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Seasonal Variation of Heavy Metal Concentration in Alternanthera Sessilis

KEYWORDS: Heavy metals, Bioconcentration factor, Bioaccumulation factor, Translocation factor

Sheetal Belkhode	Deepa Panhekar	Ashok Kalambe
Department of Chemistry, Institute of Science, Nagpur, INDIA	Department of Chemistry, Dr. Ambedkar College, Deeksha Bhoomi, Nagpur, INDIA	Department of Chemistry, Institute of Science, Nagpur, INDIA

ABSTRACT *The aim of the study was to assess the seasonal accumulation of heavy metals by Alternanthera sessilis. The plant and water samples used in this study were obtained from Ambazari Lake at different seasons. Heavy metals for which these samples were analyzed were Chromium (Cr), Arsenic (As), Nickel (Ni), Cadmium (Cd) and Lead (Pb). The metals accumulated were investigated using inductively coupled plasma atomic emission spectrometer (ICPAES). Results showed that the concentration of heavy metals in water during rainy season were higher. Plant samples were analyzed separately for their root and shoot. Metal concentration was higher in root than shoot. The metal concentration in the plant parts, in general follows the order Ni > Cr > Pb > As > Cd. Bioconcentration, bioaccumulation and translocation factors were calculated seasonally. These values suggest that Alternanthera sessilis can be considered as a good accumulator of Cr, Ni, Cd and Pb but is capable of hyperaccumulating As.*

INTRODUCTION

Heavy metal concentrations in past few years have reached a promising toxic level due to consequences of anthropogenic activities and urbanization. Human activities such as dumping of the domestic, municipal and industrial wastes into landfill and water bodies have contributed to increased levels of heavy metals in the environment. Since wastewater is considered rich in organic matter and plant nutrients, it is used profitably to irrigate crops. Metal persistence in soil and water for much longer periods and their impact on both the environment and human health is a matter of serious concern[1,2].

Heavy metals like Cr, As, Ni, Cd, Pb etc, have been classified as carcinogenic to humans[3]. Essential and nonessential heavy metals are readily taken up by plants and accumulated in toxic forms. The toxic effects of these metals have been known for a very long time.

Pollution of water bodies is no longer within safe limits for human as well as animal consumption. Also it affects aquatic flora and fauna. This may be due to the runoff from industrial and domestic wastes resulting in poorer water quality which makes it unfavourable for consumption. Excess use of pesticides and fertilizers to enhance crop productivity in agricultural activities continue to pollute ground water and surface water.

The use of plants for the removal of heavy metals to improve water quality from spillage sites, sewage waters, sludges, soils and industrial water treatment systems is well documented in the literature[4,5]. There has been considerable interest over the last 15 years in using plants as pollution control[6].

Various types of aquatic plants and weeds grow excessively in lakes or nearby water body and eradication or reasonable control of these weeds is almost impossible and difficult. Therefore immediate precautionary steps must be taken for the betterment of environment.

Various researchers have studied the accumulation of heavy metals by aquatic macrophytes[7,8]. Ma et al. reported Pteris vittata as As hyperaccumulator for As contaminated soil and waters[9].

Various studies have been carried out towards the uptake of heavy metals such as Ni, Cr and Pb from the water by Alternanthera sessilis but no study has been carried out on the accumulation of heavy metals by Alternanthera sessilis with respect to different seasons. So, the present study was carried out to study the seasonal variation in heavy metal accumulation of Alternanthera sessilis and to determine bioconcentration factor, bioaccumulation factor and translocation factor of metals seasonally. Also the level of heavy metals in water of Ambazari lake during different seasons were estimated.

Material and methods

Study area: Ambazari lake, situated at a distance of 6 kms towards the western border of Nagpur, Maharashtra, India was used for collecting plant and water samples. Over 30 years this lake was used for supplying water to the city. But it is not currently used as a water supply due to pollution. Also it is one of the famous tourist attractions who come to visit Nagpur on a leisure tour.

Sampling: Alternanthera sessilis, a free-floating plant found abundantly at Ambazari lake was collected in clean plastic bag in different seasons to investigate the amount of heavy metal uptake by it. The plant is classified as a weed belonging to family Amaranthaceae. It is a perennial herb with prostrate stems. The plant is mostly found in and near ponds, canals and reservoirs.

Plant analysis**:** The plant was washed with tap water to remove dust and sediment particles. It was separated into shoot and root and then sun dried in separate containers for 12-15 days. Thereafter, the dried plant parts i.e. shoot and root were ground till fine powder was formed using mortar and pestle.

For analysis, 1.0 g of plant sample was taken in a beaker and 50ml aquaregia along with 5% HNO3 was added and then digested for 3-4 hours on hot plate. After digestion, the sample was left to cool and then filtered with What-

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man Ashless filter paper (no. 40). The sample was then transferred to 100ml volumetric flask and the volume was made upto the mark, followed by AAS analysis of Cr, As, Ni, Cd and Pb [Thermofischer model no. IRIS Intrepid II].

Water analysis**:** Water samples were collected from Ambazari lake in the clean plastic bottle during all seasons and directly subjected to analysis by AAS for metals Cr, As, Ni, Cd and Pb contents.

Plant ability to take up heavy metals from water was evaluated by bioconcentration factor (BCF) and bioaccumulation factor (BAF). BCF is the capacity of plant shoots to take up heavy metals from water. BCF values > 1 indicate ability of plant species for phytoextraction and phytostabilization[10]. BAF is the ratio of metal concentration in plant roots to its concentration in water. Higher BAF value indicates that the plant is a metal accumulator.

Translocation factor (TF) indicates plants can translocates metals effectively from roots to shoots[11]. TF <1 depicts greater metal accumulation in root than shoot of plants and with values greater indicate that metals are transferred to the above ground parts of the plant[12].

Results and discussion

The present work was carried out to study the seasonal variation in heavy metal concentration of Alternanthera sessilis. The heavy metals studied were Chromium (Cr), Arsenic (As), Nickel (Ni), Cadmium (Cd) and Lead (Pb). Of these metals, Ni is essential for plant growth in trace concentrations,. The non-essential metals, Cr, Cd and Pb are highly toxic and are readily absorbed by plants. As, a semi metallic element is notoriously toxic for living organisms.

The plant and water samples were collected during rainy, winter and summer from Ambazari lake. The metals accumulated were investigated using inductively coupled plasma atomic emission spectrometer (ICPAES).

Table 1. Seasonal concentration of heavy metals in water

	Cr	As	Ni	Cd	Pb
Rainy	0.0334	0.036	0.34	0.34	0.0052
Winter	0.003	0.003	0.0033	0.0025	0.0036
Summer	0.0342	0.0384	0.0025	0.0038	0.004

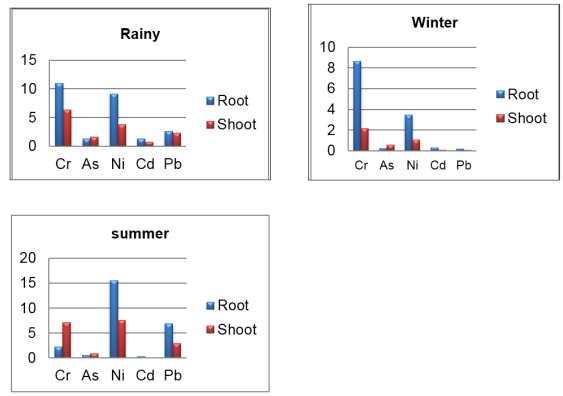
Seasonal concentrations of heavy metals (in ppm) in water are presented in Table 1. The average level of metals followed the order As > Cr > Pb > Cd > Ni. Among metals, chromium (Cr) and lead (Pb) were detected in traces and ranged from 0.003 to 0.034 ppm and 0.003 to 0.0052 ppm respectively i.e. concentration of chromium (Cr) and lead (Pb) remained below permissible limit during all seasons.

Arsenic was detected with lower value in winter (0.003) and higher in rainy (0.036) and in summer (0.0384).

The highest value for cadmium was observed during rainy season. In a similar way, Nickel (Ni) concentration was found highest during rainy season. The concentration of Ni and Cd during rainy season showed higher value, this is in line with the findings of Turgut (2003)[13].

Seasonal metal concentrations in different parts of plant are shown in fig 1.

Figure 1. Metal concentrations in root and shoot of A. sessilis at different seasons



Seasonal variations are observed in the data during the study. The heavy metal concentration in the plant parts, in general follows the order Ni > Cr > Pb > As > Cd. Alternanthera sessilis show different abilities to absorb and accumulate various heavy metals in different tissues. The highest concentrations of trace metal elements in the plant root were observed for Cr, As and Cd during rainy and for Ni and Pb during summer.

Cd was detected in traces during all seasons. Chromium shows higher concentration of metal accumulation followed by Ni and Pb. The maximum accumulation of Cr, As and Cd was observed in rainy season whereas for Ni and Pb, higher values are obtained in the summer.

In general, all metal ions were absorbed lowest during winter. Some researchers have reported the lowest metal contents during winter[14,15]. During the study, it was observed that in all seasons, Ni, Cd and Pb concentrations were higher in root whereas As concentration was found higher in shoot. Cr concentration was higher in root during rainy and winter season. Also, Cr and Ni could be accumulated in all plant organs during all seasons. According to some researchers, the roots of aquatic plants accumulate higher concentration of heavy metal as compared to other parts[16-19]. This supports our findings.

Bioconcentration Factor and Bioaccumulation factor

Bioconcentration factor and bioaccumulation factor values varied widely from one metal to other. Alternanthera sessilis showed different ability to accumulate one or more toxic metals. From the figure, it was observed that the bioaccumulation factor value for Cr and Cd were high in winter whereas for Ni and Pb higher values were obtained during summer. For As, Alternanthera sessilis had higher bioconcentration factor values as compared to bioaccumulation factor values in all seasons, indicating that the metals accumulated are largely stored in shoots. Therefore, on the basis of bioconcentration factor and bioaccumulation factor values, Alternanthera sessilis can be considered as a good accumulator of Cr, As, Cd, Ni and Pb in summer and could be used as a bioremediating plant. Almela et al. reported that Amaranthus blitoides, belonging to same family as A. sessilis, is a very good candidate for bioremediation[20].

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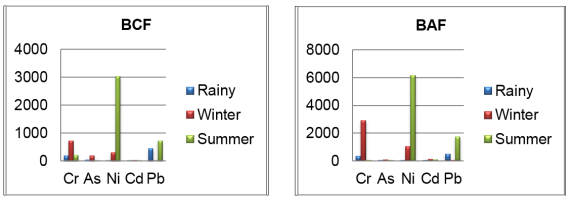
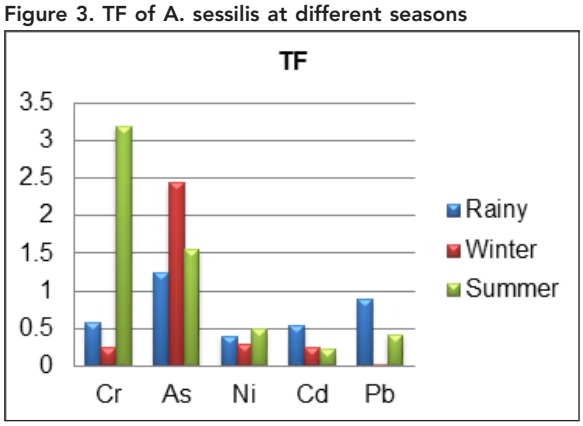
Figure 2. BCF and BAF of A. sessilis at different seasons



Translocation Factor

Figure 3. TF of A. sessilis at different seasons



As can be seen from Fig.3 Alternanthera sessilis had translocation factor value more than one for As in all seasons suggesting it could be used for phytoremediation of As contaminated water. However, for Cr, translocation factor value was found higher only in summer. However translocation factor 1 signifies that the specific plant can be used for phytostabilisation[21]. For nickel, cadmium and lead, the translocation factor values were below one for all seasons depicting greater metal accumulation in root than shoot of plants and this may enhance plants own ability to tolerate metal concentrations that are usually toxic[22].

CONCLUSION

The contamination in water and plants by heavy metals is one of the major issues to be faced throughout the world due to their negative impact on human and animal health. Results showed that the heavy metal content of arsenic, nickel and cadmium in water were recorded above the permissible limit in rainy season. Metal concentrations were higher in roots than shoots except for arsenic. BCF and BAF values are used to determine the amount of heavy metals consumed by the plant from water. Bioconcentration, bioaccumulation and translocation properties suggests that Alteranthera sessilis is a good accumulator of Cr, Ni, Cd and Pb and a hyperaccumulator of As.

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