Importance of aquatic macrophytes in controlling water quality

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Abstract

Concentrations of nine heavy metals were measured in selected macrophytes and water samples from the mouth of four main rivers of Lake Sevan Basin, Armenia. The fact that the concentrations of different heavy metals in these macrophytes were far higher than in their respective water column indicates to their role in the biogeochemical cycles of heavy metals.

Introduction

Aquatic systems often act as final receptacles to heavy metals whose concentration in interstitial waters might increase several thousand times beyond their initial concentrations by effluents from wastes (Cardwell, A., D. Hawker, M. Greenway, 2002). Many technologies have been used to reduce aquatic pollution, but they are generally costly, labor-intensive and generate secondary waste. An interesting alternative approach is phytoremediation using aquatic macrophytes (Vardanyan and Ingole., 2006; Rai, P. K., 2009). Macrophytes actively take up metals from the sediments through their roots and translocate them to the shoots, which are available for grazing by other organisms (Mishra, V. K. & B. D. Tripathi, 2008), representing a major route of bioaccumulation of heavy metals in the aquatic food chain. The present study was carried out to estimate the concentrations of different heavy metals in thirteen of the most abundant aquatic macrophytes growing in the catchment zone of the Lake Sevan (Figure 1) and the importance of the pytoremediation (Figure 2) in controlling of water quality.

Materials and Methods

Study area:

Gavaraget, Argichi, Makenis and Masrik rivers out of 28 rivers of Lake sevan basin.

Figure 1. Lake Sevan

Figure 2.
The Mechanism of phytoremediation

Sample:

No*	Name	Family	Sampling site
1	*Potamogeton natans* L.	Potamogetonaceae	C
2	*Veronica anagallis-aquatica* L.	Scrophulariaceae	A
3	*Lemna minor* L.	Lemnaceae	B
4	*Veronica beccabunga* L.	Scrophulariaceae	D
5	*Ranunculus rionii* (Lagger.)	Ranunculaceae	B
6	*Myriophyllum spicatum* L.	Haloragaceae	B
7	*Alisma plantago-aquatica* L.	Alismataceae	D
8	*Potamogeton pectinatus* L.	Potamogetonaceae	C
9	*Schoenoplectus lacustris* subsp. *tabernaemontani*	Cyperaceae	C
10	*Glyceria plicata* Fries	Gramineae	A
11	*Potamogeton crispus* L.	Potamogetonaceae	A
12	*Potamogeton perfoliatus* L.	Potamogetonaceae	C
13	*Juncus bufonius* L.	Juncaceae	B

Ten representative samples of similar sizes from each of the available 13 macrophyte species (Table1) were collected from all 4 sites. Plant samples were powdered following cleaning, sorting, and drying.

Table 1: Macrophytes

Analysis:

Acidified, filtered water samples and microwave-heat-pressure acid digested plant materials were analyzed on specific instruments following standard methods (Figure 3).

Figure 3: Method

Results

Water:

General water parameters showed little differences between the four selected sites. Concentrations of Co (0.5µg/l), Cd (0.5µg/l), Tl (0.1µg/l) and Hg (<0.3µg/l) in water were in the same range for the all sites (Table 2). For Cu, the highest concentration (2.4 µg/l) was recorded in Gavaraget and the lowest (1.3 µg/l) was in Makenis. For Ni, the highest concentration was in Masrik (3.5µg/l) and the lowest in Gavaraget (1.4µg/l). For Pb the highest (1.3 µg/l) concentration was in Gavaraget and at the rest of the sites the value was always <0.5 µg/l. Zn was the highest (34.6 µg/l) in Gavaraget and the lowest (5µg/l) in Argichi, Masrik and Makenis. It was quite obvious that the water in the Gavaraget was most polluted in terms of load of different heavy metals which could be attributed to the discharge of untreated sewage from the city of Gavaraget into the river.

Rivers Heavy metals*	Gavaraget	Argichi	Makenis	Masrik
Cd	<0.5	<0.5	<0.5	<0.5
Co	<0.5	<0.5	<0.5	<0.5
Cr	3.4	2.3	3.4	2.9
Cu	2.4	1.9	1.3	1.8
Ni	1.4	1.5	1.7	3.5
Pb	1.3	<0.5	<0.5	<0.5
Tl	<0.1	<0.1	<0.1	<0.1
Zn	34.6	5.0	5.0	5.0
Hg	<0.3	<0.3	<0.3	<0.3

Table 2:
Metals in water

Plants:

In general, there was no specific pattern in the accumulation of heavy metals by different species. Hg (<0.01mg/kg) was below detection limit in all the plants. Co was the maximum (8.94mg/kg) in *Lemna minor* L., whereas Cu (19.80 mg/kg) and Mo (2.98 mg/kg) were the highest in *Batrachium rionii* (Lagger). Cd was the highest (0.60 mg/kg) in *Veronica anagallis-aquatica* L. The highest concentrations of Pb (5.25 mg/kg) and Zn (129 mg/kg) were in *Myriophyllum spicatum* L. Tl was the highest (0.14 mg/kg) in *Lemna minor L., whereas* Ni was the maximum (15.8 mg/kg) in *Potamogeton perfoliatus* L. (figures 4A-D). ***Myriophyllum spicatum* L.** showed the highest accumulation of total heavy metals, whereas ***Potamogeton perfoliatus* L., *Ranunculus rionii* (Lagger.), *Veronica anagallis-aquatica* L.** also showed high potential of heavy metal accumulation. It is quite interesting to note that the macrophytes accumulated toxic heavy metals like Cd, Co or Pb several hundred folds than that of the water bodies where these metals were hardly detectable. This shows the unique properties of these plants in purifying the water by means of entrapment of the heavy metals in their tissues.

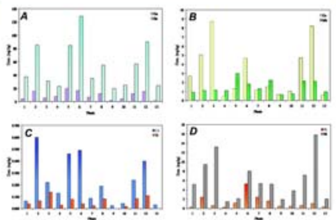

Figure 4: Concentrations of Cu & Zn (A), Co & Mo (B), Cd & Ti (C), and Pb & Ni (D) in 13 plant samples

Conclusions

We conclude that there is a uniform pattern of heavy metal variation in the macrophytes of Lake Sevan Basin. 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 water and wetlands. There is an urgent need to study more of those specific macrophytes which are "responsible" for cleaning the water body from toxic heavy metals. We are now running laboratory experiments to understand the role of root-exudates in metal chelating, root-microbes interaction to probe into the mechanism of metal-hyperaccumulation in some macrophytes.

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