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Seasonal variation of Heavy metal concentration in *Polygonum chinensis* from Ambazari lake of Nagpur, MH, India

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Abstract

Anthropogenic sources release heavy metals into the environment which cause for concern. Heavy metals are toxic pollutants that show perilous effects on all living organisms. This research shows that, the ability of Polygonum chinensis to accumulate heavy metals was examined during different seasons collected from Ambazari Lake, Nagpur, India. The plant showed different ability to absorb and accumulate different heavy metals. The bioconcentration, bioaccumulation and translocation factors revealed that the plant P. chinensis can be considered as heavy metal accumulator and can effectively translocate arsenic to aerial part.

Keywords: Heavy metals, Bioconcentration, Bioaccumulation, Translocation factor.

Introduction

The pollution of aquatic systems by heavy metals during topical years has engrossed considerable attention. Metals are natural constituents of nature[1]. The heavy metals acts as most serious potential pollutants when present beyond permissible limits because, firstly they cannot be destroyed through biological degradation and secondly tend to accumulate in the environment once entered. The metal pollutants of concern include lead, arsenic, chromium, cadmium, copper, nickel, etc. Heavy metals are highly toxic. Trace amounts of heavy metals are always present in fresh water bodies (concentration being less than one ugm/l), from various sources such as weathering of rocks, natural incident such as volcanic eruption, a variety of human activities involving mining, processing and use of metals or substances containing metal contaminants, thus resulting into geo-chemical recycling of heavy metals in these ecosystems[2]. Polluted water can be harmful to the existing life. Many scientists originate that it is basically the root system of the plant which is interacting with the contaminant. The root provides massive surface area that helps in accumulating the water as well as essential and nonessential contaminants. Macrophytes, an aquatic plants growing in or near waters which can be emergent, submerged or free floating are considered as important component of aquatic communities since they helps in oxygen production, nutrient cycling, water quality control, sediment stabilization, to afford locale and shelter for aquatic life, and also for being considered as proficient metal accumulators[3]. The increase of environmental problems and scarceness of studies related to heavy metals, make the present study an important asset to find species competent of cleaning up aquatic environments contaminated by metals. Thus the aim of this work was to evaluate the capacity of plant to accumulate and translocate heavy metals from their natural environment. The plant can be used to remove low concentrations of heavy metals from aquatic environment.

There are a small number of studies on the trace metals concentrations in plant species of Ambazari lake, and particularly insufficient data on their concentration in different parts of aquatic macrophytes and their seasonal variations.

Contamination of the environment by toxic metals is considered as an international problem for the reason that affects the ecosystem in most countries. In India, the circumstances are no better by the deeds of most industries and populace towards waste removal and management which customarily leads to the increasing level of pollution of the environment[4]. Various aquatic species have been tested for their ability to remove toxic metals from water, including Water Pennywort (*Hydrocotyle umbellate* L.)[5], Duckweed (*Lemna minor* L.)[6] and Water Hyacinth (*Eichhornia crassipes* (Mart.) Solms)[7].

The main purpose of this investigation is to study the seasonal variation in heavy metal concentration of plant *Polygonum chinensis* and to scrutinize whether the vogue of heavy metals concentration in Ambazari lake water is adequate enough to affect the environment as well as the wellbeing of the inhabitants of the area who depend on lake water, as their source of domestic and drinking water.

Materials and Methods

Ambazari Lake situated near the southwest border of Nagpur, Maharashtra (India) was used for collecting water and plant

samples. Aquatic plants have capacity to accrue heavy metals from their environment. Polygonum chinensis, a perennial herb belonging to family Polygonaceae is a weed of waterways and riparian areas. It is found in rainforest margins, waste areas, roadsides, etc. In the current study, the content of heavy metals (As, Ni, Cd and Pb) in water and different organs of the plant *Polygonum chinensis* collected from Ambazari lake, Nagpur, was investigated.

The plant was analyzed for heavy metals As, Ni, Cd and Pb. Lead (Pb) is a non essential, highly toxic element that can be harmful to humans as well as plants. Cadmium (Cd) is a nonessential toxic metal which is commonly found in industrial workplaces. Arsenic (As) is widely distributed in nature in two forms- organic and inorganic. Inorganic form of arsenic is highly toxic since it is associated with various cancer causing agents. Nickel (Ni) is essential for plant growth in trace concentrations.

Samples of the plant were collected from Ambazari Lake in three seasons. For assessment of the sample, places of maximum coverage and density were selected. Healthy plant samples were collected in polyethylene bags and transferred to the laboratory. Water samples were also taken from the same place as the plant material.

Sample analysis: The sampled plant material was washed with tap water and then with deionised water and gently dried with a paper towel. The plant samples were split into root and shoot to reveal bioaccumulation capacity of the plant organs. The plant samples were sundried for 8-10 days. The samples were ground into a fine powder with mortar and pestle.

For investigation, 1.0 g of plant sample was taken in a beaker and 50ml aquaregia along with 5% HNO_3 was added and then digested for 3-4 hours on hot plate. After digestion, the sample was left to cool and then filtered with Whatman Ashless filter paper (no. 40). The sample was then transferred to 100ml volumetric flask and the volume was made up to the mark with 5% nitric acid, followed by ICPAES analysis of 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 chemical analysis by ICPAES for metals As, Ni, Cd and Pb contents.

The capability of a plant to soak up and gather metals from the aqueous system was evaluated using bioconcentration and bioaccumulation factors. The bioconcentration and bioaccumulation factors are referred as a particular concentration of specific chemical inside biological tissues to that of surrounding environment. Higher values of these factors indicate that the plant is a metal accumulator and can be used as phytoindicator. The translocation factor is defined as the ratio of metal concentration in the shoots to that in the roots[8,9]. TF > 1 designate that plants can translocate metals well from roots to shoots and may be helpful for the phytoextraction of metals from water ecosystems[10,11].

Results and Discussion

The examination of toxic heavy metals in water is indispensable since even trivial changes in their concentration above the satisfactory levels can result in severe environmental and subsequently health problems. Seasonal concentrations of heavy metals (in ppm) in water are present in Table-1.

Table-1
Seasonal concentration of heavy metals in water (in ppm)

Seasons	Metal			
	As	Ni	Cd	Pb
Winter	0.003	0.0033	0.00254	0.003
Summer	0.0384	0.0025	0.0038	0.004
Rainy	0.036	0.34	0.34	0.0052

Low concentrations of metals were registered in the water samples. Lead (Pb) was detected in traces. There was no significant seasonal variation in Pb concentration in water samples and the concentration of Pb remained below permissible levels during all seasons. Arsenic was detected with lower value in winter and higher in rainy (0.036) and summer (0.0384), exceeding acceptable concentration during these seasons.

The highest value for cadmium (Cd) and nickel (Ni) was found during rainy season. The concentration of these metals was above the literature levels of water during rainy season. This basis for concern because this can affect the environment as well as the health of the inhabitants near lake who depend on lake water as their source of drinking and household water. Overall, the concentrations of metals were utmost during summer and rainy season while minimum concentrations were observed during winter seasons. This may be featured to the evaporation of water from lakes during summer and consequent dilution due to precipitation and run off from catchment area during rainy season[12].

Seasonal concentration of heavy metals in plant parts are revealed in Table-2. In general, the heavy metal concentrations in the plant tissues decreased in sequence Ni > Pb > As > Cd. Plants exhibits different abilities to absorb and accumulate numerous heavy metals in different tissues irrespective of their concentration in water. Plant showed different sequences of metal content and their bioaccumulation capacity. These differences advocate a different bioaccumulation competence of plants for different metals.

Table-2
Concentration of metals in plant organs (in ppm) during different seasons

Seasons	Plant part	Metals			
		As	Ni	Cd	Pb
Winter	Shoot	1.372	3.194	0.332	1.09
	Root	0.956	29.896	2.848	9.568
Summer	Shoot	1.772	3.8	0.418	3.21
	Root	1.056	4.464	0.924	3.828
Rainy	Shoot	2.472	4.79	1.114	7.966
	Root	3.42	14.176	2.014	8.114

Aquatic plants accumulate higher amount of metals in roots than that of other parts[13-16]. In this study, the plant *Polygonum chinensis* exhibited more accumulation of Ni, Cd and Pb mainly in root system in comparison with that observed in shoot system during all seasons. The plant seemed to limit the metal transfer to their aerial part. In contrast, for As, the concentration was found to be higher in shoot system during winter and summer indicating that arsenic is translocated more effectively to shoot during these seasons. Also, the highest accumulations for arsenic at all plant parts were measured in rainy season. While Ni, Cd and Pb concentration at root reached the highest value in winter. The highest Ni, Cd and Pb concentration in shoot were observed at rainy season. The roots reflect metal taken up better as compared to other plant parts[17]. Presence of higher concentrations of toxic metals in plants signifies the biomagnifications.

BCF and BAF values for the different organs of *P. chinensis* are shown in Figure-1 and varied widely from metal to metal. The BCF and BAF values for As increased during winter and cut down in summer. Similarly, for Cd, the BCF and BAF value increased during winter and fell in rainy. The bioconcentration value for Ni decreases from summer to winter and again to rainy but its bioaccumulation value lessen from winter to rainy. Whereas for Pb, the bioconcentration factor decreases from rainy to winter and its bioaccumulation factor from winter to summer.

The BCF and BAF values indicate that the plant shows good accumulation capacity. The BCF values for As and Cd were highest during winter, for Ni during summer and for Pb during rainy season. Similarly, BAF values for all metals were higher in winter. The results signify that the plant is a superior accumulator of metals during winter as compared to other seasons. The BCF and BAF values for the plant *Polygonum chinensis* decreases in the order Pb > Ni > As > Cd and Pb > As > Ni > Cd respectively during the study.

The translocation factor (TF) for the plant Polygonum chinensis during different seasons are exposed in Figure-2. The peak ratio of shoot/root (TF) concentrations was recorded for As (1.27) and the lowest was for Cd (0.37). The orders of the intensity of bioaccumulation of the examined metals in the shoot and root were different. In general TF decreases in the order- As > Pb > Ni > Cd. Therefore, the plant *Polygonum chinensis* can be a capable plant to eradicate the heavy metals. *Polygonum aviculare* belonging to same family polygonaceae is also an efficient accumulator of heavy metals[18].

Conclusion

Levels of As, Ni, Cd and Pb in Ambazari lake water have been established in this study by AAS after acid digestion. The outcomes showed that some heavy metals concentration in water were higher than the literature levels of water for the duration of rainy season. This grounds for concern as this can influence the environment as well as the health of the inhabitants near lake who depend on lake water as their source of drinking and domestic water. The bioconcentration and bioaccumulation factors revealed that the plant is a heavy metal accumulator. The TF value recommends that it can effectively translocate arsenic to above ground part. The bioaccumulation, bioconcentration and translocation of heavy metals in *P. chinensis* changes with respect to season and the type of heavy metal.

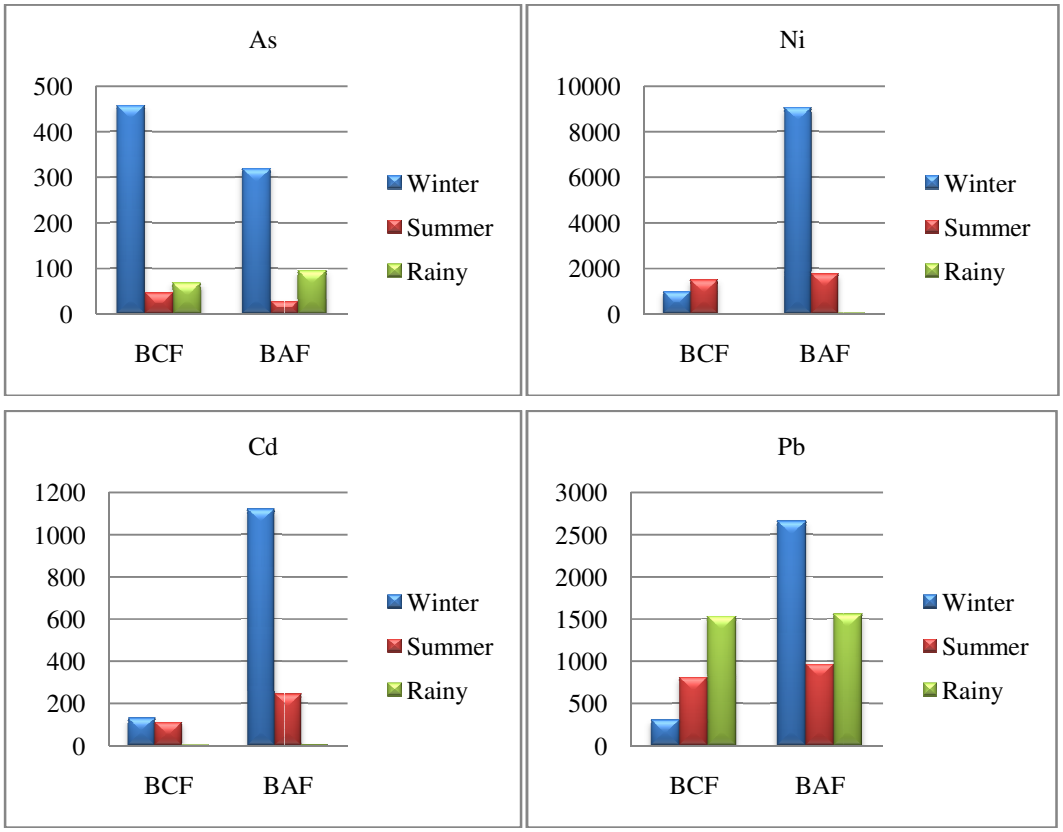

Figure-1
Bioconcentration and Bioaccumulation factors of *P. chinensis* at different seasons

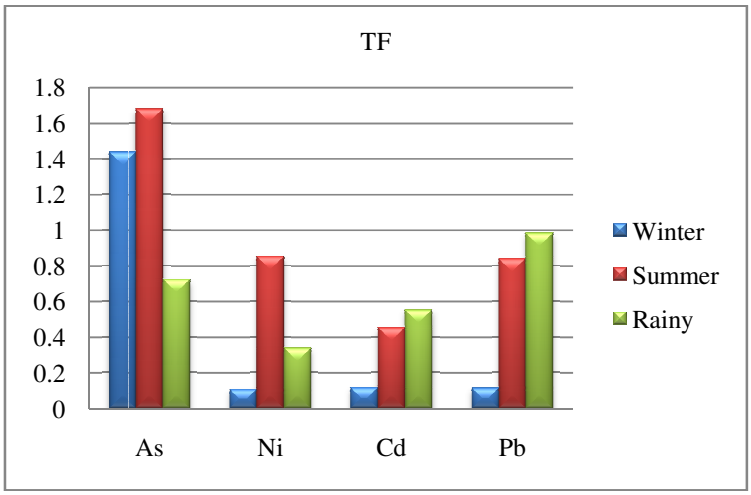

Figure-2
Translocation factor of *P. chinensis* at different seasons

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