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Role of *Trapa Natans* (Water Chestnut) in Removal of Heavy Metals from Water

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Abstract: ***Heavy metals are hazardous to the aquatic environment. They have the tendency to accumulate and magnify at different trophic levels in the aquatic ecosystems. Their hundred percent removal from water is not possible yet their removal to some extent can be done by the use of aquatic plants which have been found to have the capability of absorbing the heavy metals from the water. Trapa natans, commonly known as water chestnut or Singhada is a promising aquatic plant which can be used for the removal of heavy metals from water. In the present study the role of Trapa natans in removal of heavy metals from the water of one of the important lakes of Indore has been assessed. In addition, the extent of heavy metal removal by the plants has also been recorded. The results indicate the efficacy of Trapa natans plants in removing the heavy metals from lake water by nearly 50% approximately, on an average.***

Keywords*:* *Trapa natans*, heavy metals, lead, chromium, accumulate, magnify

1. Introduction

The metals with high density, high atomic weights or atomic numbers are called heavy metals. Examples include Cadmium, Arsenic, Chromium, Mercury, Lead, Manganese, Iron, Zinc, Nickel etc. The heavy metals are unable to be broken down into simple compounds and hence are considered as non-degradable. They are hazardous to the environment as well as the living beings [1]. The contamination of water bodies by heavy metals is one of the sensitive issues in recent times [2]. The primary sources of heavy metals in the water bodies are disposal of waste water, industrial effluents, agricultural wastes, mining etc. Many research works have shown that the heavy metals have the tendency to accumulate in plants, animals and human beings due to their highly reactive nature, causing numerous disorders and diseases, even as severe as cancer. The heavy metals bioconcentrate in the different trophic levels of food chains and food webs hence disturbing the aquatic ecosystems. Due to their toxicity, heavy metals are threats to the water reserves [3]. Thus, it is essential to remove them from the aquatic environment so that the water reserves are protected and the aquatic life is prevented from their harmful effects. For the efficient removal of the heavy metals from the water, suitable and effective methods are required. Over the years many bioremediation methods have attained great significance in removal of heavy metals from water bodies due to their eco-friendly and cost-effective nature. Different types of microorganisms and plants are engaged in removal of heavy metals from the water.

Nowadays most of the aquatic plants are employed to remove or reduce different types of heavy metals from the water. The aquatic plants remove or reduce the heavy metals mainly by four ways as explained by [4], including (I) restriction of entering heavy metals into the plants by attaching them to the cell wall, (II) absorption and accumulation of heavy metals in their roots itself (III) not allowing their translocation to other parts and (IV) hyperaccumulation, where the heavy metals are collected in a particular plant part in large amounts.

One of the efficient and effective aquatic plants used for removal of toxic heavy metals from water is *Trapa natan* commonly known as water chestnut or Singhada [5]. They are free floating aquatic plants, able to grow in shallow to deep water bodies like ponds, lakes, rivers etc [6]. *Trapa natans* has a stem in the centre with a rosette at the top made up of a special type of leaf arrangement [7]. The stem extends from base to the surface of water and anchors into the sediment by the help of a branched root system [8]. The two types of leaves are large and floating and spiny submerged [8]. The flowers are white, auxiliary, bisexual, present above the water surface in the centre of rosette [9]. Fruit is about 2 cm in diameter, with a triangular shape and bears two horns [10]. The outer covering of *Trapa natans* (Water Chestnut) is very hard thus it is difficult to peel off to obtain the edible part [11]. The dicotyledonous seed has two asymmetrical parts that includes one which is large and starchy, present inside the endocarp. Another one is small and scaly [8]. 10 to 15 fruits are produced by each rosette, each fruit is about six grams in weight or 2.1 grams as dry mass [8]. The *Trapa natans* plants are grown in many places in India, commercially for its fruits [11] which are nutritious and healthy [12].

Trapa natans have been used widely by various researchers as a plant of interest in removal of heavy metals from the water hence decreasing the heavy metal contamination. The present study was conducted to assess the ability of *Trapa natans* plants to remove the heavy metals from water and also the extent of removal of heavy metals by the plant.

2. Materials and Methods

2.1. Study sites:

The study site selected for the present study was Baroda Daulat Lake situated in village Kanadia. It is one of the primary lakes near Indore district of Madhya Pradesh, India. The lake is spread in the area of approximately one Sq. km. Commercial cultivation of *Trapa natans* in the lake is a common practice in the lake for decades. The water of Baroda Daulat Lake was found to be contaminated with heavy metals as found during the initial testing (initial values shown in the table 1). The cause of heavy metal contamination includes disposal of domestic sewage from the surrounding villages, leached fertilisers and pesticides from nearby fields, dumping of garbage by local people and washing of vehicles, clothes, cattle etc.

2.2. Samples:

Water samples and *Trapa natans* (Water Chestnut) plants from the study site (Baroda Daulat Lake)

2.3. Sample Collection:

Water samples (surface water) was collected from the study site in plastic jerry cans washed with distilled water *Trapa natans* plants were also collected from the site, washed and taken in plastic bags. The sample collection was done in March 2024.

2.4. Experimental setup:

An experiment was performed for two months (March 2024 to May 2024). In order to study the ability of the *Trapa natans* plants to remove heavy metals, their detection in the lake water was done before and after the experiment indicated in the study by initial and final values respectively. To assure the removal of heavy metals by *Trapa natans* plants themselves, heavy metal detection was also performed in the roots of the *Trapa natans* plants grown in metal contaminated water of lake (study site) during the experiment. The experimental process was carried out in triplicates. To perform the experiment, *Trapa natans* plants were grown in large containers which were filled with about hundred litres of lake water in each followed by placing four *Trapa natans* plants in each container of the experimental setup and allowed to grow for complete experimental duration of two months.

2.5. Method for Assessment of heavy metals

Various heavy metals were determined in the lake water samples as well as the roots of the *Trapa natans* plants collected from the experimental containers by using AAS (Atomic Absorption spectrophotometer) (Perkin Elmer PinAAcle 900H) as described by [13]. In the water samples them heavy metals were directly assessed while in the root samples the extract was prepared using the wet digestion method.

2.5.1 Root sample preparation

The roots were cut into small pieces, dried in air for 6 to 7 days and then dried in an oven at 80^{o}C for six hours. The dried root samples were grinded and sieved to obtain a fine powder.

2.5.2 Wet digestion

10 ml of nitric acid and perchloric acid in the ratio of 2: 1 was added to 0.5 gm of powdered root sample and kept overnight. The mixture was then boiled thoroughly for about 2 to 3 hours till the fumes became white and colourless. The final volume was made up to 50 ml by adding distilled water. The solution was further filtered and used for determination of heavy metals.

2.6. Statistical Analysis -

All the experiments were done in triple replicates. The mean, standard deviation was first calculated. The significant difference between the initial and final values was calculated using the student's T test. All the calculations were done using Microsoft Office (Excel).

3. Results and Discussion

3.1 Heavy metal concentration in water of Baroda Daulat Lake:

The initial testing of water samples of Baroda Daulat Lake presented the results (mean and standard deviation) are shown in the table 1 below. According to this table the lake water was found to be contaminated with chromium and lead initially. These metals were found in higher concentration than the permissible limits according to [14] (given in the table 1). Other heavy metals tested were either absent or were present in very low concentrations, within the permissible limits. Hence the heavy metal removal efficacy of *Trapa natans* plants was assessed in this study for two heavy metals; Chromium and Lead.

Table 1: Concentrations of heavy metals in the water of the study site (Baroda Daulat Lake)

S. No	Heavy metals	Max. permissible limits (BIS) in mg/L	Heavy Metal Concentrations in water of Baroda Daulat lake mg/L		
			Initial value	Final value	p values
1	**Cd**	0.003	-	-	-
2	**Cr**	0.05	0.341 + 0.012	0.174 + 0.021	0.04*
3	**Cu**	0.05	-	-	-
4	**Pb**	0.01	0.871 +	0.427 + 0.025	0.05*
5	**Mn**	0.1	0.006 +	-	-
6	**Ni**	0.02	-	-	-
7	**Fe**	0.3	0.002 +	-	-
8	**Zn**	5.0	0.007 +	-	-

In the table, * indicates a significant difference. BIS = Bureau of Indian Standards. Cd=Cadmium, Cr=Chromium, Cu=Copper, Pb=Lead, Mn=Manganese, Ni=Nickel, Fe=iron and Zn =Zinc.

The table 1 also shows the final value of the heavy metal (chromium and lead) concentrations in the water of Baroda Daulat Lake (study site) after the experiment (final value) as well as their significance (p values). The results given in table 1 indicates that the water of the study site (Baroda Daulat Lake) was contaminated with two heavy metals namely chromium and lead. When *Trapa natans* plants were grown in this metal contaminated water, the concentration of lead as well as chromium were found to be reduced after the experiment as indicated by their final values (Figure 1). The reduction in the concentration of chromium and lead in the water of Baroda Daulat Lake (study site) was found to be significant ($p<0.05$).

3.2 Heavy Metal Concentrations in roots of *Trapa natans*:

The mean concentration (and standard deviation) of Chromium and Lead after the experiment (final values) detected in the roots of the *Trapa natans* plants grown in the lake water (study site) are given in the table 2 below.

Table 2: Mean and standard deviation of heavy metal concentration in roots of *Trapa natans.*

S. No.	Heavy Metals	Concentration of heavy metals in roots (mg/Kg)
1.	Cr	0.127 + 0.021
2.	Pb	0.142 + 0.023

The reduction in the concentration of heavy metals (chromium and lead) was resulted due to their absorption by *Trapa natans* plants. This is confirmed by the presence of both the heavy metals, chromium and lead in the roots of the plants (Table2, Figure 2).

The decrease in heavy metal concentration (chromium and lead) in water and presence of similar heavy metals in the roots of the *Trapa natans* plants clearly indicates that the plants have absorbed the metals from the surrounding water [15] also revealed similar results that higher amounts of chromium and lead present in the lake water were reduced by *Trapa natans* plants. [16] also reported the absorption of chromium and lead by roots of *Trapa natans* plants. The concentration of chromium in the water of Baroda Daulat Lake (study site) was reduced by 48.97 % and lead by 51.09 % due to the uptake of these metals by plant roots. The concentration of chromium and lead in the water and roots are shown in the figure 1 and 2 below, respectively.

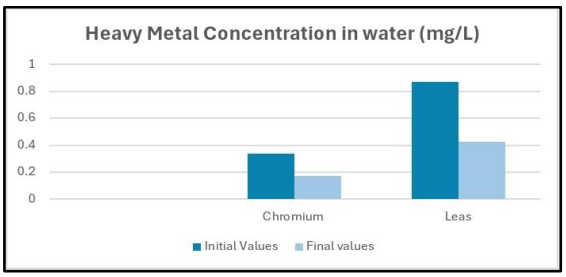

Figure 1: Chromium and Lead concentration in lake water

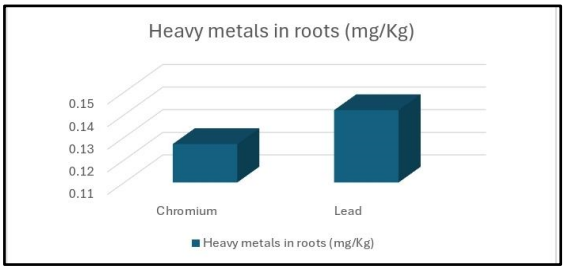

Figure 2: Concentration of Lead and Chromium in roots of *Trapa natans*.

The results of the present study shows that concentration of lead was higher than chromium in the lake water as well as

the roots of the *Trapa natans* plants suggesting that more the concentration of a heavy metal in the water more will be its uptake by *Trapa natans* roots.

4. Conclusion

The present study depicts that the water of Baroda Daulat Lake was found to be contaminated with chromium and lead. The possible reasons might be the mixing of domestic sewage in the lake water from surrounding villages, dumping of waste by local people, fertilisers and pesticides from agricultural fields situated near the lake etc. Growing of the aquatic plant *Trapa natans* (Water Chestnut) in the metal contaminated water of the lake shows that the plants have the ability to reduce the concentration of heavy metals chromium and lead from the water. The cause of this reduction, according to the present study, is the absorption of these heavy metals by the roots of the plant. The extent of absorption varies from metal to metal and also on the concentration of metal present in the water.

The accumulation tendency of *Trapa natans* plants for various heavy metals, impact of heavy metal accumulation on plant, the fate of heavy metals accumulated in roots are some of the criteria which require further studies.

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