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Toxic heavy metal lead (Pb) contamination of soils, plants and waters in Hayat Abad Industrial Estate, Peshawar, Khyber Pakhtunkhwa

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Key words: Heavy metals, Phytoextraction, Phytostabilization, BCFs, TFs, BACs

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Abstract

The present research studies were carried out in the Hayatabad Industrial Estate Peshawar to analyze the concentration of the Lead (Pb) in the soil and plant parts (Root and Shoots). Metals were analyzed in the soil of the root zone, in root and shoot of each plant. Phytoremediation potential of the analyzed plants grown in their natural habitats was evaluated by the calculation of Bioconcentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation Coefficient (BAC). Among all fifty plants species only Ten (10) species were found hyper accumulator for Lead. However most of the plant species showed feasibility for the phytoremediation; phytostabilization and phytoextraction of the selected heavy metals. Based on concentration of lead (Pb) in shoots and BCFs, TFs and BACs values twenty (20) plants were found most efficient plants for the phytoextraction of Lead (Pb). These plant species were found efficient for the phytoextraction of lead metal from the analyzed plants and soil. Similarly based on the concentration of the lead in roots and BCFs, TFs and BACs values twenty (20) plants were found efficient for the phytostabilization of lead (Pb). These plants species may be used for the phyto-immobilization of the mentioned metal contaminated soil.

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Introduction

Peshawar is one of the oldest cities in Asia and is the capital of Khyber Pakhtunkhwa Peshawar and Hayatabad is a famous industrial zone of Peshawar (Fig. 1) which was established in 1963 (Jan *et al.,* 2010). The total installed units in Hayatabad industrial estate are 372. The recent data show that 242 major industries are functional. These industries are grouped into 20 major classes. The industries effluents and solid-waste are thrown in the Kabul River through Budni Nullah without any prior treatment. This practice badly affects water quality of the river (Nafees, 2004). Literature revealed that industrial effluents have been making the water unsafe for flora and fauna of Kabul River including important medicinal plants (Khan *et al.,* 2002).

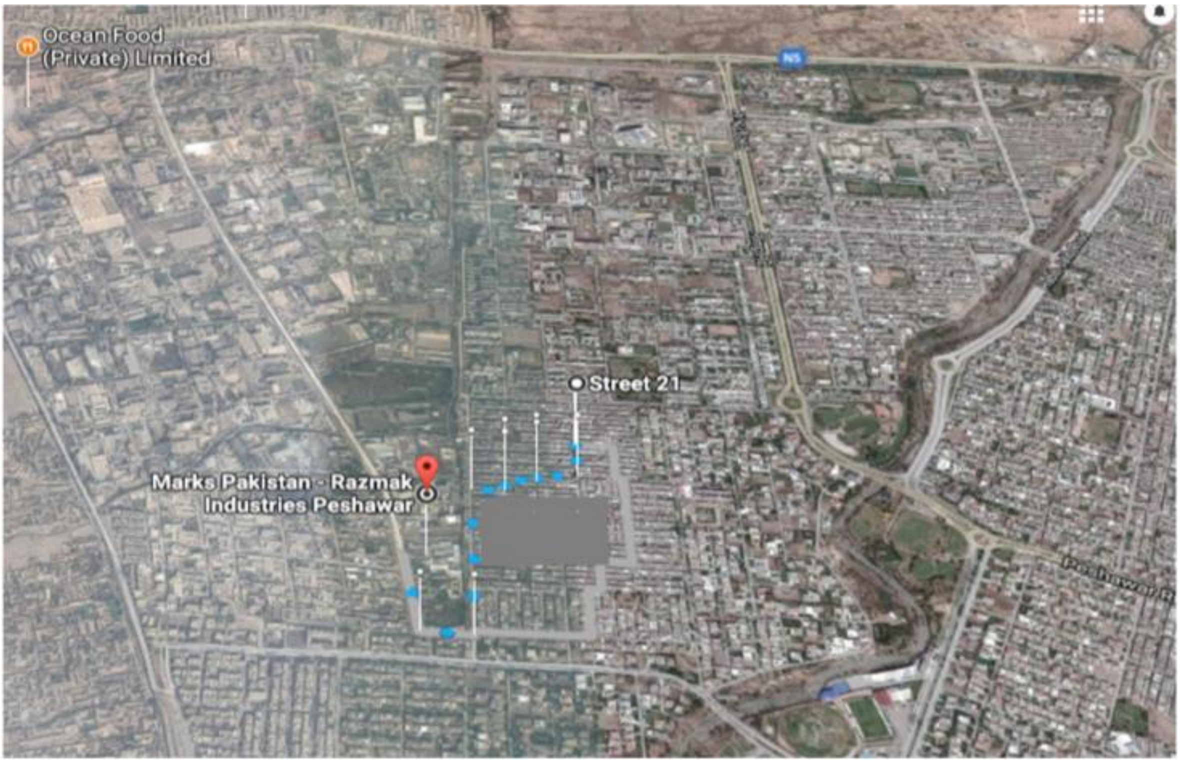


Fig. 1. Location map of Haytabad Industrial Estate.

Contamination of heavy metals legitimately and in indirect way influences the human health. These substances antagonistically influence the efficiency of soils, plants, animals and the whole condition if surpass certain points of confinement (Mapanda *et al.,* 2005). Actually sources of heavy metals contamination are mainly derived from anthropogenic in nature. Which include vehicle fumes, tire wearing, power plants, coal ignition, metallurgical industry, auto mechanics shop, synthetic substances plant, household discharge, enduring of building and asphalt surface and environmental stores.

Lead (Pb) has long been known as potential health hazard Rowchowdhury and Gautum, 1995; Shen *et al.*, 1996; Nriagu *et al.*, 1996; Al-Saleh *et al.*, 1996; Kim *et al.*, 1996; El-Zohairy *et al.*, 1996; Shannon and Graef, 1996 . A number of studies have been carried out to determine the lead concentration in soil, particulates and leaf samples in different urban areas and industrial areas around the world Duggan and Williams, 1977; Duggan, 1980; Fergusson *et al.*, 1980; Caswell and Laxen, 1984; Caswell, 1985; Fergusson and Schroeder, 1985; El Hinshery *et al.*, 1992; Gratani *et al.*, 1992; Mezger, 1995; Oyedele, 1995; Wong, 1996; Brandvold *et al.*, 1996; etc.. Soil is a significant source of lead and can raise the blood lead levels in humans particularly in children Sayre, 1981; Duggan, 1983a, 1983b; Langlois *et al.*, 1996. Lead (Pb) is a widespread toxic heavy metals present in soils, plants and waters.

It is mostly present in top layer of soil due to the deposition from air containing smoke from vehicles. The Lead (Pb) is released from the mining, industrial and agricultural chemicals. In uncontaminated soils, Lead (Pb) concentrations are generally below 50mg/kg (Reimann, 1998). The Lead (Pb) concentration in vegetation growing on such soils is often less than 10mg/kg dry mass. Soil lead ranging from 10 to 293mg/kg in agricultural areas and in the areas of pesticide manufacturing companies 57.05mg/kg were noted in different areas of Pakistan (Karishna and Govil, 2005).

Nickel occurs naturally in soils and volcanic rocks. Nickel and its salts are used in several industrial applications such as in electroplating, automobile and aircraft parts, batteries, coins, spark plugs, cosmetics and stainless steel, and are used extensively in the production of nickel–cadmium batteries on an industrial scale (Alloway, 1990). It enters into the water bodies naturally by weathering of rocks and soils and through the leaching of the minerals. The water soluble salts of nickel are the major problems of contamination in aquatic systems (Faiz *et al.,* 2009). Paint formulation and enameling industries discharges nickel containing effluents to the nearby bodies of water.

Nickel is also found in cigarettes, as a volatile compound commonly known as nickel carbonyl (Mehdi *et al.,* 2003). Nickel plays an essential role in the synthesis of red blood cells; however, it becomes toxic when taken in higher doses. Trace amounts of nickel do not damage biological cells, but exposure to a high dose for a longer time may damage cells, decrease body weight and damage the liver and heart. Nickel poisoning may cause reduction in cell growth, cancer and nervous system damage (WHO, 1984).

Motivation of the Research

Heavy metals uptake, by plants using phytoremediation technology, seems to be a prosperous way to remediate heavy metals-contaminated environment. It has some advantages compared with other commonly used conventional technologies. Several factors must be considered in order to accomplish a high performance of remediation result. The most important factor is a suitable plant species which can be used to uptake the contaminant. Even the phytoremediation technique seems to be one of the best alternatives, it also has some limitations. Prolong research needs to be conducted to minimize this limitation in order to apply this technique effectively.

Table 1. Standard Metal Concentration of Nickle and Lead.

SN	Metal Name	Effect	Standard
1	Lead (Pb)	• Toxic to humans, aquatic fauna and livestock • High doses cause metabolic poison • Tiredness, irritability anemia and behavioral changes of children • Hypertension and brain damage • Phytotoxic	• By the Environmental Protection Agency: maximum concentration 0.1mg/L. • By European Community: 0.5mg/L. • Regulation of water quality (Pak) 0.1mg/L.
2	Nickle (Ni)	• High conc. can cause DNA damage • Eczema of hands • High phytotoxicity • Damaging Fauna	• By the Environmental Protection Agency: maximum concentration: 0.1mg/L. • By European Community: 0.1mg/L. • Regulation of water quality: (Pak) 0.1mg/L.

Therefore the aim of the study to determine the concentration of heavy metals (Pb) and to find out ways and means for eradicating its environmental impacts and to quantify the concentration levels of heavy metals (Pb) in water, soil & their transfer and accumulation in plants.

Materials and methods

This study include sample of soil, plant and water. For the assortment of soil, plant and water samples Hayatabad Industrial Estate Peshawar, Metropolitan was chosen. The samples were taken in the March-November, 2018.

Samples were gathered from each matrix 0.5-Km separated for soil, plant and water. Sample from every matrix was gathered and arranged by the recommended strategy and afterward examined on Atomic Absorption Spectrophotometer (Model Thermoelectron S-Sreries) for the irresistible metals assurance.

Study area

The present study was conducted in Hayatabad Industrial estate during 2018-2019 with an attempt to study the Hayatabad industrial estate for lead and nickel minimization through Industrial symbiosis and find out ways and means for mitigating its environmental impacts. The record of Peshawar Development Authority (PDA) stated that there are 372 industries out this 242 were functional. The interview and preliminary survey revealed that the industrial estate consists of two types of industries i-e small and large. Number of small industries were 126 out of which 22 (17%) were closed. While number of large industries were 246, out of this 36 (15%) industries were closed. The decrease in functional industries is attributed to various factors. Among these security threat, lack on incentives, energy crisis. All these industrial units are releasing huge quantity of untreated city waste water into underground drains. From these drains farmers are using this contaminated water for the production of crops, especially vegetables. From these drains farmers are using this contaminated water for the production of crops, especially vegetables. Farmers consider this raw city effluent is a good source of water and nutrients, substitute of good quality water and reliable source of irrigation round the clock. Keeping in view the above facts, the studies were designed to investigate the lead and nickel contamination in soils, plants and water in the Hayatabad Industrial Estate Peshawar.

Collection and Preparation of Soil Samples

Soil samples were collected from different areas of Hayatabad Industrial Estate, Peshawar after every 0.5-Km from 0-15cm and 15-30cm. Soil samples were taken from 50 points at each grid and mixed thoroughly in a plastic bucket. Samples are taken to laboratory air dried, ground with wooden roller and sieved through 2mm stainless steel sieve. For the determination of heavy metals soil samples were extracted with AB-DTPA (Soltanpur, 1985) and analyzed on Atomic Absorption spectrophotometer (Model Thermoelectron S-Sreries). Physiochemical characteristics were also determined ECe, pHs and SAR (Allison *et al.,* 1954)

Collection and Preparation of Plant Samples

Plant samples were also collected from the above mentioned places as the soil samples taken. Two Plant samples of vegetables, crops, trees and ornamental plants depending upon the availability of vegetation were taken. Samples were taken to laboratory washed with tap water, diluted HCl water and distilled water to remove the external contamination. Samples were air dried and then placed in Oven at 65°C for drying of samples. After oven drying samples were ground and stored in plastic zipper. A 1gm sample was taken in digestion flask and 12ml diacid mixture (i.e. Pechloric acid $HClO_4$ and Nitric acid HNO_3 with a ratio of (1:3) were added and kept for overnight stay. Next day samples are digested on hot plate till the plant material digested and color was clear. After digestion sample was cooled and made 25ml volume with distilled water and stored in air tied bottles for the determination of heavy metals. Samples were analyzed on Atomic Absorption spectrophotometer (Model Thermoelectron S-Sreries). Instrument was calibrated with standard solution of respective metal.

Collection and preparation of water samples

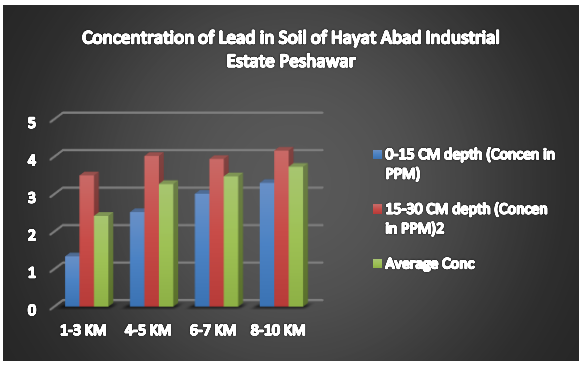
Water samples were collected from the above mentioned sites. For water samples groundwater (tube well, hand pump and motor pumps), surface water (canal) and waste water(sewerage, industries effluent) were taken depending upon the availability in the area but ground water was taken from each site. Water sample was taken to laboratory and filtered with Whatman No.40. The water samples were analyzed for EC, SAR and RSC (Allison *et al.*, 1954) after the basic analysis of water samples concentrated HCl was added to the waste water samples and Sodium Haxametaphosphat was added to ground water samples to check the metal precipitation. For the determination of heavy metal Atomic Absorption spectrophotometer (Model Thermoelectron S-Series) was used.

Results

Metals ions in the soil, plants and water collected from Hayatabad Industrial Estate Peshawar

Lead (Pb) concentration in soils

The AB-DTPA extractable Pb in soil sample collect from the Hayatabad Industrial Estate Peshawar ranged from 0.711-5.50ppm and 0.819-5.77ppm at 0-15cm and 15-30cm with mean value 1.093 and 5.509 separately. The accessible Pb focus in the soil sample is a lot higher in the 0-15cm profundity as contrast with the 15-30cm depth it might be due to the aerial deposition from the vehicle exhaust and industrial effluent. The most extreme grouping of Pb was seen at spot no: 23 i.e. junction of all drainage near northwest hospital (5.95ppm) while least fixation (0.711) was at Spot no: 1st at 0-15cm profundity. In every one of the soil samples of Hayatabad Industrial Estate Peshawar the Pb fixation was between the range (5-15ppm) proposed by Alloway (1990) revealed the high concentration of AB-DTPA extractable Pb at 0-10 and 10-20cm soil profundity around Hayatabad Industrial Estate Peshawar watered with raw water from industries of Hayatabad Industrial Estate. The high convergence of Pb in the surface layer may be because of the nonstop utilization of industrial effluent containing metals and furthermore because of the less mobility of Pb inside the soil especially in antacid soil conditions. The Pb is accounted for to assemble more in acidic scope of pH since Pb ties unequivocally with natural issue and oxides of Fe and Mn it is a low portability metal in the soil.



Concentration of lead (Pb) in analysed plants

The family, botanical name, number of site and name of the site of collection as well as the concentration of Lead (Pb) metal in the soil of different sites, root and shoot part of the plant was found in the range of 0.711-4.471, 0.94-8.002 and 1.864 8.487mg/Kg respectively.

Table 2. Family Name, Plant Name, Number of Site, Name of Site and concentration of Lead in different parts of the plants.

SN	Family	Species	SN	Concentration of Lead (Mg/Kg)		
				Soil	Root	Shoot
1.	Asteraceae	*Cnicus benedictus* Linn.	1.	1.093 ± 0.04	1.182 ±0.12	2.552 ±0.12
		Parthenium hysterophorus L.	2.	1.237 ±0.09	1.468 ±0.14	1.204 ±0.09
		Verbesina enceliodes (Cav.) Benth. &Hook. f. ex A. Gray	3.	1.388 ±0.12	1.653 ±0.14	3.215 ±0.09
		Conyza canadensis (L.) Cronquist.	4.	2.978 ±0.02	3.913 ± 0.35	1.415 ±0.10
		Xanthium strumarium L.	5.	1.354 ±0.03	1.998 ±0.08	2.354 ±0.12
		Parthenium hysterophorus L.	6.	2.862 ±0.04	4.277 ±0.08	6.145 ±0.11
		Conyza sumatrensis (S.F.Blake) pruski & G.Sancho	7.	3.352 ±0.09	4.844 ±0.18	2.352 ±0.00
		Parthenium hysterophorus L.	8.	3.421 ±0.03	5.037 ±0.05	2.325 ±0.14
2.	Amaranthaceae	*Amaranthus retroflexus*	9.	1.459 ±0.04	2.159 ±0.04	2.624 ±0.12
		Chenopodium album	10.	2.471 ±0.05	3.013 ±0.06	5.215 ±0.01
		Amaranthus viridis L.	11.	2.988 ±0.01	3.969 ±0.09	2.154 ±0.08
		Chenopodium murale L.	12.	3.541 ±0.04	5.538 ±0.06	7.248 ±0.10
3.	Brassicaceae	*Thlapsi arvense*	13.	2.461 ±0.04	3.130 ±0.09	5.241 ±0.08
		Lipidium didimum L.	14.	2.287 ±0.08	3.701 ±0.03	4.215 ±0.016
		Sisymbrium officianale (L.) Scop.	15.	4.029 ±0.07	6.049 ±0.03	3.874 ±0.08
4.	Caryophyllaceae	*Silene conoidia* L.	16.	2.874 ±0.06	4.215 ±0.03	1.241 ±0.07
		Stellaria media (L.) Vill.	17.	2.878 ±0.05	4.450 ±0.09	6.452 ±0.00
		Arenaria serpyllifolia Bourg. Ex Willk & Lange	18.	3.628 ±0.04	4.578 ±0.06	2.385 ±0.08

SN	Family	Species	SN	Concentration of Lead (Mg/Kg) Soil	Root	Shoot
		Cerastium dichotomum L.	19.	3.310 ±0.04	4.966 ±0.05	5.846 ±0.05
5.	Convulvulaceae	*Convolvulus arvensis* L.	20.	2.667 ±0.07	3.509 ±0.01	1.267 ±0.17
6.	Euphorbiaceae	*Chrozophora tinctoria*	21.	1.768 ±0.00	2.715 ±0.05	3.254 ±0.06
7.	Fabaceae	*Trifolium pratense* L.	22.	1.306 ±0.06	1.241 ±0.01	4.952 ±0.10
		Artemisia vulgaris	23.	2.314 ±0.07	3.236 ±0.05	4.278 ±0.04
		Medicago polymorpha (L.)	24.	2.542 ±0.08	3.262 ±0.03	0.784 ±0.09
		Lathyrus aphaca L.	25.	3.016 ±0.03	4.517 ±0.09	4.214 ±0.04
		Dalbergia sissoo	26.	4.471 ±0.04	8.002 ±0.02	8.487 ±0.10
		Melilotus indicus L. ALL	27.	2.284 ±0.10	3.611 ±0.07	2.469 ±0.18
8.	Lamiaceae	*Teucrium fruticans* L.	28.	0.889 ±0.04	0.985 ±0.04	1.534 ±0.11
		Thymus vulgaris L.	29.	1.188 ±0.01	1.397 ±0.01	0.687 ±0.05
		Salvia egyptiaca L.	30.	3.344 ±0.04	5.249 ±0.07	7.658 ±0.00
9.	Meliaceae	*Melia azedarach*	31.	5.185 ±0.08	7.032 ±0.10	6.285 ±0.06
10.	Malvaceae	*Bombax ceiba*	32.	4.287 ±0.10	7.652 ±0.04	2.574 ±0.01
11.	Moraceaee	*Morus alba*	33.	5.18 ±0.06	6.190 ±0.05	7.589 ±0.04
12.	Nyctaginaceae	*Mirabilis jalapa* L.	34.	0.711 ±0.05	0.94 ±0.03	1.864 ±0.00
		Boerhavia procumbens Banks ex Roxb.	35.	3.632 ±0.31	5.667 ±0.05	4.333 ±0.13
13.	Poaceae	*Digitaria sanguinalis* (L.) Scop.	36.	3.011 ±0.02	4.356 ±0.02	2.457 ±0.08
		Avena sativa L.	37.	3.975 ±0.04	5.829 ±0.06	7.548 ±0.04
		Sorghum halipense (L.) Pers.	38.	3.945 ±0.00	6.030 ±0.08	8.345 ±0.01
		Cynodon dactylon (L.) Pers	39.	4.959 ±0.03	6.198 ±0.06	5.957 ±0.00
14.	Polygonaceae.	*Polygonum plebeium* R.Br.	40.	3.241 ±0.09	3.937 ±0.05	3.512 ±0.04
		Persicaria hydropiper (Linn.) Spach	41.	2.878 ±0.06	4.142 ±0.03	3.324 ±0.01
15.	Primulaceae	*Anagallis arvensis* L.	42.	3.185 ±0.02	4.057 ±0.04	6.824 ±0.10
16.	Rananculaceae	*Ranunculus muricatus* L.	43.	2.741 ±0.04	4.091 ±0.04	1.483 ±0.07
17.	Rubiaceae	*Gallium aparine* L.	44.	3.033 ±0.09	4.766 ±0.04	3.324 ±0.05
18.	Solanaceae	*Datura metel* L.	45.	1.485 ±0.08	1.831 ±0.06	2.821 ±0.10
		Withania somnifera	46.	2.903 ±0.03	3.097 ±0.19	1.903 ±0.10
19.	Scrophulariaceae	*Verbascum Thapsus* L.	47.	3.449 ±0.04	5.454 ±0.10	4.544 ±0.53
20.	Verbenaceae	*Verbena officinale* L.	48.	2.407 ±0.02	3.683 ±0.06	2.074 ±0.01
21.	Zygophyllaceae	*Tribulus terrestris*	49.	1.430 ±0.11	2.542 ±0.01	2.256 ±0.10

S*No= Site number, Concentration of Lead (Pb) in soil and plant parts is shown as mean (n=3) ±SD.

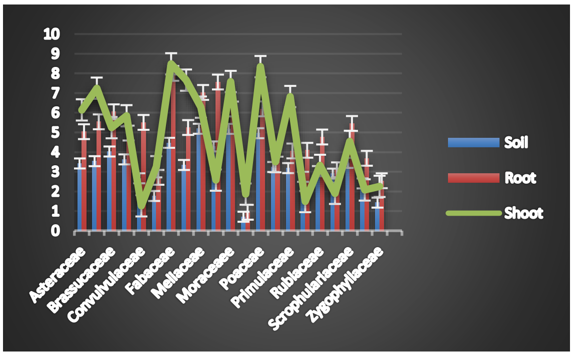


Fig. 2. Concentration of Lead (Pb) in Soil, Root and Shoot in Different Families.

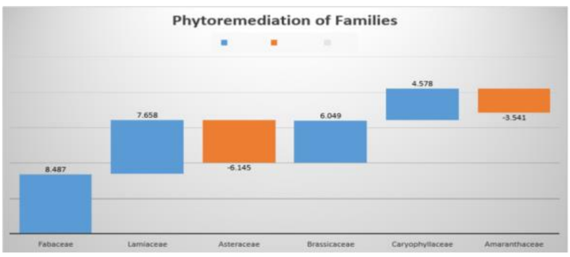


Fig. 3. Feasibility of the families for the phytoremediation of Lead (Pb).

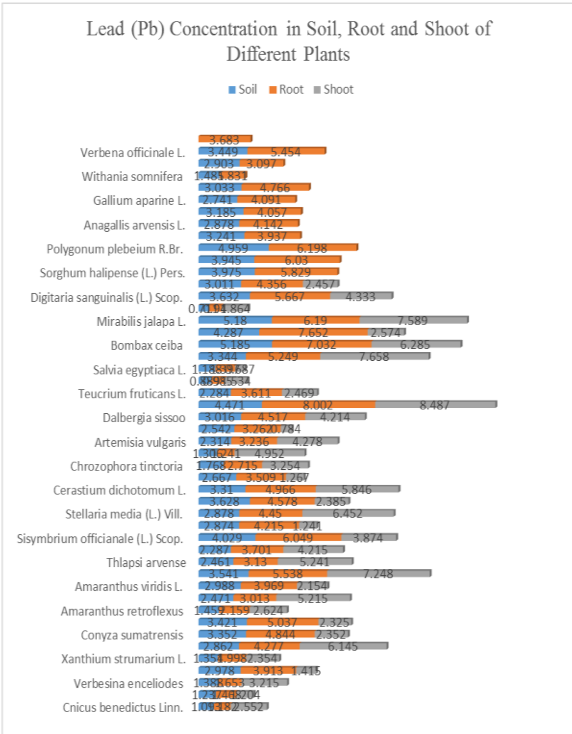


Fig. 4. Concentration of Lead (Pb) in Soil, Root and Shoot in Different Families.

Evaluation of the analyzed plants for the phytoremediation of lead (Pb)

Bioconcentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation Coefficient (BAC) of all analyses plants were calculated. The feasibility of each plant species for the phytoremediation of lead metal was evaluated as show in Table3. The BCFs, TFs, and BACs values of the plants for lead metals were found in the range of "0.6-1.05","0.4-4.16" and "0.6-3.7" respectively. Most of the plant species shows feasibility for the phytoremediation of copper metal but based on its concentration in shoots (Table 3) and BCFs, TFs and BACs value *Parthenium hysterophorus, Conyza canadensis, Conyza sumatrensis, Parthenium hysterophorus, Amaranthus viridis, Lipidium didimum, Sisymbrium officianale, Silene conoidia, Arenaria serpyllifolia* and *Cerastium dichotomum* are the most efficient plants for the phytoextraction of Lead. Similarly based on Lead concentration in roots (Table 3) and BCFs, TFs and BACs values, *Chenopodium album, Chenopodium murale, Stellaria media, Trifolium pretense, Salvia egyptiaca, Mirabilis jalapa, Sorghum halipense, Anagallis arvensis* and *Tribulus terrestris* are the most capable plants for the phytostabilization of lead metal.

Table 3. Name of the plant species and their Bioconcentration Factor, Translocation Factor and Bioaccumulation Coefficient for Lead Metal.

SN	Family	Species	Bioconcentration Factor, Translocation Factor and Bioaccumulation Coefficient			Feasibility of the plant for the phytoremediation of Lead (Pb).
			BCF	TF	BAC	
1.	Asteraceae	*Cnicus benedictus* Linn.	0.925	0.463	2.335	++**
		Parthenium hysterophorus L.	0.843	1.219	0.973	+*
		Verbesina enceliodes (Cav.) Benth. &Hook. f. ex A. Gray	0.840	0.514	2.316	++**
		Conyza canadensis (L.) Cronquist.	0.761	2.765	0.475	+*
		Xanthium strumarium L.	0.678	0.849	1.739	++**
		Parthenium hysterophorus L.	0.669	0.696	2.147	++**
		Conyza sumatrensis (S.F.Blake) pruski & G.Sancho	0.692	2.060	0.702	+*
		Parthenium hysterophorus L.	0.679	2.166	0.680	+*
2.	Amaranthaceae	*Amaranthus retroflexus*	0.676	0.823	1.798	++**
		Chenopodium album	0.820	0.578	2.110	+++***
		Amaranthus viridis L.	0.753	1.843	0.721	+*
		Chenopodium murale L.	0.639	0.764	2.047	+++***
3.	Brassicaceae	*Thlapsi arvense*	0.786	0.597	2.130	+++***
		Lipidium didimum L.	0.618	0.878	1.843	+*
		Sisymbrium officianale (L.) Scop.	0.666	1.561	0.962	+*
4.	Caryophyllaceae	*Silene conoidia* L.	0.682	3.396	0.432	+*
		Stellaria media (L.) Vill.	0.647	0.690	2.242	+++***
		Arenaria serpyllifolia Bourg. Ex Willk & Lange	0.792	1.919	0.657	+*
		Cerastium dichotomum L.	0.667	0.849	1.766	++**
5.	Convulvulaceae	*Convolvulus arvensis* L.	0.760	2.770	0.475	+*
6.	Euphorbiaceae	*Chrozophora tinctoria*	0.651	0.834	1.840	++**
7.	Fabaceae	*Trifolium pratense* L.	1.052	0.251	3.792	+++***
		Artemisia vulgaris	0.715	0.756	1.849	++**
		Medicago polymorpha (L.)	0.779	4.161	0.308	+*
		Lathyrus aphaca L.	0.668	1.072	1.397	++**
		Dalbergia sissoo	0.559	0.943	1.898	++**
		Melilotus indicus L. ALL	0.633	1.463	1.081	++**
8.	Lamiaceae	*Teucrium fruticans* L.	0.903	0.642	1.726	++**
		Thymus vulgaris L.	0.850	2.033	0.578	+*
		Salvia egyptiaca L.	0.637	0.685	2.290	+++***
9.	Meliaceae	*Melia azedarach*	0.737	1.119	1.212	++**
10.	Malvaceae	*Bombax ceiba*	0.560	2.973	0.600	+*
11.	Moraceaee	*Morus alba*	0.837	0.816	1.465	++**

SN	Family	Species	Bioconcentration Factor, Translocation Factor and Bioaccumulation Coefficient			Feasibility of the plant for the phytoremediation of Lead (Pb).
			BCF	TF	BAC	
12.	Nyctaginaceae	*Mirabilis jalapa* L.	0.756	0.504	2.622	+++***
		Boerhavia procumbens Banks ex Roxb.	0.641	1.308	1.193	+*
13.	Poaceae	*Digitaria sanguinalis* (L.) Scop.	0.691	1.773	0.816	+*
		Avena sativa L.	0.682	0.772	1.899	++**
		Sorghum halipense (L.) Pers.	0.654	0.723	2.115	+++***
		Cynodon dactylon (L.) Pers	0.800	1.040	1.201	++**
14.	Polygonaceae.	*Polygonum plebeium* R.Br.	0.823	1.121	1.084	++**
		Persicaria hydropiper (Linn.) Spach	0.695	1.246	1.155	+*
15.	Primulaceae	*Anagallis arvensis* L.	0.785	0.595	2.143	+++***
16.	Rananculaceae	*Ranunculus muricatus* L.	0.670	2.759	0.541	+*
17.	Rubiaceae	*Gallium aparine* L.	0.636	1.434	1.096	++**
18.	Solanaceae	*Datura metel* L.	0.811	0.649	1.900	++**
		Withania somnifera	0.937	1.627	0.656	+*
19.	Scrophulariaceae	*Verbascum Thapsus* L.	0.632	1.200	1.317	++**
20.	Verbenaceae	*Verbena officinale* L.	0.388	1.776	1.450	++**
21.	Zygophyllaceae	*Tribulus terrestris*	0.925	0.463	2.335	+++***

Bioconcentration Factor (BCF)= Conc. of lead in root ÷ Conc. of Lead in Soil,

Translocation Factor (TF)= Conc. of lead in shoot ÷ Conc. of lead in root,

Bioaccumulation Coefficient (BAC)= Conc. of lead in shoot ÷ Conc. of lead in soil,

+*= Metal excluders; may be used for the phytostabilization of metal, ++**= Metal indicators; May be used for the phytoextraction of metal, +++***= Metal hypo accumulator; may be used for the Phytoextraction and recovery of metal.

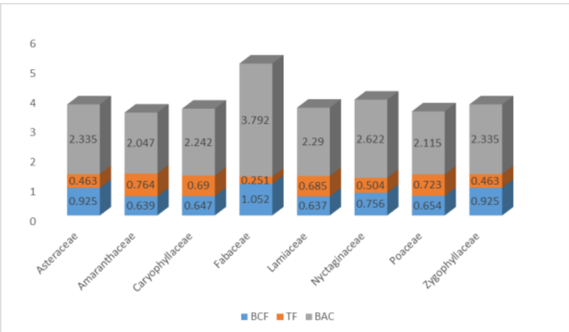


Fig. 5. Feasibility of the plant for the phytoremediation of Lead.

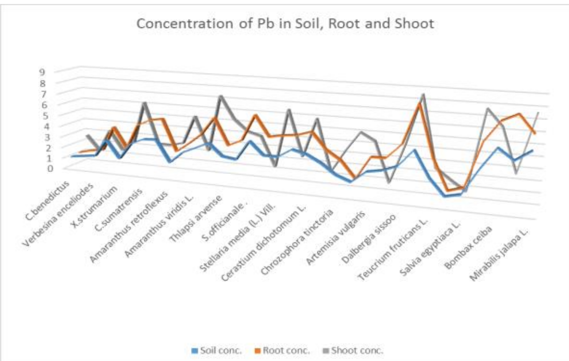


Fig. 6. Concentration of Pb in Soil, Root and Shoot of different plants.

Conclusion and recommendations

In the present research work fifty plants species belong to thirty 21 families were collected and analyzed for the concentration of Lead (Pb) metal. Lead was analyzed in the soil of the root zone, in root and shoot of each plant. Phytoremediation potential of the analyzed plants grown in their natural habitats was evaluated by the calculation of Bioconcentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation coefficient (BAC).

1. The total concentrations of the selected heavy metals were determined in the soil of different sites. The concentration of Lead (Pb) in the soil of 50 sites was found in the range of 0.711-5.50ppm and 0.819-5.77ppm at 0-15cm and 15-30cm with mean value 1.093 and 5.509 respectively.

2. The maximum concentration of Lead (Pb) was found in the soil of Site 49 (5.50ppm) and 50 (5.77ppm) while it minimum concentration was reported in the soil of site 02 (0.7ppm).

3. Ten plant species i.e. *Chenopodium album. Chenopodium murale, Thlapsi arvense, Stellaria media, Trifolium pretense, Salvia egyptiaca, Mirabilis jalapa, Sorghum halipense, Anagallis arvensis,* and *Tribulus terrestris* were found hyperaccumulators for Lead (Pb) metal.

4. Most of the plants species showed feasibility for the phytoremediation; Phytostabilization and phytoextraction of the selected heavy metals. Based on the concentration of Lead (Pb) in shoots and BCFs, TFs and BACs value *Cnicus benedictus, Verbesina enceliodes, Xanthium strumarium, Parthenium hysterophorus, Amaranthus retroflexus, Cerastium dichotomum, Chrozophora tinctoria, Artemisia vulgaris, Lathyrus aphaca, Dalbergia sissoo, Melilotus indicus, Teucrium fruticans, Melia azedarach, Morus alba, Avena sativa, Cynodon dactylon, Polygonum plebeium, Datura metel, Verbascum thapsus* and *Verbena officinale* were found the most efficient plants for the phytoextraction of Lead (Pb) metal.

5. Based on the concentration of Lead (Pb) in shoots and BCFs, TFs and BACs value *Parthenium hysterophorus, Conyza canadensis, Conyza sumatrensis, Parthenium hysterophorus, Amaranthus viridis, Lipidium didimum, Sisymbrium officianale, Silene conoidia, Arenaria serpyllifolia, Convolvulus arvensis, Medicago polymorpha, Thymus vulgaris, Bombax ceiba, Boerhavia procumbens, Digitaria sanguinalis, Persicaria hydropiper, Ranunculus muricatus* and *Withania somnifera* were found the most efficient plants for phytostabilization of lead (Pb) Metal.

On the basis of current finding, it is recommended that:

1. *Chenopodium album. Chenopodium murale, Thlapsi arvense, Stellaria media, Trifolium pretense, Salvia egyptiaca, Mirabilis jalapa, Sorghum halipense, Anagallis arvensis,* and *Tribulus terrestris* are the most efficient plants for the phytoextraction of Lead (Pb) metal. Theses plants may be used for the removal of Lead (Pb) metal from the lead contaminated soil.

2. *Cnicus benedictus, Verbesina enceliodes, Xanthium strumarium, Parthenium hysterophorus, Amaranthus retroflexus, Cerastium dichotomum, Chrozophora tinctoria, Artemisia vulgaris, Lathyrus aphaca, Dalbergia sissoo, Melilotus indicus, Teucrium fruticans, Melia azedarach, Morus alba, Avena sativa, Cynodon dactylon, Polygonum plebeium, Datura metel, Verbascum Thapsus* and *Verbena officinale* for phytostabilization of lead metal. These plant species may be used for the phytoimmobilization of the mentioned metals contaminated soil.

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