Indian J. Applied & Pure Bio. Special Vol. 2(1): 314-319 (2021). **ISSN: 0970-2091**
National e-Conference on Biodiversity Building and Natural Resource Management (NC BBNRM) Date: 22nd-23rd, December, 2021 **A web of Science Journal**

Plants for Soil pollution Control: A Review

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Abstract

Environmental pollution is the abnormal change and catastrophe of the environment and its components as a result of human activities. Soil pollution is a serious issueamong all types of environmental pollution as it is associated with health risks via the food chain. Several managements or methods have been taken for preventing soil pollution. The process of soil purification through trees is the most acceptable and eco-friendly and how the plants help to prevent soil pollution and its methods are discussed below.

Soil, the upper layer of the Earth, is the main and natural medium for plant growth. It is composed of minerals (45%), organic matter (4%), soil water (25%) and soil air (25%). It is the most important natural resource that helps us to survive. But several human activities such as industrialization, urbanization, wrong disposal methods of waste materials, including radioactive wastes, use of additional chemical fertilizers, the inappropriate use of plastic materials are speeding the process of soil contamination. Heavy metals, petroleum hydrocarbon, herbicides, pesticides, asbestos, plastics, chemical fertilizers, radioactive waste, waste materials are the main pollutants for soil contamination. Soil pollution is a major problem for us because polluted soil has adverseeffects on the environment and the health of living beings.It is very important to prevent soil pollutionto maintain the balance of the environment.Preventing soil contamination is essentialto protect the health of living beings. And in this case,the contribution of trees in preventing soil pollution is undeniable.

Soil pollution control methods using plants:

A. There are several ways to lowersoil pollution followed in the agricultural system.

i) ***Crop rotation:*** It helps to increase soil fertility, reduce soil erosion and improve soil structure. It also reduces soil-bornepathogens, nematodes and weeds[19]. Three successive corn crops (*Zea mays*)

recover fertilizer N in the soil[17]. Corn, sorghum, forages and winter cover crops, legumes are used in this process.

ii) ***Strip cropping :*** It is the other method to conserve soil and boost soil fertility in which cropsparticipates in the nitrogen fixation. In the temperate regions, alternatingstrips of corn and soybean/ dry beancrops are cultivated to reduce soil erosion on hilly areas and enhance the soil fertility[6].

iii) ***Using of plant-based green manure instead of chemical fertilizers:*** Different plant leaves such as neem (*Azadirachta indica*), indigo (*Baptisia australis*), milkweed (*Calotropis procera*), Agati (*Sesbania grandiflora*)are used to make green manure and this type of organic manure increases soil fertility, improve soil structure and control soil erosion. Moreover, green manure decontaminates hexachlorocyclohexane isomers in the soil[5].

B. ***Afforestation :*** It plays a major role in controlling all types of environmental pollution. Recent research shows that in an afforestation plot, five tree species (*Pinus koraiensis, Larix gmelinii, Pinus sylvestris* var. *mongolica, Pinus tabuliformis* and *Populus* spp.) have the potential to neutralize soil pH [10]. Afforestation helps in decreasing soil pH in alkaline-based areas and to increase soil pH in acidic soil regions[10]. Planting trees also helps to prevent soil erosion and enhance soil fertility. It is a sustainable soil management technique. Litter decomposition of plant materials in the forest returns nutrients in the soil and act as natural fertilizer of the soil. Litter decomposition plays a key role in the carbon and nutrient cycling of the forest ecosystem.

C. ***Phytoremediation-a plant-based approach:*** Plants are used to take outpollutants from the soil. The root system of plants plays a significant role in the accumulation of heavy metals from the soil and reduce the detrimental effects of heavy metals in the soil. There are various strategies of phytoremediation method for heavy metals polluted soil:

i) ***Phytoextraction :*** Fast-growing commercial crop Tobacco (*Nicotiana tabacum*) is used in the phytoextraction process and has the ability to accumulate heavy metal cadmium (Cd) in a high volume of their leaves[25]. Several plant species such as *Ipomea alpina, Rumex acetosa, Commelina communis, Aeolanthus biformifolius* are the hyperaccumulator of copper (Cu) and some arable and vegetables can extract Cu from contaminated soil[15]. More than 400-500 plant species such as *Arabidopsis, Thalaspi and* plants from Brassicaceae, Fabaceae, Poaceae, Cyperaceae are the hyperaccumulators of heavy metals[8].

ii) ***Phytostabilization :*** In this method, metal tolerance plants are used to reduce thebioavailability of heavy metals in the soil. *Miscanthus giganteus* (sterile hybrid of *M. sinensis and M. sacchariflorus*) is good for the phytostabilization of cadmium (Cd) and

Mercury (Hg) of the soil[26]. In Mexico, *Euphoria* sp (Euphorbiaceae) and *Schinus molle* L. (Anacardiaceae) has the potential to stabilize Cu, Cd, Zn, Mn, Pb metals in the soil[9]. *Typha latifolia* L. (Typhaceae) stabilises Selenium (Se) metalloid[2]. *Brassica carinata* (Brassicaceae) reduce the bioavailability of As, Cd, Cu, Pb and Zn in the soil[11].

iii) ***Phytovolatilization:*** Here plants are used to take up heavy metals from the soil and release them into the atmosphere in a volatile form. Alfa alfa (*Medicago sativa*) participates in the phytovolatilization process[16]. Common reed (*Phragmites australis*) is able to volatilize 1,4-dichlorobenzene, γ-hexachlorocyclohexane and 1,2,4- trichlorobenzene[21]. Beech seedlings (*Fagus sylvatica*) shows nitrous oxide emission[18]. *Pteris vittata* plant is a good phytovolatilizer of mettaloids arsenic (As)[20]. Recent research shows that rice plant has the potential of phytovolatilization of 2,4-dibromophenol (2,4-DBP) and 2,4-dibromoanisole (2,4-DBA)[28]. CYP2E1 transgenic plant of *Petunia hybrida* is able to remove benzene and toluene pollutants[28].

iv) ***Phytodegradation :*** Here plants degrade organic pollutants in the soil. It can occur inside the plant or rhizosphere regions. *Pueraria thunbergiana,* a terrestrial plant is able to phytodegradep,p'-DDT and enantiomers of o, p'-DDT [7]. In petroleum contaminated soil, cockspur coral tree (*Erythrina crista-galli*) shows phytodegradation potential[4].

v) ***Rhizodegradation:*** In this type of phytoremediation, rhizosphere region plays a vital role to degrade contaminants with the help of plant roots and microbial communities. The contaminant, petroleum oily sludge (a mixture of organic compounds and inorganic metalloids) is rhizodegraded by rhizosphere region of *Cajanus cajan* (pigeon pea) which increases the soil microbial ogranisms[1]. In hydrocarbon contaminated soil, rhizosphere of rye grass (*Lolium perenne* L.) shows degradation activity[12].

Soil pollution cause various diseases or health problems both directly and indirectly. It is a major problem because soil pollution has adverse effects on food security, cropyield and food quality. Soil polluted by heavy metals is harmful to living organisms and decreases the activity of soil microorganisms which are beneficial for plant growth. There are several methods to mitigate soil pollution. But using plants for soil pollution control is the best and sustainable way. Several crops are associated with the phytoremediation process to remove heavy metals and organic contaminants from the soil. It is necessary to identify sources and type of soil contaminants because human health is tightly linked via the food chain[22]. Terrestrial plant such as *Azadirachta indica* can accumulate copper, lead, zinc, chromium, manganese[13]. Through phytostabilization process metal tolerant plants decrease bioavailability of heavy metals and therefore reduce the chances to enter toxic materials into the plant body (used as food) and also in the food chain[14,24] (Table-1).

Table-1. Role of plants in controlling soil pollution

Plant	Method	Functions	Reference
Zeamays L.	Crop rotation	Increase soil fertility by recovering fertilizer N in the soil.	Olsen *et al*.,[17]
Corn and soybean	Strip cropping	Reduce soil erosion in hilly areas and enhance soil fertility.	Francis *et al*.,[6]
Green manure using plant materials	Organic farming	Decontaminates hexachlorocyclohexane isomers in the soil.	Ferreira and Raghu[5]
Pinus koraiensis, *Larix gmelinii*, *Pinus sylvestris var. mongolica*, *Pinus tabuliformis* and *Populus*	Afforestation	Neutralize soil pH.	Hong *et al*.,[10]
Plant leaves	Litter decomposition	Control carbon and nutrient cycle in forest ecosystem.	Cornwell e*t al.*, 2008
Nicotiana tabacum	Phytoextraction	Accumulate heavy metal cadmium (Cd) in their leaves.	Yang *et al*.,[25]
Aeolanthus biformifolius	Phytoextraction	Accumulate copper (Cu)	Napoli *et al*.,[15]
Miscanthus giganteus	Phytostabilization	Phytostabilization of cadmium (Cd) and Mercury(Hg) of the soil	Zgorelec *et al.*,[26]
Typha latifolia	Phytostabilization	Stabilize Serenium (Se)	Azaizeh[2]
Brassica carinata	Phytostabilization	Reduce bioavailability of As, Cd, Cu, Pb and Zn in the soil.	Irtelli *et al.*,[11]
Phragmites australis	Phytovolatilization	Volatilize 1,4-dichlorobenzene, γ-hexachlorocyclohexane and 1,2,4- trichlorobenzene	San Miguel *et al*.,[21]

Pteris vittata	Phytovolatilization	Phytovolatilizer of mettaloid arsenic	Sakakibara *et al*.,[20]
Petunia hybrida	Phytovolatilization	Remove benzene and toluene pollutants.	Zhang *et al*.,[28]
Pueraria thunbergiana	Phytodegradation	Phytodegradep,p'-DDT and enantiomers of o, p'-DDT.	Garrison *et al*.,[7]
Erythrina crista-galli	Phytodegradation	Phytodegradation potential in the petroleum contaminated soil.	De Farias *et al*.,[4]
Cajanus cajan	Rhizodegradation	Rhizodegrades pollutants in the petroleum oily sludge soil.	Allamin *et al*.,[1]
Lolium perenne	Rhizodegradation	Rhizodegradation potential in hydrocarbon contaminated soil.	Johdahl *et al*.,[12]

Using plants is the most effective way to control soil pollution. This is a one type of sustainable soil management.We need to remember that pollutant-free soil gives us healthy food and ensure food security. It is the responsibility of all of us to keep the soil pollution free in order to build a safer world for future generations.

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