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Soil Remediation

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Introduction

What is soil remediation? Over about 200 years ago, the Industrial Revolution has witnessed massive advances in human activity, industry and technology. While this has generally led to a higher quality of life for many people, it has unfortunately had undesirable consequences for the environment. The soil upon which buildings are constructed and in which our crops are grown is one such casualty of this phenomenon. When soil becomes contaminated with pollutants such as chemicals, heavy metals and hydrocarbons, it can affect the ecosystems, organisms and humans which depend upon for their survival.

There are variety of different ways like bioremediation, chemical oxidation, etc. Each of these uses a different approach the issue including heat, chemical application and filtration.

- Clean up remediation techniques to focus on boosting soil health by removing or destroying the contaminants themselves.
- Stabilization which is about stabilizing the health of the soil so as to prevent its condition from becoming any worse. It aims to immobilize and neutralize the contaminants so that they cannot infiltrate other patches of land or bodies of water.

Ex situ and in situ

Ex situ techniques involves the treatment of contaminated soil, away from the polluted site. *Ex situ* techniques involve land farming, biopile, windrow, soil washing, composting, bioreactor, ion exchange, adsorption/absorption, pyrolysis and ultrasound technology. These techniques can be successfully applied for the treatment of fuel hydrocarbons, halogenated and non-halogenated organic compounds as well as for various pesticides.

In-situ remediation is a method of breaking down and purifying hazardous substances present in soil and groundwater. It possesses the following characteristics:

- It is a simple method, involving nothing more than the impregnation of subsurface soil with nutrients that activate microorganisms.
- It is a low-cost method in comparison to excavation and removal.
- It is a method that can be applied even to soil located directly underneath buildings or at working factory sites, where excavation is difficult.
- It is a method that has little environmental impact, with no need to remove and transfer contaminated soil.

Classification of the remediation technologies

A. Physical Remediation:

The physical remediation mainly includes soil replacement method and thermal desorption. The former relies on the use of clean soil to fully or partly replace the contaminated soil with the aim of diluting the pollutant concentration and increasing the soil environmental capacity for the remediation *(Qian and Liu 2000; Zhang et al. 2001).*

The soil replacement method is also classified into three types:

(1) **Soil Replacement**: It consists of replacing the contaminated soil with new soil. This method is suitable for treatment of small-scale contamination.

(2) **Soil Spading:** It consists of deeply digging the contaminated soil, inducing the pollutant spread into the deep sites to achieve dilution and natural degradation.

(3) **New Soil Importing**: It consists of adding a large amount of clean soil into the contaminated soil, covering the surface (or mixing) to reduce pollutant levels.

These techniques either remove risk by chemically degrading hazardous substances or achieve stabilization of the contaminants within the bulk matrix by breaking pollutant linkages.

According to *Hseu et al. (2014),* thermogravimetric method heating to 550 °C for a duration of 1 h was an effective approach for Hg removal. With the employment of thermal treatment, up to 99% of Hg could be removed.

B. Chemical Remediation

Chemical remediation involves the use of chemicals to extract or stabilize pollutants in contaminated media. There are several chemical remediation methods including

1). Chemical leaching (soil washing): It consists of washing the contaminated soil with fresh water, reagents, and fluids (or gas) to leach pollutants from the soil. Soil washing is cost-effective because it can reduce the quantity of material that would require further treatment (by another technology). A new soil washing practice combined with on-site wastewater treatment was also introduced by Makino *et al*. (2007*).*

2). Immobilization techniques (solidification/stabilization vitrification, and the electrokinetic method):

Chemical fixation is adding reagents or materials into the contaminated soil to form insoluble or hardly movable, low toxic matters; it can thus decrease the migration of heavy metals to water, plant, and other environmental media *(Zhou et al. 2004)*. If the soil immobilization technique is employed, simplicity and rapidity (besides high public acceptability) will be achieved. This method is relatively inexpensive, while covering a broad spectrum of inorganic pollutants. However, as in situ immobilization is only a temporary solution (contaminants are still in the environment), the activation of pollutants may occur when soil physicochemical properties change. Hence, the reclamation process should be applied only to the surface layer of the soil (30–50 cm), and permanent monitoring is necessary *(Martin and Ruby 2004; USEPA 1997).*

Different kinds of the immobilization techniques are summarized below:

Solidification/Stabilization:

Solidification and stabilization refer to a group of clean-up methods that prevent or slow the release of harmful chemicals from wastes, such as contaminated soil, sediment, and sludge. Solidification binds the waste in a solid block of material and traps it in place. This block is also less permeable to water than the waste. Stabilization causes a chemical reaction that makes contaminants less likely to be leached into the environment. They are often used together to prevent people and wildlife from being exposed to contaminants, particularly metals and radioactive contaminants

Vitrification:

Vitrification is the rapid cooling of liquid medium in the absence of ice crystal formation. The solution forms an amorphous glass as a result of rapid cooling by direct immersion of the embryos in a polythene (PE) straw into liquid nitrogen. Vitrification is a simple and less expensive alternative to conventional freezing.

Electrokinetic Remediation:

Also termed electro kinetics, is a technique of using direct electric current to remove organic, inorganic, and heavy metal particles from the soil by electric potential. The use of this technique provides an approach with minimum disturbance to the surface while treating subsurface contaminants.

C. Phytoremediation.

Phytoremediation basically refers to the use of plants and associated soil microbes to reduce the concentrations or toxic effects of contaminants in the environment. Phytoremediation is widely accepted as a cost-effective environmental restoration technology.

Phytoremediation is an alternative to engineering procedures that are usually more destructive to the soil. Phytoremediation of contaminated sites should ideally not exceed one decade to reach acceptable levels of contaminants in the environment. Phytoremediation is, however, limited to the root-zone of plants. Also, this technology has limited application where the concentrations of contaminants are toxic to plants. Phytoremediation technologies are available for various environments and types of contaminants. These involve different processes such as *in situ* stabilization or volatilization or extraction of contaminants.

Phytostabilization: It involves the reduction of the mobility of heavy metals in soil. Immobilization of metals can be accomplished by decreasing wind-blown dust, minimizing soil erosion, and reducing contaminant solubility or bioavailability to the food chain.

Phytovolatization: It involves the uptake of contaminants by plant roots and its conversion to a gaseous state, and release into the atmosphere. This process is driven by the evapotranspiration of plants.

Phytoextraction: It uses the ability of plants to accumulate contaminants in the aboveground, harvestable biomass. This process involves repeated harvesting of the biomass in order to lower the concentration of contaminants in the soil. Phytoextraction is either a continuous process (using metal hyperaccumulating plants, or fast-growing plants), or an induced process (using chemicals to increase the bioavailability of metals in the soil).

D. Biological Remediation:

Bioremediation is a technology that uses microorganisms to treat contaminants through natural biodegradation mechanisms (intrinsic bioremediation) or through the enhancement of such capacity with the addition of microbes, nutrients, electron donors, and/or electron acceptors (enhanced bioremediation) *(EPA 2001)*. The microorganisms cannot degrade or destroy the heavy metals but can affect the migration and transformation by changing their physical and chemical characterizations.

Bioremediation is vulnerable to variables such as temperatures, oxygen, moisture, and pH value. Its applications can also be limited to some microorganisms that can only degrade special contaminants. Also, the treatment time is typically longer than that of other remediation technologies *(FAQs 2012)*.

What if contaminated soil is not treated?

When soil becomes contaminated with pollutants that becomes unsafe for cultivating crops or supporting human or animal life, it must be remediated. Failed to do so will result in the land becoming barren and unusable which will pose an even larger problem as the population of the globe continue to increase.It could have even more undesirable consequences in the shape of water contamination. Overtime, these pollutants can leach into groundwater and subterranean aquifers. It can also potentially endanger drinking water as well. So, strict precaution should be taken.

Conclusion

One of the best approaches to polluted soil remediation is the prevention of soil pollution. The best remediation methods must be determined after completing necessary laboratory studies, considering the specialties of pollutants, hydrogeologic properties of the polluted areas and economic feasibilities of the remediation methods *(Ozturk, 1989; Kocaer and Baskaya, 2003)*. It is imperative to increase the studies on prevention and remediation of soil pollution and prepare administrative rules for its prevention. A national program must be prepared to find out the best remediation methods. Projection, application, evaluation, control, observation and coordination of collaboration mechanisms of natural resources must be improved. The misuse of agricultural land and forest areas must be prevented. Inventory studies are necessary for recording, observation and remediation of the polluted areas.

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