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New Methods of Cleaning Up Heavy Metal in Soils and Water

Innovative solutions to an environmental problem

There are several options for treating or cleaning up soils contaminated with heavy metals. This paper discusses three of those methods.

Introduction

At many sites around the nation, heavy metals have been mined, smelted, or used in other industrial processes. The waste (tailings, smelter slag, etc.) has sometimes been left behind to pollute surface and ground water. The heavy metals most frequently encountered in this waste include arsenic, cadmium, chromium, copper, lead, nickel, and zinc, all of which pose risks for human health and the environment. They typically are spread out over former industrial sites and may cover acres of land. Figure 1 shows one such site in southwestern Missouri, near the city of Joplin. Here, mine spoils (locally called *chat)* cover much of the open space inside the city, and contain high levels of lead, zinc, and cadmium. Heavy metal contamination can be carried with soil particles swept away from the initial areas of pollution by wind and rain. Once these soil particles have settled, the heavy metals may spread into the surroundings, polluting new areas. Cleanup (or *remediation*) technologies available for reducing the harmful effects at heavy metal-contaminated sites include *excavation* (physical removal of the contaminated material), *stabilization* of the metals in the soil on site, and the use of growing plants to stop the spread of contamination or to extract the metals from the soil (*phytoremediation*).

Figure 1. Mine spoils called chat, near the city of Joplin, Missouri. Wind and rain can cause the chat to scatter, spreading heavy metal contamination.

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Excavation

Excavation and physical removal of the soil is perhaps the oldest remediation method for contaminated soil. It is still in use at many locations, including residential areas contaminated with lead in southwestern Missouri. Advantages of excavation include the complete removal of the contaminants and the relatively rapid cleanup of a contaminated site (Wood, 1997). Disadvantages include the fact that the contaminants are simply moved to a different place, where they must be monitored; the risk of spreading contaminated soil and dust particles during removal and transport of contaminated soil; and the relatively high cost. Excavation can be the most expensive option when large amounts of soil must be removed or disposal as hazardous or toxic waste is required (see Table 1).

Table 1. Comparative costs for different types of heavy metal soil remediation (Schnoor, 1997).

Type of Remediation	Cost/cubic meter	Time Required
Excavation and removal	$100-$400	6-9 months
In situ fixation (including soil amendments)	$90-$200	6-9 months
Phytoextraction	$15-$40	18-60 months

Stabilizing Metals in the Soil

Heavy metals can be left on site and treated in a way that reduces or eliminates their ability toadversely effect human health and the environment. This process is sometimes called *stabilization*. Eliminating the bioavailability of heavy metals on site has many advantages over excavation. One way of stabilizing heavy metals consists of adding chemicals to the soil that cause the formation of minerals that contain the heavy metals in a form that is not easily absorbed by plants, animals, or people. This method is called *in situ* (in place) fixation or stablization. This process does not disrupt the environment or generate hazardous wastes. Instead, the heavy metal combines with the added chemical to create a less toxic compound. The heavy metal remains in the soil, but in a form that is much less harmful.

One example of *in situ* fixation of heavy metals involves adding phosphate fertilizer as a soil amendment to soil that has high amounts of the heavy metal lead. Chemical reactions between the phosphate and the lead cause a mineral to form called lead pyromorphite. Lead pyromorphite and similar minerals called heavy metal phosphates are extremely insoluble. This means the new minerals cannot dissolve easily in water (Lambert et al., 1997). This has two beneficial effects. The minerals (and the heavy metals) cannot be easily spread by water to pollute streams, lakes, or other groundwater. Also the heavy metal phosphates are less likely to enter the food chain by being absorbed into plants or animals that may eat soil particles. Table 1 shows the cost of treating the soil by *in situ* fixation may be about half the cost of excavation and disposal of heavy metal contaminated soil. This method is relatively rapid and takes about the same amount of time as excavation.

Figure 2. Test plots for evaluating revegetation of chat material in Galena, Kansas. Here, tall fescue is being grown as a way of reducing sediment runoff and the spread of heavy metal pollution. The bare center plot is a control in which fescue was not planted.

Use of Plants

Growing plants can help contain or reduce heavy metal pollution. This is often called *phytoremediation* (EPA, 1988). It has the advantage of relatively low cost and wide public acceptance (Schnoor, 1997). It can be less than a quarter of the cost of excavation or *in situ* fixation. Phytoremediation has the disadvantage of taking longer to accomplish than other treatment . Plants can be used in different ways. Sometimes a contaminated site is simply revegetated in a process called *phytostabilization*. The plants are used to reduce wind and water erosion that spread materials containing heavy metals. In one example, grass or tree buffers could reduce sediment loss from the chat piles at a contaminated site in Galena, Kansas, anywhere from 18% to 25% (Green, et al. 1997). If all of the ground could be revegetated, sediment loss could be cut by approximately 70%. However, it would be necessary to find plants that could tolerate high levels of heavy metals. Figure 2 shows a series of several revegetation test plots on the chat piles in Galena, Kansas.

Another way plants can be used to clean up heavy-metal contaminated soil is called *phytoextraction*. Some plant species can take up heavy metals and concentrate them in their tissue. The plants can be harvested and the contaminated plant material disposed of safely. Sometimes soil amendments are added to the soil to increase the ability of the plants to take up the heavy metals. One type of plant used for this purpose is called Indian mustard. This plant has been used to extract lead from soil and reduce lead contamination at various contaminated sites. Other plants that may be used for phytoextraction include alfalfa, cabbage, tall fescue, juniper, and poplar trees.

Another way plants are used to treat heavy metal contamination is called *rhizofiltration* (EPA, 2000). In this method, heavy metals are removed directly from water by plant roots. The plants are grown directly in water or in water rich materials such as sand, using aquatic species or hydroponic methods. In field tests sunflowers on floating rafts have removed radioactive metals from water in ponds at Chernobyl, and other plants removed metals from mine drainage flowing through diversion troughs (EPA, 2000).

Plants used for phytoextraction may accumulate high concentrations of metals. Fences or other ways to limit access to people and animals, and disposal of plant matter as special waste is sometimes necessary.

Conclusions

During the 1990's, new methods have been developed to clean up heavy metal-contaminated soil. The expensive process of excavating and disposing contaminated soil has been augmented with new methods that treat the soil in place. In situ fixation is a process that creates new chemical coumpounds in which heavy metals are much less available to living things. This on-site cleanup is less disruptive to people's lives and to the environment compared to excavating and disposing contaminated soils elsewhere. Phytoremediation uses plants by several methods to contain or clean up heavy metals. Phytoremediation has the benefit of being a relatively low-cost, natural solution to an environmental problem.

More information on these and other new cleanup methods for contaminated soils and water is on the internet at many sites, including <http://www.clu-in.org/>.

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