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Concept and Application of Phytoremediation in the Fight of Heavy Metal Toxicity

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Abstract

Due to different activities by the human being like ore extraction and application of different processes causing the heavy metal mobility which leads to the addition of these elements in the environment. As we all know that nature of heavy metal is non- biodegradable hence accumulating in the surroundings and enters in food chain causing the impurity. This type of contamination having environmental risk as well as affecting the health of humans. Heavy metal is mutagenic, endocrine, carcinogenic and teratogenic which causes neurological problems, especially in children. By considering all these points in mind remediation of these heavy metals is important to have a safe environment for survival. There are various methods for heavy metal remediation which are having the many limitations that are alteration of soil properties, high cost, disturbance in soil microflora and high demand for labour. Among all other remediation, phytoremediation is relatively more competent to solve this severe problem. Phytoremediation is the technique to reduce the content of heavy metal concentration and its toxic level of contaminants by the use of plants as well as related microbes of soil. Having the worldwide acceptance of this technology due to various advantages like effective in cost, new, eco-friendly, efficient. This Technology plays an active place in the current research. For the usage of phytomining and phytoremediation, the application of new metal hyperaccumulators is used for the remediation of heavy metal. To understand the mechanism of metal- uptake, appropriation, translocation and plant tolerance molecular tools are used. In this review article systematically discussed the concepts, background, prospects in heavy metal phytoremediation.

Keywords: Agriculture, Biotic, Cadmium, Dose, Environment, Heavy metal, Phytomining, Phytoremediation

INTRODUCTION

As we know that environmental pollution nowadays is increasing day by day and many factors are responsible for causing pollution but among all other factors heavy metal becoming a serious issue throughout the world. The mobility mechanism of heavy metal in the environment depends upon ores extraction and different processing application which results in releasing these elements in the environment. Due to the increase in industrialization and biological cycle disturbance heavy metal pollution is a serious problem that needs a great solution to mitigate heavy metal pollution. These are non-biodegradable essentially heavy metal which accumulates in the environment leads to risk in the environment i.e. soil pollution, water, and affects the health of humans. In a living organism, these elements accumulate in their body tissue which is called bioaccumulation and concentration increase from lower trophic level to higher trophic level as they pass from it and this phenomenon is known as biomagnification. There is a decrease of soil-microbes number in the soil due to the toxic effect of heavy metal (Khan *et al.*, 2010). Heavy metals are classified as essential as well as nonessential elements based upon the biological role in organisms. Heavy metals required by the living organism in very less concentration in the physiological as well as biochemical functions are known as essential metals like Mn, Zn, Fe, Ni and Cu (Gohre *et al.*, 2006; Cempel and Nikel, 2006). Metals which are not required by the living organism for their functions are termed as nonessential metals like Pb, Hg, Cd, As and Cr which are often termed as heavy metals (Karen *et al.*, 2000; Cobbet 2003, Mertz 1981, Suzuki *et al.*, 2001; Darbonne *et al.*, 2010). Heavy metal concentration above a certain limit shows the severe effects in plants as well as inhuman.

Heavy metal sources in the environment

There are various sources of heavy metal like weathering of rocks that come under natural processes and a lot of many anthropogenic activities due to which it enters the environment. In a natural process like the disintegration of rocks, erosion as well as volcanic eruptions while human activities it includes smelting, pesticides use and phosphatic manures, mining, electroplating, industrial effluent and sludge and biosolids in agriculture (Chehregani and Malayeri, 2007; Fulekar *et al.*, 2009; Wuana *et al.*, 2011 Modaihsh *et al.*, 2004; Sabiha *et al.*, 2009). Source of arsenic metal is the use of pesticides and different preservatives of wood (Thangavel and Subbhuraam 2004). Cadmium source is phosphatic fertilizers, electroplating, use of stabilizers for plastics and paint industry (Pulford *et al.*, 2003; Salem *et al.*, 2000). For chromium mainly steel industry, leather, cement industry and tanneries (Khan *et al.*, 2007). Cupper source is the use of fertilizer in excess amounts and pesticides (Khan *et al.*, 2007). Coal combustion, mining, and waste of medical is the source for mercury metal in the environment (Memon *et al.*, 2011; Rodrigues *et al.*, 2012; Wuana *et al.*, 2011). The anthropogenic source for nickel is effluents of various industries, instruments used for surgical, alloys of steels, batteries of vehicles and kitchen appliances (Tariq *et al.*, 2006). The use of herbicides and insecticides, petrol combustion and manufacturing of batteries are the source for lead (Wuana *et al.,* 2011; Thangavel *et al.,* 2004).

Heavy metal effects on human

The heavy metal having severe harmful effects on human health and also contaminate the food chain so it required a great need and attention. Even at very low concentration sone metals are toxic and causing severe problems in human health (Kara 2005; Memon *et al.,* 2009; Arora *et al.,* 2008). Oxidative stress is formed free radicals by heavy metal (Mudipalli *et al.,* 2008) which leads to the formation of reactive oxygen species ROS. The formation of ROS damage the cell membrane and metal which are essential in enzymes in addition to pigments are replaced which disrupts the function ultimately leads to cell death (Sanchez Chardi *et al.,* 2009; Das *et al.,* 2008; Krystofova *et al.,* 2009). Based upon their toxic level most problematic metal are Pd, Cu, Hg, Zn, Cr and Sn (Ghosh, 2010; Wright et al., 2007). Among this cadmium, mercury, arsenic, and lead are considered as non -essential metals whereas zinc and copper are essential metal (trace elements). Depending upon its concentration level and oxidative state causes different health issues.

Harmful effect on human by different heavy metals

Arsenic as arsenate acts as a phosphate analogue and hence inhibits cellular processes which are essential like ATP synthesis and oxidative phosphorylation (Tripathi *et al.,* 2007). Chromium is also very carcinogenic which causes ulcers, respiratory problems, skin cancer and hair loss (Salem *et al.,* 2000). Moreover, Cadmium act as mutagenic, teratogenic, carcinogenic which inhibits by regulation of calcium in the biological system causing the failure in renal, anaemia (Sale *et al.,* 2000; Awofolo 2005; Degraeve 1981). Different levels of copper cause the damage in kidney and brain, cirrhosis in liver and irritation in the stomach as well as in intestinal (Wuana *et al.,* 2011; Salem *et al.,* 2000). Besides, Mercury is responsible to cause depression, diseases of autoimmune, fatigue, hair loss, drowsiness, short memory, ulcers, brain damage and kidney problem (Aniza *et al.,* 2010; Gulati *et al.,* 2010; Neustadt and Pieczenik 2007). Besides, Nickel cause dermatitis allergic termed as nickel itch, lung cancer, nose and sinuses, throat cancer (Salem *et al.,* 2000; Khan *et al.,* 2007 and Das *et al.,* 2008). It is also worth to highlight that Lead poisoning to cause the problems like impaired development, short memory loss, intelligence reduction, create problems in coordination, failure of renal in children(Salem *et al.,* 2000; Wuana *et al.,* 2011; Padmavathiamma and Li 2007; Iqbal 2012). Zinc also causes fatigue and dizziness when its dose is high than that of its threshold level(Hess *et al.,* 2002).

Removal of heavy metal

In the environment, heavy metal concentration is increasing every year (Govindasamy *et al.,* 2011). The deposition of cadmium, lead, and zinc in the atmosphere in the region of combine in the Netherlands with 700 km area was contaminated (Meers *et al.,* 2010). The area in china is destroyed due to the activities of mining of 46700 ha annually. Due to severe pollution and soil erosion as well as off-site pollution, there is no vegetation on that destroyed land (Xia 2007). To minimize their impact on the environment it is necessary to remove the heavy metal from contaminated soils but there are so many challenges in terms of cost and complex technical skills (Barcel *et al.,* 2003). A different method to achieve the purpose of heavy metal removal by chemical, biological as well as physical methods. The various conventional remediation ways include incineration of soil, *in situ* vitrification, landfill, washing off soil and solidification (Sheoran *et al.,* 2011 and Wuana *et al.,* 2011). Due to the high cost, more labour, the microflora of soil disturbed and properties of soil changes are the limitations of chemical and physical methods. Secondary pollutants are formed due to chemical methods. By considering these limitations it is needed to develop the remediation to remove the soil pollutants in such a way that are effective in cost, more efficient as well as eco-friendly. Phytoremediation is such a new approach in which plants or green substitute solutions are used to mitigate the effect of heavy metal in soil (Fig.1).

Phytoremediation

The plants and related microbes of soil are used to diminish the toxicity and concentration of contaminants from the soil in the process of phytoremediation (Greipsson 2011). Heavy metals, organic pollutants like polynuclear, biphenyls, pesticides, hydrocarbon, and radionuclides can be removed by using this technique. It is such new approach in which plants or green substitute solution are used to mitigate the heavy metal effect in soil (Suresh *et al.,* 2004; Chehregani and Malayeri 2007; Lone *et al.,* 2008; Kalve *et al.,* 2011; Vithanage *et al.,* 2012). This method helps in removing the soil contaminants without harming the fertility of soil as well as topsoil. By adding the organic matter into the soil it improves the fertility of the soil (Mench *et al.,* 2009). Phytoremediation word comes from Greek and Latin i.e 'Phyto' greek means plant and medium Latin means the removal of evil. There is the various mechanism under which plants goes to remove the pollutants by taking from the environment and their detoxification. During the decades of the last two years conducted research and studied that phytoremediation is recent technology. Phytoremediation concepts were first given by Chaney in 1983 and now it is accepted as good pleasant among the public (Reference please). A very large field is one of the best methods which is suitable for remediation where other methods are not effective in cost as well as practically feasible (arbisu and Alkorta 2003). As compared to the other remediation it has a very low cost for the initial instalment (Van Aken, 2009) and its cost is less than other remediation by 5 % (Prasad, 2003). When on polluted soil the vegetation is grown which also helps in metal leaching and prevents erosion of soil (Chaudhry *et al.,* 1998). In this method plants with high biomass, fast-growing like poplar, jatropha, and willow are used for the production of energy as well as phytoremediation (Abhilash *et al.,* 2012). Phytoremediation is popular nowadays among the public as 'green clean' which are alternate to chemicals (Pilon-Smits, 2005).

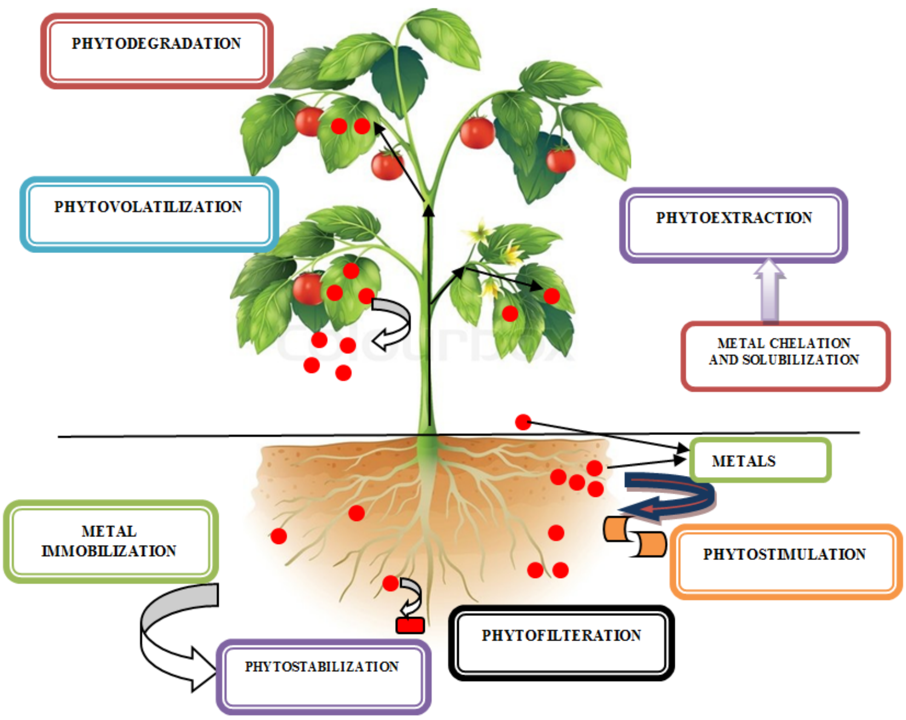

Fig1. Removal of heavy metal and their different techniques

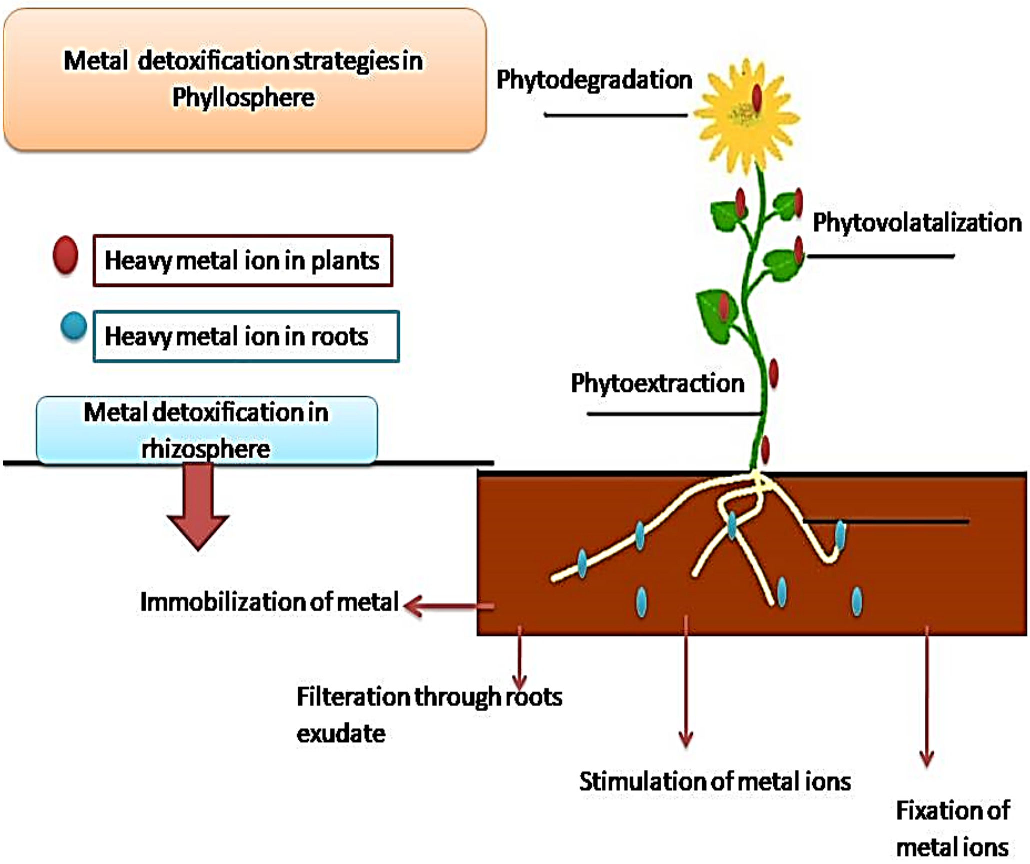

Fig 2. Different techniques of phytoremediation

Phytoremediation techniques

There are various techniques which are used for the remediation of heavy metals from contaminated soils are shown in fig 1 (Alkorta *et al.,* 2004).

Phytoextraction

Another name of the phytoextraction is photoabsorption and phytoaccumulation which helps in uptaking the soil contaminates as well as from water through their roots and accumulates in the above plant parts as biomass by the process of translocation (Sekara *et al.*, 2005; Rafati *et al.*, 2011; Yoon *et al.*, 2006). The translocation of metal from soil to roots than roots to the shooting part of plants involves the vital biochemical function is required in phytoextraction but the harvesting is not feasible in biomass of roots (Zacchini *et al.,* 2009) (Fig. 2).

Phytofiltration

The wastewater and surface water which is contaminated from pollutants is removed by the use of plants (Mukhopadhyay and Maiti 2010). Phytofiltration is of the different type named as caulofiltration in which plant shoots are used; rhizofiltration in this roots of plants are used and last is blastofiltration in which seedlings are used for phytoremediation (Mesjasz *et al.*, 2004). Phytofiltration works on the principle of absorption and adsorption which help in minimizing the underground movement of water.

Phytostabilization

Phytostabilization is also known as phytoimmobilization where particular plants are used for the contaminants stabilization in contaminated soils (Singh 2012). The mobility in addition to bioavailability contaminants is condensed which helps in preventing the entry of pollutants into the food chain as well as in restricting the groundwater migration (Erakrumen 2007). There is a various mechanism under which plants goes to immobilize the metals in the soil like precipitation, valency of metal, rhizosphere reduction and roots sorption (Barcelo *et al.*, 2003; Ghosh and Singh, 2005; Wuana *et al.,* 2011; Yoon *et al.,* 2006). The toxicity of different metals depends upon their valency. Plants excrete many enzymes that help in converting the harmful metals into less toxic metals results in decreasing the heavy metal stress. For example the conversion of hexavalent chromium to trivalent chromium results in less toxic after reduction (Wu *et al.,* 2010). This technique is not long-lasting remediation because it only restricts their movement and inactivating the contaminants present in soil (Vangronsveld et al., 2009).

Phytovolatilization

In this technique, pollutants are extracted by the plants in contaminated soil which later converts into the form of volatile and later release into the environment. For the organic pollutants and metals like Se and Hg can be removed by this particular technique but having some limitations like pollutants are not removed completely, it only transferred the toxins from soil to the air from where it can be deposited again in soil (Padmavathiama and Li 2007).

Phytodegradation

In this technique, the remediation of metals by the process in which organic pollutants are degraded by the enzymes like oxygenase as well as dehalogenase is independent of the microorganism rhizosphere (Vishnoi and Srivastava 2008). Through their metabolic activities, plants accumulate organic pollutants and then detoxify the contaminants. As we know that heavy metals are nonbiodegradable which limits the organic pollutants removal by phytodegradation. Recently studies reported the use of plants that are genetically modified like transgenic poplars in biodegradation (Doty *et al.*, 2007).

Rhizodegradation

In this technique, organic pollutants are degraded in the soil around the rhizosphere with the help of different microorganisms (Mukhopadhyay and Maiti 2010). The 1 mm rhizosphere area around the root zone and plants are under influence by this particular technique (Pilon-Smits 2005). The mechanism behind this method is increasing in the microbes population which increases the metabolic activities result in enhancing the degradation of the pollutant in the rhizosphere. Due to the carbohydrates, flavonoids, amino acid exudates are secreted in the rhizosphere which increases the 10-100 times activities of microbes. The microbe's activity is stimulated by getting the rich nutrient environment through the exudation from plant roots which provides the nitrogen as well as the carbon sources to microbes. Along with the secretion of organic exudates from roots of plants in rhizosphere plants also release some enzyme which also degrades the pollutants in soil (Kuiper *et al.,* 2004; Yadav *et al.,* 2010).

Phytodesalination

Phytoremediation is a highly reported and globally accepted technique (Zorrrig *et al.,* 2012). It refers to the removal of salt from the affected soils by the use of halophytic plants which helps in providing the normal growth to the plants (Manouski and Kalogerakis 2011; Sakai *et al.,* 2012). As compared to the glycophytic plants they were suggested to be better in heavy metals conditions (Manousaki *et al.,* 2011). From 1 ha salt-affected field the two species of halophytic plants like *Suaeda maritima* as well as *Sesuvium portulacastrum* are capable to remove 504 and 474 kg of salt respectively in four-month. These halophytes can accumulate sodium chloride from highly saline soils which help to have better crop production and harvest (Ravindran *et al.,* 2007). This technique helps in reducing the salinity stress which helps the plant to grow normally for the glycophytic test culture crop Hordeum vulgare (Rabhi *et al.,* 2010).

Heavy metal phytoextraction

For the removal of heavy metals from the contaminated soils, it is the best technique used for phytoremediation (Cluis, 2004; Milic *et al.*, 2012; Cherian and Oliveira 2005) and it is commercial adapted throughout the world

(Sun *et al.,* 2011). The efficiency of this technique depends upon factors like heavy metal bioavailability in soil, properties of soil, heavy metal speciation and different plant species. The plants should have the following characteristics which are used in phytoextraction (Mejare et al., 2001; Adesodun et al., 2010; Shabani et al., 2012). The plant should have a high rate of growth. Above the ground biomass production is high and should have a well-developed root system. Accumulated heavy metal should be translocated from the roots of plants to shoots. Plants should have the tolerance capacity to the toxic effects of heavy metal and have a better adaptation to variation of climatic conditions. Plants should have the character to resist against the pathogens and pests. The main two key factors of plants for the phytoextraction potential is the concentration of metal in shoots as well as the biomass of shoots (Li *et al.,* 2010). For phytoextraction the two different approaches in which use of hyperaccumulators helps in producing the less biomass aboveground but the accumulation of heavy metal target is high and another approach the use of indian mustard helps in producing the high biomass production aboveground but the accumulation of target heavy metal is less (Robinson *et al.,* 1998). In phytoremediation, it is more important to have high accumulation and hypertolerance rather than that of biomass production (Chaney *et al.*, 1997). For the phytoextraction, those plants are more suitable which have multiple harvesting cuts in a single period growth like Trifolium spp. (Ali *et al.*, 2012). Due to the higher adaptability to stresses, higher biomass production and high rate of growth grasses are more suitable for the phytoextraction of heavy metal rather than trees and shrubs (Malik *et al.,*2010). Recent studies reported that maize and barley are used for the phytoextraction of heavy metal. The plants and crops which are used for the phytoextraction have to face the food chain contamination considered one of the disadvantages. The field crops which are used for the extraction of heavy metals should not be used for the feed of animals and consumption of human directly (Vamerali *et al.,* 2010).

Metallophytes

The soil which is highly contaminated by the heavy metal in that particular soil metallophytes plants are used (Bothe 2011; Sheoran *et al.,* 2011). Under the local condition of the environment over thousand-year the evolution of metal which results in resistance in metallophytes. Due to the activities of mining, there is subsequently change in the metallophytes function by diminishing the habitat if enriched metals (Ernst 2000). Metallophytes are considered as the botanical inquisitiveness (Alford *et al.*, 2010). Metallophytes are the plants that come under the family of Brassicaceae. The best attractive idea for the phytoextraction of the heavy metal is when the metallophytes are used in combination with another microorganism (Bothe, 2011). There different categories of metallophytes named metal excluders, metal hyperaccumulators, and metal indicators (Fig.3).

Metal excluders

In this type of metallophytes, heavy metal is accumulated in the roots from the particular contaminated soil but there's restriction in the transportation of the metal into the aerial plant's parts (Sheoran *et al.,* 2011; Malik *et al.,* 2012). These metal excluders are efficient in purpose to phytostabilization but have the low potential for extraction of metals (Lasat 2002; Barcelo *et al.*, 2003).

Metal indicators

The name itself indicates that there is a selection of a concentration of heavy metal from the substrate and accumulation of heavy metals in the aerial plant parts (Sheoran *et al.,* 2011).

Metal Hyperaccumulators

Plants that can accumulate the heavy metal in the above-ground plant's parts with the high concentration as that of the present in that contaminated soil (Memon *et al.*, 2001; Memon and Schroder 2009). They come under the broader category of accumulators which are viewed as special hyperaccumulators (Pollard *et al.,* 2002). Hperaccumulators are considered as the high tolerant against the heavy metal which accumulates in the shoot parts of plants (Mcgrath *et al.*, 2001). Scientifically the standard for hyperaccumulators is not well defined (Nazir *et al.*, 2011). It is used for the phytoremediation for toxic heavy metal and also for the phytomining processes like Pd and Au. The concentration of metal in tissue is multiplied by the produced quantity of biomass is the amount of the metal which is extracted from hyperaccumulators (Macek *et al.*, 2008). There are some plants which are having the natural ability to extract heavy metals from the contaminated soils and act as hyperaccumulation.

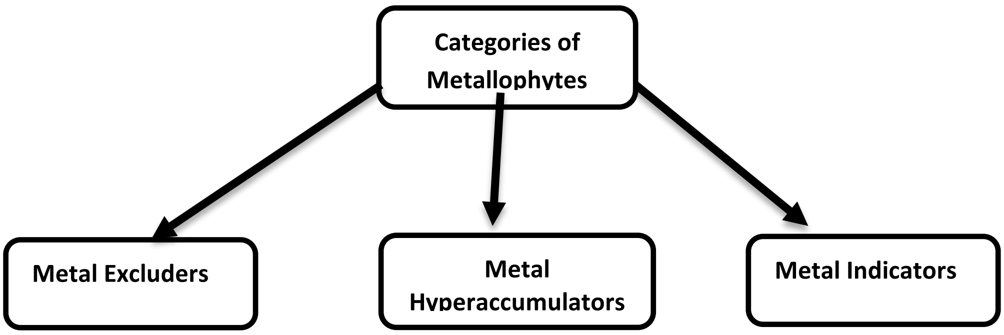

Fig 3. Different categories of Metallophytes

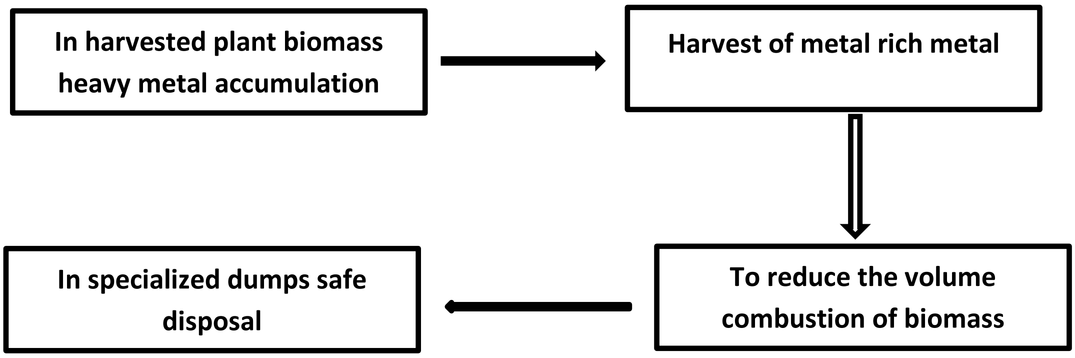

Fig 4. Post-harvest treatment of phytoremediation plant

Plant fate in phytoextraction

There is a big question in phytoextraction that fate of plants after used in the extraction of heavy metals. Burning the plants after phytoextraction may also cause the harmful waste leads to the hazardous issue but safely it should be dump in the specialized area if feasible economically and also for the recovery of the valuable and semiprecious metals and this process is known as the phytomining (Salt et al., 1998; Prasad 2003; lone et al., 2008; Sheoran et al., 2011)(Fig. 4.).

Phytomining

After the extraction of heavy metal from the contaminated soil the metal which is accumulated in plant biomass can be converted to energy by combustion and leftover ash is considered as "bio-ore" and this further used for the metal extraction. From the combustion of the plant biomass, there is the production of sale energy which is considered as its main advantage (Anderson et al., 1999). This technique is the best as it is eco-friendly and environmentally safe as compared to the other traditional extraction methods. Phytomining viability depends commercial on processed metal value and phytoextraction efficiency. This technique is commercially used for the extraction of nickel metal and found that it is cost-effective. Recent research was conducted and reported that the phytomining of nickel in agriculture has a high profit (Chaney *et al.*, 2009).

Wetland use for phytoremediation

The waste effluents and water which is drained out from the different industry is cleaned by the use of constructed wetlands (Vangronsveld *et al.*, 2009). This is the successful technique used for heavy metal remediation which is effective in cost and practically feasible technology (Williams 2002; Galvan 2010; Rai 2012). Due to the high growth rate, high biomass production and more ability to extract the pollutant of aquatic macrophytes are more suitable for the treatment of wastewater as compare to the terrestrial plants and aquatic plants having the direct contact with water which is contaminated perform the better purification (Sood *et al.*, 2012). Different species of aquatic plants are used like floating, submerged and emergent species in a wetland constructed (Fig.5). On the edges of the wetland constructed willow (Salix sp.) and Poplar (Populus ap.) are used (Pilon- Smits 2005). Accumulation of heavy metal is different in different aquatic plant sp.like in submerged metal accumulate in all plant parts and case of floating plants only in the roots accumulation of heavy metal (Rahman *et al.*, 2011).

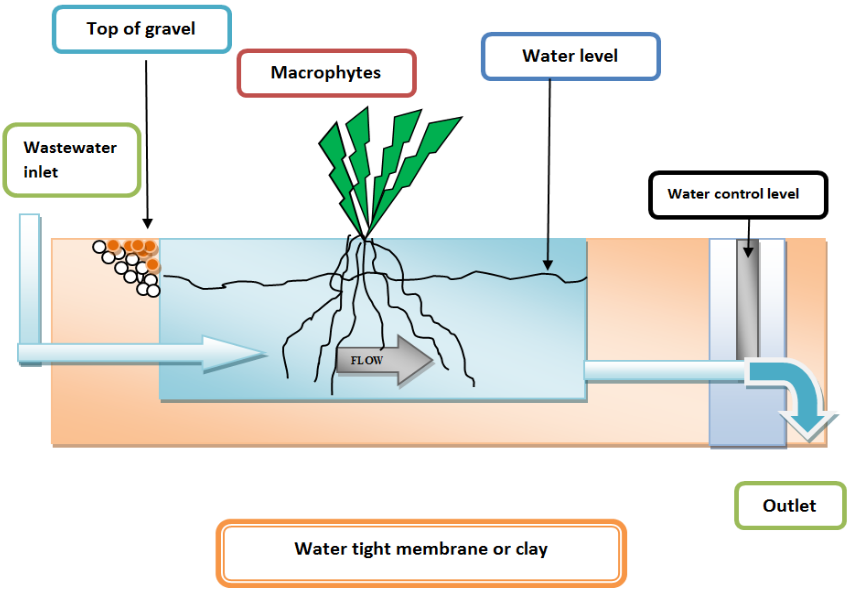

Fig 5. Phytoremediation in constructed wetlands

Translocation and uptake mechanism of heavy metal

From the contaminated soil, heavy metal is taken up by the plants through the roots and accumulate in the roots from their heavy metal ions are translocated to the shoots of plants by mean of primarily xylem vessels and over there it deposited in the vacuoles (Prasad 2004; Jabeen *et al.,* 2009). With fewer metabolic activities vacuole is the cellular organelles (Denton 2007). From the vacuole it can be removed from the cytosol and by reducing cellular metabolic interactions (Assuncao et al., 2003; Sheoran *et al.*, 2011). There are five aspects which are basic for the mechanism of phytoextraction of heavy metal first is heavy metal mobilization in soil, accumulated metals translocation from roots to aboveground plant parts, metal ions are taken up by the plant roots, metal ion sequestration in the tissue of plants and last is the tolerance against the metals. Tolerance of metal is essential for phytoremediation as well as for the metal accumulation (Clemens 2001). By the variety of molecules, the vacuoles are regulated and controlled throughout the translocation of heavy metal from the soil solution. In the transport of heavy metal cross membranes, some molecules are formed and others are involved in the formation of metal complexes. Heavy metal ions uptake depends upon channel proteins also called special transporters present in the root plasma membrane (Greipsson 2011). Those metal which is not essential compete and enters the plant's roots by the same transporters transmembrane (Thangavel *et al.,* 2004).

Phytoremediation limitation

It is the best technique for the remediation of heavy metal from contaminated soil but still suffers from some limitations (Clemens 2001; Leduc *et al.,* 2005; Tong *et al.,* 2004).

- **Time-consuming**- required for removal of heavy metal from contaminated soil is long.
- **Efficiency is less**- due to some hyperaccumulators having a slow growth rate and less production of biomass.
- **Less mobilization**- due to some tightly bound metal ions.
- **Risk in the food chain-** mismanagement and lack of proper care leads to contamination of the food chain.

Future perspective in phytoremediation related research

As we know that it is a recent technology in the field of research for the removal of heavy metal from contaminated soil. Currently, most of the work is limited up to laboratory and greenhouse only rare studies have been done to evaluate the phytoremediation efficiency in the actual field. So, the threat area of this technique to conduct the field experiment because the field is the real world where this contamination occurs and there are lot many factors in the field which are different from laboratory and greenhouse (Ji et al., 2011). Different factors affect the phytoremediation like change in temperature, moisture, precipitation, nutrients, insect pest, soil type and plant pathogens (Vangronsveld et al., 2009). Research is still in progress to identify hyperaccumulation coding genes for particular heavy metals in plants. to develop the 'superbug' plants for the phytoremediation it is important to identify and transformation of genes to other plants that are suitable for phytoremediation. Rather than having a lot many challenges still it is best green remediation used for removal of heavy metal from soil ecofriendly as well as efficiently.

The interdisciplinary research of phytoremediation

For this technique, it requires the knowledge of soil chemistry, ecology, plant biology, microbiology as well as environmental engineering. The current status and trend of the integration approach of scientific knowledge help in coming out of this problem with great results in the future (Fig. 6.).

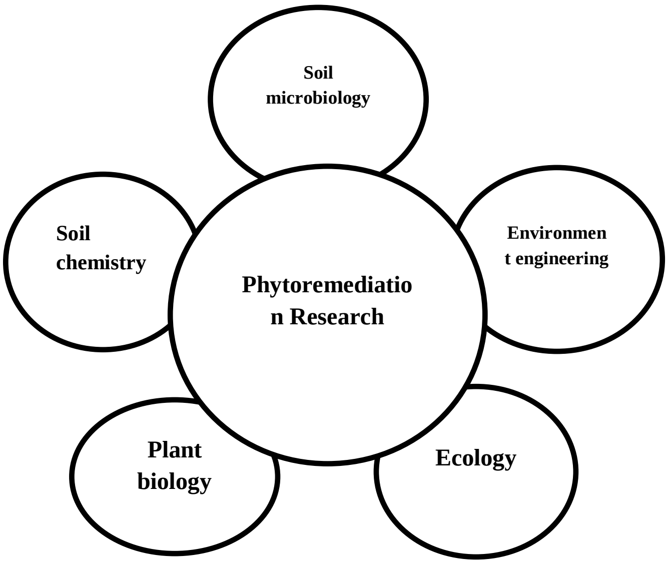

Fig 6. Interdisciplinary research of phytoremediation

CONCLUSION

As we all know that soil contamination and toxicity of these metal is increasing day by day result in many environmental problems that require a great need to solve this problem by the effective remediation methods. Due to high cost, change in soil properties, destruction in soil microbes and production of secondary pollutants are the limitations of physical and chemical methods of remediation. In comparison, phytoremediation is the best green technique that is used to solve this problem. It is eco-friendly, economically efficient and practically feasible adopted throughout the world. Phytoremediation requires the knowledge of soil chemistry, ecology, plant biology, microbiology as well as the environmental engineering highly interdisciplinary in nature. Research is still in progress to identify hyperaccumulation coding genes for particular heavy metals in plants. to develop the 'superbug' plants for the phytoremediation it is important to identify and transformation of genes to other plants that are suitable for phytoremediation. Rather than having a lot many challenges still it is best green remediation used for removal of heavy metal from soil ecofriendly as well as efficiently. To understand the mechanism which enhances the efficiency of phytoremediation to know about molecular advancements and achievements. Commercially feasible technology for remediation of heavy metal and phytomining of heavy metals by the phytoextraction.

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Author Contributions

P.D. and P.K equally contributed to writing the manuscript.

Conflict of Interest Statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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