Evaluation Of Manganese Phytoremediation Potential Of Some Plant SpeciesIn Dir Lower, KP, Pakistan

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Abstract

Environmental pollution by heavy metals is a serious issue worldwide. Manganese is one of these heavy metals which is hazardous for the flora and fauna when present in soil and water beyond the threshold level. The present research work was carried out in the area of District Dir Lower to screen plants for the phytoremediation of manganese. To achieve this goal, some of the plants in this area were collected and identified. The concentration of manganese (Mn) in the soil of the root zone and plant parts (Roots and Shoots) was analyzed. The phytoremediation potential of the analyzed plants grown in their natural habitats was evaluated by the calculation of the Bio concentration Factor (BCF), Translocation Factor (TF) and Bioaccumulation Coefficient (BAC). The concentration of Mn was determined in the soil of different sites of the research area. The concentrations of Mn in the soil of sixty-one sites were found in the range of 92.15-99.96 mg/Kg. The maximum concentration of Mn was found in the soil of site 1 (99.96) and Site 10 (99.96) mg/Kg while its minimum concentration was present in the soil of site 7 (92.15) and Site 51 (92.15) mg/Kg. Among the studied plants, *Artemisia vulgaris*, *Nonea edgeworthii*, *Arabidopsis thaliana*, *Rosularia adenotricha* and *Salvia moorcroftiana* were found efficient for the phytoextraction of Mn. Based on the concentration of the Mn in roots and BCFs, TFs and BACs values, *Cerastium glomeratum*, *Medicago minima* and *Persicaria glabra* were found feasible for the phytostabilization of manganese.

Keywords

Heavy metal, Manganese, Phytoremediation; Phytoextraction, Phytostabilization

1. INTRODUCTION

The potential toxic elements are collectively called micro and macro-elements known to be harmful to live organisms if in high concentrations in the soil. Some of them are metals i.e. Mn, Co, Cr,Cd, Hg, Zn, Pb, Ni and Mo while a few of them are metalloids that include; Sb and As, and non-metals (Se) (Antoniadis *et al*., 2021). Among these toxic elements, some are toxic even in traces such as Sn, Cd, As and Sb (Palansooriya *et al*., 2020). The term phytoremediation is a combination of two word, ("phyto" meaning plant, and the Latin suffix "remedium" meaning to clean or restore) cite to various collections of plant-based technologies that use either naturally occurring or artificial plants (genetically engineered) to clarify contaminated environments (Padmavathiamma and Li 2007). Wastewater comes to the environment from various sources such as fertilizer, pesticide, cement, electroplating, painting, ceramics, and battery, plastic, mining, and smelting industries. This waterish the cause of metal contamination in aquatic environments. Important and essential metals for plants such as iron, copper (Cu), manganese (Mn) and zinc (Zn) play an important role in biological mechanisms, but some non-essential metals like cadmium (Cd), lead (Pb) and mercury are very toxic even at minimum concentrations, while essential metals also become toxic when they are present in larger concentration for a longer period (Khatun*, et al*. 2016).Manganese (Mn) is an important as well as essential micronutrient for plants for different metabolic processes and is involved in redox reactions as a cofactor for various enzymes. However, excessive use of acidic fertilizer results in a decline the pH of soils, which increases the Mn availability and caused its toxicity to plants.

Wetland plants have a high potential for phytoremediation due to their ability to tolerate unfavourable conditions. Many wetland plants have been searched to accumulate heavy metals in their tissues, such as salix (*Salix phylicifolia* L. and *S. borealis* Fr.), cattail (*Typha latifolia* L.) and common reed (*Phragmites australis* L.)..).The high tolerance and phytoextraction ability of *Juncus effusus* to Mn has already been documented (Najeeb *et al*. 2009). Phytotolerance studies are used to find the ability of a plant which tolerate metal activities and also to determine the effect of metals on the physiological response of plants. Duckweeds (L.minor) are aquatic plants that float just beneath the surface of fresh water. It is used in wastewater treatment to remove mineral and organic contamination (Jayasri and Suthindhiran 2017). Metal tolerance is based on various mechanisms such as cell wall binding, active transport of ions into the vacuole and formation of complexes with organic acids and peptides. One of the most important processes for metal detoxification in plants appears to be the chelation of metals by lower molecular-weight proteins such as metallothioneins and peptide ligands, the phytochelatins. Glutathione a precursor of phytochelatin synthesis, not only play important role in detoxification but also in protecting plant cell from other environmental stresses (Memon and Schroder 2008). Hyperaccumulators are those plants that can accumulate naturally higher quantities of heavy metals in their areal parts other than roots. A suitable in situ technique, cost-effective and environmentally sustainable for removing metals like nickel, manganese, and chromium from soils is represented by phytoremediation, used by higher plants to clean up soils (Sajad, *et al*. 2020). Phytoremediation technology is an advanced approach. Various techniques of phytoremediation involve phytoextraction, phytofiltration, phytostabilization, phytovolatilization and phytodegradation. It is the better proposal to depose contaminants primarily from soil and separate them without crashing the soil structure and fertility (Ali *et al.*, 2012). In biogeochemical exploration techniques, plants are used to specify the presence of mineral deposits. Biogeochemical exploration required chemical analysis of plants, to detect the presence of mineralization below the earth surface (Nassem *et al*., 2009).

In the present research work, sixty-one plant species belonging to thirty families were collected and analyzed for the concentration of Mn. Mn was analyzed in the soil of the root zone and the roots and shoots of each plant. The phytoremedial potential of the analyzed plants grown in their natural habitats was evaluated by the calculation of their Bioconcentration Factor (BCF), Translocation Factor (TF) and Biological Accumulation Coefficient (BAC).

2. MATERIALS AND METHODS

2.1. Collection of Plants and Soil from the Research Area

Sixty-one plant species were collected from different locations of District Dir Lower, Khyber Pakhtunkhwa, Pakistan. The soil was collected from the root zone of each plant and was analyzed for the background concentrations of manganese (Mn). The plants were identified with the help of Flora of Pakistan or by matching them with the already preserved specimens at the Herbarium of Islamia College Peshawar as found in the previous study (Bahadur *et al*., 2022a; 2022b; 2022c; 2022d). Each plant was separated into roots and shoots. The plant parts were dried in shade for a week and then fully dried in an oven at 75°C for 24 hours. Plant parts were ground with the help of a pestle and mortar. The powdered samples were digested using HNO_3 and $HClO_4$ and analyzed for the concentrations of Mn using Atomic Absorption Spectroscopy (AAS). Bioconcentration factor (BCF), as well as a translocation factor (TF) of the collected plants, were determined and their overall feasibility for the phytoextraction and phytostabilization of Mn was evaluated (Adesodun *et al*., 2010; Padmavathiamma and Li *et al*.,, 2007; Zhuang e*t al*., 2007).

2.2. Analysis of Manganese in Soil

The collected soil of the root zone of each plant was analyzed for the background concentrations of Mn. Manganese in the soil was determined according to (Sharidah 1999): 5g sample of the soil was taken in a 100 mL beaker. 3 mL of 30% H_2O_2 was added to it. This was left undisturbed for 1 hour until the vigorous reaction ceased. Then 75 mL of 0.5 M HCl solution was added to it and heated on a hot plate for 2 hours. The digest was filtered through a Whatman filter paper. The filtrate was used for the determination of the Mn by atomic absorption spectrometry.

2.3. Analysis of Manganese in Plant Samples

For this purpose, each plant part was thoroughly washed with tap water and then with distilled water to remove dust and soil particles. The clean plant parts were dried in an oven at 105ºC for 24 hours. Then the plant samples were grinded with the help of a pestle and mortar. The powder was digested according to (Awofolu 2005): 0.5 g sample of the plant part was taken into a 100 mL beaker. 5 mL concentrated (65%) HNO_3 and 2 mL $HClO_4$wereadded to it and heated on a hot plate until the digest became clear. The digest was allowed to cool and then filtered through a Whatman filter paper. The filtrate was collected in a 50 mL volumetric flask and diluted to the mark with distilled water. The filtrate was used for the analysis of Mn by AAS.

2.4. Bioconcentration Factor, Translocation Factor and Bioaccumulation Coefficient

Bioconcentration factor (BCF) indicates the efficiency of a plant in up-taking heavy metals from soil and accumulating them in its tissues. "It is a ratio of the heavy metal concentration in the plant tissue (root, stem or leaves) to that in soil." It is calculated as follows (Zhuang *et al*., 2007).

$$\text{Bioconcerntration Factor (BCF)} = \frac{C_{harvested\ tissue}}{C_{soil}} \quad \text{A}$$

Where $C_{harvested\ tissue}$ is the concentration of the metal in the plant harvested tissue (roots) and C_{soil} is the concentration of the same metal in soil. The translocation factor (TF) shows the efficiency of the plant in translocating the accumulated heavy metals from roots to shoots. "It is a ratio of the concentration of the heavy metal in shoots to that in its roots." It is calculated as follows (Adesodun *et al*., 2010; Padmavathiamma and Li, 2007).

$$\text{Translocation Factor (TF)} = \frac{C_{Shoots}}{C_{roots}} \quad \text{B}$$

Whereas$_{shoots}$are the concentration of metal in shoots and $_{roots}$are the concentration of the metal in roots.

Bioaccumulation Coefficient (BAC) is the ratio of the concentration of heavy metals in plant shoot to that in the soil and was calculated for all the studied plants according to the equation given below (Li *et al*., 2007; Cui *et al*., 2007; Malik *et al*., 2010).

$$\text{BioaccumulationCoefficient (BAC)} = \frac{C_{shoots}}{C_{soil}} \quad \text{C}$$

Where $C_{shoots}$are the concentration of metal in the shoots and $_{Soil}$ is the concentration of metal in the soil. The bioconcentration factor, translocation factor and bioaccumulation coefficient of the studied plants for Mn were calculated according to the above formulas. From these calculations, the feasibility of the plants for the phytoextraction and phytostabilization of manganese was evaluated.

2.5. Statistical Analysis

Each experiment was conducted in triplicate (n = 3). Results are shown as mean ± Standard Deviation. Experimental data were analyzed using Excel.

3. RESULTS AND DISCUSSION

3.1. Concentration of Manganese in the Analysed Plants

The concentration of manganese in sixty-one plant species belonging to thirty plant families was analyzed. The family, botanical name, number of the site from which plants were collected and name of the sites of collection, the concentration of manganese in the soil as well as in plant parts (root and shoot) are shown in Table 1. The concentration of manganese in the soil of sites and plant parts (roots and shoots) was found in the range of 92.15- 99.96, 10.87 - 699.26 and 72.67-334.26 mg/Kg respectively.

Table 1. Family name, plant name, site code, name of site and concentration of manganese in different parts of the plants

Family	Species	S.No	Name of Site	Concentration of Manganese mg/Kg		
				Soil	Root	Shoot
Amaryllidaceae	*Allium griffithianum* Boiss.	1.	Munjae	99.96 ±0.02	222.13 ±0.35	112.4 ±0.26
Apiaceae	*Torilis leptophylla* (L.) Rchb.f.	2.	Thorathiga (Jail)	95.56 ±0.09	384.13 ±2.01	127.26 ±1.12
Apocynaceae	*Catharanthus roseus* (L.) G. Don	3.	Kheima (Kally)	95.34 ±0.03	32.97 ±0.15	234.43 ±0.32
Aspleniaceae	*Asplenium dalhousiae* Hook.	4.	Tissu Neher (Shehzadi)	94.78 ±0.03	275.96 ±0.35	114.33 ±0.42
Asteraceae	*Artemisia japonica* Thunb.	5.	Behari (Shorgar)	95.56 ±0.05	118.2 ±0.4	141.26 ±0.87
	Artemisia vulgaris L.	6.	Malakabad	92.26 ±0.36	136.26 ±0.21	252.4 ±0.6
	Calendula arvensis Boiss.	7.	Andhera (Khwar)	92.15 ±0.03	79.97 ±0.68	135.03 ±0.25
	Cirsium vulgare (Savi) Ten.	8.	Manzara Thanga (kalle)	96.53 ±0.03	114.3 ±0.62	124.36 ±0.78

Asteraceae	*Cousinia buphthalmoides* Regel	9.	Bar Darmal (Ghar)	96.78 ±0.24	124.76 ±0.21	146.4 ±0.4
Asteraceae	*Erigeron canadensis* L.	10.	Bar Darmal (Kalle)	99.96 ±0.02	103.73 ±0.87	237.3 ±2.36
Asteraceae	*Filago hurdwarica* (Wall. ex DC.) Wagenitz	11.	Malakand (Khwar)	93.22 ±0.04	269.66 ±0.42	257.16 ±0.85
Asteraceae	*Lactuca dissecta* D. Don	12.	Muslim Abad (Nawa Kalle)	97.53 ±0.04	10.87 ±0.71	176.53 ±0.25
Asteraceae	*Himalaiella heteromalla* (D. Don) Raab-Straube	13.	Kuz Darmal (Kalle)	93.18 ±0.04	91.63 ±0.4	154.3 ±0.46
Asteraceae	*Silybum marianum* (L.) Gaertn.	14.	Mian Banda (Kalle)	94.21 ±0.04	87.27 ±0.23	210.4 ±0.36
Asteraceae	*Xanthium strumarium* L.	15.	Thoratiga (Kalle)	98.85 ±0.06	117.4 ±0.72	156.3 ±0.56
Boraginaceae	*Nonea edgeworthii* A. DC.	16	Manzara Thanga (Ghar)	99.12 ±0.07	252.13 ±0.81	307.73 ±0.25
Boraginaceae	*Onosma hispida* Wall. ex G. Don	17.	Majar Camp (Kalle)	97.84 ±0.04	134.8 ±0.7	147.83 ±1.33

Brassicaceae	*Arabidopsis thaliana* (L.) Heynh.	18.	Manzara Thanga (Shorgar)	94.16 ±0.04	162.33 ±0.83	299.46 ±0.61
	Isatis tinctoria L.	19.	Shengrai	96.34 ±0.04	31.27 ±0.47	172.8 ±0.2
	Stellaria media (L.) Vill.	20.	Koz Kally (Timergara)	97.17 ±0.04	46.73 ±1.03	164.83 ±0.15
	Sisymbrium irio L.	21.	Thanga (Shah)	92.94 ±0.04	82.53 ±0.55	120.7 ±0.36
Buxaceae	*Sarcococca saligna* (D. Don) Muell.-Arg. in DC., Prodr.	22.	Rabat (Chena)	94.56 ±0.03	130.93 ±0.83	140.03 ±0.5
Cannabaceae	*Cannabis sativa* L.	23.	Shehzadi (Banr)	97.53 ±0.04	219.13 ±0.99	197.33 ±0.76
Caryophyllaceae	*Cerastium glomeratum*Thuill.	24.	Khema (Shorgar)	96.23 ±0.04	391.26 ±0.64	119.13 ±0.67
Crassulaceae	*Bryophyllum daigremontianum* (Raym.-Hamet & Perrier) A. Berger	25.	Andhera (College)	97.84 ±0.04	210.06 ±1.5	111.66 ±0.23
	Rosularia adenotricha (Wall. ex Edgew.) C.-A. Jansson	26.	Bar Darmal (Khwar)	98.74 ±0.04	227.5 ±0.6	312 ±0.72

Euphorbiaceae	*Euphorbia helioscopia* L.	27.	Udigram (Kalle)	98.83 ±0.03	126.73 ±0.97	186.56 ±0.38
Fabaceae	*Argyrolobium stenophyllum* Boiss.	28.	Asharigat (Pull)	94.25 ±0.03	195.6 ±0.2	115.66 ±0.61
	Medicago lupulina L.	29.	Kuz Darmal (Gharr)	97.53 ±0.04	339.53 ±1.17	185.36 ±0.4
	Medicago minima (L.) L.	30.	Tissu Neher (Ghar)	96.35 ±0.03	392.66 ±2.75	159.33 ±0.99
	Vicia sativa L.	31.	Kuz Darmal (Khwar)	99.1 ±0.03	259.76 ±0.25	133.76 ±0.93
Geraniaceae	*Geranium rotundifolium* L.	32.	Mian Banda (Shorgar)	96.53 ±0.03	249.4 ±1.31	184 ±0.5
Iridaceae	*Iris germanica* L.	33.	Tissue Neher (Kalle)	93.64 ±1.03	126.6 ±0.53	72.67 ±0.21
Ixioliriaceae	*Ixiolirion tataricum* (Pall.) Schult. & Schult. f.	34.	Khall (Ghar)	94.83 ±0.04	138.66 ±0.42	91.47 ±0.35
Lamiaceae	*Ajuga integrifolia* Buch.-Ham.	35.	Jabagai (Osai Ghar)	99.88 ±0.03	98 ±0.8	236.73 ±0.25
	Phlomoides superba (Royle ex Benth.) Kamelin & Makhm.	36.	Nara Thangai (Ghar)	93.15 ±0.03	118.23 ±0.25	81.83 ±0.67

Lamiaceae	*Micromeria biflora*(Buch.-Ham. ex D.Don) Benth.	37.	Ranai	99.92 ±0.02	115.36± 0.6	176.83 ±1.61
Lamiaceae	*Marrubium vulgare* L.	38.	Khadang Ghar (Bar Darmal)	95.34 ±1.71	105.5 ±0.46	188.1 ±0.36
Lamiaceae	*Rydingia limbata* (Benth.) Scheen & V.A. Albert	39.	Behari (Ghar)	96.57 ±0.02	99.57 ±0.31	114 ±0.44
Lamiaceae	*Salvia moorcroftiana* Wall. ex Benth.	40.	Majar Camp (Khwar)	93.22 ±0.03	105.2 ±0.3	263.23 ±0.31
. Lamiaceae	*Teucrium stocksianum*Boiss	41.	Sado	92.68 ±0.56	81.6 ±0.79	86 ±0.3
Papilionaceae	*Astragalus pyrrhotrichus*Boiss.	42.	Beghamdara	98.85 ±0.05	159 ±0.9	140.26 ±0.5
Plantaginaceae	*Plantago lanceolata* L.	43.	Behari (Kalle)	98.8 ±0.05	137 ±2.65	199.03 ±1.5
Plumbaginaceae	*Limonium macrorhabdon* (Boiss.) O. Kuntze, Rev. Gen.	44.	Jabagai (Thor Baba)	95.52 ±0.03	59.8 ±0.26	180.63 ±0.81
Polygalaceae	*Polygala abyssinica* R.Br. ex Fresen.	45.	Shehzadi (Kundao)	95.84 ±0.04	166.8 ±0.2	224.63 ±0.47

Polygonaceae	*Emex spinosa* (L.) Campd.	46.	Haji Abad	98.85 ±0.04	13.03 ±0.42	140.3 ±0.3
	Persicaria glabra (Willd.) M. Gómez	47.	Udigram (Ghar)	97.85 ±0.03	699.26± 0.87	262.96± 1.38
Pteridaceae	*Cheilanthes pteridoides* C. Chr.	48.	Haya Serai	97.23 ±0.02	268.33± 1.3	82.6 ±1.01
	Pteris cretica L.	49.	Behari (Khwar)	93.34 ±0.04	332.6 ±0.36	173.7 ±0.46
Ranunculaceae	*Delphinium uncinatum* Hook.f. & Thomson	50.	Bar Darmal (Shorgur)	97.54 ±0.04	84.9 ±0.96	255.3 ±0.79
	Delphinium suave Huth	51.	Lajbok	92.15 ±0.03	148.7 ±0.26	81.67 ±0.76
	Ranunculus arvensis L.	52.	Murnera	96.54 ±0.04	345.13± 0.99	217.46± 1.05
Rosaceae	*Duchesnea indica* (Jacks.) Focke	53.	Bar Darmal (School)	95.18 ±0.04	119.73± 0.38	197.83± 0.65
	Sanguisorba minor Scop.	54.	Rabat (Kalle)	98.09 ±0.01	101.66± 0.61	170.1 ±0.2
	Rosa macrophylla Lindl.	55.	Shezadi (Konahi)	99.93 ±0.03	155.06± 0.503	116.66± 0.76
Scrophulariaceae	*Verbascum thapsus* L.	56.	Khongai	93.18 ±0.03	91.13 ±0.61	334.26± 0.31
	Wulfeniopsis amherstiana (Wall. Ex Benth.) D.Y. Hong	57.	Nara Thangai (Kalle)	92.16 ±0.02	215.53± 0.45	163.9 ±0.36

Solanaceae	*Solanum nigrum* L., Sp. Pl.	58.	Nawe Kalle (Pori Ghar)	93.82 ±0.06	71.1 ±0.53	156.33 ±0.5
Thymelaeaceae	*Daphne mucronata* Royle	59.	Balambat (Chaoni)	98.83 ±0.03	89.97 ±0.45	144.8 ±0.8
Urticaceae	*Urtica pilulifera* L.	60.	Timur	98.65 ±0.03	215.8 ±2.31	131.96 ±0.47
Verbenaceae	*Verbena officinalis* L.	61.	Thraskun Hotel (Timergara)	96.61 ±0.03	84.2 ±0.43	145.7 ±0.66

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

3.2. Evaluation of the Analysed Plants for the Phytoremediation of Manganese

The bioconcentration factor (BCF), translocation factor (TF) and bioaccumulation coefficient (BAC) of all the analyzed plants were calculated. The feasibility of each plant species for the phytoremediation of manganese metal was evaluated. The BCFs, TFs and BACs values (Table 2) of the plants for manganese metal were found in the range of 0.11-7.15, 0.31-16.24 and 0.78-3.59 respectively. Most of the plant species showed feasibility for the phytoremediation of manganese metal but based on its concentration in shoots (Table 2) and BCFs, TFs and BACs values, *Artemisia vulgaris*, *Nonea edgeworthii*, *Arabidopsis thaliana*, *Rosularia adenotricha*and *Salvia moorcroftiana*are the most efficient plants for the phytoextraction of manganese while based on its concentration in roots (Table 2) and BCFs, TFs and BACs values, *Torilis leptophylla*, *Cerastium glomeratum*, *Medicago minima* and *Persicaria glabra* for the phytostabilization of manganese metal. Further, the data of table 2. shows that *Catharanthus roseus*, *Calendula arvensis*, *Lactuca dissecta*, *Himalaiella heteromalla*, *Silybum marianum*, *Isatis tinctoria*, *Stellaria media*, *Sisymbrium irio*, *Ajuga integrifolia*, *Teucrium stocksianum*, *Limonium macrorhabdon*, *Emex spinosa*, *Delphinium uncinatum*, *Verbascum thapsus*, *Solanum nigrum*, *Daphne mucronata* and *Verbena officinalis* are not feasible for the phytoremediation of Mn.

Table 2. Name of the plant Species and their Bio concentration Factor, Translocation Factor and Bioaccumulation Coefficient for manganese

S. No	Plant Species	Bio concentration Factor, Translocation Factor and Bioaccumulation Coefficient			Feasibility of plant for the phytoremediation of Manganese
		BCF	TF	BAC	
1.	*Allium griffithianum* Boiss.	2.22	0.51	1.13	+*
2.	*Torilis leptophylla* (L.) Rchb.f.	4.02	0.33	1.33	+*
3.	*Catharanthus roseus* (L.) G. Don	0.35	7.11	2.46	-
4.	*Asplenium dalhousiae* Hook.	2.91	0.41	1.21	+*
5.	*Artemisia japonica* Thunb.	1.24	1.2	1.48	++**
6.	*Artemisia vulgaris* L.	1.48	1.85	2.74	++**
7.	*Calendula arvensis* Boiss.	0.87	1.69	1.47	-
8.	*Cirsium vulgare* (Savi) Ten.	1.18	1.09	1.29	++**
9.	*Cousinia buphthalmoides* Regel	1.29	1.17	1.51	++**
10.	*Erigeron canadensis* L.	1.04	2.29	2.37	++**
11.	*Filago hurdwarica* (Wall. ex DC.) Wagenitz	2.89	0.95	2.76	+*
12.	*Lactuca dissecta* D. Don	0.11	16.24	1.81	-
13.	*Himalaiella heteromalla* (D. Don) Raab-Straube	0.98	1.68	1.66	-
14.	*Silybum marianum* (L.) Gaertn.	0.93	2.41	2.23	-
15.	*Xanthium strumarium* L.	1.19	1.33	1.58	++**

16.	*Nonea edgeworthii* A. DC.	2.54	1.22	3.11	++**
17.	*Onosma hispida* Wall. ex G. Don	1.37	1.1	1.51	++**
18.	*Arabidopsis thaliana* (L.) Heynh.	1.7	1.85	3.18	++**
19.	*Isatis tinctoria* L.	0.33	5.53	1.79	-
20.	*Stellaria media* (L.) Vill.	0.48	3.53	1.7	-
21.	*Sisymbrium irio* L.	0.89	1.46	1.3	-
22.	*Sarcococca saligna* (D. Don) Muell.-Arg. in DC., Prodr.	1.39	1.07	1.48	++**
23.	*Cannabis sativa* L.	2.25	0.9	2.02	+*
24.	*Cerastium glomeratum* Thuill.	4.07	0.31	1.24	+*
25.	*Bryophyllum daigremontianum* (Raym.-Hamet & Perrier) A. Berger	2.15	0.53	1.14	+*
26.	*Rosularia adenotricha* (Wall. ex Edgew.) C.-A. Jansson	2.3	1.37	3.16	++**
27.	*Euphorbia helioscopia* L.	1.28	1.47	1.89	++**
28.	*Argyrolobium stenophyllum* Boiss.	2.08	0.59	1.23	+*
29.	*Medicago lupulina* L.	3.48	0.55	1.9	+*
30.	*Medicago minima* (L.) L.	4.08	0.41	1.65	+*
31.	*Vicia sativa* L.	2.62	0.52	1.35	+*
32.	*Geranium rotundifolium* L.	2.58	0.74	1.91	+*
33.	*Iris germanica* L.	1.35	0.57	0.78	+*
34.	*Ixiolirion tataricum* (Pall.) Schult. & Schult. f.	1.46	0.66	0.97	+*
35.	*Ajuga integrifolia* Buch.-Ham.	0.98	2.42	2.37	-

36.	*Phlomoides superba* (Royle ex Benth.) Kamelin & Makhm.	1.27	0.69	0.88	+*
37.	*Micromeria biflora* (Buch.-Ham. ex D.Don) Benth.	1.16	1.53	1.77	++**
38.	*Marrubium vulgare* L.	1.11	1.78	1.97	++**
39.	*Rydingia limbata* (Benth.) Scheen & V.A. Albert	1.03	1.15	1.18	++**
40.	*Salvia moorcroftiana* Wall. ex Benth.	1.13	2.5	2.82	++**
41.	*Teucrium stocksianum* Boiss.	0.88	1.05	0.93	-
42.	*Astragalus pyrrhotrichus* Boiss.	1.61	0.88	1.42	+*
43.	*Plantago lanceolata* L.	1.39	1.45	2.02	++**
44.	*Limonium macrorhabdon* (Boiss.) O. Kuntze, Rev. Gen.	0.63	3.02	1.89	-
45.	*Polygala abyssinica* R.Br. ex Fresen.	1.74	1.35	2.34	++**
46.	*Emex spinosa* (L.) Campd.	0.13	10.77	1.42	-
47.	*Persicaria glabra* (Willd.) M. Gómez	7.15	0.38	2.69	+*
48.	*Cheilanthes pteridoides* C. Chr.	2.76	0.31	0.85	+*
49.	*Pteris cretica* L.	3.56	0.52	1.86	+*
50.	*Delphinium uncinatum* Hook.f. & Thomson	0.87	3.01	2.62	-
51.	*Delphinium suave* Huth	1.61	0.55	0.89	+*
52.	*Ranunculus arvensis* L.	3.58	0.63	2.25	+*
53.	*Duchesnea indica* (Jacks.) Focke	1.26	1.65	2.08	++**
54.	*Sanguisorba minor* Scop.	1.04	1.67	1.73	++**

55.	*Rosa macrophylla* Lindl.	1.55	0.75	1.17	+*
56.	*Verbascum thapsus* L.	0.98	3.67	3.59	-
57.	*Wulfeniopsis amherstiana* (Wall. Ex Benth.) D.Y. Hong	2.34	0.76	1.78	+*
58.	*Solanum nigrum* L., Sp. Pl.	0.76	2.2	1.67	-
59.	*Daphne mucronata* Royle	0.91	1.61	1.47	-
60.	*Urtica pilulifera* L.	2.18	0.61	1.34	+*
61.	*Verbena officinalis* L.	0.87	1.73	1.51	-

Bio concentration Factor (BCF) = Conc. of manganese in root ÷ Conc. of manganese in Soil, Translocation Factor (TF) = Conc. of manganese in Shoot ÷ Conc. of manganese in root, Bioaccumulation Coefficient (BAC) = Conc. of manganese in Shoot ÷ Conc. of manganese in soil, +* = Metal excluders; may be used for the phytostabilization of metal, ++** = Metal indicators; May be used for the phytoextraction of metal, +++*** = Metal hyper accumulator; may be used for the Phytoextraction and recovery of metal., - ; cannot be used for the metal remediation processes.

3.2.1. The concentration of Manganese in the Soil of the Analysed Sites

It is clear from the data in table 2 that the concentration of manganese in the soil of sixty-one sites varies in the range of 92.15- 99.96 mg/Kg. The concentration of manganese in the soil of the studied sites in mg/Kg was found in the order: Site 1 (99.96) e" Site 10 (99.96) >Site 55 (99.93) > Site 37 (99.92) > Site 35 (99.88) > Site 16 (99.12) > Site 31 (99.1) > Site 15 (98.85) e" Site 42 (98.85) e" Site 46 (98.85) > Site 27 (98.83) e" Site 59 (98.83) > Site 43 (98.8) > Site 26 (98.74) > Site 60 (98.65) > Site 54 (98.09) > Site 47 (97.85) > Site 17 (97.84) e" Site 25 (97.84) > Site 50 (97.54) > Site 12 (97.53) e" Site 23 (97.53) e" Site 29 (97.53) > Site 48 (97.23) > Site 20 (97.17) > Site 9 (96.78) > Site 61 (96.61) > Site 39 (96.57) > Site 52 (96.54) > Site 8 (96.53) e" Site 32 (96.53) > Site 30 (96.35) > Site 19 (96.34) > Site 24 (96.23) > Site 45 (95.84) > Site 2 (95.56) e" Site 5 (95.56) > Site 44 (95.52) > Site 3 (95.35) > Site 38 (95.34) > Site 53 (95.18) > Site 34 (94.83) > Site 4 (94.78) > Site 22 (94.56) > Site 28 (94.25) > Site 14 (94.21) > Site 18 (94.16) > Site 58 (93.82) > Site 33 (93.64) > Site 49 (93.34) > Site 11 (93.22) e" Site 40 (93.22) > Site 13 (93.18) e" Site 56 (93.18) > Site 36 (93.15) > Site 21 (92.94) > Site 41 (92.68) > Site 6 (92.26) > Site 57 (92.16) > Site 7 (92.15) e" Site 51 (92.15). The permissible value of manganese for soil is 320 mg/Kg (Nergus 2002). It is pertinent to mention here that the concentration of manganese in the soil of all the sites is less than the permissible limit.

3.2.2. Concentration of Manganese in the Roots of the Analysed Plants

Data from table 2 shows that the concentration of manganese in the roots of the plant was found in the range of 10.87 - 699.26 mg/Kg. Its concentration in the roots of all the analyzed plants in mg/Kg was found in the order: *Persicaria glabra* (699.26) >*Medicago minima* (392.66) > *Cerastium glomeratum*(391.26) > *Torilis leptophylla* (384.13) >*Ranunculus arvensis* (345.13) >*Medicago lupulina* (339.53) > *Pteris cretica* (332.6) > *Asplenium dalhousiae* (275.96) > *Filago hurdwari* (269.66) >*Cheilanthes pteridoides* (268.33) > *Vicia sativa* (259.76) > *Nonea edgeworthii* (252.13) > *Geranium rotundifolium* (249.4) > *Rosularia adenotricha* (227.5) > *Allium griffithianum* (222.13) > *Cannabis sativa* (219.13) > *Urtica pilulifera* (215.8) > *Wulfeniopsis amherstiana* (215.53) > *Bryophyllum daigremontianum* (210.06)> *Argyrolobium stenophyllum* (195.6) > *Polygala abyssinica* (166.8) > *Arabidopsis thaliana*(162.33) > *Astragalus pyrrhotrichus*(159) > *Rosa macrophylla* (155.06) > *Delphinium suave* (148.7) > *Ixiolirion tataricum* (138.66) > *Plantago lanceolata* (137) > *Artemisia vulgaris* (136.26) > *Onosma hispida* (134.8) >*Sarcococca saligna*(130.93) > *Euphorbia helioscopia* (126.73) > *Iris germanica* (126.6) > *Cousinia buphthalmoide* (124.76) > *Duchesnea indica* (119.73) >*Phlomoides superb* (118.23) >*Artemisa japonica* (118.2) > *Xanthium strumarium* (117.4) > *Micromeria biflora* (115.36) > *Cirsium vulgare* (114.3) > *Marrubium vulgare* (105.5) > *Salvia moorcroftiana* (105.2) > *Erigeron Canadensis* (103.73) > *Sanguisorba minor* (101.66) > *Rydingia limbata* (99.57) > *Ajuga integrifolia* (98) > *Himalaiella heteromalla* (91.63) > *Verbascum thapsus* (91.-13) > *Daphne mucronata* (89.97) > *Silybum marianum* (87.27) > *Delphinium uncinatum* (84.9) > *verbena officinalis* (84.2) > *Sisymbrium irio* (82.53) > *Teucrium stocksianum* (81.6) > *Calendula arvensis* (79.97) > *Solanum nigrum* (71.1) > *Limonium macrorhabdon* (Boiss.), Kuntze, Rev. Gen. (59.8) > *Stellaria media* Vill. (46.73) > *Catharanthus roseus* G. Don (32.97) > *Isatis tinctoria* (31.27) > *Emex spinosa* Campd. (13.03) > *Lactuca dissecta* D.Don (10.87).WHO's a maximum permissible limit of Manganese in plants is 200 mg/Kg (Shah et. al., 2013). Results showed that the concentration of manganese in mg/Kg in the roots of *Persicaria glabra* (Willd.) M. Gómez (699.26), *Medicago minima* (392.66), *Cerastium glomeratum*(391.26), *Torilis leptophylla* (384.13), *Ranunculus arvensis* (345.13), *Medicago lupulina* (339.53), *Pteris cretica* (332.6), *Asplenium dalhousiae* (275.96), *Filago hurdwarica* (Wall. ex DC.) Wagenitz (269.66), *Cheilanthes pteridoides* (268.33), *Vicia sativa* (259.76), *Nonea edgeworthii* (252.13), *Geranium rotundifolium* (249.4), *Rosularia adenotricha* (227.5), *Allium griffithianum* (222.13), *Cannabis sativa* (219.13), *Urtica pilulifera* (215.8), *Wulfeniopsis amherstiana* (215.53) and *Bryophyllum daigremontianum* (210.06) is higher than the permissible limit while in the root of the rest of the plants is less than this limit.

3.2.3. Concentration of Manganese in the Shoots of the Analysed Plants

It is evident from the data of table 2 that the concentration of manganese in the shoots of the analyzed plant was found in the order: *Verbascum thapsus* (334.26) > *Rosularia adenotricha* (312) > *Nonea edgeworthii* (307.73) > *Arabidopsis thaliana* (299.46) > *Salvia moorcroftiana* Wall. ex Benth. (263.23) > *Persicaria glabra*(Willd.) M. Gómez (262.96) > *Filago hurdwarica* (Wall. ex DC.) Wagenitz (257.16) > *Delphinium uncinatum* Hook.f. & Thomson (255.3) > *Artemisia vulgaris* (252.4) > *Erigeron canadensis* (237.3) > *Ajuga integrifolia* (236.73) > *Catharanthus roseus* (234.43) > *Polygala abyssinica* (224.63) > *Ranunculus arvensis* (217.46) > *Silybum marianum* Gaertn. (210.4) > *Plantago lanceolata* (199.03) > *Duchesnea indica* (197.83) > *Cannabis sativa* (197.33) > *Marrubium vulgare* (188.1) > *Euphorbia helioscopia* (186.56)> *Medicago lupulina* (185.36) > *Geranium rotundifolium* L. (184) > *Limonium macrorhabdon* (180.63) > *Micromeria biflora* (176.83) > *Lactuca dissecta* D.Don (176.53) > *Pteris cretica* (173.7) > *Isatis tinctoria* (172.8) > *Sanguisorba minor*(170.1) > *Stellaria media* (164.83) > *Wulfeniopsis amherstiana* (163.9) > *Medicago minima* (159.33) > *Solanum nigrum* (156.33) > *Xanthium strumarium* (156.3) > *Himalaiella heteromalla* (D.Don) Raab-Straube (154.3) > *Onosma hispida* (147.83) > *Cousinia buphthalmoides* Regel (146.4) > *Verbena officinalis* (145.7) > *Daphne mucronata* Royle (144.8) > *Artemisia japonica* (141.26) > *Emex spinosa spinosa*(140.3) > *Astragalus pyrrhotrichus* (140.26) > *Sarcococca saligna* (140.03) > *Calendula arvensis* (135.03) > *Vicia sativa* (133.76) >*Urtica pilulifera* (131.96) > *Torilis leptophylla* (127.26) > *Cirsium vulgare* (Savi) Ten. (124.36) > *Sisymbrium irio* (120.7) > *Cerastium glomeratum* (119.13) > *Rosa macrophylla* (116.66) > *Argyrolobium stenophyllum* (115.66) >*Asplenium dalhousiae* Hook. (114.33) > *Rydingia limbata* (114) > *Allium griffithianum* (112.4) > *Bryophyllum daigremontianum*(111.66) > *Ixiolirion tataricum* (91.47) > *Teucrium stocksianum* (86) > *Cheilanthes pteridoides* (82.6) > *Phlomoides superba* (81.83) > *Delphinium suave* (81.67) > *Iris germanica* (72.67).WHO's maximum permissible limit of manganese in plants is 200 mg/Kg (Shah *et. al.,* 2013). Results indicate that the concentration of manganese in the shoot of Verbascum *thapsus* (334.26), *Rosularia adenotricha* (312), *Nonea edgeworthii* (307.73), *Arabidopsis thaliana* (299.46), *Salvia moorcroftiana* (263.23), *Persicaria glabra* (Willd.) M. Gómez (262.96), *Filago hurdwarica* (257.16), *Delphinium uncinatum* (255.3), *Artemisia vulgaris* (252.4), *Erigeron Canadensis* (237.3), *Ajuga integrifolia* (236.73), *Catharanthus roseus* (234.43), *Polygala abyssinica* (224.63), *Ranunculus arvensis* (217.46) and *Silybum Silybum marianum* (210.4) in mg/kg is greater than the permissible limit while in the shoot of the rest of the plants is below the permissible limit.

3.2.4. Bio concentration Factor Analysed Plants for Manganese

Data from table 2 shows that the Bio-concentration factor (BCF) was calculated as manganese concentration ratio of plant roots to soil (Nazir *et al*. 2011; Malik *et al*., 2010; Yoon *et al*.,2006). The calculated bioconcentration factor (BCF) of all the plants was found in the order: *Persicaria glabra* (7.15) > *Medicago minima* (4.08) > *Cerastium glomeratum* Thuill.

(4.07) > *Torilis leptophylla* (4.02) > *Ranunculus arvensis* (3.58) > *Pteris cretica* (3.56) > *Medicago lupulina* (3.48) > *Asplenium dalhousiae* (2.91) > *Filago hurdwarica* (2.89) > *Cheilanthes pteridoides* (2.76) > *Vicia sativa*(2.62) > *Geranium rotundifolium* (2.58) > *Nonea edgeworthii* (2.54) > *Wulfeniopsis amherstiana* (2.34) > *Rosularia adeno-tricha*(2.3) > *Cannabis sativa* (2.25) > *Allium griffithianum* (2.22) > *Urtica pilulifera* (2.18) > *Bryophyllum daigremontianum* (2.15) > *Argyrolobium stenophyllum* (2.08) > *Polygala abyssinica* (1.74) > *Arabidopsis thaliana* (1.7) > *Astragalus pyrrhotrichus* Boiss. (1.61) e" *Delphinium suave* Huth (1.61) > *Rosa macrophylla* (1.55) > *Artemisia vulgaris* (1.48) > *Ixiolirion tataricum* (1.46) > *Sarcococca saligna* (1.39) e" *Plantago lanceolata* (1.39) > *Onosma hispida* (1.37) > *Iris germanica* (1.35) >*Cousinia buphthalmoides* (1.29) > *Euphorbia helioscopia* (1.28) > *Phlomoides superba* (1.27) > *Duchesnea indica* (1.26) > *Artemisia japonica* (1.24) > *Xanthium strumarium* (1.19) > *Cirsium vulgare* (1.18) > *Micromeria biflora* (1.16) > *Salvia moorcroftiana* (1.13) > *Marrubium vulgare* (1.11) > *Erigeron Erigeron canadensis* (1.04) e" *Sanguisorba minor* Scop. (1.04) > *Rydingia limbata* (1.03) > *Himalaiella heteromalla* (0.98) e" *Ajuga integrifolia* (0.98) e" *Verbascum thapsus* (0.98) > *Silybum marianum* Gaertn. (0.93) >*Daphne mucronata* (0.91) > *Sisymbrium irio* (0.89) > *Teucrium stocksianum* (0.88) > *Calendula arvensis* (0.87) e" *Delphinium uncinatum* (0.87) e" *Verbena officinalis* (0.87) > *Solanum nigrum* (0.76) > *Limonium macrorhabdon* (0.63) > *Stellaria media*(0.48) > *Catharanthus roseu*(0.35)> *Isatis tinctoria* (0.33) > *Emex spinosa* Campd. (0.13) > *Lactuca dissecta* (0.11). (Sheoran et al.,2011) stated that the plants are not feasible for the phytoextraction of metal if bioconcentration factor is less than one. (Fitz and Wenzel 2002) demonstrated that plants exhibiting BCF value of less than one are unsuitable for the phytoextraction of metals. Results showed that the calculated bioconcentration factor of all the plants was greater than one except *Himalaiella heteromalla* (0.98), *Ajuga integrifolia*(0.98), *Verbascum thapsus* (0.98), *Silybum marianum* (0.93), *Daphne mucronata* (0.91), *Sisymbrium irio* (0.89), *Teucrium stocksianum* Boiss. (0.88), *Calendula arvensis* (0.87), *Delphinium uncinatum* (0.87), *Verbena officinalis* (0.87), *Solanum nigrum* (0.76), *Limonium macrorhabdon* (0.63), *Stellaria media*(0.48), *Catharanthus roseus*(0.35), *Isatis tinctoria* (0.33), *Emex spinosa*(0.13) and *Lactuca dissecta* (0.11).

3.2.5. Translocation Factor of the Analysed Plants for Manganese

Data from table2 indicates that the Translocation Factor (TF) was described as the ratio of manganese in plant shoot to that in plant root (Nazir et al., 2011; Malik et al., 2010; Cui et al., 2007; Li et al.,2007). The translocation factor of the plants was found in the order: *Lactuca dissecta* D.Don (16.24) >*Emex spinose*Campd. (10.77) > *Catharanthus roseus* (7.11) >*Isatis tinctoria* (5.53) >*Verbascum thapsus* (3.67) > *Stellaria media* Vill. (3.53) > *Limonium macrorhabdon* (Boiss.) Kuntze, Rev. Gen. (3.02) > *Delphinium uncinatum* (3.01) > *Salvia moorcroftiana*(2.5) > *Ajuga integrifolia* (2.42) > *Silybum marianum* (2.41) > *Erigeron Canadensis* (2.29) > *Solanum nigrum* (2.2) > *Artemisia vulgaris* (1.85) e" *Arabidopsis thali-*

ana Heynh. (1.85) > *Marrubium vulgare* (1.78) > *Verbena officinalis* (1.73) > *Calendula arvensis* Boiss. (1.69) > *Himalaiella heteromalla* (1.68)> *Sanguisorba minor* Scop. (1.67) > *Duchesnea indica (Jacks.) Focke* (1.65) > *Daphne mucronata* (1.61) >*Micromeria biflora*(1.53) > *Euphorbia helioscopia* (1.47) > *Sisymbrium irio* (1.46) > *Plantago lanceolata* (1.45) > *Rosularia adenotricha* (1.37) > *Polygala abyssinica* (1.35) > *Xanthium strumarium* L. (1.33) > *Nonea edgeworthii* (1.22) > *Artemisia japonica* (1.2) >*Cousinia buphthalmoides* (1.17) > *Rydingia limbata* (1.15) > *Onosma hispida* (1.1) > *Cirsium vulgare* (1.09) > *Sarcococca saligna* (1.07) > *Teucrium stocksianum* Boiss. (1.05) > *Filago hurdwarica* (0.95) > *Cannabis sativa* (0.9) > *Astragalus pyrrhotrichus* Boiss. (0.88) > *Wulfeniopsis amherstiana* (0.76) > *Rosa macrophylla* (0.75) > *Geranium rotundifolium* (0.74) > *Phlomoides superba* (0.69) > *Ixiolirion tataricum* (0.66) > *Ranunculus arvensis* (0.63) > *Urtica pilulifera* (0.61) >*Argyrolobium stenophyllum* (0.59) > *Iris germanica* (0.57) > *Medicago lupulina* (0.55) e" *Delphinium suave* (0.55) > *Bryophyllum daigremontianum*(0.53) > *Vicia sativa* (0.52) e" *Pteris cretica* (0.52) > *Allium griffithianum* (0.51) > *Asplenium Asplenium dalhousiae* (0.41) e" *Medicago minima* (0.41) >*Persicaria glabra* (Willd.) M. Gómez (0.38) > *Torilis leptophylla* (0.33) > *Cerastium glomeratum* (0.31) e" *Cheilanthes pteridoides* (0.31). Translocation factor value Ã than one indicates the translocation of metal from root to above ground part (Jamil *et al.,* 2009).Results showed that the TF value of *Lactuca dissecta* (16.24), *Emex spinosa*(10.77), *Catharanthus roseus*(7.11), *Isatis tinctoria (5.* 53), *Verbascum thapsus* (3.67), *Stellaria media* (3.53), *Limonium macrorhabdon* (3.02), *Delphinium uncinatum* (3.01), *Salvia moorcroftiana* (2.5), *Ajuga integrifolia* (2.42), *Silybum marianum* (2.41), *Erigeron canadensis* (2.29), *Solanum nigrum* (2.2), *Artemisia vulgaris* (1.85), *Arabidopsis thaliana*(1.85), *Marrubium vulgare* (1.78), *Verbena officinalis* (1.73), *Calendula arvensis* (1.69), *Himalaiella heteromalla* (1.68), *Sanguisorba minor* (1.67), *Duchesnea indica* (1.65), *Daphne mucronata* (1.61), *Micromeria biflora*(1.53), *Euphorbia helioscopia* (1.47), *Sisymbrium irio* (1.46), *Plantago lanceolata* (1.45), *Rosularia adenotricha* (1.37), *Polygala abyssinica*(1.35), *Xanthium strumarium* (1.33), *Nonea edgeworthii* (1.22) > *Artemisia japonica* (1.2), *Cousinia buphthalmoides* (1.17), *Rydingia limbata* (1.15), *Onosma hispida* (1.1), *Cirsium vulgare* (1.09), *Sarcococca salinga* (1.07) and *Teucrium stocksianum* (1.05) is greater than one while it is lesser than one in the rest of the plants.

3.2.6. Bioaccumulation Coefficient (BAC) of the Analysed Plants for Manganese

It is clear from the data of table 2 that the Bioaccumulation Coefficient (BAC) was calculated as the ratio of manganese metal in shoots to that in soil (Nazir *et al*. 2011; Malik *et al*., 2010; Li *et al*., 2007; Cui et al., 2007).The calculated bioaccumulation of each plant species was found in the order: *Verbascum thapsus* (3.59) > *Arabidopsis thaliana* (3.18) > *Rosularia adenotricha* (3.16) > *Nonea edgeworthii* (3.11) > *Salvia moorcroftiana* (2.82) > *Filago hurdwarica* (2.76) > *Artemisia vulgaris* (2.74) > *Persicaria glabra*(2.69) > *Delphinium unci* *natum* (2.62) > *Catharanthus roseus* (2.46) >*Erigeron Canadensis* (2.37) e” *Ajuga integrifolia* (2.37) > *Polygala abyssinica* (2.34) > *Ranunculus arvensis* (2.25) > *Silybum marianum* (2.23) > *Duchesnea indica* (2.08) > *Cannabis sativa* (2.02) e” *Plantago lanceolata* (2.02) > *Marrubium vulgare* (1.97) >*Geranium rotundifolium* (1.91) > *Medicago lupulina* (1.9) > *Euphorbia helioscopia* (1.89) e” *Limonium macrorhabdon* (1.89) > *Pteris cretica* (1.86) > *Lactuca dissecta* (1.81) > *Isatis tinctoria* (1.79) > *Wulfeniopsis amherstiana* (1.78) > *Micromeria biflora*(1.77) > *Sanguisorba minor* (1.73) > *Stellaria media* (1.7) > *Solanum nigrum* (1.67) > *Himalaiella heteromalla* (1.66) >*Medicago minima* (1.65) > *Xanthium strumarium* (1.58) > *strumarium Cousinia buphthalmoides* (1.51) e” *Onosma hispida* Wall. ex G. Don (1.51) e” *Verbena officinalis* (1.51) > *Artemisia japonica* (1.48) e” Sarcococca *saligna* (1.48) > *Calendula arvensis* (1.47) e” *Daphne mucronata* (1.47) > *Astragalus pyrrhotrichus* Boiss. (1.42) e” *Emex spinosa*(1.42) > *Vicia sativa* (1.35) > *Urtica pilulifera* (1.34) > *Torilis leptophylla* (1.33) >*Sisymbrium irio* (1.3) > *Cirsium vulgare* (1.29) > *Cerastium glomeratum* (1.24) > *Argyrolobium stenophyllum* (1.23) > *Asplenium dalhousiae* (1.21) > *Rydingia limbata* (1.18) > *Rosa macrophylla* (1.17) > *Bryophyllum daigre-montianum* (1.14) > *Allium griffithianum* Boiss. (1.13) > *Ixiolirion tataricum* (0.97) > *Teucrium stocksianum*(0.93) > *Delphinium suave* (0.89) > *Phlomoides superba* (0.88) > *Cheilanthes pteridoides* (0.85) > *Iris germanica* (0.78). Only plant species with BCF, BAC and TF Ã than one have the potential for the remediation process (Nazir *et al.,* 2011). Results showed that the BA-C value of *Ixiolirion tataricum* (0.97), *Teucrium stocksianum* (0.93), *Delphinium suave* Huth (0.89), *Phlomoides superba* (0.88), *Cheilanthes pteridoide* (0.85) and *Iris germanica* (0.78) is less than one while that of all the plants is greater than one. However, further taxonomic studies are recommended (Ashfaq *et al*., 2018; 2020; Nabila *et al*., 2022) to correctly identify the species to authenticate the phytoextraction potential of these plants. Moreover, these plants should be further explored for their functional strategies and its association with the nutrients as found in the previous studies (Long *et al*., 2022; Yaseen *et al*., 2022).

4. CONCLUSION

The phytoremediation potential of the analyzed plants grown in their natural habitats was evaluated by the calculation of the Bioconcentration Factor (BCF), Translocation Factor (TF) and Bio- accumulation Coefficient (BAC). The con- centrations of Mn in the soil of sixty-one sites were found in the range of 92.15-99.96 mg/Kg. The maximum concentration of Mn was found in the soil of site 1 (99.96) and Site 10 (99.96) mg/Kg while its minimum concentration was present in the soil of site 7 (92.15) and site 51 (92.15) mg/Kg. Metal indicators accumulate heavy metals in their aerial parts. Translocation factor value greater than one indicates the translocation of the metal from root to above ground part and only plant species with both BCF and TF value greater than one have thepotential to be used for phyto extraction. The study concluded that among the studied plants, *Artemisia vulgaris*, *Nonea edgeworthii*, *Arabidopsis thaliana*, *Rosularia adenotricha* and *Salvia moorcroftiana* were found efficient for the phytoextraction of Mn. Based on the concentration of the Mn in roots and BCFs, TFs and BACs values, *Cerastium glomeratum*, *Medicago minima* and *Persicaria glabra* were found feasible for the phyto- stabilization of manganese.

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