Phytoremediation

B.S. Kherawat[1], Rachna Singh[1], Ashish Ojha[2], Rajesh Kumar[1] and Sushil Kumar[3]

[1]Central Soil Salinity Research Institute, KARNAL (HARYANA) INDIA
[2]Directorate of Wheat Research, KARNAL (HARYANA) INDIA
[3]Department of Agricultural Chemistry and Soil Science, C.C.R. (P.G.) College, MUZAFFAR NAGAR (U.P.) INDIA

Phytoremediation (*phyto* meaning "plant" and remedium, meaning "restoring balance") describes the treatment of environmental problems. Phytoremediation is the use of green plants to remove pollutants from the environment or render them harmless. In natural ecosystems, plants act as filters and metabolize substances generated by nature. The term "phytoremediation" is relatively new, coined in 1991. Many plants such as mustard plants, alpine pennycress, hemp, and pigweed have proven to be successful at hyperaccumulating contaminants at toxic waste sites.

Process of phytoremediation:

Phytoremediation consists of mitigating pollutant in contaminated soils, water, or air and plants able to contain, degrade, or eliminate metals, pesticides, solvents, explosives, crude oil and its derivatives. A range of processes mediated by plants or algae are useful in treating environmental problems:

– *Phytoextraction* — uptake and concentration of substances from the environment into the plant biomass.

– *Phytostabilization* — reducing the mobility of substances in the environment, for example, by limiting the leaching of substances from the soil.

– *Phytotransformation* — chemical modification of environmental substances as a direct result of plant metabolism, often resulting in their inactivation, degradation (phytodegradation), or immobilization (phytostabilization).

– *Phytostimulation* — enhancement of soil microbial activity for the degradation of contaminants, typically by organisms that associate with roots. This process is also known as *rhizosphere degradation*. Phytostimulation can also involve aquatic plants supporting active populations of microbial degraders.

– *Phytovolatilization* — removal of substances from soil or water with release into the air, sometimes as a result of phytotransformation to more volatile and/or less polluting substances.

– *Rhizofiltration*— filtering water through a mass of roots to remove toxic substances or excess nutrients. The pollutants remain absorbed in or adsorbed to the roots.

Phytoremediation groundcovers:

Phytoremediation ground covers are widely used application and have been applied at various remediation projects. Phytoremediation ground covers are vegetated systems applied to surface soils, which refers to phytoremediation systems for deep soils and groundwater. The range of phytoremediation ground covers is about 30-60 cms below ground surface while the depth is 1.5 meters. These groundcover systems can also be used as certain types of landfill covers that also promote the degradation of the underlying waste. These have been referred to as bioreactor landfills. Phytoremediation groundcovers have been widely applied to soils impacted with recalcitrant compounds such as PAHs, PCBs.

Phytoremediation in agriculture:

Phytoremediation play an important role in agriculture. The waste materials which are generated from the industries along with the required material are buried inside the soils which are toxic for the soils. The farmers grow their crops in these areas, due to these toxic materials inside the soil the productivity of the crops is affected. These pollutants even make the land unproductive. To solve these problems phytoremediation is the major application. By planting more tress these contaminated pollutants can be removed.

Plants are used to clean up, or remediated, contaminated sites. To remove these pollutants from soil and water, plants firstly break down these organic pollutants and then stabilise metal contaminants by acting as filters or traps. The root of the plants provides an enormous surface that absorbs and accumulates the water and nutrients essential for growth as well as other non-essential contaminants. Phytoremediation involves growing plants in a contaminated matrix, for a required growth period, to remove contaminants from the matrix, or facilitate immobilisation (binding/containment) or degradation (detoxification) of the pollutants. The plants can be subsequently harvested, processed and disposed.

Use of trees in place of smaller plants is more effective in removing deeper contamination as the roots of the trees penetrate more deeply into the ground. Plant roots also cause changes at the soil-root interface as they release inorganic and organic compounds (root exudates) in the rhizosphere. These root exudates affect the number and activity of the microorganisms, the aggregation and stability of the soil particles around the root, and the availability of the contaminants. Root exudates, by

themselves can increase (mobilise) or decrease (immobilise) directly or indirectly the availability of the contaminants in the root zone (rhizosphere) of the plant through changes in soil characteristics, release of organic substances, changes in chemical composition, and/or increase in plant-assisted microbial activity.

Some plants used for phytoremediation are:

– Alfalfa - symbiotic with hydrocarbon-degrading bacteria

– Transgenic *Arabidopsis* - carries a bacterial gene that transforms mercury into a gaseous state

– Bamboo family - accumulates silica in its stalk and nitrogen as crude protein in its leaves

– Indian mustard (*Brassica juncea*) - accumulates selenium, sulfur, lead, chromium, cadmium, nickel, zinc, and copper

– Chinese ladder fern (*Pteris vittata)* - accumulates arsenic Cottonwood (with added *E.coli* gene) – accumulates mercury

– Tomato and alpine pennycress - accumulates lead, zinc and cadmium

Advantages and limitations:

Advantages:

– The main advantage of phytoextraction is environmental friendliness.

– Phytoremediation is cost effective as compared to in-situ and ex-situ bioremediation.

– Plants are easy to grow and it's easy to monitor them.

– It is the least harmful method as it used natural occurring organism and preserves the environment.

– This process make re-use of valuable metals.

Limitations:

– Phytoremediation is limited to the surface area and depth occupied by the roots.

– It is not suitable completely to prevent the leaching of contaminants into the groundwater.

– Due to the toxicity of the contaminated land, the survival of the plant is difficult.

– Bio-accumulation of contaminants, especially metals, into the plants which then pass into the food chain, from primary level consumers upwards or requires the safe disposal of the affected plant material.

– As this process is controlled by plants, it takes more time than anthropogenic soil clean-up methods.

Future of phytoremediation:

Breeding programs and genetic engineering are powerful methods for enhancing natural phytoremediation capabilities, or for introducing new capabilities into plants. Genes for phytoremediation may originate from a micro-organism or may be transferred from one plant to another variety better adapted to the environmental conditions at the cleanup site. For example, genes encoding a nitroreductase from a bacterium were inserted into tobacco and showed faster removal of TNT and enhanced resistance to the toxic effects of TNT. Some natural, biodegradable compounds, such as exogenous polyamines, allow the plants to tolerate concentrations of pollutants 500 times higher than untreated plants, and to absorb more pollutants.

Conclusion:

Phytoremediation is considered a clean, cost-effective and non-environmentally disruptive technology, as opposed to mechanical cleanup methods such as soil excavation or pumping polluted groundwater. Over the past 20 years, this technology has become increasingly popular and has been employed at sites with soils contaminated with lead, uranium, and arsenic. However, one major disadvantage of phytoremediation is that it requires a long-term commitment, as the process is dependent on plant growth, tolerance to toxicity, and bioaccumulation capacity.

Phytoremediation is an alternative or complimentary technology that can be used along with or, in some cases in place of mechanical conventional clean-up technologies that often require high capital inputs and are labour and energy intensive. Phytoremediation is an in situ remediation technology that utilises the inherent abilities of living plants. It is also an ecologically friendly, solar-energy driven clean-up technology, based on the concept of using nature to cleanse nature.

* * * * *