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Review

A Review on the Current Scenario of Phytoremediation in Pakistan

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Abstract. Phytoremediation is a promising technique to clean the noxious contaminants from soil, air and water as the pollutants like heavy metals which severely affect the environment due to anthropogenic activities. Most of pollutants de-contamination methods are costly and have low performance. Phytoremediation is effective and affordable green technology which uses selected green plants. Different plants species experimentally proven to absorb different metals like Pb, Zn, As, Cd, Cr from contaminated sites. This review focuses on development of phytoremediation of metals from environmental compartments. The aim of this review to conduct the studies on phytoremediation in Pakistan in the last two decades phytoremediation has different mechanisms such as phytoextraction, phytodegradation, phytovolatilization, phytostabilization and Rhizofiltration. In Pakistan out of 400 plant species only 50 plant species were observed to clean contaminated soil, air and water. Heavy metals contamination has become most alarming problem worldwide. A previous study revealed about 1.7 billion places are affected from heavy metals contamination especially in developing countries. Metals are non bio-degradable and tend to bio-accumulate and biomagnify in food chain and linked with many diseases, their remediation using plants is economical and environmental friendly.

Keywords: heavy metals, contaminants, environment, phytoremediation, plant species

Introduction

Major environmental problems are initiated by anthropogenic activities like Industrial revolution and urbanization that contaminate the soil, air and water. Lots of uncontrolled and controlled removal of waste, accidental leakage, mining and production of metalliferous ores and municipal sludge wastes cause pollution. In present epoch trace elements produce the atmospheric pollution that is very serious issue and threats in urban environment (Contardo *et al.*, 2020).

Heavy metal pollution is a serious issue of environment in worldwide (Sajad *et al*., 2023). Heavy metals pollution in soil and water now become a worldwide problem. Almost all the countries have been affected extremely by this pollution. According to the previous study approximately 1.4 million locations were highly affected by metals pollution and about 3 million are categorized in contaminated areas. The metal pollutant sites in eastern Europe and central Europe are shockingly higher (McGrath *et al*., 2001; Gade, 2000). In America, about 6 million sites are reported that are polluted by heavy metals and it is necessary to recover them. Many developing countries like Pakistan have reported heavy metals pollution. As compared to the other heavy metals in Pakistan, mercury (Hg) has been found much higher in river and aquatic systems (Mubeen *et al*., 2010; Tehseen *et al*., 1994; Tariq *et al*., 1994).

Along with natural transportation most human activities play a role in heavy metals pollution that are directly released into the environment. These pollutants migrate towards non pollutant sites through dust or leachates of soil and the sewage contains the contaminated heavy metals which dispersed in the ecosystem (Gaur and Adholeya, 2004). Different methods and strategies have been developed every year to mitigate the environmental pollution (Tonelli *et al*., 2022). In previous studies different methods were used to clean this type of pollutants involving high cost and have not shown the best performance. Different chemical technologies produce the high volumetric sludge and maximize the cost (Rakhshaee *et al*., 2009). Other methods have difficult principles such as chemical and thermal methods which are costly too. These methods can also degrade the important components of the soil. (Hinchman *et al*., 1995).

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The current review on phytoremediation has proved that it is a most effective and affordable technique which has solutions to clean the polluted soil, air and water. Different plants are used in phytoremediation techniques to clean the environment. This is a non-hazardous and low cost technique. The plants which have extraordinary metal-accumulating ability are called hyper accumulator plants. Different plant species have been experimentally proven that they can absorb the contaminated heavy metals such as Pb, Zn, As, Cd and Cr from the soil (Tonelli *et al*., 2022). There are different types of phytoremediation but to clean the soil from the contaminated heavy metals, phytoextraction can be used to uptake different heavy metals like Fe, Zn, Mn, Cu, Ni and Mg that are necessary for the growth of plants. Many other heavy metals can also be accumulated for other biological processes. Industries and households continuously release the wastewater that can cause heavy metals contamination into soil at high levels. Industrial wastewater and solid waste not only damage the composition of the soil but also affect the growth of plants and crops. These contaminated heavy metals are absorbed by plants through soil. Then these toxic heavy metals enter the human body through the food chain which causes serious health problems (Akhtar *et al*., 2023)

Materials and Methods

The current study is focused on the review of 100 research paper from various journals related to phytoremediation. This data is collected after going through vigorous review of phytoremediation techniques used in Pakistan, the literature was gathered between 2012 to 2023 by searching the databases including Google, Science direct, Scopus and Research gate. The data and literature review show the importance of phytoremediation specially in developing countries, as it is ecofriendly and economical.

Phytoremediation: a green technology. In phytoremediation, green plants and their related micro biota are used for the removal of pollutants from soil, air, sediments and water. These green plants have ability to exhibit the containments for collecting, mobilizing and transmuting. Different mechanisms are involved such as uptake, concentration and transformation of contaminants. Phytoremediation is a low energy consuming, artistically attractive method for remediating sites. In this process selected engineered plants are used that have ability to remediate the sites effectively as compared to traditional method.

A best phytoremediation method should be able to tolerate the heavy metals and degrade the contaminant from roots. Plants should be able to absorb the maximum contaminants from soil and collect them in their above ground part and have potential to easily harvest and produce less secondary waste that can be easily disposed off (Sharma, 2018; Paz-Alberto and Sigua, 2013).

Some hyper accumulator plants species.

Scientific name	**Common name**
Brassica juncea	Indian mustard
Medicago sativa	Alfalfa
Pisum sativum	Pea
Sorghum sudanense	Sudan grass
Zea mays	Corn
Vicia faba	Broad Bean
Hordeum vulgare	Common barley, cereal barely
Brassica napus	Turnip, rape
Triticum	Wheat
Helianthus annuus	Sunflower

(Paz-Alberto and Sigua, 2013)

History of phytoremediation. Phytoremediation is not a new technology to clean the environment from heavy metals. Approximately 300 years ago plants were used for the management of the pollutant water that was released from different industries (Hartman, 1975). First time two plant species were used to collect the maximum levels of heavy metals in their leaves these species were *Thlaspi caerulescens* and *Viola calaminaria* (Rascio, 1977). Bayer reported in 1935 that the genus Astragalus has the ability to collect the selenium (Se) about 0.6% in the dry upper part of plants. Currently (Rascio, 1977) *Thlaspi caerulescens* plant species have been found to have maximum ability to collect the zinc (Zn) in their shoots. The term of phytoremediation introduced by Chaney (1983) (Tonelli *et al*., 2022) and in 1991 Zn and Cd were used in field experiments (Baker *et al*., 1991).

Mechanism of phytoremediation. Phytoremediation is a technology in which plants are used to clean up the different environmental compartments (soil, water, air) from the hazardous pollutants (Reichenauer and Germida, 2008). The different processes of phytoremediation are given below and also indicated in Fig. 1.

Phytoextraction. Phytoextraction is a process in which plants' roots absorb the pollutants from the contaminated soil and water and transfer or accumulate these pollutants to the upper parts of the plant such as buds and green leaves. In phytoextraction those plant species are used that have the ability to accumulate the contamination (mainly metals) into their biomass. (Sterckeman *et al*., 2019; Lei *et al*., 2018; Suman *et al.*, 2018).

Phytodegradation/Phytotransformation. Phytodegradation is also known as the phytotransformation. In this process complex organic molecules are changed into the simple form or accumulate the biomass into plant tissues (Trapp *et al.*, 2001).

Phytovolatilization. Phytovolatilization is the procedure in which plants absorb the pollutants from the soil and transport the pollutant chemicals by xylem, convert these hazardous pollutants into less hazardous and change into volatile form. These less toxic contaminants are then released into the atmosphere. The phytovolatilization process has been used to remove those metals which have highly volatile ability such as mercury (Hg), selenium (Se). (Cristaldi *et al*., 2017; Wang *et al*., 2012).

Phytostabilization. In the phytostabilization process contaminants metals are absorbed on the roots hairs and minimized the mobility of heavy metals into soil. In the phytostabilization process plants are used to change the chemistry of the soil and easy the heavy metals precipitation from the soil. (Basharat *et al*., 2018; Garcia-Sanchez *et al*., 2018; Zhang *et al*., 2009).

Rhizofiltration. In the Rhizofiltration process, plants are absorbed and precipitate the inorganic and organic pollutants on roots and release them. These contaminants are absorbed from the wastewater, surface water and groundwater. The plants which are selected for the rhizofiltration process have different abilities such as hypoxia accepting, large surface area for absorption and metals tolerant (Cristaldi *et al*., 2017; Zhang *et al*., 2009).

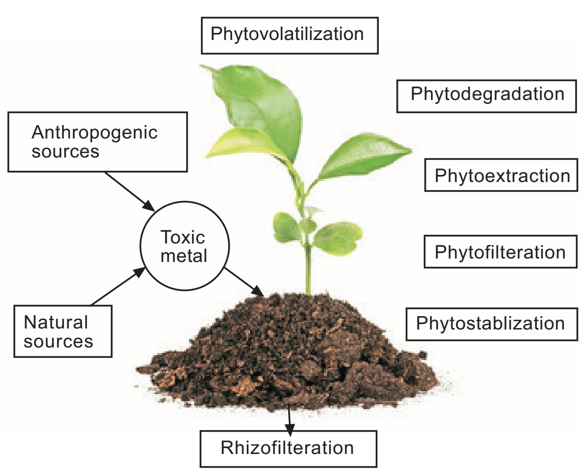

Fig. 1. Mechanism of phytoremediation

Plant residual management after phytoremediation. After phytoremediation of heavy metals all plants harvested from contaminated area that contain massive amount of dangerous metals, now this metal rich plant biomass (MRPB) must be destroyed in proper manner without any environmental risk. To minimize the volume of biomass it should be fermented or changed into gas. Metal-rich biomass can be reused to get the valuable metals or they can be disposed of in suitable locations (Selamoğlu *et al*., 2021; Alinia *et al*., 2019; Zhang *et al*., 2010).

Phytoremediation in Pakistan. Pakistan has unique geography with a variety of climatic zones with rich floral diversity. Pakistan has more than 6,000 species of higher plants (Ali and Qaiser,1986). Presently, more than 400 plant species among angiosperms have been examined and identified as hyper accumulators all over the world (Greipsson, 2011). However, in Pakistan, only 50 species have been examined and identified as metal-accumulators to remediate contaminated soil, air and water (Table 2) (Kamran *et al*., 2014).

Phytoremediation studies conducted in Pakistan. Along with Pakistan in all developing countries, contamination of water by heavy metals (Pb, Zn, Mn, Hg, Cd, Cr and Cu) has become a serious problem. Heavy metals pollutants are released from a lot of industrial sectors, cultivation and anthropogenic actions. People are affected by heavy metals through drinking, eating, skin contact and breathing. The agricultural and industrial wastewaters have become an alarming problem in Pakistan. Coliform microbes, heavy metals and pesticides are the main reason to contaminate the ground and surface water (Jabeen *et al*., 2017; Azizullah *et al*., 2011).

There is no proper systems in developing countries to clean up or remediate the wastewater. 80% of waste water world wide is dumped without treatment. In Pakistan native plants have a lot of ability to clean the contaminated wastewater through phytoremediation techniques (Hussain *et al*., 2010; Mubeen *et al*., 2010; Mukhtar *et al*., 2010; Malik *et al*., 2009; Jamali *et al*., 2007; Qadir *et al*., 2001). This review presents the current scenario of phytoremediation in Pakistan. Along with over population, the disposal of wastewater is also increased from the textiles and tannery industries. Table 2 is showing the use of different plants to clean different environments from contaminants. Previous few years different studies have been reported on removal of heavy metals by phytoremediation in different media (Kausar *et al*., 2012; Bareen and Tahira, 2011; Hadi and Bano, 2010; Hussain *et al*., 2010; Malik *et al*., 2010; Mirza *et al*., 2010; Rashid *et al*., 2009; Wahla and Kirkham, 2008; Jamali *et al*., 2007; Malik and Husain, 2006; Khan 2001). Few studies which are conducted on phytoremediation technology in various regions of Pakistan are summarized in Table 2.

Phytoremediation study in environmental compartments soil. Phytoremediation has various advantages and disadvantages as mentioned in Table 1. Plants species used by different researchers in Pakistan are cited in Table 2. Yasin *et al*. (2021), used the two plant species *E. camaldulensis* and *M. Alba* in their study. They found that Pb and Cd have high concentration on leaves of the plants. Khan *et al*. (2021), used the *Chenopodium album* and *Cynodon dactylon* to remove Pb in soil, they found maximum concentration of Pb accumulated in these plant species.

The chromium toxicity in soil investigated Amin *et al*. (2019), sowing the different plant species such as *Cyamopsis tetragonoloba*, *Glycine max, Avena sativa*, *Abelmoschus esculentus*, *Sesamum indicum* and *Guizotia abyssinica.* The researchers found that *Avena sativa, Abelmoschus esculentus* and *Cyamopsiste tragonoloba* have higher ability to tolerate the toxicity of Cr in their tissues. (Khalid *et al*., 2019) used the *Xanthium strumarium*. This study proved that *Xanthium strumarium* has the best phytoremediation of roadside soil heavy metals.

Ullah *et al*. (2019), used the *Parthenium*, *Cannabis*, *Euphorbia* and *Rumex* species used to remediate the lead and chromium. Sajad *et al*. (2023), used *Artemisia vulgaris, Nonea edgeworthii, Arabidopsis thaliana, Rosularia adenotricha* and *Salvia moorcroftiana, Cerastium glomeratum, Medicago minima* and *Persicaria glabra* species to phytostabilization of Mn in Lower dir, KPK.

Water. Sajad *et al.* (2020b), used the species from dir lower, KPK to remove chromium from ground water. They found the maximum concentration of chromium in the root and shoot of each plant mentioned in Table 2. Ullah and Muhammad (2020) found the plants species *Phoenix dactylifera* L. (*P. dactylifera*) and *Calotropis procera* L. (*C. procera*) as best heavy metals (Mn, Pb, Cr, Ni, Co, Cd, Fe) accumulators in Zhob valley.

Ullah *et al.* (2022), used *Lemnoideae* (Duckweed), *Pistia stratoites* (water lettuce) *Ceratophyllum demersum* (Coontail) species for treatment of sewage wastewater. Open containers containing sewage wastewater used

Table 1. Pros and cons of phytoremediation

Advantages	Disadvantages
• Different organic and inorganic compound are managed phytoremediation process. Phytoremediation technique can be used in both in situ and ex situ application. (USEPA, 2000a; Raskin and Ensley, 2000). • *In situ* applications are more considerable as compared to the *ex situ* because in *in situ* application risk of soil disturbance and dispersal of the waste are very low. • Phytoremediation is a green technology, it is environmental friendly as well as it provides aesthetic pleasure for public (Lewis, 2006; Ghosh and Singh, 2005; Raskin and Ensley, 2000). • This technology is also applicable for mega projects where other method would be very costly and unsuccessful (Prasad and Freitas, 2003; Vidali, 2001). • This green technology does not need any expensive equipment and highly experience person for implementation (USEPA, 2000a; Raskin and Ensley, 2000). • This technology also reduces the risk of transferred of pollutants and excavation (Hegedusova *et al*., 2009).	• In this technology, root depth of the remediative plant is limited. • It is very long process technology that may take few years to clean up the contaminated site, and not surely that hazardous sites fully cleaned after long time remediation (Rajakaruna *et al*., 2006; Vidali, 2001). • It can also affect the biodiversity by using the nonnative plant species. It is very dangerous for wild animals that can feed on the contaminated plants. • In phytoextraction process harvested plant biomass is produced, that may be categorized as a RCRA hazardous waste. • Furthermore, it is very difficult to maintain the vegetation for widely hazardous site (Vidali, 2001). • It is also very dangerous for human health because pollutants can be taken through food chain (Pivetz, 2001). • Climate change is also the important factor that can affect the growth of the plant, thus reducing the efficiency of the process (USEPA, 2000b).

Table 2. Current studies on phytoremediation in Pakistan

Cities	Year	medium	Plants species	Contaminated study	References
Lahore	2018	Landfill leachate	Lemnoideae	Zn, Cu, Ni, Fe, Pb	Daud *et al*. (2018)
Lahore	2019	Landfill leachate	*Eichhornia crassipes, Pistia stratiotes*	Zn, Cu, Ni, Fe, Pb	Abbas *et al.* (2019)
Faisalabad	2019	Soil	*Xanthium strumarium*	Cd, Pb, Ni, Zn	Khalid *et al.* (2019)
Jamshoro	2019	Soil	*Cyamopsis tetragonoloba*, *Glycine max*, *Avena sativa*, *Abelmoschus esculentus*, *Sesamum indicum* and *Guizotia abyssinica*	Cr	Amin *et al.* (2019)
Risalpur	2019	Soil	*Parthenium*, *Cannabis*, *Euphorbia* and *Rumex*	Pb, Cr	Ullah *et al*. (2019)
Khyber Pakhtunkhwa	2020	Soil, sediments and groundwater	*Argyrolobium stenophyllum*, *Silybum marianum*, *Bryophyllumdaigre montianum*, *L. Imonium macrorhabdon*, *C. alendula Arvensis* and *Delphinium suave*	Cr	Sajad *et al.* (2020)
Balochistan	2020	Soil	*P. dactylifera*, *C. procera*	Mn, Pb, Cr, Fe, Ni, Co, Cd	Ullah and Muhammad (2020)
~~Faisalabad~~	~~2021~~	~~Soil~~	~~*Eucalyptus camaldulensis*~~ and *Morus alba*	~~Cu, Cd, Pb~~	~~Yasin *et al.* (2021)~~
Nowshera cantonment	2021	Soil	*Chenopodium album* and *Cynodon dactylon*	Pb	Khan *et al*. (2021)
Khyber Pakhtunkhwa, Mardan	2022	Water	Lemnoideae, *Pistiastratoites*, *Ceratophyllum demersum*	Sewage wastewater	Ullah *et al.* (2022)
Faislabad	2022	Soil, Air	*Azadirachta indica*, *Cassia fistula*, *Conocarpus erectus*, *Eucalyptus camaldulensis*, *Morus alba* and *Populus deltoids*	lead (Pb), zinc (Zn), cadmium (Cd) and copper (Cu)	Rehman *et al*. (2022)
Khyber Pakhtunkhwa	2023	Soil of Marble waste	*Adintum capillus-veneris*, *Ailanthus altissima, Albizia lebbeck*, *Calotropis procera*, *Cynodon dactylon*, *Datura innoxia, Debregeasia salicifolia*, *Desmostachya bipinnata*, *Dodonaea viscosa*, *Erigeron bonariensis*, *Ficus carica*, *Morus alba*, *Morus nigra*, *Parthenium hysterophorus*, *Persicaria glabra*, *Ricinus communis*, *Setaria viridis*, *Tamarix aphylla* and *Withania somnifera*	Cr, Ni, Cu, Mn, Zn, Fe, Co, Cd, Ca and Mg	Ahmed *et al*. (2023)
Faisalabad	2023	Contaminated water	water hyacinth (WH) plants	Pb, petroleum hydrocarbons	Ali *et al*. (2023)
Khyber Pakhtunkhwa	2023	Soil	*Artemisia vulgaris*, *Nonea edgeworthii*, *Arabidopsis thaliana*, *Rosularia adenotricha and Salvia moorcroftiana*, *Cerastium glomeratum*, *Medicago minima and Persicaria glabra*	Mn	Sajad *et al*. (2023)
KPK	2023	Contaminated industrial soil	*Erigeron conyzanthus* L. and *Chenopodium murale*	Pb, Cr, Cu, Ni, Cd	Ahmed *et al*. (2023)

for the experiment work. These species had ability to remove the contaminants from the wastewater. *Lemnoideae* have maximum ability to remove the pollutants as compared to other two species. Removal efficiency of these species reported greater initially then with passage of time the removal efficiency was reduced.

Daud *et al*. (2018), removed the Zn, Cu, Ni, Fe, Pb from landfill leachate by using *Lemnoideae* (Duck weed). Lemnoideae showed the maximum reduction percentage for copper, it was 91%. Abbas *et al.* (2019), used *Eichhornia crassipes, Pistia stratiotes* in their study to remove the heavy metals (Zn, Cu, Ni, Fe, Pb). Bed floating technique was applied in phytoremediation. These species showed the maximum removal efficiency to zinc (80% - 90%). Both species accumulate heavy metals from landfill leachates without any negative impact. The aquatic plants proved to be more suitable to reduce or remove the pollutants from the landfill leachates.

Ali *et al*. (2023), conducted their study using the water hyacinth (WH) plants for the remediation of Pb and petroleum hydrocarbons in industrial contaminated water, these plants reduced the Pb 93% degraded the 72% of petroleum hydrocarbons.

Air. Rehman *et al.* (2022), used *Azadirachta indica*, *Cassia fistula*, *Conocarpus erectus*, *Eucalyptus camaldulensis*, *Morus alba* and *Populus deltoids* to found out the removal of lead (Pb), zinc (Zn), cadmium (Cd) and copper (Cu) in soil and air and reported the decrease in the concentration of heavy metals in this order Zn > Pb > Cu > Cd.

The literature review of last decade of different plant species that have better ability to reduce the heavy metals is given below (Table 3).

Floating treatment wetland technology (FTWT). Floating treatment wetland systems are an innovative technology in Pakistan that has been established to be adaptable for industries and domestic wastewater treatment and bioremediation. FTWT are cost effective and sustainable alternative technique for treatment of effluents because it is highly efficient and very simple in structure and design. Different plants species are used in this system such as *Water hyacinth*, *Typha latifolia*, *Triticum aestivum* L., *Phragmites australis* L., *Phragmites australis*, *Brachia mutica*, *Eichhornia crassipes* and *Pistia stratiotes* etc. These plants have great tolerance to accumulate the heavy metals without showing reduction in growth. So, these plants are highly

Table 3. Plants species which are used in Phytoremediation technique in Pakistan

Plant species	Potential contaminants	References
Glycine max L. *merrill*	Cd, Mn	Ali *et al*. (2012)
Brassica juncea	Cu, Fe	Motior *et al*. (2013)
Amaranthu spaniculatus	Fe, Cu	Motior *et al.* (2013)
Pistia stratiotes L (Araceae)	Fe, Zn, Cu, Cr and Cd	Khan *et al*. (2014)
Vicia faba	Pb	Shahid *et al*. (2015)
Lemna minor	Cu, Cd, Pb, Ni	Bokhari *et al.* (2016)
Vallisneria spiralis	Cu, Cd	Akhtar *et al.* (2017)
Sorghum halepense	TPHs (Total petroleum hydrocarbons)	Alavi *et al*. (2017)
Trifoliuma lexandrinum	Cu, Cd, Pb, Cr	Iram *et al.* (2018)
Salicaceae	Ar	Malik and Qayyum (2018)
Salix tetrasperma	Ar	Malik and Qayyum (2018)
Triticum aestivum	Cu, Cd, Pb, Cr	Iram *et al.* (2018)
Zea mays	Cd, Pb, Cu, Cr	Iram *et al.* (2019)
Helianthus annuus	Cd, Pb, Cu, Cr	Iram *et al.* (2019)
Lacuta dissecta	Ni	Sajad *et al.* (2020a)
Lolium multiflorum	Cr	Sajad *et al*. (2020b)
Torilis leptophylla	Ni	Sajad *et al.* (2020a)
Xanthium strumarium	Cu, Cd, Pb, Zn	Ullah *et al.* (2021)
Eichhornia crassipis	Cr, Cu	Irfan (2021)
Typhalatifolia	Tu, Color, EC, Fe, Cu, Zn	Abbas *et al*. (2021)
Azadirachtaindica, *Cassia fistula*, *Conocarpus erectus*, *Eucalyptus camaldulensis*, *Morusalba* and *Populus deltoids*	lead (Pb), zinc (Zn), cadmium (Cd) and copper (Cu)	Rehman *et al.* (2022)
Erigeron conyzanthus L. and *Chenopodium murale*	Pb, Cr, Cu, Ni, Cd	Ahmed *et al.* (2023)

recommended for the removal of pollution burden from the landfill leachate (Rashid *et al*., 2023; Younas *et al.*, 2022; Nawaz *et al*., 2020; Abbas *et al*., 2019; Shahid *et al*., 2019; Rehman *et al*., 2018).

Microbes assisted the phytoremediation (MAP). Microbes have highest metals removal efficiency for remediation of wastewater. In Pakistan different bacterial species are used successfully for the removal of organic and inorganic pollutants from wastewater such as *Bacillus subtilis* strain LORI66, *Klebsiella* sp. strain LCRI87, *Acinetobacter Junii* strain TYRH47, *Acinetobacter* sp. strain LCRH81, *Burkholderia phytofirmans PsJN*, *Acinetobacter lwofii ACRH76*, *Pseudomonas aeruginosa PJRS20*, *Bacillus* sp. *PJRS25*, *Acinetobacter lwoffii ACRH76*, *Bacillus pumulis C2A1*, and *Acinetobacter* sp. *HN3.* Plants are inoculated with bacteria strains that boost up their potential for removal of metals from waste effluents (Rashid *et al*., 2023; Shah *et al*., 2022; Shaid *et al*., 2019; Rehman *et al*., 2018).

Conclusion and Recommendations

There are different methods to remediate the pollutant sites by using the different plant species. Plants can easily break down the organic contaminant into inorganic pollutants and remediate the environment like strainers. Phytoremediation is an environmental friendly and low cost technique. The developing countries like Pakistan cannot afford the expensive technology to clean the contaminant sites, phytoremediation is a low cost method as compared to others. The flora of different regions can be utilized pertaining to the ability of plants species to clean the environment in an economical way. Further, research is needed to focus on genetic engineering for improving the development of phytoremediation technologies to have better phytoremediator plant species supportive to speed up the metal accumulation, translocation and detoxification significantly. Phytoremediation is a time consuming technique, the best hidden plant species should be worked out to remediate the high contaminated areas in short period of time. The research funding will support in the researchers and farmers. The commercialization of the techniques will guarantee the food security. Some essential metals can be recovered by phytomining. The biofortification of the grains, fruits and vegetables would help in increasing the nutritional value of edibles.

The vegetation is not only important for the remediation purpose but they clean the air and work as a sink for green house gas the CO_2. Thus they help in the climate change scenario too acting a multiremedial solution for a sustainable planet.

Conflict of Interest. The authors declare that they have no conflict of interest.

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