

# *Phytoremediation potential of contaminated soils using native plants: A review*

[Uma Sakthivel and G. Swaminathan]

**Abstract**— Green remediations of soils are highly contaminated with toxic elements can be achieved by suitable plants. Such phytoremediation techniques are considered for remediating the toxic concentrations in plants and not produced biomass. Therefore, the main objective of the present study reviews the phytoremediation potential approaches applicable to the contaminated soil using native plants in Tiruchy location. The major toxic contaminants are heavy metals and other contaminants released through wastewater disposing of them in a soil stratum. The native plants are *Azadirachta indica* *Scirpus grossus* and *Sorghastrum nutans* L. growing in the locality. The native plants are possibly used to improve the absorption capacity of soils especially concerning heavy metals. This review paper covers the roles and potential role of native plants in the phytoremediation of contaminated soils. It has also reviewed recent research work on the efficiency of *Azadirachta indica* *Scirpus grossus* and *Sorghastrum nutans* L. in soil remediation and identified areas for further studies in phytoremediation processes for wastewater.

**Keywords**— contaminated soils; phytoremediation; stabilization; native plants; heavy metals

## I. Introduction

As per data identified by CPCB, the critically polluted industrial areas, and the cluster or potential impact zone are based on its Comprehensive Environmental Pollution Index (CEPI) rating. Forty-three critically polluted zones were reported within the 16 states, which have a CEPI rating of quite 70. Among these 43 sites, 21 sites exist in only four states namely Gujarat, Uttar Pradesh, Maharashtra, and Tamil Nadu. Soil health assessment survey Department in India The research conducted on contamination of soil with heavy metals in the impact zone. From the survey, highly polluting activities are happening in the country.

Soil contamination is one of the major problems in the world. Especially, contaminated soil in India requires immediate remediation. Contamination with toxic elements (TEs) in the soils becomes a serious threat to human health due to intensively increasing agricultural and industrial activities, as well as disturbances of natural ecosystems. Even though TEs are natural components of soil, anthropogenic activities such as the application of agrochemicals, sewage sludge, manure, wastewater irrigation, etc. have accelerated their accumulation in soils [1]. Accumulation of TEs causes severe health issues in humans and other living organisms in the soil. TEs are non-biodegradable which are different from organic pollutants, and are highly determined in soils [2]. Therefore, the remediation of TEs-contaminated soils remains particularly challenging in the present scenario. Phytoremediation is a technique that uses plants for

remediation of polluted soils recommended as a cost-effective technology for remediation of polluted soils under selected conditions. Besides, Phytoremediation is utilized for stabilizing the soils in the contaminated zones. Plants yield the ability to takeup contaminants and accumulate the organic and inorganic materials into the roots, which purify the soil stratum around the locations. However, phytoremediation of TEs in arid and semi-arid soils has certain limitations including low bioavailability of TEs, low soil fertility, water and nutrient deficiency, soil salinity, and sodic conditions. For the practical service of this phytoremediation, the first step is the evaluation of soil contamination risk analysis and determination of the objectives for remediation [3]. This paper reviews the phytoremediation potential applicable to contaminated soils using native plants present in the locations. Furthermore, the limitations against phytoremediation of TEs from the soil stratum were discussed. Finally, the various strategies to overcome these limitations and to improve the phytoremediation of TEs from the soil stratum were also addressed.

## II. Role of native plants in phytoremediation of contaminated soils

Contaminated soils have different inorganic substances which will alter their natural balance and heavy metals are the foremost represented. There's no universally accepted definition of heavy metals supported on the physicochemical properties, but they are so defined if they need characteristics like ductility, conductivity, ligand specificity, and an atomic number greater than 20 [4]. Metals are natural constituents of the soil, but their presence has exponentially grown since the start of the economic revolution [5]. Heavy metals are naturally occurring throughout the earth's crust, but several heavy metals, like Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Lead (Pb), Nickel (Ni), Zinc (Zn), and therefore the metalloid Arsenic (As), are widely used by industries, agriculture and consequently released into the environment [6]. Some of the samples of pollutants released into the environment are the wastewater from tanneries, transporting various malodorous chemical substances containing hydrogen sulphide, ammonia, and chromium, widely utilized in the tanning industry [7]. Similarly, several metals are also released into the environment by the petrochemical industry and vehicle traffic. Figure 1 shows the representation of contaminants transferred into the soil stratum and its applications of phytoremediation potential on soils.



Figure 1. Phytoremediation potential of soil Stratum

### III. Findings

Bioremediation, as reported by the US EPA (2001), is defined: —Use of living organisms to wash up oil spills or remove other pollutants from soil, water, or wastewater; use of organisms such as non-harmful insects to get rid of remove agricultural pests or counteract diseases of trees, plants, and garden soil (US EPA, United States Environmental Protection Agency). Azubuike et al. 2016 [8] has defined bioremediation as —the process whereby organic wastes are biologically degraded under controlled conditions to an innocuous state or levels below concentration limits established by regulatory authorities. This activity are often administrated by several microorganisms like bacteria and fungi, which are capable to enzymatically degrade organic pollutants and a few of the terrestrial and aquatic plants, are capable to remove pollutants from the soil or water by absorption through the roots and further accumulation into the leaves. Microorganisms of particular species can interact with plants through several biochemical pathways to form the remediation process even more proficient. There is wide diversification of bioremediation techniques that are developed in recent years; these techniques are summarized in Table 1 [9].

TABLE I. FOR METHOD OF BIOREMEDIATION CONTAMINATED SOILS

Method of bioremediation	Principles of remediation	References
Natural attenuation	Natural presences in the soil of native microorganisms can degrade the organic and inorganic contaminants.	[10]
Bioaugmentation	Addition of non-native microorganisms able to degrade the contaminants resistant to the action of the native microbiota.	[11]
Biostimulation	Nutrient addition promotes the growth and development of native microorganisms to increase their metabolic activity and elevates the degradation of the contaminants.	[12]
Bioleaching	Utilize specific microorganisms for promoting solubilization of the metals by soil.	[13]
Biofilters	Application of bacteria in bio-filters used for the decontamination of polluted water, sludge treats with wastewaters, or landfills.	[14]
Biopiling	Materials processed by nutrient accumulation over an aerated system.	[15]
Biosorption	Adsorption of metals and certain ions present in an aqueous solution of polluted soil by using ion-exchange resins (biological materials).	[16]
Bioventing	Remove volatile compounds and, oxidative degradation of organic contaminants by providing ventilated system.	[17]
Phytoremediation	Utilize plants extract to sequester or detoxify soil or aquatic environments by inorganic and organic pollutants.	[18]
Landfarming	Soil is arranged in piles and regularly revolved to agricultural practices to stimulate microorganisms degradation.	[19]
Composting	Nutrient addition to the polluted soil along with forced aeration for microbial activation.	[20]
Rhizoremediation	Microbial feed on rhizosphere promotes both the growth of the same plant and degradation of the contaminants.	[21]

However, the attention focused on phytoremediation and therefore the different techniques included during this review. Currently, this phytoremediation is an attractive technique among stakeholders worldwide either for its application in soil remediation, for its ability to improve waste management of related issues. It is the reason because contamination of the environment involves serious risks and it has an impact on human health Viz many pollutants are carcinogenic, mutagenic, teratogenic, and harmful to the nervous and endocrine systems, particularly in children[18]. Different physical and chemical methods have been used to restore the various matrices, however with many limitations, because the traditional methods are expensive, they require excessive processing and cause changes in the soil properties, disturbing the native microflora. Phytoremediation is proposed as a relatively recent technology with sustainable costs.

Phytoremediation processes use green plants, including herbs (e.g. *Thlaspi caerulescens*, *Brassica juncea*, *Helianthus annuus*) and woody (eg. *Salix spp*, *Populus spp*) species, because of the capability to remove,

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uptake, or render harmless various environmental contaminants like heavy metals, organic compounds and radioactive compounds in soil or water, thanks to their transport capacity and accumulation of contaminants [22]. Moreover, phytoremediation prevents excavation of contaminated sites, reduces the risk of contaminants dispersion, and it is applicable for the decontamination of sites with various pollutants [9]. Mechanisms and efficiency of the phytoremediation depend on several factors such as the nature of contaminant, bioavailability, soil properties, plant species [2]. The plants considered more efficient in phytoremediation processes are the so-called —hyperaccumulatorl. These plants can tolerate and accumulate metals present in the soil, but they have a low production of biomass [18]. The extraction efficiency of the pollutants also depends on the biomass produced by the plant: the ability of plant biomass to uptake a big quantity of metals but it will require more harvests to remove the plants. Consequently, the number of harvests will determine the total cost of the entire operation, including disposal, incineration or composting of biomass [1].

Phytoremediation has some disadvantages such as slowness of the process, the affected area of the land is next to the root, several species cannot be planted in places strongly polluted, but it is applicable at various types of remediation treatment represented by (i) provides aesthetic value through plant cover and, (ii) Requires Labour. Biomass harvested can be used in the field of renewable energies like biofuel production that reduce waste disposal [9]. The cost of phytoremediation is very low compared to the resources required for the use of conventional technologies (Table 2) such as vitrification of contaminated soil at high temperatures, excavation and conferment of the soil in a landfill, soil washing with water and solubilizing agents, electrochemical separation, solidification through use of stabilizing agents [9]. Figure 2 represents the contaminants absorbed by plants [23].

TABLE II. DIFFERENT APPROACHES OF PHYTOREMEDIATION

Techniques	Explanation
Phytoextraction	Pollutants are absorbed by the roots, transported and accumulated in the shoots and leaves.
Phytostabilization	Pollutants are immobilized in the root system and it reduces their mobility.
Phytovolatilization	Pollutants are converted in less toxic forms and released into atmosphere.
Phytodegradation	Plant enzymes degrade organic contaminants.
Phytodesalination	Removal of salts from salt-affected soils through halophyte plants.
Rhizodegradation	Degradation of pollutants in the rhizosphere through rhizospheric microorganisms.
Rhizofiltration	Removal of pollutants from surface water or wastewater by adsorption or precipitation.

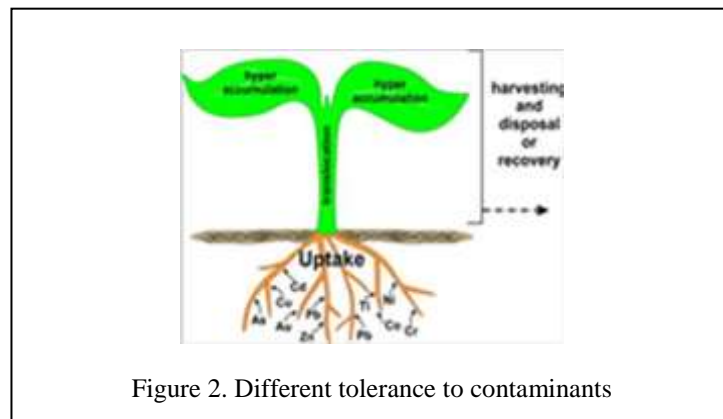


Figure 2. Different tolerance to contaminants

#### iv. Conclusions

Phytoremediation is a promising technique empowered by the removal or recovery of excess nutrients from polluted waste sources. The appliance of native plants in the phytoremediation of soil is beneficial due to the tremendous capacity to absorb and degrade pollutants from the contaminated soils. In this review the phytoremediation techniques confirm the recovery of contaminated soils by metals and organic substances were reported. Conventional methods have a better removal efficiency of contaminants, the times of application are shorter than the phytoremediation, but they are costlier and alter the characteristics of both soil and groundwater. Instead, phytoremediation can be a worthy alternative to standard physicochemical methods (excavation and landfilling, washing, vitrification, electrochemical separation) due to its cleanliness and economically feasible by using this method. Furthermore, Phytoremediation provides paybacks, and the product biomass can be employed again for cogeneration of energy and production of biofuels, after removing the extracted contaminants; the metals recovered after the incineration of the plants may become the raw material for industrial processes. Furthermore, additional benefits are often obtained by genetically modified plants to maximize the purification efficiency concerning to a particular contaminant.

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