Review Article

iMedPub Journals
www.imedpub.com

Trends in Green Chemistry
ISSN 2471-9889

2021
Vol.7No.1:1

Phytoremediation: An Overview

Iqra Tabassum*

Department of Biology, Lahore Garrison University, Lahore, Pakistan

***Corresponding author:** Iqra Tabassum, Department of Biology, Lahore Garrison University, Lahore, Pakistan

Received date: February 4, 2021; **Accepted date:** February 18, 2021; **Published date:** February 25, 2021

Citation: Tabassum I (2021) Phytoremediation: An overview Treands in Green ChemVol.7

Abstract

The serious implication for human health and the environment is metal pollution which comes from the anthropogenic activities. Heavy metal pollution have the severe effect on health of the ecosystem including animal, plants and human health which may cause many harmful diseases like cardiovascular diseases, anemia, cancer, kidney failure etc. To overcome this pollution remediation technologies play a vital role and helps to remediate metals by applying different remediation technologies like chemical, physical and biological methods but all these technologies have many drawbacks and is not ecofriendly. Among all the remediation techniques Phytoremediation is one of the effective, safest and the most innovative tools to remediate heavy metals. It is a green technology with good public perception. Phytoremediation includes its types which are Phytoextraction, Phytodegradation and Rhizofilteration. This review article explains Phytoremediation and its types.

Keywords: Heavy metals; Immobilization; Phytoextraction; Phytodegradation; Rhizofilteration

Introduction

One of the serious concern in most of the countries is contaminated soil and water which contaminated by heavy metals. Heavy metals which includes copper, chromium, cadmium, lead nickel and zinc are the important environmental pollutants .These heavy metal contamination comes from anthropogenic activities i.e., by human activities which includes the industrial wastes and it damages our environment, soil, water, plants and animals etc.[1]. Heavy metals cause much toxicity around the world. According to a report that is released by U.S. environmental action group, the world's most polluted and contaminated places threaten the health of more than 10 million people in many countries [2]. The contaminated soil is a great challenge for industrial, agriculture and urban territories. Traditionally for disposal of heavy metal wastes, soil has been used which require treatment to get rid of metal contaminant. Conventional methods of heavy metals have been used currently but it is very expensive and is not environmental friendly.

When plants are grown in contaminated soil which contains metals and it uptake metals from soil which is harmful and when humans or animals eat that plant they may become ill and many major health risks occurs that is related with heavy metals which includes chronic anemia, heart disease, cognitive disorders, cancer, kidney failure, nervous disorders, osteoporosis and many other harmful diseases [3]. Thus, the land where metals are present that land is not suitable for the growth of plants and destroys the biodiversity. Many metals are important also, whereas; every metal is harmful or toxic when they are present in high concentration because at higher concentration they cause oxidative stress by the formation of free radicals. The other reason of metal toxicity is that they can replace important metals in enzymes or pigments which destroy or disrupt its function [4]. Organic contaminant can be degraded or removed by soil microorganisms while metal contaminants require immobilization or physical removal of metals from soil. So metals can only be absorbed, removed or degraded by organisms and cannot be degraded or decomposed by bacteria. There are two limitations to use bacteria for heavy metals; the biomass of bacteria is small and heavy metals absorption capacity is small.

Although there are many regulatory steps which have been used so that release of pollutants in soil should be restricted or reduced but this is not sufficient to control metal contaminants in soil. To overcome these problems different approaches are used like biological, physical and chemical methods. These methods are used to remediate or to clean the soil for about last 20 years. These approaches have many drawbacks i.e., these approaches are labour intensive, costly, time consuming, may disturb the indigenous microflora, and may also changes the physiochemical properties. These approaches are used but it is not effective at all. It is very difficult to reduce the health risks but it is only possible by the removal of heavy metals from the soil.

To overcome all the limitations the safest method to remediate heavy metals from soil is Phytoremediation [2]. Use of living green plants to fix, inhibit or adsorb contaminants and clean the contaminants from soil is known as Phytoremediation. In this method we basically use natural products to reduce the contamination, it also remediate the soils, sludge's, sediments and contaminated water by organic and inorganic contaminants. Phytoremediation is green or clean technology which is used to remediate heavy metals naturally or by using genetically

modified plants. On the basis of economic imputations, the focus of Phytoremediation can be on three stages: (1) extraction of metals on the basis of plants with financial benefit i.e. Ni, Tl;

(2) risk mitigation(phytostabilization); and

(3) sustainable soil management in which Phytoremediation gradually raises soil fertility allowing for follow up crop growth with added economic value. This method is most effective, ecofriendly, have low cost, not labour intensive, and have high public acceptance, it also increases the soil fertility and efficacy without damaging the soil. It easily reduces the metal contaminants from soil.

On the basis of different uptake mechanisms Phytoremediation is divide into different modern technologies which includes; phytoextraction, phytodegradation, phytostabilization, phytovolatilization and rhizofilteration. This article presents an overview of types of Phytoremediation for heavy metals removal in contaminated soils.

Sources of Metal Pollution

The primary causes of heavy metal pollution are geological and anthropogenic activities. Anthropogenic activities may include metal pollution, including toxic waste, fuel processing, mining, smelting processes, military operations, use of agricultural chemicals, small-scale industries such as battery manufacturing, metal goods, metal smelting and cable industry, brick kilns, and coal combustion [4]. Municipal waste also constitutes one of the main sources of heavy metal pollutants. Such waste is further used as landfills for irrigation purposes while sewage water is used. This waste also contains some nutrients which is useful for plants and may also contain some toxic materials. Some other sources of metal contaminants are the use of chemical fertilizers, pesticides and fungicides which are unsafe to use and also banned to some extent, biofertilizers are used in place of it. Firing bullets contains heavy metals and when armed forces fire in firing ranges than the nearby soil also contains the these heavy metals. Bullets mostly contain Pb with other metals such as arsenic, antimony and nickel **(Figure 1).**

Figure1: Shows the sources of metal pollution in the soil.

Five Main Subgroups of Phytoremediation

Phytoextraction

Phytoextraction is also known as phytoaccumulation, phytoaborption or phytosequestration. It is the process in which plants are used to transfer, absorbs or store toxic contaminants from soil matrix into the tissues of roots and shoots and it degrades contaminants, mainly heavy metals from soil and water which may be harmful to other organisms. Phytoextraction can be performed by those plants that can uptake low level of pollutants but due to the high growth rate and biomass production they may remove the contaminants from soil. Migration of metals to shoots is of great importance for biochemical processes that are suitable for successful phytoextraction as it is usually not possible to harvest root biomass [5].

Hyperaccumulators plants are capable of accumulating phytotoxic elements of concentration of about 100 times than those found in non-accumulators. It works on the principle of Phytoextraction so that is why it is of great importance. Hyperaccumulators are capable of removing metals from polluted soil and returning the soil to less toxicity. There are about 500 species of flowering plants which have the hyperaccumulative ability for example Arabidopsis and Brassicacae specie have hyperaccumulative ability.there are different keypoints to select hyperaccumulator plant for phytoextraction:in lower concentration a plant should have higher accumulation efficiency on heavy metals; ii) it should accumulate higher content of heavy metals in that part of plant which is easy to harvest; iii) the plant should have ability to combat against diseases and pests; iv) plant should have the ability to grow faster and have high biomass; v) it should have the ability to accumulate or extract different kinds of heavy metals; vi) it should be ecofriendly and cost effective. Shen et al. (1998) used Thlaspi caerulescens J and C Presl to uptake Zn, Cu, Mn and Fe from solution, and proved that T. caerulescens is a hyperaccumulator for Zn.

Phytodegradation

Phytodegradation is the mechanism in which we use plants to store, absorb and degrade pollutants in their tissues. Phytodegradation is also known as phytotransformation in which contaminants are breakdown within the plants by metabolic process which happens in plants, or breakdown of contaminants at the sides of plants by different enzymes which catalyzes or accelerate degradation. There are some organic pollutants which is useful for the plant growth. Such organic compounds are firstly broken down into simpler form and then incorporated within the plant tissues which increase the plant growth.

Phytostimulation/Rhizodegradation

Phytostimulation is also known as rhizodegradation. In this method rhizosphere is associated between the symbiotic soil microbes and plants to degrade the contaminants. This approach may also enhance biodegradation of the rhizosphere, plant-assisted bioremediation or rhizodegradation[29]. The degradation of pollutants in the soil with increased microbial activity in the plant's root zone also known as rhizosphere. Microbial activity may be stimulated in rhizosphere by several methods:

Compounds such as carbohydrates, amino acids, enzymes and acetates which are exuded by roots containing indigenous microbes.

Oxygen is carried by root system to rhizosphere which ensures aerobic transformation.

Mycorrhizal fungi can degrade organic pollutants that cannot be converted by bacteria due to specific enzyme pathways.

Root biomass increases the availability of organic carbon.

Plants are increasing the habitat and behavior of the microbial communities

Phytovolatilization

Phytovolatilization is plants ' ability to remove the contaminants from the growth matrix and to convert or volatilize the pollutants into the soil. In this process contaminants are released in the atmosphere in volatile form through the process of transpiration. This process occurs as plants consume or absorbs water and toxins from organic matter [14]. As water flows from the roots to the leaves along the plant vascular network that is adjusted and modified along the way. In this way some of the pollutants pass into the leaves through the plants, and then volatilize or evaporate into the atmosphere. This method is primarily used to remove mercury and selenium from soil, which is converted into less toxic metals.

As long as this method is only used to volatile pollutants but there are certain limitations for this method which is that when the pollutants volatilizes into the atmosphere it may cause health problems in humans and wildlife. So this method should be used carefully. However there should be some proper equipment developed so that before the toxic heavy metal is releasing into air it would collect the volatile toxic contaminant in them so that health of humans and wildlife should be safe. As far as, it may make it effective to remove volatile metals from the soil.

Rhizofilteration

Rhizofilteration comes from the word rhizo means roots and filtration means to filter and is also known as phytofilteration. Rhizofilteration includes the use of roots for processing or extracting pollutants from aqueous growth matrix or filtering pollutants from groundwater, surface water and wastewater by roots to remove contaminants. Contaminated water contains many toxic substances like heavy metals which are very harmful to human health and causes many fatal diseases such contaminants must be removed so that living organisms should be get rid of all these contaminants. This method uses large surface area and uses uptake capacity. Its mechanism is similar to phytoextraction. The suitable material for phytofilteration is aquatic, wetland and terrestrial plants. Reed beds are one of the possible methods to use phytofilteration to remove heavy metals from waste water.

Phytostabilization

Phytostabilization limits the strength or mobility of heavy metals in soil. This method immobilizes the metals into the soil matrix which may reduce the bioavailability of soil. Metals can be immobilised by decreasing the dust that can be blown by wind, reducing soil erosion, and lowering contaminant solubility or bioavailability to the food chain. By incorporating soil modifications, such as organic matter, alkalizing agents, phosphates, and biosolids that reduce the solubility of metals in soil and prevent leaching to groundwater. Plants and some additive substances are used by Phytostabilization to decrease mobility, toxicity and bioavailability of pollutants. Thus, phytostabilization is not a hopeful way to remediate heavy metal pollution **(Table 1).**

Technique	Description
Phytoextraction	In the harvestable part of the plant heavy metals are deposited i.e. shoots
Phytodegradation	Associated plants and microbes degrade the organic contaminants
Phytostabilization	The plant roots reduce the mobility and bioavailability of rhizosphere contaminants
Phytovolatilisation	The contaminants are converted into volatile form and released its subsequent into the atmosphere

Table 1: Summary of Phytoremediation technique.

Impact of Phytoremediation

Heavy metals are toxic materials which have harmful impact on plants and other living organisms. The metal contaminated soil has three plant strategies for growth:

Metal excluders

Metal excluder avoid or prevent metals from reaching the aerial part of plant and preserve low and continuous concentration of metal over a wide range of soil metal concentration and control metal in the roots. Plants can improve their membrane permeability; it can increase the metal binding potential of cell walls or by exuding more chelating substances.

Metal indicators

Metal indicators are the species which actively collect metal in their aerial tissues and they generally represent the level of metal in the soil. They tolerate existing level of metals by creating intracellular metal binding compounds known as chelators or by storing metals in non-sensitive parts by altering the pattern of sectionalization.

Metal accumulator plant species

Metal accumulator plant species is also known as hyperaccumulator such species can concentrate metal in their aerial part of plant to the level far exceeding soil. Hyper accumulator absorbs high concentration of pollutants in its roots, shoots, or leaves, such as heavy metals. Many researchers have identified hyper accumulator species by collecting plants from different sources where soil contains more heavy metals. From 22 families approximately 400 hyper accumulator species are known. The Brassicaceae family contains a large number of hyper accumulating species which contains wide range of metals, these includes 87 species from 11 genera.

Conclusion

Land pollution/soil pollution contains heavy metals and it is a major environmental problem. Metals and other inorganic compounds are the widespread form of contaminants which is found in waste water, sludges, ground water, sediments etc and it may causes many harmful diseases. Phytoremediation is one of the cost effective and ecofriendly methods which use green plants to remediate degrade or inhibit the heavy metal contaminants by different methods. This method stabilizes the environment. The harvesting of plant shoots will permanently remove the pollutants from the soil. Phytoremediation has no detrimental effect on soil fertility, and structure as some of the technologies has such as acid extraction and soil washing. Phytoremediation is one of the best methods which is more effective, less costly and invasive remedial method. There are no conflicts of interest to declare with regard to this paper.

References

1. Abhilash PC,Powell JR, Singh HB, Singh BK (2012) Plant–microbe interactions: novel applications for exploitation in multipurpose remediation technologies. Trends in biotechno 30: 416-420.
2. Adriano DC, Wenzel WW, Vangronsveld J, Bolan NS (2004) Role of assisted natural remediation in environmental cleanup. Geoderma 122: 121-142.
3. Aresta M, Dibenedetto A, Fragale C, Giannoccaro P, Pastore C, et al. (2008) Thermal desorption of polychlorobiphenyls from contaminated soils and their hydrodechlorination using Pd-and Rh-supported catalysts. Chemosphere 6: 1052-8.
4. Burken JG, Schnoor JL (1996 Phytoremediation: plant uptake of atrazine and role of root exudates. J Environ Engi 122: 958-63.
5. Cheng S (2003) Heavy metals in plants and phytoremediation. Environ Sci Pollu Rese 10: 335-340.
6. Yakushko O (2009) Xenophobia: Understanding the roots and consequences of negative attitudes towards immigrants. Couns Psychol 37: 36-66.
7. Hermann D, Cornelius (2011) Virtual worlds and criminality. Springer.
8. Khoza A (2017) New social media research finds xenophobia rife among South Africans.
9. Smith JA, Breakwell GM, Wright DB (2010) Research methods in psychology. 4th Edition.
10. Ritzer G, Murphy WW (2019) Introduction to sociology.
11. Touwen CJ (2009) Reporting on xenophobia in South Africa ernesto burning: An analyses of Dutch print media coverage on the 2008 xenophobic violence in South Africa.
12. Biagi S (2015) Media/Impact an Introduction to Mass Media.
13. Hussein S, Hitomi K (2013) Xenophobia in South Africa: Reflections, narratives and recommendation. Southern African Peace and Security Studies 2: 5-30.