Biotechnol Res 2017; Vol 3(4):99-103
eISSN 2395-6763

ORIGINAL RESEARCH

A Comparative Study of Metal Hyper Accumulation Capacity of Selected Macrophytes

K.S GAYA[1], M.G. Ramesh BABU[2*], Lissy MATHEW[3]
[1]Bharathiar University, Coimbatore
[2]SNGIST Arts and Science College, North Paravaur
[3]Department of Botany, St. Teresas College, Ernakulam
*Corresponding Author email: rameshbabumg@gmail.com

• Received: 17 July 2017 • Revised: 22 August 2017 • Accepted: 05 September 2017 • Published: 26 September 2017 •

ABSTRACT
General contamination of heavy metals in the environment is a major global concern, which has provoked the emergence of phytoremediation technologies for cleaning aquatic environment. The aim of the present study was to make a comparative evolution of the capacity of five native macrophytes namely *Lagenandra toxicaria, Hydrilla verticellata, Pistia statotes* and *Salvinia molesta*, *Eichornia crassipes* to accumulate and remove heavy metals in a laboratory condition the highest accumulator of Pb, Cu, Cd show by plant sample II and the lowest by plat sample V. As with Mm highest accumulation rate is shown by *Salvinia molesta* and lowest by *Lagendra toxicaria*. The study further revealed that differences in the up take rate was found depend on the species of plant, heavy metal concentration and the time of interval (24, 48, at 72 at 96 hrs).

KEY WORDS: *Heavy metal, Bio accumulator, Aquatic macrophytes Pollution, Phytoremediation.*

INTRODUCTION

Contamination of environment by different pollutants arises as a result of increasing urbanization, industrialization and over population growth as well as ever enhancing demand for clean water for everyone's daily use(Dana Ahmed, 2014). Water bodies are the main and final destination for capturing these pollutants, leading to water pollution and as a matter of great concern, especially developing countries like India. Developed countries have water pollution problems mainly due to industrial proliferation and modern agricultural technologies, which are mainly addressed through improving wastewater treatment techniques. However, the lack of technical knowhow, weak implementation of environmental policies, and limited financial resources have given rise to serious challenges (Anjuli Sood *et al*., 2012).

Among various water pollutants, heavy metals are of major concern because of their persistent and bioaccumulation nature (Rai *et al*., 1981, Lokeshwari and Chandrappa, 2007, Chang *et al*.,.2009. Water is an indispensable part for the sustenance of mankind and the increasing awareness about the environment, especially aquatic ecosystems have attracted the attention of researchers worldwide. Coagulation, precipitation, ion exchange, reverse osmosis, electrolysis, precipitation and sedimentation are the most usable treatments in practice for sanitation of water and up taking these contaminants (Danh, 2009). The majority of these conventional methods in practice consumes huge economic resources, and are producing lots of non-eco-friendly wastes as well as highly power consuming. Hence a definite need exists to develop a low cost and eco-friendly technology to remove pollutants particularly heavy metals, thereby improving water quality.

In India, where most of the developmental activities are still dependent upon water bodies, heavy metal pollution is posing serious environmental and health problems (Sanchez- Chardi *et. al.,* 2009, Heavy metals are the stable metals or metalloids with a high atomic weight and density much greater (at least five times) than water, namely, mercury, cadmium, cobalt, lead, molybdenum, nickel, copper, zinc etc. (Nies, 1999) Heavy metals are natural constituents of the Earth's crust. They are stable and cannot be degraded or destroyed, and therefore they tend to accumulate in soils/ rock to water through anthropogenic sources.

In recent times anthropogenic inputs, such as discharge of untreated effluent (waste water), have contributed to the predominant causation. A survey carried by Central Pollution Control Board (2008) reported that ground water in 40 districts from 13 states of India and five blocks of Delhi is contaminated with heavy metals.

Heavy metals are especially toxic due to their ability to bind with proteins and prevent DNA replication (Kar and Sahoo 1992). Many technologies have been used to reduce aquatic pollution but they are generally costly, labour-intensive and generate secondary waste. An interesting alternative approach is phytoremediation (rhizofiltration) (Flathman and Lanzo, 1998, EPA, 2000)

Removal of metals from these soils and waters using natural or induced metal tolerance /accumulation capacities of some plant species or populations originating from contaminated areas is the goal of phytoremediation (Baker and Brooks 1989, Salt *et al*., 1998, Mc Cutcheon at Schnoor, 2003). In 1991, Baker *et al*. concluded that phytoremediation by using certain species could offer a low cost and low technology alternative to current clean up technologies. Best plant candidates for phytoremediation must show accumulating capacities and tolerance to elevated contaminant concentrations to be able to survive and produce biomass. Some trace metals eg. Cu, Fe, Zn, Mn, Ni, Se etc. are essential for normal growth, although both essential and non-essential metals (e.g. Hg, Cd, Pb, As) can result in growth inhibition and toxicity symptoms (Poschenrieder *et al*., 2006).

Phytoremediation is a biological process in which living plants are used to remove, accumulate, degrade or contain environmental contaminants. This passive remediation technique is based on the natural ability of vegetation to utilize nutrients, which are transported by capillary action from the soil and ground water through plants root system. Macrophytes are aquatic plants growing in or near water which can be emergent, submerged or free floating. They are important component of aquatic communities due to their roles in oxygen production, nutrient cycling, water quality control, sediment stabilization to provide habitat and shelter for aquatic life, and also for being considered efficient heavy metal accumulators (Vardaniyan and Ingole, 2006). Due to these characteristics these plant have been success fully used as biological monitors and remediators of environments contaminated with heavy metals.

Many researches haven conducted regarding the ability of aquatics to remove heavy metals from contaminated waters. The purpose of the present study is to compare the phytoextraction capacity of 5 aquatic macrophytes in a laboratory scale with regard to 4 metals namely, Pb, Cu, Cd and Mn.

RESULTS AND DISCUSSION

The problem of environment protection and rational utilization is extremely urgent today and its solution requires availability of great amount of ecological information. Hydro chemical and hydrobiological investigations provide the main part of such information. Besides hydrobiological factors, anthropogenic impact, agricultural development, recreational load, settlements growth, industry, affected the water quality. However, one should recall that an increase in the concentration of these microelements in water is toxic for hydrobionts. Many of them produce toxic salts that occur in very low concentrations and therefore for their determination, special methods with high determination accuracy is required. One of the major properties of heavy metals is their ability to interact with a number of organic compounds such as cyanide, radonide and thiosulfates by combining with ions (Babayan, 1988).

Heavy metals generally penetrate from aquatic medium into human through water-plant-human or water plant-animal-human biological chains (Smirnova, 1984). Therefore finding solution to the problem of toxin tolerance in an aquatic medium is essential for an ecosystem and its components. There are reports with a variety of data detailing the effects of heavy metals on water and water plant structure and their properties, their enzymatic activity and nutrition pattern

(Wittman, 1979) of water plants, by accumulating heavy metals in their tissues, play an important role in heavy metal transport mechanism. The accumulation of heavy metals in plants greatly depends on the concentration of these microelements in the medium. Experiments studying on microelements accumulating properties of water plants revealed that they 'prefer' Mn, Ni, Ca, Mo, V, Sr, Ba, Fe, Al (Gregor 1999).

The AAS results of the hyper accumulation by five macrophytes with regards to four heavy metals were analyzed and tabulated. Water plants, by accumulating heavy metals in their tissues, play an important role in heavy metal transport mechanism.

In the present study, experiments showed that with regard to Pb, during treatment with plant sample I the decrease in concentration of metal in the medium ranged from 88% in 24 hrs, to 32% in 96 hrs. In plant sample II it varied from 55% to 20%, with sample III, the concentration varied from 66% to 24% with sample IV, 73% to 33% and finally with sample V it ranged from 92% to 33% during the period from 24 to 96%. Thus maximum absorption is shown by sample II and the least by sample V.

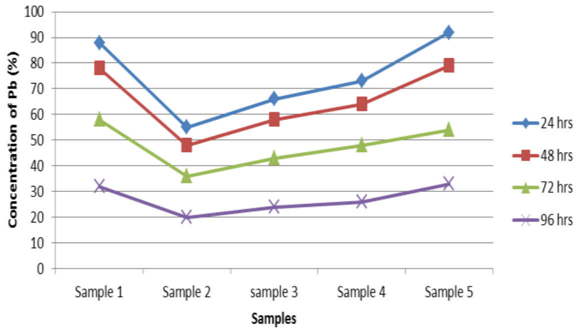

Figure 1: Heavy metal absorption by aquatic macrophytes: Decrease in concentration of Pb in percentage in a time interval of 24, 48, 72 and 96 hours (Sample 1 *Lagenandra toxicaria*, Sample 2 *Hydrilla verticellata*, Sample 3 *Pistia stratiotes*, Sample 4 *Salvinia molesta*, Sample 5 *Eichornia crassipes*)

In the case of Cu, treatment with sample I, concentration in the medium ranged from 63% to 23%, sample II, 51 to 5%, sample III, 54 to 19%, sample IV, 59 to 20%, sample V, 66 to 11.5%. Maximum absorption is shown by plant sample II and least by plant sample V.

Cadmium concentration varied from 31 % to 11.5% from 24 to 96 hours of treatment with plant sample I. The concentration in the medium decreased from 9% to 3.6% from 24 to 96% with plant sample II, with plant sample III, the concentration varied from 14.5% to 2.4% from 24 to 96 hours. The concentration decreased from 24% to 95% in 24 to 96 hours, during treatment with plant sample IV, further during treatment with plant sample V, the concentration in the medium decreased from3.5% to 9.6% during 24 to 96 hours. In the present study maximum absorption is shown by plant sample II and least by plant sample V.

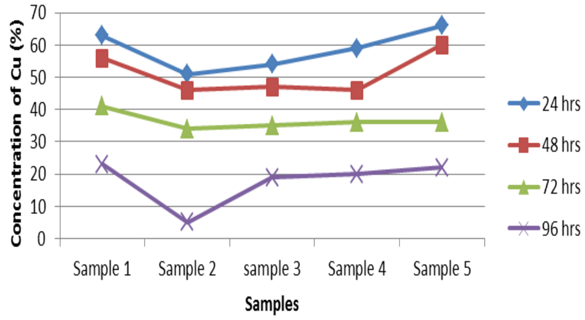

Figure 2: Heavy metal absorption by aquatic macrophytes: Decrease in concentration of Cu in percentage in a time interval of 24, 48, 72 and 96 hours

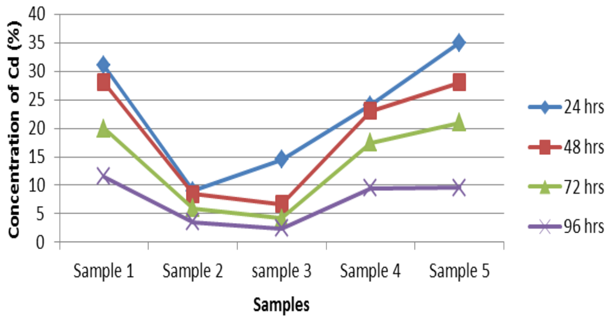

Figure 3: Heavy metal absorption by aquatic macrophytes: Decrease in concentration of Cd in percentage in a time interval of 24, 48, 72 and 96 hours (Sample 1 *Lagenandra toxicaria*, Sample 2 *Hydrilla verticellata,* Sample 3 *Pistia stratiotes*, Sample 4 *Salvinia molesta*, Sample 5 *Eichornia crassipes*)

Similarly the concentration of manganese decreased from 52% to 19% from 24 to 96 hours during treatment with plant sample I. with plant sample II the concentration of manganese varied from 39% to 14% from 24 to 96 hours of treatment. During treatment with plant sample III the concentration varied from 59% to 18% from 24 to 96 hours. Treatment with plant sample IV, the concentration decreased from 33% to 12% during 24, 48, 72 to 96 hours. The concentration of manganese in the medium decreased from 57% to 11% during treatment with plant V as time passes from 24 to 96 hours.

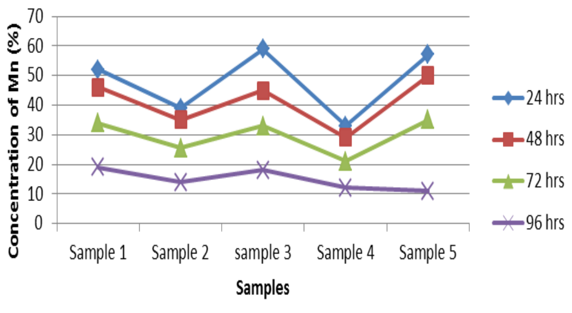

Figure 4: Heavy metal absorption by aquatic macrophytes: Decrease in concentration of Mn in percentage in a time interval of 24, 48, 72 and 96 hours (Sample 1 *Lagenandra toxicaria*, Sample 2 *Hydrilla verticellata*, Sample 3 *Pistia stratiotes*, Sample 4 *Salvinia molesta*, Sample 5 *Eichornia crassipes*)

Thus with regard to manganese, maximum absorption is shown by plants sample II and least by plant sample V.

CONCLUSION

The present study was carried out on 5 species of aquatic macrophytes, with the aim to determine the capacity for accumulation of four metals (Pb, Cu, Cd, Mn), which in turn is important for bioindication, bioremediation and biomonitoring of aquatic ecosystems. The highest hyper accumulation by Pb is shown by plant sample II and the lowest by the plant sample V. As with Cu, plant sample II again showed the highest hyper accumulation capacity and lowest by plant sample V. With regard to Cd the highest hyper accumulation is exhibited by plant sample II whereas lowest by plant sample V. The higher accumulation of Mn is shown by plant sample V and lowest by plants sample I. The study further revealed that hyper accumulation of heavy metals vary with different species as well as with the types of heavy metals.

The data presented here is indispensable information for studies of related nature. The aquatic macrophytes were found to be the potential source for accumulation of heavy metals from aquatic ecosystems. Therefore, such studies should become an integral part of the sustainable development of the ecosystem and pollution assessment program.

MATERIALS AND METHODS

During the experiment the following five macrophytes were used (*Salvinia molesta*, *Pistia statiotes, Eichornia crassipes, Hydrilla verticellata* and *Lagenandra toxicaria*). The above mentioned species were grown in an aquarium tanks for two weeks, after that they were kept separately in 5 glass troughs (10 liters capacity) filled with well water collected from different wards of N. Paravur Municipality.

After the growing period, the plants were treated with for Lead, Copper, Cadmium and Manganese for phytoremediation experiments. They were kept for acclimatization for a period of 3 days in modified Hoagland nutrient solution in laboratory condition. The heavy metal stock solutions were made of salts such as Lead chloride, Copper nitrate, Cadmium chloride and Manganese chloride. In order to determine the phytoremediation capacity of the five macrophytes for the above four metals, water samples from the glass troughs were collected in a time interval of 24, 48, 72, 96 hours and reduction in concentration in the medium were estimated using AAS and percentage of absorption of metals were calculated.

During phytoremediation experiment the plants were exposed to laboratory condition at a temperature of 26-31^{o}c. After the adaptation period, the plants were exposed separately with different metallic salts of appropriate quantity in water and noted for phytoremediation experiment. The final concentration of the heavy metal salt solutions was adjusted as 500ppm. In this monometallic phytoremediation experiment, the control plants were left without heavy metal salt treatment. It is essential to specify that the monometallic system can be defined as a process by which each plant perform separate absorption of every heavy metal one-by-one. Phytoextraction capacity of each plant samples with respect to the above four metal samples were thus estimated.

REFERENCES

Sood, A., Uniyal, P. L., Prasanna, R., & Ahluwalia, A. S. (2012). Phytoremediation potential of aquatic macrophyte, Azolla. *Ambio*, *41*(2), 122-137.

Baker, A. J. M., & Brooks, R. R. (1989). Terrestrial Higher Plants which Hyperaccumulate Metallic Elements. A Review of Their Distribution, Ecology and Phytochemistry. Biorecovery, 1, 81-126. *Bull. Environ. Contam. Toxicol*, *64*, 489-496.

Baker, A. J. M., Reeves, R. D., & McGrath, S. P. (1991). In situ decontamination of heavy metal polluted soils using crops of metal-accumulating plants-a feasibility study. *In situ bioreclamation. Boston, Butterworth-Heinemann*, 600-605.

Central Pollution Control Board (2007). Status water quality in India 2007, New Delhi, India: CPCB.

Chang, J. S., Yoon, I. H., & Kim, K. W. (2009). Heavy metal and arsenic accumulating fern species as potential ecological indicators in As-contaminated abandoned mines. *Ecological Indicators*, *9*(6), 1275-1279.

Danh, L. T., Truong, P., Mammucari, R., Tran, T., & Foster, N. (2009). Vetiver grass, Vetiveria zizanioides: a choice plant for phytoremediation of heavy metals and organic wastes. *International journal of phytoremediation*, *11*(8), 664-691.

Barznji, D. A. M. (2014). Role of aquatic plants in improving water quality. *UJPBS*, *2*(05), 12-16.

EPA 2000 U.S Enviromental Agency Report EPA/600/R-99/107. Introduction to phytoremediation 72.

Flathman, P. E., & Lanza, G. R. (1998). Phytoremediation: current views on an emerging green technology. *Journal of soil contamination*, *7*(4), 415-432.

Greger, M. (1999). Metal availability and bioconcentration in plants. In *Heavy metal stress in plants* (pp. 1-27). Springer Berlin Heidelberg.

Prasad, M. N. V. (Ed.). (2013). *Heavy metal stress in plants: from biomolecules to ecosystems*. Springer Science & Business Media.

Kar, R. N., Sahoo, B. N., & Sukla, L. B. (1992). Removal of heavy metal from mine water using sulphate reducing Bacteria. *Pollution Research*, *11*(1), 13-18.

Lewis, W. M. (1995). Defining the riparian zone: lessons from the regulation of wetlands. In *At the water's edge: the science of riparian forestry. Conference Proceedings June* (pp. 19-20).

Lokeshwari, H., & Chandrappa, G. T. (2007). Effects of heavy metal contamination from anthropogenic sources on Dasarahalli tank, India. *Lakes & Reservoirs: Research & Management*, *12*(3), 121-128.

McCutcheon, S. C., & Schnoor, J. L. (2004). *Phytoremediation: transformation and control of contaminants* (Vol. 121). John Wiley & Sons.

Nies, D. H. (1999). Microbial heavy-metal resistance. *Applied microbiology and biotechnology*, *51*(6), 730-750.

Poschenrieder, C., Tolrà, R., & Barceló, J. (2006). Can metals defend plants against biotic stress?. *Trends in plant science*, *11*(6), 288-295.

Rai, L. C., Gaur, J. P., & Kumar, H. D. (1981). PHYCOLOGY AND HEAVY-METAL POLLUTION. *Biological Reviews*, *56*(2), 99-151.

Sánchez-Galván, G., Monroy, O., Gómez, J., & Olguín, E. J. (2008). Assessment of the hyperaccumulating lead capacity of Salvinia minima using bioadsorption and intracellular accumulation factors. *Water, air, and soil pollution*, *194*(1-4), 77-90.

Salt, D. E., Smith, R. D., & Raskin, I. (1998). Phytoremediation. *Annual review of plant biology*, *49*(1), 643-668.

Vardanyan, L. G., & Ingole, B. S. (2006). Studies on heavy metal accumulation in aquatic macrophytes from Sevan (Armenia) and Carambolim (India) lake systems. *Environment international*, *32*(2), 208-218.