BROOKHAVEN NATIONAL LABORATORY

TECHNOLOGY FACT SHEET

PECONIC RIVER REMEDIAL ALTERNATIVES

Phytostabilization

Introduction

Phytoremediation is the name given to technologies that use plants to clean up contaminated sites. Many techniques and applications are represented under phytoremediation. They differ in the way plants can remove, immobilize, or degrade contaminants, as well as the type of contaminants that plant species can target. For example, a process in which plants are used to immobilize metals and radionuclides in the soil (and thus minimize their mobility in water or dust) is called phytostabilization (described in this fact sheet). In another process, called phytoextraction, plants are used to take up contaminants from the soil and store them in harvestable tissue (described in a separate technology fact sheet).

Technology Description

Phytostabilization is the immobilization of a contaminant in soil through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants (see Fig. 1), and the use of plants and plant roots to prevent contaminant migration via wind and water erosion, leaching, and soil dispersion (USEPA, *Introduction to Phytoremediation*). Phytostabilization occurs through contaminant accumulation in plant tissue and in the soil around the roots because of changes in the chemistry of the contaminants, which become insoluble and/or immobilized on soil components. Insoluble contaminants are usually less toxic. Phytostabilization also refers to establishing a plant cover on the surface of the contaminated soil or sediment, which greatly reduces exposure of the soil or sediment to wind, water, and direct contact with humans or animals. Specifically, metal-immobilizing chemicals and plant species that are tolerant of higher levels of contaminants are used to decrease toxicity and enable the growth of vegetation over areas where contaminant concentrations are toxic to plants. The restored vegetation acts as a barrier to erosion and exposure of the contaminated soil. Native or introduced plant species may be utilized.

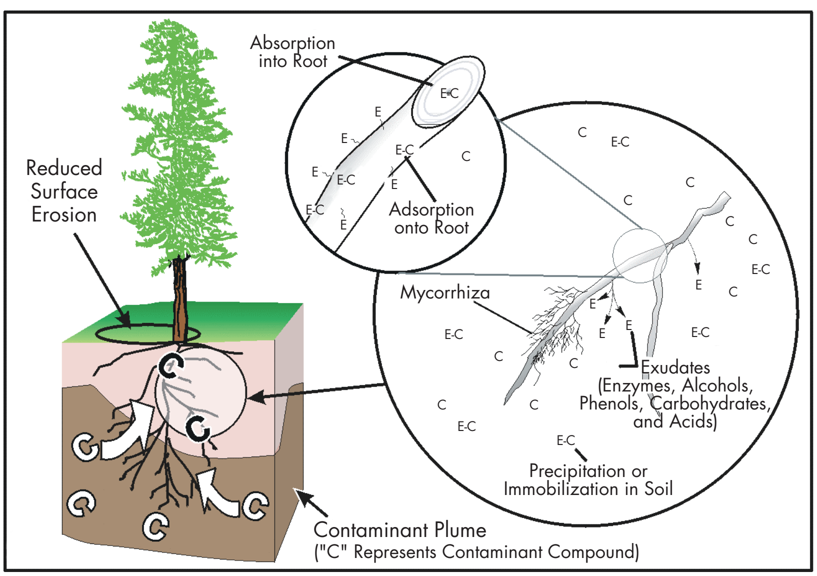

Figure 1. Phytostabilization of inorganics or organics.

Source: Phytotechnology Technical and Regulatory Guidance Document, Interstate Technology and Regulatory Cooperation Work Group.

How Does the Technology Work?

After a thorough study of the contaminant chemistry in the soil, the soil is "farmed": traditional fertilizers or specific products are used to improve soil conditions for plant growth and to reduce the chemical mobility and plant toxicity of the contaminants. In the Peconic River environment, these operations will be conducted while the sediment is dry, either during the summer dry season or by redirecting the river's flow around the area to be treated. Plant species are selected, based on local conditions and native flora, soil composition, and plant tolerance to the contaminants. After soil preparation, the selected species are planted, and their growth is closely monitored. If necessary, irrigation is provided, as well as supplemental fertilization and/or soil amendment. Success is achieved when a stable vegetative cover is developed, and the amounts of contaminants in the plant tissue and the mobile portions of metals in the soil are decreased to nontoxic or background levels. To reduce costs, waste-derived amendments of local origin—such as composted yard waste and/or biosolids, wood ash, log yard debris—may be used if they are compatible with the required functions.

The technology influences the contaminants' mobility in different ways:

- The amendments directly alter the soil factors that influence metal mobility (acidic or alkaline conditions, organic matter, oxygen levels);
- Proteins and enzymes are released by the roots into the adjacent soil, leading to precipitation and immobilization of the contaminants either in the soil or on the root surface;
- The contaminants are taken up by the plants and sequestered in the root system;
- The surface of the soil is vegetated, and the vegetation acts as a barrier for physical contact and to minimize erosion by wind and water.

A number of patents regarding specific plants and processes have been awarded to various companies that specialize in phytostabilization.

Advantages

- This technology (see Fig. 2) reduces the mobility, and therefore the risk, of inorganic contaminants without removing them from their location. This technology does not generate contaminated secondary waste that needs treatment.
- Compared with other remediation technologies, such as excavation, materials handling is limited (similar to that for agricultural processes), and costs are typically lower.
- Usually the technology enhances the soil fertility. It may combine treatment with ecosystem restoration.

Disadvantages

- The contaminants are left in place, so the site must be monitored perpetually to make sure the stabilizing conditions continue.
- If the contaminant concentrations are elevated, toxic effects may prevent plants from growing until extensive amendment application reduce their bioavailability to plants.
- If soil additives are used, they may need to be periodically reapplied to maintain the effectiveness of the immobilization.

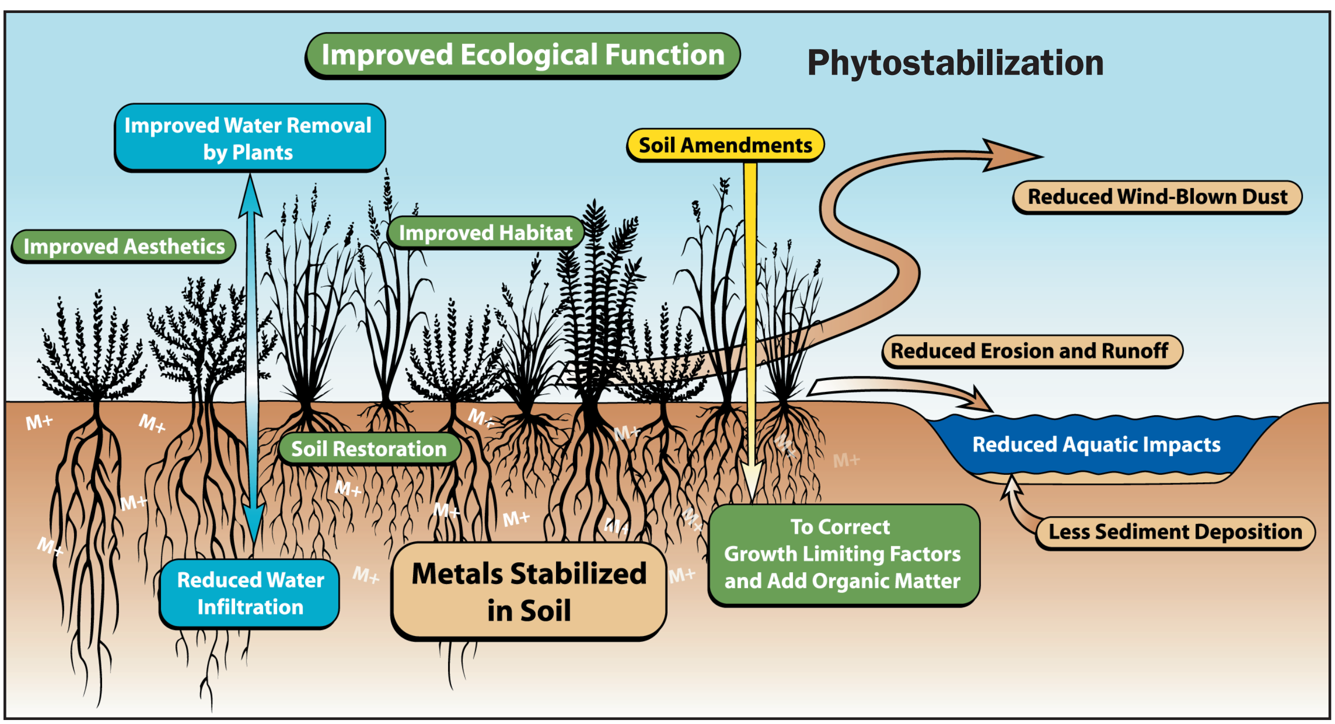

Figure 2. Benefits of phytostabilization.
Source: Pierzynski et al., 2001, Copyright Kansas State University

- Phytostabilization will not directly treat the organic contaminants (PCB, DDD). However, microbial activity associated with the plant roots may accelerate the degradation of these contaminants to non-toxic forms.
- Elevated water flow rates may erode applied amendments.

Relative Cost

Phytostabilization is typically less costly than excavation; however, actual costs depend on site-specific conditions (depth of contamination, soil condition, need for soil conditioning and tilling). On the basis of the Bunker Hill site (below), costs are estimated at about $3,000 per acre.

Maturity of the Technology

This technology has been applied in the field for many years. Original applications include the reclamation of mine spoil and of other huge expanses of land compromised by mining and landfilling operations. Although none of the contaminants present in the Peconic River have been phytostabilized in a real-case situation, there is sufficient scientific knowledge about the chemical behavior of these metals to hypothesize a successful deployment of this technology at the Peconic River. This technology has never been tested for the cleanup of PCBs and DDD, and has been tested only on a limited basis in wetland environments.

Project Histories

Bunker Hill in Idaho is a Superfund site where phytostabilization was tested in large-scale plots and in the adjacent wetland to decrease the phytotoxicity of lead, zinc, and cadmium from historic mining, in both upland and wetland environments, and to reestablish vegetation. In this case (see Fig. 3), log yard debris, biosolids compost, and wood ash were applied to the highly contaminated areas in 1997, enabling a plant community to be reestablished. Similar projects include the reclamation of a Superfund site in Palmerton, Pennsylvania, and the Whitewood Creek, South Dakota, Superfund site.

Performance Data

At the Bunker Hill site, vegetation was reestablished promptly in the treated area (indicating that the soluble metal levels had decreased to plant-acceptable values), while metals in the plants were within normal range. Soil analysis confirmed that the more soluble forms of the metals in the soil were decreased substantially. Non-treated plots did not record appreciable revegetation.

Potential Technology Applicability – Peconic River

Phytostabilization is considered less disruptive than excavation. In addition, its compatibility with the wetland environment and aesthetic factors make it a desirable choice. It is possible that the current mix of plants is stabilizing the contaminants to some degree. However, commercial phytostabilization techniques that include soil treatments may optimize the process. From the available information, it appears that contaminants are not present in the Peconic River at phytotoxic levels, thereby making the deployment of this technology relatively easier than in the cases mentioned above. However, the remedial design must address standing water during wet seasons and any significant floods.

Implementation Requirements

Infrastructure Requirements

The areas to be treated will need to be accessible to farm implements (tractors with tilling/plowing,

Figure 3. Bunker Hill, Idaho, site.

fertilizing, seeding, and harvesting equipment), at least during the dry season when the soil amendment and preparation activities will be performed. When the plants are still young, irrigation may occasionally be needed to supplement rainfall outside the wetlands area to encourage plant establishment.

Long-Term Remedy

In the long term, the area will look like a restored wetland/upland area.

Impact to Wetlands/Adjacent Areas

Phytostabilization can be used in wetland areas. Some temporary impact to the wetland is expected if this technology is applied, because some soil treatment will have to be performed. Plant composition may also be altered.

Site Restoration Requirements

The phytostabilized soil will be fertile and able to support the growth of plants and microflora. Phytostabilization may be incorporated into the final site restoration design.

Process Residuals Management

No process residuals are expected, except in the case of an occasional mowing. In any case, the aboveground biomass is not expected to have any significant concentrations of contaminants and, therefore, probably will not constitute a significant disposal issue.

Ability to Meet Site Closure Requirements

This ability must be determined by means of site-specific treatability studies. While the contaminants will not be removed, the technology is expected to lower the mobility of the contaminants to acceptable levels. A long-term monitoring plan will have to be carried out to ensure continuing effectiveness.

Need for Site-Specific Testing

Bench-scale or laboratory testing is likely to be necessary, especially if the wetland environment is to be integrated into the treatment process.

If the bench-scale test results are encouraging, pilot-scale or field testing can be conducted on contaminated areas where the technology would be applicable.

Both bench- and pilot-scale testing can be conducted within 18 months.

Need for Long-Term Monitoring

Phytostabilization implies that the contaminants are left in place. Therefore, long-term monitoring is necessary to make sure that the stabilizing conditions are maintained in the future.

Synergy with Other Technologies

Phytostabilization can be used in conjunction with wetland restoration or constructed wetlands technologies.

Resources

A Citizen's Guide to Phytoremediation, USEPA, Office of Solid Waste and Emergency Response, August 1998.

Introduction to Phytoremediation, USEPA, Office of Research and Development, EPA/600/R99/107, February 2000.

http://www.itrcweb.org/PHYTO2.pdf.

http://faculty.washington.edu/clh/wet.html.

Contact

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