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Soil Contamination and Various Remediation Methods

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Various types of pollutants are emitted as a result of rising global industrialization, inflicting significant harm to all life forms (Quintella *et al.*, 2019). Pollutants including crude hydrocarbons, heavy metals, and pesticides harm the environment and devastate ecosystems. In humans, there is a danger of cancer and mutagenesis, as well as other negative outcomes (Kuppusamy *et al.*, 2020). To restore the functionality of the contaminated environment for both environmental preservation and urban expansion, contamination sites must be remedied. There are three types of soil remediation methods:

• Chemical,
• Physical,
• Biological

The latter is done either on the spot (on the spot) or outside of the polluted area (ex situ). Phyto- and bioremediation are two bioprocesses that have recently gotten a lot of interest since they are ecologically friendly, can quickly remove a variety of pollutants, and are very inexpensive when compared to current treatments (Kumar *et al.*, 2018) (Soleimani *et al.*, 2018). Bioremediation techniques are natural processes that may biodegrade a wide range of toxins, including persistent pollutants, and hence can be a viable and successful way of soil pollution mitigation. The most suitable and feasible in-situ or ex-situ biological remediation procedures will be found after preliminary evaluations of the environmental conditions, type of pollutant soil composition, removal costs, and time available for treatment. The most crucial stage in accomplishing successful bioremediation, on the other hand, is characterisation of the polluted site. Surfactants and biosurfactants stand out among other choices in remediation operations because they can reduce interfacial and surface tensions while also speeding up biodegradation in polluted soils.

Soil Contaminants

Persistent hazardous chemicals, chemical compounds, radioactive wastes, salts, or diseases that have a negative impact on biological processes and persist in the soil are known as soil contaminants (Okrent 1999) (Mareddy 2017). As a result, increased levels of hazardous substances in the soil, especially due to heavy metals, pesticides, and petroleum derivatives, affect ecosystem balance and human health (Palansooriya *et al.*, 2020). When a pollutant strikes the soil, it can be deposited, transported away by wind and runoff, or leached into groundwater by infiltration water that passes through the lower layer (CETESB). The following are among the most common sources of soil contamination:

- Agriculture residues
- By products
- Air pollutants
- Irrigation

- Accidental oil spills
- Inadequate management of municipal waste and sewage
- Heavy metals
- Hydrocarbon deposition
- A study of soil pollution in Europe found that many countries have long lists of polluted sites and are concentrating their efforts on remediation studies, with heavy metals and mineral oils being the most common pollutants. (Van Liedekerke 2018).
- In agriculture, lower agricultural production, reduced soil fertility and nitrogen fixation, increased soil erosion and nutrient depletion, sludge storage, and an imbalance between plant and animal life in the soil.
- Soil composition and microflora changes, as well as land availability or productivity for crops meant for human consumption.
- Trash management challenges and public health hazards, such as contaminated drinking water in cities.

In general, the main sources of soil contamination in Worldwide are summarized as follows

Petroleum Derivatives	Exploration, production, refining, transport and consumption.
Chemical war	Contaminants, toxic chemical compounds, and ground contamination from cold war army operations.
Urban source	Energy generation, emissions, soil pollution by transportation and manufacture, soil contamination by residues and sludge from waste water treatment.
Agrochemical source	Insecticides, herbicides, fungicides, pesticides and fuel spills on farms.
Biological warfare	Bacteria, viruses, fungi and toxins.

Heavy Metals

Heavy metals, which are found naturally in rocks, can be found in all types of soils, even ones that aren't contaminated, in varying levels depending on the position and wear of the rocks that carry them (Ashraf 2014). Lead (Pb), cadmium (Cd), chromium (Cr) (only the Cr (VI) form is dangerous), mercury (Hg), nickel (Ni), copper (Cu), zinc (Zn), and the semimetal arsenic (As) appear to have no metabolic role and are harmful to humans and animals (Hembroom *et al.*, 2020). Increased heavy metal concentrations in soils and their harmful effects on humans are caused by manufacturing, metallurgy, mineral extraction, farming, and fuel combustion, as well as improper disposal of heavy metal-containing materials such as municipal waste, paints, electronic waste, and waste water (Gupta 2020).

Remediation Methods

Bioremediation

- The employment of biological processes to degrade, convert, or essentially remove pollutants from soil and water is known as bioremediation. Microorganisms such as bacteria and/or fungi use the pollutant as a food source in this process. As a result, bioremediation is commonly employed to remove organic pollutants and can be an efficient method of reducing:
- Hydrocarbons
- halogenated organic solvents
- halogenated organic compounds
- non-chlorinated pesticides and herbicides

- nitrogen compounds
- metals (lead, mercury, chromium)
- radionuclides

Often, bioremediation presents a more economic option to disposal, however it can take anything from one to several months to carry out.

Chemical oxidation

Chemical oxidation is a type of chemical decontamination in which reactive chemical oxidants are injected into the soil and groundwater to destroy contaminants quickly and completely. In situ chemical oxidation (ISCO) is a versatile approach for removing contaminants from difficult-to-reach locations, such as deep soils or soils beneath buildings. Chemical oxidation has numerous applications, including the treatment of organic pollutants such as TPH, BTEX, and PCBs.

Soil stabilization

By successfully trapping toxins in the soil, stabilisation decreases the possibility of contamination. It can be accomplished in two ways: first, by changing the contamination in the ground to a less harmful form, and second, by solidification, which reduces the contaminant's mobility and binds it in place, preventing it from reaching any receptors. The addition of immobilising chemicals to the soil reduces the leachability and bioavailability of pollutants. Due to stronger resistance and reduced permeability, this technique can also be utilised to improve the geotechnical competency of the ground, making it more acceptable for construction operations.

Soil washing

By washing the soil with a liquid wash solution, dangerous pollutants are removed. Fine-grained soils, such as silts and clays, are washed away during this process, along with pollutants that are more likely to bond to fine soils. As a result, contaminated particles are separated from cleaned coarse-grained soils, such as sands and gravels, which can be reused safely. Because soil washing does not kill or remove toxins, contaminated soil must be disposed of in a licenced facility.

Phytoremediation

Phytoremediation is the technique of cleaning contaminated land and water by planting trees and other plants. Phytoremediation has become more cost-effective and feasible than traditional remediation approaches for a wide range of polluted sites, thanks to recent advances in plant microbiology, while providing communities with a host of co-benefits inherently offered by trees—shade, carbon sequestration, watershed health, and wildlife habitat.