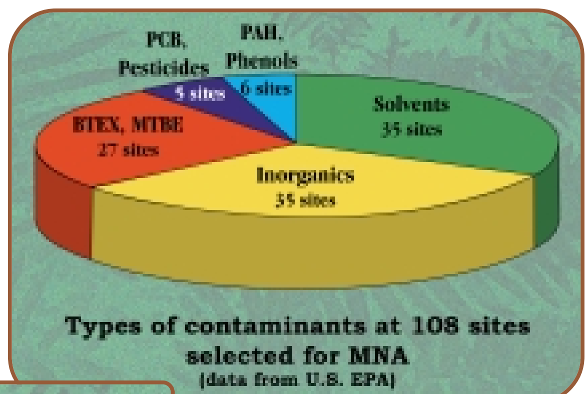
Monitored Natural Attenuation

A Cost-Effective Approach to Cleanup

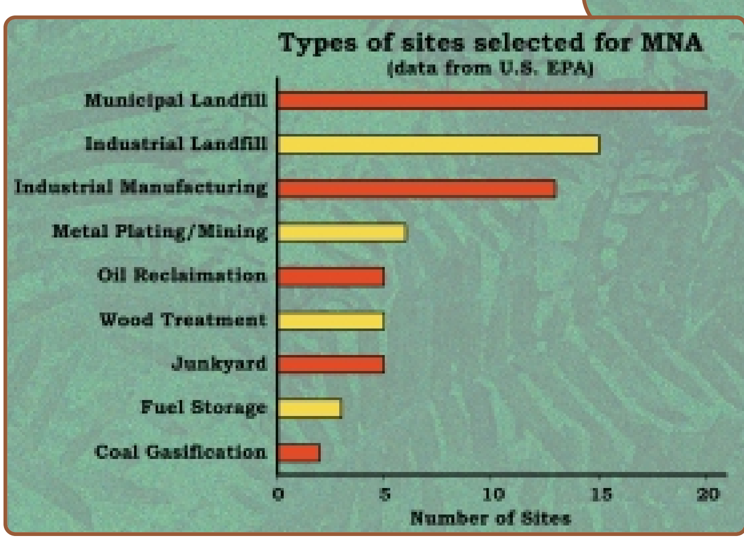
What is Monitored Natural Attenuation?

A variety of natural physical, chemical, and biological processes act to reduce the amount, toxicity, mobility and concentration of contaminants in the environment. Monitored natural attenuation (MNA) makes use of these processes to clean up contaminated soils and groundwater, thereby reducing levels of risk to human health and the environment. These processes include biological degradation, dilution, sorption to soil or aquifer particles, volatilization to the atmosphere, and chemical reactions with natural materials. For organic compounds, the preferred pathway is biodegradation, especially if this results in complete mineralization to CO_2. Organic contaminants present at sites that have been selected for MNA include pesticides, benzene and benzene derivatives (BETX) in gasoline, polycyclic aromatic hydrocarbons (PAH), and chlorinated solvents such as tetra- and trichloroethylene (PCE and TCE). Inorganic contaminants, such as metals, cannot be degraded but may be transformed into different chemical forms which are nontoxic or immobile, or are physically unavailable for uptake by organisms. For example, chromium (VI) is mobile in groundwater and, due to its carcinogenicity, presents a significant health risk. In subsurface environments depleted of oxygen, such as wetlands associated with floodplains, the oxidation state of chromium (VI) is reduced to chromium (III) which is significantly less toxic and, because it strongly binds to minerals, relatively immobile.



Types of contaminants at 108 sites selected for MNA
(data from U.S. EPA)

MNA is not a "do nothing" approach but rather requires comprehensive site characterization and implementation of an appropriate monitoring plan. MNA will often be considered as part of an overall clean-up plan that includes the use of active, or "engineered," treatment technologies to remove or contain the source of contamination at a site. In addition, studies must demonstrate that MNA will reduce the contaminant concentrations in the soil or groundwater to below regulatory limits in a reasonable time period. Determination of an acceptable time frame will be site-specific and depend on current and potential future activities at or near the site. It will also require that appropriate monitoring and institutional controls be maintained during the time necessary to achieve the cleanup goals. However, where MNA is deemed an appropriate clean-up strategy, it can provide significant cost savings and be less disruptive to the ecosystem, compared with engineered technologies.

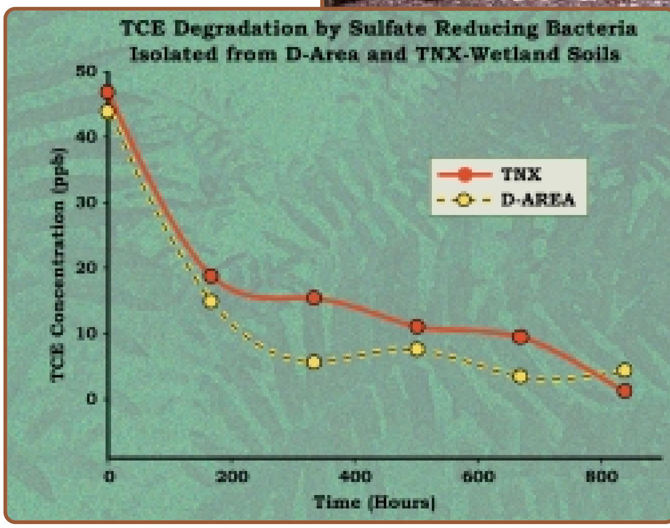


Types of sites selected for MNA
(data from U.S. EPA)

SREL Research on MNA

SREL researchers are studying natural attenuation processes in soil and groundwater at several contaminated areas on the Savannah River Site (SRS). TCE is a common groundwater contaminant on the SRS and elsewhere throughout the U.S. Iron and sulfate reducing bacteria were isolated from soils at D-Area and a wetland near the TNX facility. These bacteria are active in oxygen-deficient environments and use iron and sulfate instead of oxygen during respiration while simultaneously employing a process called co-metabolism to remove chlorine atoms from the TCE molecule. Through a series of subsequent reactions the TCE can be completely degraded. SREL scientists have determined the TCE degrading capabilities of these microorganisms and are now characterizing their genetic characteristics. Identifying these TCE-degrading bacteria in soils is one step toward demonstrating the feasibility of selecting MNA as an acceptable cleanup option for these contaminated sites.

SREL researchers are studying the applicability of MNA at an area near the TNX facility on the SRS that is contaminated with TCE (above). SREL research suggests that the action of TCE-degrading soil bacteria may be an essential component of MNA at such sites (left).



In other studies, SREL scientists have investigated the fate of diesel contaminants originating from leaking underground storage tanks at the Central Shops Area. Diesel hydrocarbons were extracted and analyzed from samples collected from subsurface sediments in the unsaturated region that lies between the surface soil and the water table, termed the vadose zone. The complex assemblages of diesel hydrocarbons in samples collected along the contaminant plume were characterized using gas chromatography-mass spectrometry and then compared to the analysis of the source material. Since bacteria degrade different hydrocarbons at very different rates, changes in relative concentrations of specific diesel components can be used to determine the degree to which the fuel has been degraded by microorganisms. Several of these diagnostic hydrocarbon markers had changed more than tenfold from the source region to the farthest extent of the plume. This change was interpreted as evidence of microbial degradation of the diesel fuel as it moves both downward and outward from the source.

The fraction of an inorganic contaminant, such as a metal, that is biologically available for uptake by plants and animals generally decreases over time because of natural chemical reactions, even though the total contaminant concentration in a soil or sediment remains constant. A challenge in implementing natural attenuation for inorganic contaminants is to understand the mechanisms underlying these natural reactions that physically or chemically bind contaminants in forms that are not biologically available. This understanding is important to accurately assess the potential for contaminant transport and bioavailability over a wide range of environmental conditions and over long periods of time. Furthermore, if these natural reactions are understood, it may be possible to manipulate environmental conditions using minimally invasive techniques to enhance the reactions and thereby facilitate natural attenuation. SREL researchers are studying the natural attenuation of various radionuclides and metals in contaminated soils and sediments on the SRS. Studies are focusing on the biogeochemical mechanisms involved in immobilization processes and how they affect the bioavailability, toxicity, and trophic transfer of contaminants. The information being generated will be useful for evaluating ecological risk and for suggesting when natural attenuation may be an appropriate remediation approach.

MNA promises to be a cost-effective and noninvasive approach for the cleanup of contaminated soils and groundwater. Ongoing research at SREL will contribute to the database necessary to determine sites for which MNA is an acceptable option.

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