

# Remediation of Heavy Metal Contaminated Soils using Weed Species

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**Abstract** - The present study was designed to identify the naturally enhanced phytoextraction potential using different weed species *Phyllanthus niruri*, *Acharanthes aspera*, *Amaranthus viridis*, *Acalypha indica* and *Abutilon indicum*. The physiochemical parameters and heavy metals in soil and plant samples were determined. Results revealed that all sampling plants have relatively good Bioconcentration Factor more than 1 and low Translocation factor less than 1. Except *Abutilon indicum*, *Acalypha indica* and *Amaranthus viridis*, none of other test plant species suitable for phytoextraction but all test plant species having relative good Bioconcentration Factor more than 1. It can conclude that all the sampling plant species could not reach the standard of hyper accumulator for all metals. Test plant species such as *Abutilon indicum*, *Acalypha indica* and *Amaranthus viridis* are suitable for phytoextraction of cadmium, lead and chromium contaminated soils respectively.

**Key words**-Weeds, phytoextraction, *phyllanthus niruri*, chromium

## I. INTRODUCTION

Discharge of organic and inorganic waste by the industries led to addition of toxic metal ions and contaminate agricultural ecosystems.[1-3]. In general, metal ions are very essential for the maintenance of biological functions of all life systems however, the same metal present in excess produce errors in genetic information system and responsible for alterations in chromosome structure, chromosome number etc. It may result in many cytotoxic effects on plant, animals and human beings [4]. At higher concentrations these metal ions effects germinations of seeds, stunted growth of plants, visible symptoms include chlorotic spots, senescence of leaf [5-7].

Thus remediation of heavy metal contaminated soil is very essential for ecological balance. At present, there are various physical, chemical and biological methods available. However, these developed technologies are expensive and often take long time for remediation. Usage of plants for the removal of heavy metals is not new and it is called as phytoremediation which can be considered as feasible, ecofriendly and widely accepted technology which is cost effective and reliable.

Many researches concentrating and paying attention on phytoremediation for the remediation of heavy metals [8]. In this world there are many plant are there which can consider as hyper accumulators [9]. The term hyper accumulators was coined for plant which can actively take up excess amounts of one or more heavy metal translocated to shoot and above ground organs from soil. There are 400 different species of known hyper accumulator are there which can contain more than 0.1% of Ni, Co, Cu, Cr and Pb in its leaves with irrespective of metal concentration in soil. Plant can grow in adverse environmental conditions and do not show any symptoms of phytotoxicity [10-14].

Therefore, the plant selected for the remediation must be able to tolerate all environmental conditions such as low temperature, low sun light, poor drainage, unproductive soil and chemicals from different sources. Thus, various researchers investigated and highlighted that weed species are having highly tolerable and adoptable to adverse environmental conditions and suitable for restoration of contaminated soils. One of the crucial factor to consider weed are suitable for remediation is rather than other crops weeds can easily grow and tolerate adverse conditions. In this present study five different families of weed species such as *Phyllanthus niruri*, *Acharanthes aspera*, *Amaranthus viridis*, *Acalypha indica* and *Abutilon indicum* have selected to identify the potential of metal up take. The main objective of the present study was to identify the potential of selected weed species belong to different families in accumulation and translocation of heavy metals from soils.

## II. MATERIALS AND METHODS

Tirupati one of the most famous pilgrim city having major industries. The atmospheric conditions of these region posses high heat in summer and average cold in winter with moderate rainfall. The most dominant weed species *Phyllanthus niruri*, *Acharanthes aspera*, *Amaranthus viridis*, *Acalypha indica* and *Abutilon indicum* and their associated soils soil samples collected from 3 Km around the industries at 0-20km depth. The collected soil samples were sieved through 60mm and sieved material was stored for further analysis. The physiochemical

properties of the soil were determined by standards methods of APHA [15]. 1 gram of homogenized soil sample was collected and heavy metals were determined using acid digestion procedure [16-17]. Plant materials were oven-dried at 75°C and grounded to a fine powder. In this way, homogeneous samples were obtained for each plant organ approximately 0.2 gram of leaves and roots powder were weighed and digested according to method described by Allen [18]. Soil and plant samples were analyzed for heavy metals by AAS. All the analyses were carried out on three subsamples. Chemicals, stock solutions and reagents were obtained from Merck and were of analytical grade. All glassware before use were washed with distilled water, soaked in nitric acid (30%) overnight, rinsed in demonized water and air-dried. Biological Concentration Factor (BCF) was calculated as metal

concentration ratio of plant roots to soil. Translocation Factor (TF) was described as ratio of heavy metals in plant shoot to that in plant root [19-20].

### III. RESULTS AND DISCUSSION

The soil pH (6.9) was determined in a mixture of soil and demonized water (1:2, w/v) with a glass electrode [21]. Total organic carbon (content was determined using the Walkey-Black wet oxidation [22], Total Nitrogen (1.0) was determined using the Kjeldhal method [23]. Total phosphorus (1.40) was determined calorimetrically. Total background cadmium concentration was determined using Atomic Absorption Spectrophotometer (Buck scientific, 210 VGP). The electrical conductivity (EC) was measured by using digital meters (Elico, Model LI-120).

Figure1 (a-e) showing weed species



1(a) Phyllanthus niruri,

1(b) Acharanthes aspera



1(c) Amaranthus viridis

1(d) Acalypha indica

*1(e)Abutilon indicum*

Table (1) Cadmium uptake by weed species

Cadmium concentration in soil (mg/kg-1)	<i>Phyllanthus niruri</i>	<i>Acharanthes aspera</i>	<i>Amaranthus viridis</i>	<i>Acalypha indica</i>	<i>Abutilon indicum</i>
Total	3.5±0.02	4±0.03	7.2±0.01	6.4±0.04	4.2±0.02
Root	1.2±0.01	1.5±0.01	3.5±0.01	3.2±0.05	1.9±0.03
Shoot	1±0.03	1.2±0.05	2.4±0.03	2.2±0.02	1.7±0.02
BCF of Shoot	2.0	2.7	2.1	2.0	2.2
BCF of Root	3.5	3.3	3.0	2.9	2.5
TF	0.8	0.8	0.9	0.7	0.8

Results are means±SD(n=5)

Table (2) Lead uptake by weed species

Lead concentration in soil (mg/kg-1)	<i>Phyllanthus niruri</i>	<i>Acharanthes aspera</i>	<i>Amaranthus viridis</i>	<i>Acalypha indica</i>	<i>Abutilon indicum</i>
Total	3.5±0.01	6.2±0.02	4.5±0.03	6±0.01	4.1±0.02
Root	1.8±0.02	1.6±0.02	1.4±0.01	1.9±0.03	1.7±0.01
Shoot	1.2±0.03	2.4±0.03	1.5±0.02	2.5±0.01	1.4±0.06
BCF of Shoot	1.9	2.1	2.4	2.1	2.2
BCF of Root	2.9	2.6	3.0	2.4	2.9
TF	0.6	0.8	0.8	0.9	0.7

Results are means±SD(n=5)

Table (3) Chromium uptake by weed species

Chromium concentration in soil (mg/kg-1)	<i>Phyllanthus niruri</i>	<i>Acharanthes aspera</i>	<i>Amaranthus viridis</i>	<i>Acalypha indica</i>	<i>Abutilon indicum</i>
Total	2.8±0.06	2.9±0.02	4.7±0.05	4.9±0.04	3.5±0.06
Root	1.2±0.02	1.2±0.03	2.4±0.02	2.2±0.03	1.5±0.04
Shoot	1±0.01	1±0.04	2.2±0.01	2.1±0.02	1.2±0.03
BCF of Shoot	2.3	2.9	2.4	2.2	3.5
BCF of Root	2.8	2.4	2.1	2.3	2.3
TF	0.8	0.9	0.9	0.9	0.8

Results are means±SD(n=5)

From the table (1) and Fig (2) it was clear that uptake of cadmium is more in root than in shoot and there was significant variation on all sampled weed species. In *Phyllanthus niruri* maximum concentration in shoot and root was 1.0 and 1.2mg/kg respectively. In *Acharanthes aspera* maximum concentration in shoot and root was 1.2 and 1.5mg/kg respectively. In *Abutilon indicum* maximum concentration in shoot and root was 2.4 and 3.5mg/kg

respectively. In *Acalypha indica* maximum concentration in shoot and root was 2.2 and 3.2mg/kg respectively. In *Amaranthus viridis* maximum concentration in shoot and root was 1.7 and 1.9mg/kg respectively. It was shown that the maximum uptake was observed in roots than shoots among all test species. The sequence of uptake of cadmium among test plant species was *Abutilon indicum*>*Acalypha indica*>*Amaranthus viridis*>*Acharanthes aspera*>*Phyllanthus niruri*. *Abutilon indicum* was shown highest up take of cadmium among all test plant species.

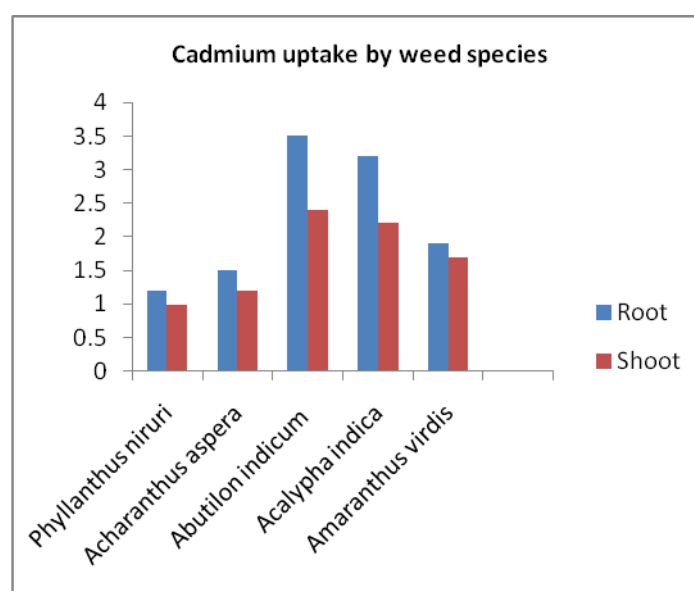


Figure (2) Accumulation of cadmium in root and shoot of different weed species

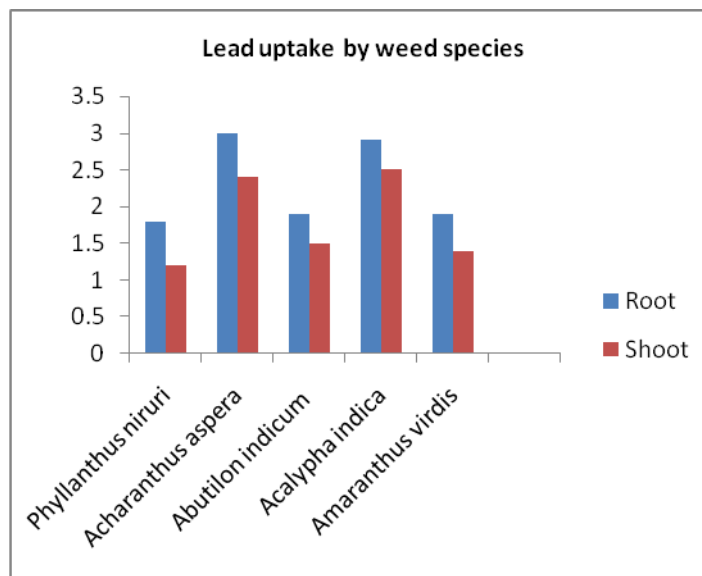


Figure (3) Accumulation of lead in root and shoot of different weed species

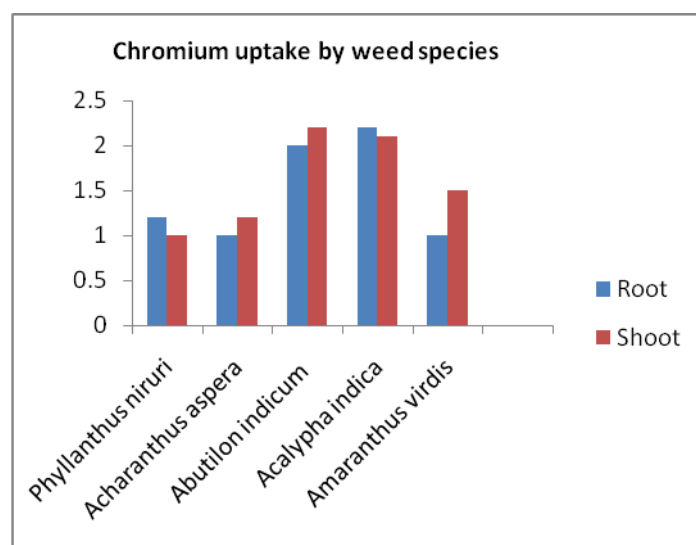


Figure (4) Accumulation of chromium in root and shoot of different weed species

Table(2) and and Fig(3) shown that maximum uptake of lead was found in *Acalypha indica*. In *Phyllanthus niruri* maximum concentration in shoot and root was 1.2 and 1.8mg/kg respectively. In *Acharanthus aspera* maximum concentration in shoot and root was 2.4 and 2.8mg/kg respectively. In *Abutilon indicum* maximum concentration in shoot and root was 1.5 and 1.9mg/kg respectively. In *Acalypha indica* maximum concentration in shoot and root was 2.5 and 2.9mg/kg respectively. In *Amaranthus viridis* maximum concentration in shoot and root was 1.4 and 1.9mg/kg respectively. It was shown that the maximum uptake was observed in roots than shoots among all test species. The sequence of uptake of cadmium among test

plant species was *Acalypha indica*>*Acharanthus aspera*>*Abutilon indicum* >*Amaranthus viridis*> *Phyllanthus niruri*.

Table (3) and Fig (4) shown that maximum uptake of chromium was found in *Amaranthus viridis*. In *Phyllanthus niruri* maximum concentration in shoot and root was 1.2 and 1.0mg/kg respectively. In *Acharanthus aspera* maximum concentration in shoot and root was 1.0 and 1.2mg/kg respectively. In *Abutilon indicum* maximum concentration in shoot and root was 2 and 2.2mg/kg respectively. In *Acalypha indica* maximum concentration in shoot and root was 1.5and 1.0mg/kg respectively. In *Amaranthus viridis* maximum concentration in shoot and root was 2.2 and 2.4mg/kg respectively. It was shown that

the maximum uptake was observed in roots than shoots among all test species. The sequence of uptake of cadmium among test plant species was *Amaranthus viridis* > *Acalypha indica* > *Abutilon indicum* > *Acharanthus aspera* > *Phyllanthus niruri*.

Bioconcentration factor (BCF) was used to evaluate the efficiency of phytoextraction. In soil contaminated with cadmium, lead and chromium the Bioconcentration Factor in all the test plant species of root and shoot varied from 2.0 to 2.9, 2.5 to 3.5 and 2.4 to 2.1 respectively. The result shown from Table (1-3) soils contaminated with cadmium, lead and chromium the maximum Bioconcentration Factor was found in *Abutilon indicum*, *Acharanthus aspera* and *Abutilon indicum*. The Bioconcentration Factor was more than 1 in all test plant species.

Translocation Factor is a measure of the ability of plants to transfer accumulated metals from the roots to the shoots. The translocation Factor in all the test plant species was in the range of 0.7 to 0.9, 0.6 to 0.9 and 0.8 to 1.5 in cadmium, lead and contaminated soils respectively. Translocation Factor below 1 indicates the plant are not suitable for phytoextraction. Among all test plant species in cadmium, lead and chromium contaminated soils except *Abutilon indicum*, *Acalypha indica* and *Amaranthus viridis* none of them were suitable for phytoextraction but all of the test plant species were suitable for phytostabilization.

#### IV. CONCLUSION

Plants with both Bioconcentration Factor and Translocation Factor greater than one (TF and BCF > 1) have the potential to be used in phytoextraction. Plants with Bioconcentration factor greater than one and translocation factor less than one (BCF > 1 and TF < 1) have the potential for phytostabilization [24]. By comparing BCF and TF, the ability of different plants in taking up metals from soils and translocating them to the shoots can be compared. Basing on results it was revealed that in cadmium, lead and chromium contaminated soils all sampling plants have relatively good bioconcentration Factor and low Translocation factor. Except *Abutilon indicum*, *Acalypha indica* and *Amaranthus viridis* none of other test plant species suitable for phytoextraction but all test plant species having relative good bioconcentration Factor more than 1. It can conclude that all the sampling plant species could not reach the standard of hyper accumulator for all metals. *Abutilon indicum* is suitable for phytoextraction of cadmium contaminated soils, *Acalypha indica* is suitable for phytoextraction of lead contaminated soils and *Amaranthus viridis* is suitable for phytoextraction

chromium contaminated soils. However, remaining test plant species are suitable for phytostabilization. Field trials are important to identify the hyper accumulators.

#### REFERENCES

- [1] Yadav, R.K., Goyal, B., Sharma, R.K., Dubey, S.K., Minhas, P.S., 2002. Post-irrigation impact of domestic sewage effluent on composition of soils, crops and groundwater – a case study. *Environ. Int.* 28, 481–486.
- [2] Singh, S., Saxena, R., Pandey, K., Bhatt, K., Singha, S., 2004. Response of antioxidant in sunflower (*Helianthus annuus* L.) grown on different amendments of tannery sludge: its metal accumulation potential. *Chemosphere* 57, 1663–1673.
- [3] Chen, Y., Wang, C., Wang, Z., 2005. Residue and sources identification of persistent organic pollutants in Farmland soils irrigated by effluents from biological treatment plants. *Environ. Int.* 31, 778–783.
- [4] Sharma, A., Talukder, G., 1987. Effects of metals on chromosome of higher organisms. *Environ. Mutagen.* 9, 191–226
- [5] Fargasova, A., 1994. Effect of Pb, Cd, Hg, As, and Cr on germination and root growth of *Sinapis alba* seeds. *Bull. Environ. Contam. Toxicol.* 52, 452–456.
- [6] Malone, C.P., Miller, R.J., Koeppe, D.E., 1978. Root growth in corn and soybeans: effects of cadmium and lead on lateral root initiation. *Can. J. Bot.* 56, 277–281
- [7] Mesmar, M.N., Jaber, K., 1991. The toxic effect of lead on seed germination, growth, chlorophyll and protein contents of wheat and lentil. *Acta Biol. Hung.* 42, 331–344.
- [8] U.S. Environmental Protection Agency (US EPA), A Citizen's Guide to Phytoremediation, Office of Solid Waste and Emergency Response, (5102 G) EPA 542-F-98-001 (1998).
- [9] Briat, J.F., Lebrun, M., 1999. Plant responses to metal toxicity. *C. R. Acad. Sci. Paris* 322, 43–54.
- [10] N. Rascio, Metal accumulation by some plants growing on zinc-mine deposits, *Oikos* 29 (1977) 250–253.
- [11] R.D. Reeves, Hyperaccumulation of trace elements by plants, in: J.L. Morel, G. Echevarria, N. Goncharova (Eds.), *Phytoremediation of Metal-Contaminated Soils*, NATO Science Series: IV: Earth and Environmental Sciences, Springer, NY, 2006, pp. 1–25.
- [12] T. Jeffery, R. R. Brooks, J. Lee and R. D. Reeves, *Ebertia Accuminata*, A Nickel-Accumulating Plant from New Caledonia, *Science*, 193, 579-580 (1976).
- [13] A. J. M. Baker and P. L. Walker, Ecophysiology of Metal Uptake by Tolerant Plants, In Aj Shaw, Ed., *Heavy Metal Tolerance in Plants, Evolutionary Aspects*, CRC Press, Boca Raton, FL, 155-177 (1990).
- [14] S. L. Brown, R. L. Chaney, J. S. Angle and A. J. M. Baker, Zinc and Cadmium Uptake by *Thlaspi caerulescens* and *Silene-Vulgaris* in Relation to Soil Metals and Soil pH, *J. Environ. Qual.*, 23, 1151-1157 (1994).

- [15]APHA, 2005. Standard Methods for the Examination of Water and Wastewater, 21sted. American Public Health Association, Washington, DC, New York
- [16]Krumbein, W.C. and F.J. Pettijohn, 1938. Manual of Sedimentary Petrology. Appleton, Century and Crofts, Inc., New York, N.Y., pp: 549
- [17]Wade, T.L., J.M. Brooks, M.C. Kennicutt, T.J. McDonald, J.L. Sericano and T.L. Jackson, 1993 GERG Trace Metals and Organic Contaminants Analytical Techniques. In G.G. Lauenstein and A.Y. Cantillo (Eds.), Sampling and Analytical Methods of The National tatus and Trend Program. National Benethic Surveillance and Mussel Watch Projects 1984-1992, NOAA Technical Memorandum NOS ORCA 71. Silver Spring, MD, pp: 121-139.
- [18]18. Allen, S.E., 1989. Chemical Analysis of Ecological Materials, 2 ed., Blackwell Scientific Publication, Oxford.
- [19]Cui, S., Q. Zhou and L. Chao, 2007. Potential hyper-accumulation of Pb, Zn, Cu and Cd in endurant plants distributed in an old smeltery, northeast China. Environ. Geol., 51: 1043-1048.
- [20]Li, M.S., Y.P. Luo and Z.Y. Su, 2007. Heavy metal concentrations in soils and plantaccumulation in a restored manganese mineland in Guangxi, South China. Environ Poll., 147: 168-175.
- [21]McLean EO., (1982), Soil pH and lime requirement. In 'Methods of soil analysis, Part 2: Chemical and microbiological properties'. 2nd edn. Agronomy Monograph No. 9. (Eds AL Page, RH Miller, DR Keeney), (American Society of Agronomy: Madison, WI) pp. 199–224.
- [22]Nelson DW., Sommers LE., (1982), Total carbon, organic carbon, and organic matter, In: A.L. Page, R.H. Miller, D.R. Keeney (Eds.), Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Agronomy Monograph 9, 2nd ed., Agronomy Society of America and Soil Science Society of America, Madison, WI, USA, pp 539– 577.
- [23] Bremner. J.M, Mulvaney C.S., (1982), Nitrogen total content, In: A.L. Page, R.H. Miller, D.R. Keeney (Eds.), Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. Agronomy 9, 2nd ed., Agronomy Society of America and Soil.
- [24]Yoon. J., Cao X., Zhou Q., and Ma LQ., (2006), Accumulation of Pb, Cu, and Zn in native plants growing on a contaminated Florida site. Science of the Total Environment, 368, pp456-464