International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 1359-1366

Received: 19-05-2019
Accepted: 21-06-2019

Sona BR
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat Road, Chakgaria, Panchasayar, Kolkata, West Bengal, India

Vijay Sundar Deva G
Aquatic Environment and Health Management Division, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra, India

Soumalika Guha
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat Road, Chakgaria, Panchasayar, Kolkata, West Bengal, India

RR Anupama
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat Road, Chakgaria, Panchasayar, Kolkata, West Bengal, India

Sriparna Chakraborty
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat Road, Chakgaria, Panchasayar, Kolkata, West Bengal, India

Dayal Devadas
Fisheries Resources Harvest & Post-Harvest Management Division, ICAR- Central Institute of Fisheries Education, Mumbai, Maharashtra, India

Sangram Keshari Rout
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat Road, Chakgaria, Panchasayar, Kolkata, West Bengal, India

Correspondence
Sona BR
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat Road, Chakgaria, Panchasayar, Kolkata, West Bengal, India

Use of water hyacinth *Eichhornia crassipes* (MART.) Solms as phytoremediator in sewage fed aquaculture system

Sona BR, Vijay Sundar Deva G, Soumalika Guha, RR Anupama, Sriparna Chakraborty, Dayal Devadas and Sangram Keshari Rout

Abstract
Wastewater management is of prime importance in the era of water deficiency for domestic purposes, agriculture and aquaculture. Phytoremediation involves utilisation of aquatic plants for remediating heavy metals and other pollutants from aquatic ecosystems. Efficiency of *Eichhornia crassipes* (Mart.) Solms as a potential bioremidiator in the Ramsar site Nalban bheri wetland of West Bengal is studied here. About 120 ha of area of Nalban bheri wetland were selected for the study, and were divided into three sections. Floating weed *Eichhornia crassipes* were maintained on water spread area and were screened for the presence and accumulation of heavy metals in plants, monthly. Bioconcentration factor and translocation factor were also estimated and discussed herewith. The present study recommends water hyacinth as a potential bioremidiator for controlling heavy metasl in open freshwater bodies.

Keywords: *Eichhornia crassipes,* phytoremediator, aquaculture

Introduction
Wastewater is not essentially a pollutant but a nutrient resource that can be recycled through integrated farming practices. There are traditional practices of recycling effluents such as from agriculture, horticulture and aquaculture practiced in several countries (Kumar and Sierp, 2003) [8]. In the scarcity of suitable water for fish production, sewage water acts as a best supplement for high fish protein production but this is accepted that there is an urgent need to develop technologies to remove or detoxify these materials present in wastewater. Many studies has been widely used the conventional remediation techniques to remediate heavy metals and nutrients. But these methods have negative effect to environment and are expensive also (Rai and Tripathi 2009) [14]. Accordingly, there is a need for an alternative system to overcome these drawbacks and achieve a high elimination rate of pollutants. The use of green plants to remove pollutants from the environment or to render them harmless is known as phytoremediation. Phytoremediation is a cost effective plant based approach for removal of not only heavy metals but also excessive nutrients from soil and water (Terry and Banuelos, 2000) [17]. Such plants are known as pollution mitigators. Among the free-floating species, the water hyacinth (*Eichhornia crassipes*) appears to be a promising candidate for pollutant removal owing to its rapid growth rate and extensive root system. The abilities of water hyacinth such as higher growth rate, pollutant absorption efficiency, low operation cost and renewability shows that using this plant it can be considered as a suitable technology for the treatment of wastewater. The unique character of this plant is high ability of tolerant capacity in high level of contaminant and it can accumulate in large quantity in their plant tissue therefore it is named as best bio accumulator.
However, there is limited studies to understand the efficiency of water hyacinth in metal removal by accumulating in different parts of the plant from wastewater-fed bodies. The present study is concentrated to estimate the accumulation of metal in different parts like leaf, stem and root which can be give the idea about the proper utilization of suitable plant part.

Materials and methods
The East Kolkata Wetlands is the largest sewage fed aquaculture system in the world. In this system about 600 million litre of sewage and waste water are discharged daily. The Nalban bheri (wetland) lies between latitude 22˚25’–22˚40’ N and longitude 88˚20’–88˚35’ E covering

an area of 267.45 ha with total 18 ponds. From the total area a perennial lentic water body having around 120 ha was selected for the present study. Water hyacinth population were maintained along the embankment area of the water body by using bamboo sticks. They act as a phytoremediator by removing suspended materials, nutrients and heavy metals from sewage water with great efficiency and thus the sites were selected along the levee of the water body.

The study was conducted during July 2016 to March 2017. Three sites were selected from the total area. Site 1 (S1) was selected in the opposite side of sewage water inlet, Site 2 (S2) was selected in the middle stretch of the water body and Site 3 (S3) was selected near the inlet of sewage water. Water and water hyacinth samples were collected from each site once in first week of every month during July 2016 to March 2017.

Metals analyses in water (APHA, 2012)

50 ml of water sample was digested by adding 5 ml of conc. HNO_3 in a hot plate. The digested content were passed through Whatman® 42 filter paper and washed with Milli Q® grade water. Final volume was made to 15 ml. Then concentration of metals Cu and Pb were estimated in flame mode of GBC 932 B+ Atomic Absorption Spectroscope.

Metals analysis in Water hyacinth (Tandon and Azis, 2000) [16]

The collected plant samples were dried in hot air oven at 65˚C for overnight. After drying the whole plants were separated into parts viz leafs, stems and roots. The each separated parts were grounded properly using homogenizer and used for the estimation of heavy metals like Cu and Pb. One gram of each part dry weight plant sample was digested by adding 5ml of H_2O_2 followed by addition of mixture of acids containing conc. HNO3: HClO4: H2SO4 14:2:1 in a hot plate. Then the digested sample were filtered through Whatman® 42 filter paper and washed with Milli Q® grade water. Final volume was made to 50ml. Aliquot was directly used to estimate the concentration of metals Cu and Pb in flame mode of GBC 932 B+ Atomic Absorption Spectroscope.

Bio concentration factor and Translocation factor

Bio concentration factor (BCF) and Translocation factor (TF) evaluates the feasibility of plant for the phytoremediation of heavy metals (Pandey, 2012) [12]. The digested samples were analyzed for Cu and Pb and the BCF and TF of each metal were calculated separately using the following formula,

BCF = Trace element concentration in plant tissue at harvest / Initial concentration of the element in water

According to Zhu *et al*., (1999) [23] a BCF value ≥ 1000 has been suggested to indicate that a plant species are hyperaccumulator.

TF = C shoot / C root

Where, C shoot and C root are metals concentration in the shoot (mg/kg) and root of plant (mg/kg), respectively. If TF values are >1 represent that translocation of metals effectively was made to the shoot from root (Baker and Brooks, 1989; Zhang *et al*., 2002; Fayiga and Ma, 2006) [3, 22, 6].

Results and discussion

Heavy metals in water

Heavy metals are important environmental pollutants and many of them are toxic even at very low concentrations. The metallic elements with atomic weight of more than 100 and those with a relative density of greater than 5 grams are considered as heavy metals. From the present investigation the different heavy metals from sewage water were estimated to be below detection level as detected by the Atomic Absorption Spectrophotometer. But by the calculation method (LOD=3 s/m, where 's' being the standard deviation corresponding to blank injections and 'm' the slope of the calibration graph) the concentration of heavy metals in sewage water was calculated as 0.005 and 0.14 mg/l for copper and lead respectively.

Several workers analysed the heavy metal concentration of water from different water bodies as discussed below. Tiwari *et al*. (2007) [18] analysed the heavy metals in water samples collected from three points of polluted lake and recorded as 0.98 to 0.20 mg/l for copper and 0.9 to 0.3 mg/l for lead. Chatterjee *et al*. (2006) [5] analysed the concentration of trace metals in water collected from both uncontaminated and wastewater fed ponds and observed that the copper and lead concentration in uncontaminated water was nil and in wastewater fed fish ponds was 0.62 and 0.46 mg/l respectively. All the above findings are in agreement with the findings of the present study. The heavy metals in the water have been detected to be very low. This might be due to the absorption of heavy metals from the water body by the water hyacinth. As observed the heavy metal concentration in different parts of the water hyacinth is quite high in comparison to the water itself where water hyacinth grows.

Heavy metals in water hyacinth

Root

The maximum copper concentration was recorded in S1, S2 and S3 as 24.312 ± 0.002 mg/kg (September), 21.674 ± 0.002 mg/kg (September) & 40.121 ± 0.002 mg/kg (October) (Fig. 1). The maximum lead accumulation in the root were recorded in S1, S2 & S3 as 39.269 ± 0.002 mg/kg (January), 57.439 ± 0.050 mg/kg (August) & 54.439 ± 0.002 mg/kg (August) respectively (Fig. 2).

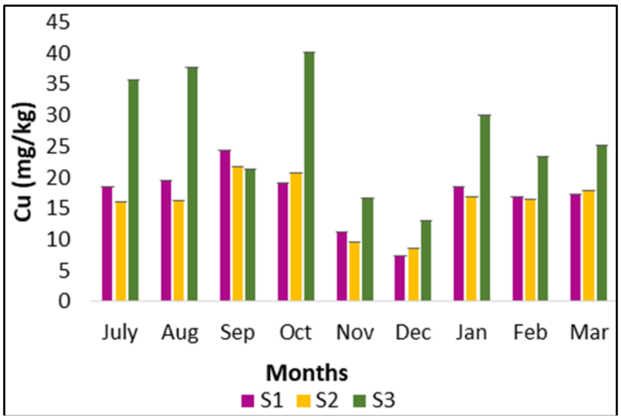

Fig 1: Average monthly variation of copper in root (mg/kg) with SD in three sites of the experimental area during the study period.

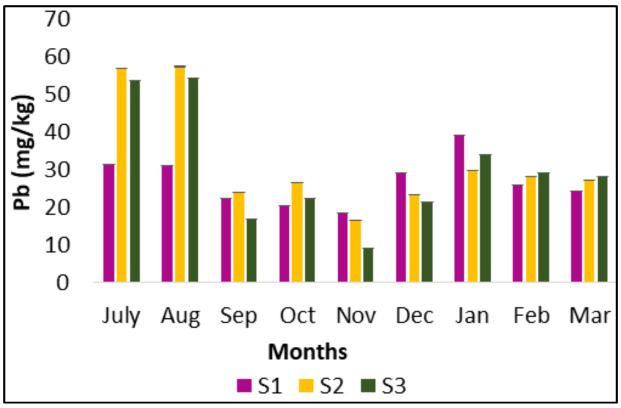

Fig 2: Average monthly variation of lead in root (mg/kg) with SD in three sites of the experimental area during the study period.

Sasidharan *et al*., (2013) [15] recorded the heavy metals from water hyacinth roots of Vembanad Lake. From the results different heavy metals recorded are as 82.93 mg/kg and 0.36 mg/kg for Cu and Pb respectively. The findings are similar with the present observations followed the order as Cu >Pb in the roots of the plant.

Stem The maximum accumulation of copper in stem observed in S1, S2 & S3 was 10.222 ± 0.002 mg/kg (September), 8.424 ± 0.002 mg/kg (October) & 10.027 ± 0.002 mg/kg (October) respectively (Fig 3). The maximum lead concentration reported at S1, S2 & S3 was 28.218 ± 0.002 mg/kg (January), 27.813 ± 0.002 mg/kg (January) & 26.175 ± 0.002 mg/kg (March) respectively.

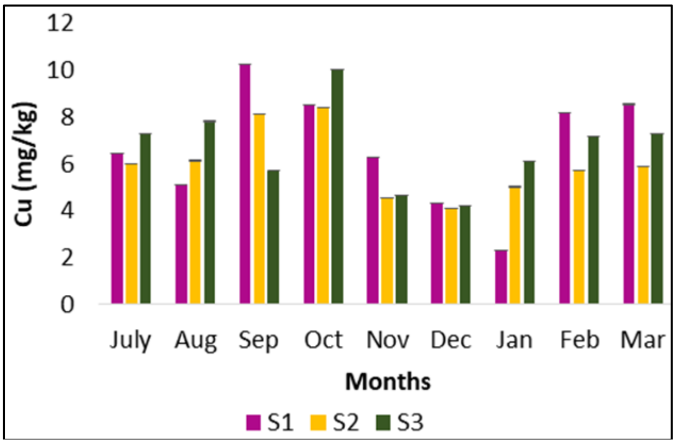

Fig 3: Average monthly variation of copper in stem (mg/kg) with SD in three sites of the experimental area during the study period.

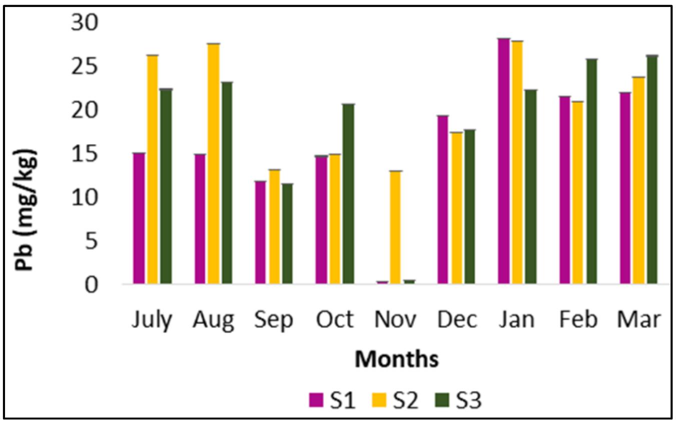

Fig 4: Average monthly variation of lead in stem (mg/kg) with SD in three sites of the experimental area during the study period.

Manju and Darsana (2014) [9] analysed the heavy metal accumulation in water hyacinth stem from Akulam Lake, Thiruvananthapuram, Kerala and the values ranged from 0.06 ± 0.005 to 0.01 ± 0.01 and 0.15 ± 0.001 to 0 for Cu and Pb respectively. The findings are similar with the present observations following the order as Pb > Cu. Sasidharan *et al*., (2013) [15] recorded the heavy metals from water hyacinth shoots + petiole of Vembanad Lake 32.73 mg/kg and 1.18 mg/kg for Cu and Pb respectively.

Leaf

During the study the maximum copper absorption in the leaf was recorded in S1, S2 and S3 as 10.353 ± 0.002 mg/kg (September), 9.988 ± 0.002 mg/kg (September) & 11.484 ± 0.004 mg/kg (January) respectively (Fig. 5). The maximum values recorded for Pb at S1, S2 & S3 was 27.436 ± 0.002 mg/kg, 28.823 ± 0.001 mg/kg & 29.405 ± 0.002 mg/kg respectively (Fig. 6).

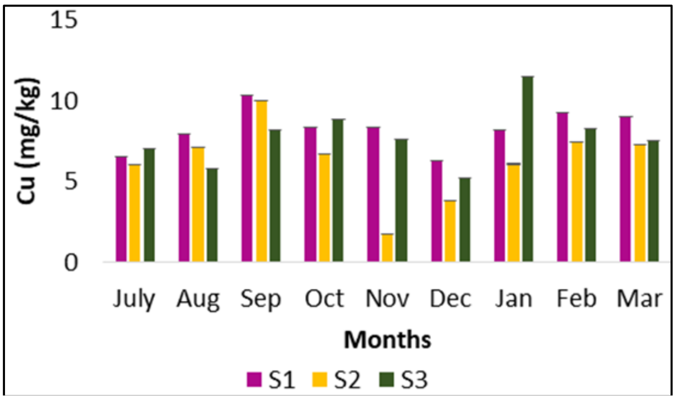

Fig 5: Average monthly variation of copper in leaf (mg/kg) with SD in three sites of the experimental area during the study period.

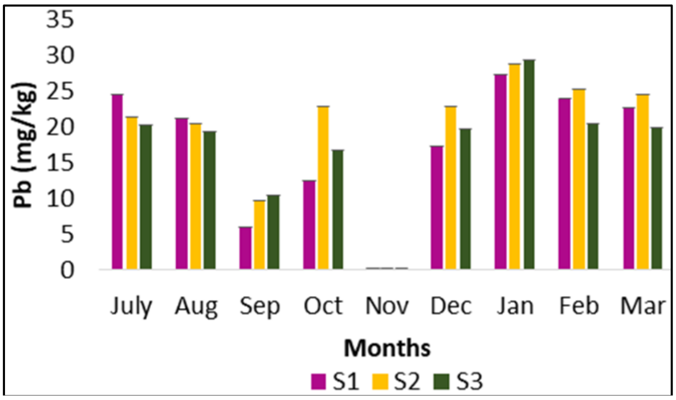

Fig 6: Average monthly variation of lead in leaf (mg/kg) with SD in three sites of the experimental area during the study period

Manju and Darsana (2014) [9] analysed the heavy metal accumulation in water hyacinth from Akulam Lake, Thiruvananthapuram, Kerala and obtained that the leaves absorbed more heavy metals than stem and flowers, in the order of Pb (0.31 ± 0.01), and Cu (0.18 ± 0.001) mg/kg. The findings are similar with the present observations. Sasidharan *et al*., (2013) [15] recorded the heavy metals from water hyacinth leaf of Vembanad Lake were they observed the values as 33.73 mg/kg and 0.04 mg/kg for Cu and Pb respectively. In the present study almost similar range of all metals like Cu and Pb have also been recorded from the leaves.

Bioconcentration factor

BCF is an index of hyperaccumulation as well as efficiency of metal sequestration. According to Abd (2003) [1], the ratio between plant metal concentration and that of the growth media expresses the BCF which reflects the affinity of aquatic macrophytes to a specific heavy element or pollutant.

Copper

The BCF of copper in root values were reported in S1, S2 and S3 as 4862.4 to 1454.333, 4334.8 to 1730.8 and 8024.2 to 2587.533 respectively (Fig. 7). The BCF of copper in stem values were reported in S1, S2 and S3 as 2044.333 to 467.133, 1684.8 to 821.4 and 2005.467 to 847.333 respectively (Fig. 8). The BCF of copper in leaf values were reported in S1, S2 and S3 as 2070.667 to 1257.667, 1997.533 to 349.467 and 2296.73 to 1041.733 respectively (Fig. 9).

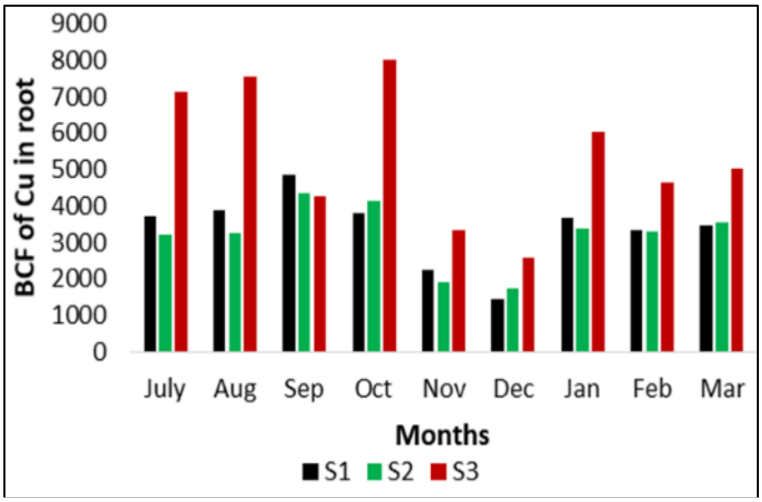

Fig 7: BCF values of Cu in water hyacinth root in three sites of the experimental area during the study period.

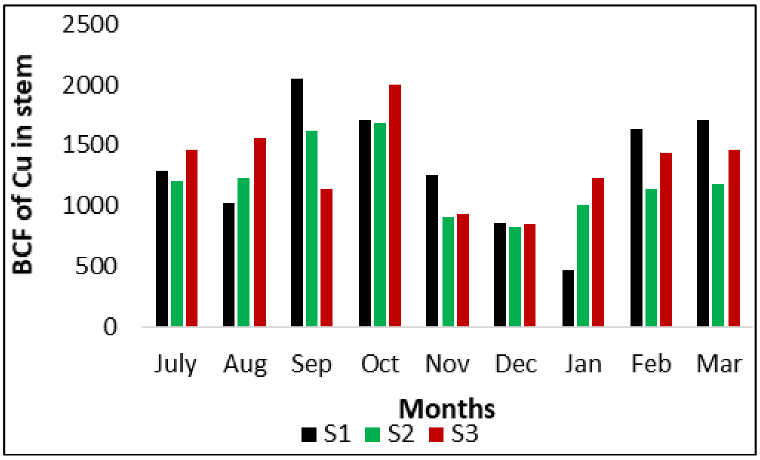

Fig 8: BCF values of Cu in water hyacinth stem in three sites of the experimental area during the study period

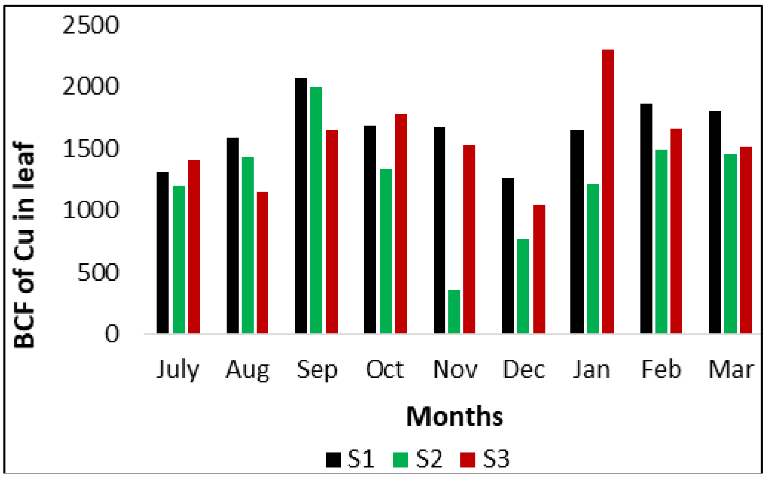

Fig 9: BCF values of Cu in water hyacinth leaf in three sites of the experimental area during the study period.

Lead

The BCF of lead in root values were reported in S1, S2 and S3 as 280.491 to 132.769, 410.279 to 119.579 and 388.85 to 65.648 respectively (Fig. 10). The BCF of lead in stem values were reported in S1, S2 and S3 as 201.560 to 2.176, 198.667 to 92.636 and 186.962 to 2.524 respectively (Fig 11). The BCF of lead in leaf values were reported in S1, S2 and S3 as 195.971 to 1.438, 205.881 to 1.488 and 146.362 to 1.5 respectively (Fig 12).

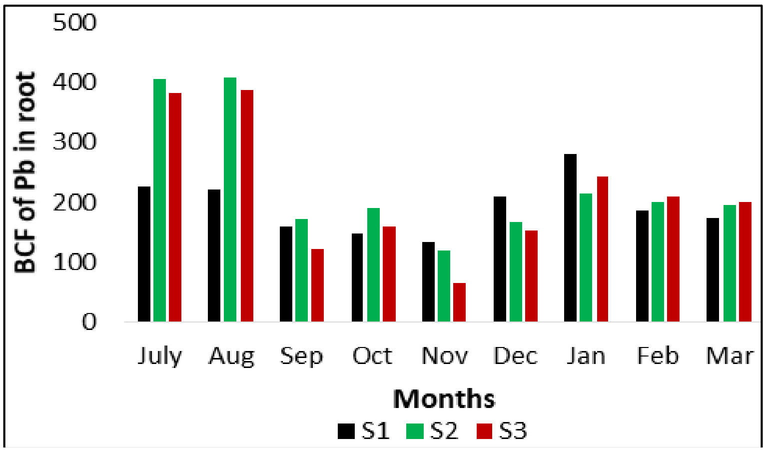

Fig 10: BCF values of Pb in water hyacinth roots in three sites of the experimental area during the study period

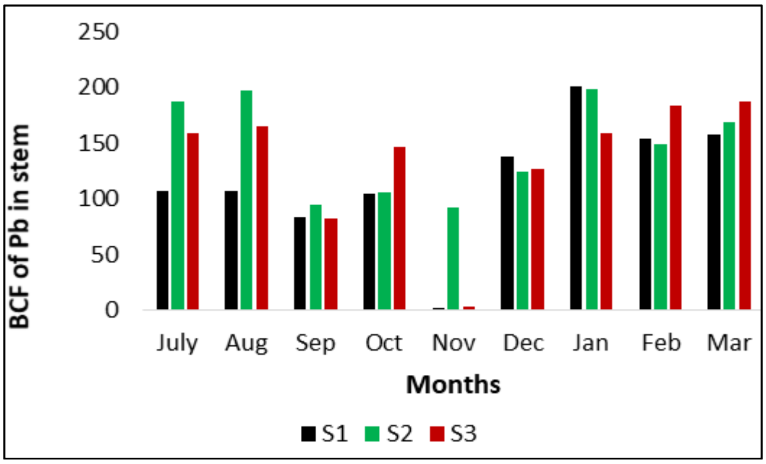

Fig 11: BCF values of Pb in water hyacinth stem in three sites of the experimental area during the study period.

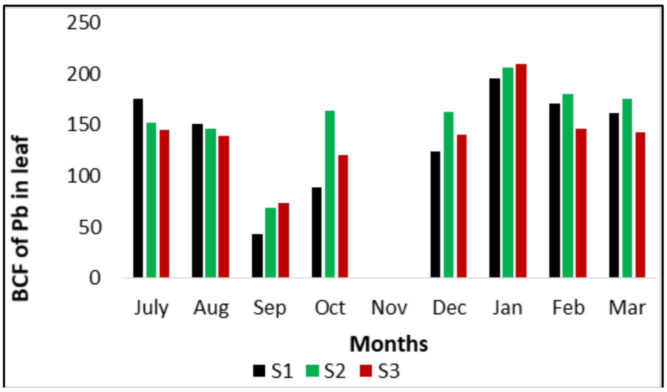

Fig 12: BCF values of Pb in water hyacinth leaf in three sites of the experimental area during the study period.

In the present study, mostly the BCF values of Cu and Pb increase when their concentrations in ambient water decreased. Carvalho and Martin (2001) [4] found that Cd, Cu, Ni, Pb, and Zn were associated with large BCF at low concentrations. Weiliao and Chang (2004) [21] determined that when the external environment had a low concentration of Cu level at 0.18 mg/l, the BCF of roots was highest at 6,166. In the present study, BCF values of copper in root exceeds 1000 in all sampling sites. Roots, stem and leaf of water hyacinth did not exceed 1000 for Pb. But for Cu the stem and leaf did not exceed 1000. And the investigation revealing that the efficiency of water hyacinth plant is accumulating Cu is higher than that for Pb. Based on the BCF values of the two metals in plant roots, water hyacinth can be primarily used as a good phytoaccumulator of Cu followed by Pb.

Translocation factor

The translocation of the metals from roots to other parts of the plants is defined as TF. If TF value are low it indicates roots accumulate more concentration than leaves.

Copper

The translocation factor of copper from root to leaf were recorded in the range of 0.865 to 0.353, 0.461 to 0.183 and 0.457 to 0.153 in S1, S2 and S3 respectively (Fig. 13). The translocation factor of copper from root to stem were recorded in S1, S2 and S3 with the range of 0.596 to 0.127, 0.477 to 0.297 and 0.327 to 0.204 respectively (Fig. 14).

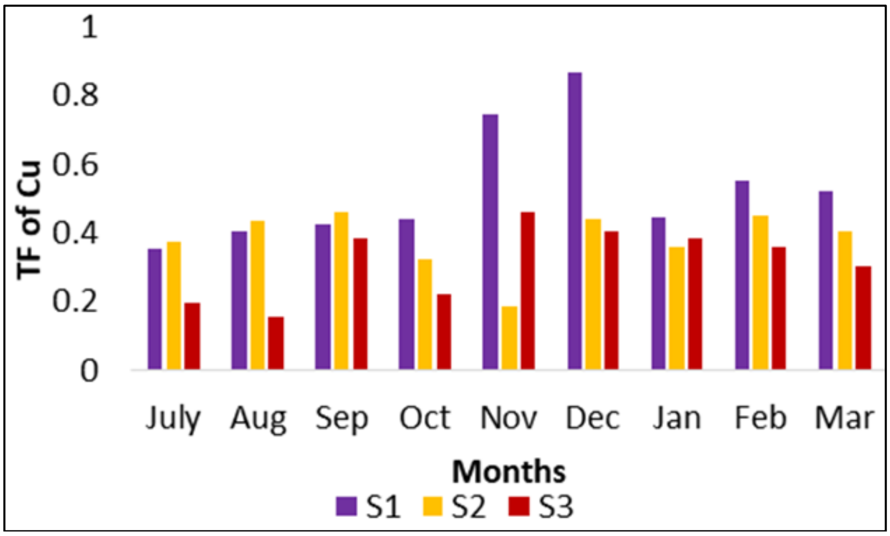

Fig 13: Translocation factor of copper from root to leaf in three sites of the experimental area during the study period.

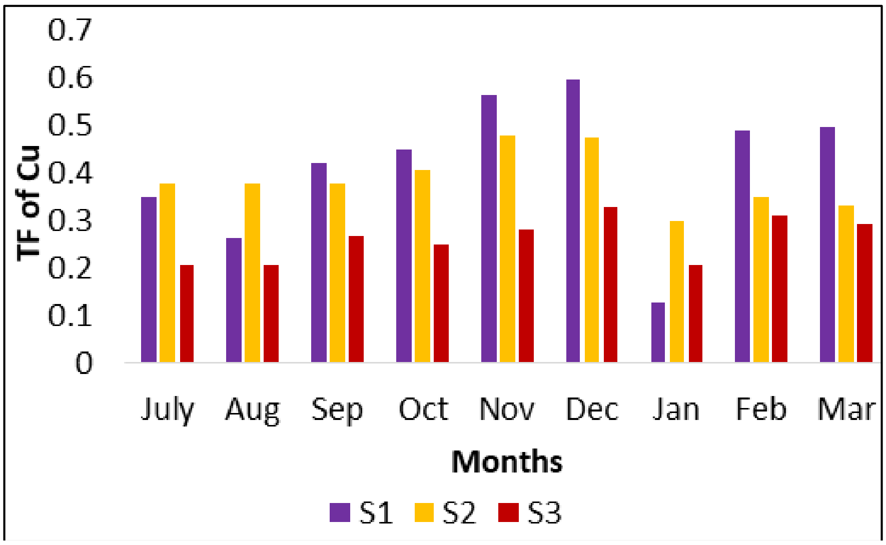

Fig 14: Translocation factor of copper from root to stem in three sites of the experimental area during the study period.

Lead

The translocation factor from root to leaf were recorded in S1, S2 and S3 with the range of 0.932 to 0.010, 0.976 to 0.012 and 0.916 to 0.023 respectively (Fig. 15). The translocation factor for lead from root to stem were ranged from 0.904 to 0.016, 0.869 to 0.461 and 0.933 to 0.038 in S1, S2 and S3 respectively (Fig. 16).

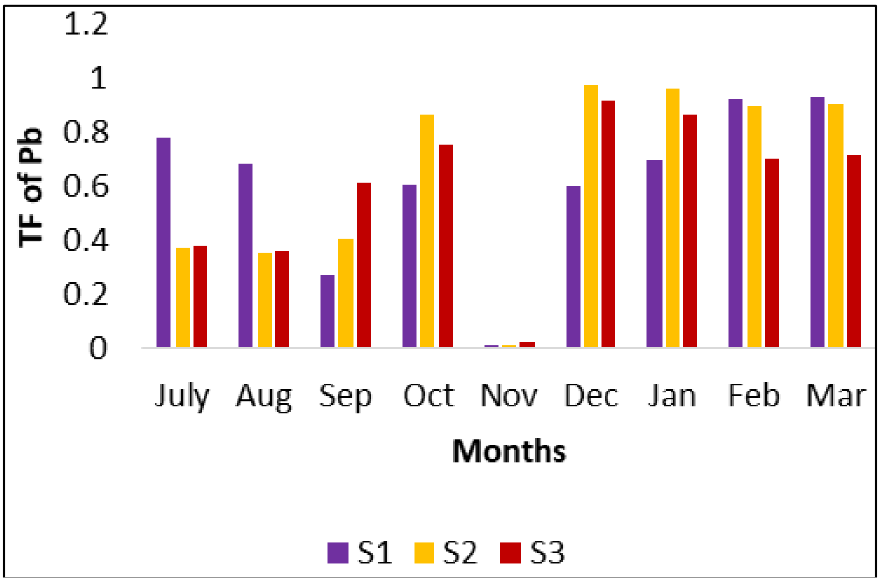

Fig 15: Translocation factor of lead from root to leaf in three sites of the experimental area during the study period.

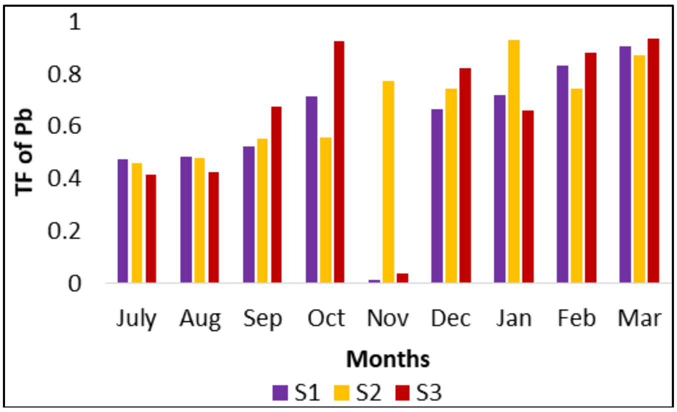

Fig16: Translocation factor of lead from root to stem in three sites of the experimental area during the study period

Melignani and Ana (2015) [10] observed that, the Cu translocation from roots to leaves was low. Cu accumulation in water hyacinth was considerably high, particularly in roots. Translocation factors in the present study was also much lower than in the literature (Mishra *et al*., 2008; Upadhyay *et al*., 2007) [11, 20]. Ugya *et al*., (2015) [19] conducted a laboratory experiment on the use of water hyacinth in the removal of some heavy metals from a stream polluted by waste water from Kaduna Refinery and Petrochemical Company. Mean BTF factor of above 1 was recorded for Pb of the water hyacinth sample, signifying that the metal were effectively moved from the water through the root to the shoot. These observations are in corroboration with the present findings. The translocation factor for the selected metals of the present study was indicating the less movement of metals from root to stem and leaves, confirming more accumulation of heavy metals in the roots.

Conclusion

During the present study, the heavy metal concentration in water and different parts of water hyacinth revealed that, the heavy metals concentration in water is very low, which might be due to the absorption of heavy metals from the water by the water hyacinth. Based on the BCF values of the two metals in plant roots, it can be stated that, the water hyacinth can be primarily used as a good phytoaccumulator of Cu followed by Pb. Translocation factor which has been calculated during the present study is indicating the worst movement of metal from root to stem and leaf. Heavy metals concentration in root of water hyacinth was high when compared to other parts. So, the root of the plant which is used as phytoremediation may be separated and disposed as per the suitable disposable methods and the remaining plant can be used for various other purposes.

References

1. Abd EEM. Response of hyper and non-hyper accumulator plants to nickel element. Annals of Agricultural Science, Moshtohor. 2003; 41:1701-1710.
2. APHA/AWWA/WEF. American Public Health Association/American Water Works association, Water Environment Federation. Standard methods for the examination of water and waste water, 22nd Edn, Washington DC, USA, 2012.
3. Baker AJM, Brooks RR. Terrestrials higher plants which hyper accumulate metallic elements. A review of their distribution, ecology and phytochemistry. 1989; 1:81-26.
4. Carvalho KM, DF Martin. Removal of aqueous selenium by four aquatic plants, Journal of Aquatic Plant Management. 2001; 39:33-36.
5. Chatterjee S, Buddhadeb C, Mukhopadhyay SK. Trace metals distribution in tissues of Cichlids (*Oreochromis niloticus* and *O. mossambicus*) collected fom wastewater fed fish ponds in East Calcutta wetlands, A Ramsar site. Acta Ichthyologica ET Piscatoria. 2006; 36(2):119-125.
6. Fayiga AQ, Ma LQ. Using phosphate rock to immobilize metals in soils and increase arsenic uptake in *Pteris vittata*. Science Total Environment. 2006; 359:17-25.
7. Kumar A, Mathur RP. Bioaccumulation kinetics and organ distribution of lead in a fresh water teleost, *Colisa fasciatus*. Environmental Technology. 1991; 12:731-735.
8. Kumar MS, Sierp M. Integrated wastewater treatment and aquaculture production-A report for the rural industries research and development corporation. RIRDC Publications, South Australia, 2003, 69.
9. Manju KG, Darsana S. *Eichhornia sp*. as sentinel of pollution in Aquatic Ecosystems. Journal of Aquatic Biology and Fisheries. 2014; 2:334-335
10. Melignani ELIC, Ana MF. Copper uptake by *Eichhornia crassipes* exposed at high level concentrations. Environmental Science Pollution Research. 2015; 22:8307-8315.
11. Mishra VK, Upadhyay AR, Pandey SK, Tripathi BD. Heavy metal pollution induced due to coal mining effluent on surrounding aquatic ecosystem and its management through naturally occurring aquatic macrophytes. Bioresource Technology. 2008; 99:930-936.
12. Pandey VC. Phytoremediation of heavy metals from fly ash pond by *Azolla caroliniana*, Ecotoxicology of Environmental Safety. 2012; 82:8-12.
13. Patel SJ, Promith B, Suman B, Lakshmi B, Namratha. Phytoremediation of copper and lead by using sunflower, Indian mustard and water hyacinth plants. International Journal of Science and Research. 2013; 4(3):113-115.
14. Rai PK, Tripathi BD. Comparative assessment of Azolla pinnata and Vallisneria spiralis in Hg removal from GB Pant Sagar of Singrauli Industrial region, India. Environmental Monitoring and Assessment. 2009; 148(1-4):75-84.
15. Sasidharan NK, Azim T, Ambika DD, Samuel M. Water hyacinth for heavy metal scavenging and utilization as organic manure. Indian Journal of Weed Science. 2013; 45(3):204-209.
16. Tandon S, Azis PKA. Methods of analysis of soils, plants, water and fertilizers. Edition, 2000, 49-66.
17. Terry N, Banuelos G. Phytoremediation of contaminated soil and water. Lewis Publishers, New York, 2000, 389.
18. Tiwari S, Dixit S, Verma N. An effective means of bio-filtration of heavy metal contaminated water bodies using aquatic weed *Eichhornia crassipes*. Environmental Monitoring and Assessment. 2007; 129:253-256.
19. Ugya AY, Imam TS, Hassan AS. The use of *Eicchornia crassipes* to remove some heavy metals from romi stream: A Case study of Kaduna refinery and petrochemical company polluted stream. IOSR Journal of Pharmacy and Biological Sciences. 2015b; 10(1):43-46.
20. Upadhyay AR, Mishra VK, Pandey SK, Tripathi BD. Biofiltration of secondary treated municipal wastewater in a tropical city. Ecological Engineering. 2007a; 30:9-15.

21. Weiliao S, Chang WL. Heavy metal phytoremediation by water hyacinth at constructed wetlands in Taiwan, Journal of Aquatic Plant Management. 2004; 42:60-68.
22. Zhang WH, Cai Y, Tu C, Ma QL. Arsenic speciation and distribution in an arsenic hyperaccumulating plant. Science Environment. 2002; 300:167-177.
23. Zhu YL, Zayed AM, Qian JH, Souza M, Terry N. Phytoaccumulation of trace elements by wetland plants: Water Hyacinth, Journal of Environmental Quality. 1999; 28:339-344.