

Executive Summary

Purpose of the this report

Solid rocket motor fuel contains large quantities of ammonium perchlorate as the primary oxidant and this material has been shown to be toxic to life. In the event of an aborted rocket launch, it is possible that unspent propellant could be deposited near the launch site and coastal marine and terrestrial habitats could be adversely impacted. The purpose of this report is to present the results of a study of the effects of perchlorate on various ecosystem components expected to occur in the vicinity of launch sites. In particular, experiments were conducted on the effects of perchlorate on primary and secondary production in freshwater and marine water samples, decomposition processes in marine and freshwater sediments, freshwater wetland peat and upland soils, and effects on the behavior and growth of the fish species, the threespine stickleback. In addition, the potential bioaccumulation of perchlorate by freshwater and marine plankton and in the threespine stickleback was investigated.

General Methodology

The effects of perchlorate on primary and secondary aquatic production was investigated in the laboratory by monitoring photosynthesis and the uptake of an amino acid, respectively, in freshwater and seawater samples in the presence of various concentrations of perchlorate. The rates of both processes were determined using a radiotracer methodology. The effects of perchlorate on decomposition processes in sediments, wetland peat and soil material were determined by measuring carbon dioxide, and in some cases methane formation, in laboratory incubation vessels supplemented with various concentrations of perchlorate. The effects of perchlorate on fish were determined in laboratory aquaria supplemented with various concentrations of perchlorate or with uniform pieces of solid rocket propellant. Fish mating and offspring rearing behavior were monitored as well as the growth of offspring. The accumulation of perchlorate in fish and plankton was also determined by extracting perchlorate using an automated extraction system followed by the removal of contaminating materials by ion exchange columns and the measurement of perchlorate by ion chromatography coupled to conductivity detection.

Summary of Results and Conclusions

Aquatic primary production was only affected by perchlorate concentrations of 1000 ppm and this effect was minimal compared to control samples. There were no statistically significant decreases in production in the presence of either 10 or 100-ppm perchlorate compared to unamended controls or controls amended with 1000 ppm KCl (salt control). Hence, it is possible that perchlorate will affect photosynthesis in aquatic systems, but this effect appears to occur only when perchlorate levels are extremely high. The deleterious effect of perchlorate on photosynthesis tended to occur at light levels below maxima that occur at the surface of water bodies. Since most aquatic primary production occurs at light levels well below the maximum, it

is possible that any adverse effects of perchlorate on primary production would occur at water depths where the bulk of the depth integrated production occurs.

Bacterial production also was not adversely affected by the presence of perchlorate except at very high levels of perchlorate in seawater samples. Since coastal waters are constantly circulating, it is unlikely that phytoplankton or bacterioplankton will encounter such high levels of perchlorate for periods other than a few minutes.

Respiration in marine and freshwater sediments and wetland peat was not adversely affected by perchlorate concentrations as high as 1000 ppm. It is unlikely that concentrations exceeding this level would be encountered in sediments except in small regions in direct contact with solid propellant for extended periods of time. Perchlorate concentrations did not tend to decrease over time, at least during seven-day incubations. Anaerobic bacteria are capable of respiring perchlorate and this process has been observed in perchlorate-contaminated sediments. However, this ability tends to be associated with chronically contaminated environments and the samples used here had not been previously exposed to high levels of perchlorate and had not developed the capacity to degrade perchlorate. This is also the case in areas near launch sites, so it is unlikely that these sites would actively remove perchlorate anaerobically until they had been exposed for many months.

Soil samples exhibited significant decreases in respiration activity in the presence of 100 and 1000-ppm perchlorate. Therefore, it is possible that the deposition of perchlorate to coastal soils following a flight abortion could decrease the rate that material is decomposed in soil, which could adversely affect the recycling of nutrients and eventually plant growth. The extent of this effect will be controlled by the amount of propellant deposited, the average surface to volume ratio of deposited particles, and the number of particles deposited per area unit. Perchlorate dissolution data suggested that 100-ppm concentrations could be achieved in solutions in which volumes are restricted, and this may occur in soil water adjacent to dissolving propellant.

The presence of potassium perchlorate at concentrations up to 10 ppm and perchlorate concentrations nearing 30 ppm in aquaria containing solid propellant had no effect on stickleback mating or the birth and growth of fry. Fry mortality occurred in all treatments, but none were statistically different from controls. It is possible that fry will experience morphological or behavioral abnormalities, but these effects will not be detected until fry have grown further.

Perchlorate accumulated in both the algal/bacterial community and in fish in aquaria amended with perchlorate. The magnitude of the increase corresponded with the exposure concentration. It was unclear whether fish accumulated perchlorate by consuming contaminated algal material in aquaria or directly from dissolved perchlorate since fish food was not amended with perchlorate. Nonetheless, both the microbial and fish components accumulated significant levels of perchlorate that could be passed on to following trophic levels. Although this study did not detect severe effects of perchlorate stress, it is likely that the continued accumulation of perchlorate would lead to deleterious effects at some level.