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BIODIVERSITY PROSPECTS OF METALOCOLES IN AND AROUND THE CRACKER CITY (SIVAKASI)

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ABSTRACT

Metalocoles in their diversified form ensure, the envisaged clean environment. This study was designed to assess the total contents of nine toxic metals *viz.,* Ba, Cu, Zn, Cd, Ni, Al, Mg, As and Ti in the soil and plants of fireworks waste dump site, Sivakasi. The concentration of transfer and accumulates on of metals from soil to roots and shoots were evaluated in terms of Accumulation Factor (AF) and Translocation Factor (TF). Total metal concentrations pattern in roots were Ti> Ba> As> Zn> Cu> Ni> Al and Cd. Three plant species identified as hyperaccumulators are *Amaranthus spinosa* L., *Abutilon indicum* G.Don and *Amaranthus dublis* L. However, based on AFs and TFs values, most of the studied species found to initiate phytostabilization and phytoextraction *Amaranthus dublis* L. and *Abutilon indicum* G.Don are suggested for phytoextraction of As, Ti, Mg, whereas *Parthenium hysterophoirus* L., *Datura metal* L. and *Solanum nigrum* L. for rhizofiltration of soil contaminated with Ba, Cu, Zn, Cd, Ni, As and Ti. This hyperaccumulation process involves absorption and concentration the metals in their roots and shoots. These metal hyperaccumulating plants when transplanted on fireworks polluted soil would serve as natural decontaminants of metals.

KEYWORDS: Hyperaccumulator, Fireworks pollution, Accumulation Factor, Translocation Factor.

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INTRODUCTION

Pollution of the environment with toxic metals has been increased by the onset of the industrial revolution. Sivakasi is a home town to around 765 fireworks and 447 match box manufacturing units (The Hindu, 17.09.2012). For preparation of crackers various chemical elements including eight heavy metals are being used. Naturally some plants are commonly growing in and around the fire cracker unit to render harmless of these toxic metals and make verdant land for agriculture.

Biodiversity prospecting would lead to the discovery of wild plants that would lean polluted environments of the world. Biodiversity prospecting offers several opportunities of which the most important is to save as much as possible the world's immense variety of ecosystem (Prasad and Freitas, 2003). Phytoremediation is one of the promising methods for reclamation of soil contaminated with toxic metals using hyperaccumulator plants (Baker *et al*., 2000; Ghosh and Singh, 2005). Plants accumulating metals to exceptionally high concentrations in their shoots are called hyperaccumulators (Bakers and Brooks, 1989; Baker *et al*., 2000; Reevas and Baker 2000; Ma *et al*., 2001).

The use of plants species to decontaminate and remediate polluted soils with heavy metals is not common in Sivakasi. Transfer of toxic elements from soil and polluted water from fire-cracker and match box manufacturing units to plants is of great concern (Ramasubramanian *et al*., 2004; Ramasubramanian and Jayaprakash 2007). Any heavymetal hyperaccumulator or tolerant plant species is yet to be studies form the fire cracker contaminated soil. In this study eight plant species belonging to six families were investigated for metals such as Barium, Zinc, Copper, Cadmium, Aluminium, Magnesium, Nickel, Arsenic and Titanium from fire-cracker industry sites of Sivakasi. The aim of the present study was to assess the total metal concentration of selected metals in the soil and plant samples. Species which have the potential for phytoremediation process such as phytostabilization and phytoextraction were also identified.

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MATERIAL AND METHODS

Five firecracker dumping sites were selected for the collection of plants and soil samples. Plant species collected were the most common / dominant species at these sites. A total of eight species such as *Amaranthus spinosa* L., *Tephrosia purpurea* Pers., *Abutilon indicum* G.Don., *Amaranthus dublis* L., *Parthenium hysterophoirus* L., *Datura metal* L., *Solanum nigrum* L. and *Cleom viscosa* L. were collected during February and March 2012. The plant samples collection was by the method of Malik *et al*., (2010). Entire plant samples including roots, stems and leaves of each species were collected from each site and mixed to form a composite sample, placed in labelled bags and transported to laboratory for further analysis. Before analysis, from each plant roots and mixture of stems and leaves were carefully removed and washed (for 2 – 3 minutes approximately) with tap water and with deionized water to remove any soil surface dust.

Plant samples were dried a room temperature for two weeks, pulverized and passed through 2mm stainless steel sieve. Soil samples (3 – 5 replicated) at 0 – 20 cm depth from rhizophere of each plant were taken from each site from where plant samples was rooted. Soil samples (a composite mixture) were air dried at room temperature for two weeks, crushed and pulverised to pass through 2mm sieve. The metal concentration of each plant and soil samples was analysed using method of Baker *et al.*, (1994). Each samples was digested in a mixture of nitric acid and perchloric acid (10:1) the solution was centrifuges at 5000 rpm for 5 minutes, double filtered with Whatman filter paper No.1 and the collection was analysed for metal concentration by Atomic Absorption Spectrometry (Model AA 6300).

The accumulation factor (AF) of metal was used to determine the quantity of metal absorbed by the plant from the soil and was calculated using the formula (Nirmal Kumar *et al*., 2009).

Accumulation Factor (AF) =

$$\frac{Mean\ plant\ concentration\ (\mu g/g)\ (Roots + Stems + Leaves)}{Mean\ soil\ avilability\ (\mu g/g)\ concentration}$$

To evaluate the potential of the species for phytoextraction, the

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translocation factor (TF) was calculated (Mellem *et al.*, 2009). This ratio is an indication of the ability of the plant to translocate metals from the root to the aerial parts of the plant (Marchiol *et al.*, 2004). It is represent by the ratio

$$\text{Translocation Factor (TF)} = \frac{Metal\ concentrations\ (Stems + Leaves)}{Metal\ concentrations\ (Roots)}$$

RESULTS

During the present study, heavy metals such as Ba, Cu, Zn, Cd, Ni, Al, Mg, As and Ti were accumulated in particular wild plant components in a high concentration (Table – 1). It was observed that high content of Ba was accumulated in roots of *Amaranthus spinosa* L. (148.35), Cu in *Parthenium hysterophoirus* L. (29.67) Al in *Tephrosia purpurea* Pers. root (35.14), Ni in the root of *Parthenium hysterophoirus* L. (31.69) Mg in *Abutilon indicum* G.Don. root (37.94) Ti in roots of *Amaranthus spinosa* L. (174.65) and arsenic in *Abutilon indicum* G.Don. root (47.35). Heavy metal also accumulate in leaves at different concentrations present study revealed that *Amaranthus spinosa* L. accumulate Ba (110.43) and Ti (101.37) in their leaves *Tephrosia purpurea* Pers. accumulate Zn (44.24) and Al (18.69) in leaves. The leaves of *Amaranthus dublis* L. showed high concentration of nickel (17.35) and the leaves of *Parthenium hysterophoirus* L. accumulate high concentration of nickel (17.35) and the leaves of *Parthenium hysterophoirus* L. accumulate high concentration of Cu (18.46) and Cd (10.91).

On other hand, it was observed that the heavy metal such as Mg, Ni, As and Cd were present in a low concentration n particular plant component. The lowest concentration of Mg (0.94) fund in *Solanum nigrum* L. stem. The lowest concentration of Ni (1.520 was found in *Abutilon indicum* G.Don. root and As content in *Parthenium hysterophoirus* L. (1.96) root.

Most of the plant species had the accumulation factor greater than on (AF>1). In general, the accumulation factor values Ba, As and Ti was highest as compared to other metals (Table – 2). The accumulation factor values of Ba (2.081, 1.927) was high in *Amaranthus spinosa* L. and Arsenic (91.927, 1.811 and 1.528).

and *Amaranthus spinosa* L. for Titanium (1.664). The higher accumulation factor in various studied wild plant components could be found as Ba> As> Ti> Zn> Al> Mg> Cd> Co.

Among the plant species screened for Ba, Cu, Zn, Cd, Ni, Al, Mg, As and Ti, most of the species were efficient to take up and translocate more than one heavy metal from roots to shoots. Variations between Translocation Factor (TF) values were found (Table – 2). The highest translocation factor value was found for *Abutilon indicum* G.Don., *Datura metal* L. and *Tephrosia purpurea* Pers. 3.158 for Ni, 2.597, 2.597 for Mg and 2.108 for Mg. *Abutilon indicum* G.Don. was efficient in translocating metals such as Ni, Cu, Mg and Ti from roots to shoots. *Amaranthus dublis* L. had translocate metal such as Ni, Mg, As, Ti, Cd, Al, Zn and Ba showed TF > 1.

Table – 2 indicates that the all eight plant species screened for total metal concentration showed value of TF>1 for one or more heavy metals, four species such as *Amaranthus spinosa* L., *Tephrosia purpurea* Pers., *Abutilon indicum* L. and *Amaranthus dublis* L. had AF > 1. Three plant species such as *Abutilon indicum* G.Don., *Amaranthus dublis* L. and *Tephrosia purpurea* Pers. had TF>1 for six heavy metals.

DISCUSSION

Plants are known to sequester and stimulate the degradation of organic contaminants in soil (Anderson and Walsh, 2007). The Sequestration of heavy metal by plants in an effective method of reducing heavy metal contamination in soil (Cunningham *et al*., 1995). Sequestration of toxicants by plants is an important area of phytoremediation research. Some wild plants are known to accumulate a variety of toxicants from fire-cracker contaminant soil. In view of its biodiversity prospects of metalocoles has been gaining importance in the rehabitilization of fire-cracker contaminated sites.

The concentration of heavy metals was moderate in roots could be due to increased mobility of heavy metals form soil to root indicated the tendency of roots to accumulate good amount of metals from soil and transfer a little to above ground biomass. These results were confirmed with the findings of Jarvis *et al*., (1976) and Leita *et al*., (1991). Who noticed modrate accumulation of heavy metals in root system. It reveals that roots acts as barriers to transfer the toxic metals through soil-plant system (Jones and Clemant, 1972). Mechanism of metal accumulation was found significant in terms of Accumulation Factor (AF) of a particular plant component. Root showed high accumulation of heavy meals (174.65), followed by moderate accumulation in leaves (110.43) and poor content in stem (20.11), this results were coinciding with the findings of Nirmal Kumar *et al*., (2009).

Accumulation Factor and Translocation Factor values are greater than 1 (>1) has been used to evaluate the potential of plant species for phytoextraction and phytostabilization (Yoon *et al*., 206; Li *et al*., 2007). The results indicated that *Abutilon indicum* G.Don. had highest TF values for Ni (3.159) than *Tephrosia purpurea* Pers. for Mg (2.108) and *Amaranthus dublis* L. for Ni (2.029). High root to shoot translocation of these metals indicated that these plants have vital characteristics to be used in phyto-extraction of these metals as indicated by Ghosh and Singh (2005) and Lazaro *et al*., (2006). Plant species with slow plant growth, shallow root system and small biomass production are generally not preferred for phytoremediation (Malik *et al*., 2010). These three plant species such as *Amaranthus spinosa* L., *Abutilon indicum* G.Don. and *Amaranthus dublis* L. had high biomass and based on high translocation factor (TF) values could have enormous potential to be used for phytoextraction of Ni, As, Ba and Zn than other species which showed TF>1 for different metals. A sequence of decreasing translocation values: Ni > Mg > As > Zn >Ba > Ti > Cu >Al > Cd was found for plant species.it is easy for plant species with translocation factor greater than one (TF>1) to translocate metals from roots to shoots than those which restrict metals in their roots. High metal accumulation may be attributed to well develop detoxification mechanism based on sequestration of metal ions in vacuoles, by binding them on appropriate ligands such as organic acids, proteins and peptides in the presence of

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enzymes that can function at high level of metalicions (Cui *et al*., 2007) and metal exclusion strategies of plant species (Ghosh and Singh 2005). Plant species with high translocation factor (TF) values were suitable for phytoextraction generally requires translocation of heavy metals in easily harvestable plant parts (Yoon *et al*., 2006). According to Ghosh and Singh (2005) phytoextraction is a process to remove the contaminants from soil without destroying soil structure and fertility.

Accumulation Factor (AF) of studied plant species were highest for Ba followed by As and Ti. Four plant species showed accumulation factor (AF>1) for one or more than one meals. Based on higher accumulation factor values (AF) *Amaranthus spinosa* L., *Abutilon indicum* G.Don. and *Amaranthus dublis* L. was efficiently accumulated three heavy metals *viz*. Ba, As and Ti. The results coincide with the findings of Malik *et al*., (2010). The results indicate that the three plant species are hyperaccumulator that is *Amarantus spinosa* L., *Abutilon indicum* G.Don. and *Amaranthus dublis* L. for Ba, Ni, As respectively. All other species are either phytostabilization of rhyzofiltration because they accumulate Ba, Cu, Zn, Cd, Ni, Al, Mg, As and Ti in less than 100mg / kg (Baker and Brooks 1989). Though all higher plants are capable of accumulating heavy metals in different concentrations, a significant difference in metal accumulation exist between and within plant populations (Mellam *et al*., 2012).

In could be concluded that the fire-cracker waste could be phytoremediated by introducing the hyperaccumulator and phytostabilized plants on fire-cracker polluted sites to remove the toxicity and make the environment sans pollution for sustainable agriculture.

REFFERENCES

Anderson,L. and Walsh,M.M. Arsenic uptake by common marsh fern *Thelypteris palutris* and its potential for phytoremediation. *Sci. Total Environ.* 379: 263 – 265 (2007).

Baker, A.J.M. and Brooks,R.R. Terrestrial higher plants with hyperaccumulate metal elements: A review of their distribution, ecology and phytochemistry. *Biorecovery* 1: 81 – 126 (1989).

Baker,A.J.M., Mc Grath,S.P., Reevas,R.D. and Smith,J.A.C. Metal hyperaccumulator plants: A review of ecology and physiology of a biological resource for phytoremediation of contaminated soil and water. (Eds). N. Terry and others. Baca Raton, FL 7 Lewis Publishers. Pp. 129 – 158 (2000).

Cui,S., Zhou,Q. and Chao,L. Potential hyperacccumulation of Pb,Zn,Cu and Cd in endurant plants distributed in an old smeltery, Northeast China. *Environ. Geology*. 51: 1043 – 1048 (2007).

Cunningham,S., Berti,W. and Huang,J.W. Phytoremediation of contaminated soils. TIBTECH 13: 393 – 397 (1995).

Ghosh,M. and Singh,S.P. A review on phytoremediation of heavy metals and utilization of its by products. *App. Ecol. & Environ. Res.* 3: 1 – 18 (2005).

Jarvis,S.C. Jones,L.H.P. and Hooper,M.J. Cadmium uptake from solution by plants and its transport from roots to shoots. *Plant and Soil*. 44: 179 – 191 (1976).

Jones,L.H.P. and Clement,C.R. Leas uptake by plants and its significance for animal In: Lead in the environment. (Happle,P. Ed:). Applied science publishers Barking. Pp: 29 – 33 (1972).

Lazaro,D.J. Kiddb,P.S. and Martyneza,T. A phytochemical study of the Tras-os-Montes region (NE Portugal): Possible species for plant based soil remediation technologies. *Sci.the total Environ*. 354: 265 – 27 (2006).

Leita,L., Enne,G. Denobili,M., Ballini,M. and Sequi,P. Heavy metal bioaccumulation in lamb and sheep bred in smelting and mining areas of SW. Sardinia (Italy). Bulletin of Environ. Contamination and toxicol. 46: 887 – 893 (1991).

Li,M.S., Luo,Y.P. and Su,Zy. Heavy metal concentrations in soils and plant accumulation in a restored manganese mineland in Guangx, South China. *Environ.Pollution*. 147: 168 – 175 (2007).

Ma, L.Q., Komar, K.M., Tu, C., Zhang, W., Cai, Y. and Kennelley, E.D. A fern that hyperaccumulates arsenic. *Nature*. 409 (6820): 579 – 595 (2001).

Malik,P.N., Hussain,S. and Nazir,I. Heavy metal contamination in soil and wild plant species from industrial area of Islamabad, Pakistan. *Pak.J.Bot.*42(1): 291 – 301. (2010).

Mellam,J.J., Bijnath,H. and Odhav,B. Bioaccuulation of Cr, Hg, As, Pb, Cu and Ni with the ability for hyperaccumulation by *Amaranthus dublis*. *Afri. J. Agri. Res.* 7(4): 591 – 596 (2012).

Nirmal Kumar, J.I. Soni,H. Kumar,R.N. and Bhatt,I. Hyperaccumulation and mobility of heavy metals in vegetable crops in India. *J.Agricul & Environ.* 10: 29 – 38 (2009).

Prasad, M.N.V. and Freitas, H.M. Metal hyperaccumulation in plants- Biodiversity prospecting for phytoremediation technology. *Elec.J.Biotech*. 6(3): 285 – 321 (2003).

Ramasubramanian,V. and Jeyaprakash,R. Efficacy of plant based remediation in some physio-chemical parameters of match industry effluent. *Asian. J. Microbiol.Biotech. Env.Sci*. 9(3): 619 – 620 (2007).

Ramasubramanian,V., Sumathi,M. and Jeyaprakash,R. 2004. Effect of seaweed extract on the growth and biochemical characteristics of match factory effluent treated *Abelmascus esculentus* (L.) Medikus. (Behendi) Seedlings. *Seaweed Res. Utilin*. 26(142): 147 – 153 (2007).

Reevas, R.D. and Baker, A.J.M. Metal-accumulating palnts. In: phytoremediation of toxic metals: using plants to clean-up the environement. (Eds). Raskin,I. and Ensley, B.D. John Wiley and Sons, New York. Pp. 193 – 230 (2000).

Yoon,J. Cao,X. Zhou,Q. and Ma,L.Q. Accumulation of Pb, Cu and Zn in native plants growing on a contaminated Flarida site. *Sci.the Total Environ.* 368: 456 – 464 (2006).

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Table - 1

Metals		Metal Concentration in PPM							
		Amaranthus spinosa L.	*Tephrosia purpurea Pers.*	*Abutilon indicum* G.Don.	*Amaranthus dublis* L.	*Parthenium hysterophoirus* L.	*Datura metal* L.	*Solanum nigrum* L.	*Cleom viscosa* L.
Barium	Root	148.35 ± 0.096	50.18 ± 0.058	21.41 ± 0.073	16.52 ± 0.083	27.59 ± 0.034	15.31 ± 0.028	8.27± 0.069	5.16 ± 0.072
	Stem	126.25 ± 0.105	29.43 ± 0.023	10.16 ± 0.076	10.28 ± 0.046	11.36 ± 0.052	10.54 ± 0.115	3.59 ± 0.016	2.62 ± 0.025
	Leaf	110.43 ± 0.138	18.16 ± 0.084	8.31 ± 0.103	4.75 ± 0.094	8.13 ± 0.081	6.48 ± 0.074	0.18 ± 0.117	0.95 ± 0.147
Copper	Root	27.16 ± 0.516	29.35 ± 0.938	12.56 ± 0.059	8.52 ± 0.193	34.81 ± 0.046	27.54 ± 0.165	11.42 ± 0.082	9.18 ± 0.029
	Stem	12.11 ± 0.083	14.56 ± 0.059	10.12 ± 0.275	3.16 ± 0.065	16.12 ± 0.032	6.34 ± 0.197	7.12 ± 0.261	5.67 ± 0.384
	Leaf	9.25 ± 0.456	12.31 ± 0.0243	13.12 ± 0.142	1.51 ± 0.025	18.46 ± 0.156	10.42 ± 0.134	2.39 ± 0.347	1.59 ± 0.419
Zinc	Root	39.62 ± 0.731	42.54 ± 0.031	7.47 ± 0.093	15.73 ± 0.079	25.18 ± 0.148	36.16 ± 0.296	19.42 ± 0.214	11.31 ± 0.095
	Stem	25.34 ± 0.152	30.37 ± 0.172	0.59 ± 0.278	10.62 ± 0.382	13.18 ± 0.062	10.74 ± 0.172	7.38 ± 0.133	8.16 ± 0.089
	Leaf	40.17 ± 0.054	44.24 ± 0.165	2.72 ± 0.053	7.58 ± 0.104	8.41 ± 0.073	12.57 ± 0.027	2.19 ± 0.072	1.57 ± 0.067
Cadmium	Root	12.16 ± 0.068	13.52 ± 0.302	10.73 ± 0.086	11.52 0.418	29.67 ± 0.186	19.41 ± 0.084	20.58 ± 0.0753	10.74 ± 0.075
	Stem	8.42 ± 0.294	10.48 ± 0.439	5.04 ± 0.874	3.18 ± 0.076	10.11 ± 0.790	6.32 ± 0.753	7.53 ± 0.192	8.36 ± 0.093
	Leaf	3.93 ± 0.153	6.83 ± 0.074	7.31 ± 0.010	10.91 ± 0.865	11.69 ± 0.867	2.47 ± 0.830	3.51 ± 0.208	0.45 ± 0.301
Nickel	Root	22.76 ± 0.68	19.21 ± 0.216	1.52 ± 0.427	12.57 ± 0.437	31.69 ± 0.451	8.56 ± 0.557	10.72 ± 0.375	7.37 ± 0.366
	Stem	11.21 ±0.039	10.74 ± 0.183	0.63 ± 0.273	8.16 ± 0.014	9.76 ± 0.385	3.67 ± 0.839	8.41 ± 0.267	0.245 ± 0.012
	Leaf	9.48 ± 0.728	7.32 ± 0.338	4.17 ± 0.745	17.35 ± 0.322	11.53 ± 0.453	0.27 ± 0.564	2.59 ± 0.106	0.57 ± 0.874
Aluminium	Root	33.47 ± 0.263	35.14 ± 0.910	7.51 ± 0.192	3.64 ± 0.107	18.63 ± 0.784	15.62 ± 0.347	18.31 ± 0.042	11.52 ± 0.486
	Stem	20.11 ± 0.521	21.63 ± 0.045	3.67 ± 0.954	2.16 ± 0.584	6.58 ± 0.823	7.39 ± 0.104	10.43 ± 0.177	8.31 ± 0.237
	Leaf	16.51 ± 0.654	18.69 ± 0.961	2.18 ± 0.296	3.19 ± 0.182	9.27 ± 0.720	5.13 ± 0.067	5.66 ± 0.045	1.73 ± 0.064
Magnesium	Root	21.67 ± 0.197	27.52 ± 0.075	37.94 ± 0.742	31.6 ± 0.493	3.27 ± 0.063	0.67 ± 0.019	6.59 ± 0.848	8.356 ± 0.620
	Stem	7.31 ± 0.093	20.46 ± 0.906	30.57 ± 0.164	23.74 ± 0.579	0.61 ± 0.817	1.38 ± 0.946	0.08 ± 0.617	1.539 ± 0.481
	Leaf	16.54 ± 0.762	37.56 ± 0.850	41.83 ± 0.103	39.28 ± 0.037	1.57 ± 0.260	0.36 ± 0.239	0.94 ± 0.052	0.857 ± 0.855
Arsenic	Root	32.73 ± 0.473	35.31 ± 0.976	47.35 ± 0.938	43.62 ± 0.863	1.96 ± 0.075	3.165 ± 0.735	5.15 ± 0.061	3.19 ± 0.563
	Stem	18.41 ± 0.056	20.79 ± 0.940	30.24 ± 0.612	29.41 ± 0.075	0.094 ± 0.856	0.53 ± 0.918	3.07 ± 0.969	0.352 ± 0.912
	Leaf	4.56 ± 0.153	47.82 ± 0.064	53.46 ± 0.291	50.13 ± 0.053	1.24 ± 0.563	1.48 ± 0.262	0.542 ± 0.724	0.951 ± 0.536
Titanium	Root	174.65 ± 0.854	69.52 ± 0.796	74.16 ± 0.728	70.32 ± 0.434	25.36 ± 0.854	24.31 ± 0.577	21.42 ± 0.638	12.18 ± 0.083
	Stem	50.18 ± 0.058	45.31 ± 0.067	51.46 ± 0.269	44.15 ± 0.049	12.31 ± 0.671	11.42 ± 0.062	10.18 ± 0.186	5.13 ± 0.946
	Leaf	101.37 ± 0.387	57.64 ± 0.094	84.36 ± 0.135	79.63 ± 0.479	7.67 ± 0.960	4.16 ± 0.308	7.43 ± 0.187	3.79 ± 0.206

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Table – 2

Metals		*Amaranthus spinosa* L.	*Tephrosia purpurea* Pers.	*Abutilon indicum* G.Don.	*Amaranthus dublis* L.	*Parthenium hysterophoirus* L.	*Datura metal* L.	*Solanum nigrum* L.	*Cleom viscosa* L.
Barium	AF	2.081 ± 0.075	0.528 ± 0.040	0.216 ± 0.085	0.170 ± 0.003	0.254 ± 0.086	0.175 ± 0.028	0.065 ± 0.081	0.047 ± 0.184
	TF	1.595 ± 0.139	0.948 ± 0.184	0.862 ± 0.167	0.910 ± 0.132	0.706 ± 0.360	1.111 ± 0.296	0.456 ± 0.058	0.691 ± 0.080
Copper	AF	0.298 ± 0.127	0.345 ± 0.057	0.220 ± 0.032	0.081 ± 0.029	0.426 ± 0.125	0.271 ± 0.025	0.128 ± 0.540	0.101 ± 0.095
	TF	0.786 ± 0.038	0.915 ± 0.052	1.850 ± 0.318	0.548 ± 0.207	0.993 ± 0.037	0.608 ± 0.956	0.832 ± 0.076	0.790 ± 0.058
Zinc	AF	0.876 ± 0.005	0.926 ± 0.026	0.090 ± 0.123	0.283 ± 0.075	0.390 ± 0.574	0.495 ± 0.036	0.242 ± 0.381	0.175 ± 0.470
	TF	1.653 ± 0.087	1.753 ± 0.702	0.443 ± 0.106	1.157 ± 0.092	0.857 ± 0.562	0.644 ± 0.048	0.493 ± 0.120	0.860 ± 0.192
Cadmium	AF	0.285 ± 0.019	0.358 ± 0.273	0.268 ± 0.078	0.298 ± 0.014	0.598 ± 0.088	0.372 ± 0.007	0.368 ± 0.475	0.227 ± 0.632
	TF	1.016 ± 0.103	1.280 ± 0.044	1.151 ± 0.706	1.223 ± 0.135	0.735 ± 0.590	0.452 ± 0.122	0.536 ± 0.443	0.820 ± 0.901
Nickel	AF	0.807 ± 0.246	0.693 ± 0.159	0.117 ± 0.257	0.707 ± 0.066	0.985 ± 0.364	0.232 ± 0.043	0.403 ± 0.177	0.152 ± 0.138
	TF	0.909 ± 0.509	0.940 ± 0.135	3.158 ± 0.089	2.029 ± 0.156	0.671 ± 0.0207	0.460 ± 0.280	1.026 ± 0.119	0.110 ± 0.038
Aluminium	AF	0.876 ± 0.125	0.943 ± 0.025	0.167 ± 0.217	0.112 ± 0.007	0.431 ± 0.054	0.351 ± 0.075	0.430 ± 0.037	0.269 ± 0.095
	TF	1.094 ± 0.114	1.147 ± 0.103	0.778 ± 0.169	1.469 ± 0.022	0.850 ± 0.015	0.801 ± 0.053	0.878 ± 0.055	0.871 ± 0.152
Magnesium	AF	0.367 ± 0.096	0.689 ± 0.071	0.889 ± 0.039	0.763 ± 0.065	0.043 ± 0.161	0.019 ± 0.035	0.061 ±0.071	0.086 ± 0.106
	TF	1.101 ± 0.243	2.108 ± 0.090	1.908 ± 0.076	1.994 ± 0.303	0.667 ± 0.083	2.597 ± 0.019	0.154 ± 0.078	0.286 ± 0.074
Arsenic	AF	0.819 ± 0.011	1.528 ± 0.235	1.927 ± 0.206	1.811 ± 0.047	0.048 ± 0.176	0.076 ± 0.103	0.128 ± 0.054	0.066 ± 0.401
	TF	0.701 ± 0.208	1.943 ± 0.075	1.767 ± 0.087	1.823 ± 0.547	0.680 ± 0.122	0.635 ± 0.071	0.701 ± 0.379	0.408 ± 0.064
Titanium	AF	1.664 ± 0.147	0.879 ± 0.089	1.071 ± 0.327	0.990 ± 0.162	0.203 ± 0.052	0.203 ± 0.049	0.199 ± 0.013	0.107 ± 0.065
	TF	0.867 ± 0.054	1.481 ± 0.158	1.831 ± 0.144	1.760 ± 0.238	0.787 ± 0.048	0.640 ± 0.088	0.822 ± 0.129	0.732 ± 0.034

Values are an average of five observations with respect to control. Mean ± Standard Error; AF = Accumulation Factor; TF = Translocation Factor