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[FRTSSDS- June 2018] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1321904 Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

STUDY OF PHYTOREMEDIATION POTENTIAL IN CATHARANTHUS ROSEUS (PERIWINKLE)

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ABSTRACT

Phytoremediation is an emerging technology that uses various plants to degrade, extract, contain or immobilize contaminants from soil and water. Plants can help clean up many kinds of pollution including metals, pesticides, explosives and oil. This technology has been receiving attention as an innovative, cost-effective alternative to the more established treatment methods used at hazardous waste sites. Contaminated soils and waters pose a major environmental and human health problem. Oil refineries and chemical plants produce billions of gallons of contaminated wastewater each year. Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, waste water irrigation, coal combustion residues, spillage of petrochemicals and atmospheric deposition. In the present study Catharanthus roseus has been used for phytoremediation. Experiments were conducted using Chemistry lab effluent.

Accumulations of the heavy metals were analyzed after 30, 60 and 90 days in flowers, leaves, stem and roots by AAS. The results showed that metals are highly accumulated by the roots than stem and leaves. It was concluded that the plant species was a good accumulator of metals.

Keywords: *Phytoremediation, Catharanthus roseus (periwinkle), metal uptake, phytoextraction, etc.*

I. INTRODUCTION

Phytoremediation technique has been identified as a cost-effective approach for remediating heavy metal contaminated sediments [1-3]. Phytoremediation approaches to utilize a particular group of plants, known as hyper-accumulators, to extract and concentrate particular heavy metal elements from the environment. Hyper-accumulator plant species are capable of accumulating metals at levels 100 fold greater than those typically found in common plants [4-5]. These hyper-accumulator species have strongly expressed mechanism of metal sequestration and, sometimes, greater internal requirement for specific metals. It offers removal of heavy metal in a particular site by maintaining the biological activity and structure of the soils and with the possibility of bio-recovery of metals [6]. The field of phytoremediation is harnessing greater acceptance because phytoremediation technique can offer the only effective means of restoring hundreds and thousands of square kilometers of land area and water that have been polluted by irresponsible activities of humans [3, 7, 8].

Metals are natural components in soil. Some of these metals are micronutrients necessary for plant growth, such as Zn, Cu, Mn and Co, while others have unknown biological function, such as Cd, Pb, Ni, Cr, As and Hg [9-10]. Many species of plants have been successful in absorbing contaminants such as lead, cadmium, chromium, arsenic, and various radionuclides from soils. Toxic heavy metals such as Pb, Co, Cd, Ni, As, Cr are accumulated in the plants and animals. Heavy metals are the major environmental contaminants and pose a severe threat to human and animal health by their long-term persistence in the environment [11-12]. Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg) and nickel (Ni)[13].

The plants act both as "accumulators" and "excluders". Accumulators survive despite concentrating contaminants in their aerial tissues. They biodegrade or biotransform the contaminants into inert forms in their tissues. The excluders restrict contaminant uptake into their biomass. Plants to be used for phytoextraction should have: (a) tolerance to high concentrations metals, (b) high metal-accumulation capability, (c) heavy biomass, (d) ability to grow fast and a (e) profuse root system. The success of phytoextraction depends especially on the plant's ability (a) to accumulate biomass rapidly, and (b) to store large quantities of the uptaken metals in the shoot tissue [14-17].

The present research aims to study the potential use of Catharanthus roseus (periwinkle) in remediating heavy metal contaminated soils

II. MATERIALS AND METHOD

Mechanisms of metals uptake

It is important to note that of the total amount of ions associated with the root, only a part is absorbed into cells. A significant ion fraction is physically adsorbed at the extracellular negatively charged sites (COO^-) of the root cell walls. The cell wall-bound fraction cannot be translocated to the shoots and, therefore, cannot be removed by harvesting shoot biomass (phytoextraction). Thus, it is possible that a plant exhibiting significant metal accumulation into the root, to express a limited capacity for phytoextraction. For example, many plants accumulate Pb in roots, but Pb translocation to shoot is very low [18]. Binding to the cell wall is not the only plant mechanism responsible for metal immobilization into roots and subsequent inhibition of ion translocation to the shoot. Metals can also be transformed into metal complex and sequestered in cellular structures (e.g., vacuole), which become unavailable for translocation to the shoot [19]. In addition, some plants, coined excluders, possess specialized mechanisms to restrict metal uptake into roots. However, the concept of metal exclusion is not well understood [20].

Uptake of metals into root cells, the point of entry into living tissues, is a step of major importance for the process of phytoextraction. However, for phytoextraction to occur metals must also be transported from the root to the shoot. Movement of metal-containing sap from the root to the shoot, termed translocation, is primarily controlled by two processes: (a) root pressure and (b) leaf transpiration.

Experimental setup

Catharanthus roseus seedlings were planted in an area of 360 cm x 60 cm in the college premises and in pots. The garden area was irrigated with the chemistry lab effluent after neutralization.

Plant Harvesting

Plant area was divided into three parts and one third of the plants were harvested after 30 days, 60 days and the remaining one third were harvested after 90 days. Similar potted plants were also harvested after 30 days, 60 days and 90 days. The plants were divided into five parts as roots, stem, leaves, flowers and seeds.

Digestion of Sample

The different parts of the plants were dried in shadow for 2 days and then in hot air oven for 8 hours, then the sample was ground in a grinder. The grinded samples were digested with nitric acid for extraction of metal ions. For digestion, 2.5 ml concentrated nitric acid was added to 1 gm grinded oven dried sample taken in a 100 ml beaker. Then the beaker was heated on the hot plate till complete dryness. The content of the beaker was dissolved in distilled water and finally filtered using a filter paper (0.45 micron) in a 100 ml volumetric flask. The filtrate was stored in a plastic bottle for analysis using an AAS or atomic absorption spectrophotometer.

Plant Details

Kingdom	**:** Plantae
Phylum	**:** Magnoliophyta
Class	**:** Magnoliopsida
Order	**:** Gentianales
Family	**:** Apocynaceae

ISSN 2348 – 8034
Impact Factor- 5.070

Genus : *Catharanthus*
Species : *Catharanthus roseus*

Figure 1 Catharanthus roseus (periwinkle)

This genus contains small annual or perennial herbs native to Madagascar, that were formerly included in the genus Vinca. The species *C. roseus* had an earlier scientific name of *Vinca rosea.* Furthermore, *C. roseus* has quite a few common names some of which include: the Periwinkle, Madagascar Periwinkle, Rosy Periwinkle, Cape Periwinkle, and the Old Maid. The species can be seen in Figure 1.

III. RESULTS AND DISCUSSION

The different parts of the plants were analysed for four metals viz. Iron (Fe), Nickel (Ni), Cadmium (Cd) and Copper (Cu). The analyses data for metal uptake by different parts of the plants using AAS is shown in the tables 1-3.

Table 1:Analyses of plant parts after 30 days

Plant part	Control plant (mg/kg biomass)				Experimental plant (mg/kg biomass)			
	Fe	**Ni**	**Cd**	**Cu**	**Fe**	**Ni**	**Cd**	**Cu**
Roots	0.10	0.05	ND	0.07	2.17	0.84	0.12	0.21
Stems	0.11	0.06	ND	0.04	2.31	0.55	0.15	0.33
Leaves	2.13	0.08	ND	0.02	4.27	0.36	0.17	0.53
Flowers	10.80	0.12	ND	ND	18.91	0.23	0.19	0.61
Seeds	-	-	-	-	-	-	-	-

Table 2:Analyses of plant parts after 60 days

Plant part	Control plant (mg/kg biomass)				Experimental plant (mg/kg biomass)			
	Fe	**Ni**	**Cd**	**Cu**	**Fe**	**Ni**	**Cd**	**Cu**
Roots	0.54	0.04	0.04	0.19	4.35	1.25	0.47	0.82
Stems	1.22	0.08	0.01	0.13	6.74	1.56	0.62	0.59
Leaves	5.67	0.17	ND	0.02	10.44	0.88	0.55	1.22
Flowers	17.42	0.11	ND	0.04	26.19	0.75	0.19	1.89
Seeds	15.11	0.15	ND	0.01	27.90	0.22	0.22	2.20

[FRTSSDS- June 2018] ISSN 2348 – 8034
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Table 3:Analyses of plant parts after 90 days

Plant part	Control plant (mg/kg biomass)				Experimental plant (mg/kg biomass)			
	Fe	Ni	Cd	Cu	Fe	Ni	Cd	Cu
Roots	0.57	0.11	0.01	0.46	8.79	2.12	1.21	2.04
Stems	3.87	0.18	0.01	0.34	9.12	2.44	1.22	0.76
Leaves	10.41	0.22	ND	0.12	13.42	1.37	1.46	2.88
Flowers	20.93	0.35	ND	0.04	28.65	1.48	0.64	3.15
Seeds	37.05	0.46	0.02	0.04	46.41	0.66	0.43	4.62

From the tables 1-3 it is seen that the metal uptake by the specie is significant and it has increased with time. The metal uptake is found to be more in leaves than other parts of the plant.

IV. CONCLUSION

Heavy metals uptake by plants using phytoremediation technology seems to be a prosperous way to remediate heavy metals contaminated environment. Fast growing plants with high biomass and good metal uptake ability are needed. In most of the contaminated sites hardly, tolerant, weed species exists in phytoremediation, through these and other non-edible species can restrict the contaminant from being introduced into the food web.

In the present study, Catharanthus roseus, as non-edible, shrub species, aesthetically pleasant with beautiful flowers is used for metal uptake successfully. Plants showed high accumulation of metals in all plant parts with the maximum being in leaves and the least in flowers.

REFERENCES

[1] *Pilon-Smiths, E., 2005. Phytoremediation: Annual Review of Plant Biology. Plant Biology, Volume 56, pp. 15-39.*

[2] *Rugh, C. L., Bizily, S. P. & Meagher, R. B., 2000. Phytoreduction of environmental mercury pollution. In: Phytoremediation of toxic metals: using plants to clean-up the environment. Newyork: John Wiley and Sons, pp. 151-170.*

[3] *Meagher, R. B.; Rugh, C. L.; Kandasamy, M. K.; Gragson, G.; Wang, N. J., 2000. Engineered phytoremediation of mercury pollution in soil and water using bacterial genes. In: Phytoremediation of contaminated soil and water. Florida: Lewis Publishers, Boca Raton, pp. 201-219.*

[4] *Chaney, R. L.; Li, Y. M.; Angle, J. S.; Baker, A.J.M.; Reeves, R. D.; Brown, S. L.; Homer, F. A.; Malik, M.; Chin, M., 1999. Improving Metal Hyperaccumulators Wild Plants to Develop Commercial Phytoextraction Systems: Approaches and Progress. In: Phytoremediation of Contaminated Soil and Water (edited by N Terry, GS Bañuelos). Boca Raton, FL: CRC Press, pp. 129-158.*

[5] *Raskin, I. & Ensley, B. D., 2000. Phytoremediation of toxic metals using plants to clean up the environment. New York: Wiley.*

[6] *Baker, A. J. M., McGrath, S. P., Sidoli, C. M. D. & Reeves, R. D., 1994. The possibility of in situ heavy metal decontamination of polluted soils using crops of metal-accumulating plants. Environmental biotechnology in waste treatment and recycling , 11(1-4), pp. 41-49.*

[7] *Imam, S. 2017. Phytoremediation: A method to reduce metal ions present in waste water. International Journal of Engineering Sciences and Research Technology, 6(7): 629-634.*

[8] *Imam, S. 2017. Phytoremediation: A green method to combat environmental pollution. International Journal of Engineering Sciences and Research Technology, 6(8): 418-421.*

[9] *Gaur, A. and Adholeya, A. (2004). Prospects of arbuscular mycorrhizal fungi in phytoremediation of heavy metal contaminated soils. Current Science ., 86(4): 528–534.*

[10] *Lasat, M. M. (2000). Phytoextraction of metals from contaminated soil: a review of plant/soil/metal interaction and assessment of pertinent agronomic issues. Journal of Hazardous Substance Research., 2(5): 1–25.*

[FRTSSDS- June 2018] **ISSN 2348 – 8034**
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[11]Gisbert, C., Ros, R., De Haro, A., Walker, D. J., Bernal, M. P., Serrano, R. and Navarro-Avino, J. (2003). A plant genetically modified that accumulates Pb is especially promising for phytoremediation. Biochem. Biophys. Res. Comm ., 303: 440–445.

[12]Halim, M., Conte, P. and Piccolo, A. (2003). Potential availability of heavy metals to phytoextraction from contaminated soils induced by exogenous humic substances. Chemosphere., 52: 265–275.

[13]GWRTAC. (1997). Remediation of metals contaminated soils and groundwater. Tech. Rep. TE-97-01, GWRTAC, Pittsburgh, Pa, USA.

[14]Blaylock, M. J. and Huang, J. W. (2000). Phytoextraction of metals. In: I. Raskin and B. D. Ensley (eds). Phytoremediation of toxic metals: using plants to clean up the environment. Wiley, New York. 53–69.

[15]Blaylock, M. J., Salt, D. E., Dushenkov, S., Zakharova, O., Gussman, C., Kapulnik, Y., Ensley, B. D. and Raskin, I. (1997). Enhanced accumulation of Pb in Indian mustard by soil-applied chelating agents. Environ. Sci. Tech ., 31; 860–865.

[16]McGrath, S. P. (1998). Phytoextraction for soil remediation. In: R. R. Brooks (ed). Plants that hyperaccumulate heavy metals. CAB International, New York. 109–128.

[17]Niharika Shivhare & Momita Roy, 2013. Gravel bed constructed wetland for treatment of sewage water. Pollution Research, 32(2): 227-231.

[18]Blaylock, M. J. & Huang, J. W., 1999. Phytoextraction of Metals. In: Phytoremediation of Toxic Metals: Using Plants to Clean up the Environment (Edited by I Raskin, BD Ensley). New York: John Wiley and Sons Inc., pp. 53-70.

[19]Lasat, M. M., Baker, A. J. & Kochian, L. V., 1998. Altered Zn Compartmentation in the Root Symplasm and Stimulated Zn Absorption into the Leaf as Mechanisms Involved in Zn Hyperaccumulation in Thlaspi caerulescens. Plant Physiology, 118(3), pp. 875-883.

[20]Peterson, P. J., 1983. Adaptation to Toxic Metals. In: Metals and Micronutrients: Uptake and Utilization by Plants (edited by DA Robb, WS Pierpoint). London: Academic Press, pp. 51-69