the spread on the samples taken in the recognition year, reflected in the confidence intervals. However, any other important change (more than 20%) in the type or source of input material should be taken into account in the sample measurement frequency, as to avoid sudden unnoticed contamination of the final product.	

4.5 Requirements on input materials

The purpose of criteria on input materials is to check indirectly the quality of the material, when this can provide a more workable alternative than checking output quality criteria. Alternatively it can also provide an additional safeguard next to output quality criteria.

A subject of intense debate within the Technical Working Group was the eligibility of **sewage sludge and mixed municipal solid waste**, as well as other input streams, as input materials for EU end-of-waste compost or digestate. Arguments pro and contra have been discussed above in section 4.1 "Scope options and proposed definition". These included possible issues with compliance cost, consumer confidence, encouraging separate collection, legal certainty, ensuring a level playing field, market impact, respecting subsidiarity and technology neutrality.

Other arguments to demand the exclusion of sewage sludge and mixed MSW were an assumed high seasonal variation in compost/digestate quality and the risk of unexpected increases in contamination. Other stakeholders suggested that the latter two arguments are arguably equally valid for materials derived from source separation. Especially the occurrence of seasonal variations in organic pollutants in materials from source separate collection seemed to be supported by literature data (Brändli et al., 2005).
Stakeholders in favour of a broad spectrum of eligible input materials referred to the methodology developed by JRC on setting end-of-waste criteria (IPTS, 2008), which states that *"the main target of the criteria is to ensure the fulfilment of product quality requirements"* and hence to the fact that materials should be judged on their output quality rather than on the input used.
A number of stakeholders also proposed to exclude certain input materials as Member States have specific legislation in place that regulate the use of these materials, such as for instance manure. However, other stakeholders suggested that labelling allows customers and authorities to respect all existing national or regional legislation in this regard without the need for excluding input materials at Community level and hence should be the better approach for setting EU wide end-of-waste criteria.
As discussed in section 4.1 "Scope options and proposed definition", it was ultimately proposed to exclude sewage sludge and mixed municipal waste as input materials from the EU end-of-waste framework, whilst allowing existing national end-of-waste or similar product systems to continue operating at national level for these non-scope materials for the time being.

A topic of concern was the **possibility of targeted dilution** by processing highly contaminated input materials with cleaner input, in an attempt to just meet the product quality criteria. Therefore, it could be proposed to put restrictions on the possibilities for reprocessing of compost/digestate materials that do not meet end-of-waste criteria. Reprocessing of off-specification compost or digestate, or derived materials thereof, such as liquor or leachate, by a new composting or aerobic digestion step, in order to meet the product quality criteria for end-of-waste may only be allowed in case the failure to meet end-of-waste criteria for the original material is not related to the content of heavy metals or organic pollutants. For example, a compost batch not meeting the end-of-waste product quality criteria for pathogens may be composted again, but a compost batch not meeting the end-of-waste product quality criteria for nickel concentration should not be composted again with the aim to obtain end-of-waste status. This should apply both to the full off-specification unit and to mixtures of off-specification material and other input materials.

Moreover, there was large support to include **renewable primary products** such as energy crops and catch crops as eligible input materials, as long as the composting or digestion process results in output that is considered waste. The rationale behind this decision is that good quality materials that partially contain primary products would otherwise not be able to receive a product status. Hence their continued waste status would hinder them in the competition with end-of-waste products that are derived from waste inputs only. However, it must be emphasized that the scope of this document does not consider compost/digestate materials that could be regarded as (by-)products of an industrial process, but only such materials that are considered waste.

In general, stakeholders favoured a **clear indication of the main input materials** used for the compost or digestate (e.g. green waste or biobin waste) without the need to list in detail every input material present. The presence of any manure should also be mentioned. Furthermore, it should be clearly indicated whether any animal by-products are present in the produced material.

For **setting the exact boundaries of allowable input materials** several options were discussed with the TWG experts. One option is that the input material criteria acknowledge most input sources, and only prohibit the materials that pose a specific environmental, health or quality concern if not treated adequately, or limit specific input sources. This is defined as the negative list approach. A second option is to list in detail the types of input materials that are preferred because their origin ensures absence or minimisation of risks, for instance a requirement that only garden and park waste from separate collection are acceptable for end-of-waste material production. The latter is defined as the positive list approach.
A positive list approach bears the risk of letting aside suitable sources of biodegradable waste, or sources which can become suitable as new technologies become available. Negative lists bear the concern of not excluding all potentially unsuitable materials. Following discussions during the first and second workshops and subsequent stakeholder consultations, it emerged that the vast majority of stakeholders initially supported the application of a positive list to define input materials for compost and digestate. However, establishing the positive lists for compost and digestate appeared challenging for various reasons:

- experts had different opinions on what materials should be allowed or not;
- experts had different opinions on how to exactly formulate a certain allowed input material. For instance, light contamination of a material was deemed acceptable to some experts but unacceptable to others;
- certain experts insisted on listing European Waste Catalogue (EWC) codes, in line with national practice, whereas others argued that these should just be used for illustrative purposes;
- experts experienced difficulties in proposing a fast and workable update mechanism for the positive list.

Ultimately, it was proposed to set the boundaries for the input materials by a precise scope definition. This solution was discussed at the Third Workshop and is presented in section "4.1.5 Proposed scope definition". It offers following main advantages:

- it renders the need for a detailed and commonly agreed positive and/or negative list superfluous;
- it offers the advantage of a fast update mechanism, as new candidate input materials can be introduced in the EU end-of-waste compost/digestate system after examination and confirmation by the competent national authorities that a material falls under the scope for EU end-of-waste compost/digestate.

Table 14 provides a number of examples of input material sources that may fall within the proposed scope. It should be stressed that the table is non-exhaustive and only serves for illustration purposes and therefore should not be interpreted as a positive list or other form of limiting description.

The scope definition also excludes several input materials by definition, a.o. contaminated materials. 'Contaminated' is defined as having a level of chemical, biological or physical contamination that may cause difficulties in meeting the end-of-waste output product quality requirements or that may result in other adverse environmental or human health impacts from the normal use of the output compost/digestate material. This means that the supplier or compost/digestate producer knows or could reasonably assume that using the input material in customary proportions will lead to failing the end-of-waste output product quality requirements or that using the output material may result in other adverse environmental or human health impacts. Examples are green waste from roadsides with heavy traffic, agricultural waste from areas affected by the outbreak of serious plant or animal diseases or biodegradable waste from areas where pollution involving accidents took place.

It should be noted, however, that besides for the known contaminated input materials, the scope definition above does not imply any a priori judgement on the quality of the used input materials that fall outside the scope of EU end-of-waste criteria.

Member States' competent authorities should have the possibility to explicitly prohibit certain input materials for production of EU end-of-waste compost/digestate materials, to limit the maximum share of certain input materials and/or to prescribe mandatory pretreatment of an input material. Such restrictions may be imposed when the Member State's competent authorities can reasonably demonstrate that either the input material does not fall within the scope definition or that without such measures the use of a given input material would lead to difficulties in meeting the end-of-waste output product quality requirements in normal composting/digestion operations or that the normal use of the output compost/digestate material would result in other adverse environmental or human health impacts. Any decisions should be based on available scientific and technical data and take into account existing practices across the EU.

A slight drawback of the here proposed approach may be the arising of possible issues with transborder shipments because of slightly different materials being in use for compost/digestate production in different Member States. However, it is believed that these issues would be irrelevant as long as the Member State competent authorities strictly adhere to the scope definition for judging on the suitability of candidate input materials and do not impose any import restrictions on compost/digestate materials produced in another Member State according to input material provisions applicable in that Member State.

Table 15 provides a number of examples of input materials that fall outside the scope. It should be stressed that the table is non-exhaustive and only serves to illustrate materials that may fall outside the scope, and therefore should not be interpreted as a negative list or other form of limiting description. Moreover, it should be added that certain input materials could become eligible for use in end-of-waste systems following prior treatment, such as waste pre-packed food that is fully separated from its non-biodegradable packaging prior to entering a composting/digestion operation.

The stakeholders commonly agreed that **additives** should only serve to improve the composting or digestion process, or to improve the environmental performance of the composting/digestion process. Certain metal compounds for instance can improve the biogas formation in the digestion process. Moreover, additives should only be added up to a dose that can be justified by the necessity to improve the process performance and/or environmental performance of the composting/digestion process. In order to avoid unnecessary use of additives or intentional dilution, authorization should be obtained from the competent authorities whenever the total additive dose constitutes a considerable fraction of the input materials. Furthermore, any additives used in the digestion process should not have a negative effect on the composting process if the digestate is to be post-composted. In general, any used additives should undergo all treatment processes as stipulated in 4.6 to ensure full hygienisation, unless this would hinder the composting/digestion process.

Additives that are used to increase the usefulness or economic value of the product, such as nutrients, should be added *after* the product receives end-of-waste status.

Furthermore, the TWG agreed that **visual inspection** of the input materials is the method of choice for input control in the case of compost. In order to allow control of origin and type of material, it may be desirable to avoid mixing of input materials prior to delivery to the composting/digestion installation and visual inspection should be carried out before mixing the input materials. Regarding digestate, it is mentioned that visual inspection of liquid input material may be difficult and dangerous to workers. Such material may be transported in container trucks that only have small openings for control or release of the material. As such, visual inspection may be hampered by a lack of visibility or by the fact that toxic gases (e.g. H_2S) escape upon opening the sampling hatch. In this case, it is proposed that samples are taken of the input materials, which should be stored and can be analysed in case of doubts or issues with the quality of the output material. Alternatively, anaerobic digestion input material quality may be guaranteed by a contractual supply agreement. Such contractual supply agreements may be used in general by the producer as an additional quality assurance, apart from visual controls.

As long as a strict definition of eligible input materials is used, all input materials should be allowed without **restrictions** according to the stakeholder feedback. However, having due regard to the different nature of composting and anaerobic digestion technologies and operational conditions of different sites, plant operators should have the possibility to adopt specific restrictions on input materials, on account of operational constraints, environmental concerns, risk of nuisance and any other conditions affecting viability, operational efficacy and long-term operability of the recycling process.

Table 14: Examples of input materials used for producing compost/digestate materials falling within the proposed scope for EU end-of-waste criteria

Input material sources	**Examples/Specifications[2]**
Parks, gardens, cemeteries and other green spaces[1]	Examples: Leaves, grass, branches, fruit, flowers, plants and plant parts
Households[1]	Examples: Bio-waste from households: Fruit and vegetable remainders, coffee and tea remainders, food remainders, plants and soil attached to plant parts Bags for source-separated household waste shall be biodegradable (consisting of paper or biodegradable plastics according to EN 13432 or EN 14995).
Caterers and restaurants[1]	Examples: Fruit and vegetable remainders, coffee and tea remainders, food remainders.
Food and beverage related retail premises[1]	Examples: Bio-waste from markets, food and feed remainders
Food and beverage processing plants[1]	Examples: Food waste, food washing waste, sludge from food and feed processing plants not containing pollutants
Horticulture[1]	Examples: Leaves, grass, branches, fruit, flowers, plants, plant parts bark, weeds, mushrooms, soil attached to plant parts and peat
Forestry[1]	Examples: Bark, wood, wood chips, sawdust
Agriculture[1]	Examples: Straw, harvest remainders, silage, plant material, energy crops[3] and catch crops[3] Manure as defined in ABP Regulation (EC) No 1069/2009
Fishery and aquaculture[1]	Examples: Slaughter waste and fodder residues from traditional fisheries and aquaculture industry, crustacean shells and similar residues, seaweed
Animal by-products Category 2 and 3	See the ABP Regulation (EC) No 1069/2009 and implementing Regulation (EU) 142/2011 for allowable input materials

[1)] If this category includes animal by-products the Regulation (EC) No 1069/2009 for animal by-products should be followed.
[2)] Only 'source-separated' input materials; digested or composted materials derived from these materials may be used as well.
[3)] Only if the treatment process is a waste treatment process, i.e. the resulting output is considered a waste material

Table 15: Examples of input materials used for producing compost/digestate materials falling outside the proposed scope for EU end-of-waste criteria

Input material sources	**Examples/Specifications**
The organic fraction from mixed waste separated through mechanical, physicochemical, biological and/or manual treatment	Example: The organic fraction from MSW obtained in a MBT installation
Sludges other than those falling under the scope of allowed materials	Examples: Sewage sludge, sludge from paper industry, industrial sludges
Materials carrying a considerable risk for contamination	Examples: Hazardous waste, materials carrying considerable risk for contamination with inorganic or organic pollutants or microbial contamination, possibly contaminated waste from pharmaceutical production, medical waste
Materials collected from sites with elevated risk of pollution through atmospheric deposition, irrigation, leaching or other pathways	Examples: Material from areas in proximity of intensive motorized traffic, from sites with elevated industrial pollution, from landfills, from (bio)remediation sites, from radio-actively contaminated sites
Non-biodegradable materials	Examples: Non-biodegradable polymers and plastics (including oxo-biodegradable plastics), metal, glass, stones, ground rock, sand, soil other than that attached to plant parts, non-biodegradable oils and fats
Biodegradable material containing non-biodegradable fractions	Examples: Bio-waste and similar material containing visually detectable non-biodegradable items such as bags, flower pots or packaging material; Items containing a biodegradable fraction and a non-biodegradable fraction (e.g. non-biodegradable sanitary products); Wood containing veneers, coatings, chemical additives or preserving substances
Materials containing any ingredients that might negatively affect the composting/digestion process	Examples: Materials with an assumable presence of biocides, preservatives or other substances that negatively affect the composting/digestion process

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following input material requirements **for compost and digestate could be proposed:**

Criteria	Explanations	Reasons
Compost and digestate materials shall be produced from input materials exclusively originating from: **a) the separate collection of bio-waste and/or;** **b) manure and/or;** **c) living or dead organisms or parts thereof, provided the latter are unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, by extraction with water, by steam distillation or by heating solely to remove water, or which are extracted from air by any means and/or;** **d) processed living or dead organisms or parts thereof other than c), as well as biodegradable packaging materials, provided all such materials are certified biodegradable according to EN 13432, EN 14995 or equivalent and 90% biodegradability in 6 months has been demonstrated in a single or combined composting and/or anaerobic digestion process and/or;** **e) any material listed in points a), b), c) and/or d) that has previously been**	'Bio-waste' is defined according to Article 3(4) of the Waste Framework Directive 2008/98/EC as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants. 'Contaminated' is defined as having a level of chemical, biological or physical contamination that may cause difficulties in meeting the end-of-waste output product quality requirements or that may result in other adverse environmental or human health impacts from the normal use of the output compost/digestate material. 'Manure' is defined according to Article 3(20) of the Animal By-Products Regulation (EC) 1069/2009 as any excrement and/or urine of farmed animals other than farmed fish, with or without litter. 'Separate collection' is defined according to Article 3(11) of the Waste Framework Directive 2008/98/EC	Composting and digestion is suitable as treatment only for biodegradable wastes. Dilution of other wastes with biodegradable waste needs to be avoided.

Criteria	Explanations	Reasons
composted and/or digested; **Input materials must not be contaminated.**	as the collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment. Non-biodegradable components that are already associated with biodegradable waste streams at source, should, however, be allowed if they are not dominant in quantity, do not lead to exceeding the pollutant concentration limits (see product quality requirements) and do not impair the usefulness of the compost/digestate. Example: soil-like material attached to garden waste.	
The type and source of the <u>input materials</u> used for the production of end-of-waste compost/digestate must be registered by the producer. **It shall be indicated on the product what the material is based on, <u>in large terms</u>, using one or more of the following definitions:** • **Separately collected bio-waste from households, restaurants,**	Users must be clearly informed about the origin of the input materials, also allowing them to comply with specific national use legislation.	Transparency on the input materials is important for the confidence of users in compost/digestate quality and can therefore strengthen compost/digestate demand. The information on the input material is needed to allow the use of compost/digestate in compliance with existing legislation. If animal by-products were input, compliance with the Animal By-products Regulation[50] is required. Furthermore, users, for instance farmers, often wish to know the origins and source materials of compost/digestate.

[50] Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

Criteria	Explanations	Reasons
caterers and retail premises, and comparable waste from food processing plants or of agricultural and forest products • **Garden and park waste** • **Agricultural waste containing manure** • **Agricultural waste not containing manure** • **Other input materials** **Any presence of <u>manure</u> must be clearly indicated.** **It should be indicated whether any <u>animal by-products</u> have been used to produce the material and all provisions of the Animal By Products Regulation EC 1069/2009 should apply.**		
<u>Reprocessing</u> of off-specification compost or digestate, or derived materials thereof, such as liquor or leachate, by a new composting or aerobic digestion step, in order to meet the product quality criteria for end-of-waste can only be allowed in case the <u>failure</u> to meet end-of-waste criteria for the original material is <u>not related to the content of heavy metals or</u>	This applies both to the full off-specification unit and to mixtures of off-specification material and other input materials.	Polluted compost/digestate materials should not receive end-of-waste status through post-processing or dilution.

Criteria	Explanations	Reasons
organic pollutants.		
Only additives are allowed that are needed to improve the process performance and/or environmental performance of the composting/digestion process. **Additives must not be added in any quantity higher than justifiable by the necessity to improve the process performance and/or environmental performance of the composting/digestion process.** **Prior authorization by the competent authorities is required wherever the total concentration of all additives used exceeds 5% of the input material weight. In that case, all additives and their respective concentrations shall be labelled on the product.**	The producer must be able to demonstrate that the used additives and their respective quantity only serve to improve the composting or digestion process, or to improve environmental performance of the composting/digestion process.	Additives can be used as input to the composting/digestion process in minor quantities, if they improve the compost/digestate quality or they have a clear function in the composting/digestion process. In practice, additives are sometimes needed to improve the composting/digestion process or the compost/digestate quality.
Suitable procedures for controlling the quality of input materials need to be followed by the operators of composting/digestion plants. **Visual inspection is the method of choice to control input materials**	It is agreed that in many cases visual inspection and approval of origin will be suitable procedures. Visual inspection of input materials should be done prior to any mixing. Visual inspection of	Controlling the input materials is a key factor (probably the single most important) for assuring reliable quality of the compost or digestate. Control of input covers also avoidance of mixing with other wastes not covered by the scope.

Criteria	Explanations	Reasons
for compost and digestate. **When visual inspection would entail <u>health or safety risks, visual inspection shall be replaced by sample taking and storage for possible analysis or by a supply agreement.</u>** **See also section on criteria regarding quality control procedures.**	liquid materials in containers or bulk trucks may be dangerous due to the escaping gases or difficulties in approaching the material. In such cases, samples should be taken or the quality should be assured through contractual supply agreements.	

4.6 Requirements on treatment processes and techniques

The purpose of introducing requirements on processes and techniques is to check indirectly product quality.

Apart from biodegradable waste which is directly used before collection (e.g. home composting), biodegradable waste is collected in varying quantities, processed and eventually may become compost/digestate used on soil or other purposes. Biodegradable waste may need sorting and removal of undesired components, such as packaging from expired food products.

Without pre-judging the point in the treatment chain where end-of-waste is reached, the purpose of the introduction of process requirements is to define minimum treatment conditions which are known to result in quality suitable for end-of-waste in all cases. When reaching end-of-waste status, the material must have undergone all minimum necessary treatment processes that make it fit for marketing and use. The treatment processes must also ensure that transporting, handling, storage (loose or packed), trading and using compost/digestate takes place without increased environmental and health impact or risks.

The required treatment processes to achieve this differ depending on the waste streams from which the compost/digestate has originally been obtained. The criteria on processes and techniques can include:

- basic general process requirements that apply to all types of waste inputs;
- specific process requirements for specific types of waste inputs.

Generic requirements that do not prescribe a specific collection scheme, origin, type of operator (municipal/private/local/global) or technology are preferred, since industry and authorities in the biodegradable waste recycling chain should not be prevented from adjusting processes to specific circumstances and from following innovation. However, restrictions may be justified if it is proven that e.g. a given collection scheme or treatment systematically is not able to meet the standards required by the quality criteria.

From the TWG stakeholder consultation, it emerged that nearly all stakeholders are in favour of imposing **both an indicator organism product quality criterion and a time-temperature profile** as they offer complementary advantages. Organism testing may e.g. reveal inferior mixing during the process whereby only a certain part of the material was exposed to the correct time temperature profile, leading to insufficient hygienisation. On the other hand, time temperature profiles allow monitoring the hygienisation process in real time and hence allow to react quickly in case of possible process irregularities that could lead to inferior hygienisation of the compost batch.

"Annex 9: Time-temperature profiles for compost" lists temperature-time profiles required by the Animal By-products Regulation[51] and national legislation and standards for composting plants. Based on the list in this Annex, a number of allowable time-temperature profiles could be proposed for materials subject to composting and not including any animal by-products.

For **compost**, a number of time temperature profiles have been supported by the stakeholders, whereby following remarks apply:

- Animal by-products regulations should remain fully applicable for any material containing animal by-products.
- The competent authorities of a Member State should be allowed to grant authorization for other time-temperature profiles after demonstration of their equal effectiveness for hygienisation (e.g. based on HACCP[52] principles).
- Process homogeneity should be ensured, as well as the prevalence of aerobic conditions at all times, especially for composts with considerable fractions of small particles. This might in many cases best be realized by turning over and/or mixing of the compost at regular time intervals.

For **digestate**, a number of time temperature profiles have been proposed as well. As anaerobic digestion can be either mesophilic (generally operated between 37 and 40°C) or thermophilic (generally operated between 50 and 55°C), distinction has to be made between these two processes. Following remarks apply:

- Animal by-products regulations should remain fully applicable for any material containing animal by-products.
- The competent authorities of a Member State should be allowed to grant authorization for other time-temperature profiles after demonstration of their equal effectiveness for hygienisation (e.g. based on HACCP principles).
- Process homogeneity should be ensured, as well as the prevalence of anaerobic conditions at all times. This might in many cases best be realized by turning over and/or mixing of the digestate throughout the reactor.

The following measures, which received large support from the TWG stakeholders, are proposed to avoid **cross-contamination**:

- Plants that produce end-of-waste compost or digestate should only be allowed to process approved materials falling within the proposed scope.

[51] Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

[52] HACCP: Hazard Analysis and Critical Control Points

- The possibility of physical contact between input materials and final products must be prevented.

In this context, it should be clarified that a plant is defined as a unit for which physical contact with other activities is excluded through physical barriers (e.g. a fence) and/or quality procedures acknowledged by the competent authorities. This allows for large waste treatment installations to have (a) certain line(s) for end-of-waste compost/digestate material production but at the same time treat other wastes (e.g. cardboard or glass for recycling). However, it should be avoided at all times that non-eligible input materials can be mixed with eligible input materials for the production of end-of-waste compost/digestate.

It should be noted that although plants producing end-of-waste materials are only allowed to process input materials falling within the proposed scope, they should be left the free choice to apply for end-of-waste status for a restricted number of their output materials. For example, plants might apply for end-of-waste status for the separated fibre fraction of digestate, but not for the liquid fraction.

Several TWG experts proposed to regulate the **storage** for compost/digestate materials. If not managed properly, medium to long-term storage of compost/digestate may lead to important (biological) changes beyond any normal natural processes taking place in all compost/digestate materials. These changes may be related to exposure to heat, cold, humidity, etc. Furthermore, long term storage may increase the risks for contamination by other materials and may lead to considerable accumulated emissions of greenhouse gases and odour compounds. Nonetheless, many stakeholders believed that compost/digestate materials should be granted at least temporary storage, to allow for a buffer period between finishing the production of a material and being able to put it on the market or use it oneself. Most stakeholders agreed that such storage should happen under proper conditions while allowing external control of the production date and storage time.
A particular arrangement for off-site storage of compost/digestate was proposed by some, mainly British, experts. Within the current UK end-of-waste framework, finished compost/digestate materials can be stored off-site under the product regime, even if they have not been transferred to the next holder. The main advantage of this approach would be that off-site storage can occur without costly waste permits. However, other experts indicated the possible difficulties of expanding such a system to the EU framework. A major problem is the lack of possible control on storage conditions for materials that are no longer waste but products. Moreover, legal complications may be expected because of the link of end-of-waste status with recovery and recycling targets, as described in Article 6(3) of the Waste Framework Directive and Article 2(6) of Commission Decision 2011/753/EU. As such, a material could be considered recovered/recycled although it is still stored without any certainty of being sold or used. Furthermore, Article 24 of the Waste Framework Directive already allows for exemptions from permitting in the case of recovery operations. Annex II of the WFD lists biological processes, including composting, among the recovery operations. Therefore, the competent authorities already have the possibility at present to exempt plants from (costly) permits for (off-site) storage of compost/digestate materials. In conclusion, it seems desirable to maintain the link between product status and transfer or use, after storage by the producer.

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following criteria on treatment processes and techniques **for compost and digestate could be proposed:**

Criteria	Explanations	Reasons
The producer must demonstrate for each compost/digestate batch that a suitable <u>temperature-time profile</u> was followed during the composting/digestion process for all material contained in the batch. **Three time-temperature profiles are allowed for materials subject to <u>composting and not containing any animal by-products</u> other than defined in Annex V, Chapter III, Section 2, Point 2 of Regulation (EU) No 142/2011:** • **65 °C or more for at least 5 days** • **60 °C or more for at least 7 days** • **55 °C or more for at least 14 days** **In the case of anaerobic <u>digestion for materials not containing any animal by-products</u> other than defined in Annex V, Chapter III, Section 2, Point 2 of Regulation (EU) No 142/2011, following time-temperature profiles are allowed:** • **Thermophilic anaerobic digestion at 55°C during at least 24h and a hydraulic retention time of at least 20 days** • **Thermophilic anaerobic digestion at 55°C with a treatment process**	The desired risk control can be achieved, avoiding being overly descriptive, by allowing a number of alternative temperature-time profiles from existing standards or regulations. The producer must comply with at least one profile that has been approved as suitable for the type of composting/digestion process applied and is specified in the licence/permit by the competent authority. It must be ensured that all of the material undergoes appropriate conditions. Depending on the process type, this may require for example suitable turning, oxygen supply, presence of enough structural material, homogenisation, etc.	As is common in existing regulations and standards, there should be process requirements to ensure that the processes yield composts and digestates without hygienic risk.

Criteria	Explanations	Reasons
including a pasteurization step (70°C, 1h) • **Thermophilic anaerobic digestion at 55°C, followed by composting according to EoW time-temperature profiles for composting** • **Mesophilic anaerobic digestion at 37-40°C, with a treatment process including a pasteurization step (70°C, 1h)** • **Mesophilic anaerobic digestion at 37-40°C, followed by composting according to EoW time-temperature profiles for composting** **The producer is allowed to apply an <u>alternative time-temperature profile</u> for which he can demonstrate equal or better effectiveness for hygienisation as the above indicated time-temperature profiles and provided he is granted authorization by the Member State competent authorities.** **<u>Animal by-product regulations should remain fully applicable</u> for any compost or digestate material containing animal by-products (inclusive possible relaxations for national rules pursuant to Article 15(2)(a)(ii) of Regulation (EC) No 1069/2009 and restrictions of placing certain compost/digestate materials**		

Criteria	Explanations	Reasons
only on national Member State markets)		
In order to avoid cross-contamination, following measures should be respected: **Plants that produce end-of-waste compost or digestate should <u>only be allowed to process approved materials falling within the proposed scope</u>.** **The possibility of <u>physical contact between input materials and final products must be prevented</u>.**	Apart from ensuring correct processing conditions during composting/digestion, cross-contamination needs to be minimized.	Cross-contamination can cause a carefully produced material to pose quality problems and/or environmental or health concerns.
Compost/digestate materials shall be <u>stored under proper conditions to minimize emissions</u> of greenhouse gases, odour or other compounds that have a negative impact on the environment and/or human health. **Where liquid digestate materials are not stored under aerobic conditions, they shall be stored in closed containers or tanks.**	Proper storage conditions for compost/digestate shall help avoid undesired emissions from finished materials.	Suboptimal storage conditions may lead to emissions negatively affecting the environmental benefits of well managed composting/digestion operations.

4.7 Requirements on the provision of information

Requirements on the provision of information are a complementary element of end-of-waste criteria. The criteria have to minimise any onerous administrative load, recognising when current practice is competent in providing a valuable material for recycling, respecting existing legislation, and protecting health and the environment.

The provided information should also demonstrate that compost or digestate is an adequate alternative to primary raw-materials.

Not only could the provided information mention the actual levels of those parameters that are bound by limits. The criteria could also require the declaration of additional parameters related to the fitness of the material for use, such as CaO content, pH, grain size, density, or water content.
When the mentioned parameters need to be quantified, the criteria would likely include requirements on how each of the parameters has to be tested. These testing requirements can be generic, allowing a degree of freedom within a framework of minima, or if found appropriate, be specific and refer to e.g. existing testing standards.

The formulation of end-of-waste criteria shall aim to be as simple as possible, for clarity, and easier communication and implementation. In the pursue of this aim, the included parameters shall be the minimum strictly necessary to fully characterise the completeness of treatment of compost/digestate, while ensuring that the material is fit for a safe use in the different potential outlets.

Whereas compost and digestate hold large similarities, there are differences that should be reflected in the parameters to declare.

"Annex 10: Possible compost product property parameters" and "Annex 11: Initial proposal product quality requirements compost" provide a description of product parameters whose mandatory declaration was discussed during the pilot study (IPTS, 2008) and initial TWG consultations. Some of these parameters have been excluded from the final list. Reasons include absence of relevance for a specific material (e.g. grain size for digestate) and the end-of-waste conditions (e.g. market may demand different plant response levels).

Furthermore, a majority of TWG stakeholders proposed that **parameters subject to product quality** criteria should not be declared individually, but the statement of conformity should mention that all end-of-waste criteria have been met. Other stakeholders stated that these data are often needed in order to comply with national legislation on the application and use of compost/digestate materials. However, it would be reasonable to assume that in Member States with such legislation only products containing detailed product information will find a market outlet. Nevertheless, following discussions at the Third Workshop on raising limit values for **micronutrients Cu and Zn**, many TWG experts were in favour of indicating the concentrations of both if at least one of these elements surpasses a threshold level (100 ppm for Cu and 400 ppm for Zn). This should make it clear to potential buyers or users that the compost/digestate materials have a particular value as micronutrient fertilisers.

Some stakeholders also suggested that the producers should indicate whether any declared parameter values are typical values, based on measurement data from the mandatory measurement frequency cycle, or actual values referring to a specific batch. However, most stakeholders seemed to agree that the values should reflect the typical value, as in practice it will not be feasible to analyse every produced batch.

Notwithstanding individual demands for the use of certain national standards, most experts tended to agree that any measurement of parameters subject to mandatory declaration should be based on the **same sampling and analysis principles applicable for the product quality criteria**. This means that available Horizontal (CEN TC 400) standards are used where available, followed by CEN TC 223 standards. Only in the absence of any relevant CEN TC

400 or TC 223 standard, alternative options should be envisaged. Such an approach should help in ensuring a level playing field across the EU.

A number of experts also called for the mandatory declaration of dry matter content, as many quality parameters are expressed on this value. Proper use of compost/digestate products may be complicated without the knowledge of this parameter, especially where legal requirements on maximum pollutant loads to soils have to be respected. Moreover, analytical laboratories have to determine dry matter content anyway, in order to be able to report other analytical parameters on a dry matter basis, and hence the measurement value should be readily available.

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following criteria on provision of information **for compost could be proposed:**

Criteria	Explanations	Reasons
Declaration of the following parameters (product properties) when placing <u>compost</u> on the market: **Usefulness concerning soil improving function:** **• Organic matter content** **• CaO content** **Usefulness concerning fertilising function:** **• Nutrient content (N, P, K, Mg)** **• Micronutrient content (Cu and Zn) in case the concentration of Cu>100 mg/kg d.m. or the concentration of Zn>400 mg/kg d.m.** **Biological properties:** **• Contents of germinable seeds and plant propagules** **General material properties** **• Bulk density/volume weight** **• Grain size** **• Dry matter content** **• pH** **• Electrical conductivity (salinity)** **Any measurement of these parameters should be based on the same sampling and analysis principles applicable for the**	The parameters to be included determine the usefulness of compost and the environmental and health impacts and risks of compost use.	Composts can be used as a safe and useful product only if the relevant properties of the material are known to the user and the corresponding regulatory authorities. This information is needed to adapt the use to the concrete application requirements and local use conditions as well as the corresponding legal regulations (e.g. the provisions on soil protection that apply to the areas where the compost is used). An adequate declaration of the material properties is therefore a prerequisite for placing compost on the market and for the waste status to be lifted.

product quality criteria.		

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following criteria on provision of information **for digestate could be proposed:**

Criteria	**Explanations**	**Reasons**
Declaration of the following parameters (product properties) when placing <u>digestate</u> on the market: **Usefulness concerning soil improving function:** **• Organic matter content** **• CaO content** **Usefulness concerning fertilising function:** **• Nutrient content (N, P, K, Mg)** **• Micronutrient content (Cu and Zn) in case the concentration of Cu>100 mg/kg d.m. or the concentration of Zn>400 mg/kg d.m.** **• S content** **• Mineral nitrogen content (NH4-N, NO3-N)** **General material properties** **• Water or dry matter content** **• pH** **• Electrical conductivity (salinity)** **Any measurement of these parameters should be based on the same sampling and analysis principles applicable for the product quality criteria.**	The parameters to be included determine the usefulness of digestate and the environmental and health impacts and risks of digestate use.	Digestates can be used as a safe and useful product only if the relevant properties of the material are known to the user and the corresponding regulatory authorities. This information is needed to adapt the use to the concrete application requirements and local use conditions as well as the corresponding legal regulations (e.g. the provisions on soil protection that apply to the areas where the digestate is used). An adequate declaration of the material properties is therefore a prerequisite for placing digestate on the market and for the waste status to be lifted.

Labelling of compost and digestate may allow the consumer to judge about additional properties of the material that cannot be defined through a limited set of product quality criteria. It may also be a legal necessity in some cases, for instance to determine whether an end-of-waste compost is suitable for use in organic farming or eligible for the production of growing media or soil improvers being rewarded with the Community eco-label.

The stakeholder consultation on this issue showed that many stakeholders indicated the need of the issuance of the **statement of conformity**.

Furthermore, following TWG stakeholder consultation, following elements have emerged as **necessary information to provide**:

- The name and address of the compost/digestate producer
- The name, electronic address and if possible the logo and physical address of the external Quality Assurance organization
- Compost/digestate designation identifying the product by general type (see also requirements under Product Quality Criteria labelling the presence of manure and/or animal by-products)
- Batch code or equivalent identification code for materials issuing from continuous production systems
- Quantity (to be expressed by preference in weight or otherwise in volume)
- The parameters to declare through labelling
- A statement indicating the conformity with end-of-waste requirements
- A description of the application areas for which the compost/digestate may be used and any limitations on use
- Recommendations for the proper use
- Reference to Animal By-Product Regulation requirements where applicable

Some stakeholders pointed to difficulties with defining a **batch** code for materials being produced in continuous production systems, such as anaerobic digestion. Nonetheless, most buyers will generally receive a material in a given quantity, e.g. a certain truck load. Therefore, in this context a batch code may be interpreted as an identification code that allows the compost/digestate producer to trace back a certain output material to the used input materials and applied process parameters.

It was generally agreed that **recommendations on use** of the product are very useful. However, distinction should be made between general recommendations and codes of good agricultural practice, on the one hand, and references to regional, national or EU-wide specific requirements, on the other hand.

In general, the TWG stakeholders argued that the aimed reduction of the administrative burden linked to the product status could be jeopardized by imposing extreme **traceability** demands on the compost/digestate receiving end-of-waste status. Hence, traceability should stop at the producer stage, meaning that any direct buyer or user can trace back the compost/digestate to the producer and there should not be any obligation for the producer to track the final use of the compost/digestate, unless other requirements are imposed by the Animal By-Products Regulation EU 1069/2009. Nonetheless, it should be mentioned that some stakeholders advocated a stricter system allowing full traceability under the responsibility of the producer.

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following criteria on provision of information **for compost and digestate could be proposed:**

Criteria	Explanations	Reasons
When placing compost or digestate on the market, or in case of own use, the producer must declare the following:	A use of compost/digestate can be considered as recognised only if there are suitable regulations or other rules in place that ensure the protection	It is a condition for end-of-waste that the product fulfils the technical requirements for a specific purpose and meets the

Criteria	Explanations	Reasons
•The name and address of the compost/digestate producer **•The name, electronic address and if possible the logo and physical address of the external Quality Assurance organization** **•Compost/digestate designation identifying the product by general type in line with the input materials requirement (indicating any presence of manure and/or animal by-products)** **•Batch code or equivalent identification code for materials issuing from continuous production systems** **•Quantity (in weight and/or volume)** **• The parameter values that are required to be declared in labelling** **•A statement indicating the conformity with EU end-of-waste requirements** **•A description of the application areas for which the compost/digestate can be used and any limitations on use** **•Recommendations for the proper use** **•Reference to Animal By-Product Regulation requirements where applicable (inclusive restrictions on export)**	of health and of the environment. The applicability of such rules must not depend on the waste status of the compost/digestate.	existing legislation and good practice standards applicable to products. The producer could be requested to identify the legal norms that regulate the use according to the identified purposes in the markets on which the product is placed.
The product should be accompanied by <u>instructions on safe use and application recommendations.</u>	For example, instructions and recommendations may refer to the maximum amounts and recommended times, for spreading on agricultural land.	Application instructions and recommendations help to avoid bad use of the compost/digestate and the associated environmental

Criteria	Explanations	Reasons
The instructions should also make reference to the need of <u>compliance with any legal regulations, standards, and good practice applying to the recommended uses</u>.	Spreading and incorporation in soil e.g. have to follow good agricultural practice. At the same time, national or regional regulations may impose additional requirements, depending on e.g. the local soil conditions.	and health risks and impacts. Reference to legal requirements and standards for use are intended to support legal compliance by the compost/digestate user. These instructions shall not be more burdensome than those required for products with the same function, e.g. peat or fertilisers.
<u>Traceability:</u> The information supplied to the <u>first buyer or user</u> together with the compost/digestate should allow the identification of the producer of the compost/digestate, the batch or production time and the input materials used. Traceability requirements by the Animal By-Products Regulation EU 1069/2009 fully remain valid where applicable.	Member States may require users to keep records of these data for certain uses so that the compost/digestate can be traced back to the origin when needed.	For the event of environmental or health problems that can potentially be linked to the use of compost/digestate, there is a need to provide traceability trails for any investigations into the cause of the problems.

4.8 Requirements on quality assurance procedures (quality management)

Quality assurance is an element of end-of-waste criteria of importance because it is needed to establish confidence in the end-of-waste status.

The acceptance control of input materials, the required processing and the assessment of compliance with final quality requirements shall have been carried out according to good industrial practice regarding quality control procedures.

In this context, quality assurance is needed to create confidence in the quality control on the compost/digestate undertaken by its producer, and reliability on the end-of-waste criteria that distinguish consignments meeting end-of-waste criteria from consignments that have not applied for or do not meet end-of-waste criteria. The producer of the material applying the end-of-waste status will have to have implemented and run a quality assurance system to be able to demonstrate compliance with all the end-of-waste criteria, and use this as documentation when the material is shipped.

Both in the qualitative and quantitative end-of-waste criteria that refer to procedures and process controls, it is considered essential that there is a quality management system in place which explicitly covers the key areas of operation and the quality of the final products where compliance with end-of-waste criteria has to be demonstrated.

One of the possible options to demonstrate compliance is having implemented and run an internationally recognised and externally verified quality management system based on ISO 9001 or a quality assurance scheme respecting certain provisions like the one operated by the European Compost Network. External verification is a compulsory element of these, and should assess if the quality management system is effective and suitable for the purpose of demonstrating compliance with the end-of-waste criteria.

A suitable quality management system for compost/digestate is expected to include:

- acceptance control of input materials based on a strict scope definition;
- monitoring and record keeping of processes to ensure they are effective at all times;
- procedures for monitoring product quality (including external sampling and analysis) that are adjusted to the process and product specifics according to good practice;
- periodical third-party surveillance with quality control of compost/digestate analyses and on-site inspection of the composting/digestion plant inclusive inspection of records and the plants' documentation
- plant certification for declaration and labelling of input materials, the product characteristics, the product type and the producer;
- information on conformity with national regulations, quality assurance and end-of-waste standards and requirements of the competent authority
- measures for review and improvement of the plant's quality management system;
- training of staff.

The competent authority must be able to commission an independent second party audit of the implemented quality management system to satisfy itself that the system is suitable for the purpose of demonstrating compliance with end-of-waste criteria.

In respect of the frequency of monitoring, the appropriate frequency for each parameter should be established by consideration of the following factors (see also section on product quality testing regarding minimum monitoring requirements):

- the pattern of variability, e.g. as shown by historical results;
- the inherent risk of variability in the quality of waste used as input to the recovery operation and any subsequent processing;
- the inherent precision of the method used to monitor the parameter; and
- the proximity of actual results to the limit of compliance with the relevant end-of-waste condition.

Frequency of monitoring includes the number of times a parameter is monitored over any given time period depending on the plant treatment capacity so that it is a representative sample of the total. In the absence of historical results for any relevant parameter, it is good monitoring practice to carry out an intensive monitoring campaign over a limited period (e.g. less than 12 months) in order to characterise the material stream, thereby considering seasonal variations in composition. The results from this initial monitoring campaign should thus provide a basis for determining an appropriate longer term monitoring frequency.

The result of the monitoring frequency determination should subsequently provide a stated statistical confidence (often 95% confidence level is used) in the ultimate set of monitoring results. The process of determining monitoring frequencies should be documented as part of the overall quality assurance scheme and as such should be available for auditing. The detail on the verification, auditing or inspection of the quality assurance scheme can follow different national approaches.

It was generally proposed that a description of the **sampling frequency and methods** should be part of the quality assurance scheme of the producing plants, duly taking into account any minimum sampling frequency from the end-of-waste quality criteria and available Horizontal or CEN TC 223 sampling standards. Several stakeholders also indicated the importance of clarifying in the quality assurance scheme how to deal with analysis of semi-continuously produced materials (such as digestate), delays between production and receiving sampling results and actions to take in case the measurement result indicates that limit values for a parameter have been exceeded.

Following TWG stakeholder consultation, it was revealed that for compost the stakeholders generally supported the ECN-QAS system as the **quality management system**. For digestate, such a system is currently under development by the European Compost Network and stakeholders generally referred to national systems being set-up in some Member States.

Stakeholders agreed that **independent bodies** should verify the quality management system for producers of end-of-waste compost/digestate.

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following criteria on quality management **for compost and digestate could be proposed:**

Criteria	Explanations	Reasons
Compost/digestate producers are required to operate a <u>quality management system</u> in compliance with quality assurance standards that are recognised as suitable for compost/digestate production by Member States or the Community. **It should include following elements:** **•Acceptance control of input materials based on a strict scope definition;** **•Monitoring and record**	Recognised quality assurance standards for compost and digestate are set out, for example, in the British publicly available specification BSI PAS 100 (Compost) and 110 (Digestate), and the German BGK's RAL quality assurance system. Besides the national standards, the European Compost Network has established a quality management system for compost, which is widely supported. Furthermore, it is	Users and the authorities that are in charge of controlling the use of the compost/digestate need to have reliable quality guarantees. Trust in the quality of the material is a precondition for a sustained market demand. The actual product properties must correspond well to what is declared and it must be guaranteed that the material minimum quality requirements as well as the requirements concerning the input materials and processes

Criteria	Explanations	Reasons
keeping of processes to ensure they are effective at all times (records must be kept for 5 years); **•Procedures for monitoring product quality (including external sampling and analysis) that are adjusted to the process and product specifics according to good practice;** **•Periodical third-party surveillance with quality control of compost/digestate analyses and on-site inspection of the composting/digestion plant inclusive inspection of records and the plants' documentation** **•Plant certification for declaration and labelling of input materials, the product characteristics, the product type and the producer;** **•Information on conformity with national regulations, quality assurance and end-of-waste standards and requirements of the competent authority** **•Measures for review and improvement of the plant's quality management system;** **•Training of staff**	currently developing a similar system for digestates.	are actually met when a product is placed on the market.
The quality assurance system is audited externally by the competent authorities or by quality assurance organisations acknowledged by Member State authorities.		The reliability of product quality will be acceptable only if the quality assurance systems are audited by the authorities or an officially acknowledged third-party organisation.

4.9 Application of end-of-waste criteria

For the application of end-of-waste criteria laid out above it is understood that a consignment of compost/digestate ceases to be waste when the producer certifies that all of the end-of-waste criteria have been met.

It is assumed that compost/digestate that has ceased to be waste can become waste again if it is discarded and not used for the intended purpose, and therefore fall again under waste law. This interpretation does not need to be specifically stated in the end-of-waste criteria, as it applies by default.

It was proposed that the application to end-of-waste from a producer or importer refers to a statement of conformity, which the producer or the importer shall issue for each consignment of compost/digestate. Most TWG stakeholders were in favour of a system in which the **producer transmits the statement of conformity to the next holder of the consignment**. They should retain a copy of the statement of conformity for a period of time to be defined (e.g. at least one year after its date of issue) and make it available to competent authorities upon request. The statement of conformity may be issued as an electronic document. Nonetheless, it should be mentioned that some stakeholders advocated a stricter system allowing full traceability under the responsibility of the producer. Other stakeholders advocated a system in which the statement of conformity can only be issued by the quality assurance organisation or competent authorities and not directly by the producer.

Following consultation, it emerged that the majority of stakeholders is not in favour of a demand that end-of-waste compost or digestate loses its end-of-waste status when it is not put on the market. There may be legitimate reasons for which these products are not put on the market, such as **direct use of the product by the producer** (e.g. in the case of on-farm composting whereby the produced compost is used on the own fields). Producers of compost or digestate using their own materials might still want to apply for end-of-waste status in this case, as it demonstrates the quality of their process and material.

Experts also discussed about the **allowable storage time** for finished products, with some advocating short times in order to ensure that products will be put on the market. Other experts suggested longer or indefinite storage times, whereas some experts proposed to make the storage time dependent on the natural (agricultural) cycle in which products are normally used.
In order to avoid extended storage, any limits on storage time should be calculated from the beginning of the production process, rather than the end. Such an approach evades possible discussions about whether maturation of stored materials is part of the production process cycle or not. Obviously, compost/digestate materials that have exceeded the maximum storage time to be eligible for end-of-waste status may be reused again as input materials for a new end-of-waste composting/digestion process, subject to the general conditions on input materials.
If the compost/digestate is **mixed or blended** with other material before being placed on the market, the product quality criteria should apply to the compost/digestate before mixing/blending according to most TWG stakeholders. Meeting the limit values relevant for product quality by means of dilution with other materials should not be allowed.

Furthermore, the initial proposal from the first working document of having to inform national authorities did not receive positive acclaim as it is feared that such obligation may lead to jeopardizing the advantages of the product status compared to the waste status. Strict end-of-waste criteria should be the safeguard for environmental protection and the responsibility of the producer should end at the gate, according to a majority of the TWG experts.

Many TWG stakeholders suggested that any imported end-of-waste compost/digestate from outside the EU – made from any materials that included controlled biodegradable wastes- shall be independently certified compliant with the EU end-of-waste criteria by a Quality Assurance Organization accredited in the EU.

Following the discussions at the three workshops in Seville, the various written consultations of the TWG and taking into account the different stakeholder views discussed above, following elements for the application of end-of-waste criteria **for compost and digestate could be proposed:**

Criteria	Explanations	Reasons
Compost/digestate ceases to be waste, provided all other end-of-waste criteria are fulfilled, <u>when used by the producer or upon its transfer from the producer to the next holder</u>, accompanied by the issuing of a statement of conformity. **Compost/digestate materials that have not been used by the producer or transferred to the next holder <u>within 18 months</u> after the start of their production process shall no longer be eligible for end-of-waste status.**		The end-of-waste criteria are defined so that compliant compost/digestate can be stored and traded freely as a product once it is placed on the market by the producer. The benefits of the end-of-waste criteria are made actual if compost/digestate users are not bound by waste legislation (this means, for example, that farmers or landscapers using compliant compost/digestate do not require waste permits nor do formulators of growing media that use compost/digestate as a component). Users have, however, the obligation to use the product according to purpose and to comply with the other existing legislation and standards applicable to compost. Compost/digestate materials should be used within a reasonable time frame after production to avoid alteration and loss of quality.
If the compost/digestate is mixed/blended with other material before being placed on the market, the product quality criteria		Meeting the limit values relevant for product quality by means of dilution with other materials should not be allowed.

Criteria	Explanations	Reasons
apply to the compost/digestate <u>before</u> <u>mixing/blending</u>.		

5 Description of impacts

The establishment of end-of-waste criteria is expected to support recycling markets by creating legal certainty and a level playing field, as well as by removing unnecessary administrative burdens. This section outlines keys impact issues of the implementation of end-of-waste criteria on the environment, markets, and the application of existing legislation. It is based on the proposed Scope Option 3 (see section 4.1.4).

5.1 Environmental and health impact

Chapter 2.8 concluded that there were three main groups of environmental and health issues related to composting and digestion that needed to be managed:

1. Climate change impacts of methane emissions during the composting and digestion process, pre-treatment and storage

2. Local health and environmental impacts and risks at, and close to, the composting or digestion facility (linked to odour, gas emissions, leachate and pathogens in bioaerosols)

3. Soil, environment and health protection when using compost/digestate, especially when applying the material to land

The proposed end-of-waste criteria affect the first two groups only indirectly because they do not imply any change of the legal situation during composting or digestion. Composting and digestion of waste materials always has to be considered a waste treatment activity and as such is covered by waste regulatory controls.

As an indirect effect of end-of-waste criteria, there is a good chance that the requirement to operate a quality management system will have a **positive effect** also on the management of the process related environmental impacts. Furthermore, if end-of-waste criteria induce changes in composting and digestion capacities and the amount of compost and digestate produced, this will also affect the compost/digestate production related environmental impacts, and those of the alternative waste treatment activities. It could be expected that clarifying the legal situation for compost/digestate producers, authorities and markets will increase the supply of composts and digestates. At the same time, the introduction of strict limits on (in)organic pollutants and imposing requirements on input materials will enhance the confidence in the product and therefore is likely to increase demand, thus replacing soil improvers and fertilisers with a higher environmental footprint.

The exact size of these indirect effects and their overall balance (positive or negative) can hardly be measured. In any case, the indirect effects of end-of-waste will not be decisive factors for the environmental impacts from composting or digestion facilities. A much more important legal development in this respect is the coverage of composting and digestion plants in the Industrial Emissions Directive[53]. Composting plants with a capacity of more than 75 tonnes per

[53] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ L 334 17.12.2010, p. 17)

day are covered in this directive, as well as anaerobic digestion plants with a capacity of at least 100 tonnes per day.

The third group of environmental and health impacts, however, are affected directly by end-of-waste criteria because end-of-waste criteria will alter in most cases the regulatory controls applicable to compost use and are also very likely to affect the quality of compost produced and used.

The proposed end-of-waste criteria have been designed in a way that rules out intolerable impact and risks to human health and the environment in absolute terms. The criteria include minimum compost and digestate quality requirements regarding sanitation, impurities and contents of hazardous substances. Furthermore, they stipulate that compost and digestate may cease to be waste only if placed on the market for purposes for which a suitable regulation on compost/digestate use is in place to ensure environmental and health protection. There is, however, the possibility of relative changes of environmental impacts when comparing a "no action" scenario with a scenario where the proposed end-of-waste criteria are applied. As such, it should not be investigated what is the potential adverse environmental impact of the use of compost or digestate, but what is the impact of moving compost or digestate from a waste status to a product status and the different legislation it becomes submitted to.

Such relative changes, i.e. the *marginal* environmental impact, are assessed in this chapter.

5.1.1 Average contents of hazardous substances in compost and digestate

Hazardous substance concentration is a useful proxy indicator for the potential overall environmental impact of compost and digestate use because more benefit can be obtained from compost and digestate used at the same potential of negative toxicological and ecotoxicological impacts when concentrations of hazardous substances are reduced.

The overall environmental impact of compost and digestate use is determined by the balance of specific positive and negative impacts. The soil improving function of compost, for instance, has positive environmental impacts, such as reduced soil erosion and improved water retention. The main negative aspects are the potential toxicological and eco-toxicological impacts due to the contents of hazardous substances (mainly heavy metals and organic pollutants). A quantitative comparison of the positive and negative impacts of compost and digestate use in the different scenarios (with and without end-of-waste criteria) is not practicable. However, it can be assessed if end-of-waste criteria are likely to lead to a change of the average concentrations of hazardous substances in compost and digestate used and produced in a country.

Referring to Table 19 in "Annex 11: Initial proposal product quality requirements compost", it can be seen that in most countries the end-of-waste criteria would introduce new quality standards for compost production that are slightly stricter than the current standards. The same goes for the standards with regard to digestate. This is expected to lead to a **reduced average concentration of hazardous substances**, in particular heavy metals, in compost and digestate. An effective relaxation of the quality standards regarding the allowed concentrations of hazardous substances could only occur in the Netherlands. This might theoretically open the door for tolerating higher hazardous substance concentrations in compost production for exports. Since quantitative restrictions of compost use in the Netherlands are set by fertiliser law and independent of the waste status, end-of-waste criteria should however not alter the contents of hazardous substances of compost used in the Netherlands. A similar scenario is valid for Denmark, where current levels are set at 0.8 mg/kg for Cd and Hg, which are stricter than the EU Ecolabel limits.

Regarding organic pollutants, the effect of introducing mandatory requirements for the measurement of these compounds will vary in the different Member States. Some Member States already have requirements for organic pollutant measurements, either for all compost types or specific types (e.g. sewage sludge compost). Other Member States currently don't have such requirements, based on the assumption that e.g. source separate collection will not lead to pollution by organic pollutants, based on earlier measurement campaigns indicating the low organic pollutant contamination levels in such compost and/or based on the assumption that the pathways followed by organic pollutants will not result in unacceptable risks to all the possible receptors. The JRC Sampling and Analysis campaign has shown that compost/digestate materials from source separation may indeed generally contain low organic pollutant levels, yet source separation does not provide a complete safeguard against organic pollutants. It could be expected that countries or regions where separate collection is in its infancy may struggle in some cases with keeping contamination levels low as it takes substantial efforts to introduce and communicate the concept of well separating biodegradable materials from unwanted input materials. Moreover, the literature data presented in Chapter 3 suggested that high PAH concentrations of compost/digestate materials may often be linked to input materials originating from zones with important atmospheric deposition, e.g. from areas with heavy traffic (Brändli et al, 2007a). Therefore, it is believed that the introduction of organic pollutant requirements will help in **ensuring compost/digestate quality** regardless of the market on which end-of-waste materials are traded.

5.1.2 Hazardous substance flows to soil

A second way to compare the environmental impact of compost or digestate use with and without end-of-waste criteria is to look at the size of the hazardous substance flows to soil associated with compost and digestate use. Hazardous substance flows are an indicator of the size of the potential ecotoxic and toxicological impacts of compost and digestate use. They are determined by the combined effect of changes in concentrations and of amounts of compost or digestate used.

While, as argued above, average concentrations are likely to decrease, it is more difficult to foresee how the total amount of compost and digestate used (both compliant and non-compliant with end-of-waste criteria) would be affected by end-of-waste criteria. An overall conclusion on the combined effect on hazardous substance flows is therefore not possible. It is likely, however, that there will be increased hazardous substance flows at certain locations where the quality of compost and digestate used is approximately the same with and without end-of-waste criteria and more compost and digestate will be used due to increased availability. However, since the end-of-waste criteria include minimum compost and digestate quality requirements and demand that there must be suitable locally applicable use rules, it can be expected that the **overall environmental balance** of increased compost and digestate use is still **positive**.

5.1.3 Risks related to misuse of compost or digestate

A third aspect to assess consists of the risks of environmental impacts (likeliness and size) because of compost or digestate misuse (not for recognised purpose or not complying with quantitative use restrictions). These risks may change when end-of-waste criteria lead to a new market situation (alterations in compost and digestate supply and demand) and affect the regulatory controls applicable to compost and digestate trade and use.

Locally, there may be increased risks related to compost and digestate misuse if end-of-waste criteria lead to new situations of oversupply, because of facilitated imports, which the market cannot handle efficiently. This theoretical possibility appears most relevant for the main compost and digestate producing countries and where little experience exists yet with compost use. However, the **pollutant limits** in the end-of-waste criteria are **set at a level that keeps any potential environmental impacts low, even in the case of misuse**. As a complementary measure to end-of-waste criteria it may be indicated that some countries put means in place for the monitoring of compost and digestate flows (e.g. registration and analysis of data of compost placed on the market) in order to detect and manage possible situations of oversupply.

Finally, it may be assumed that the requirement of a minimum stability for end-of-waste compost and digestate will lead to a **reduction in uncontrolled emissions** related to storage, transport and application.

5.1.4 Conclusion

Altogether, the **overall environmental impact** of compost and digestate use in the end-of-waste scenario is **expected to be more positive** or at least neutral than in the "no action" scenario, both at the EU level and at the level of individual Member States. There is the theoretical possibility of a locally less favourable balance at certain places but there are proportionate accompanying measures to detect and counter any undesired developments.

The existence and enforcement of adequate compost and digestate use rules is an important factor supporting the positive environmental balance of end-of-waste criteria, especially in countries where composting and/or digestion is not a common practice today.

5.2 Economic impact

5.2.1 Costs of compost and digestate production

Costs related to necessary adaptation of the process

Analytical data presented in Chapter 3 on (in)organic pollutants and physical impurities has demonstrated that for an overwhelming majority of European compost and digestate produced from source separated input, the proposed end-of-waste quality criteria can easily be met. This is especially the case where such plants are already working under national end-of-waste or similar product regimes. Therefore, it can be expected that these installations will have limited to no costs related to adaptation of their process. Nonetheless, operators of composting/digestion plants should take care to avoid possibly contaminated input materials (clippings from roadsides with heavy traffic, biobins with unauthorized materials, etc.) in order not to jeopardize the possible end-of-waste status of their materials.

Sporadic exceedings of quality parameter limit values, as discussed in Chapter 3, could often be traced back to regional specificities (natural background concentrations or historical pollution). In other cases, such as for digestate containing manure, the used input material seemed the most critical factor. Hence, **by strictly selecting the input materials, compost and digestate producers should be able to meet the proposed EU end-of-waste quality criteria without major changes to their process**. As a result, some of the costs may be transferred to the suppliers of the input material. Examples of this are gate fees that depend on the input material quality (to be certified by analysis results) or pay-as-you-throw schemes, which have shown to result in cleaner and larger fractions of bio-waste being delivered to the composting or

digestion installation (DG ENV, 2012). Nonetheless, in many cases opportunities will still exist for the input material suppliers to reduce costs. For instance, it is believed that relatively simple actions could be taken at the source that result in a better efficiency of Cu and Zn uptake by livestock and less dissipation, resulting in a substantial reduction of Cu and Zn in manure and hence lower gate fees to be paid.
The JRC Sampling and Analysis campaign and other data sources also indicated that certain technologies are more likely to meet all proposed product quality requirements than others. As such, a large majority of existing MBT materials seemed likely to fail the proposed EU end-of-waste physical impurities requirements, which were easily met by the compost samples derived from source separate collection. By excluding MBT technologies from the EU end-of-waste scope materials, it has been avoided that existing MBT installations would suffer from sudden and important technology investments in order to maintain the end-of-waste status they might currently enjoy at national level. Under the current proposal, installations can continue to operate under national end-of-waste legislation and investments to improve product quality can be spread over time. The same applies for sewage sludge based materials for which a large share of the existing materials would have experienced difficulties in meeting the proposed EU end-of-waste heavy metal limits.

It is difficult to estimate what the different costs will be for operators of end-of-waste compost/digestate materials, but it is clear that installations that use input materials with low source pollution will have important economic advantages by avoiding or minimizing downstream costs related to increased analytical measurement frequencies and waste related charges for off-specification materials.

Quality assurance costs

A main cost factor of end-of-waste criteria for compost and digestate production is quality assurance in the case of composting or digestion plants where an upgrading of quality assurance is required. ORBIT/ECN (2008) produced an overview of quality assurance costs for compost according to the main schemes currently in place in various countries. Table 16 shows that the quality assurance costs are mainly determined by the size of the composting plant and range from below EUR 0.08/tonne of input to more than EUR 3/tonne of input. Taking into account the typical conversion rates of input material into compost, the costs expressed per tonne of compost produced are about twice these values. The quality assurance costs in Table 16 reflect the external expenses in the renewal procedure of certificates or quality labels during the continuous operation of the plants. In the first application and validation period (first one to two 'recognition' years) costs are considerably higher on account of a first evaluation of the plants and the higher frequency of tests. Additional costs are incurred through the internal staff requirements for operating the quality management system.

The total compost production costs in a best practice composting plant with 20 000 tonnes capacity were estimated at 45 Euro/tonne of input (Eunomia, 2002). A comparison with the typical quality assurance costs for a plant of this size according to Table 16 shows that the external quality assurance costs represent less than 1 % of total production costs.

For open-air windrow composting the cost can be less than 20 Euro/tonne. In this type of plant the throughput is usually much smaller and, in the case of 500 tonnes annual input, quality assurance can make up more than 15 % of total costs.

Although for digestion, less specific cost information with regard to the quality assurance system is available, it can be reasonably assumed that the costs will be in the same order of magnitude as for composting, given that the same processes are followed and that analyses also cover similar parameters. Compared to the production cost of digestate (30 to 80 Euro/tonne input), the weight of the quality assurance in the total production cost for digestion is similar to the one for compost.

However, many composting and digestion plants have already suitable quality assurance systems in place (at least one fifth of all composting plants in the EU), and most others regularly carry out some form of compliance testing, so that not all of the quality assurance costs associated with the EU end-of-waste system would be additive.

Table 16: Cost of compost quality assurance in selected European countries. Source: ORBIT/ECN (2008).

Quality assurance costs/tonne input and year (EURO excluding VAT)										
Throughput/ year (tonnes)	**AT (1) (ARGE) Agriculture plants**	**AT (2) (KGVÖ) Industrial plants**	**DE (3) (BGK)**	**IT (4) (CIC)**	**NL (5) (BVOR) (Green C. plants)**	**NL (6) (VA) (VFG plants)**	**SE (7) (SP)**	**UK (8) (TCA) Use in agriculture/ horticulture**	**UK (9) (TCA) Other uses**	**EU Mean value**
500	2.15	3.36	—	—	—	—	—	—	—	—
1 000	0.94	1.80	—	—	—	—	—	—	—	—
2 000	0.97	1.32	0.82	—	1.62	1.99	1.21	1.13	1.10	1.26
5 000	0.63	0.67	0.52	0.48	0.76	0.80	0.48	0.45	0.44	0.59
10 000	0.44	0.58	0.34	0.46	0.53	0.40	0.29	0.28	0.27	0.42
20 000	0.26	0.44	0.31	0.45	0.39	0.20	0.15	0.23	0.22	0.32
50 000	0.17	0.36	0.19	0.43	0.21	0.08	0.06	0.20	0.19	0.23

Sources: Personal information from:

(1) KGVÖ Compost Quality Society of Austria — operates mainly bio-waste treatment plants. Costs include membership fees, laboratory costs and external sampling.

(2) ARGE Compost & Biogas Association Austria — decentralised composting of separately collected bio-waste in cooperation with agriculture. Costs include membership fees, laboratory costs, external sampling and external audits of composting/digestion sites

(3) BGK German Compost Quality Assurance Organisation. Costs include membership fees, laboratory costs and external sampling.

(4) CIC Italian Compost Association CIC — including company fee according to turnover plus external sampling and laboratory costs

(5) BVOR Dutch Association of Compost Plants — costs at green waste plants which include membership fees, laboratory costs and the costs for yearly audits by external organisations — no external sampling.

(6) VA Dutch Waste Management Association — costs at bio-waste (VFG) plants including membership fees, laboratory and external sampling costs, and the costs for yearly audits by external organisations. The expenses are slightly higher compared to BVOR because of additional analysis of sanitisation parameter and the external sampling.

(7) SP Swedish Standardisation Institute execute the QAS scheme — costs include membership fees, laboratory costs, and costs for yearly audits by SP — sampling is done by the plants besides the yearly audit.

(8) TCA the UK Compost Association certification for compost in agriculture and horticulture — total costs associated with certification scheme fees for all parameter and lab testing. Costs associated with testing the compost are higher compared to other application areas, as the compost producer is required to test parameters like total nutrients, water soluble nutrients and pH in addition sampling is done by the plants. For compost used in agriculture and field horticulture, the UK Quality Compost Protocol has introduced for the land manager/farmer the requirement to test the soil to which compost is applied. The costs associated with soil testing are not incorporated here because it is mostly not the compost producer, but the farmer or land manager who pays for.

(9) TCA the UK Compost Association certification for compost used outside agriculture and horticulture — total costs associated with certification scheme fees and lab testing. Sampling is done by the plants.

It can be expected that the **major changes in QA costs** by the possible introduction of EU end-of-waste criteria, compared to existing systems, will be **related to product testing**. These changes originate from likely modifications to the requirements for independent sampling, measurement of organic pollutants and the use of CEN/Horizontal standards. Costs for e.g.

auditing and administration are less likely to change substantially for those plants already working under a QA system.

Several Member States already require external sampling, whereas others allow the plant operators to perform the sampling themselves (e.g. in the UK). The estimated costs for external sampling, based on information from TWG experts, vary widely and are estimated around 200 Euro per sample, as discussed in section 4.4 "Product quality requirements for compost and digestate". In Member States where independent external sampling is already considered an established practice, reported prices for independent sampling generally tend to be the lowest. Nonetheless, the current proposal includes the possibility of reducing external sampling after the recognition year, requiring only one yearly independently collected sample for plants up to 10000 tonne annual input and 3 for plants up to 50000 tonne annual input, effectively reducing the cost for external sampling to less than a few cents per tonne.

Although some Member States, such as France or Belgium, already require routine measurements of PAH, other Member States do not require the continuous measurement of PAH or other organic pollutants in compost/digestate products. The estimated cost for PAH_{16} measurement is less than 150 Euro per sample, as discussed in section 4.4 "Product quality requirements for compost and digestate". Based on the proposed PAH_{16} measurement frequency, the mandatory measurement of PAH_{16} would cost between 150 and 750 Euro in the recognition year and less than 150 Euro in the second year for plants up to 50000 tonne annual input, i.e. the large majority of plants in the EU. In other words, PAH_{16} measurements would create an additional cost of less than 0.005 Euro/tonne input material for a plant of 15000 tonne annual input capacity after the recognition year and still less than 0.03 Euro/tonne input material in the recognition year. These values are arguably very low compared to the typical gate fees and production costs. Prices are even likely to drop in the future thanks to increased analytical demand and competition between laboratories and by the purchase of "analysis packages" in which PAH_{16} measurements are included.

Finally, estimates on costs incurred by shifting to Horizontal standards are very scarce. In general, standardization is known to lead to cost reductions on the longer term (DIN, 2000). According to a UK impact study, the accreditation costs for introducing CEN/Horizontal standards could be as high as £ 240 000 per matrix (compost/wet digestate/dry digestate). It is reasonable to assume that these costs will be recovered from the final customers, in which case the costs could be reflected in a possible analysis price increase. Nonetheless this necessary investment may be partially offset by the possibilities for analytical laboratories to offer their services in an EU-wide market and hence to benefit from economies of scale. Moreover, additional accreditation costs may also be partially transferred to analytical services for other sectors, such as the production of waste compost/digestate materials or similar fertilizing materials.

5.2.2 Cost of compost and digestate use

Users of end-of-waste compost and digestate need not comply with waste regulatory controls. Other legal obligations, for example based on fertiliser or soil protection law, are independent of waste status. There is also the possibility of new regulatory obligations being introduced as accompanying measures to end-of-waste criteria. The net difference of the cost of compost or digestate use in an ‘end-of-waste scenario’ compared to a ‘no action scenario’ **depends therefore on the specific legal situation in each country** and may even be different between regions of one country. The case of the compost quality protocol in the United Kingdom can serve as an example. The Composting Association (2006) estimated that for agricultural use of compost under the quality protocol (equivalent to end-of-waste) the agricultural compliance costs are reduced by EUR 1.69 (GBP 1.29)/tonne of compost[54].

In this context, it should be noted that a number of digestate producers may incur costs due to **REACH and CLP registration obligations** for digestate materials becoming products. This is due to **certain digestate materials** not being exempt from REACH registration obligations (see also sections 5.4.2 and 5.4.3 for a legal interpretation of the current REACH and CLP provisions regarding compost and digestate products). It is difficult to estimate these costs, as no data on current REACH and CLP related costs for digestate product materials under national legislation could be retrieved from literature or through the TWG expert network.

5.2.3 Benefits

Where end-of-waste criteria lead to an upgraded quality assurance it can, in principle, be expected that the compost or digestate will be of **improved quality**, rendering additional benefits to users, for instance agronomic benefits in the case of agricultural use. This should in turn result in considerably **higher sales prices** for compost and digestate. The net revenues should even be further increasing, thanks to reduced marketing costs. Alternatively, plants producing end-of-waste materials may be **able to charge higher gate fees** (WRAP, 2009a).

In addition, users would benefit from a **reduced use of mineral fertilizer**. WRAP (2009a) estimated that the introduction of the PAS 110 end-of-waste system for digestate in the UK would amount to a net overall cost saving of 1.86 million pounds for the UK AD sector over a period of 10 years, compared to a baseline waste scenario.

In contrast to these direct monetary benefits, other benefits are less easily quantifiable, such as an **improved carbon balance** and **soil improvement** from incorporating organic matter. WRAP (2009a) estimated that the carbon benefit of the PAS 110 system would amount to 5.79 million pounds for the UK AD sector over a period of 10 years, compared to a baseline waste scenario.

Even **Member States that currently own a well-established national product system** for compost/digestate **may benefit from harmonization** of end-of-waste criteria at EU level, according to several TWG experts. Obviously, a change from national to EU-wide product criteria would imply certain efforts and costs, e.g. due to changes to analytical follow-up or quality assurance procedures. Nonetheless, the necessary efforts to comply with a new EU end-of-waste framework will generally be much less for Member States with well-established markets compared to those with less developed markets. Moreover, the discussions above indicated that a large majority of existing compost/digestate producing plants covered by the proposed EU scope would technically be able to meet the proposed quality requirements.
Several clear economic advantages linked to EU harmonization may be discerned for Member States with a well-established national product system, both in the short and the long run (see also section 5.3 Market impact):

- the development of an EU-wide market for end-of-waste compost/digestate materials may enable to **capitalize acquired know-how through sales of technology and services** in Member States with a developing market;

[54] 1 March 2008 exchange rate.

- because of EU-wide standardization of measurement methods, producers may benefit from a larger range of companies offering analytical services and hence **more competitive prices for product analysis**;
- the level playing field generated through uniform rules and quality requirements for compost/digestate ensures **fair competition** between local compost/digestate producers and users (e.g. farmers) and their counterparts in other Member States;
- compost/digestate producers located in border regions can **export** their materials under the product regime, **without waste-related restrictions**;
- **compliance costs** for compost/digestate producers in border regions wishing to export their materials are **reduced** through extensive harmonization of measurement methods.

Apart from the strictly economic benefits, harmonization also ensures that **consumers of derived products**, such as agricultural produce could enjoy the guarantee that materials have been grown on compost/digestate materials of the **same quality standards, regardless of their origin within the EU territory**.

5.2.4 Overall assessment

Where quality certified compost or digestate is used today under waste regulatory controls, end-of-waste criteria are likely to lead to a **net cost reduction**. The cost reductions accrue in the use sector, and may possibly be transferred back to some extent, through the acceptance of increased compost and digestate prices, to compost and digestate producers, and through reduced gate fees to municipalities or other relevant waste generators.

Where the quality certification of compost and digestate needs to be upgraded for complying with end-of-waste criteria, this creates increased costs for compost and digestate producers, which are not likely to be very significant in relative terms for large scale compost and digestate production, but may represent more than 20 % of total costs in the case of very small-scale production. This may be compensated, at least partly, by increased revenues through higher prices in compost and digestate sale, if users accept that there is a sufficiently high benefit to them in terms of avoided compliance costs and better and more reliable product quality. Finally, clear carbon benefits and other environmental benefits can be reaped from shifting to end-of-waste status.

Nonetheless, it should be clear that **for very small plants**, sometimes operating without the income from gate fees, applying for end-of-waste status **may not be economically feasible**. This group typically comprises small scale community composting systems that work on a voluntary basis or with limited financial means. In this context, some experts had suggested to further relax or lift requirements on mandatory measurements for these small plants, in order to allow them to operate within the end-of-waste framework. However, other experts signalled that such relaxations could undermine the trustworthiness of the proposed end-of-waste system and jeopardize the level playing field. It could also lead to mushrooming of small plants with limited controls. Moreover, opponents of relaxed requirements for very small plants indicated that Member States already have the necessary means at their disposal to recognize the valuable contributions of these plants to the recycling chain, outside of the end-of-waste framework. As such, Article 2(6) and Annex I and II of Commission Decision 2011/753/EU allow Member States to count the input to the aerobic or anaerobic treatment as recycled where that treatment generates compost or digestate which, following any further necessary reprocessing, is used as a recycled product, material or substance for land treatment resulting in benefit to agriculture or ecological improvement. Hence, compost or digestate from small scale plants can be included when calculating recycling levels. Moreover, Article 24 of the Waste Framework Directive enables Member States to exempt composting/digestion operations from permit requirements, allowing for reduced operational costs for small scale plants.

5.3 Market impact

The main direct impact to be expected from end-of-waste criteria is a strengthened market demand for compost and digestate through:

- Export and import facilitation for compost/digestate
- Product quality evolution by improved perception by potential users
- Avoidance of compliance costs for compost/digestate use.
- Investment decisions for new biodegradable waste treatment plants
- Benefits from impacts on associated markets

5.3.1 Export and import facilitation for compost/digestate

Given its restricted market value, compost and digestate are generally not traded over large distances. Most **compost and digestate is sold within a distance of maximum 100 km** from the production plant, although transports of bulk compost over distances of 200 km have been reported by TWG experts. The practical transport distance may also depend on the monetary value and formulation of a material. For instance, dried digestate pellets may be transported over a longer distance than liquid digestate.

Facilitated exports are especially relevant in border regions and areas where the compost or digestate market is saturated because of use restrictions due to strong supply of competing materials for soil spreading, especially manure. According to ORBIT/ECN (2008), shortage in national demand because of competition of other cheap organic material (mainly manure) was the main reason for compost exports in the cases of Belgium (Flanders) and the Netherlands. The Netherlands, for instance, combine a very high population density, one of the highest separate collection rates of kitchen and garden waste (ca. 190 kg/inhabitant/y), a very large excess of animal manure on the one hand and a very restrictive nutrient/fertilising legislation on the other. Even if theoretically there could still be enough market potential for compost in the Netherlands, prices achieved for compost are low, often even negative, and the Dutch composting industry has already exported considerable amounts of compost under current framework conditions. On average 4.5 % of the annual compost production in Flanders and the Netherlands was exported in 2005 and 2006. In 2011, a shortage was again reported for compost in the Netherlands, as fierce competition with manure was no longer an issue, according to the Dutch Environmental Ministry. Dutch exports to Germany required the participation of Dutch composting plants in the German compost quality certification scheme and bilateral agreement with German *Länder* governments. Currently, Belgian (Flemish) exports to France need to demonstrate both compliance with the Belgian (Flemish) VLACO standard and the French NF U44-051 standard (analysis and certification by French laboratories). It is expected that export possibilities could more easily be developed with European end-of-waste criteria.

Despite the relative short distances over which compost and digestate can be traded, the introduction of European end-of-waste criteria could have a number of clear **advantages** related to facilitated cross-border trade:

- a **larger fraction of the EU population would have access to high quality compost/digestate** products, also users living in areas where currently little compost/digestate is being produced;
- producers located in border areas would benefit from **expanded markets to sell their products**;
- consumers in border areas may benefit from **increased competition** and a larger offer of products;
- exports of compost/digestate could stimulate the development of new markets and production centers in areas with a limited production history of quality composts/digestates and result in a cross-border transfer of technological know-how. Such cross-border initiatives may in turn constitute an important **trigger for the wider expansion of quality composting/digestion operations** across the EU.

Several TWG experts suggested that current compost/digestate trade across intra-EU borders did not amount to more than 1 to 2 per cent of the total market. In order to estimate the possible **fraction of the market that could benefit from facilitated export and/or import**, it should be calculated where cross-border trade could reasonably take place and how much this trade could represent out of the total theoretical market. It is reasonable to assume that the production of compost/digestate materials from waste is proportional to the production of biodegradable waste, which in turn depends on the size of the population. Hence, the local production of these materials should be proportional to the local population density. Furthermore, it may be presumed that compost/digestate transport distances are limited to about 100 km and that transport only happens over land for cost reasons. As such, the number of people living within a zone of 100 km at each side of a land border between two Member States of the EU can be calculated, as an indicator for the fraction of the market that may benefit from cross-border trade. A graphical representation of these boundary conditions is presented in Figure 14.

Calculations were made to determine the total population of every EU-27 Member State living in a zone of maximum 100 km distance from an intra-EU land border. These calculations were based on 1 km^2 grid population density information and the methodology has been described in more detail in "Annex 21: Calculation of the population in EU border zones".

Table 17 displays the results from the population calculations in the intra-EU land border zones. Recalling the assumption that the production of compost/digestate is linked to the number of inhabitants in a certain area, it is clear that the **growth potential for intra-EU cross-border trade of compost/digestate is very large**. **<u>Up to 37%</u> of the EU population could directly benefit from facilitated cross-border trade**. For 17 Member States, these benefits could apply to at least a quarter of their theoretical internal market and for 13 Member States even to half or more of their theoretical internal market.

Contrary to what certain TWG experts suggested, the possibility of cross-border trade seems not only relevant to small countries like those in the Benelux area, but may **also be beneficial to several large Member States**. As such, more than half of the German market could theoretically enjoy the benefits of facilitated cross-border trade through EU end-of-waste criteria, two fifths of the Polish market and even a quarter of the French market. Nonetheless, cross-border trade opportunities may remain limited for the Nordic countries, the UK and Italy, mainly due to a low population density near the borders (Nordic countries) or a limited length of land borders compared to the total border length (UK, IT).

On the one hand, it may be suggested that these calculations are rather conservative. As such, any overseas transport has been excluded (e.g. between Corsica and Sardinia), or any trade with neighbouring EEA countries (e.g. Switzerland, Norway). Moreover, high value products such as dried digestate are likely to be transported over larger distances than the 100 km maximum applied for the present calculations. On the other hand, in cross-border areas that already enjoy fully developed local quality compost and digestate markets, with comparable supply, demand and price structures at both sides of the border, it may be unlikely that EU harmonization will lead to a surge in cross-border trade of end-of-waste materials.

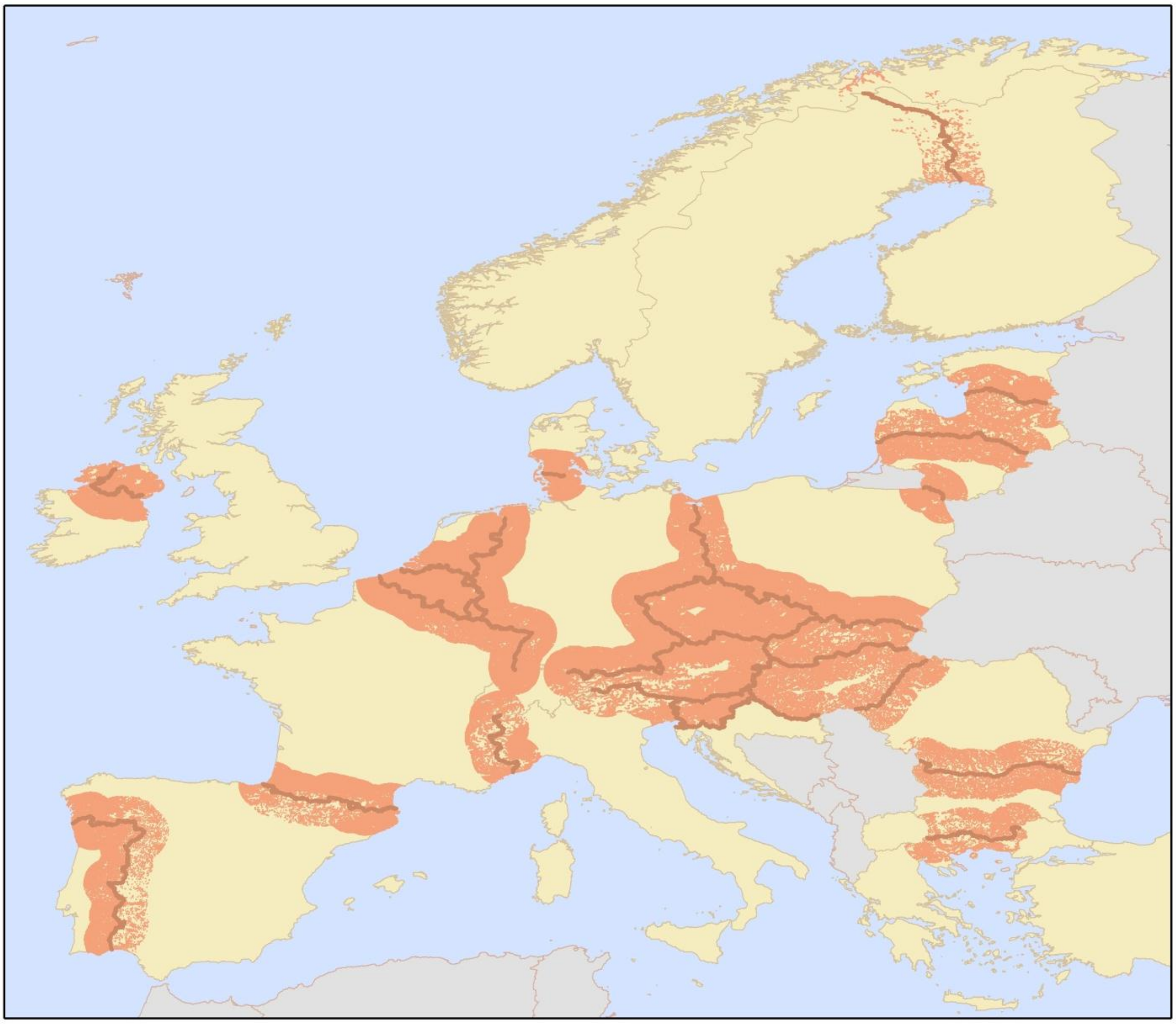

Figure 14: Graphical overview of EU population living in zones of maximum 100 km distance from an intra-EU land border.

Table 17: Country-specific population living in a zone of maximum 100 km distance from an intra-EU land border (absolute values and fraction of total population). Malta and Cyprus are not listed because of a lack of land borders. Population density data for Croatia were not available.

Country Code	Population within border zone of 100 km (thousand inhabitants)	Fraction of total population (%)
BE	10,640	100
BG	5,139	67
CZ	10,216	100
DK	759	14
DE	43,836	53
EE	432	32
IE	2,214	53
GR	2,128	19
ES	8,313	19
FR	15,270	24
IT	6,562	11
LV	2,130	96
LT	2,221	68
LU	487	100
HU	9,627	96
NL	14,755	90
AT	8,283	100
PL	15,173	40
PT	4,866	46
RO	8,749	41
SI	1,979	99
SK	5,430	100
FI	80	1.5
SE	49	0.5
UK	1,743	2.9
Total EU-27	**181,102**	**37**

5.3.2 Product quality evolution by improved perception

At present, quality requirements vary widely in the European compost and digestate landscape, ranging from non-existent to very strict. The current proposal for EU end-of-waste materials includes strict but feasible quality criteria for compost and digestate materials and therefore should improve the quality perception by consumers. It should also generate a level playing field across the EU for all producers of compost and digestate.

Today, consumers, authorities and industry may still have prejudices towards compost or digestate due to the fact that they are unfamiliar with these materials or due to memories of low quality materials released to the market in the past. Quality assessment is often based on sensory perception (e.g. colour, smell, fluidity, grain size, presence of physical impurities) and a fear for invisible - bacterial or chemical - contamination. By imposing strict limitations on visual contamination (low physical impurities contents) together with tight limits for a wide spectrum of biological, inorganic and organic pollutants, the end-of-waste status for compost and digestate ensures very low contamination levels in the whole of the EU. It is believed that this will improve demand from consumers for end-of-waste materials and hence it is reasonable to assume that producers of compost and digestate will work to obtain or keep end-of-waste status and as a result **more high quality products will become available on the market**.

In this respect, it should be noted that a large number of experts suggested that the inclusion of sewage sludge and especially mixed municipal waste within the EU end-of-waste scope could possibly undermine market confidence in compost and digestate in several Member States, despite possible strict requirements on organic and inorganic pollutants. Some stakeholders, especially those operating in Member States where established markets currently exist for these materials, disagreed with this view. Because of the strongly diverging expert opinions, these materials have been excluded from the currently proposed scope for EU end-of-waste criteria, ensuring a minimal local market disturbance by letting existing national frameworks to continue operating.

The strengthening of domestic markets is especially relevant in countries where composting and digestion is only incipient at the moment. By setting EU-wide quality standards for compost and digestate that ensure good and reliable product quality of compliant compost and digestate, end-of-waste criteria, together with accompanying measures to define the conditions for compost and digestate use, may provide a boost to quality compost and digestate markets in these countries.

5.3.3 Avoidance of compliance costs for compost/digestate use

Avoiding compliance costs for compost and digestate use if waste regulatory controls are not required is also a factor that favours the compost and digestate market demand. This has been an advantage considered in the development of the compost quality protocol in the United Kingdom.

For compost and digestate materials that do not meet end-of-waste criteria it will be increasingly difficult to find market outlets, because their use will require waste regulatory compliance and they will be clearly differentiated as of lower quality. In other cases, such as in the UK, existing long-term contracts between authorities and compost or digestate producers require that the output material meets end-of-waste status. Changes in the end-of-waste criteria may thus lead to failure to meet the contractual requirements.
Distinction can be made between two different situations:

a) *The compost or digestate material is likely to be upgradable to receive end-of-waste status*.

In some cases, efforts to improve quality management and product quality may be needed in order to succeed in meeting the requirement. As discussed above, the key factor will often be to obtain purer input materials. Other issues may be linked to process conditions that might need to be changed to meet the hygienisation requirements. Necessary additional investments to reach the end-of-waste status may be recovered by the producer through higher revenue from the end-of-waste materials, compared to continue producing waste materials or the avoidance of waste permits.

b) *The compost or digestate material is not likely to be upgradable to receive end-of-waste*

In other cases, it might be more difficult or even impossible to obtain end-of-waste status for compost or digestate materials without a thorough revision of the process scheme. This may be due to the fact that a certain input material, currently used in large quantities, contains an elevated level of pollutants. It can even occur that certain compost or digestate materials that currently enjoy product status in national legislation may no longer be eligible for product status and receive waste status. In this case, the economics of composting and digestion will deteriorate due to lower sales prices, compost or digestate production may be abandoned and plants may have to find new outlets for their material, such as landfill or incineration. Penalties may arise as well for breach of existing contracts.

5.3.4 Investment decisions for new biodegradable waste treatment plants

Setting clear end-of-waste criteria at EU level may diminish uncertainties with regard to investment decisions. Available choices will be clearer shaped for decisions on new treatment capacities for biodegradable waste: either production of EU end-of-waste compliant compost/digestate or one of the alternative options. Through strengthening the market demand, while changing the costs of high-quality compost and digestate production only marginally, it can be expected that at more places than today there will be favourable conditions for opting for EU end-of-waste compost or digestate production. It can also be expected that the establishment of new capacities for the production of non-end-of-waste-compliant compost or digestate will become rather unattractive because of difficulties to find an outlet for the compost or digestate.

In this respect it should be mentioned that it is proposed to currently exclude compost/digestate containing certain input materials (e.g. sewage sludge and mixed MSW) from the scope of EU end-of-waste legislation, while allowing them to operate under existing national end-of-waste or similar frameworks. Whereas this allows existing plants to continue operating without sudden and major investment costs for the time being, it also sends a clear signal for new investment decisions. In this context, the **legal certainty and market advantages of the EU end-of-waste framework** will have to be weighed by investors and authorities against possible legal or market advantages and disadvantages offered by technologies operating within a national end-of-waste framework.

5.3.5 Impacts on associated markets

Historical examples have shown that a quality label for agricultural produce can help stimulate the development of new markets. Introduction of a label may be either producer driven or because of consumer demand. An example is the French Cerafel quality-environmental initiative for export of produce from Brittany, mainly to Germany, which was based on consumer demand. In a similar way, EU-wide end-of-waste criteria could serve as a very strong marketing tool for compost and digestate in the Community **agricultural market**. They would offer the advantage of an **EU-wide uniform quality standard for compost and digestate for produce**, regardless of the country or region of origin. Traders and purchasers of fruit and vegetables, whether small retailers or internationally operating supermarkets, are currently being confronted with a wide spectrum of compost/digestate and other fertilizing standards across the EU. The level playing field offered by EU end-of-waste criteria would provide them with simplicity and legal certainty when buying agricultural produce in any EU region. Hence, a provision such as "produced with EU end-of-waste compost/digestate according to Regulation XX YY/20ZZ" could serve as a basis for simplifying purchase contracts for vegetables and fruits. Moreover, compost/digestate producers, together with retailers, could use this quality feature as a marketing argument towards consumers of vegetables and fruit. In this way, consumers of agricultural produce could create an indirect pull effect for EU end-of-waste compost/digestate materials.

Moreover, businesses indirectly involved with the compost/digestate production sector are also likely to be affected by the possible introduction of EU end-of-waste criteria for compost/digestate.

For providers of **analytical services**, it has been stated above that the introduction of Horizontal standards may lead to a temporary surge in costs, related to renewed accreditation and training for the new measurement methods. On the other hand, companies operating in different Member States will no longer be required to maintain accreditation and training for up to 28 different national measurement methods for a certain parameter. Hence, this may create possibilities for expansion of their markets. In turn, compost/digestate plant operators may benefit from this through lower prices for analytical services thanks to increased competition. Furthermore, given the relatively low shipping costs for samples, compared to the price of a full measurement, analytical companies may serve large parts of the European market without the need of physical presence in the individual Member States.

For **providers of technology and know-how**, standardization will allow them to enter new markets and benefit from economies of scale. This development may be catalysed by the possibly increased interest from local authorities for compost/digestate production because of the legal certainty the EU end-of-waste framework could provide. Here as well, compost/digestate plant operators may benefit from this through lower prices for investment and operation thanks to increased competition.

Similarly, **Quality Assurance organisations** may operate in different Member States while enjoying the benefits of a simple and standardized framework.

5.4 Legislative impact

The section below reflects the legislative impact of moving compost or digestate from the waste status to the product status. It analyses the legislation as it currently stands and indicates important points that should be considered.

5.4.1 Impact on national legislation

In some Member States there already exists specific compost or digestate legislation based on waste law, including explicit provisions on the status of compost or digestate as waste or not (e.g. bio-waste and compost ordinances in Germany and Austria respectively). It can be foreseen that such legislation would have to be **adapted** when EU end-of-waste criteria are introduced for compost and digestate.

In other cases there are official rulings or practices by regulatory authorities that link end-of-waste to compliance with certain standards or protocols, like in the United Kingdom. An adaptation to EU end-of-waste criteria (for example concerning limit values or the need for quality assurance) would also be required in these cases, although these would probably not have to be of a full legislative nature.

As an accompanying measure to end-of-waste criteria, there is a need to adapt existing legislation in Member States regulating the use of compost and digestate to harmonised technical standards on product parameters, sampling and analysis. Furthermore, it is **advisable** that the **use of compost or digestate should be regulated** also in those places where no such legislation exists yet, in order to maximize environmental benefits and minimize possible risks to human health and environment by inappropriate usage.

5.4.2 REACH impact on product status of compost and digestate

One of the most important pieces of legislation with regard to the product status of end-of-waste compost and digestate is REACH.

REACH is the European Community Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (EC 1907/2006)[55]. The law entered into force on 1 June 2007. The aim of REACH is to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances. The REACH Regulation places greater responsibility on industry to manage the risks from chemicals and to provide safety information on the substances. Manufacturers and importers are required to gather information on the properties of their substances, which will allow their safe handling, and to register the information in a central database run by the European Chemicals Agency (ECHA) in Helsinki. One of the main reasons for developing and adopting the REACH Regulation was that a large number of substances have been manufactured and placed on the market in Europe for many years, sometimes in very high amounts, and yet there was insufficient information on the risks that they posed to human health and the environment. REACH was set up to ensure that industry had the information necessary to manage its substances safely.

For compost and digestate falling under the waste regime, REACH is not applicable, as it is stated in Article 2(2) of EC 1907/2006 that "Waste as defined in Directive 2006/12/EC[56]of the European Parliament and of the Council is not a substance, preparation or article within the meaning of Article 3 of this Regulation."

However, compost and digestate no longer holding waste status under end-of-waste, is to be regarded as a substance and therefore falls under the scope of the REACH Regulation.

Article 2(7)(b) of the Regulation (EC) No 1907/2006 (REACH) and its amendment by Regulation (EC) No 987/2008 of 8 October 2008 sets out criteria for *exempting* substances covered by Annex V from the registration and evaluation requirements as well as certain downstream user obligations as described in Title V, because registration is deemed inappropriate or unnecessary and their exemption does not prejudice the objectives of REACH. Substances included in Annex V are exempted from registration (as well as downstream user requirements and evaluation) for all their possible uses irrespective of the tonnage at which they are manufactured or imported (currently or in the future). It should be noted that the companies benefiting from an exemption must provide the authorities (on request) with appropriate information to show that their substances qualify for the exemption.

[55] See for more information on REACH: http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm
[56] Replaced by Directive 2008/98/EC (Waste Framework Directive)

Basically, two major exemption cases in Annex V are relevant with regard to compost and digestate, and have been clarified in the "Guidance for Annex V - Exemptions from the obligation to register"[57].

Compost (Entry 12 in Annex V)
This exemption covers compost when it is potentially subject to registration, i.e. when it is no longer waste according to Directive 2008/98/EC (WFD), and is understood as being applicable to substances consisting of solid particulate material that has been sanitised and stabilised through the action of micro-organisms and that result from the composting treatment.
It should be noted that a similar clear exemption is mentioned for biogas, but *not* for digestate as such.[58]

Naturally occurring substances, if they are not chemically modified (Entries 7 & 8 in Annex V)
This group of substances is characterised via the definitions given in Articles 3(39) and 3(40):
According to Article 3(39), 'substances which occur in nature' means 'a naturally occurring substance as such, unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, by extraction with water, by steam distillation or by heating solely to remove water, or which is extracted from air by any means'.

Furthermore the guidance document (Guidance on Annex V) states:
It should be noted that whole living or unprocessed dead organisms (e.g. yeast (…), freeze-dried bacteria) or parts thereof (e.g. body parts, blood, branches, leaves, flowers etc.) are not considered as substances, mixtures or articles in the sense of REACH and are therefore outside of the scope of REACH. The latter would also be the case if these have undergone digestion or decomposition resulting in waste as defined in Directive 2008/98/EC, even if, under certain circumstances, these might be seen as non-waste recovered materials.

This would imply that digestate derived from *unprocessed* biological materials (e.g. fruit waste) is outside the scope of REACH, whereas digestate derived from *processed* biological materials (e.g. residues from jam production) falls under the scope of the REACH regulation.

In conclusion, it follows that:

- **compost would be exempt from the REACH registration obligations** when it has not reached end-of-waste status but also when it has as it is included in Annex V;
- **digestate** would be exempt from the REACH Regulation so long as it is still waste, **exempt from REACH registration obligations when containing non chemically modified biological materials** because of entries 7 and 8 of Annex V, **but subject to REACH when containing chemically modified biological materials** as it would no longer be waste and could not benefit from the exemptions in entries 7 and 8 of Annex V.

As such, under the current circumstances, digestate producers will have to comply with REACH under certain conditions when the end-of-waste digestate contains chemically modified input materials.

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[57] See for more information: http://guidance.echa.europa.eu/docs/guidance_document/annex_v_en.pdf
[58] A draft version of the Guidance document to Annex V included exemptions for "anaerobic digestion product of bio-waste", but this was not retained in the final Guidance document to Annex V.

5.4.3 Classification, Labelling and Packaging Regulation

The Classification, Labelling and Packaging Regulation (EC) No 1272/2008 on substances and mixtures (CLP) introduces the Globally Harmonised System of the United Nations (GHS) for the classification and labelling of chemicals (GHS) into all EU Member States. It contributes to the GHS aim that the same hazards will be described and labelled in the same way worldwide. Waste is not considered to be a substance, article or mixture under the CLP Regulation. As long as residues from waste treatment operations are waste, i.e. they are disposed of (e.g. land-filled), they do not fall under the scope of CLP. However, residues which are recovered as substances or mixtures do fall under the scope of CLP. Categories of substances or individual substances listed in the Annex V of the REACH Regulation which are exempted under REACH obligations for registration, evaluation and downstream user provisions, must be notified to the Classification and Labelling inventory only when exhibiting hazardous properties. However, as long as a manufacturer or importer concludes that it is inappropriate to classify a specific substance covered by the Annex V of the REACH Regulation, this substance shall not need to be notified to the Classification and Labelling Inventory.

It can be reasonably concluded that **compost fulfilling end-of-waste criteria** (e.g. will not lead to overall adverse environmental or human health impacts) does not exhibit any hazardous properties, and thus **has not to be labeled according to CLP** since it is not classified as hazardous according to CLP. **For end-of-waste digestate exempt from REACH obligations** for registration according to the stipulations in Annex V, the same reasoning on the hazardous properties would be valid and it would hence **be excluded from the CLP obligations** as well. However, it appears that **end-of-waste digestate subject to REACH might be subject to the obligations of the CLP**.

5.4.4 Legal liability and law enforcement

One of the points deserving particular interest is that Member States may have to adjust their control mechanisms when compost or digestate shifts from a waste status to a product status.

It implies that waste regulatory controls will cease to be imposed and that product regulatory controls need to be established.
Furthermore, market surveillance mechanisms should be applied with the aim to detect any fraudulent 'end-of-waste' products in the market. In particular, Member States should ensure that materials outside the scope of the EU end-of-waste framework that are enjoying national product status should be treated according to waste legislation when leaving the national territory.

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7 Glossary, abbreviations and acronyms

AD: anaerobic digestion

ABPR: **Animal By-Products Regulation**: Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

Biodegradable waste: defined in the Landfill Directive as any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard

Bio-waste: means biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants. It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste (natural textiles, paper or processed wood).

CLP: Classification, Labelling and Packaging Regulation (EC) No 1272/2008

Collection: (Follows the definition of the Waste Framework Directive (2008/98/EC)): the gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility.

Compost: compost is the solid particulate material that is the result of composting and which has been sanitised and stabilised.

Consignment: means a batch of compost/digestate for which delivery from a producer to another holder has been agreed; one consignment might be contained in several transport units, such as containers.

Digestate: digestate is the semisolid or liquid product of anaerobic digestion of biodegradable materials.

Disposal: (Follows the definition of the Waste Framework Directive (2008/98/EC)): any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I of the Directive sets out a non-exhaustive list of disposal operations.

d.m.: dry matter

EoW: end-of-waste

EPA: Environmental Protection Agency

Holder: means the natural or legal person who is in possession of compost/digestate.

Importer: means any natural or legal person established within the Union who introduces compost/digestate which has ceased to be waste into the customs territory of the Union.

JSAC: JRC Sampling and Analysis Campaign on compost and digestate organised in 2011-2012

MBT: **Mechanical Biological Treatment**: means a two-step treatment of mixed municipal solid waste consisting of a mechanical separation and sorting step followed by a biological treatment step. Depending on the final goal of MBT, the biological step is either aimed at delivering a landfillable "stabilate" fraction with a minimum of unstable organic material, *not* called compost/digestate, or at producing a composted/digested organic fraction with a minimum of impurities, called compost/digestate. During the MBT process, several materials may be recovered for recycling (e.g. metals, plastics and glass).

MBS: **Mechanical Biological Stabilisation** is a subcase of the MBT process, aiming at stabilizing the organic fraction in waste destined for landfill or incineration. This process does *not* aim at producing compost/digestate materials for use in agriculture.

MS: Member State

MSW: Municipal solid waste. Means non-sorted, mixed waste from households and commerce, collected together. This waste flow excludes the flows of recyclables collected and kept separately, be it one-material flows or multi-material (comingled) flows.

Mt: Million tonnes. 1 tonne = 1000 kg (International System of Units)

OM: organic matter

PAH: polyaromatic hydrocarbon

PCB: polychlorinated biphenyl

PCDD/F: Polychlorinated dibenzodioxin (PCDD) and polychlorinated dibenzofuran (PCDF)

PFC: perfluorinated compound

POP: Persistent Organic Pollutant

QA(S): Quality Assurance (System)

Qualified staff: staff which is qualified by experience or training to monitor and assess the properties of compost/digestate and its input materials

REACH: European Community Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (EC 1907/2006)

Recovery: (Follows the definition of the Waste Framework Directive (2008/98/EC)): any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II of the Directive sets out a non-exhaustive list of recovery operations.

Recycling: (Follows the definition of the Waste Framework Directive (2008/98/EC)): any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.

Separate collection: (Follows the definition of the Waste Framework Directive (2008/98/EC)): the collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment.

Treatment: (Follows the definition of the Waste Framework Directive (2008/98/EC)): recovery or disposal operations, including preparation prior to recovery or disposal.

TWG: Technical Working Group, composed of experts from Member States administration, industry, NGOs and academia

Visual inspection: means inspection of consignments using either or all human senses such as vision, touch and smell and any non-specialised equipment. Visual inspection shall be carried out in such a way that all representative parts of a consignment are covered. This may often best be achieved in the delivery area during loading or unloading and before packing. It may involve manual manipulations such as the opening of containers, other sensorial controls (feel, smell) or the use of appropriate portable sensors.

WEEE: waste electrical and electronic equipment

WFD: Waste Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives).

Annexes

Annex 1: Biodegradable waste management in the EU

Overview of the management of biodegradable waste in EU Member States

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

Legend:

Bio and green waste composting	Anaerobic digestion	Mixed municipal solid waste composting	Other mechan. biological treatment	Landfilling	Incineration
B/GWC	AD	MSWC	MBT	LAND	INCIN

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
AT	**x**	**x**	**-**	**x**	**-**	**x**

Biological waste treatment

Country wide statutory separate collection of bio- and green waste and the necessary composting and digestion capacity exist.

Landfilling and mechanical biological treatment

Austria has realised a national ban on landfilling of untreated and biodegradable waste in 2004 and meets the targets of the EU landfill directive. MBT plants with 0.5 million tons of treatment capacity stabilise the organic part of the residual MSW (after separate collection of bio-waste) so it meets the Austrian acceptance and storage criteria for landfills.

Incineration

Incineration is well established in Austria but besides sewage sludge not for organic waste.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
BE	**x**	**-**	**-**	**-**	**-**	**x**

The Waste Management System in Belgium is assigned to the 3 regions. Each region has its own waste management legislation and policy. No information from the Brussels region is available.

Biological waste treatment

Separate collection of bio- and green waste and the necessary composting capacity exist in Flanders and Wallonia supplemented by a waste prevention programme which reduces the waste amount for landfilling and incineration.

Landfilling and mechanical biological treatment

Landfilling of waste is intended to be reduced to the maximum level by waste prevention, recycling and mechanical biological treatment in Flanders. Only waste which can't be recycled or incinerated should be landfilled. Flanders meets already the reduction targets of the landfill directive after a ban on landfilling of organic waste in 2005.

In Wallonia biodegradable waste are either biologically treated (mainly through composting, a in a lesser extent through anaerobic digestion), or are incinerated with energy recovery. There is no MBT plant processing organic waste, and the regional legislation prohibits the landfilling of certain wastes (AGW 18/03/2004) such as treatment plant sludge (prohibited on 1/1/2007), household refuse (prohibited on 1/1/2008), and organic waste (1/1/2010). It should be noted that the objective of the Landfill directive are already met. Only compost from separate collection of organic wastes (mainly greenwaste and household organic wastes) can be recovered on agricultural soils, otherwise it goes to incineration.

Incineration

Incineration is well established in Flanders and Wallonia.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
CY	**-**	**-**	**-**	**-**	**x**	**-**

Biological waste treatment

In order to meet the EU diversion targets biological waste treatment capacities have to be built.

Landfilling

The full implementation of the landfill directive is planned for the year 2009. It requires a number of up to 100 existing landfill sites to be closed and replaced by 4 non-hazardous waste treatment and disposal centres plus 1 hazardous waste treatment centre. It also requires the establishment of a separate collection system for recyclable (packaging) waste and the promotion of composting of biodegradable waste.

Incineration

No essential capacities recorded

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
CZ	**x**	**-**	**-**	**-**	**x**	**x**

Biological waste treatment

The National Waste Management Plan 2002 -2013 in the Czech Republic includes challenging targets for separate collection and composting of bio-waste in its Implementation Programme for biodegradable waste.

Landfilling

An implementation plan of the Landfill Directive has been prepared already in the year 2000 to meet all the nine key requirements of the EU landfill directive.

Incineration

Incineration capacity is part of the Czech waste management.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
DE	**x**	**x**	**-**	**x**	**-**	**x**

Biological waste treatment

Country wide separate collection of bio- and green waste and the necessary composting and anaerobic digestion capacity of around 12 million t annually exist.

Landfilling and mechanical biological treatment

Germany has realised a national ban on landfilling of untreated and biodegradable waste by June 2007 and surpassed the targets of the EU landfill directive already. Around 50 MBT plants with 5.5 million tons of treatment capacity stabilise the organic part of the residual MSW (after separate collection of bio-waste) so it meets the German acceptance and storage criteria for landfills.

Incineration

Incineration is well established in Germany but, except for sewage sludge, not for organic waste. Additional capacity is under construction especially designed for the high calorific fraction from MBT.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
DK	**x** GWC	**-**	**-**	**-**	**-**	**x**

Biological waste treatment

Collection and composting of green waste is well developed and diffused in Denmark. Bio-waste composting stays more or less on a pilot scale.

Landfilling

The number of landfill facilities in Denmark is expected to be reduced further. The requirements laid down in the Statutory Order on Landfill Facilities are expected to lead to the closure of 40-60 landfill facilities (out of the approx. 150 existing facilities) before 2009.

Incineration

Denmark largely relies on waste incineration. The general strategy is a ban on landfilling of waste that can be incinerated (is suitable for incineration).

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
EE	**x**	**-**	**-**	**-**	**-**	**-**

Biological waste treatment

The current Estonian National Waste Plan (2008-2013) suggests the collection of garden waste in cities and enhancing home composting in rural areas. The new Waste Plan (2014-2020) will also suggest the collection of source separated biodegradable waste.

Landfilling

For biodegradable municipal waste, the Estonian National Waste Plan gives a general priority to separate bio-waste from mixed MSW before landfilling. Furthermore, the current Estonian National Waste Plan (2008-2013) provides reduction targets for landfilling of biodegradable waste relative to the amount of 320 000 tonne from reference year 1995: 25% by 2010, 50% by 2013 and 65% by 2020.

Incineration

By the end of 2013, an incineration plant will open in Tallinn with an annual capacity of 200 000 tonne.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
ES	**x**	**x**	**x**	**-**	**x**	**x**

Biological waste treatment

The national Waste Management Plan (NWMP 2008-2015) indicates a general target for the separate collection of the organic fraction of MSW to be treated by composting or AD. This should be increased up to 2 million tonnes (from 417.078 tonnes separate collected in 2006).

Landfilling

Biodegradable waste going to landfills should be reduced from 7.768.229 tonnes in 2006 (68% of MSW) to 4.176.950 in 2016 in order to fullfill the targets established in the Landfill Directive.

Incineration

The plan foresees to increase the incineration capacity with energy recovery from 2,1 million tonnes in 2006 to 2,7 million tonnes in 2012. A 9% of the total MSW collected in 2006 were incinerated.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
FI	**x**	**x**	**-**	**x**	**x**	**-**

Biological waste treatment
A most important policy document in relation to biodegradable waste management is the National Strategy on Reduction of Disposal of Biodegradable Waste on landfills according to the EU landfill directive requirements. This strategy also provides means and assistance in order to reach the objectives set out in the landfill directive. Scenarios of the strategy give statistics and forecasts for biodegradable waste production and treatment for the years 1994, 2000, 2006 and 2012.
The strategy contains an assessment of present biodegradable waste quantities and a forecast and various technological (incl. composting, digestion, mechanical biological treatment) and infrastructural scenarios including waste prevention.
Landfilling
The Finish waste management strategy in the past was already quite effective in reduction efficiency for biodegradable waste on landfills with less than 50 % of the volume than 10 years before.
Incineration
No essential capacities recorded.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
FR	**x**	**-**	**x**	**x**	**x**	**x**

Biological waste treatment and mechanical biological treatment MBT
Composting of selected biodegradable MSW is increasing but is still not consolidated (141,000 t in 2002). MSW mixed bio-composting (called raw waste composting) is expected to increase essentially due to advanced technology screening and new lower national thresholds for the compost quality.
In the last years the collection of green waste has strongly progressed through the setting up of collection points. Also, the French agency ADEME has supported numerous composting projects.
The biological pre-treatment of waste is not widespread in France, but the experiences of the existing sites are followed with interest.
Landfilling
Today waste landfilling still represents the most applied management options for MSW in France: 42% of MSW are sent to landfills in 2002. From 2009 all landfills shall comply with the EU landfill directive requirements and diversion requirements.
France already largely respects the targets of 2006 and 2009 set by EU Directive on landfills. However, the estimated amount of biodegradable municipal waste going to landfill in 2016 is 40% of the total amount produced in 1995 but 35% is required by the EU Landfill directive for 2016. In accordance with this requirement the waste management plans have been revised with a stronger orientation towards recycling.
Incineration
There are approximately 130 incinerators at present in France. Some waste management plans foresee the construction of new incineration plants, some of which are already under construction. It is estimated that the amount of waste going to incineration will increase by 1- 2% in the next years. The capacity allows the biodegradable waste can be incinerated to a certain extent.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
GR	**-**	**-**	**-**	**x**	**x**	**-**

Biodegradable waste treatment
Legislation JMD 50910 repeats the dual commitment of the Greek government to close down all illegal landfills by the end of 2008 and to reduce the biodegradable municipal waste to 65% by 2020. Intermediate targets are: 25% (2010) and 50% (2013). The targets will be achieved through the operation of recycling and composting facilities in almost all regions of the country as well as through the full operation of the separate collection systems for selected waste streams.
At the moment, there are no facilities processing source separated organic waste, although it would be fairly easy to do so with at least the green wastes, as they are collected separately anyway and some municipalities have thought of doing so.
Mechanical biological treatment MBT
Various regional waste management plans foresee the construction of MBT plants as the main tool to meet the Landfill Directive targets. At present 3 such plants are in operation. Obviously, while the option to revise the waste management plans to include other options such as thermal treatment or source separation is always open, but conditions for any of these options do not seem to be mature yet.
Landfilling
Until the early 1990s, the use of uncontrolled dumps was the "traditional" method of solid waste disposal. Since then, the overall situation has dramatically improved: There are 45 sanitary landfills constructed in Greece (41 already operational) whereas 47 more sites are under construction including the expansion of existing ones. Last data for the year 2003 reports that 1032 dumping sites, mainly small, were still operating in various municipalities of the country. It is expected that by the end of 2008, uncontrolled waste dumping will cease to exist.
Incineration is not well diffused in Greece

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
HU	**x**	**-**	**-**	**x**	**x**	**-**

The National Waste Management Plan (NWMP) valid from 2003 till 2008 prescribes the general tasks of waste management in Hungary. Main goals and targets:
Biological waste treatment

50% reduction of landfilled quantity of biodegradable waste of the volume generated in 1995 till 2007 The National Bio-waste Programme (BIO-P, 2005-2008) has the following preferences to reduce BMW: recycling (paper), composting, anaerobic digestion (biogas generation), MBT, thermal utilisation.
The needed capacity building until 2008 is 460.000 t/y composting and 100.000 t/y MBT (HU[59])

Landfilling

Revision and liquidation of the old landfill sites till 2009. At the end of 2008 approximately half of all waste not including biomass must be recovered or used in power engineering

Incineration

The old waste incinerators will be renovated or closed till 2005 (accomplished).

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
IE	**x**	**x**	**-**	**x**	**x**	**-**

The Irish waste management policy includes a strategy for a dramatic reduction in reliance on landfilling, in favour of an integrated waste management approach which utilises a range of waste treatment options to deliver effective and efficient waste services and ambitious recycling and recovery targets. Alternative waste treatment options like composting, digestion, MBT or incineration more or less doesn't exist.

National Strategy on Biodegradable Waste (2004) sets the following targets for 2013:

- Diversion of 50% of overall household waste away from landfill
- A minimum 65% reduction in Biodegradable Municipal Waste (BMW) sent to landfill
- Developing biological treatment capacity (composting, MBT or AD) of up to 300,000 t/y
- Recycling of 35% of municipal waste
- Rationalisation of municipal waste landfills to a network of 20 state-of-the art sites
- Reduction of methane emissions from landfill by 80%

Composting and digestion are undertaken in Ireland. The mechanical treatment of mixed municipal waste is increasing but the biological treatment of the mixed municipal fines produced is still at low levels.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
IT	**x**	**-**	**-**	**x**	**-**	**x**

Integrated biodegradable waste management with composting, MBT and incineration

Italy has established waste management in an integrated way according to the specific properties of the different material flows using separate collection and recycling and the treatment options incineration (incl. energy recovery), mechanical biological treatment (12 million t annual capacity - to segregate the high calorific faction and to stabilise the organic part before landfill) and composting of source separated bio- and green waste (2.8 million t/y).

Landfilling and biological mechanical treatment MBT

In Italy the implementation of the Landfill Directive includes strict limits as regards organic matter (TOC) and the calorific value of the waste to be landfilled. So pre-treatment of the waste by means mechanical biological treatment to allow to stabilisation or energy recovery is necessary.
Coherently with decree 36/03 the Regions shall plan a strategy in order to decrease the amount of biodegradable waste going to landfills. Before 27 March 2008 biodegradable municipal waste must be reduced to less than 173 kg per inhabitant per year, before 27 March 2011 to less than 115 kg and before 27 March 2018 to be reduced to less than 81 kg per inhabitant per year
The waste management strategy identifies the following instruments to be implemented in order to achieve the targets:

- economic instruments to discourage landfill disposal
- separate collection of organic, wooden and textiles fractions
- mechanical/biological treatment
- biological treatment
- incineration with energy recovery
- ban on landfilling of certain waste streams

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
LT	**x**	**x**	**-**	**x**	**x**	**-**

Biological waste treatment

The development of the overall waste management system in Lithuania from 2006 aimes at meeting the targets of diverting biodegradable waste from landfills set in the landfill directive. It is assumed that set targets will be met by increasing the efficiency of separate collection of biodegradable waste and recyclables and implementation of facilities for treatment and recovery of biodegradable waste, i.e. composting.
In regional waste management projects currently under implementation, construction of green waste composting facilities is foreseen in most of the municipalities. However, in order to meet the stringent requirements of the Landfill Directive it is also

([59]) STRATEGIC EVALUATION ON ENVIRONMENT AND RISK PREVENTION UNDER STRUCTURAL AND COHESION FUNDS FOR THE PERIOD 2007-2013 - Contract No. 2005.CE.16.0.AT.016. "**National Evaluation Report for Hungary - Main Report"** Directorate General Regional Policy. A report submitted by GHK Brussels, Nov. 2006, p. 217. http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/strategic_environ.pdf (download 15 Oct. 2007)

envisaged that in future some form of additional waste treatment will be required, i.e. incineration (with energy recovery), mechanical-biological treatment, anaerobic digestion, etc.
In Lithuania many waste management companies have started composting activities due to a ban on the disposal in landfills of biodegradable waste from gardens, parks and greeneries,.

Landfilling

The lack of environmentally safe waste disposal sites is a key problem of waste management in Lithuania. Special efforts have to be invested into the development of new landfills which meet all environmental requirements included in EC Directive 1999/31/EC. Lithuania has indicated that no landfilling will take place in non-complying landfills after 16 July, 2009.

Incineration

There are no waste incinerators in Lithuania designed specifically for the combustion of waste.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
LU	**x**	**x**	**-**	**-**	**x**	**-**

National and local Waste Management Plans from 2005 includes the following quantitative objectives (% by weight) should be attained for domestic waste, bulky waste and similar wastes (reference year: 1999):

- organic wastes: rate of recycling of 75 %
- rate of recycling of 45 %
- other recoverable wastes: rate of recycling of 45 %

No further detailed information on landfilling and incineration is available.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
LV	**x**	**-**	**-**	**-**	**x**	**x**

Biological waste treatment

No biological treatment besides pilot projects

Landfilling

Latvia relies on landfilling

Incineration

No incineration capacity for MSW.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
MT	**-**	**-**	**-**	**-**	**x**	**-**

Biological waste treatment

No biological treatment, only one pilot project on composting. Activities for separate collection and composting were intended for 2006 with no real progress until now.

Landfilling

Malta relies on landfilling

Incineration

No incineration capacity for MSW.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
NL	**x**	**-**	**-**	**-**	**-**	**x**

The Ministry of Environment has issued a National Waste Management Plan for the period 2009-2021 with the essential provision to promote waste recovery, particularly by encouraging waste separation at source and subsequent separation of waste streams. Waste separation allows for product reuse, material reuse and use as fuel. The level of waste recovery must accordingly increase from 83% in 2006 to 85% in 2015.

Biological waste treatment

The Netherlands show with 3.3 million tons/year the highest recovery rate for source separated bio- and green waste in Europe.

Landfilling

Landfilling of the surplus combustible waste, as currently happens, must be finished within five years. The Waste (Landfill Ban) Decree came into force in 1995 and prohibits landfilling of waste if there is a possibility for reusing, recycling or incinerating the waste.

Incineration

Incineration should optimise use of the energy content of waste that cannot be reused by high energy efficiency waste incineration plants.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
PL	**x**	**-**	**x**	**x**	**x**	**-**

Biological waste treatment

Biological waste should be collected separately by a 2 bins system mainly in the cities. Before July 2013 not less than 1.7 million tons/year, before 2020 not less than 2.2 million tons capacity should be installed which means the construction of 50 composting plants between 10.000 t and 50.000 t capacity.
In practice today there is only mixed waste composting with low qualities mainly used as landfill cover.
Referring to garden waste n the National Waste Management Programme it is implied that 35% of this waste category will undergo the process of composting in 2006, and 50% in 2010.

Landfilling

Poland has been granted a transition until 2012 for the implementation of the Landfill Directive. According to the Treaty of Accession, intermediate targets until 2012 were set out for each year, how much waste may be deposited in landfills.

Incineration

No essential capacities recorded

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
PT	**x**	**x**	**x**	**x**	**x**	**x**

Biological waste treatment

In order to reduce biological waste going to landfills the 2003 National Portuguese Strategy promotes separate collection and composting or anaerobic digestion. An increased capacity from 285.000 t for organic waste in 2005 up to 861.000 t in 2016 should be constructed with 10 large and several small organic waste treatment plants.

Landfilling

In 2003 the National Strategy for the reduction of biodegradable urban waste from landfills came into force in order to meet the EU Landfill Directive requirements. Additional recycling and incineration capacities should help to fulfil the diversion targets. Lately, mechanical biological treatment is prioritised instead of recycling via composting or digestion of separately collected organic waste.

Incineration

A third incineration plant and extension of the existing incinerators is intended.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
SE	**x**	**x**	**-**	**-**	**-**	**x**

Biological waste treatment

- • 2010 at least 50% of household waste is recycled, incl. biological treatment
- • 2010 at least 35% of food waste from households, restaurants, institutions and shops is recycled through separate collection and biological treatment.
- • 2010 food waste from food industry is recycled through biological treatment.
- Biological treatment will be mainly - besides green waste composting - based on anaerobic digestion.

Landfilling

Ban on combustible waste 1 January 2002 and on compostable waste: 1 January 2005

Inadequate statistics on how much combustible and organic waste is landfilled make it difficult to assess the need for increased capacity to comply with the prohibitions.

No essential activities on mechanical biological treatment MBT

Waste incineration is well accepted and diffused

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
SI	**x**	**x**	**-**	**-**	**x**	**-**

Biological waste treatment

The management of biodegradable waste is determined by various legislation documents. The Decree on the landfill of waste lays down the permitted quantities of biodegradable components in municipal waste that may be landfilled in Slovenia.

In order to reduce the quantities of biodegradable waste, concurrent with introducing limits on volume of biodegradable waste, three additional regulations have been adopted, Decree on the management of organic kitchen waste and garden waste, Decree on the treatment of biodegradable waste and Decree on the management of waste edible oils and fats. The Decree on the treatment of biodegradable waste introduced compulsory operations considering the treatment of biodegradable waste and conditions for use, as well as in regard to placing treated biodegradable waste on the market.

From the aspect of protecting natural resources, increasing the proportion of recycled and recovered waste as well as reducing the negative environmental impact from landfilling, Slovenia adopted in 2008 an Operational programme on elimination of wastes with objective to reduce the quantities of biodegradable waste disposal. Its main aim is to reduce quantities of biodegradable waste as well as establishment of a complete network of facilities and plants for waste management. In line with population number and geographical distribution, the plan was developed for 13-15 waste management centres. The general concept of waste management envisages activities on three levels – local, regional and supra-regional. In the beginning of 2011 the revision of the Operational program is expected.

Landfilling

Today waste landfilling still represents the most applied management option for MSW in Slovenia.

According to the Statistical Office of the Republic of Slovenia, 822.700 t of waste were deposited on landfills in 2008. The average structure of waste deposited on public infrastructure landfills in 2008 was as follows: 79.2% municipal waste, 9.4% construction waste, 3.8% sludge from waste water treatment, 0.1% packaging waste, 0.7% waste from wood and paper processing and 6.7% other types waste.

See also data :ARSO | KOS

Incineration

There are no waste incinerators in Slovenia designed specially for the combustion of municipal solid waste.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
SK	**x**	**-**	**-**	**-**	**x**	**-**

Waste Act No. 223/2001 Coll. regulates the whole waste management. The waste management plan WMP SR for 2006-2010 was approved by the Government in 2006. Municipalities prepare waste management plans and are responsible for all waste generated within.

Biological waste treatment

Article 18 (3m) of Act No 223/2001 does not allow to landfill green waste and also entails an obligation of separate collection of biodegradable municipal wastes to municipalities. The WMP defines the target for 2010 as decrease of biodegradable municipal waste landfilling on 20% of 2005. The municipalities are responsible for recovery of green waste. Usually they operate (or co-operate with agricultural farms) composting or biogas plant.

Landfilling and incineration

Targets for 2010 for waste management for non hazardous wastes are the following 70% recovery, 0 % incineration and 19 % landfilling.

The Slovak Report about the needs for the next Cohesion Funds period estimates until 2013 the need of 400 to 900 small municipal compost plants and 6 to 10 large ones. [60]

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
UK	**x**	**x**	**-**	**x**	**x**	**-**

Biological waste treatment

The UK Government and the National Assembly have set challenging targets to increase the recycling of municipal waste: To recycle or compost at least 25% of household waste by 2005, at least 30% of household waste by 2010 and at least 33% of household waste by 2015. No further provisions are made to which extent alternative treatments like MBT or AD are part of the strategy.

Green waste composting is well developed and diffused in UK. AD shows growing interest.

Regions in UK have different specific targets recycling and treatment target exceeding the national requirements

Landfilling: Landfilling allowances can be traded within the municipalities by the LATS Landfill Allowance and Trading Scheme.

Incineration:

Incentives exist to shift waste treatment from incineration, which is not very well diffused in UK.

[60] Strategic evaluation on environment and risk prevention under structural and cohesion funds for the period 2007 -2013 - Contract No. 2005.CE.16.0.AT.016. "National Evaluation Report for Slovakia - Main Report" Directorate General Regional Policy. A report submitted by GHK Brussels, Nov. 2006. http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/strategic_environ.pdf (download 15 Oct. 2007)

Annex 2: Waste and product approaches for compost

National approaches and criteria to define whether compost produced from waste may be marketed as product or is still within the waste regime

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) compost ceasing to be waste and/or 2) placing on the market and use of compost even under the WASTE regime

AT	**PRODUCT**	Compost Ordinance BGBl. I 291/2001	• Central registration of compost plant
			• Positive list of input materials
			• Comprehensive documentation of
			  o Waste reception
			  o Process management and material movement
			  o Compost quality criteria
			  o Product designation, declaration, labelling and selling of compost
			• External sampling and product certification by acknowledged institute
			If all criteria are met and approved by the external certification system all types of compost can be marketed as PRODUCT.

BE Flanders	**PRODUCT (secondary raw material)**	VLAREA Flemish Regulation on waste prevention and management (B.S. 1998-04-16)	Total quality control of the VLACO-certificate includes: • Input criteria, • Process parameters, • Standards for end-product • Correct use If conditions are met, compost loses the status of waste material and becomes raw material.. User certificate by OVAM is necessary only for the application of sewage sludge compost
BE Wallonia	**WASTE**	Decree on compost and digestates (currently being examined by the Walloon Government)	Compost does not cease to be waste Four classes (A, B, C, D) and two subclasses (B1, B2) are defined in the classification system proposed by the administration for all materials. Composts belong to class B, and are distributed between class B1 and B2 according to the type or origin of the material Material of class D can not be used on or in the soils; Material of class C can not be used on or in agricultural soils; Material of class A of B can be used on or in agricultural soils. i. Norms of subclass B2 are those applied for treatment plant sludge that can be recovered in agriculture in accordance with European legislation, i.e. a management at the field level together with a preliminary soil analysis must be undertaken (field level traceability with soil analysis). In order to protect soils from metallic element traces, a maximum quantity of material spreading is defined and the soil is preliminary analysed for metallic element traces (in order to avoid exceeding a defined level) ii. Norms of subclass B1 are less restrictive than subclass B2 due to the lower concentration in metallic element traces and in organic compound traces of certain material (such as wastes from food-processing industry, green wastes compost, decarbonation sludge, etc), and due to criteria that must be followed within the Water Code on sustainable nitrate management in agriculture. Therefore, preliminary soil analyses are not needed for subclass B1, which simplifies the use of these materials on or in agricultural soils. The presence of a quality management system allows the traceability to be at the farm/firm level,

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) compost ceasing to be waste and/or 2) placing on the market and use of compost even under the WASTE regime
			otherwise the field level traceability is maintained.
BG	**---**	---	---
CY	**---**	---	---
CZ	**PRODUCT**	Act on fertilisers 156/1998 Sb. by the Public Ministry of Agriculture ČSN 46 5735 Průmyslové komposty Czech Compost Standard	Fertiliser Registration System; Central Institute for Supervising and Testing in Agriculture, the Czech Environmental Inspectorate One Compost Class; Quality requirements correspond to Class 1 of the Czech Compost Standard but with less quality parameter compared to the waste composts. The use is not restricted to agriculture. Compost has only to be registered for this group and the inspection/control of samples is done by the Control and Test Institute for Agriculture which is the Central Institute for Supervising and Testing in Agriculture.
	PRODUCT	Bio-waste Ordinance (In preparation)	All 3 Classes foreseen in the new draft Compost Ordinance are defined as end-of-waste criteria
DE	**WASTE**	Fertiliser Ordinance (26. November 2003) Closed Loop Management and Waste Act (KrW-/AbfG); Bio-waste Ordinance (BioAbfV, 1998)	Compost also from source separated organic waste is seen as WASTE due to its waste properties and its potential to pose negative impacts to the environment. (risk of contamination) • Positive list for input materials • Hygienically harmless • Limit value for heavy metals • Requirements for environmentally sound application • Soil investigation • Official control of application by the waste authority • Documented evidence of approved utilisation All classes and types of compost, which are produced from defined source materials under the Bio-waste Ordinance remain WASTE
	WASTE-product (!)	RAL Gütesicherung RALGZ 251	When participating in a voluntary QA scheme relaxations are applied with respect to the regular control and approval protocols under the waste regime. Though, legally spoken compost remains WASTE quality assured and labelled compost can be extensively treated and handled like a product. The relaxations are: • No soil investigation • No official control of application by the waste authority • No documented evidence of approved utilisation In principle all classes and types of compost, which are produced from defined source materials under the Bio-waste Ordinance remain WASTE, but in practice, if certified under QAS of the RALGZ 251 compost can be marketed and used quasi like a PRODUCT.
DK	**WASTE**	Stat. Order 1650 of 13.12.06 on the use of waste (and sludge) for agriculture	The use of compost based on waste is under strict regulation (maximum of 30 kg P/year/ha etc. and the concentration of heavy metals in the soil were applied must not exceed certain levels. For this reason the authorities want to know exactly where the compost ends up which is only possible if handled as waste and not as a product (for free distribution). Compost from garden waste is not formally regarded as a product but is treated according to the general waste regulation for which the municipalities are responsible.
EE	**WASTE**	Environmental Ministry regulations 2002.30.12 nr. 78 and in Environmental Ministry regulation	Heavy metal limits in compost (sludge compost) No specific regulation on compost from bio-waste and green waste

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) compost ceasing to be waste and/or 2) placing on the market and use of compost even under the WASTE regime
		2002.01.01 nr. 269.	
ES	**PRODUCT**	Real Decree 506/2013 on Fertilisers Products	• Input list (Annex IV) • Documentation (Art. 16): declaration of raw materials, description of production processes, certification to declare the fullfillment of all legal requirements • Minimum criteria for fertilizer products to be used on agriculture or gardening (Annex I): raw materials, how it shall be obtained, minimum nutrient contents and other requirements, parameters to be included on the label. • Quality criteria for final compost (Annex V): heavy metals content, nitrogen %, water content, Size particle, maximum microorganism content, limitations of use.
FI	**WASTE** **PRODUCT**	Jätelaki (Waste Act) Fertiliser Product Act 539/2006 Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	WASTE status changes to PRODUCT if compost fulfils the criteria of fertiliser regulation and is spread to land or mixed into substrate. But there is no external approval or inspection scheme. Samples can be taken by compost producer! Waste can be used in fertiliser product, if compost fulfils the criteria of the national fertiliser product legislation. The fertiliser product must be produced in an approved estab-lishment which has self-supervision. The fertilisers products have to full fill the the general require-ments and type designation requirement before marketing
FR	**PRODUCT**	NF U44-051 Standard	Mixed waste compost – no positive list 4 Product types • “Organic soil improvers - Organic amendments and supports of culture” • “Organic soil improvers - Composts containing substances essential to agriculture, stemming from water treatment (sludge compost)” • “Organic amendments with fertiliser” • “supports of culture” Further following quality criteria: • Limit values for: trace metal concentrations and loads (g/ha*y), impurities, pathogens, organic micro-pollutants • Labelling requirements There is no regular external approval or inspection scheme. Samples can be taken by compost producer. However, there exists a legal inspection by the competent authority based on the IPPC procedure which in FR is also applied to composting facilities. Compost which is not produced according to the standard is WASTE and has to follow a spreading plan and may apply for a temporary product authorisation. By this way the standard can easily be by-passed.
GR	**PRODUCT**	Common Ministerial Decision 114218, 1016/B/17- 11-97. Fertiliser law (Law 2326/27-6-1995, regulating the types of licenses for selling fertilisers).	Compost is considered as product and may be sold, provided it complies with the restrictions of the frame-work of Specifications and General Programs for Solid Waste Management. No sampling protocol and analysis obligations/ organisations are defined. Composts produced from materials of agricultural origin (olive-mill press cake, fruit stones, tree trimmings, manures etc) are considered products and sold under the fertilisers law
HU	**PRODUCT**	36/2006 (V.18.) Statutory rule about licensing, storing, marketing and application of fertiliser products	Composts are in waste status as long as they are not licensed under the Statutory rule Nr. 36/2006 (V.18.). After the licensing composts may become a PRODUCT. To achieve the product status needs to be in accordance with the Statutory rule Nr. 36/2006 (V.18.). Criteria: • Input-List,

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) **compost ceasing to be waste and/or** 2) **placing on the market and use of compost even under the WASTE regime**
			• External quality approval by acknowledged laboratories, • physical, chemical and biological quality parameter for final compost.
IE	**PRODUCT**	EPA Waste license or Local Authority waste permit	Product status is based on site specific waste licence or waste permit; compliance with all operational and product requirements laid down in the consent document must be shown by producer. There is NO legal standard or QAS or quality protocol in Ireland at the moment which will say when waste becomes a product.
IT	**PRODUCT**	L. 748/84 (law on fertilisers); D.M. 05/02/98 (Technical Regulation on simplified authorization procedures for waste recovery)	Criteria for product status are based on National Law on Fertilisers, which comprises: • Qualitative input list (source segregated organic waste • Quality parameters for final compost • Criteria for product labelling Compost from MBT/mixed waste composting plants may still be used under the old Decree DPR 915/82 - DCI 27/7/84 as WASTE for restricted applications (brown fields, landfill reclamation etc).
LT	**PRODUCT**	Decree of the Ministry for Environment (D1-57/Jan 2007)	According to environmental requirements for composting of bio-waste the compost producer must provide a certificate on the compost quality • Compost sampling is done by the PRODUCER (!) • NO external approval or plant inspection
LU	**PRODUCT**	Waste licence	The Product Status is achieved only when a QAS is applied. QAS is an obligatory element of the waste licensing of composting plants. The further criteria are: • Positive list for input materials • Hygienically harmless (Process requirements and indicator pathogens) • Limit value for heavy metals • Requirements for environmentally sound application (labelling
LV	**PRODUCT**	Licensing as organic fertiliser (Cabinet Regulation No. 530 " Regulations on identification, quality, conformity and sale of fertilisers" 25.06.2006)	Quality of the compost, its composition. The Product Status is achieved only when it is registered and tested by certificated laboratory. The further criteria are: • Hygienically harmless • Limit value for pollutants
MT	**WASTE**	---	NO provisions for compost

NL	**PRODUCT**	Fertiliser act (2008)	One or more organic components, but no animal manure, broken down by micro-organisms into such a stable end product that the composting process is slowed down considerably.
			• key criteria
			    o The composting process (hygienisation) and its documentation
			    o stability (no value) and
			    o the absence of animal manure.
			    o heavy metal limits
			    o minimum organic matter content
			    o declaration & labelling

PL	**WASTE**	Waste law	Ministerial Approval by Min. of Environment
	PRODUCT	Fertiliser law	Ministerial Approval by Min. of Agriculture and Rural Development Criteria: • Limit values for heavy metals (3 classes; also coarse and fine compost)

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) compost ceasing to be waste and/or 2) placing on the market and use of compost even under the WASTE regime
			Test on Pathogens
PT	**PRODUCT**	NP 1048 – Standard for fertilisers Portaria 672002 pg 436	Compost is interpreted as organic soil amendment *“Correctivo organico”* There are no specific regulations available.
RO	---	---	NO provisions for compost
SE	**WASTE**	Private QAS and SPRC 152 (compost standard)	Waste Criteria: definition according to European court of justice. The compost standard is managed by the Swedish Standardisation Institute SP)
SI	**PRODUCT**	Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	If compost meets the requirements of this Decree, compost is a PRODUCT. If limit values are not met the compost can be used as WASTE. Provided risk assessment is carried out by an accredited laboratory. Criteria: Limit values for heavy metals (3 classes) and AOX, PCBs Maximum levels for glass, plastics, metals But: Compost sampling is done by the producer (!); no QAS certification!
SK	**PRODUCT**	Act No. 223/2001 Col. on waste as amended Slovak technical standard (STS) 46 57 35 Industry composts Act No. 136/2000 Col. on fertilisers Act No. 264/1999 Col. about technical requests for products Regulation of the Government No. 400/1999 Col. which lays down details about technically requirements for products	After bio-waste has gone through recovering process it is considered as compost, but such product can not be marketed Compost may be marketed in case it is certified by an authorised person according to Act No. 264/1999 Col. Key criteria for the PRODUCT status: • Quality parameter for final compost – STS 46 57 35 • Process parameter (sanitisation) – STS 46 57 35§ • Quality approval by acknowledged laboratory or quality assurance organisation – Act No. 264/1999 Col.
UK	**WASTE**	Waste Management Licensing Regulations Animal By-Products Regulations	England, Wales, Scotland and Northern Ireland: Compost must be sold/supplied in accordance with the Waste Management Licensing Regulation rules for storing and spreading of compost on land (these rules apply whether or not the compost is derived from any animal by-products). There are not any quality criteria / classes but in the application form and evidence (test results for the waste) sent to the regulator, ‘agricultural benefit’ or ‘ecological improvement’ must be justified. The regulator makes an evaluation taking account of the characteristics of the soil / land that is intended to receive the waste, the intended application rate and any other relevant issues. Compost derived in whole or in part from animal by-products must be placed on the market and used in accordance with the animal by-products regulations.
	PRODUCT	BSI PAS 100:2005 BSI PAS 100:2005 + Quality Compost	Scotland: requires certification to PAS 100 (or an equivalent standard), that the compost has certainty of market, is used without further recovery, is not be subjected to a disposal activity and is not be mixed with other wastes, materials, composts, products or additives. Northern Ireland: similar position as Scotland’s. England & Wales: both, the Standard and the Protocol have to be

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for 1) **compost ceasing to be waste and/or** 2) **placing on the market and use of compost even under the WASTE regime**
		Protocol	fulfilled to sell/supply/use "Quality Compost" as a PRODUCT. Key criteria: • Positive list of allowed input types and source types • QM system including HACCP assessment; standard process including hygienisation • Full documentation and record keeping • Contract of supply per consignment • External quality approval • Soil testing on key parameters • Records of compost spreading by land manager who receives the compost (agriculture and land based horticulture • N.B.: In each country of the UK, if compost 'product' is derived in whole, or in part from animal by-products, placed on the market, stored, used and recorded as required by the Animal By-Products Regulations.

Annex 3: Heavy metal limits for compost/digestate

Heavy metal limits in European compost and digestate standards

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg d.m.								
AT	Compost Ord.:Class A+ (organic farming)	Statutory Ordinance	0.7	70	-	70	0.4	25	45	200	-
	Compost Ord.:Class A (agriculture; hobby gardening)		1	70	-	150	0,7	60	120	500	-
	Compost Ord.: Class B limit value (landscaping; reclam.) (guide value)*		3	250	-	500 (400)	3	100	200	1,800 (1,200)	-
BE	Royal Decree, 07.01.1998, case by case authorisation, Compost	Statutory decree	2	100	-	150	1	50	150	400	20
	Royal Decree, 07.01.1998, case by case authorisation, **DIGESTATE**	Statutory decree	6	500	-	600	5	100	500	2000	150
BG	No regulation	-	-	-	-	-	-	-	-	-	-
CY	No regulation	-	-	-	-	-	-	-	-	-	-
CZ	Use for agricultural land (Group one)	Statutory	2	100	-	100	1	50	100	300	10
	Landscaping, reclamation (draft Bio-waste Ordinance) (group two)	Statutory Class 1	2	100	-	170	1	65	200	500	10
		Class 2	3	250	-	400	1.5	100	300	1200	20
		Class 3	4	300	-	500	2	120	400	1500	30
	Fertilizer law 156/1998, ordinance 474/2000 (amended)	**DIGESTATE** with dry matter > 13%	2	100		150	1	50	100	600	20
	Fertilizer law 156/1998, ordinance 474/2000 (amended)	**DIGESTATE** with dry matter < 13%	2	100		250	1	50	100	1200	20
DE	Quality assurance RAL GZ - compost / digestate products	Voluntary QAS	1.5	100	-	100	1	50	150	400	-
	Bio waste Ordinance	Statutory decree (Class I)	1	70	-	70	0.7	35	100	300	-
		(Class II)	1.5	100	-	100	1	50	150	400	-

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
							mg/kg d.m.				
DK	Statutory Order Nr.1650; Compost after 13 Dec. 2006	Statutory decree	0.8	-	-	1,000	0.8	30	120/60 for priv. gardens	4,000	25
EE	Env. Ministry Re. (2002.30.12; m° 87) Sludge regulation	Statutory	-	1000	-	1000	16	300	750	2500	-
ES	Real decree 506/2013 on fertilisers Class A	Statutory	0.7	70	0	70	0.4	25	45	200	-
	Class B		2	250	0	300	1.5	90	150	500	-
	Class C		3	300	0	400	2.5	100	200	1000	-
FI	Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	Statutory decree	1.5	300	-	600	1	100	100	1,500	25
FR	NF U44-051	standard	3	120		300	2	60	180	600	
GR	KYA 114218, Hellenic Government Gazette, 1016/B/17- 11-97 [Specifications framework and general programmes for solid waste management]	Statutory decree	10	510	10	500	5	200	500	2,000	15
HU	Statutory rule 36/2006 (V.18)	Statutory Co: 50; Se: 5	2	100	-	100	1	50	100	--	10
IE	Licensing/permitting of treatment plants by competent authority stabilised MBT output or compost not meeting class I or II	Statutory	5	600	-	600	5	150	500	1500	-
	(Compost – Class I)	Statutory	0.7	100	-	100	0.5	50	100	200	-
	(Compost – Class II)	Statutory	1.5	150	-	150	1	75	150	400	-
IT	Law on fertilisers (L 748/84; and: 03/98 and 217/06) for BWC/GC/SSC	Statutory decree	1.5	-	0.5	230	1.5	100	140	500	-
Luxembourg	Licensing for plants		1.5	100	-	100	1	50	150	400	-
LT	Regulation on sewage sludge Categ. I (LAND 20/2005)	Statutory	1.5	140		75	1	50	140	300	-
LV	Regulation on licensing of waste treatment plants (n° 413/23.5.2006) – no specific compost regulation	Statutory =threshold between waste/product	3			600	2	100	150	1,500	50
Netherlands	Amended National Fertiliser Act from 2008	Statutory	1	50		90	0.3	20	100	290	15
PL	Organic fertilisers	Statutory	5	100		-	2	60	140	-	-
PT	Standard for compost is in preparation	-	-	-	-	-	-	-	-	-	-
Sweden	Guideline values of QAS	Voluntary	1	100	-	100	1	50	100	300	

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg d.m.								
	SPCR 152 Guideline values	Voluntary	1	100	-	600	1	50	100	800	-
	SPCR 120 Guideline values **(DIGESTATE)**	Voluntary	1	100	-	600	1	50	100	800	-
SI	Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	Statutory: 1st class*	0.7	80	-	100	0.5	50	80	200	-
		Statutory: 2nd class*	1.5	200	-	300	1.5	75	250	1200	-
		Statutory: stabilized biodegradable waste*	7	500	-	800	7	350	500	2500	-
		* normalised to an organic matter content of 30%									
SK	Industrial Standard STN 46 5735 Cl. 1	Voluntary (Mo: 5)	2	100		100	1	50	100	300	10
	Cl. 2	Voluntary(Mo: 20)	4	300		400	1.5	70	300	600	20
UK	UKROFS fertil.org.farming, 'Composted household waste'	Statutory (EC Reg. 889/2008)	0.7	70	0	70	0.4	25	45	200	-
	Standard: PAS 100	Voluntary	1.5	100	-	200	1	50	200	400	-
	Standard: PAS 110 **(DIGESTATE)**	Voluntary	1.5	100	-	200	1	50	200	400	-
EU ECO Label	COM Decision (EC) n° 64/2007 eco-label to growing media COM Decision (EC) n° 799/2006 eco-label to soil improvers	Voluntary [Mo: 2; As: 10; Se: 1.5; F: 200 [only if materials of industrial processes are included]	1	100	-	100	1	50	100	300	10
EU Regulation on organic agriculture	EC Reg. n° 889/2008. Compliacne with limits required for compost from source separated bio-waste only	Statutory	0.7	70	-	70	0.4	25	45	200	-

Annex 4: Impurities limits for compost

Limits on the content of impurities in compost in national compost regulations and standards

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

Country		Impurities	∅ Mesh size	Limit values % d.m. (m/m)
AT	Compost Ordinance	Total; agriculture Total; land reclamation Total; technical use Plastics; agriculture Plastics; land reclamation Plastics; technical use Plastics; agric. excl. arable land Plastics; technical use Metals; agriculture	2 mm > 2 mm > 2 mm > 2 mm > 2 mm > 2 mm > 20 mm > 20 mm ---	≤ 0.5 % < 1 % < 2 % < 0.2 % < 0.4 % < 1 % < 0.02 % < 0.2 % < 0.2 %
BE	Royal Decree for fertilisers, soil improvers and substrates	Total Stones	> 2 mm > 5 mm	< 0.5 % < 2 %
CZ	Act on fertilisers Bio-waste Ordinance	Total, agriculture Total, land reclamation	> 2 mm > 2 mm	< 2% < 2 %
DE	Bio waste Ordinance	Glass, plastics, metal Stones	> 2 mm > 5 mm	< 0.5 % < 5 %
ES		Total impurities (glass, metals, plastic)	> 2 mm	< 3 %
FI	Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	Refuse (glass, metal, plastics, bones, rocks) In packaged products Sold in bulk	---	<0.2 % of fresh weight < 0.5 % of fresh weight
FR	NF U44-051	Plastic films Other plastics Metals	> 5 mm > 5 mm > 2 mm	< 0.3 % < 0.8 % < 2.0 %
HU		No restrictions	---	---
IE	EPA waste license	Total; compost class 1 & 2 Total; low grade compost/MBT Stones	> 2 mm > 2 mm > 5 mm	≤ 0.5 % ≤ 3 % ≤ 5 %
IT	Fertiliser law d.lgs. 75/2010	Glass, plastics, metals Stones	>2 mm >5 mm	< 0.5 % < 5 %
LV	Cabinet Regulation No. 530 , 25.06.2006	Total (glass, metal, plastics)	> 4 mm	< 0.5 %
NL	Fertiliser act + various certification systems	Total Glass Glass Stones Biodegradable parts	> 2 mm > 2 mm > 16 mm > 5 mm > 50 mm	< 0.5 % < 0.2 % 0 < 2 % 0

Country	Impurities	∅ Mesh size	Limit values % d.m. (m/m)
	Non soil based, non biologically degradable parts		< 0.5 %
SI Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	Glass, plastics, metal		
	1st class	< 2mm	< 0.5 %
	2nd class	< 2mm	< 2 %
	Stabilized biodegradable waste	< 2mm	< 7 %
	Minerals, stones		
	1st class	< 5mm	< 5 %
	2nd class	< 5mm	< 5 %
	Stabilized biodegradable waste	< 5mm	-
UK PAS 100 voluntary. standard	Total Herein included plastic	> 2 mm	< 0.5 % < 0.25 %
	Stones: other than *'mulch'* Stones: in *'mulch compost'*	> 4 mm > 4 mm	< 8 % < 16 %

Annex 5: Hygienisation provisions for compost

Provisions for the exclusion of pathogens, germinating weeds and plant propagules in compost in several European countries

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

	Indirect TIME- TEMPERATURE Regime				Direct methods		
	°C	% H_2O	part. size mm	time	Application area	pathogens / weeds	product (P)/ approval of technology (AT)
ABP Regulation *1069/2009*	70		12	1h	Cat. 3 material	*Escherichia coli OR Enterococcaceae* *Salmonella*	**Process validation**: < 1000 / g in 4 of 5 samples *1000-5000* / g in 1 of 5 samples **Final Compost:** Absent in 25g in 5 of 5 samples
EC/ 'eco-label' *2006/799/EC* *2007/64/EC*					Soil improver growing media	*Salmonella sp.* *E. coli*[61] *Helminth Ova*[61] **Weeds/propagules**	Absent in 25 g < 1000 MPN *(most probable number)*/g Absent in 1.5 g Germinated plants: ≤ 2 plants /l
AT *Statutory 'Guidline – State of the Art of Composting'*	55 – 65 flexible time/temp. regimes are described at min. 55°C 1 to 5 turnings during a 10 – 14 days thermophilic process			10 d	Land reclam. Agriculture Sacked, sport/ playground Technical use Horticulture/ substrates	*Salmonella sp.* *Salmonella sp.* *E. coli* *Salmonella sp.* *E. coli,* *Camylobacter,* *Listeria sp.* --- **Weeds/propagules**	Absent Absent If positive result recommendation for the safe use Absent Absent Absent Absent No requirements Germination ≤ 3 plants /l
BE	60 55			4 d 12 d		*process control* **Weeds**	Time, temp relation Absent
CZ *Bio-waste Ordinance*	55 65			21 d 5 d		*Salmonella spp.* *E. coli* *Enterococcaceae*	Absent < 10^3 CFU / g < 10^3 CFU / g
DE *Bio-waste Ordinance*	55 60 1) 65 2)	40 40 40		14 d 7 d 7 d		*Salmonella senft.* *Plasmodoph. Brass.* *Tobacco Mosaic virus 1* *Tomato seeds* *Salmonella senft.* **Weeds/propagules**	**Process validation** 3): Absent Infection index: ≤ 0.5 Guide value bio-test: ≤ 8 /plant Germination rate /sample: ≤ 2% **Compost production**: Absent in 50 g sample Germination ≤ 2 plants/l
DK	55			14 d	Controlled sanitised compost	*Salmonella sp.* *E. coli,* *Enterococcaceae*	Absent < 100 CFU /g FM < 100 CFU /g FM
ES						*Salmonella sp.* *E. coli*	Absent in 25 g < 1000 MPN *(most probable*

([61]) For those products whose organic content is not exclusively derived from green, garden and park waste

	Indirect TIME- TEMPERATURE Regime				Direct methods		
	°C	% H_2O	part. size mm	time	Application area	pathogens / weeds	product (P)/ approval of technology (AT)
							number)/g
FI						*Salmonella* *Eschrichia coli* Root rot fungus (for instance Fusarium) Globodera riostochiensis and pallida, Clavibacter michicanensis, Ralstonia solanacearum, Synchytrium endobioticum, Rhitzomania, Meloidogyne spp Other quarantine pests causing plant diseases	not found in a sample of 25 grams 1000 CFU/g Not ascertainable in substrates used in seedling production Not ascertainable in a fertiliser product manufactured from root vegetable, beet and potato raw materia or from topsoil fractions accompanying these to the factory or barking plant. Not ascertainable in fertiliser products manufactured from plant waste or substrates in greenhouse production
FR	60			4 d	Gardening/ retailer Other uses	*Salmonella sp.* *Helminth Ova* *Salmonella sp.* *Helminth Ova*	Absent in 1 g Absent in 1 g Absent in 25 g Absent in 1.5 g
IE *Green waste*	---	---	---	---	Individual license! 2004	*Salmonella sp.* *Faecal colimforms*	Absent in 50g ≤ 1,000 MPN/g
Catering waste	60		400	2 x 2 d	Individual license! 2007	*Salmonella sp.* *Faecal colimforms*	Absent in 50g ≤ 1,000 MPN/g
Cat3 ABP	70		12	1 h			
IT *Fertil. law*	55			3 d		*Salmonella sp.* *E. Coli*	Absent in 25 g sample ≤ 1.0 x 10^3 CFU/g
LV *Cabinet Regulation No. 530 25.06.2006*					Fertilisers	*Salmonella sp.* *E. coli*	Absent in 25 g sample < 2500 CFU /g
NL *Beoordelingsrichtlijn keurcompost*	55			4 d		*Eelworms* *Rhizomania virus*[62] *Plasmodoph. Brass.* *Weeds*	Absent Absent Absent Germinating plants: ≤ 2 plants/l
PL					All applications	*Ascaris* *Trichuris* *Toxocara* *Salmonella sp.*	Absent Absent Absent Absent

[62] According to information provided by the Dutch Waste Management Association, this parameter is not measured anymore

	Indirect TIME- TEMPERATURE Regime				Direct methods		
	°C	% H_2O	part. size mm	time	Application area	pathogens / weeds	product (P)/ approval of technology (AT)
SI Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08	55 60 65			14d 7d 7d		*Salmonella sp.*	Absent in 25 g
UK *PAS 100 voluntary standard*	65	50 min. 2 turnings		7 d[4)]	All applications	*Salmonella ssp.* *E. coli* **Weeds/propagules**	Absent in 25 g < 1000 CFU *(colony forming units)*/g Germinating weedplants: 0/l

Annex 6: Compost use regulation

Regulation of the use of compost

Source: ORBIT/ECN (2008) and stakeholders survey December 2010

	Regulation	Requirements or restriction for the use of compost
AT	Compost Ordinance	• Agriculture: 8 t d.m. /ha*y on a 5 year basis • Land reclamation: 400 or 200 t d.m. /ha*y within 10 years depending on quality class • Non food regular application: 20 or 40 t d.m. /ha*y within 3 years dep. on quality class • El. Conductivity > 3 mS/cm: excluded from marketing in bags and for private gardening
	Water Act	• Specific application requirements pursuant to the Action Programme following the EU Nitrate Directive (e.g. limitation to 210 or 170 kg total N per hectare an year)
BE *Flanders*	Royal decree for fertilisers, soil improvers and substrates Fertiliser Regulation (nitrate directive) VLAREA waste regulation	• An accompanying document with user information is obligatory. • Fertiliser Regulation limits N and P, partly more compost use possible because of beneficial soil effects compared to manure. • VLAREA require VLACO Certificate for use and limits max. level of pollutants and show conditions for max application rates
Wallonia	Arrêté du Gouvernement wallon favorisant la valorisation de certains déchets	• Not specifically for organic waste, so all the conditions are laid down in the certificate of use
BG	No data available	n.d.
CY	No data available	n.d.
CZ	Bio-waste Ordinance, Waste Act (2008)	• According to the coming Bio-waste Ordinance (2008) for the first class there are restrictions according to Ordinance on hygienic requirements for sport areas, the 2nd best can be used with 200 t d.m/ha. in 10 years.
	Fertiliser law	• Fertiliser law requires application according to good practice.
DE	Bio-waste Ordinance (BioAbfV 1998) Soil Protection Ordinance (BbodSchV 1999) Fertiliser Ordinance (DÜMV, 2003)	• The Bio-waste Ordinance regulates agricultural use with compost Class I 20 t d.m. in 3 years, Class II 30 t d.m. in 3 years. • Soil Protection Ordinance for non agricultural areas between 10 and 65 t d.m. compost depending on use. • Fertilising with compost according to good practice
DK	Stat. Order 1650 0f 13.12.06 of the use of waste (and sludge) in agriculture	• 7 t d.m. /ha*y on a 10 year basis • Restriction of nitrogen to 170 kg /ha*y • Restriction of phosphorus to 30 kg /ha*y average over 3 years • The levels for heavy metals and organic compounds are restricted in the INPUT material for the composting process
EE	No compost restrictions	Only restrictions for the use of stabilized sludge "sludge compost"
ES	Real Decree 506/2013 on Fertiliser Products	• Class C compost (mixed waste compost) 5t d.m./ha*y
FI	Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07	• Maximum Cd load/ha 6 g during 4 years (crop growing area), 15 g during 10 years (landscape gardening), 60 g during 40 years (forestry); • Soluble phosphorus load per 5 years 400 kg (farming), 600 (horticulture) and 750 (landscape gardening); soluble nitrogen load during 5 years in landscape gardening max. 1250 kg.
FR	Organic soil improvers - Organic amendments and supports of culture NF U44-051	From the moment a compost meets the standard NF U44-051 there is no rule for the use. In the standard, flows in heavy metals, and elements are restricted to the maximum loading limits: • Per year g/ha: As 270, Cd 45, Cr 1,800, Cu 3,000, Hg 30, Ni 900, Pb 2,700, Se 180, Zn 6,000 • Over 10 years g/ha: As 900, Cd 150, Cr 6,000, Cu 10,000, Hg 100, Ni 3,000, Pb 9,000, Se 600, Zn 30,000

	Regulation	Requirements or restriction for the use of compost
		• Application should follow good agrarian practices, and agronomical needs which are taken into account for the use of composts.
GR	Common National Ministerial Decision 114218/1997 Hellenic Ministerial Decision	Upper limits for amounts of heavy metals disposed of annually in agricultural land Cd 0,15, Cu 12, Ni 3, Pb 15, Zn 30, Cr 5, Hg 0,1, kg/ha/y
HU	49/2001 Statuory Rule about the protection of the waters and groundwaters being affected by agricultural activities 10/2000. (VI. 2.) KöM-EüM-FVM-KHVM - Water protection rule	• Compost application on agricultural land is limited by the amount of nutrient with 170 kg/ha Nitrogen. • Dosage levels depending on background contamination and nutrient content level in the soil laid down in the National Statutory Rule about the threshold values for the protection of the ground- and subsurface waters and soils.
IE	Statutory Instruments SI No. 378/2006 Good agricultural practice for protection of waters: Statutory instrument 253 of 2008	• IE Nitrate regulation: Compost has to be included in the Nutrient Management Plan. Availabilty of nutrients calculated like cattle manure. • There are specific waiting periods to consider for animal access to land fertilised with bio-waste compost based on the Animal-By-Product Regulations. o Catering waste: 21 d for ruminant animals; 60 d for pigs; o Former foodstuff & fish waste compost: 3 years (under revision)
IT	National law on fertilisers L. 748/84 (revised in 2006 with the new law on fertilisers, D.lgs. 217/06) Regional provisions	• Compost has to be considered a product to be used according only to Good Agricultural Practice as long as it meets the standards. No restriction is set on loads for unit area • Some regions have codified approaches for low grade materials applications and landfill reclamation, building on the old regulation on "mixed MSW compost" (DCI 27/7/84)
LT	Environmental Requirements for Composting of bio-waste, approved by the Ministry of the Environment on 25 January 2007, No. D1-57 Standards for sewage sludge use for fertilising and redevelopment LAND 20-2005 (Gaz., 2005, No. 142-5135)	• When compost used for improve the quality of the soil, the annual quantity of the heavy metals can not exceed norms according LAND 20-2005. • Compost application in agriculture and or soil reclamation purposes, is restricted by contamination with pathogenic microorganisms, organic micropollutants and heavy metals (according to LAND 20-2005) • Compost application on agricultural land is limited by the amount of nutrient with 170 kg/ha Nitrogen and 40 kg/ha Phosphorous per year
LU	EU Nitrate Directive	• No specific regulations; advise (voluntary): 15 t d.m. /ha *y • Only record keeping about the compost use and send to the Ministry
LV	No regulations	only for sewage sludge compost
MT	No data available	
NL	Fertiliser Act (2008)	• Compost has to meet the national standard (heavy metals) • In the new fertiliser legislation limitations for application are only based on the nutrient content for agriculture, so called standard values of max. 80 kg P_2O_5 /ha*y, 100 kg N /ha*y, 150 K_2O /ha*y, 400 kg neutralizing value /ha*y or 3000 kg organic matter /ha*y • For some crops which grow in the soil (e.g. potatoes) compost needs certification and a low glass content < 0.2 %
PL	The Act of 10 July 2007 on fertilisers and fertilisation (Journals of Laws No. 147, item 1033, as amended)	• Organic fertilisers and plant conditioners containing compost can be marketed and used on the Polish territory on the basis of a license from the Agricultural Ministry; • Products containing compost are used exactly as given in the instructions for using and storing the product, which is an integral part of the license; • A limit for nitrogen use of 170 kg of nitrogen (N) in the pure ingredient per ha and per year only applies to natural fertilizers

	Regulation	Requirements or restriction for the use of compost
PT	No regulations available	---
RO	No data available	n.d.
SE	The Swedish Board of Agriculture: SJV 1998:915 (sewage sludge regulation)	• Fixed maximum heavy metal load Maximum heavy metal load (g/ha*y): Pb 25; Cd 0.75; Cu 300; Cr 40; Hg 1.5; Ni 25; Zn 600
	Nitrate directive	Agriculture: nitrogen: 150 kg/ha*y and phosphorus: 22 – 35 kg/ha*y
SI	Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	• Class I can be used without any restrictions. • Class II can be spread with a special permission with a limited application rate considering the heavy metal content and load after an evaluation and risk assessment performed by a lab (but not more than 10 t d.m./ha /year).
	Decree concerning the protection of waters against pollution caused by nitrates from agricultural sources (Official Gazette of the Republic of Slovenia, no. 113/09)	• Application of organic fertilizer on agricultural land is limited by the amount of nutrient with 250 kg/ha Nitrogen.
SK	Act No. 220/2004 Col. on protection and using of agricultural soils	• Lays down limit concentrations of risk elements in agricultural soils
	Ministry of Agriculture Decree No. 26/2000, on fertilisers.	• Lays down fertiliser types, max. concentration of risk elements in organic fertilisers, substrates and commercial fertilisers, storage and take-off conditions, and methods of fertiliser testing
UK	Each country of the UK has different requirements Here is an example of parts of the regulations applicable for England and Wales	• Use in agriculture and applications to soil other than land restoration**:** A Waste Management Licence Exemption, Paragraph 7A, must be obtained by the land owner/manager before accepting and storing then spreading compost. The compost must be made from source segregated bio-waste. Per Paragraph 7A exemption: • ‘Benefit to agriculture’ or ‘ecological improvement’ must be demonstrated, which is done by spreading compost as per Nitrate Vulnerable Zone regulations if within a NVZ, and following the Codes of Good Agricultural Practice for the Protection of Soils and Water. Given the typical total nitrogen content of ‚Green compost‘, the application rate would be approximately; • 30 - 35 fresh tonnes per hectare per year where a field NVZ limit of 250 kg total nitrogen per hectare applies, • 30 fresh tonnes per hectare per year if ‚Not NVZ‘ but as per good agricultural practice, or • 60 – 70 fresh tonnes per hectare once per two years if ‚Not NVZ‘ but as per good agricultural practice. • If the compost is classed as a waste, the Environmental Permitting Regulations apply (paragraph 7 exemption, U10 exemption or Standard Rules Permit) and a permit or exemption will be required by the land owner/manager before storing or spreading the compost. If the compost has ceased to be waste
		• Voluntary Code of Good Agricultural Practice for the Protection: limitation of nitrogen of 250 kg /ha/y (for all types of ‘organic manure’ used, including composts); compost can also be applied at a rate of 500 kg/ha once per two years

Annex 7: Metal dosage limits

Admissible maximum dosage of heavy metals to the soil in national legislation and standards [g/ha* y]

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

Country		Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As	Se
		[g/ha y]*									
EC	**'Sewage sludge'** 1) 10 y basis	150	3,000	-	12,000	100	3,000	15,000	30,000	-	-
AT	Sewage sludge 2)	20	1,250	-	1,250	20	250	1,000	5,000	-	-
	Fertiliser. Ord. 2 years basis	5	300	-	350	5	200	300	1,500	-	-
BE	Flanders: VLAREA (compost)yearly	12	500	-	750	10	100	600	1,800	300	-
	Wallonia: B1 type compost (field management without preliminary analyses of soil)	5	500	-	600	5	100	500	2,000		
	Wallonia: B2 type compost (field management with preliminary analyses of soil)	10	1000	-	1200	10	200	1000	4000		
CY	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CZ	Sewage sludge yearly *max. 5 t d.m./3y in agriculture*	5	200		500	4	100	200	2,500	30	
DE 1)	sewage sludge	16	1,500	-	1300	13	300	1,500	4,100	-	-
DK	7 t d.m. basis / calculated	5.6	700		7,000	5.6	210	840	28,000	-	-
	related to 30 kg P_2O_5/ha / calculated	3	-	-	-	6	75	300	-	-	-
EE	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
ES	RD 1310/1990 (SS) 10 years basis	150	3,000		12,000	100	3,000	15,000	30,000	-	-
FI	Sewage sludge	3	300		600	2	150	150	1,500	-	-
	Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 12/07 (average based on 4,10 or 40 years application)	1.5									
FR	NF U 44 51 (comp.) 10 years basis	15	600		1,000	10	300	900	3,000	90	60
	NF U 44 51 (comp.) yearly	45	1,800		3,000	30	900	2,700	6,000	270	180
GR	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
HU	Sewage sludge (under Nr. 50/2001.)	150	10,000	-	10,000	100	2,000	10,000	30,000	500	1,000
IE	SI 148/1998 [use of sewage sludge in agriculture]	10	1000	-	1000	10	300	750	2500	-	-
IT	DCI 27/07/84 - MWC from mixed waste	15	2,000	15	3,000	15	1,000	500	10,000	100	-
LT	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
LU	No regulation	-	-	-	-	-	-	-	-	-	-
LV	Sewage sludge	30	600		1,000	8	250	300	5,000		
MT	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
NL	Nutrient loads (N,P) are the dosage limiting factor	-	-	-	-	-	-	-	-	-	-
PL	Sewage sludge	20	1,000		1,600	10	200	1,000	5,000	-	-
PT 1)	Sewage sludge /10 y basis	150	4,500		12,000	100	3,000	15,000	30,000	-	-
RO	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SE	SNFS 1992:2 (sewage sludge)	0.75	40		300	1.5	25	25	600	-	-

SI	Sewage sludge use in agriculture on 10 year basis	15	2000	-	3000	15	750	2500	12000	-	-
SK	No regulation	-	-	-	-	-	-	-	-	-	-
UK	Sludge (use in agriculture) Regulations [3] sewage sludge average annual loading over 10 years	150	?	-	7,500	100	3,000	15,000	15,000	-	-

[1] Directive 86/276/EEC; average within 10 years [2] Sew. Sludge Ordinance, Lower Austria (Class III)

[3] S (UiA) regulations: Statutory Instrument 1989 No. 1263, The Sludge (Use in Agriculture) Regulations 1989

The QCP (England and Wales) sets maximum allowable concentrations for PTEs in soils that receive Quality Composts, as specified in the Sludge (Use in Agriculture) Code; these are more stringent than the soil PTE maximum allowable concentrations allowed in the regulations.

SS: Sewage Sludge

Annex 8: Compost quality assurance schemes

Compost quality assurance schemes in EU Member States

Source: ORBIT/ECN (2008)

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
AT	Fully established quality assurance system based on Austrian Standards ÖNORM S2206 Part 1 and 2 and Technical Report ONR 192206 published by the Austrian ÖNORM Standardisation Institute. Up to now two non-profit associations have adopted these standards for granting a compliance certification with the QAS: • the Compost Quality Society of Austria KGVÖ (Kompostgüteverband Österreich) • the Compost & Biogas Association – Austria (ARGE Kompost & Biogas – Österreich) The certification schemes comprise both, operational process and quality management and final product approval. Thereby the most important references are the requirements set by the Austrian Compost Ordinance which provides for a comprehensive documentation and monitoring programme. Compost can get product status if it meets one of the 3 classes based on precautionary requirements (class A+ (top quality for organic farming), class A "Quality compost"(suitable for use in agriculture, horticulture, hobby gardening and Class B (minimum quality for "compost" restricted use in non-agricultural areas)
	Under the roof of **Compost Quality Society of Austria (KGVÖ)** large scale compost producers supplemented by experts, grant an additional quality seal for the marketing of high quality composts on the basis of the officially acknowledged quality assurance system. External labs collect the samples and analyses. Evaluation of the results, documentation and granting of the label is carried out by an independent quality committee with expert members of the KGVÖ. (16 members - 300.000 t capacity) **Compost & Biogas Association Austria (ARGE** Kompost & Biogas) was founded to establish the decentralised composting of separately collected bio-waste in cooperation with agriculture (on-farm composting). Nowadays the association has grown to a full-scale quality assurance organisation on the basis of the common Austrian standards. ARGE uses external auditors for sample taking, plant inspection, evaluation, documentation and certification of the plants. (370 members - 300.000 t capacity)
BE	Fully established statutory quality assurance system for compost in the Flanders region operated by the non-profit **Flemish compost organisation VLACO vzw** with its members from municipalities, government and composting plants. (Around 40 green and bio-waste plants with 840.000 t of capacity). Based on the Flemish Regulation on Waste Prevention and Management VLAREA act VLACO vzw show a very unique but effective integrated approach and a broad range of tasks. The organisation executes: 1. Waste prevention and home composting programmes 2. Consultation and advice for process management incl. co-composting and co-digestion 3. Sampling, organisation of the analysis and evaluation of the results 4. Organisation of field trials and development of application information 5. Marketing and Public Relation for organic waste recycling and first of all for the compost So by means of this integrated approach the whole organic loop from source material to the use of the final product is in one hand. Nevertheless some modifications are made lately in order to include elements of ISO 9000 and the Total Quality Management TQM the quality assurance of anaerobic digestion residuals and of manure into the system. Not only the end-product is controlled but the whole process is followed up. In TQM the input (the bio or green waste), the process and the output are monitored and analysed. The reason to put standards on the input is that this allows no dilution. Depending on source materials and product characteristics up to 15 different products can be certified (statutory) and labelled (voluntarily) by VLACO vzw.
CZ	Voluntary quality assurance scheme proposed by the regional **Environmental and Agricultural Agency ZERA** is in preparation for a quality assurance scheme for 2008 after new bio-waste Ordinance is in force. Main task is to create a compost market by certifying compost products and organise a practical inspection and control of compost. The certification scheme is based on requirements of the Czech institute of accreditation in the agreement with international norm CSN EN ISO/ IEC 45011:1998.
DE	Fully established voluntary quality assurance system for compost and anaerobic digestion residuals in which the **Compost Quality Assurance Organisation (Bundesgütegemeinschaft Kompost BGK)** organisation is the carrier of the RAL compost quality label. It is recognised by RAL, the German Institute for Quality Assurance and Certification, as being the organisation to handle monitoring and controlling of the quality of compost in Germany.

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
	The BGK was founded as a non-profit organisation in order to monitor the quality of compost. Through consistent quality control and support of the compost producers in the marketing and application sectors, the organisation promotes composting as a key element of modern recycling management. 425 composting and 67 digestion plants with 5.9 mio t capacity plants take part in the quality assurance system and have applied for the RAL quality label. Besides the central office, a quality committee works as the main supervision and expert body in the quality assurance system. In addition BGK runs a database with all indicators of the composting plants and analyses results of the products. Meanwhile it includes more than 35.000 data sets. The BGK has defined a general product criteria quality standard (the RAL quality label GZ 251 for fresh and mature compost as well as for compost for potting soil compost and for different types of digestion residuals RAL GZ 245 (new since 2007 RAL GZ 246 for digestion products residuals from treatment renewable resources (e.g. energy crops)) and established a nationwide system for external monitoring of plants and of compost and digestion products. The quality assurance system comprises the following elements: Definition of suitable input in accordance with bio-waste and fertiliser regulation. • Operation control by plant visits of independent quality managers. ▪ External and internal monitoring ▪ Quality criteria and quality label do demonstrate the product quality; ▪ Compulsory declaration and information on correct application; ▪ Documentation for the competent authorities. The successful work is respected by the authorities in Germany by exempting member plants from some control requirements which are subject to the waste legislation. By means of that procedure quality assured compost show a "quasi" product status in Germany.
DK	A quality assurance system for compost (quality criteria, standardised product definition, analysing methods) is prepared by **DAKOFA (Danish Association on waste management)** but is not applied. No further progress expected for the moment because separate collection of kitchen waste will not increase before the present legal background. Green waste collection and composting is very well diffused but not subject to any waste and quality standards regulation in Denmark.
ES	Draft statutory Spanish standard on compost legislation, laying down standardised, nationwide rules concerning the production, marketing and labelling of compost as a product prepared by the Ministry of Environment. A lot of studies confirmed for Spain the need to improve the compost quality in order to open up markets. This was in the outcome of a LIFE Project too deemed to investigate the production and use of quality compost in Andalusia. Based on the results the **Andalusia´s Regional Ministry of Environment** has designed and registered a trademark *"Environmental Accreditation of Compost"* that allows - on a voluntary basis - companies producing compost to show its quality. The Order 20/07/07 Environmental Accreditation of Compost Quality. BOJA nº 156 8/8/2007 explains how to get and use it .Compost should fulfil some limits according to the Real Decree 506/2013, 8/7/05, about fertilisers. It is the Andalusia´s Regional Ministry of Environment who will control the label use and define accredited laboratories to analyse compost samples. There is no independent sample taking.
HU	Voluntary Hungarian Compost Quality Assurance System is prepared (but not implemented) by the Hungarian Compost Association and waiting for the revision of the existing regulations which are intended for sewage sludge and fertilisers and are not applicable for composting. The **Hungarian Compost Association** has completed in 2006 the framework of the assurance system (similar to the German BGK and Austrian KGVÖ examples) and is now waiting for the new Hungarian Statutory rule about production, nominating, marketing and quality assurance for composts. Basic elements of the future Compost Quality Assurance Systems (implementation in 2009) are: 1. Raw material list (permissive list) 2. Compost Classes The Ordinance will define three different quality classes for compost based on the contaminant content. Will also define ways of utilisation. The classes (similar to the Austrian ones) will be: Class A - top quality (suitable for organic farming use) Class B - high quality (suitable for agricultural use) Class C - minimum quality (not suitable for agricultural use) 3. Quality control End-product controlling and process controlling. Independent sample taking and analysis is intended.
IE	A first draft for a voluntary compost quality standard was presented in Ireland (2007). This task and the follow up establishment of a quality assurance system are elements of the national Market Development Plan

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
	- intended to create market for recyclables - have recently started. The **Irish Composting Association CRE supports** is involved in these developments. Limits for pollutants, stability, etc. are specified in waste authorisations (e.g. EPA Waste licences and Local Authority waste permits).
IT	Voluntary quality assurance on operated by the **Italian Compost Association CIC,** the Italian National Association for the compost industry. It started as certification system for compost products in order to show compliance with the national fertiliser regulation and the statutory quality standards for green and mixed compost are laid down there. No monitoring of the standard is proposed. Basically, the quality label ensures fulfilment of statutory standards (assessment of compliance is usually an issue due to the rather poor performance of controlling authorities, hence CIC aims to reinforce the “declaration of compliance”).Within the scheme samplings are made by certificated personnel from the Italian Composting Association (CIC) and analyzed at a single accredited laboratory. Now the scheme turns step by step into a quality assurance system e.g. with preparation of certifying the entire production process and above all (as requested by consumers) the traceability of compost. The CIC Quality Label is considering this to be a very important initiative for the industry because it provides an independent element of security upon which consumers and operators can make their choices. Currently, the quantities of compost that can be certified amount to approx. 250,000 tons /y, which represents approximately 20% of the Italian production.
LU	Statutory system which relies on the German Quality Assurance System and on the German Organisation **(Bundesgütegemeinschaft Kompost e.V. BGK).** The request to execute a "quality assurance system like the one of BGK or similar" is part of the licensing procedure for every composting plant. Missing alternatives have established the BGK system in Luxembourg as the one and only. All independent sampling, control functions and documentation functions will be executed by the BGK representatives. (5 compost plants with around 50.000 t/y total capacity are part of the scheme)
LV	On the starting stage (from Nov. 2006), quality assurance organization Environmental Agency
NL	After 10 years of experiences the Dutch Government decided that not the quality but the nutrients are the primary precautionary problems with compost. Less strict heavy metal thresholds and no obligations for control any more is one result. In addition no longer is the applied amount of compost but the nutrient load limited. All compost which is used for crops which grow in the soil must be independently certified with a very strict threshold for glass. Because the sales area of compost is not predictable while the production, more or less all bio-waste composts, will be certified in future and compost certification will become quasi statutory. As of 2012, there is one certification type for both VFG and green waste. The BVOR Dutch Association of Compost Plants and Dutch Waste Management Association DWMA/VA manage the certification system in both the green waste and VFG sectors which doesn't require external sampling but independent institutes/auditors for the evaluation of the process and the analysis results.
PL	Quality Assurance refers only to the final product. The Ministry of Agriculture and Rural Development gives the certificate of organic fertiliser based on its chemical properties and pathogen status after the compost receives a positive expertise from the designated institution (depending on planned application area).
SE	Voluntary quality assurance system for compost and digestion products is operated by the **Swedish Waste Management Association Avfall Sverige** together with Swedish Standardisation Institute SP. For the moment Sweden has no statutory standard, but the necessity of standards is seen clearly by involved parties and the government. Producers and users are of the opinion that sustainable recycling of organic wastes demands clear regulations regarding what is suitable to be recycled and how it should be managed and controlled. A well-founded quality assurance programme definitely increases sustainable recycling of organic wastes. The regulations for the voluntary Swedish certification of compost and digestion residues are based on purely source-separated organic waste, with special emphasis on the acceptability of raw materials for input, the suppliers, the collection and transportation, the intake, treatment processes, and the end product, together with the declaration of the products and recommendations for use. 6 digestion and 1 composting plant are included in the certification system and have applied for the certificate.
UK	Voluntary standard BSI PAS 100 and the supplementing Quality Compost Protocol (QCP) set criteria for the production and minimum quality of quality composts. The **UK Composting Association** owns a certification scheme aligned to BSI PAS 100, which has been upgraded to incorporate the additional requirements of the QCP. Composting plants and compost particle size grades that meet all the requirements

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
	can get their composts certified and use the Composting Association's quality mark. Around 150 composting producers are under assessment, treating more than 2 mio t of source segregated bio and green waste, and 40 % of the compost they produce is already certified. BSI PAS 100:2005 specifies the minimum requirements for the process of composting, the selection of materials from which compost is made, minimum compost quality, how compost is labelled and requires that it is traceable. It also requires Hazard Analysis and Critical Control Point assessment, the implementation of a compost Quality Management System and correct compost labelling and marking. Compliance with requirements of the QCP is considered sufficient to ensure that the recovered bio-waste may be used without risk to the environment or harm to human health and therefore without the need for waste regulatory control. In addition, The Quality Compost Protocol requires compost certification to PAS 100 and also imposes restrictions on materials from which quality composts can be made and in which markets they can be used as 'product'. The QCP also requires the producer to supply customers with contracts of supply, and if Quality Compost is stored and used in agriculture or field horticulture, this must be done in accordance with the Codes of Good Agricultural Practice and that soil PTE concentrations do not exceed the Sludge Use in Agriculture Code's limits. The Quality Protocol further aims to provide increased market confidence in the quality of products made from bio-waste and so encourage greater recovery of source-segregated bio-waste. In England and Wales, compost must be independently certified compliant with both PAS 100 and the Quality Compost Protocol for it to be supplied to the designated market sectors as a 'product'. In Scotland, for compost to be supplied as a 'product' it must be certified to PAS 100 (or an equivalent standard), have certainty of market, be used without further recovery, not be subjected to a disposal activity and not be mixed with other wastes, materials, composts, products or additives. Northern Ireland's position is currently similar to Scotland's. Compost can be placed on the market as a recovered waste material in any of the countries of the UK; in this circumstance, waste management licensing regulation requirements must be adhered to. A number of local authorities have required PAS 100 certification in contracts with compost producers, and in England and Wales in particular, may start requiring certification to the Quality Compost Protocol as well.

Annex 9: Time-temperature profiles for compost

Temperature-time profiles required during the composting process in existing legislation and standards

Source: ORBIT/ECN (2008) and stakeholder survey December 2010

	Indirect TIME- TEMPERATURE Regime			
	°C	**% H_2O**	**part. size mm**	**time**
ABP Regulation 1069/2009/EC	70		12	1h
EC/ 'eco-label' 2006/799/EC 2007/64/EC				
AT Statutory 'Guideline – State of the Art of Composting'	55 – 65 flexible time/temp. regimes are described at min. 55°C 1 to 5 turnings during a 10 – 14 days thermophilic process			10 d
BE	60 55			4 d 12 d
CZ Bio-waste Ordinance	55 65			21 d 5 d
DE Bio-waste Ordinance	55 60 1) 65 2)	40 40 40		14 d 7 d 7 d
DK	55			14 d
ES				
FI				
FR	60			4 d
IE Green waste catering waste Cat3 ABP	--- 60 70	---	--- 400 12	--- 2 x 2 d 1 h
IT Fertil. law	55			3 d
LV Cabinet Regulation No. 530 25.06.2006				
NL Beoordelingsrichtlijn Keurcompost	55			4 d
PL				

	Indirect TIME- TEMPERATURE Regime			
	°C	**% H_2O**	**part. size mm**	**time**
SI Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	55 60 65			14d 7d 7d
UK PAS 100 voluntary standard	65	50		7 d[4)]
	min. 2 turnings			

Annex 10: Possible compost product property parameters

Proposal from First Working Document: possible product property parameters that need to be declared when placing compost on the market

Usefulness concerning soil improving function:
- Organic matter content
- Alkaline effective matter (CaO content)

Usefulness concerning fertilising function:
- Nutrient content (N, P, K, Mg)
- Mineral nitrogen content (NH_4-N, NO_3-N)

Biological properties:
- Stability/maturity
- Plant response
- Contents of germinable seeds and plant propagules

General material properties
- Water or dry matter content
- Bulk density/volume weight
- Grain size
- pH
- Electrical conductivity (salinity)

Hygienic aspects relevant for environmental and health protection
- Presence of salmonellae
- Presence of E.coli

Pollutants and impurities relevant for environmental and health protection
- Contents of macroscopic impurities (such as glass, metals, plastics)
- Contents of Pb, Cd, Cr, Cu, Ni, Hg, Zn

Annex 11: Initial proposal product quality requirements compost

Proposal from First Working Document: possible parameters and limit values of minimum product quality requirements

a) Minimum organic matter content

The minimum organic matter content of the final product, after the composting phase and prior to any mixing with other materials shall be 20%. (This is pretended to prevent dilution of compost with mineral components (e.g. sand, soil).

b) Minimum stability

A member state has suggested the Oxitop method, alternatively Oxygen Uptake Rate may be measured according to EN16087-1 or a self-heating test may be performed according to EN 16087-2.

c) Absence of pathogen indicator organism

No salmonella sp. in 50 g sample.

d) Limitation of macroscopic impurities

Total impurities (non-biodegradable matter) > 2 mm shall be < 0.5 % (dry matter).

e) Limitation on organic pollutants

Currently there is no proposal for organic pollutants. Denmark holds limit values for 4 persistent organic pollutants: LAS, PAH, NPE and DEHP. France holds limit values for PAH and in the case of compost containing sewage sludge as input material also for PCBs.

f) Limitation of potentially toxic elements (heavy metals)

In the final product, just after the composting phase and prior to any mixing with other materials, the content of the following elements shall be lower than the values shown below, measured in terms of dry weight:

Element	mg/kg (dry weight)	*times the limit in the EU eco-label criteria for soil improvers and growing media (2007/64/EC and 2006/799/EC)*
Zn	400	*4/3*
Cu	100	*1*
Ni	50	*1*
Cd	1.5	*3/2*
Pb	120	*6/5*
Hg	1	*1*
Cr	100	*1*

The limits apply to the compost just after the composting phase and prior to any mixing with other materials.

Rationale for the limit values:

There a number of factors to be considered for finding the most suitable limit values. Some factors are best addressed by very low (i.e. strict) limits, others are reasons for not being too strict. Therefore, a solution is needed that best reconciles the different demands in an acceptable way.

On the one hand, strict limits are needed to meet the following demands:

- There should be no overall adverse environmental or human health impact from the use of end-of-waste compost
- Environmental impacts in the case of misuse of compost should be within acceptable limits
- The limits should promote the production of higher compost qualities and prevent a relaxation of quality targets (end-of-waste criteria should not lead to higher contamination levels of composts than today)
- The limits should be an effective barrier to diluting more contaminated wastes with compost
- The limits should exclude compost from end-of-waste if it cannot be used in a dominant part of the market because it does not meet the existing standards and legislation on use.

On the other hand,

- The benefits of compost use should not be sacrificed because of disproportionate risk aversion
- Limits should not be so strict that they disrupt current best practice of compost production from the biodegradable fractions of municipal solid waste
- Composting as a recycling route for biodegradable wastes should not be blocked by demanding unrealistic and unnecessarily strict limits.

Well-balanced limit values can be found by the following considerations:

1. The limits in the EU eco-label criteria for soil improvers and growing media are the lower bound of what can reasonably be demanded as limits.

The Community eco-label criteria for soil improvers and growing media include limits for hazardous substances. The eco-label criteria were decided by the European Commission in accordance with the corresponding Committee of Member State representatives. They introduced harmonised limit values at Community level[63].

These limits apply to the growing media constituents in the case of growing media and to the final product in the case of soil improvers. The explicit aim of these eco-label criteria is to promote "the use of renewable materials and/or recycling of organic matter derived from the collection and/or processing of waste material and therefore contributing to a minimization of

[63] Note that the eco-label limit values are valid unless national legislation is more strict. Correspondingly, this paper argues that limits in rules on certain compost uses may be stricter than end-of-waste criteria if justified.

solid waste at the final disposal (e.g. at landfill)". For soil improvers, the criteria aim at promoting "the reduction of environmental damage or risks from heavy metals and other hazardous compounds due to application of the product." In the case of growing media, the eco-label criteria "are set at levels that promote the labelling of growing media that have a lower environmental impact during the whole life cycle of the product."

The eco-label were established with compost in mind as the prime organic constituent of the eligible growing media and soil improvers and it is apparent that the eco-label criteria have the same aim as the end-of-waste criteria: to promote the recycling of organic waste while reducing environmental impacts throughout the life cycle and avoiding environmental damage or risks when using the product on land.

The study by ORBIT/ECN (2008) shows that when composts comply with the eco-label limits even continued yearly applications of compost on land would not lead to any unacceptable accumulation of metals in soil within 100 years. This underlines that the eco-label criteria are sufficiently strict to protect the environment.

It also needs to be considered that it would make European legislation inconsistent if end-of-waste limits were stricter than the eco-label limits. This would lead to paradoxical cases where composts labelled as soil improver with the EU flower-label could not cease to be waste.

It can be concluded that the eco-label criteria are sufficiently strict also as end-of-waste criteria.

2. The eco-label limits would exclude a considerable part of current and potential compost production from the source segregated biodegradable fractions of household, garden and park waste.

End-of-waste criteria should not disrupt the successful existing national approaches to composting. Limits for hazardous substances should be oriented at the compost qualities that have proven feasible (can be reliably produced) in the existing best practice compost systems. Best practice currently includes compost production with reliable quality assurance systems and the use of source-segregated biodegradable wastes as input materials.

A study for UBA (Reinhold, 2008) made a statistical evaluation of the compost quality achieved by composting plants that participate in the German quality assurance and certification scheme (which allows the use of source segregated input materials only). From the study it can be shown that with current testing practice about 60 composting plants would not be able to warrant compliance with limits for Zn. For both Pb and Cd there are 36 plants that would not be able to guarantee compliance, and for Cu 18[64]. For Ni, Hg and Cr almost all plants would comply. See also Table 18.

Table 18: Possibility to guarantee compliance with individual limit vales of German composting plants participating in the German compost quality assurance scheme. Compiled from Reinhold (2008) Anlage 5.

	Eco-label limits [g/kg (dry weight)]	% of 367 composting plants that can warrant

[64] It should be noted that by increasing the precision of the testing (more samples) further plants would be in a position to demonstrate compliance. This would come however at higher testing costs.

		concentrations below the limit at a 95% level of confidence
Cu	100	95.2
Zn	300	83.5
Pb	100	90.2
Cd	1	90.2
Ni	50	98.2
Hg	1	99.7
Cr	100	100

The study by ORBIT / ECN shows that other countries with advanced source separation and composting systems (BE-Flanders, NL, AT) show a very similar level and distribution of heavy metals in both bio-waste compost and green waste compost as DE. In Italy and the UK, concentrations of metals in composts from bio-waste and green waste compost are comparatively higher (approximately by a factor two higher for most of the metals in the case of Italy, and for Pb in bio-waste compost in the case of UK)

For compost producers in 'newcomer' countries it is expected to be very hard to meet limits with the ambition of the ecolabel criteria in the early phase of setting up suitable waste collection systems. A certain relaxation of the most critical limits (Zn, Pb, Cd) would open the door to newcomers by allowing them to have a more realistic perspective of being able to meet end-of-waste criteria.

One also has to keep in mind that the eco-label is a voluntary instrument that is intended to be selective. Article 4-2(c) of the former eco-label Regulation[65] set out that "the selectivity of the criteria shall be determined with a view to achieving the maximum potential for environmental improvement." End-of-waste criteria also aim at an environmental improvement, but not necessarily for a maximum potential because also other aspects of waste management, such as economic cost need to be taken into account.

There are therefore good reasons for end-of-waste criteria to include higher limits for the most critical elements than the EU eco-label criteria.

3. It is possible to meet the conditions of end-of-waste criteria even if the critical metal concentration limits are increased to a certain extent compared to the eco-label criteria

ORBIT/ECN (2008) estimates that even with metal concentrations corresponding to the limits of the relatively tolerant French NF U44-051 standard and continued yearly compost applications to soil, critical soil threshold values of the German Soil Protection Ordinance would not be exceeded within more than 50 years in the case of Zn and more than 100 years in the cases of Pb and Cd. The limits of that standard at least triple the eco-label limits for Zn, Pb, Cd. Also misuse by applying to soil higher amounts than phosphate limited application rates are unlikely to lead to critical impacts unless extremely high amounts or repeated over prolonged periods (several years).

However, applying the limits of the NF U44-051 standard would relax the quality targets that are currently used in most places where compost is being produced in significant amounts.

[65] EC 1980(2000), replaced by EC 66/2010

Furthermore, agricultural use, as main outlet for compost, would not be allowed by current use rules in most of the main compost using countries.

Table 19 gives an overview of the proposed heavy metal limits, compared to compost limits in the Member States for compost aimed at normal agricultural applications. The table also includes the EU Eco-label limits and the EU regulation on organic agriculture.

Table 19: Heavy metal limits for compost aimed at use in agriculture compared to proposed limit values from the IPTS (2008) study except Cu and Zn (values from proposal in this final report), all values in mg/kg (dry weight). Red color shading indicates that a MS has a stricter limit than the proposal, green shading indicates equal or less strict limits.

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg d.m.								
AT	Compost Ord.:Class A (agriculture; hobby gardening)	Ordinance	1	70	-	150	0.7	60	120	500	-
BE	Royal Decree, 07.01.1998	Statutory decree	1.5	70	-	90	1	20	120	300	-
BG	No regulation	-	-	-	-	-	-	-	-	-	-
CY	No regulation	-	-	-	-	-	-	-	-	-	-
CZ	Use for agricultural land (Group one)	Statutory	2	100	-	100	1	50	100	300	10
DE	Quality assurance RAL GZ - compost / digestate products	Voluntary QAS	1.5	100	-	100	1	50	150	400	-
DK	Statutory Order Nr.1650; Compost after 13 Dec. 2006	Statutory decree	0.8	-	-	1000	0.8	30	120	4000	25
EE	Env. Ministry Re. (2002.30.12; m° 87) Sludge regulation	Statutory	-	1000	-	1000	16	300	750	2500	-
ES	Real decree 824/2005 on fertilisers Class B	Statutory	2	250	0	300	1.5	90	150	500	-
FI	Fertiliser Regulation (12/07)	Statutory decree	1.5	300	-	600	1	100	150	1500	25
FR	NFU 44 051	standard	3	120		300	2	60	180	600	-
GR	KYA 114218, Hellenic Government Gazette, 1016/B/17- 11-97 [Specifications framework and general programmes for solid waste management]	Statutory decree	10	510	10	500	5	200	500	2000	15
HU	Statutory rule 36/2006 (V.18)	Statutory	2	100	-	100	1	50	100	--	10
IE	(Compost – Class I)	Statutory	0.7	100	-	100	0.5	50	100	200	-
IT	Law on fertilisers (L 748/84; and: 03/98 and 217/06) for BWC/GC/SSC	Statutory decree	1.5	-	0.5	230	1.5	100	140	500	-
LT	Regulation on sewage sludge Categ. I (LAND 20/2005)	Statutory	1.5	140		75	1	50	140	300	-
LU	Licensing for plants		1.5	100	-	100	1	50	150	400	-
LV	Regulation on licensing of waste treatment plants (n° 413/23.5.2006) – no specific compost regulation	Statutory	3	-		600	2	100	150	1500	50
NL	Amended National Fertiliser Act from 2008	Statutory	1	50		90	0.3	20	100	290	15
PL	Organic fertilisers	Statutory	5	100		-	2	60	140	-	-
PT	Standard for compost is in preparation	-	-	-	-	-	-	-	-	-	-
SE	SPCR 152 Guideline values	Voluntary	1	100	-	600	1	50	100	800	-
SI	Decree on the treatment of biodegradable waste (Official Gazette of the Republic of Slovenia, no. 62/08)	Statutory	0.7	80	-	100	0.5	50	80	200	-
SK	Industrial Standard STN 46 5735 Cl. 1	Voluntary	2	100		100	1	50	100	300	10
UK	Standard: PAS 100	Voluntary	1.5	100	-	200	1	50	200	400	-
EU ECO Label	COM Decision (EC) n° 64/2007 eco-label to growing media; COM Decision (EC) n° 799/2006 eco-label to soil improvers	Voluntary	1	100	-	100	1	50	100	300	10
EU Regulation on organic agriculture	EC Reg. n° 889/2008. Compliance with limits required for compost from source separated biowaste only	Statutory	0.7	70	0	70	0.4	25	45	200	-
Proposed limit values (IPTS, 2008) except Cu/Zn			1.5	100		200	1	50	120	600	

With the current proposal, 16 out of the 25 listed Member States have stricter limits for at least one element whereas 9 Member States have equal or less strict limits for all elements. The proposed values could thus be seen as ambitious but realistic to achieve for compost producers in countries with new or emerging compost markets.

For the other elements (Ni, Hg, Cr) an increase compared to the eco-label limits is not needed because most composting plants following best practice are able to meet the eco-label limits.

Annex 12: Compost and digestate sampling and testing methods

The sampling and measurement standards to be used **for compost and digestate** should be those developed by **CEN TC 400 (Former CEN TF 151 and project Horizontal)**. A CEN standard is considered effective once the prEN standard is adopted by all participating Member States, so even before publication of the national equivalents or final EN standards.

Until horizontal standards elaborated under the guidance of CEN TC 400 become available, testing and sampling **for compost** shall be carried out in accordance with test methods developed by Technical committee **CEN TC 223 'Soil improvers and growing media'**.

In the case of absence of final Horizontal (CEN TC 400) and CEN TC 223 test methods, other internationally recognised test methods may be used, unless the competent authorities of a Member State prescribe a certain standard. For instance, if consolidated and approved test methods for composts or digestates are used in Member States or third countries, these should be used in the absence of CEN TC 400 or TC 223 test methods.

Where required testing is not covered by CEN standards or CEN standards in progress of adoption, other test methods are pointed out in this Annex. These methods are indicative by nature and, as stated above, may be substituted by Member State methods in use.

Analysis should be carried out by reliable laboratories that are accredited for the performance of the required tests in an acknowledged quality assurance scheme.

Terms and definitions

The glossary is regarded to be useful for a uniform comprehension and in order to keep univocal interpretation on test methods.

"Alkaline effective matter": calcium and magnesium in basifying form (e.g. as oxide, hydroxide and carbonate)

"Bulk density": ratio of the dry mass and volume of the sample in grams per litre measured under standard suction conditions (suction pressure: 10 cm); it is sometimes referred to as "apparent density".

"Dry matter**:** the portion of substance that is not comprised of water. The dry matter content (%) is equal to 100 % minus the moisture content %.

"Electrical conductivity": measure of a solution's capacity to carry an electrical current; it varies both with the number and type of ions contained in the solution; it is an indirect measure of salinity.

"Heavy metals": elements whose specific gravity is approximately 5 or higher. They include lead, copper, cadmium, zinc, mercury, nickel, chromium.

"Impurities": physical impurities are defined as all non-biodegradable materials (glass, metals, plastics) with a size > 2 mm.

"Maturity": Maturity (see also "stability") can be defined as the point at which the end product is stable and the process of rapid degradation is finished, or, a biodegraded product that can be used in horticultural situations without any adverse effects. The term maturity can also be interpreted in a wide sense, and also includes the term stability. An attempt to define maturity could be that it is a measure of the compost's readiness for use that is related to the composting process. This readiness depends upon several factors, e.g. high degree of decomposition, low levels of phytotoxic compounds like ammonia and volatile organic acids.

"Moisture content": the liquid fraction (%) that evaporates at 103 ± 2°C (EN 15934).

"Organic matter" (OM): The carbon fraction of a sample which is free from water and inorganic substances, clarified in EN 15935 as "loss on ignition" at 550 ± 10 °C.

"Plant response": evaluating the plant response by determining the germination rate, fresh weight, abnormalities and overall plant growth of test plant species (EN 16086-1 and EN 16086-2 of CEN/TC 223 for soil improvers and growing media)

"Stability/stabilisation"**:** this parameter refers to a stage in the decomposition of organic matter during composting/digestion. The stability is measured as residual biological activity by means of the Oxygen uptake rate or a Self-heating test. The Oxygen uptake rate test can be used as well for digestate materials when these are put under aerobic conditions. Material that is not stable, but still putrescent, gives rise to nuisance odours and may contain organic phytotoxins.

"Test methods": Analytical methods approved by Member States, institutions, standardising bodies (CEN, UNI, DIN, BSI, AFNOR, OENORM etc.) or by reliable manufacturers' associations (BGK in Germany, TCA in UK, etc.).

"Weed seeds": all viable seeds (and propagules) of undesired plant species found in end products.

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
General material properties			
pH value	EN 13037:2011	A sample is extracted with water at 22°C $\pm$ 3.0°C in an extraction ratio of 1+5 (V/V). The pH of the suspension is measured using a pH meter.	EN 15933:2012 Extraction with $CaCl_2$
Electrical conductivity	EN 13038:2011	A sample is extracted with water at 22°C $\pm$ 3.0°C in an extraction ratio of 1+5 (V/V). The specific electrical conductivity of the extract is measured and the result is adjusted to a measurement temperature of 25°C.	CEN/TS 15937:2013
Water content	EN 13040:2007	Dry the sample (50g) at 103 $\pm$ 2°C in an oven and cool in the desiccator.	EN 15934:2012
Dry matter content	EN 13040:2007	Dry the sample (50g) at 103 $\pm$ 2°C in an oven and cool in the desiccator.	EN 15934:2012
Organic matter content (Loss on ignition)	EN 13039:2011/ EN 12829	The test portion is dried at 103°C, than ashed at 450°C/550°C. The residue on ignition (loss on ignition) is a functional dimension for the organic matter content in composts.	EN 15935:2012 Determination at 550 °C
Alkaline effective matter (CaO content)	BGK 2006[66] BGBl 1992[67] Teil 1 S. 912 VDLUFA , 1995[68] (WI 00223049 under CEN TC 223 discontinued)	The method is based on the detemination of basifying substances in fertilisers and sludges. The method is applicable on treated bio-waste like compost containing calcium and magnesium in basifying form (e.g. as oxide, hydroxide and carbonate). The substance shall be rendered soluble with acid and the excess of acid back-titrated. The basifying substances shall be specified as % CaO.	no
Particle size distribution/Grain size	EN 15428:2007	The standard describes a method to determine the particle size distribution in growing media and soil improver by sieving (Sieve size: 31.5 mm, 16 mm, 8 mm, 4 mm, 2 mm, 1 mm).	no
Bulk density	EN 13041:2011	Ratio of the dry mass and volume of the sample in grams per litre, measured by the weight and volume of material in a sample ring.	None (WI 00400024 discontinued)
Nutrients			
N (total) (Kjeldahl N)	EN 13654-1	The moisture sample is extracted with a sulphuric acid, is distilled in boric acid. To titrate the ammonia with sulphuric acid 0.1 N.	EN 16168:2012 EN 16169:2012

[66] BGK, 2006:Methodenbuch zur Analyse organischer Düngmittel, Bodenverbesserungsmittel und Kultursubstrate, ISBN 3-939790-00-1
[67] Federal Law Gazette BGBl, I p. 912, 1992: Sewage Sludge Ordinance (AbfklärV).
[68] VDLUFA, 1995: Methodenbuch Band II. Die Untersuchung von Düngemitteln, Kap. 6.3 Bestimmung der Basisch wirksamen Bestandteile in Kalkdüngemitteln, 4. Auflage, VDLUFA-Verlag.Darmstadt

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
P (total)	EN 13650	The sample is finely ground and extracted with a hydrochloric/nitric acid mixture by standing for 12 hours at room temperature, followed by boiling under reflux for two hours, the extract is clarified and extracted elements are determined by inductive coupled plasma (ICP).	EN 16174:2012 EN 16170:2012 EN 16171:2012
K (total)	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
S (total)	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
Mg (total)	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
$N0_3$-N (dissolved)	EN 13651	An aliquot of the homogenised fresh material is shaken for 1 h with 1 mol/l potassium chloride solution at room temperature. The ratio of extractant to material varies according to the material tested. The extraction solution is centrifuged or filtered and an aliquot of the filtrate is analysed by flow injection analysis (FIA) or continuous flow analysis (CFA) or by manual methods as distillation and titration or spectrophotometric method.	CEN/TS 16177:2012
NH_4-N (dissolved)	EN 13651 DIN 38405 E5	Idem	CEN/TS 16177:2012
1.1 Biological parameters			

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
Stability	EN 16087-1:2011 and EN 16087-2:2011 Part I: Oxygen uptake rate EN 16087-1:2011 Part II: Self-heating EN 16087-2:2011	This parameter refers to a stage in the decomposition of organic matter during composting. The stability is measured as residual biological activity by means of the Oxygen uptake rate or a Self-heating test. The Oxygen uptake rate test can be used as well for digestate materials when these are put under aerobic conditions. Material that is not stable, but still putrescent, gives rise to nuisance odours and may contain organic phytotoxins. This European Standard describes a method to determine the aerobic biological activity of growing media and soil improvers or constituents thereof by measuring the oxygen uptake rate (OUR). The oxygen uptake rate is an indicator of the extent to which biodegradable organic matter is being broken down within a specified time period. The material is suspended in water. The respiration rate (i.e. oxygen uptake rate) is estimated by measuring the pressure drop in the headspace (i.e. gas phase in the closed space above the water phase). The produced CO_2 (carbon dioxide) is removed by a suitable alkaline absorbent. The measurements are performed under defined conditions. This European Standard describes a method to determine the aerobic biological activity using a self-heating test. This method is only applicable to composted material. Self-heating is measured in a Dewar vessel, where the maximum measured temperature is an indicator of the state of aerobic biological activity	None (WI 00400032 discontinued)
Viable seeds and reproductive parts of plants		This standard specifies a test procedure for the assessment of contamination by viable plant seeds and propagules on soil, treated bio-waste and sludge. Test sample material is filled into seed trays. The trays are kept at temperature suitable for plant germination for 21 days. The germinated plants have to be counted.	FprCEN/TS 16201

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
Plant response	Pot growth test with Chinese cabbage EN 16086-1:2011 Petri dish test using cress EN 16086-2:2011	Depending on the material to be tested, one of the two methods described in this standard shall be used. *Pot experiment with direct use of the prepared sample* Sowing a defined quantity of Chinese cabbage into pots containing the prepared sample, cultivating under controlled conditions for a defined period of time and evaluating the plant response by determining the germination rate, fresh weight, abnormalities and overall plant growth. If the presence of graminacious herbicides is suspected, Spring barley shall be used in addition to Chinese cabbage. For testing of other specific effects, the use of additional plant species (for example lettuce) can be considered. *Pot experiment using an extract of the original sample* Mixing the original sample with nutrient solution as an extractant, soaking for 4 h at ambient temperature and collecting the freely available nutrient solution. Filling pots with perlite saturated with the extract, irrigating during the test period with a fixed quantity of the extract and afterwards water. If the presence of graminacious herbicides is suspected, Spring barley shall be used in addition to Chinese cabbage. For testing of other specific effects, the use of additional plant species (for example lettuce) can be considered. Cress seeds are exposed to the test material for a few days under controlled conditions. The germination and growth of young roots are measured and compared with a control sample.	no
1.2 Physical contaminants			
Impurities	BGK 2006[69]	After drying, the sample is dry sieved, then, if necessary, either water-washed and/or bleach-washed and wet sieved on a 2 mm sieve (as necessary). The fraction > 2 mm are again dried when necessary and the fractions of stones > 5 mm and differentiated impurities > 2 mm are determined by weight or, for plastics, by weight and area.	FprCEN/TS 16202
1.3 Chemical contaminants – Heavy metals			

[69] BGK, 2006:Methodenbuch zur Analyse organischer Düngmittel, Bodenverbesserungsmittel und Kultursubstrate, ISBN 3-939790-00-1

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
Cd	EN 13650	The dried sample is finely ground and extracted with a hydrochloric/nitric acid mixture by standing for 12 hours at room temperature, followed by boiling under reflux for two hours, the extract is clarified and the extracted elements are determined by ICP-MS or ICP-OES.	EN 16174:2012 EN 16170:2012 EN 16171:2012
Cr	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
Cu	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
Ni	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
Pb	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
Zn	EN 13650	Idem	EN 16174:2012 EN 16170:2012 EN 16171:2012
Hg	ISO 16772	Determination of mercury in aqua regia soil extracts with cold-vapour atomic absorption spectrometry or cold-vapour atomic fluorescence spectrometry	CEN/TS 16175-1:2013 CEN/TS 16175-2:2013
1.4 Chemical contaminants – Organic pollutants			
PAH		Determination of polycyclic aromatic hydrocarbons (PAH) by gas chromatography (GC) and high performance liquid chromatography (HPLC)	FprCEN/TS 16181

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
PCB		Determination of polychlorinated biphenyls (PCB) by gas chromatography with mass selective detection (GC-MS) and gas chromatography with electron-capture detection (GC-ECD)	EN 16167:2012
PCDD/F		Determination of dioxins and furans and dioxin-like polychlorinated biphenyls by gas chromatography with high resolution mass selective detection (HR GC-MS)	CEN/TS 16190:2012
PFC	DIN 38414-14	Determination of selected polyfluorinated compounds (PFC) in sludge, compost and soil - Method using high performance liquid chromatography and mass spectrometric detection (HPLC-MS/MS)	no
1.5 Hygienic aspects			
Salmonellae	CEN/TC 308 (CEN/TR 15215-1:2006, CEN/TR 15215-2:2006, CEN/TR 15215-3:2006) ISO 6579 (WI 00223054 under CEN TC 223 discontinued)	The Salmonella procedure in sludges, soils and treated bio-wastes comprises three methods (EN 15215-1, EN 15215-2, EN 15215-3). The absence of Salmonellae in treated bio-waste is an indicator that the process requirements in respect to hygienic aspects are fulfilled and that the material is sanitized.	None (WI 00400037 discontinued)
E. Coli		Three methods for the detection and enumeration of Escherichia coli in sludge, treated bio-waste and soil: - Method A - Membrane filtration method for quantification - Method B - Miniaturised method (Most Probable Number, MPN) by inoculation in liquid medium; - Method C - Macromethod (Most Probable Number) in liquid medium	CEN/TR 16193:2013
1.6 Sampling			
Sampling	EN 12079	Soil Improver and growing media – Sampling	This has been elaborated by CEN TC 223
Framework on sampling		Framework for the preparation and application of a sampling plan: This standard specifies the procedural steps to be taken in the preparation and application of the sampling plan. The sampling plan describes the method of collection of the laboratory sample necessary for meeting the objective of the testing programme.	WI00400017
Selection and application of criteria for sampling		Sampling Part 1: Guidance on selection and application of criteria for sampling under various conditions	WI00400043
Sampling techniques		Sampling Part 2: Guidance on sampling techniques	WI00400042
Sub-sampling in the field		Sampling Part 3 Guidance on sub-sampling in the field	WI00400018

Testing parameters	Standards and methods other than from project Horizontal	Short description	EU-Project HORIZONTAL (Draft) Standards CEN TF 151 & CEN TC 400
Sample packaging, storage etc.		Sampling Part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery	WI00400044
Sampling plan		Sampling Part 5: Guidance on the process of defining the sampling plan	WI00400045
Sample pre-treatment		Guidance for sample pre-treatment	EN 16179:2012

The reports include the following documents:
PART 1. Sampling of sewage sludge, treated bio-wastes and soils in the landscape - Framework for the preparation and application of a Sampling plan
PART 2. Report on sampling draft standards
Sampling of sludges and treated bio-wastes.

A. Technical Report on Sampling – Guidance on selection and application of criteria for sampling under various conditions.
B. Technical Report on Sampling – Guidance on sub-sampling in the field.
C. Technical Report on sampling – Guidance on procedures for sample packaging, storage, preservation, transport and delivery.

Sampling of sewage sludge and treated bio-wastes - Guidance on sampling techniques 30-3-2006
Sampling of sewage sludge and treated bio-wastes - Definition of the sampling plan 27-4-2006

Annex 13: UK PAS 110 for digestate

Test parameters, upper limit values and declaration parameters for validation for UK PAS 110: 2010 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials

Source: http://www.wrap.org.uk/farming_growing_and_landscaping/producing_quality_compost_and_digestate/bsi_pas_110_.html

Parameter	Method of test	Upper limit and unit
Pathogens (human and animal indicator species) in WD / SL / SF		
ABP digestate: human and animal pathogen indicator species	As per appropriate ABP regulation or any other method approved by the competent authority / Animal Health vet / Veterinary Service vet	As specified by the competent authority / Animal Health vet / Veterinary Service vet in the 'approval in principal' or 'full approval'
Non-ABP digestate: *E. coli*	SCA MSS Part 3A or BS ISO 16649-2	1000 CFU / g fresh matter
Non-ABP digestate: *Salmonella* spp	Method as specified by appropriate ABP regulation, according to nation in which digested material is produced, or SCA MSS Part 4A	Absent in 25 g fresh matter
Potentially Toxic Elements in WD / SL / SF. If necessary, WD and SL may utilize the exemption provisions in clauses 13.2, 14.1.6 and 14.1.7 with the declarations required under the * provision below in this table		
Cadmium (Cd)	BS EN 13650 (soluble in aqua regia)	1.5 mg / kg dry matter
Chromium (Cr)	BS EN 13650 (soluble in aqua regia)	100 mg / kg dry matter
Copper (Cu)	BS EN 13650 (soluble in aqua regia)	200 mg / kg dry matter
Lead (Pb)	BS EN 13650 (soluble in aqua regia)	200 mg / kg dry matter
Mercury (Hg)	BS ISO 16772	1.0 mg / kg dry matter
Nickel (Ni)	BS EN 13650 (soluble in aqua regia)	50 mg / kg dry matter
Zinc (Zn)	BS EN 13650 (soluble in aqua regia)	400 mg / kg dry matter
Stability of WD / SL / SF		
Volatile Fatty Acids	Gas chromatography (example provided in OFW004-005)	Screening value: 0.43 g COD / g VS
Residual Biogas Potential	OFW004-005 (WRAP)	0.25 l / g VS
Physical contaminants in WD / SL / SF		
Total glass, metal, plastic and any 'other' non-stone, man-made fragments > 2 mm	REA-DM-PC&S	0.5 % m/m dry matter, of which none are 'sharps' (see 3.72)
Stones > 5 mm	REA-DM-PC&S	8 % m/m dry matter

NOTE Separated liquor is exempt from physical contaminants tests only if the separation technology used by the producer results in all particles < 2 mm in the separated liquor fraction.

Parameter	Method of test	Declaration and unit
Characteristics of WD / SL / SF for declaration, without limit values, that influence application rates		
pH	BS EN 13037	Declare result as part of typical or actual characteristics
Total nitrogen (N)	BS EN 13654-1 (Kjeldahl) or BS EN 13654-2 (Dumas)	Declare result as part of typical or actual characteristics, units as appropriate (e.g. kg m^{-3} fresh matter and nutrient units per 1000 gallons fresh matter)
Total phosphorus (P)	BS EN 13650 (soluble in aqua regia)	
Total potassium (K)	BS EN 13650 (soluble in aqua regia)	
Ammoniacal nitrogen (NH_4-N) extractable in potassium chloride	SOP Z/004 (soluble in potassium chloride)	
Water soluble chloride (Cl^-)	BS EN 13652 (soluble in water)	
Water soluble sodium (Na)	BS EN 13652 (soluble in water)	
Dry matter (also referred to as total solids)	BS EN 14346	Declare result as part of typical or actual characteristics, % m/m of fresh sample
Loss on ignition (also referred to as volatile solids and a measure of organic matter)	BS EN 15169	Declare result as part of typical or actual characteristics, units as appropriate
*** Characteristics of WD / SL for declaration when PTE limit values are exceeded, that influence application rates (see 13.2, 14.1.6 and 14.1.7)**		
Potentially toxic elements (Cd, Cr, Cu, Pb, Hg, Ni, Zn) in whole digestate or separated liquor if the digested material type exceeds any PTE limit in this table	As specified above in this table for the appropriate PTE	If any PTE limit in this table is exceeded in whole digestate or separated liquor, declare results for all PTEs in the digested material type, either as actual results for the sampled portion of production or as part of typical characteristics (see 13.2), in mg / kg dry matter

NOTE 1 If a digestate sample's VFA result exceeds the VFA 'screening value' above, this will be assumed indicative of the sample failing the RBP test. In such circumstance, the RBP test is not required to be carried out and the sample has failed the digestate 'stability' test. Assessment of RBP test pass or fail should use the average of the triplicate RBP values that each sample test generates.

NOTE 2 PAS 110 does not require testing and declaration of digested material particle size. If such information is desired, the maximum particle size and the > 2 mm particle size distribution of digested material can be tested according to the method 'Kapitel II. A 3.1, 1. Lfg. 9/2006, BGK' [25].

NOTE 3 PAS 110 does not require testing and declaration of all water soluble nutrients and elements. If further nutrient and element information is desired, digested material can be tested according to the method in BS EN 13652 (see Clause 2).

Annex 14: Swedish SPCR 120 for digestate

Swedish SPCR 120 QAS for digestate: requirements for final product Source: http://www.avfallsverige.se/fileadmin/uploads/Rapporter/Biologisk/B2009b.pdf

Metals

Guideline values for metal content in digestate are set out in Table 1.

Table 1. Guideline values for metal content in compost.

METAL	MAXIMUM CONTENT, mg/kg TS[1])
Lead	100
Cadmium	1
Copper	600[2)]
Chromium	100
Mercury	1
Nickel	50
Zinc	800[2)]

1) All values, aside from those of copper and zinc, are conforming to the guideline values for soil impro vers according to the "EU flower".

2) The values applied to copper and zinc are the same as for waste water sludge allowed for dispersion on fields, see SNFS 1998:4.

Disease control

The product must meet the requirements for disease control specified in Appendix 3.

Visible impurities

'Visible impurities' means foreign substances such as plastic, glass, metals and composites. The total content of visible impurities >2 mm must not exceed 0.5 % of the dry substance weight.

If the input material is of a kind that has a low probability for visible impurities, the certifying authority can give approval of dispensation from this requirement.

Requirements for solid digestate

- **Viable weed seeds and plant parts** – requirements for approval are that the product contains less than 2 viable weed seeds or plant parts per liter.
- **Organic substance** – The product must contain at least 20 % of organic substance, measured as loss on ignition in percent of the dry substance weight.

Annex 15: German RAL GZ 245 for digestate

Quality criteria for digestate products from bio-waste according to German RAL GZ 245 quality assurance scheme

Source: http://www.kompost.de/uploads/media/Quality_Requirements_of_digestion_residuals_in_Germany_text_02.pdf

Quality criteria	Quality requirements
Hygienic aspects	- Proof for successful treatment for sanitization (heating of the input material to 70 °C for at least 1 hour or input-output control) - Proof of compliance with the hygienic requirements by temperature profiles (monitoring the process temperature) - Maximum of 2 germinable weeds and sprouting plant parts per liter - Salmonella not traceable
Impurities	- Maximum 0,5 M.-% dm selection and weighing of impurities (glass, plastics and metals > 2 mm - With an impurity content > 0,1 M.-% dm: maximum area sum of the selected impurities shall not exceed 25 cm^2/l fm
Degree of fermentation	- Organic acids (total) < 1500 mg/l
Odour	- Free from annoying odours
Organic Matter	- Minimum 30 M.-% dm, determined by loss on ignition (for liquid digestate)
Heavy metal content (Pb, Cd, Cr, Cu, Ni, Hg, Zn)	- Limit values correspond to the waste and fertiliser legislation - For micronutrients Cu and Zn exception from limit value possible if allowed by local authority
Parameter for declaration	- Product type (digestate product liquid or solid) - Name of producer - Bulk density (volume weight) - Dry matter content - pH-value - Salt content - Plant nutrients (total) (N, P_2O_5, K_2O, MgO, S) - Nitrogen soluble (NH_4-N; NO_3-N) - Micro-nutrients (according to fertiliser legislation) - Organic matter - Alkaline effective matter (CaO) - Benefit value index - Weight or volume - References for good practical use

Annex 16: Belgian VLACO QAS for digestate

Quality assurance system for digestate in Flanders (Belgium) by VLACO

The quality assurance system is obligatory for all professional composting and digestion plants in Flanders (Belgium). The QAS is based on the principles of integral chain management. The QAS takes into account all aspects of the processing chain, from the acceptance of bio-waste, the quality of the treatment process, end product quality up to customer support for a reasoned use. The outcome of the QAS on treatment plant level is one or several product certificates, showing that the compost, digestate or biothermically dried fertiliser, is produced according to the criteria set up in the certification scheme and the waste legislation. Without the control certificate, treated bio-waste cannot be used as a secondary material. Control of compliance with this certification scheme is done through means of regular audits and product sampling.
The most important aspects of the VLACO quality assurance system are:

(a) a strict acceptance protocol
(b) process management according to ISO-principles
(c) quality monitoring of the end product
(d) reasoned use of the end products

(a) a strict acceptance protocol

Treatment plants must have procedures describing the acceptance of inputs. Only separately collected bio-waste is allowed to be used as an input. Regular sorting analyses must be carried out. Through visual control at the gate and regular sorting tests of the bio-waste being presented, treatment plants ensure an input stream of continuous high quality. In case of non-conformity with the acceptance criteria, the bio-waste is refused, and the cause of incompliance has to be dealt with. The quality of separately collected bio-waste from households, if insufficient, can be adequately improved through information campaigns. The acceptance of a fraction of industrial bio-waste from food industries is only possible when regular analyses on agricultural and environmental parameters are carried out.
For digestion plants, the control of the input registers is an important part of the audit. It is explicitly verified whether the various input streams meet VLAREA policies and whether principles in the Waste policies are imposed, including non-dilution principle, registration and traceability,
This requires an understanding of the composition of all input streams. Where digesters accept mixtures processed by an external supplier delivered as a blend, there is in practice no traceability to the individual streams. This information is often not provided by the supplier of the mix, for practical and commercial reasons. Therefore, VLACO has developed a separate quality assurance system for this mix, to be independently monitored (through sampling and analysis) and attested, ensuring that the use of organic-biological waste mixes meets the quality requirements of the digestion plants.

(b) process management according to ISO-principles

VLACO has set up a QAS for professional treatment plants of bio-waste according to the principles of the ISO 9000 certification standard and integral chain management. The whole chain of bio-waste treatment, from input quality over the treatment process and quality assessment of the end products is monitored using an integral quality management system, set in place on every treatment plant. Experience showed that a quality assessment only based on end product testing is insufficient. Non-conformities are reported and countered with adequate measures ensuring a progressive improvement of the quality of the production. Registration of the key aspects (dates, batch numbers, type and quality of input material, process parameters e.g. temperature, management actions e.g. …) leads to an auto control system that allows tracking and tracing of the products. During the important step of hygienisation of the bio-waste, temperature and management are to be checked very carefully. Moreover, other legislation on regional, federal or European level (e.g. the Animal By-products Regulation 1069/2009, the intended EPPO-guidelines for treatment of bio-waste of plant origin) also suggest the importance of a well-founded QAS on treatment plant level together with adequate and sufficient product testing.
The outcome of the system audits together with continued product testing can lead to a control certificate, approving that the products are in accordance with the quality requirements.

(c) quality monitoring of the end product

The VLAREA-legislation for use of treated bio-waste as a secondary material (fertiliser or soil improver) sets up limit values for the most important environmental parameters, both organic (PAH, PCB, volatile compounds, …) and inorganic (heavy metals). The VLACO QAS is based on limit values that are even stricter than these values, and carries along parameters indicating the agronomic importance of the end products (nutrients, soil organic matter) as well as the physical and biological quality aspects (impurities, viable seeds, stability). In the tables below the quality standards for digestate are shown. Nutrient composition is tested and to be declared to the user, not regulated.
The necessary samples are taken by VLACO and dispatched for analysis to accredited laboratories using recognised methods. The amount of samples necessary per treatment plant is calculated on the basis of bio-waste input. When several product types are produced at the same location, the sampling and analysis protocol is carried out by VLACO on all product types. The outcome of one analysis is always compared to the product standards, but the decision about certification is based on a progressive set of sample results, with quality objectives that are stricter than the product standards. By reviewing several product analysis results on a continuous time scale, the quality assurance organisation (VLACO) is able to observe temporal product incompliance. This can be related to non-conform process parameters which must be solved in an action plan. Solitary product analysis reports are insufficient sources of information for assessing a compost production plant. Compost or digestate are thought to be not only a product, but the result of a controlled and sustainable biological treatment process of separately collected bio-waste.
Besides the analyses carried out by VLACO, the treatment plants are themselves obliged to take product samples for internal quality assurance.

(d) reasoned use of the end products

Not only the composition of the end product is a possible risk from the point of view of environmental or public health matters, also the unreasoned use could pose a problem, e.g. excessive application rates with undesired side effects such as phytotoxicity, nutrient overshoot or imbalance, … Therefore, the VLACO QAS imposes the professional composting plants to inform the consumers about the use of the product(s), in all possible applications. This is done by an information leaflet mentioning the composition, usual application rates, application manner, hygienic safety, …

The integration of quality assurance measures all along the production chain of compost, with strong emphasis on product input, regular product testing and reasoned use of product output, enhances the possibility to assure environmental and public health safety. This is guaranteed through the issuing of control certificates for the different products by VLACO.

The assessment for the granting of control certificates for other types of biological processing (anaerobic digestion and biothermally drying) is similar to the assessment of composting.The control certificate is reflecting the application possibilities of the output streams. Without a certificate the final product can not be applied to Flemish soil (VLAREA) and will not obtain a derogation of the FPS (Federal Public Service), meaning that it can not be traded in Belgium as fertilizer or soil improver. For export outside Flanders, the output product is still considered as waste and as such subject to European waste regulations.

Flanders Vlaco-standards for digestate (agronomic parameters and product standards)

Agronomic parameters:

	VLAREA-standard	Vlaco-standard	Federal standard (raw digestate)	Unity
GENERAL PARAMETERS				
Dry matter	-	-	>4	weight%
Organic matter	-	-	>2	weight%
pH (water)	-	6,5 - 9,5	6,5 - 9,5	-
HEAVY METAL CONCENTRATION				

	VLAREA-standard	Vlaco-standard	Federal standard (raw digestate)	Unity
Arsenic (As)	<150	<150	<150	mg/kg DM
Cadmium (Cd)	<6	<6	<6	mg/kg DM
Chromium (Cr)	<250	<250	<250	mg/kg DM
Copper (Cu)	<375	<375	<375	mg/kg DM
Mercury (Hg)	<5	<5	<5	mg/kg DM
Lead (Pb)	<300	<300	<300	mg/kg DM
Nickel (Ni)	<50	<50	<50	mg/kg DM
Zinc (Zn)	<900	<900	<900	mg/kg DM
IMPURITIES, STONES AND VIABLE SEEDS				
Impurities > 2 mm	-	<0,5	<0,5	weight %
Stones >5 mm	-	<2,0	<2,0	weight %
Viable seeds	-	Max. 1	<1	#/l
STABILITY				
Oxigen consumption (Oxitop®)	-	50	-	mmol O_2/kg OS/h

Product standards (concentrations) for all secondary materials (maximum level of pollutants, VLAREA Annex 4.2.1.A) including digestate:

	Total concentration	Unity
METALS[70,71]		
Arsenic (As)	150	mg/kg DM
Cadmium (Cd)	6	mg/kg DM
Chromium (Cr)	250	mg/kg DM
Copper (Cu)	375	mg/kg DM
Mercury (Hg)	5	mg/kg DM
Lead (Pb)	300	mg/kg DM
Nickel (Ni)	50	mg/kg DM
Zinc (Zn)	900	mg/kg DM
MONOCYCLIC AROMATIC HYDROCARBONS (BETXS) [72]		
	Total concentration	**Unity**
Benzene	1,1	mg/kg DM
Ethylbenzene	1,1	mg/kg DM
Toluene	1,1	mg/kg DM
Xylene	1,1	mg/kg DM
Styrene	1,1	mg/kg DM
POLYCYCLIC AROMATIC HYDROCARBONS (PAH) [3]		
Benzo(a)anthracene	0,68	mg/kg DM
Benzo(a)pyrene	1,1	mg/kg DM
Benzo(g,h,i)perylene	1,1	mg/kg DM
Benzo(b)fluoranthene	2,3	mg/kg DM

([70]) The concentration counts for the metal and the compounds expressed as the metal
([71]) Measurement of the total concentration of metals according to the method CMA 2/II/A.3 from the Compendium for Sampling and Analysis for Waste
([72]) Measurement of the total concentration of organic compounds according to the methods in part 3 from the Compendium for Sampling and Analysis for Waste

Benzo(k)fluoranthene	2,3	mg/kg DM
Chrysene	1,7	mg/kg DM
Phenanthrene	0,9	mg/kg DM
Fluoranthene	2,3	mg/kg DM
Indeno(1,2,3c,d)pyrene	1,1	mg/kg DM
Naphtalene	2,3	mg/kg DM
OTHER ORGANIC POLLUTANTS[3]		
Monochlorobenzene	0,23	mg/kg DM
Dichlorobenzene	0,23	mg/kg DM
Trichlorobenzene	0,23	mg/kg DM
Tetrachlorobenzene	0,23	mg/kg DM
Pentachlorobenzene	0,23	mg/kg DM
Hexachlorobenzene	0,23	mg/kg DM
1,2-dichloroethane	0,23	mg/kg DM
Dichloromethane	0,23	mg/kg DM
Trichloromethane	0,23	mg/kg DM
Trichloroethene	0,23	mg/kg DM
Tetrachloromethane	0,23	mg/kg DM
Tetrachloroethene	0,23	mg/kg DM
Vinyl chloride	0,23	mg/kg DM
1,1,1-trichloroethane	0,23	mg/kg DM
1,1,2-trichloroethane	0,23	mg/kg DM
1,1-dichloroethane	0,23	mg/kg DM
cis+trans-1,2-dichloroethane	0,23	mg/kg DM
Hexane	5,5	mg/kg DM
Heptane	5,5	mg/kg DM
Octane	5,5	mg/kg DM
Extractable Organic Halogens (EOX)	20	mg/kg DM
Mineral oil C10-C20	560	mg/kg DM
Mineral oil C20-C40	5600	mg/kg DM
Polychlorinated biphenyls (PCB as sum of 7 cogeners)	0,8	mg/kg DM

Annex 17: UK Biofertiliser Scheme

UK Biofertiliser Certification Scheme

This quality assurance scheme is owned by the Renewable Energy Association and has been created for the purpose of certifying AD/biogas plants in England, Wales and Northern Ireland against the requirements of:

- the British Standards Institution's PAS 110:2010, 'Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials' (see http://www.biofertiliser.org.uk/certification/england-wales/pas110); and
- the 'Quality Protocol for the production and use of quality outputs from the anaerobic digestion of source-separated biodegradable waste' (see http://www.environment-agency.gov.uk/static/documents/Business/AD_Quality_Protocol_GEHO0610BSVD-E-E.pdf). Later in this section this protocol is referred to as the AD QP. This document is a joint Environment Agencies for England, Wales & Northern Ireland, Defra and WAG initiative and defines the point at which digestates cease to be waste and can be used as a product, without the requirement for waste management controls.

In order for digestate to be used as 'product' in Scotland, the AD/biogas plant and its digestate must be certified compliant with PAS 110 (not also the AD QP) with further conditions specified by the Scottish Environment Protection Agency (SEPA).

Specifications for digestate

In the countries of the UK, PAS 110 is currently the only specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials. In summary, PAS 110:

- sets a minimum baseline standard for digestates; some customers may require the digestates to achieve quality characteristics that are more stringent than those in the specification or cover a wider range of parameters. The AD operator is responsible for checking and agreeing with the customer any quality requirements that are more stringent or wider ranging than the minimum baseline specified in this PAS.
- requires that the digestates are only made from source-segregated biodegradable waste;
- specifies controls on input materials and the management system for the process of anaerobic digestion and associated technologies; the management system must include a Hazard Analysis and Critical Control Point Plan;
- sets minimum quality criteria for whole digestate, separated liquor and separated fibre; and
- establishes the information that is required to be supplied to digested material customers.

Minimum quality criteria

The minimum quality criteria for digestates are shown in Table 1, page 31 of the specification (http://www.biofertiliser.org.uk/pdf/PAS-110.pdf). Table 2, page 34, provides minimum quality criteria for digested material made only from manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arises within the producer's premises or holding. These criteria apply only if the digestate is used entirely within the same premises or holding.

Labelling / declaration requirements
Section 14, page 44 of PAS 110 specifies the information that shall be supplied to each customer. This shall include the typical characteristics or laboratory test results corresponding with the portion of production dispatched, and include:

a) PTE concentrations;
b) pH;
c) total nitrogen;
d) total phosphorus;
e) total potassium;
f) ammoniacal nitrogen (NH4-N);
g) water soluble chloride;
h) water soluble sodium;
i) dry matter (also referred to as total solids); and
j) loss on ignition (also referred to as volatile solids, and a measure of organic matter).

Sampling and analysis of digestate
For validation: See PAS 110, section 11.2, basis of this being 'For each parameter in Table 1, the three most recent digested material sample test results shall not exceed the corresponding upper limit. This applies to each digested material output type for which PAS 110 conformance is claimed (whole digestate, separated fibre and/or separated liquor).'

After validation: see PAS 110, section 12.2, basis of this being 'For each parameter in Table 3, the three most recent digested material sample test results shall not exceed the corresponding upper limit. Samples of digested material shall be tested at least at the minimum frequencies specified in the Table below. This applies to each digested material output type for which PAS 110 conformance is claimed (whole digestate, separated fibre and/or separated liquor).'

PAS 110– Minimum frequencies for testing representative samples of digested material after validation

Parameter	Minimum frequencies for testing representative samples
If ABP digested material: human and animal	As specified by the competent authority / Animal Health pathogen indicator species vet in the 'approval in principal' or 'full approval'
If non ABP digested material: *E. coli*	1 per 5,000 m^3 of WD (whole digestate)/ SF (separated fibre) / SL (separated liquor) produced, or 1 per 3 months whichever is the soonest
If non ABP digested material: *Salmonella* spp	1 per 5,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest
Potentially Toxic Elements	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest
Stability	2 per 12 months and not within 3 months of each other, or (Volatile Fatty Acids and Residual Biogas sooner if and when significant change occurs (see 4.8.5) Potential, subject to Note 1 to Tables 3 and 5)
Physical contaminants	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest
pH	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months

	whichever is the soonest
Total N, P & K	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest
Ammoniacal nitrogen, water soluble chloride	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months, whichever is the soonest
Water soluble sodium	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest
Dry matter (total solids)	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest
Loss on ignition (measure of organic matter)	1 per 6,000 m^3 of WD / SF / SL produced, or 1 per 3 months whichever is the soonest

Annex 18: AD Quality Protocol

England, Wales and Northern Ireland 'Quality Protocol for the production and use of quality outputs from the anaerobic digestion of source-separated biodegradable waste' (AD QP).

According to the AD QP, the quality digestate will be classed as a product only if:
a) It has been produced using only those source-segregated input materials listed in Appendix B (positive list of allowed wastes, can be found at page 14 of the AD QP (http://www.environment-agency.gov.uk/static/documents/Business/AD_Quality_Protocol_GEHO0610BSVD-E-E.pdf)
b) meets the requirements of an approved standard (BSI PAS 110:2010); and
c) is destined for appropriate use in one of the designated market sectors.

In addition, the AD operator must obtain certification by an independent certification body, which must be accredited by the United Kingdom Accreditation Service.
Thus, in England, Wales and Northern Ireland, digestates that are certified under the BCS for compliance with the requirements of BSI PAS 110 and the AD QP are regarded as 'product', thus, can be transported, stored, handled and used without the need for waste regulatory controls.

The AD QP requires that records of digestate use are kept by the land manager (the person responsible for the exploitation of the agricultural land concerned directly or through the use of agents or contractors). These records must enable the land manager to demonstrate that the following have been complied with:

a) NVZ rules, Cross Compliance and good agricultural practice have been followed; and
b) The maximum permissible levels for the soil PTE (potentially toxic elements, namely, heavy metals) in the Code of Practice for Agriculture Use of Sewage Sludge (1989) have not been exceeded as result of the digestate applications.

To date Scotland has not adopted the AD QP and compliance with the requirements of BSI PAS 110 only is sufficient to confer the digestate the status of 'product', providing that the conditions specified in the Scottish Environment Protection Agency are satisfied (see SEPA's position statement at http://www.biofertiliser.org.uk/pdf/SEPA-Position-Statement.pdf).

Digestate as 'waste'
In the UK, digestates that are not certified under the Biofertiliser Certification Scheme are classed as 'wastes', thus, must be supplied, and transported according to duty of care requirements, by registered waste carriers.

In addition, uncertified digestates must be used under waste regulatory controls, which means that end users must hold the appropriate authorisation granted by the regulator to spread the digestates (e.g. environmental permit [England, Wales], waste management licence [Scotland, Northern Ireland], or exemption from a waste management licence or environmental permit). Information about the waste regulatory controls that apply to the use of digestates can be found for:

a) England and Wales at http://www.environment-agency.gov.uk/business/topics/permitting/117161.aspx
b) Scotland at http://www.sepa.org.uk/waste/waste_regulation/application_forms/exempt_activities/paragraph_7.aspx
c) Northern Ireland at http://www.doeni.gov.uk/niea/waste-home/authorisation/exemption/wml_complex_exemptions/paragraph_9.htm

Registration/certification systems for digestate

The Biofertiliser Certification Scheme procedures for registration and certification are as follows:

a) When ready to apply for certification, the AD operator selects a Certification Body from the two contracted organisations and requests an application form together with any documentation that is necessary for certification.
b) The AD operator then forwards the full application form plus accompanying documents and fee to the Certifying Body.
c) The application is reviewed by a Certification Officer (CO) to ascertain if the plant system is in line with the requirements of the certification scheme, and if it is, then an appointment to visit the site is made.
d) If however there is still work to be completed, the Certification Officer (CO) notifies the plant of the requirements and when the changes have been made the CO will make a site visit.
e) A site inspection is carried out by a Certification Officer
f) If successful this marks the start of validation
g) If there are corrective actions then these are notified to AD operator The corrective actions taken are then notified to the CO who will decide whether a further site visit is necessary.
h) When the corrective action is accepted successfully, certification is awarded.

More information about the procedures can be found in the BCS Scheme rules (England, Wales and Northern Ireland, downloadable from http://www.biofertiliser.org.uk/pdf/scheme-rules.pdf; Scotland: http://www.biofertiliser.org.uk/pdf/scheme-rules.pdf).

Input material for end-of-waste digestate

End-of-waste criteria regarding digestate are set in the AD QP (see http://www.environment-agency.gov.uk/static/documents/Business/AD_Quality_Protocol_GEHO0610BSVD-E-E.pdf).

Digestate ‘products’ must only be produced from:

a) ‘…non-waste biodegradable materials. These are not listed separately in this Quality Protocol.’ (see clause 2.2.2 i) of the AD QP)
b) ‘Where a digester operator accepts waste materials, they may accept only those waste types listed in Appendix B and they must be source-segregated, i.e. they must been kept separate from any other wastes and non-biodegradable materials’.

The AD QP’s positive list does not include mixed wastes and sewage sludges.

According to PAS 110 input materials shall be source-segregated bio-wastes and/or source segregated biodegradable materials. Input materials to the digestion system shall not include contaminated wastes, products or materials.

The AD QP's reference to non-waste biodegradable materials' and PAS 110's reference to 'source segregated biodegradable materials' allow the inclusion of virgin materials (e.g. energy crops) to the digestion process. These are important provisions for encouraging digestion of suitable biodedradable wastes and materials, and should be particularly valuable where a digestion facility is located near to supply of energy crop(s) and other suitable non-waste materials that are source-segregated and biodegradable.

Animal by-product treatment requirements
According to PAS 110, digested materials shall be produced by an anaerobic digestion process that includes:

a) one of the combinations of pasteurization criteria specified in Table A1; or
b) the specific pasteurization criteria approved by the Competent Authority (Animal Health vet) for digesting ABPs.

Table A.1 of PAS 110 sets out the key provisions in the Animal By-Products Regulations that can be regarded as a pasteurization step, or part of the anaerobic digestion process, within the context of PAS 110.

Table A.1 – Minimum anaerobic digestion requirements specified in the animal by-products regulations

System	National ABP Regulations, option for catering waste only	National ABP Regulations, option for catering waste only	EU ABP regulation 1774/2002 [5a] (See Note 4)
Treatment technology	Closed reactor	Closed reactor	Closed reactor
Maximum particle size	50 mm	60 mm	12 mm
Minimum temperature	57 °C	70 °C	70 °C
Minimum time spent at the minimum temperature	5 hours	1 hour	1 hour
Additional requirements	Followed by storage for an average of 18 days if digestate is made from catering wastes that include meat		No post treatment minimum storage period specified

See also the notes to Table A.1, page 46 of PAS 110 (http://www.biofertiliser.org.uk/pdf/PAS-110.pdf).

Digested materials made only from manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arise within the producer's premises or holding and that are used entirely within the same premises or holding are exempt from the pasteurization step. However, the producer shall determine the process steps, the Critical Control Point and its Critical Limits (e.g. minimum timescale and suitable mesophilic temperature range) that are effective for producing digested materials of the quality required in the PAS 110.

Exemption from the pasteurization step is also allowed for manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arises within the producer's premises or holding, if such input materials are co-digested with pasteurized biodegradable materials / wastes from any source(s) outside the producer's premises or holding. This material source-specific exemption from pasteurization is conditional upon all the digested material being used within the producer's premises or holding.

Requirements for dispatch and use of digestates
According to PAS 110, for each consignment of whole digestate, separated liquor or separated fibre derived in whole or in part from ABP material, which is dispatched for a use other than disposal, the producer shall inform the customer that the product includes or consists of treated ABP material and that the user will have committed an offence if he/she does not comply with ABP Regulation requirements that place restrictions on use and require the user of ABP-digestate to keep records.

The national Animal By-Product Regulations in force in the countries of the UK[73] include controls on the placement of digested materials made from catering or other ABP source-segregated bio-wastes on the market, livestock grazing ban periods after spreading such materials, records that must be made and kept by the user, and obligations associated with any transfrontier shipment of animal by-products, whether treated or untreated.

Example excerpts from The Animal By-Products (Enforcement) (England) Regulations 2011 (SI 2011, No. 881):
'Use of organic fertilisers and soil improvers, Article 7.
(1) Where organic fertilisers or soil improvers are applied to land, no person may allow pigs to have access to that land or to be fed cut herbage from such land for a period of 60 days beginning with the application of the organic fertiliser or soil improver.
(2) Paragraph (1) does not apply to the following organic fertilisers or soil improvers—
(a) manure;
(b) milk;
(c) milk-based products;
(d) milk-derived products;
(e) colostrum;
(f) colostrum products; or
(g) digestive tract content.'

'Part 4, Offences and Penalties, Article 17.
(1) A person who fails to comply with an animal by-product requirement commits an offence.
(2) "Animal by-product requirement" means any requirement in Column 2 of Schedule 1 to these Regulations as read with the provisions in Column 3 to that Schedule.'

* The national ABP Regulations for England, Wales, Northern Ireland and Scotland can be found here:
England and Wales: http://www.legislation.gov.uk/uksi/2011/881/contents/made
Scotland: http://www.legislation.gov.uk/ssi/2011/171/contents/made
Northern Ireland: http://www.legislation.gov.uk/nisr/2011/124/contents/made

[73] The national ABP Regulations for England, Wales, Northern Ireland and Scotland can be found here:
England and Wales: http://www.legislation.gov.uk/uksi/2011/881/contents/made
Scotland: http://www.legislation.gov.uk/ssi/2011/171/contents/made
Northern Ireland: http://www.legislation.gov.uk/nisr/2011/124/contents/made

Legislation on digestate use under waste status

In the UK, digestates that are not certified under the Biofertiliser Certification Scheme are classed as ‘wastes’, thus, must be supplied, and transported according to duty of care requirements, by registered waste carriers.

In addition, uncertified digestates must be used under waste regulatory controls, which means that end users must hold the appropriate authorisation granted by the regulator to spread the digestates (e.g. waste management licence, environmental permit, or exemption from a waste management licence or environmental permit). Information about the waste regulatory controls that apply to the use of digestates can be found for:

a) England and Wales at http://www.environment-agency.gov.uk/business/topics/permitting/117161.aspx

b) Scotland at http://www.sepa.org.uk/waste/waste_regulation/application_forms/exempt_activities/paragraph_7.aspx

c) Northern Ireland at http://www.doeni.gov.uk/niea/waste-home/authorisation/exemption/wml_complex_exemptions/paragraph_9.htm

In order to obtain the relevant authorisation to spread the digestate, the organization responsible for the spreading activity must demonstrate that:

a) the landspreading activity will be carried out without causing a risk to the environment; and

b) the land treatment will result in agricultural benefit or ecological improvement.

Annex 19: Proposed end-of-waste criteria from 2nd Working Document

Overview of end-of-waste criteria for compost and digestate, as proposed in the **Second Working Document** for End-of-waste criteria on Biodegradable waste subject to biological treatment (11 October 2011, 203p.)

Product quality requirements for compost and digestate

Parameter	Value	Comments
(1) Minimum organic matter content:	15% on dry matter weight	The minimum organic matter content of the final product, after the composting/digestion phase and prior to any mixing with other materials. This is intended to prevent dilution of compost/digestate with mineral components (e.g. sand, soil).
(2) minimum stability	For compost: 15 mmol O_2/kg organic matter/hr For digestate: 1500 mg organic acids (total) per litre digestate	The stakeholders agreed that this parameter shall be limited by a method for which a standardized test exist.
(3) no content of pathogens	No *Salmonella* sp. in 50 g sample 1000 CFU/g fresh mass for *E. Coli*	Measurement of this parameter should be complemented by a requirement on processing, e.g. a temperature-time profile, based on stakeholder input
(4) limited content of viable weeds and plant propagules	2 viable weed seeds per litre of compost/digestate	Measurement of this parameter should be complemented by a requirement on processing, e.g. a temperature-time profile, based on stakeholder input
(5) limited content of macroscopic impurities	0.5% on dry matter weight for glass, metal and plastics > 2mm	There is a need to distinguish between natural impurities such as stones and manmade impurities.
(6) limited content of heavy metals and persistent organic compounds:	mg/kg (dry weight)	In the final product, just after the composting/digestion phase and prior to any mixing with other materials
Zn	400	
Cu	100	
Ni	50	
Cd	1.5	
Pb	120	

Hg	1	
Cr	100	
No requirement to measure organic pollutants		Measurement of organic pollutants is not deemed necessary when applying a strict positive list of input materials excluding sewage sludge, mixed solid waste or possibly contaminated streams

Requirements on product testing for compost and digestate

Requirements on product testing (sampling and analysis): **Compost and digestate producers must demonstrate by external independent testing that there is a sufficiently high probability that any consignment of compost/digestate delivered to a customer complies with the minimum quality requirements and is at least as good as the properties declared.** **The details of the sampling programme may be adjusted to the concrete situation of each compost/digestate plant. The competent authorities will, however, have to check compliance with the following requirements:** • **The compliance testing has to be carried out within external, independent quality assurance by laboratories that are accredited for that purpose** • **The CEN/Horizontal standards for sampling and analysis have to be applied as far as available. See Annex 13**	In the case of metal concentrations, the probability that the mean value of the concentration in a sample exceeds the legal limit should be less than a certain percentage (a confidence level of 95 % is typically used). This implies that the mean concentration of the whole population of the compost/digestate sold plus the confidence interval needs to be below the legal limit. (Usually, it will be impractical to sample from the total population and a subset of the overall population that can be considered typical of the whole population will have to be defined as part of the quality assurance process. Usually, the population will correspond to all the compost/digestate sold from a composting plant throughout a year or shorter periods of time). The scale of sampling needs to be chosen depending on the sales/dispatch structure of a composting/digestion plant. The scale should correspond to the minimum quantity of material below which	A high level of environmental protection can be achieved only if there is reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. To manage compost/digestate so that environmental impacts and risks are kept low, it must be possible for compost/digestate users and regulatory authorities to interpret the declared product properties in the right way and to trust in conformity. Therefore, standardisation of product parameters, sampling and testing is needed as well as quality assurance.

for a list of standards and sampling and testing methods. • **Probabilistic sampling should be chosen as the sampling approach and appropriate statistical methods used in the evaluation of the testing.**	variations are judged to be unimportant. The better the precision of the testing programme (the narrower the confidence interval), the closer the mean concentrations may be allowed to be to the legal limit values. The costs of a testing programme of compost/digestate with very good quality (parameter values far from the limits) can therefore be held lower than for compost/digestate with values that are closer to the limit. When a new compost/digestate plant is licensed there is usually an initial phase of intensive testing to achieve a basic characterisation (for example one year) of the compost/digestate qualities achieved. If this proves satisfactory, the further testing requirements are then usually reduced.	

Requirements on input materials

Criteria	Explanations	Reasons
<u>Clean, biodegradable wastes are the only wastes allowed to be used as input materials</u> for the production of end-of-waste compost and digestate. **Annex 9 presented in the 2nd Working Document lists biodegradable wastes that are currently regarded as suitable for composting in one or more Member States.** **Following amendments are proposed:**	Non-biodegradable components that are already associated with biodegradable waste streams at source, should, however, be allowed if they are not dominant in quantity, do not lead to exceeding the pollutant concentration limits (see product quality requirements) and do	Composting and digestion is suitable as treatment only for biodegradable wastes. Dilution of other wastes with biodegradable waste needs to be avoided.

Criteria	Explanations	Reasons
Micelles from antibiotics production (1.4.02): can only be allowed if no antibiotics are present **Municipal waste: other fractions not otherwise specified (1.4.07): EXCLUDE** **Off-speciation compost (1.4.15): include only if compost is derived from materials coming from the positive list; this item is not relevant for digestate** **Liquor/leachate from a composting process (1.4.16): include only if material is coming from same plant** **Liquor from anaerobic treatment of municipal waste (1.5.02): include only if anaerobic treatment is using materials coming from the positive list** **Muncipal sewage sludge (3.01): EXCLUDE** **Municipal solid waste- not source separated (3.03): EXCLUDE** **Primary raw materials should be allowed as well as input materials as long as the composting/digestion operation considers a waste treatment process.**	not impair the usefulness of the compost/digestate. Example: soil-like material attached to garden waste.	
The <u>input materials</u> used for the production of end-of-waste compost/digestate must be known by the producer. **It shall be indicated on the product what the material is based on, <u>in large terms</u>, using the definitions** • **Separately collected bio-waste from**	The waste classification of the European Waste Catalogue should be used, ideally together with additional specifications, such as in the waste list in Annex 9 presented in the 2nd Working Document .	Transparency on the input materials is important for the confidence of users in compost/digestate quality and can therefore strengthen compost/digestate demand. The information on the input material is needed to allow the use of compost/digestate in compliance with existing legislation.

Criteria	Explanations	Reasons
households • **Garden and park waste** • **Agricultural waste** • **Food industry waste** • **Other input materials (any specific material present in a quantity of more than 5% of the initial weight should be declared)** **It should be indicated whether any <u>animal by-products</u> have been used to produce the material.**		For example, the Community legislation of organic farming has specific rules for the use of compost from source-separated household waste. The restriction of input to source segregated material is considered current best practice in compost production. It has been demonstrated that concentrations of the relevant metals and of persistent organic pollutants in these waste types are robustly low enough for the production of high-quality composts (IPTS, 2008) If animal by-products were input, compliance with the Animal By-products Regulation ([74]) is required. Furthermore, users, for instance farmers, often wish to know the origins and source materials of compost/digestate.

<u>Additives</u> (material other than biodegradable waste) can only be used when these are listed on the positive list
 	
Amendments proposed to the additives list in Item 4 of Annex 9 presented in the 2nd Working Document are:
• **For compost:**
    o **Commercial inoculants for composting**
    o **Bio-dynamic compost preparations**
 	
• **For digestate:**
    o **Iron salts**
    o **Iron oxides**
    o **Iron hydroxides**
    o **Magnesium salts**
    o **Aluminium salts**
	Additives should only serve to improve the composting or digestion process, or improve environmental performance of the process	Additives can be used as input to the composting/digestion process in minor quantities, if they improve the compost/digestate quality or they have a clear function in the composting/digestion process and the metal concentrations (based on dry matter) do not exceed the concentration limits for end-of-waste compost/digestate.
		
		In practice, additives are sometimes needed to improve the composting/digestion process or the compost/digestate quality.

([74]) Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

Criteria	Explanations	Reasons
up to 0.1 % fresh matter o **Organic polymers used for dewatering in the case of dewatered digestate**		
Suitable procedures for controlling the quality of input materials need to be followed by the operators of composting/digestion plants. **Visual inspection is the method of choice to control input materials for compost and digestate.** **When visual inspection would entail health or safety risks, as in the case of liquid input materials, visual inspection shall be replaced by sample taking and storage for possible analysis.** **See also section on criteria regarding quality control procedures.**	It is agreed that in many cases visual inspection and approval of origin will be suitable procedures. In order to facilitate visual inspection, mixes of input materials in one delivery should be banned. Visual inspection of liquid materials in containers or bulk trucks may be dangerous due to the escaping gases or difficulties in approaching the material. In such cases, samples should be taken	Controlling the input materials is a key factor (probably the single most important) for assuring reliable quality of the compost or digestate. Control of input covers also avoidance of mixing with other wastes not listed in the positive list.

Requirements on treatment processes and techniques

Criteria	Explanations	Reasons
It must be demonstrated for each compost/digestate batch that a suitable temperature-time profile was followed during the composting/digestion process for all material contained in the batch. **Annex 10 lists temperature-time profiles required by the Animal By-products**	The desired risk control can be achieved, avoiding being overly descriptive, by allowing a number of alternative temperature-time profiles from existing standards or regulations. The producer must comply with at least one profile that has been approved as suitable for the type of composting process applied and is	As is common in existing regulations and standards, there should be process requirements to ensure that the processes yield composts and digestates without hygienic risk.

Criteria	Explanations	Reasons
Regulation ([75]) and national legislation and standards for composting plants. Based on the list in Annex 10, a set of three allowable time-temperature profiles could be proposed for <u>materials subject to composting and not including and animal by-products</u>: **65 °C or more for at least 5 days** **60 °C or more for at least 7 days** **55 °C or more for at least 14 days** **In the case of anaerobic <u>digestion for materials not containing any animal by-products</u>, a time temperature profile of 55 °C during at least 24h and a hydraulic retention time of at least 20 days should ensure complete hygienisation.** **<u>Member States</u> should be allowed to <u>grant authorization for other time-temperature profiles after demonstration of their effectiveness</u> for hygienisation.** **<u>Animal by-products regulations should remain fully applicable</u> for any compost or digestate material containing animal by-products**	specified in the licence/permit by the competent authority. It must be ensured that all of the material undergoes appropriate conditions. Depending on the process type this may require, for example, suitable turning, oxygen supply, presence of enough structural material, homogenisation, etc.	

([75]) Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

Criteria	Explanations	Reasons
In order to avoid cross-contamination, following measures should be respected: **Plants that produce End of Waste compost or digestate should <u>only be allowed to process approved materials from the positive list</u>.** **In the case of <u>using animal by-products, separate storage</u> is required to avoid cross-contamination with non animal by-product containing materials.** **The possibility of <u>physical contact between input materials and final products must be excluded</u>.**	Apart from ensuring correct processing conditions during composting/digestion, cross-contamination needs to be minimized.	Cross-contamination can cause a carefully produced material to pose quality problems and/or environmental or health concerns.

Requirements on the provision of information

The different requirements that could be part of the criteria regarding provision of information for **compost and digestate** are presented below:

Criteria	Explanations	Reasons
Declaration of the following parameters (product properties) when placing <u>compost/digestate</u> on the market: **Usefulness concerning soil improving function:** **• Organic matter content** **• Alkaline effective matter (CaO content)** **Usefulness concerning fertilising function:** **• Nutrient content (N, P, K, Mg) and also S in the case of digestate** **• Mineralisable nitrogen content (NH4-N, NO3-N)** **Biological properties:** **• Stability/maturity** **• Plant response**	The parameters to be included determine the usefulness of compost/digestate and the environmental and health impacts and risks of compost/digestate use.	Composts/digestates can be used as a safe and useful product only if the relevant properties of the material are known to the user and the corresponding regulatory authorities. This information is needed to adapt the use to the concrete application requirements and local use conditions as well as the corresponding legal regulations (e.g. the provisions on soil protection that apply to the areas where the compost/digestate is used). An adequate declaration of the material

• Contents of germinable seeds and plant promulgates **General material properties** **• Water or dry matter content** **• Bulk density/volume weight** **• Grain size** **• pH** **• Electrical conductivity (salinity)** **Hygienic aspects relevant for environmental and health protection** **• Presence of Salmonellae** **• Presence of E.coli** **Pollutants and impurities relevant for environmental and health protection** **• Contents of macroscopic impurities (such as glass, metals, plastics)** **• Contents of some heavy metals and persistent organic compounds** (See also details in Annex 11 and 12)		properties is therefore a prerequisite for placing compost/digestate on the market and for the waste status to be lifted.

Criteria	Explanations	Reasons
When placing compost or digestate on the market, the producer must declare the following: **•The name and address of the compost/digestate producer** **•Compost/digestate designation identifying the product by general type** **•Batch code** **•Quantity (in weight and/or volume)** **•The obligatory parameter values** **•A statement indicating that End of Waste criteria are met** **•Product declaration in line with national regulations in the Member State where the material has been produced** **•The conformity with national quality assurance requirements in the**	A use of compost/digestate can be considered as recognised only if there are suitable regulations or other rules in place that ensure the protection of health and of the environment. The applicability of such rules must not depend on the waste status of the compost.	It is a condition for end-of-waste that the product fulfils the technical requirements for a specific purpose and meets the existing legislation and good practice standards applicable to products. The producer could be requested to identify the legal norms that regulate the use according to the identified purposes in the markets on which the product is placed.

Criteria	Explanations	Reasons
Member State where the material has been produced **•The conformity with End of Waste requirements** **•The recommended conditions of storage** **•A description of the application areas for which the compost/digestate can be used and any limitations on use** **•Recommendations for the proper use**		
The product should be accompanied by <u>instructions on safe use and application recommendations.</u> **The instructions should also make reference to the need of <u>compliance with any legal regulations, standards, and good practice applying to the recommended uses</u>.**	For example, instructions and recommendations may refer to the maximum amounts and recommended times, for spreading on agricultural land. Spreading and incorporation in soil e.g. have to follow good agricultural practice. At the same time, national or regional regulations may impose additional requirements, depending on e.g. the local soil conditions.	Application instructions and recommendations help to avoid bad use of the compost/digestate and the associated environmental and health risks and impacts. Reference to legal requirements and standards for use are intended to support legal compliance by the compost/digestate user. These instructions shall not be more burdensome than those required for products with the same function, e.g. peat or fertilisers.
<u>Traceability:</u> The information supplied to the <u>first buyer or user</u> together with the compost/digestate should allow the identification of the producer of the compost/digestate, the batch and the input materials used.	Member States may require users to keep records of these data for certain uses so that the compost/digestate can be traced back to the origin when needed.	For the event of environmental or health problems that can potentially be linked to the use of compost/digestate, there is a need to provide traceability trails for any investigations into the cause of the problems.

Requirements on quality assurance procedures (quality management)

Criteria	Explanations	Reasons

Criteria	Explanations	Reasons
Compost/digestate producers are required to operate a <u>quality management system</u> in compliance with quality assurance standards that are recognised as suitable for compost/digestate production by Member States or the Community. **It should include following elements:** **• acceptance control of input materials based on a positive list;** **• monitoring and record keeping of processes to ensure they are effective at all times;** **• procedures for monitoring product quality (including external sampling and analysis) that are adjusted to the process and product specifics according to good practice;** **• periodical third-party surveillance with quality control of compost/digestate analyses and on-site inspection of the composting/digestion plant inlcusive inspection of records and the plants' documentation** **• plant certification for declaration and labelling of input materials, the product characteristics, the product type and the producer;** **• information on conformity with national regulations, quality assurance and EoW standards and requirements of the competent authority**	Recognised quality assurance standards for compost and digestate are set out, for example, in the British publicly available specification BSI PAS 100 (Compost) and 110 (Digestate), and the German BGK's RAL quality assurance system. Besides the national standards, the European Compost Network has established a quality management system for compost, which is widely supported. Furthermore, it is currently developing a similar system for digestates.	Users and the authorities that are in charge of controlling the use of the compost need to have reliable quality guarantees. Trust in the quality of the material is a precondition for a sustained market demand. The actual product properties must correspond well to what is declared and it must be guaranteed that the material minimum quality requirements as well as the requirements concerning the input materials and processes are actually met when a product is placed on the market.

Criteria	Explanations	Reasons
• measures for review and improvement of the plant's quality management system; **• training of staff**		
The quality assurance system is audited externally by the competent authorities or by quality assurance organisations acknowledged by Member State authorities.		The reliability of product quality will be acceptable only if the quality assurance systems are audited by the authorities or an officially acknowledged third-party organisation.

Application of end-of-waste criteria

Criteria	Explanations	Reasons
Compost/digestate ceases to be waste, provided all other end-of-waste criteria are fulfilled, <u>when used by the producer or upon its transfer from the producer to the next holder</u>. However, if there is no final lawful use, compost/digestate will be considered waste.		The end-of-waste criteria are defined so that compliant compost/digestate can be stored and traded freely as a product once it is placed on the market by the producer. The benefits of the end-of-waste criteria are made actual if compost/digestate users are not bound by waste legislation (this means, for example, that farmers or landscapers using compliant compost/digestate do not require waste permits nor do formulators of growing media that use compost/digestate as a component). Users have, however, the obligation to use the product according to purpose and to comply with the other existing legislation and standards applicable to

Criteria	Explanations	Reasons
		compost.
If the compost/digestate is mixed/blended with other material before being placed on the market, the product quality criteria apply to the compost/digestate before mixing/blending.		Meeting the limit values relevant for product quality by means of dilution with other materials should not be allowed.

Annex 20: Proposed end-of-waste criteria from 3rd Working Document

Overview of end-of-waste criteria for compost and digestate, as proposed in the **Third Working Document** for End-of-waste criteria on Biodegradable waste subject to biological treatment (August 2012, 244p.)

Product Quality Requirements for compost and digestate

Parameter	Value	Comments
(1) Minimum organic matter content:	15% on dry matter weight	The minimum organic matter content of the final product, after the composting/digestion phase and prior to any mixing with other materials. This is intended to prevent dilution of compost/digestate with mineral components (e.g. sand, soil).
(2) no content of pathogens	No *Salmonella* sp. in 25 g sample 1000 CFU/g fresh mass for *E. Coli*	Measurement of this parameter should be complemented by a requirement on processing, e.g. a temperature-time profile.
(3) limited content of viable weeds and plant propagules	2 viable weed seeds per litre of compost/digestate	Measurement of this parameter should be complemented by a requirement on processing, e.g. a temperature-time profile.
(4) limited content of macroscopic impurities	0.5% on dry matter weight for glass, metal and plastics > 2mm to be determined by the bleach method	There is a need to distinguish between natural impurities such as stones and manmade impurities. The bleach method allows a destruction of organic material and therefore avoids that small impurities are not detected due to confusion with organic material.
(5) limited content of heavy metals and organic pollutants:	mg/kg (dry weight), except for PCDD/F	In the final product, just after the composting/digestion phase and prior to any mixing with other materials
Zn	400	
Cu	100	
Ni	50	
Cd	1.5	
Pb	120	
Hg	1	
Cr	100	
PCB_7 (sum of PCBs 28, 52, 101, 118, 138, 153 and 180)	0.2	
PAH_{16} (sum of	6	

naphthalene, acenaphtylene, acenaphtene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene)		
PCDD/F (ng I-TEQ/ kg dry weight)	30	
PFC (sum of PFOA and PFOS)	0.1	

Requirements on product testing for compost and digestate

Requirements on product testing (sampling and analysis): **Compost and digestate producers must demonstrate by external independent testing that there is a sufficiently high probability that any consignment of compost/digestate delivered to a customer complies with the minimum quality requirements and is at least as good as the properties declared.** **The details of the sampling programme may be adjusted to the concrete situation of each compost/digestate plant. The competent authorities will, however, have to check compliance with the following requirements:** • **The compliance testing**	In the case of heavy metal and organic pollutant concentrations, the probability that the mean value of the concentration in a sample exceeds the legal limit should be less than 5%. This implies that the mean concentration of the whole population of the compost/digestate sold plus the 95% confidence interval needs to be below the legal limit. (Usually, it will be impractical to sample from the total population and a subset of the overall population that can be considered typical of the whole population will have to be defined as part of the quality assurance process. Usually, the population will correspond to all the compost/digestate sold from a composting plant	A high level of environmental protection can be achieved only if there is reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. To manage compost/digestate so that environmental impacts and risks are kept low, it must be possible for compost/digestate users and regulatory authorities to interpret the declared product properties in the right way and to trust in conformity. Therefore, standardisation of product parameters, sampling and testing is needed as well as quality assurance.

has to be carried out within <u>external, independent quality assurance</u> by laboratories that are <u>accredited</u> for that purpose (through an accreditation standard and accreditation organisation accepted at EU level or by the Member State competent authority). • **The CEN/Horizontal standards for sampling and analysis have to be applied as far as available. See Annex 13 for a list of standards and sampling and testing methods.** • **Probabilistic sampling should be chosen as the sampling approach and appropriate statistical methods used in the evaluation of the testing.** **The <u>minimum</u> sampling and analysis frequency in the <u>first year</u> (the recognition year) should be at least 4 (one sample every season), unless the plant treats less than 4000 tonnes of input material (in that case: one sample for every 1000 tonnes input material, rounded to the next integer, is required).** **The minimum sampling and analysis frequency for the <u>following years</u> should be calculated according to the formula:** ***number of analyses per year = amount of input material (in tonnes)/10000 tonne + 1***	throughout a year or shorter periods of time). The scale of sampling needs to be chosen depending on the sales/dispatch structure of a composting/digestion plant. The scale should correspond to the minimum quantity of material below which variations are judged to be unimportant. The better the precision of the testing programme (the narrower the confidence interval), the closer the mean concentrations may be allowed to be to the legal limit values. The costs of a testing programme of compost/digestate with very good quality (parameter values far from the limits) can therefore be held lower than for compost/digestate with values that are closer to the limit. When a new compost/digestate plant is licensed there is usually an initial phase of intensive testing to achieve a basic characterisation (for example one year) of the compost/digestate qualities achieved. If this proves satisfactory, the further testing requirements are then usually reduced. In order to be exempted from the regular measurement of organic pollutants from the year following the recognition year, the probability that the mean value of the concentration of all organic pollutants in a	

with a maximum of 12 analysis per year. Any non-integer value should be rounded to the next integer. The frequency therefore being at least 2, and limited at 12. **Plants for which <u>organic pollutant concentrations are all below the maximum values</u> in the recognition year (at 95% confidence level), may be exempted from regular organic pollutant measurement requirements after the recognition year, except for at least 1 full analysis on a cumulative sample, called pool sample. The exemption only applies if all 4 organic pollutant criteria (PAH, PCB, PCDD/F and PFC) meet this requirement.** **The procedure for generating the pool sample is:** • **Whenever a sample is taken for heavy metal analysis, a parallel sample is taken according to the same procedure and stored in a way to minimize biological change and loss of organic matter (preferably freezing in sealed airtight containers).** • **The pool sample for every year shall consist of aliquot parts (based on wet weight) of the different stored samples.** **This approach can be**	sample exceeds the legal limit should be less than 5%. This implies that the mean concentration of the whole population of the compost/digestate sold plus the 95% confidence interval needs to be below the legal limit. The measurement frequency for inorganic and organic pollutants must be adapted to possible changes in the input material. Seasonal variations on the composition of the input material are accounted for through the spread on the samples taken in the recognition year, reflected in the confidence intervals. However, any other important change (more than 5%) in the type or source of input material should be taken into account in the sample measurement frequency, as to avoid sudden unnoticed contamination of the final product.	

maintained as long as the results from the pool sample indicate that all organic pollutant concentrations are below the limit values, taking into account the earlier established 95% confidence intervals. If this is no longer the case, the measurement frequency for the organic pollutants will be reset to the measurement frequency of the recognition year. **In case of <u>important changes (> 5%) regarding the source or composition of the input material</u>, the measurement frequency for inorganic and organic pollutants is reset to the measurement frequency of the first year.**		

Requirements on input materials

Criteria	Explanations	Reasons
<u>Clean, biodegradable wastes are the only wastes allowed to be used as input materials</u> for the production of end-of-waste compost and digestate. **Annex 9 presented in the 3rd Working Document provides the positive lists of biodegradable wastes that are currently regarded as suitable for composting and digestion.** **Primary raw materials should be allowed as well as input materials**	Non-biodegradable components that are already associated with biodegradable waste streams at source, should, however, be allowed if they are not dominant in quantity, do not lead to exceeding the pollutant concentration limits (see product quality requirements) and do not impair the usefulness of the compost/digestate. Example: soil-like material attached to garden waste. Assessment of	Composting and digestion is suitable as treatment only for biodegradable wastes. Dilution of other wastes with biodegradable waste needs to be avoided.

Criteria	Explanations	Reasons
as long as the composting/digestion operation is considered a waste treatment process.	biodegradability of biodegradable materials should be done according to the final process before reaching end-of-waste status, i.e. mere aerobic composting, mere anaerobic digestion or anaerobic digestion followed by aerobic composting.	
The <u>input materials</u> used for the production of end-of-waste compost/digestate must be known by the producer. **It shall be indicated on the product what the material is based on, <u>in large terms</u>, using one or more of the following definitions:** • **Separately collected bio-waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants or of agricultural and forest products** • **Garden and park waste** • **Mixed municipal waste** • **Sewage sludge** • **Agricultural**	The waste classification of the European Waste Catalogue should be used, ideally together with additional specifications, such as in the waste list in Annex 9 presented in the 3rd Working Document.	Transparency on the input materials is important for the confidence of users in compost/digestate quality and can therefore strengthen compost/digestate demand. The information on the input material is needed to allow the use of compost/digestate in compliance with existing legislation. For example, the Community legislation of organic farming has specific rules for the use of compost from source-separated household waste. If animal by-products were input, compliance with the Animal By-products Regulation ([76]) is required. Furthermore, users, for instance farmers, often wish to know the origins and source materials of compost/digestate.

([76]) Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p. 1-33).

Criteria	Explanations	Reasons
waste containing manure • **Agricultural waste not containing manure** • **Other input materials** **Any presence of <u>mixed municipal waste, sewage sludge and/or manure</u> must be clearly indicated.** **It should be indicated whether any <u>animal by-products</u> have been used to produce the material and all provisions of the Animal By Products Regulation EC 1069/2009 should apply.**		
<u>Reprocessing</u> of off-speciation compost or digestate, or derived materials thereof, such as liquor or leachate, by a new composting or aerobic digestion step, in order to meet the product quality criteria for end-of-waste can only be allowed in case the <u>failure</u> to meet end-of-waste criteria for the original material is <u>not related to the content of heavy metals or organic pollutants.</u>	This applies both to the full off-speciation unit and to mixtures of off-speciation material and other input materials.	Polluted compost/digestate materials should not receive end-of-waste status through post-processing or dilution.
<u>Additives</u> (material other than biodegradable waste) can only be used when	Additives should only serve to improve the composting or digestion process, or	Additives can be used as input to the composting/digestion process in minor quantities, if they improve the compost/digestate quality or they have a

Criteria	Explanations	Reasons
these are listed on the positive list.	improve environmental performance of the process	clear function in the composting/digestion process and the pollutant concentrations (based on dry matter) do not exceed the concentration limits for end-of-waste compost/digestate. In practice, additives are sometimes needed to improve the composting/digestion process or the compost/digestate quality.
Suitable procedures for controlling the quality of input materials need to be followed by the operators of composting/digestion plants. **Visual inspection is the method of choice to control input materials for compost and digestate.** **When visual inspection would entail health or safety risks, as in the case of liquid input materials, visual inspection shall be replaced by sample taking and storage for possible analysis or by a supply agreement.** **See also section on criteria regarding quality control procedures.**	It is agreed that in many cases visual inspection and approval of origin will be suitable procedures. In order to facilitate visual inspection, mixes of input materials in one delivery should be banned. Visual inspection of liquid materials in containers or bulk trucks may be dangerous due to the escaping gases or difficulties in approaching the material. In such cases, samples should be taken or the quality should be assured through contractual supply agreements.	Controlling the input materials is a key factor (probably the single most important) for assuring reliable quality of the compost or digestate. Control of input covers also avoidance of mixing with other wastes not listed in the positive list.

Requirements on treatment processes and techniques

Criteria	Explanations	Reasons
It must be demonstrated for each compost/digestate batch that a suitable temperature-time profile was followed during the	The desired risk control can be achieved, avoiding being overly descriptive, by allowing a number of alternative temperature-time	As is common in existing regulations and standards, there should be process requirements to ensure that the processes yield composts

Criteria	Explanations	Reasons
composting/digestion process for all material contained in the batch. **Three time-temperature profiles are allowed for <u>materials subject to composting and not including and animal by-products</u>:** • **65 °C or more for at least 5 days** • **60 °C or more for at least 7 days** • **55 °C or more for at least 14 days** **In the case of anaerobic <u>digestion for materials not containing any animal by-products</u>, following time-temperature profiles are allowed** • **Thermophilic anaerobic digestion at 55°C during at least 24h and a hydraulic retention time of at least 20 days** • **Thermophilic anaerobic digestion at 55°C followed by pasteurization (70°C, 1h)** • **Thermophilic anaerobic digestion at 55°C, followed by composting according to EoW time-temperature profiles for composting** • **Mesophilic anaerobic digestion at 37-40°C, followed by pasteurization (70°C, 1h)** • **Mesophilic anaerobic digestion at 37-40°C, followed by composting according to EoW time-temperature profiles for**	profiles from existing standards or regulations. The producer must comply with at least one profile that has been approved as suitable for the type of composting/digestion process applied and is specified in the licence/permit by the competent authority. It must be ensured that all of the material undergoes appropriate conditions. Depending on the process type this may require, for example, suitable turning, oxygen supply, presence of enough structural material, homogenisation, etc.	and digestates without hygienic risk.

Criteria	Explanations	Reasons
composting **<u>Member States</u> should be allowed to <u>grant authorization for other time-temperature profiles after demonstration of equal effectiveness</u> for hygienisation as the above indicated time-temperature profiles.** **<u>Animal by-products regulations should remain fully applicable</u> for any compost or digestate material containing animal by-products (inclusive restrictions of placing certain compost/digestate materials only on national Member State markets)**		
In order to avoid cross-contamination, following measures should be respected: **Plants that produce End of Waste compost or digestate should <u>only be allowed to process approved materials from the positive list</u>.** **In the case of <u>using animal by-products, separate storage</u> is required to avoid cross-contamination with non animal by-product containing materials.** **The possibility of <u>physical contact between input materials and final products must be excluded</u>.**	Apart from ensuring correct processing conditions during composting/digestion, cross-contamination needs to be minimized.	Cross-contamination can cause a carefully produced material to pose quality problems and/or environmental or health concerns.

Requirements on the provision of information

The different requirements that received support from the stakeholders regarding provision of information for **compost** are presented below:

Criteria	Explanations	Reasons
Declaration of the following parameters (product properties) when placing compost on the market: **Usefulness concerning soil improving function:** **• Organic matter content** **• Alkaline effective matter (CaO content)** **Usefulness concerning fertilising function:** **• Nutrient content (N, P, K, Mg)** **Biological properties:** **• Contents of germinable seeds and plant promulgates** **General material properties** **• Bulk density/volume weight** **• Grain size** **• pH** **• Electrical conductivity (salinity)** (See also details in Annex 11 and 12)	The parameters to be included determine the usefulness of compost and the environmental and health impacts and risks of compost use.	Composts can be used as a safe and useful product only if the relevant properties of the material are known to the user and the corresponding regulatory authorities. This information is needed to adapt the use to the concrete application requirements and local use conditions as well as the corresponding legal regulations (e.g. the provisions on soil protection that apply to the areas where the compost/digestate is used). An adequate declaration of the material properties is therefore a prerequisite for placing digestate on the market and for the waste status to be lifted.

The different requirements that received support from the stakeholders regarding provision of information for **digestate** are presented below:

Criteria	Explanations	Reasons
Declaration of the following parameters (product properties) when placing digestate on the market: **Usefulness concerning soil improving function:** **• Organic matter content** **• Alkaline effective matter (CaO content)** **Usefulness concerning fertilising function:** **• Nutrient content (N, P, K, Mg)** **• S content** **• Mineralisable nitrogen content (NH4-N, NO3-N)** **General material properties** **• Water or dry matter content**	The parameters to be included determine the usefulness of digestate and the environmental and health impacts and risks of digestate use.	Digestates can be used as a safe and useful product only if the relevant properties of the material are known to the user and the corresponding regulatory authorities. This information is needed to adapt the use to the concrete application requirements and local use conditions as well as the corresponding legal regulations (e.g. the provisions on soil protection that apply to the areas where the compost/digestate is used). An adequate

• pH **• Electrical conductivity (salinity)** (See also details in Annex 11 and 12)		declaration of the material properties is therefore a prerequisite for placing digestate on the market and for the waste status to be lifted.

The proposed criteria on requirements on the provision of information for **compost and digestate** include:

Criteria	Explanations	Reasons
When placing compost or digestate on the market, the producer must declare the following: **•The name and address of the compost/digestate producer** **•The name, address and possible logo of the external Quality Assurance organization** **•Compost/digestate designation identifying the product by general type (indicating any presence of mixed municipal waste, sewage sludge, manure and/or animal by-products)** **•Batch code** **•Quantity (in weight and/or volume)** **•The obligatory parameter values to declare through labelling** **•A statement indicating that end-of-waste criteria have been met** **•The conformity with end-of-waste requirements** **•A description of the application areas for which the compost/digestate can be used and any limitations on use** **•Recommendations for the proper use** **•Reference to Animal By-Product Regulation requirements where**	A use of compost/digestate can be considered as recognised only if there are suitable regulations or other rules in place that ensure the protection of health and of the environment. The applicability of such rules must not depend on the waste status of the compost.	It is a condition for end-of-waste that the product fulfils the technical requirements for a specific purpose and meets the existing legislation and good practice standards applicable to products. The producer could be requested to identify the legal norms that regulate the use according to the identified purposes in the markets on which the product is placed.

Criteria	Explanations	Reasons
applicable (inclusive restrictions on export)		
The product should be accompanied by <u>instructions on safe use and application recommendations.</u> **The instructions should also make reference to the need of <u>compliance with any legal regulations, standards, and good practice applying to the recommended uses</u>.**	For example, instructions and recommendations may refer to the maximum amounts and recommended times, for spreading on agricultural land. Spreading and incorporation in soil e.g. have to follow good agricultural practice. At the same time, national or regional regulations may impose additional requirements, depending on e.g. the local soil conditions.	Application instructions and recommendations help to avoid bad use of the compost/digestate and the associated environmental and health risks and impacts. Reference to legal requirements and standards for use are intended to support legal compliance by the compost/digestate user. These instructions shall not be more burdensome than those required for products with the same function, e.g. peat or fertilisers.
<u>Traceability:</u> The information supplied to the <u>first buyer or user</u> together with the compost/digestate should allow the identification of the producer of the compost/digestate, the batch and the input materials used. **Traceability requirements by the Animal By-Products Regulation EU 1069/2009 fully remain valid where applicable.**	Member States may require users to keep records of these data for certain uses so that the compost/digestate can be traced back to the origin when needed.	For the event of environmental or health problems that can potentially be linked to the use of compost/digestate, there is a need to provide traceability trails for any investigations into the cause of the problems.

Requirements on quality assurance procedures (quality management)

Criteria	Explanations	Reasons

Criteria	Explanations	Reasons
Compost/digestate producers are required to operate a <u>quality management system</u> in compliance with quality assurance standards that are recognised as suitable for compost/digestate production by Member States or the Community. **It should include following elements:** **•Acceptance control of input materials based on a positive list;** **•Monitoring and record keeping of processes to ensure they are effective at all times (records must be kept for 5 years);** **•Procedures for monitoring product quality (including external sampling and analysis) that are adjusted to the process and product specifics according to good practice;** **•Periodical third-party surveillance with quality control of compost/digestate analyses and on-site inspection of the composting/digestion plant inclusive inspection of records and the plants' documentation** **•Plant certification for declaration and labelling of input materials, the product characteristics, the product type and the producer;** **•Information on conformity with national regulations, quality assurance and EoW standards and requirements of the competent authority**	Recognised quality assurance standards for compost and digestate are set out, for example, in the British publicly available specification BSI PAS 100 (Compost) and 110 (Digestate), and the German BGK's RAL quality assurance system. Besides the national standards, the European Compost Network has established a quality management system for compost, which is widely supported. Furthermore, it is currently developing a similar system for digestates.	Users and the authorities that are in charge of controlling the use of the compost need to have reliable quality guarantees. Trust in the quality of the material is a precondition for a sustained market demand. The actual product properties must correspond well to what is declared and it must be guaranteed that the material minimum quality requirements as well as the requirements concerning the input materials and processes are actually met when a product is placed on the market.

Criteria	Explanations	Reasons
•Measures for review and improvement of the plant's quality management system; **•Training of staff**		
The quality assurance system is audited externally by the competent authorities or by quality assurance organisations acknowledged by Member State authorities.		The reliability of product quality will be acceptable only if the quality assurance systems are audited by the authorities or an officially acknowledged third-party organisation.

Application of end-of-waste criteria

Criteria	Explanations	Reasons
Compost/digestate ceases to be waste, provided all other end-of-waste criteria are fulfilled, <u>when used by the producer or upon its transfer from the producer to the next holder</u>. However, if there is no final lawful use, compost/digestate will be considered waste.		The end-of-waste criteria are defined so that compliant compost/digestate can be stored and traded freely as a product once it is placed on the market by the producer. The benefits of the end-of-waste criteria are made actual if compost/digestate users are not bound by waste legislation (this means, for example, that farmers or landscapers using compliant compost/digestate do not require waste permits nor do formulators of growing media that use compost/digestate as a component). Users have, however, the obligation to use the product according to purpose and to comply with the other existing legislation and standards applicable to

Criteria	Explanations	Reasons
		compost.
If the compost/digestate is mixed/blended with other material before being placed on the market, the product quality criteria apply to the compost/digestate before mixing/blending.		Meeting the limit values relevant for product quality by means of dilution with other materials should not be allowed.

Annex 21: Calculation of the population in EU border zones

This section explains how the total population in a zone of maximum 100 km from an intra-EU land border was calculated

By courtesy of Dr. Hande Demirel, Action Transport Sector Economic Analysis, Unit Economics of Climate Change, Energy and Transport (ECCET), JRC-IPTS

Introduction

Since compost/digestate production tonnages eligible for cross-border trade are presumably related to the population living in zones within 100km of a land border, such calculations could be conducted by means of spatial analyses.

Data & Methodology

a) EU 1km*1km grid population information:
http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/popups/references/population_distribution_demography
b) NUTS Regions, including country borders:
http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction
http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/popups/references/administrative_units_statistical_units_1

The population information based on 1km*1km grids was produced in 2006. Therefore, in order to keep the spatial analyses consistent the 2006 dataset was selected for NUTS regions.

It may be noted that the EU-27 population is rather stable, with only a 2% increase between 2006 and 2013, according to Eurostat.

The following steps were followed to conduct the analyses:

1. Overlaying the layers
2. Selecting the intra-EU borders
3. Creating a buffer zone of 100 km
4. Spatial joining of population data and the created buffer zone
5. Summarize the population information.

Results

The screenshots and table below illustrate the results
Some screen shots, was provided below.

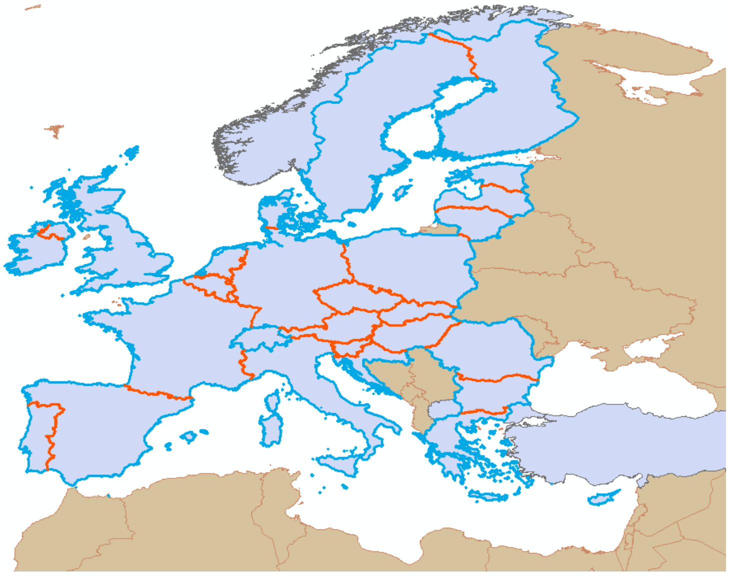

Figure I: Selected intra-EU borders (highlighted in orange)

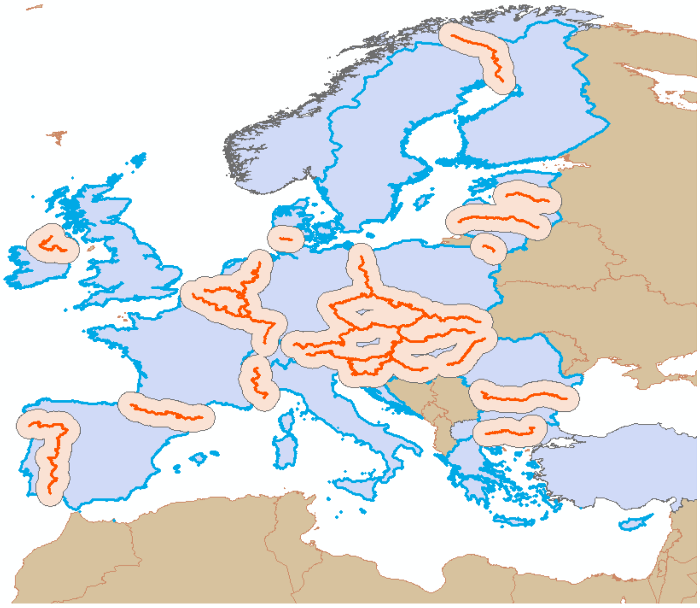

Figure II: 100 km buffer zone creations

The 1km*1km population information was queried and selected within the buffer zones.

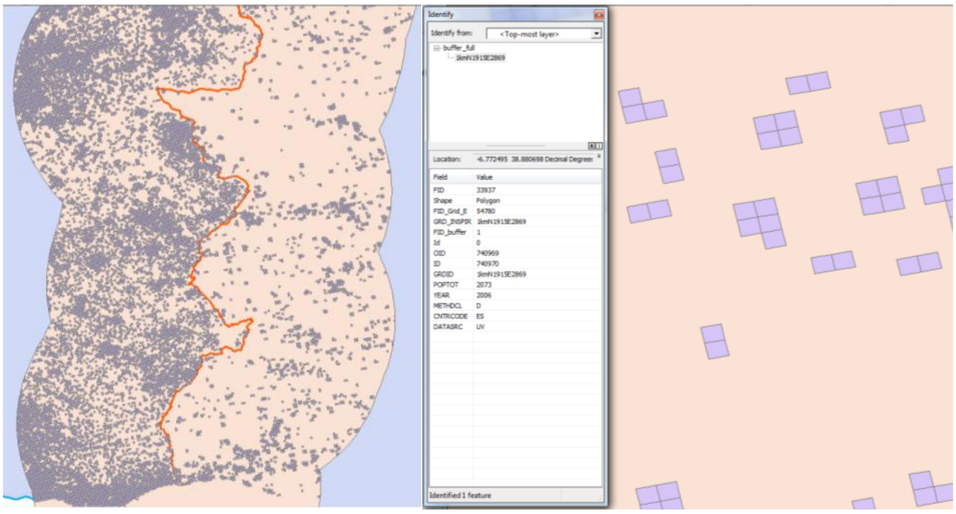

Figure III: Population information of the buffer zones

As a result of these analyses, a map could be produced.

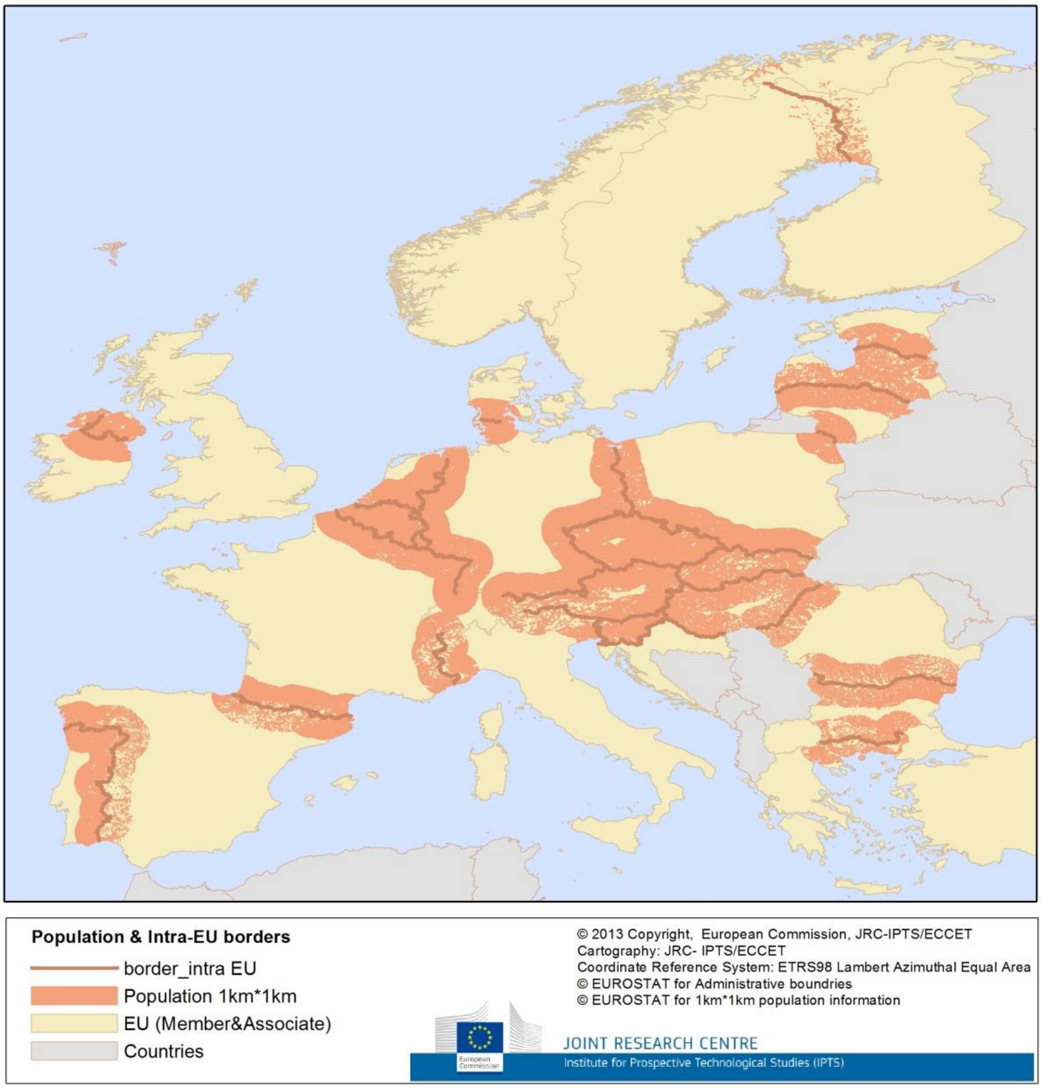

Figure IV: Map of population within intra-EU border zones

Border zone population calculation results for the EU-27 countries are listed in the table below.
Cyprus and Malta were not included within the analyses, due to a lack of intra-EU physical land borders. Population density data for Croatia were not available.

Table I: Country-specific population living in a zone of maximum 100 km distance from an intra-EU land border (absolute values and fraction of total population). Malta and Cyprus are not listed because of a lack of land borders. Population density data for Croatia were not available.

Country Code	Population within border zone of 100 km (thousand inhabitants)	Fraction of total population (%)
BE	10,640	100
BG	5,139	67
CZ	10,216	100
DK	759	14
DE	43,836	53
EE	432	32
IE	2,214	53
GR	2,128	19
ES	8,313	19
FR	15,270	24
IT	6,562	11
LV	2,130	96
LT	2,221	68
LU	487	100
HU	9,627	96
NL	14,755	90
AT	8,283	100
PL	15,173	40
PT	4,866	46
RO	8,749	41
SI	1,979	99
SK	5,430	100
FI	80	1.5
SE	49	0.5
UK	1,743	2.9
Total EU-27	**181,102**	**37**

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Abstract
This report is the JRC-IPTS contribution to the development of the end-of-waste criteria for biodegradable waste subject to biological treatment (compost/digestate) in accordance with Article 6 of Directive 2008/98/EC of the European Parliament and of the Council on waste (the Waste Framework Directive).

This report includes a possible set of end-of-waste criteria and shows how the proposals were developed based on a comprehensive techno-economic analysis of the biodegradable waste derived compost/digestate production chain and an analysis of the economic, environmental and legal impacts when such compost/digestate ceases to be waste. The purpose of end-of-waste criteria is to avoid confusion about the waste definition and to clarify when certain waste that has undergone recovery ceases to be waste. Recycling should be supported by creating legal certainty and an equal level playing field and by removing unnecessary administrative burdens. The end-of-waste criteria should provide a high level of environmental protection and an environmental and economic benefit.

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