International Journal of Research in Advent Technology, Vol.6, No.6, June 2018
E-ISSN: 2321-9637
Available online at www.ijrat.org

An Assessment of Bioaccumulation Potential of the Heavy Metals by *Spirodela polyrhiza*

Mansi N. Banker[1], Rita N. Kumar[2], Nirmal kumar J. I[3], Rashmi M. Thakkar[4] and Dharitri B. Ramanlal[5]

Department of Environmental Science & Technology
Natubhai V. Patel College of Pure & Applied Sciences [1, 2, 4, 5]
Institute of Science & Technology for Advance studies & Research [3]
Email: mansibanker@gmail.com[1], ritankumar@yahoo.co.in[2], istares2005@yahoo.com[3], reshamthakkar@gmail.com[4], dharitripateleso@gmail.com[5]

Abstract- Some unavoidable drawbacks of traditional technologies have made phytoremediation a promising alternative for the removal of heavy metals from contaminated soil and water. Phytoremediation is a cost-effective and eco-friendly method. Aquatic macrophytes attain a good interest in the field of phytoremediation. They have great potential to accumulate heavy metals. *Spirodela polyrhiza* is one of such most common macrophyte growing in wetlands because of large uptake of nutrients and contaminants. Most of the heavy metals are harmful or carcinogenic in nature and may create a threat to human health and therefore the environment at higher concentrations. To carry out this study, 12 plastic tubs with 15 litter capacity were taken and labeled for a treatment i.e. 5ppm, 10ppm and 15ppm of Zinc, Cadmium, and Lead. Fifty gm of biomass was inoculated in every tub. The plants were allowed to grow for a period of eight days. The Heavy metals Cd, Pb, and Zn were measured at the end of treatment period using ICP analyzer from water as well as plant samples. The biological parameters recorded decline with increasing concentrations as well as the treatment period. Plant species was proved to be good hyperaccumulator for heavy metal Lead. The lead was completely absorbed from every treatment. In case of Cadmium, the plant was not able to tolerate 15 ppm concentration but successfully absorbed and accumulated 10 ppm concentration. While for Zinc, plants accumulated up to 9.66 ppm from 15 ppm dosage. The findings revealed *Spirodela polyrhiza* efficient hyperaccumulator of heavy metals with high accumulation potential of Pb> Cd >Zn.

Index Terms-Phytoremediation, *Spirodela polyrhiza*, Heavy metals

1. INTRODUCTION

Rapid urbanization and industrialization are the reasons for releasing large amounts of toxic contaminants to the environment. Phytoremediation is a promising alternative for removal of heavy metals from contaminated soil and water. Heavy metals are known as toxic pollutants released into the surface and groundwater as a result of different activities such as industries, mining and agriculture [1]. Phytoremediation of industrial waste through aquatic macrophytes have emerged as a simple, cost-effective and self-sustaining alternative of the traditional treatment methods. Various other wetland plants are screened for heavy metals accumulation from the natural wetland by several workers [2],[3] and [4]. Further, the use of wetland plants in constructed wetland ecosystem for remediation of wastewater has recently drawn global attention for the systematic study of the potential wetland plants for environment management [5]. The metal accumulation ultimately affects the growth and physiology of the plants, which has been reported by several workers [6]. There is evidence that wetland plants such as duckweed (*Lemna minor*) [7], water hyacinth (*Eichhornia crassipes*) [8], Salix [9], Cattail (*Typha latifolia*) and common reed (*Phragmites australis*) can accumulate heavy metals in their tissues. The small size, simple structure, and rapid growth make duckweed very suitable for toxicity tests, able to remove and accumulate large amounts of heavy metals, principally through the fronds [6]. Duckweeds are found in ponds and eutrophic ditches which can be observed like dense floating mats. Duckweeds fall into four genera*; Lemna, Spirodela, Wolfia, and Wolffiella*. About 40 species of duckweeds are recognized worldwide. Duckweeds fronds are round or oval or round having a size of around 1 mm to 1cm. It produces a root-like structure which is open in water to attain nutrients. Duckweed appears to be the better alternative and has been recommended for wastewater treatment because it has the capability of rapid growth on a wide range of pH and temperature throughout the year [10]. Duckweed has the capacity to produce faster in biomass than any other aquatic plant and has the potential as an efficient alternative for heavy metals accumulation.

2. MATERIALS AND METHODS

Fresh *Spirodela polyrhiza* plants were collected from the surface waters of Vadtal pond (N22035'35.4169" and E72052'26.6663), 10 km away from headquarters. The plants were thoroughly washed several times under tap water to remove any impurities from roots as well as fronds. Plants were acclimatized in pond water for a period of one week. Healthy mature plants of similar size and shape were selected and kept separately in 20L capacity troughs. Fifty gm of *Spirodela polyrhiza* plants were transferred into each tub. They were placed under natural sunlight for a period of 10 days. Stock solutions of heavy metals were prepared with the help of Cadmium chloride, Zinc oxide, and Lead Nitrate. An experiment was designed in three sets of 5, 10 and 15 ppm for all three heavy metals. Plants were exposed to 10L tap water (control) and to elevated concentrations of heavy metals Cd, Pb and Zn in triplicates for a period of eight days.

Heavy metal analysis

At the end of the treatment period, the acclimatized plants were examined to find out the concentration of heavy metals absorbed by plants. The plant samples were collected from every concentration and they were sun-dried to achieved constant weight. They were homogenized and grounded to a fine powder. Accurately 1 gm of dry powder of each treatment was weighed. All samples were digested with 10 ml of concentration. HNO3 by boiling and reducing to 50% volume. The solutions were made to 25 ml each using double distilled water, filtered and further analyzed using Inductive Coupled plasma Analyzed (ICPA) at Sophisticated Instrumentation Centre for Applied Research and Testing(SICART), Vallabh Vidhyanagar, Gujarat, India. The samples of water and plants-parts were chemically examined for detection of Pb, Zn, and Cd by Inductive Coupled Plasma Analyzer (ICPA).

The bioconcentration factor provides associate degree index of the ability of the plant to accumulate the metal in relation to a metal concentration within the substrate. The bioconcentration factor was calculated because of the ratio of the tracer concentration within the plant tissues at harvest to the concentration of the element in the external environment [11], [12].

The BCF was calculated by using the formula:

BCF = P/E, …..(5)

Where P represents the trace element concentration in plant tissues (ppm), E represents the residual concentration in water (ppm) or in sediment (ppm dry wt).

3. RESULTS AND DISCUSSION

Heavy metals analysis

The Initial concentrations of Zn, Cd, and Pb in plants were 2.08 mg/l, 0.34 mg/l, and 2.19 mg/l respectively. Lead treatment100% accumulation was recorded. The concentration of 5ppm, 10 ppm, and 15 ppm Pb in plants was 6.05 mg/l, 10.93 mg/l, and 16.84 mg/l respectively. The water samples showed zero concentration of heavy metals. The capacity of three Lemna species namely L. minuta, L. minor, and L. trisulca to purify water polluted with Zn was investigated by [13],[14]. Percentage removal by Lemna spp. for 1,5, 10, 15, and 20 mg/l Zn treatment for 10 days incubation was found to be the highest by *L. trisulca* (97%) as compared to *L. minuta* (89%) and *L. minor* (83%). *Lemna minor* is proved as good hyperaccumulator to treat water polluted with cadmium [15].

In case of Cadmium, 5 ppm and 10 ppm treatment showed 99.9% reduction of heavy metals from water but couldn't uptake 15ppm concentration. The remaining concentration of Cadmium was 10.32 mg/l in 15 ppm treatment. Plants accumulated 4.98 mg/l of Cadmium in 15 ppm treatment. The efficiency of duckweed in improving the quality of effluent from oil refinery was tested [16]. The heavy metal removal efficiency was found to be 99.8%, 99.6%, 98.7% and 72% for Copper, Cadmium, Lead and Zinc, respectively The result evidenced that duckweed is a good accumulator of Cd, and Cu, a moderate accumulator of Chromium, and a poor accumulator of Lead. The toxicity result of each trace element on plant growth was within the order: Cu > Pb> Cd >Cr [6].

The treatments of Zinc showed 99.9 % reduction except for 15 ppm treatment. The concentration of Zn in 15 ppm treatment in water and plants was detected as 5.92 mg/l and 9.66 mg/l respectively. The highest rates of reduction after 8days of treatment were for heavy metals, accounting 95%, 79%, and 66% for Lead, Copper, and Zinc The bioaccumulation of metals (Cu, Pb, and Zn) by *Lemna gibba*. Heavy metals were ranked according to the preference for bioaccumulation by *L. gibba*, Zn came in the first place followed by Pb and Cu with bioaccumulation factors 13.9, 6.3, 5.5 and 2.5 respectively [17] [18].

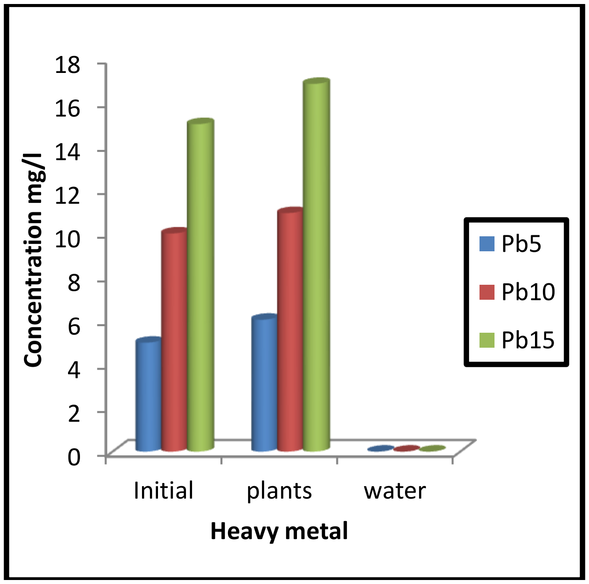

Figure 1: Accumulation after 8 days of exposure under different concentration of Lead by *Spirodela polyrhiza*. ($p<0.05$).

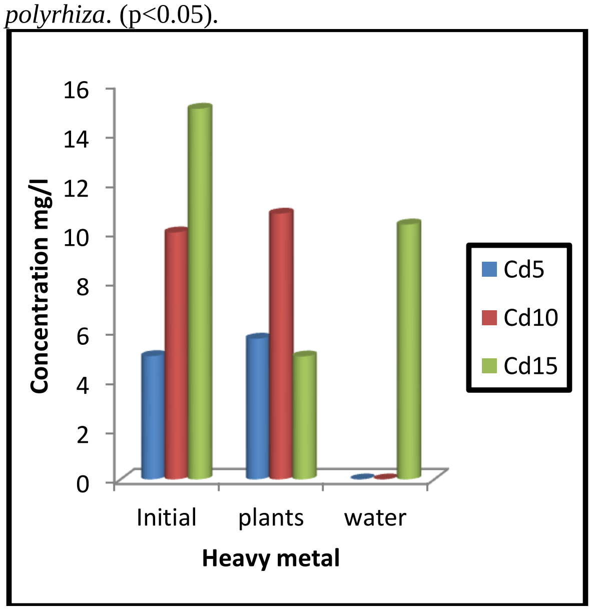

Figure2: Accumulation of Cadmium after 8 days of exposure under different concentration by *Spirodela polyrhiza*. ($p<0.05$).

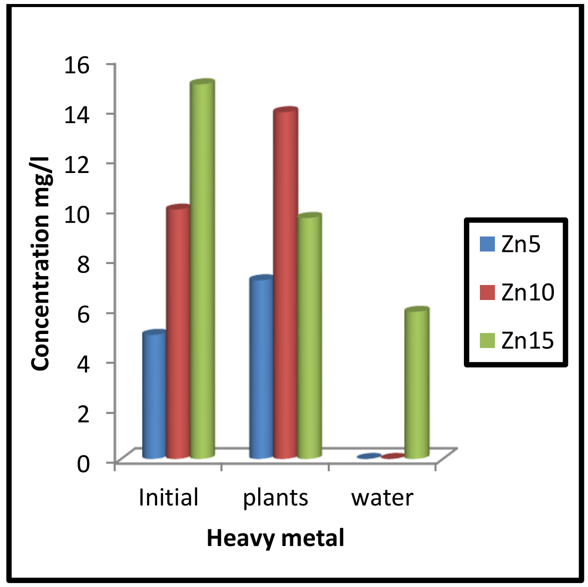

Figure 3: Accumulation after 8 days of exposure under different concentration of Zinc by *Spirodela polyrhiza*. ($p<0.05$).

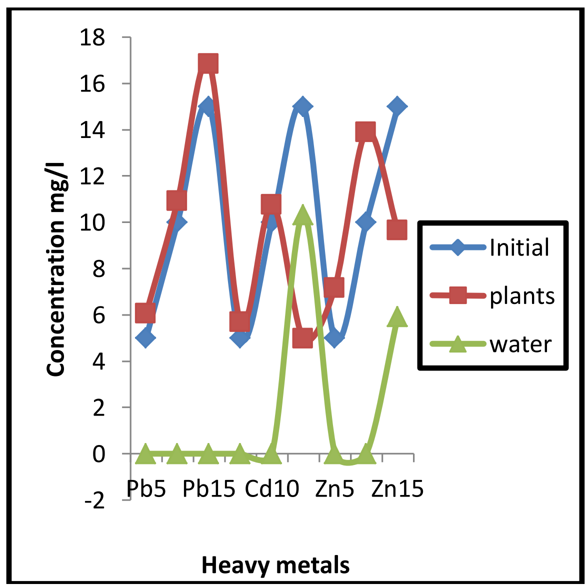

Figure 4: Comparison of all three heavy metals Accumulation after 8 days of exposure under different concentration in *Spirodela polyrhiza*. ($p<0.05$).

Bioconcentration factor

Table 1: Treatments and its Bioconcentration Factor

Treatment	BCF
Pb5	121.052
Pb10	109.32
Pb15	112.2867
Cd5	154.062
Cd10	107.58
Cd15	33.22733
Zn5	191.616
Zn10	138.87
Zn15	64.45067

Bioconcentration Factor (BCF) is a useful parameter to evaluate the potential of the plants in accumulating metals and this value is calculated on a dry weight basis. The BCF value for water velvet (*Azolla pinnata*) and duckweed (*Lemna minor*) treated with Pb and Zn, gradually decreased with increasing metal concentration in the feed solution [19]. Metal accumulations by macrophytes can be affected by metal concentrations in water and sediments. The ambient metal concentration in water was the major factor influencing the metal uptake efficiency of plants [20].

4. CONCLUSION

In the current study macrophyte duckweed *Spirodela polyrhiza* was employed as effective phytoremediation agent in the heavy metal polluted water. The findings revealed *Spirodela polyrhiza* as a hyper accumulator of heavy metals with high accumulation potential of Pb> Cd >Zn.

REFERENCES

[1] Hawari, A. H., & Mulligan, C. N. (2006).Biosorption of lead (II), cadmium (II), copper (II) and nickel (II) by anaerobic granular biomass. *Bioresource technology*, *97*(4), 692-700.

[2]Cardwell, A. J., Hawker, D. W., & Greenway, M. (2002).Metal accumulation in aquatic macrophytes from southeast Queensland, Australia. *Chemosphere*, *48*(7), 653-663.

[3] Demırezen, D., &Aksoy, A. (2004). Accumulation of heavy metals in Typhaangustifolia (L.) and Potamogetonpectinatus (L.) living in Sultan Marsh (Kayseri, Turkey). *Chemosphere*, *56*(7), 685-696.

[4] Yoon, J., Cao, X., Zhou, Q., & Ma, L. Q. (2006).Accumulation of Pb, Cu, and Zn in native plants growing on a contaminated Florida site. *Science of the total environment*, *368*(2), 456-464.

[5] Klomjek, P., &Nitisoravut, S. (2005). Constructed treatment wetland: a study of eight plant species under saline conditions. *Chemosphere*, *58*(5), 585-593.

[6] Zayed, A., Gowthaman, S., and Terry, N. (1998).Phytoaccumulation of Traces Elements by Wetland Plants: I. Duckweed. Journal of Environmental Quality, 27,715–721.

[8] Vesk, P. A., Nockolds, C. E., &Allaway, W. G. (1999). Metal localization in water hyacinth roots from an urban wetland. *Plant, Cell & Environment*, *22*(2), 149-158.

[9] Stoltz, E., &Greger, M. (2002).Accumulation properties of As, Cd, Cu, Pb and Zn by four wetland plant species growing on submerged mine tailings. *Environmental and Experimental Botany*, *47*(3), 271-280.

[10] Chaudhary, E., & Sharma, P. (2014). Duckweed plant: a better future option for phytoremediation. *Int J EmergSciEng (IJESE)*, *2*(7), 39-41.

[11] Veselý, T., Tlustoš, P., &Száková, J. (2012). Organic acid enhanced soil risk element (Cd, Pb and Zn) leaching and secondary bioconcentration in water lettuce (Pistiastratiotes L.) in the rhizofiltration process. *International journal of phytoremediation*, *14*(4), 335-349.

[12] Rivelli, A. R., De Maria, S., Puschenreiter, M., &Gherbin, P. (2012). Accumulation of cadmium, zinc, and copper by Helianthus annuus L.: impact on plant growth and uptake of nutritional elements. *International journal of phytoremediation*, *14*(4), 320-334.

[13] Jafari, N., and Akhavan, M. (2011).Effect of pH and Heavy Metal Concentration on Phytoaccumulation of Zinc by Three Duckweed Species. American – Eurasian Journal of Agricultural and Environmental Science, 10 (1), 34-41.

[14] Lahive, E., O'Halloran, J., & Jansen, M. A. K. (2011).Differential sensitivity of four Lemnaceae species to zinc sulphate. *Environmental and Experimental Botany*, *71*(1), 25-33.

[15]Bianconi, D., Pietrini, F., Massacci, A., and Iannelli, M. A. (2013). Uptake of Cadmium by Lemna minor, a (hyper?-) Accumulator Plant Involved in Phytoremediation Applications. E3S Web of Conferences 1 13002 DOI:http://dx.doi.org/10.1051/e3sconf/20130113002

[16] Azeez, N. M., &Sabbar, A. A. (2012).Efficiency of duckweed (Lemna minor L.) in phytotreatment of wastewater pollutants from Basrah oil refinery. *Journal of Applied*

Phytotechnology in Environmental Sanitation, *1*(4), 163-172.
[17] Loveson, A., and Sivalingam, R. (2013).Phytotoxicological Assessment of Two Backwater Wetlands in Kannamaly, Ernakulam Using Aquatic Macrophyte – Spirodelapolyrhiza. Journal of Environmental and Analytical Toxicology, 3 (180) .doi:10.4172/2161-0525.1000180
[18] Hegazy, A. K., Kabiel, H. F., and Fawzy, M. (2009).Duckweed as Heavy Metal Accumulator and Pollution Indicator in Industrial Wastewater Ponds. Desalination and Water Treatment, 12 (1), 400-406.
[19] Jain, S.K., Vasudevan, P. &Jha, N.K. 1990 Azollapinnata R.Br and Lemna minor L for removal of Lead and zinc from polluted water. Water Research 24, 177–183.
[20] Rai, U. N., & Chandra, P. (1992). Accumulation of copper, lead, manganese and iron by field populations of Hydrodictyonreticulatum (Linn.) Lagerheim. *Science of the total environment*, *116*(3), 203-211.