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Remediation Technologies for Perchlorate Contamination in Water and Soil (PERC-2)

EXECUTIVE SUMMARY

Perchlorate, an anion, consists of one chlorine atom bonded to four oxygen atoms (ClO_4^-) and is both naturally occurring and manmade. Highly soluble and mobile in water, perchlorate is generally very stable in the dissolved state. Most of the attention focused on perchlorate has concerned its presence in groundwater and surface water. However, perchlorate can also be found in soil and vegetation and has entered the human and environmental food chains. Perchlorate occurrence in drinking water and food supplies is a human health concern because it can interfere with iodide uptake by the thyroid gland and result in decreased thyroid hormone production.

Past management practices were not concerned with the release of perchlorate to the environment because it was not recognized or regarded as a contaminant of concern. Widespread perchlorate presence in the United States was observed after the spring of 1997 when an analytical method was developed with a quantitation level of 4 parts per billion. Subsequent advances in analytical chemistry have proven perchlorate to be more widespread in the environment than previously thought. Chapter 1 provides an overview of perchlorate issues.

The success or failure of a treatment technology often depends on having a complete understanding of the nature and extent of the release. Site investigators start with a conceptual site model, which is gradually refined through sampling and other investigative techniques. Chapter 2 discusses this and other site evaluation issues.

A variety of remediation technologies are currently commercially available and are being used for perchlorate remediation. Most of these remediation technologies fall into two broad categories: physical and biological treatment processes. Chapter 3 discusses considerations for the selection of a particular remedy.

Perchlorate remediation system installation and operation could involve various local, state, and federal government departments. These entities might require compliance to various rules or permits that directly or indirectly involve the operation of planned remedial systems. Information regarding compliance with local, state, federal or tribal regulations to install and operate a perchlorate treatment system should be researched and obtained at the outset of a project to prevent unforeseen delays to treatment projects. Chapter 4 discusses regulatory considerations.

Physical treatment processes remove perchlorate from impacted media but do not alter its chemical composition. Considerable progress has been made in developing innovative physical processes for removing perchlorate from drinking water, groundwater, and surface water. Some technologies are proven and commercially available, while others are still in the research and development phase. Chapter 5 discusses physical processes for treatment of perchlorate-impacted water, including ion exchange, granular activated carbon, reverse osmosis, nanofiltration/ultrafiltration, electrodialysis, capacitive deionization, and electrolysis.

Ion exchange, the most proven and widely accepted physical process technology for perchlorate treatment, is a process by which ions of a given species are displaced from an insoluble exchange material by ions of a different species in solution. Perchlorate selective ion exchange targets perchlorate using conventional ion exchange resin beds with specially designed resins that preferentially remove perchlorate anions.

Biological degradation of perchlorate involves reducing bacteria, which are widespread in the environment. Perchlorate-reducing bacteria have the ability to grow in either the presence or absence of air, provided proper nutrients are available in the environment. Both in situ and ex situ biological treatment systems have been applied at full scale to treat perchlorate. Chapters 6 and 7, respectively, discuss in situ and ex situ bioremediation technologies for perchlorate in water.

Soil impacted with perchlorate can be treated using in situ bioremediation, ex situ bioremediation, and ex situ thermal treatment. Shallow soil can generally be treated in place or excavated and treated on site by bioremediation methods such as composting or intrinsic bioremediation. Excavated soils may also be treated using thermal desorption. Chapter 8 discusses remediation technologies for soil. Phytoremediation shows promise to treat both vadose zone soils and groundwater. Chapter 9 discusses phytoremediation and constructed wetlands. Cost-effective treatment of deeper occurrences represents an important challenge.

Most environmental sites affect local communities at some level. The federal government, states, and sovereign tribal nations regulate and/or mandate the participation of stakeholders in the investigation and remediation process. Remediation concerns common to all stakeholders typically relate to health issues, economic or monetary issues, inconvenience, and natural resource issues. Chapter 10 discusses stakeholder issues such as these.

Chapter 11 provides a comprehensive listing of references, and appendices are included for case studies, team contacts, and acronyms. Case studies include the Aerojet site in Rancho Cordova, California; the American Pacific Corporation site near Henderson, Nevada; and the Naval Weapons Industrial Reserve Plant in McGregor, Texas. These case studies document the remediation of perchlorate in soil and groundwater using a variety of technologies.