POLLUTION OF SOIL ECOSYSTEMS–SOURCES, IMPACT AND MANAGEMENT

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Soil Pollution

- Generally refers to the entry of organic and inorganic chemicals into the soil body resulting in adverse effects on one or several components of our environment and/or disrupting one or several essential processes of ecosystem

Entry of pollutants to the soil

- Some of the pollutants are constituents of extensively used agrochemicals like fertilizers (e.g. Cd through phosphatic fertilizer), herbicides & pesticides (e.g., Zn,Cu, Sn, Hg, organic pollutants) etc. enter the rhizosphere of the soil when used as inputs for increasing agricultural production.
- Heavy metals and other xenobiotics (Chemicals foreign to a biological system) are added to soil through municipal solid waste compost or sewage sludge composts used as organic manures .
- Pollutant chemicals enter the soil body from industries as effluents and emissions from several industries, power plants, vehicles, radioactive and toxic chemical fallouts during disasters.
- Gas-dust releases into the atmosphere under high temperature technological processes (e.g. power plants, metal smelting, the burning of raw materials for cement, etc.), waste incineration and fuel combustion.
- Polluted surface water and groundwater add several harmful chemicals into the soil body when used as irrigation source

Adverse effects of pollution on soil ecosystem

- Soil structural breakdown
- Loss in crop productivity due to deterioration of rhizosphere environment
- Loss in produce quality due to elemental imbalance in edible plant parts
- Adverse effect on health of animal and human beings due to food chain contamination
- Loss in soil biodiversity
- Adverse impact on socioeconomic condition of people

Kinds of pollutants in soil

Heavy metals

- Sources of heavy metal contaminants include metalliferous mining and smelting, metallurgical industries, sewage sludge treatment, warfare and military training waste disposal sites, fertilizers and electronic industries (Alloway 1995).
- Some phosphate,micronutrient fertilizers, and liming materials contain elevated levels of As, Cd, and Pb)
- Phosphate rock contain small amounts of heavy metal contaminants like Cd
- Municipal solid waste compost and sewage sludges are the main organic manures having heavy metal contaminants

- Saha et al. (2010) reported high concentration of heavy metals (Cd,Cr, Cu, Pb, Ni and Zn) in composts from mixed municipal solid wastes in many cities of India
- Heavy metals accumulate in soil with repeated application of compost
- Cd is the heavy metal of most concern because of its adverse effect on human health.
- Heavy metals of possible significance in soil are arsenic (As), chromium(Cr), lead (Pb), mercury (Hg), nickel (Ni), and vanadium (V)

Salt Accumulation

- Many industries like textile mills, paper mills, tanneries, electroplating ,and agro-industries release high amount of salts in soil and water bodies through effluents.
- Salts have high mobility (particularly Na and Cl) through soil, and also been found to contaminate groundwater in and around the industrial area.
- Considerable portion of such salts contaminate agricultural land when salt loaded effluents, surface water and groundwater are used for irrigating crops, degrading soil structure and decreasing crop productivity

Organic Pollutants

- Organic pollutants polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs),
- Persistent organic pollutants (POPs) have adverse effect on human beings like kidney and liver damage, jaundice (due to PAH); cancer, adverse effects on immune system, reproductive system, nervous and endocrine system (PCBs, POPs}
- Contamination of crop plants and microbes with known toxic organic contaminants is negligible

Pesticide contamination of soil and its impact

- Pesticides are organic pollutants as some of them are carcinogens and have adverse effect on nervous system, endocrine systems, eye, skin etc.
- Impair biodiversity in the soil because they do not just kill the intended pest but often kill many of the other small organisms.
- Due to the limited bioavailability of the pesticides in soil rich in clay and organic carbon content no adverse effects of pesticides on microbial cycling of C, N and S in soil have been reported
- Integrated Soil Management should include strategies for the rapid degradation and minimizing the bioavailability of POPs in soil so as to protect food from contamination

Management Strategies For Polluted Soils

Regulating entry of pollutant into soil

- Entry air borne pollutants in soil is difficult to control,
- Farmers and farm input manufacturers can take several measures to minimize pollution of land resources.
- Manufacturing phosphatic fertilizers from low heavy metal containing mineral materials can reduce Cadmiumd contamination in soil.
- Preparing composts from source separated biodegradable municipal solid wastes can significantly reduce heavy metal entry and enhance productivity of agricultural land.
- Safe limits for heavy metal in India which can protect soil microbes, plant and animal have to be worked out
- Information on maximum permissible levels in farm input materials (like sewage-sludge, MSW compost, P fertilizers etc.) for different pollutants for different agro ecological situations are required in the quality control protocol for land resources

Decontamination of polluted site using physical and chemical methods

- Most of the chemical and physical treatments, however, are costly and irreversibly affect soil properties, destroys biodiversity and render the soil unfit as a medium for plant growth

Bioremediation

- Involves the use of microbes for remediation of heavy metal contaminants
- The bioremediation and biotransformation methods endeavor to harness the astonishing, naturally occurring, ability of microbes to degrade, transform or accumulate a huge range of compounds
- In recent years genomic, manipulations to tailor microbes for specific situations in soil contamination are possible
- Exploring and utilizing the vast soil biodiversity potential for bioremediation of contaminated soils is the need of the hour

Phyto remediation

- Plants and their associated rhizosphere microorganisms are used to remove various pollutants from contaminated soils, sediments, groundwater and surface water.
- Plants are used to treat many classes of contaminants, including petroleum hydrocarbons, chlorinated solvents, pesticides, metals, radionuclides, explosives and excess nutrients.
- The plants used in Phyto remediation / phyto degradation are generally selected on the basis of their growth rate and biomass, the depth of their root zone, their potential for evapo transpiration of groundwater and their ability to tolerate and bio accumulate particular contaminants
- Some naturally occurring plants, termed metallic hyper accumulator plants, can accumulate 10–500 times higher levels of elements than crops.
- Plant parts are then harvested and the incinerated plant ash can be disposed as hazardous matter in specialized dumps

- Resistant plants are usually located growing on soils with underlying metal ores or on the boundary of polluted sites.
- Once a tolerant plant species has been selected, traditional breeding methods are used to optimize the tolerance of a species to a particular contaminant.
- The use of phyto remediation is limited by the soil type, climatic and agroecological conditions of the site to be cleaned.
- It takes longer than other technologies and the formation of vegetation may be limited by the extent of contamination
- Plants for phyto remediation have to be selected based on soil type, level of contamination in soil, climate etc.
- Soil management methods such as the application of fertilizers, chelators, and pH adjusters can be utilized to further improve the potential for phyto remediation.

Crop/Cropping system modification

- Vegetable crops, particularly spinach, lettuce with high metal uptake capacity have be avoided in metal polluted soils.
- Non-edible crops like flowering plants, fibre crops, agroforestry aids protection of food chain from contamination.

Management of salt polluted soils

- Integrated soil management should include different strategies to reduce salt ions in the rhizosphere include *in situ* rainwater conservation, subsurface drainage, organic manure incorporation, enriching Ca in the exchange sites through gypsum/lime application and growing salt tolerant crops
- Soil moisture conservation measures like mulching to reduce capillary rise of salts.
- Lime application reduce the adverse impact of metal pollution as high pH favors sorption and precipitation as oxides, hydroxides, and carbonates
- Use of different industrial byproducts like basic slag, red mud has also showed their capacity to reduce heavy metal availability in soil by raising pH and providing surface area for sorption
- Organic manure (specifically humus) forms complexes with metals owing to its high content of anionic functional groups having chelating ability and reduces the availability of metals to plant in cases of high contamination level.

Reference

Rajesh Kumar Mishra, Naseer Mohammad and N. Roychoudhury, 2005, Soil pollution Causes, effects and control, Van Sangyan Vol. 3, No. 1


Thank You