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Study on Bioaccumulation and Translocation of Trace Metals by, *Eichhornia crassipes* and *Pistia stratiotes* from Selected Fresh Water Ecosystems of Goa

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***Abstract*:** Aquatic species show different capacities for metal uptake and can accumulate trace metals in roots, stems and/or leaves thereby improving the lake ecosystems. Present study compares the trace metal bioaccumulation and translocation capabilities of two aquatic macrophytes viz. *Eichhornia crassipes,* and *Pistia stratiotes* from selected fresh water bodies of Goa. Trace metals from water were extracted using APDC (ammonium pyrorolidene dithio carbamate) and MIBK (methyl isobutyl ketone). Root and shoot samples of selected macrophytes were digested using nitric acid and were aspirated for detection of trace metals using Atomic Absorption Spectrophotometer. Metal concentration in water except Zinc, exceeded the drinking water limits prescribed by WHO. Lotus lake was more contaminated as compared to Curtorim lake as far as trace metal concentration is concerned. Aquatic macrophytes showed absorption of trace metals in the following order for *E. crassipes* - Fe>Cu>Mn>Zn>Ni>Pb and for *P. stratiotes* – Cu>Mn>Fe> Zn>Pb>Ni. Absorbed metals were accumulated and translocated in the plant body. Differences in bioaccumulation and translocation factor (BAF and TF) indicate the preferential accumulation/uptake and translocation of metals due to morphological and anatomical peculiarities of selected species. Both aquatic plants have rapid growth rate, high biomass yield, show uptake of a large amount of trace metals, the ability to transport metals in aboveground parts of plants is high, so also the mechanism to tolerate metal toxicity is very high. Environmental factors like pH, solar radiation and nutrient availability greatly influence phytoremediation potential and growth of these plants. BAF and TF were higher than 1 in most of the metals analyzed in case of both the species thus proving to be highly potential for phytoremediation of aquatic bodies contaminated with trace metals.

Keywords: Trace metals, Phytoremediation, Bioaccumulation and translocation factor, *Eichhornia crassipes, Pistia stratiotes*

Aquatic ecosystems are heavily influenced by human activity over the years. Many industrial and mining processes cause trace metal pollution, which contaminate fresh water systems and become a hazard to human health **(**Delbari and Kulkarni 2013, Kumar and Balamurugan 2018, Mohanakavitha et al 2019**)**. Colonization of macrophytes on water or sediments polluted with trace metals and their role in transportation of metals is very important. Submerged, emergent and free-floating aquatic macrophytes are known to accumulate and bioconcentrate trace metals from the water, producing an internal concentration several fold greater than their surroundings (Lu et al 2010). Many of the aquatic macrophytes are potential scavengers of trace metals from water (Ugya et al 2015). The present investigation was planned and executed to understand the potential of macrophytes *E. crassipes* and *P. stratiotes* as a biological filter of the aquatic environment.

MATERIAL AND METHODS

Study has been carried by selecting two water bodies from South Goa district in viz; Lotus and Curtorim Lakes. Lotus lake is situated between 15.2°N Latitude and 73.9°E Longitude at Benaulim in Salcete taluka. The lake is polluted and has abundant growth of aquatic weeds. Curtorim Lake is situated between 15.2°N Latitude and 74.0°E Longitude at Curtorim in Salcete taluka. Lake is a source of irrigation for paddy crop (Fig. 1). Water and plant samples were collected during pre-monsoon, monsoon and post Monsoon seasons. Trace metals *viz.,* Fe, Mn, Cu, Ni, Zn and Pb were analyzed from water and aquatic plants using standard protocols.

Sample collection, preparation and analysis: Sterile plastic containers (washed with detergent, later with 1:1 nitric acid and rinsed with deionized water) of one litre capacity were used sample collection. Samples were acidified by adding few drops of concentrated HNO_3. After transportation to laboratory it was filtered using 0.45 microns pore (Millipore) filter. From this 500 ml of water sample was taken in 1000 ml separating funnel and pH was adjusted to 4-5 with dilute NH_3. Trace metals from water were extracted using APDC (ammonium pyrorolidene dithio carbamate) and MIBK (methyl isobutyl ketone) (APHA, 2012). Ten ml of APDC and 15 ml MIBK was added to sample and mixture was shaken for two minutes. The two phases were allowed to separate after 15-30 minutes. Upper organic layer was drained into 100ml

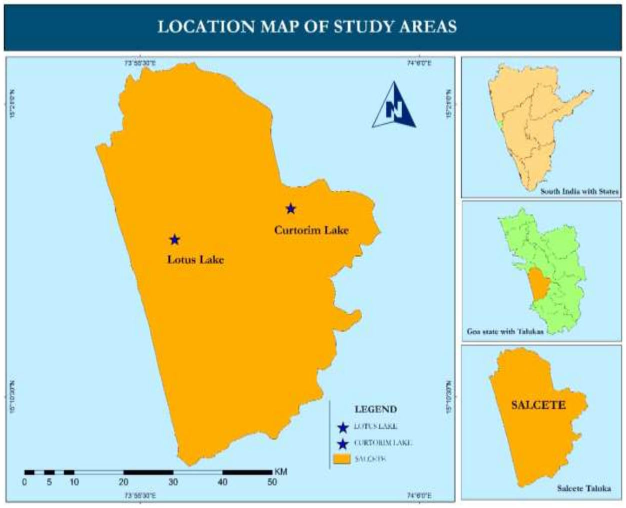

Fig. 1. Location of study sites

separating funnel (ensuring that MIBK extract was free from water sample). The procedure was continued by adding 5 ml APDC and 10 ml MIBK to water sample and the contents were transferred in a separating funnel. The contents were shaken again for 2 minutes and both the extracts were combined. Aquatic plants were handpicked from the habitat that is Lotus and Curtorim Lakes and washed with lake water carefully. For estimation of trace metals, roots and shoots of *E. crassipes* and *P. stratiotes* were separated, washed in distilled water and dried at 70°C in hot air oven for 48 hours. Dried samples were homogenized and ground to yield fine powder. Nitric acid digestion method was followed for extraction of trace metals from plants (Zheljazkov and Nielson 1996). One gram of powdered sample was taken to which 10 ml of concentrated HNO_3 was added. The sample was heated for 45 minutes at 90°C, and then the temperature was increased to 150°C at which the sample was boiled for at least 8 hours until a clear solution was obtained. Concentrated HNO_3 (5 ml) was added thrice to the sample. Digestion was carried out until the volume was reduced to 1 ml. After cooling, 5 ml of 1% HNO_3 was added to the sample. The solution was filtered using Whatman No. 42 filter paper and transferred to a 25 ml volumetric flask by adding milique water. The digested sample solutions were aspirated for trace metals using Atomic Absorption Spectrophotometer after ensuring the technicalities as per standard procedures (APHA, 2012). Average values of three replicates were taken for all detections. The BAF and TF were calculated as follows:

BAF= Metal concentration in plant tissue / Metal concentration in water (Klavins et al 1998).

TF= Metal concentration in root / Metal concentration in shoot (Wu and Sun 1998).

RESULTS AND DISCUSSION

There were significant differences in the trace metal concentration in both the water bodies. Aquatic plants always develop extensive root and shoot system which help them to accumulate contaminants in their body. The metal concentration in water and plants is depicted in Table 1 and 2. The concentration of analyzed metals in water was compared with the drinking water limits prescribed by WHO 2008 (Table 2).

Iron content in water ranged from 0.42 to 8.61 ppm, exceeding the WHO (2008) drinking water limit. Iron concentration in plants ranged from 0.37 to 12.36 ppm. *E. crassipes* roots showed more accumulation compared to *P. stratiotes* roots while it ranged from 0.04 to 4.29 ppm, in shoots of *E. crassipies*. Total concentration of Fe was higher in *E. crassipes*. Manganese in water ranged from 0.004 to 0.60 ppm which exceeded WHO drinking water limit. It was higher in Curtorim Lake than in lowest at Lotus Lake. Manganese concentration ranged from, 0.07 to 2.65 ppm in root and from 0.02 to 0.34 ppm in shoots. The highest concentration was in *P. stratiotes*. Copper concentration in water varied from 0.014 to 1.72 ppm, which was more than the WHO limit for drinking water and ranged from 0.01 to 3.06 ppm in roots while it varied from BDL to 0.40 ppm in the shoots. Highest concentration of Cu was in *P. stratiotes* followed by *E. crassipes*. Nickel concentration in water varied from BDL to 1.40 ppm exceeding the WHO limit and ranged from BDL to 1.10 ppm in roots and from BDL to 0.06 ppm in shoots. Highest concentration of Ni was in *E. crassipes.* Zinc in water ranged from BDL to 2.52 ppm. However the concentration was lower than WHO limit. It ranged from 0.01 to 1.31 ppm in the roots while it varied from BDL to 0.71 ppm, in shoots. Highest Zn concentration was in *E. crassipes* and *P. stratiotes*. Lead in water ranged from BDL to 0.32 ppm which was higher than WHO drinking water limit. Lead concentration BDL to 0.74 ppm in roots and BDL to 0.51 ppm in shoots and *highest* was in *E. crassipes*. Metal concentration in selected macrophytes was in the following order for *E. crassipes* – Fe>Cu>Mn>Zn>Ni>Pb and for *P. stratiotes* – Cu>Mn>Fe> Zn>Pb>Ni

Earlier workers suggested that *E. crassipes* and *P. stratiotes* are hyper accumulators and can be applied for the remediation of surface waters (Jindal and Kauri 2000, Syed et al 2010, Qin Lu et al 2011, Ndeda and Manohar 2014). Because *E. crassipes* and *P. stratiotes* have quick growth rate, high biomass yield, they uptake of a large amount of trace metals. The ability to transport metals in aboveground parts of plant is high, so also the mechanism to tolerate metal toxicity is very high. Environmental factors like pH, solar radiation and nutrient availability greatly influence phytoremediation potential and growth of the plant.

Bioaccumulation and translocation factor (BAF): The absorption of metals depends upon the degree and extent of exposure of the water body to anthropogenic activities, size of the water body, amount of rainfall, life cycle of an exposed plant species, besides light intensity, oxygen and even the age of the sampled plant from that particular sampling point (Siriwan et al 2006). Bioaccumulation factor for analyzed metals was: Fe - *Eichhornia* > *Pistia;* Mn - *Eichhornia* > *Pistia;* Cu - *Pistia* > *Eichhornia;* Ni - *Eichhornia* > *Pistia;* Zn - *Pistia* > *Eichhornia;* Pb - *Eichhornia* **>** *Pistia.* Both aquatic plants growing in the study area exhibited variations in trace metal concentrations due to their internal tolerance mechanism and internal detoxification. Metal uptake was more during dry season compared to monsoon. Temperature and pH played an important role in the metal up-take and can be attributed to elevated temperatures in dry season that enhances evapo-transpiration which transports metals at a faster rate from the soil solution to root, steam and leaf. Low water pH during dry season increased metal bioavailability in hydrophytes. Both the aquatic plants showed difference in translocation of accumulated metals. TF for analyzed metals was in following order**:**

Fe - *Pistia* > *Eichhornia;* Mn - *Eichhornia* >*Pistia;* Cu - *Eichhornia* > *Pistia; Ni* - *Pistia* > *Eichhornia;* Zn - *Eichhornia* > *Pistia*; Pb - *Eichhornia* > *Pistia*

Active transport of trace metals in free-floating aquatic plants occurs from the roots, from where metals are transferred to other parts of the plant body. Passive transport is associated with plant body and pollution medium. In passive transport, heavy metals mainly accumulate in upper parts of the plant body. *E. crassipes* and *P. stratiotes* are the most frequently used free-floating plants for the remediation of trace metals (Tabinda et al 2018). *E. crassipes* has the advanced tendency of remediating different pollutants like organic material, trace metals and removal of nutrients. *P. stratiotes* possesses extraordinary tolerance for extensive range of pH and temperature. Extension and proliferation of water lettuce occured with the production of daughter plants and also produced seeds which remained present in water and their germination occured during the wet seasons because of which it is an excellent contender for the phytoremediation (Forni et al 2006). Yanquan et al (2005) reported that when the TF value is greater than 1, the plants are considered as *accumulator species* whereas when TF value is less than 1 the plants are considered as *excluder species*. Akinbile and Yusoff (2012) observed differences in TF values thereby indicating the preferential accumulation/

Table 1. Concentration of trace metals in water in Lotus Lake and phytoaccumulation by *Eichhornia crassipes*

Metal	Pre - monsoon			Monsoon			Post - monsoon		
	Water	*Eichhornia* (Root)	*Eichhornia* (Shoot)	Water	*Eichhornia* (Root)	*Eichhornia* (Shoot)	Water	*Eichhornia* (Root)	*Eichhornia* (Shoot)
Fe	1.03	7.32	0.37	1.35	1.19	0.16	8.61	12.36	4.29
Mn	0.22	0.43	0.30	0.22	1.22	0.09	0.004	1.40	0.02
Cu	BDL	0.01	BDL	1.72	0.20	0.01	0.014	2.25	0.31
Ni	BDL	BDL	BDL	1.32	0.29	0.05	BDL	1.10	0.06
Zn	BDL	0.01	BDL	2.52	1.00	0.30	1.69	1.31	0.49
Pb	0.27	0.41	0.01	0.32	0.05	0.02	BDL	0.74	0.51

Legend : BDL = below detectable level; Fe - Iron, Mn - Manganese, Cu - Copper, Ni -Nickel, Zn - Zinc, Pb – Lead; units -ppm
All values are mean of three readings

Table 2. Trace metal concentration (water) in Curtorim Lake and phytoaccumulation by *Pistia stratiotes*

Metal	Pre - monsoon			Monsoon			Post - monsoon			Maximum permissible limit in water (WHO, 2008) (mg l^{-1})
	Water	*Pistia* (Root)	*Pistia* (Shoot)	Water	*Pistia* (Root)	*Pistia* (Shoot)	Water	*Pistia* (Root)	*Pistia* (Shoot)	
Fe	0.42	0.37	0.04	3.10	1.04	0.59	3.31	2.01	1.26	0.30
Mn	BDL	0.92	0.34	0.40	0.37	0.06	0.60	2.65	1.06	0.10
Cu	BDL	3.06	0.40	1.47	2.45	0.10	0.018	0.08	0.01	0.05
Ni	BDL	0.04	0.01	1.40	BDL	BDL	BDL	BDL	BDL	0.05
Zn	0.65	0.49	0.30	0.90	0.31	0.16	0.26	0.25	0.04	5.00
Pb	0.21	0.10	0.02	0.20	BDL	BDL	BDL	BDL	BDL	0.05

See Table 1 for details

Table 3. Bioaccumulation and translocation factor of selected macrophytes

Metal	*Eichhornia crassipes*		*Pistia stratiotes*	
	BAF	TF	BAF	TF
Fe	2.33	2.88	0.77	1.59
Mn	7.86	1.43	5.40	2.50
Cu	4.12	7.25	5.22	7.65
Ni	1.14	5.80	0.03	4.00
Zn	0.73	1.40	0.85	1.63
Pb	2.94	1.45	2.48	5.00

uptake and it translocation of metals due to morphological and anatomical peculiarities of the species and also influences of elevated temperature enhancing evapotranspiration and low pH during dry season.

CONCLUSION

Fresh water bodies provide number of environmental benefits like replenishing ground water; preserve biodiversity, opportunities for recreation and tourism, source of irrigation, supply water for drinking purpose, besides others. Present study revealed that with exception of zinc; the concentration of all other trace metals exceeded the drinking water limits prescribed by WHO (2008). Lotus lake was more contaminated as compared to Curtorim lake as far as trace metal concentration is concerned. In a small state like Goa, discharge of nutrient loads into fresh water bodies has increased resulting in the degradation of fresh water bodies. In order to restore the lakes and to mitigate bad conditions phytoremediation technique can be effectively used. The selected macrophytes showed bioaccumulation and translocation of analyzed metals. Maximum absorption was observed in roots compared to shoots in both the macrophytes. Both BAF and TF were higher than 1 in selected metal accumulator species and thus proves to be useful potential for phytoremediation of metal polluted aquatic bodies.

REFERENCES

Akinbile CO and Yusoff MS 2012. Water hyacinth (*Eichhornia crassipes*) and lettuce (*Pistia stratiotes*) effectiveness in aquaculture wastewater treatment in Malaysia. *International Journal of Phytoremediation* **14**: 201-211.

APHA 2012. *Standard Methods for Examination of Water and Wastewater.* American Public Health Association. Washington, D C.

Delbari AS and Kulkarni DK 2013. Assessing heavy metal pollution in agricultural soil in Pune. *Indian Journal of Ecology* **40**(1): 119-122.

Forni C, Patrizi C and Migliore L 2006. Floating aquatic macrophytes as a decontamination tool for antimicrobial drugs. *Soil and Water Pollution Monitoring, Protection and Remediation*; 3-23 pp.

Jindal R and Kaur B 2000. Effect of heavy metal toxicity on the productivity of a freshwater ecosystem. *Indian Journal of Ecology* **27**(1): 27-32.

Klavins M, Briede A, Parele A, Rodinov V and Klavina I 1998. Metal accumulation in sediments and benthic invertebrates in lakes of Latvia. *Chemosphere* **36**(15): 3043-3053.

Kumar PS and Balamurugan P 2018. Evaluation of ground water quality by using water quality index near magnesite mines, Salem District, Tamil Nadu. *Indian Journal of Ecology* **45**(2): 380-383.

Lu Q, He ZL, Graetz DA, Stoffella PJ and Yang X 2010. Phytoremediation to remove nutrients and improve eutrophic stormwaters using water lettuce (*Pistia stratiotes* L.). *Environmental Science and Pollution Research* **17**: 84-96.

Mohanakavitha T, Divahar R, Meenambal T and Keredin T 2019. Assessment of water quality of surface water in Kalingarayan canal for heavy metal pollution, Tamil Nadu. *Indian Journal of Ecology* **46**(1): 49-54.

Ndeda LA and Manohar S 2014. Bio concentration factor and translocation ability of heavy metals within different habitats of hydrophytes in Nairobi Dam, Kenya. *Journal of Environmental Science, Toxicology and Food Technology* **8**(5): 42-45.

Qin Lu, Zhenli L, Donald A, Peter J and Stoffella XY 2011. Uptake and distribution of metals by water lettuce (*Pistia stratiotes* L.) *Environmental Science and Pollution Research* **18**(6): 978-986.

Siriwan P, Maleeya K, Prayad P and Suchart U 2006. Toxicity and bioaccumulation of cadmium and lead in *Salvinia cucullata. Journal of Environmental Biology* **27**(4): 645-652.

Syed TH, Tariq M and Salman AM 2010. Phytoremediation technologies for Ni++ by water hyacinth. *African Journal of Biotechnology* **9**(50): 8648-8660.

Tabinda A,Yasar A, Iqbal A and Irfan R 2018. Phytoremediation potential of *Pistia stratiotes* and *Eichhornia crassipes* to remove chromium and copper. *Environmental Technology* **41**(9): 1-16.

Ugya YA, Tijjani SI and Salisu MT 2015. The use of *Pistia stratiotes* to remove some heavy metals from Romi Stream: A case study of Kaduna refinery and petrochemical company polluted stream. *Journal of Environmental Science, Toxicology and Food Technology* **9**(1): 48-51.

WHO (World Health Organization) 2008. *Guidelines for Drinking-water Quality* Fourth Edition, Geneva, Switzerland.

Wu FY and Sun EJ 1998. Effects of copper, zinc, nickel, chromium and lead on the growth of water convolvulus in water culture. *Environmental Protection* **21**(1): 63 - 72.

Yanqun Z, Yuan, L, Jianjun, C, Haiyan C, Li Q and Schvartz C 2005. Hyper-accumulation of Pb, Zn and Cd in herbaceous grown on lead-zinc mining area in Yunnan. China. *Environmental International* **31**: 755-762.

Zheljazkov D and Nielson NE 1996. Effect of heavy metals on peppermint and corn mint. *Plant Soil* **178**: 59-66.

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