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Study of Heavy Metal Remediation Potential of *Eichhornia crassipes* on Ponds of Raipur District

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Abstract

The floating macrophyte known as the water hyacinth, Eichhornia crassipes, originated in tropical South America and is now found in all tropical climates. The water hyacinth is also criticized for reducing biodiversity. In any case, it could conceive serious water activity issues due to its vegetative reduplication and high development rate, assuming it's brought into unfamiliar submarine biological systems. all things considered, it's colossal biomass item rate, its high avoidance to contamination, and its weighty pith and supplement submersion limits qualify it for use in wastewater treatment lakes. Due to its rapid growth and substantial biogas production, the water hyacinth (*Eichhornia crassipes*) has the potential to purify colorful wastewater. The present study is focused on the heavy metal remedial potential of water hyacinth. The plants were grown in water tanks containing salts of heavy metals of known concentration for 14 days. The Atomic Absorption Spectrum analysis revealed considerable deterioration in the concentration thus confirming its phytoremediation potential.

Keywords: *Heavy metals, phytoremediation, Eichhornia crassipes, Atomic Absorption Spectrum*

Introduction

Water is an essential natural resource for humans, agriculture, and the maintenance of life on Earth. Unfortunately, numerous human activities, including rapid industrialization, urbanization, and unplanned agricultural practices, have significantly increased the number of contaminants in water over the past few decades (CPCB, 2008; Giripunje*et al.*, 2015). a lot of different businesses, like the textile, tannery, paper and pulp, battery, printing, electroplating, iron-steel, paint, pesticide, and pharmaceutical industries, among others. consume a lot of water and chemicals whose composition and toxicity vary, which are released as wastewater into various water systems.

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Phytoremediation is an emerging technology that is rapidly gaining interest and promises effective and inexpensive clean-up of hazardous waste sites contaminated with metals, hydrocarbons, pesticides, and chlorinated solvents (Macek*et al*., 2000; Susarla*et al*., 2002;Xia *et al*., 2003).According to Singhal and Rai (2003), the water hyacinth (*Eichhornia crassipes Solms*) has the potential to purify a variety of wastewaters due to its rapid growth and substantial biogas production. Nitrate, ammonium, and soluble phosphorus are examples of inorganic contaminants (Reddy et al., 1982; Heavy metals (Muramoto and Oki, 1983; Reddy, 1983; Zhu and co., 1999) which can be effectively eliminated by the water hyacinth through accumulation and uptake.

Since cultivated plants are the primary entry point for heavy metals into the food chain, posing a risk to human health, the toxicity of heavy metals has become a particular concern over the past ten years (Tatar *et al*.,). This has increased the risk posed by the consumption of contaminated food.Food chains, ingestion, and inhalation are all methods by which heavy metals typically enter the body. However, the immune system is stimulated when these metals enter the body, which can result in nausea, anorexia, vomiting, gastrointestinal abnormalities, and dermatitis (Tchounwou*et al*., 2012).

The issue of heavy metal pollution requires ongoing investigation and monitoring. These metals tend toget biomagnified in humans through the food chain and do not degrade; subsequently there is a vital necessity for elimination ofheavy metals from debased destinations. As a result, numerous researchers have concentrated on specific control strategies for removing heavy metals from various wastewater systems (Adhoum et al., 2004; 2008, Heidmann and Calmano; Kabdasl et al., 2012; Ahmad and co., 2016a).

Materials and Methods

The city of Raipur is both the administrative center of Raipur District and the state capital of Chhattisgarh. Raipur District is bordered by Bilaspur by the north, Bastar& Orissa by the South, Raigarh& Orissa by the East, and the Durg to the West. The district is divided into two major divisions, namely the Chhattisgarh and the Hilly Areas. Raipur city is situated at the center of the Raipur District. It covers an area of 180sq km and it maintains a height of 298.16 meters above mean sea level. According to the census report 2001, the city has a population of 605132.

The study area - The Siltara industrial area, which is on NH-200 and is about 10 kilometers away from Raipur, the Chhattisgarh capital, has about 97 industries. Small and medium-sized businesses

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occupy a total of 1300 hectares (ha) of the industrial area. Godawari Power and Ispat is the largest plant with a 0.495 MTPA capacity, followed by SKS Ispat (0.27 MTPA) (CSIDC). Sponge iron, Ferroalloy, and cooking gas bottling plants are the main businesses in the study area (Tiwari, 2016). Water sample was taken from five distinct water bodies near industries for the current study. The water samples were subjected to the physicochemical tests. The plants of *Eicchornia crassipes* were obtained from local water bodies and were then identified by experts.

Survey for collection of water samples- From November 2019 to March 2020, water samples were collected at random from two location viz. at themiddle of the water bodies and near the banks of the selected ponds on a monthly basis. Additionally, samples were collected in triplicates at random from a range of 500-meter intervals between each sampling site. Based on their proximity to various industries in the Siltara industrial area, Raipur (C.G.), the following locations were chosen for the sampling:

1. Birsabudha Talab- Near Jaiswal Neco Industries
2. Rawabhata Talab- Near Metal Park Raipur
3. Dongia Talab- Near IOCL Botteling Plant
4. Chatwa Talab- Near Sarvottam Food Industry
5. Sitla Talab- Near Sarda Energy and Minerals

Degradation and Purification of Heavy metal contaminated Water Samples-

Jars with 2 litre capacity were filled with 1 litre of water samples to keep space for the growth of the plant. For the study of each metal, three experimental jars were placed and one was kept as a control.

The samples were subjected to Atomic Absorption Analysis prior to treatment, which revealed the presence of various heavy metals. Based on their prevalence and contribution to environmental pollution, five of them were identified for the current study: Mercury(Hg), Lead (Pb), Cadmium (Cd), Copper(Cu), and Zinc (Zn).

The plants were thoroughly cleaned of dirt using both tap water and distilled water during the phytoremediation process. For 20 days, the acclimatization was carried out in the laboratory using only tap water. After that, the corresponding salts were used to prepare a heavy metal concentration of 50 µg/ml, which was then added to the tanks at their initial level. The debasement examination was then performed. The macrophytes die as a result of the effluent's alkaline nature. Thus, the pH was then neutralized to 7.2 using 1% Acetic Acid solution for additional treatment. *Eicchornia crassipes* samples were first planted in a tank containing tap water after the pH was neutralized. These samples were taken from areas with a lot of growth. The plants were moved into each tank

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after they had grown and were kept in an area with enough air flow and sunlight. In two of the three treatments, the collected samples were placed, and in one tank the plant was not used serving as a control. The samples were then examined for heavy metal degradation, namely Mercury (Hg), copper (Cu), chromium (Cr), lead (Pb), cadmium (Cd), and chromium (Cr) The water samples were then prepared for atomic absorption spectrum analysis after 14 days of proliferation(Peuke and Rennenbourgh, 2005).

Digestion of water samples with Nitric Acid

Samples under study were first digested using the wet digestion method. Briefly approx. 2ml of the water samples were taken in 100ml volumetric flasks and about 4 ml of HNO_3 was added the solution was allowed to stand for a few hours then it was carefully heated over a water bath till red fumes coming from the flask completely ceased. Flasks were allowed to cool at room temperature and then about 4 ml of perchloric acid was added. Flasks were heated again over a water bath to evaporate till a small portion was left which was then filtered out through Whatman filter paper no.41 (Shreekanth *et al.,* 2013) and made up the volume using distilled water to 100ml. A similar process was repeated for the control samples. The samples were then kept in air-tight containers till dispatched for Atomic Absorption Spectrum analysis. The Atomic Absorption Analysis of water samples in this study was performed at IITR, Lucknow (U.P), India.

Result And Discussion

The water sample was digested first, as previously said, and then put through an AAS test to determine whether or not heavy metals were present. For removal and degradation investigations, heavy metals like zinc (Zn), copper (Cu), cadmium (Cd), lead (Pb), and mercury (Hg) were chosen based on their occurrence. The chosen solvents were prepared using the corresponding salts. All the metals were initially present in a concentration of 0.050 μg/ml. the preparatory steps Several heavy elements, including Mercury, Lead, Copper, Arsenic, and Zinc, were found in water samples after being subjected to an AAS examination. varying concentrations of cadmium and strontium between 0.012 and 0.042 g/ml. Lead, Cadmium, Copper, Zinc, and Mercury were found in higher concentrations, thus they were examined.

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Fig. 1: Lab setup for determination of heavy metals

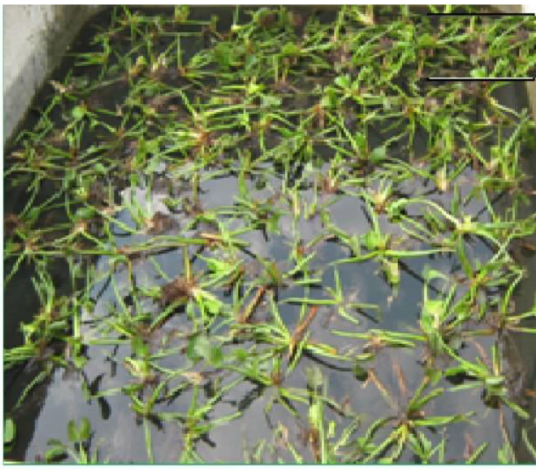

Fig. 2: Initial set up for determination of heavy metals

Fig. 3: Final set up for determination of heavy metals

Results and Discussion

The water sample was digested first, as previously said, and then put through an AAS test to determine whether heavy metals were present. For removal and degradation investigations, heavy metals like zinc (Zn), copper (Cu), cadmium (Cd), lead (Pb), and mercury (Hg) were chosen based on their occurrence. The chosen solvents were prepared using the corresponding salts. All the metals were initially present in a concentration of 0.050 g/ml. the preparatory steps Several heavy elements, including Mercury, Lead, Copper, Arsenic, and Zinc, were found in water samples after being subjected to an AAS examination. varying concentrations of cadmium and strontium between 0.012 and 0.042 g/ml. Lead, Cadmium, Copper, Zinc, and Mercury were found in higher concentrations, thus they were examined. The following results were obtained.

Sampling site 1: Dongia Talab

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Name of Heavy Metal	Concentration before treatment (µg /ml)	Concentration after treatment (µg /ml)
Zn	0.050	0.042
Cu	0.050	0.035
Cd	0.050	0.043
Pb	0.050	0.027
Hg	0.050	0.034

When the first sample was treated with *Eicchornia,* the concentration of Cadmium (Cd) was found to be the highest of all the heavy metals studied, while the concentration of Lead (Pb) was found to be the lowest, indicating that the rate of Lead degradation was most effective.

Sampling site 2: Rawabhata Talab

Name of Heavy Metal	Concentration before treatment(µg /ml)	Concentration after treatment(µg /ml)
Zn	0.050	0.030
Cu	0.050	0.023
Cd	0.050	0.048
Pb	0.050	0.054
Hg	0.050	0.027

The concentration of lead (Pb) was found to be highest in the second Rawabhata Talab sample, and the concentration of Copper (Cu) was lowest after treatment with *Eicchornia*depicting most effective degradation of Copper.

Sampling site 3: Birsabudha Talab

Name of Heavy Metal	Concentration before treatment(µg /ml)	Concentration after treatment(µg /ml)
Zn	0.050	0.030
Cu	0.050	0.031
Cd	0.050	0.045
Pb	0.050	0.055
Hg	0.050	0.047

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The highest concentration of zinc (Zn) was found in the third Birsabudha Talab sample, while the highest concentration of lead (Pb) was found following treatment with *Eicchornia*exhibiting its highest degradation.

Sampling site 4: Chatwa Talab

Name of Heavy Metal	Concentration before treatment(µg /ml)	Concentration after treatment(µg /ml)
Zn	0.050	0.036
Cu	0.050	0.031
Cd	0.050	0.042
Pb	0.050	0.046
Hg	0.050	0.032

The highest concentration of lead (Pb) was found in the fourth sample taken from Chatwa Talab, while the highest concentration of copper (Cu) was found after *Eicchornia* treatment, indicating the best degradation.

Sampling site 5: Sitla Talab

Name of Heavy Metal	Concentration before treatment(µg/ml)	Concentration after treatment(µg /ml)
Zn	0.050	0.043
Cu	0.050	0.032
Cd	0.050	0.027
Pb	0.050	0.046
Hg	0.050	0.047

Mercury (Hg) concentrations were highest in the fifth Sitla Talab sample, while Cadmium (Cd) concentrations were highest after *Eicchornia* treatment, indicating the best degradation.

Eichhornia crassipes uptake capacity of Pb, Zn, Cu, Cd, and Cr was studied. The plant tissue analysis made by Alka and Triphati (2007) revealed a higher accumulation of metals in roots than in leaves of water hyacinths. It is known that lead in high concentrations is a potential health risk, especially around large cities or industrial areas. The Lead (Pb) uptake and accumulation of Pb is higher in the case of Birsabudha Talab referring to its proximity to polishing industries. The

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accumulation of this metal in the roots is sufficiently high such that *Eichhornia crassipes* is recommended for filtration of wastewater.

Zinc is an essential and beneficial element for human bodies and plants. Complete exclusion of Zn is not possible due to its dual role, an essential microelement on the one hand and a toxic environmental factor on the other (Xiaomei et al., 2004). Zinc is considered cadmium to be a very mobile and bio-accessible metal, which through its accumulation in soils and plants can reach the food chain.Among the three elements tested in his study, Cd was the most toxic. The greater absorption was registered at Cr better than Zn and Cd. Similarly, in the present study, the absorption of Zinc (Zn) was found to be sufficient in all the samples collected explaining the potency of *Eicchornia crassipes* for zinc absorption.

The phytoremediation of Cadmium (Cd) was found to be significant only in two samples collected from Sitla Talab andRawabhata Talab. The location of these two ponds was near bottling plant and steel industries hence the amount of cadmium as the principal pollutant is high making the *Eichhornia crassipes* present as local flora more adapted for high uptake and bioabsorption of cadmium as compared to other sampling sites which lack such ability due to absence of such industries in the proximity.

Copper sulphate (CuSO4) is used as a fungicide and as algae control in domestic lakes and ponds. It is used in gardening powders and sprays to kill mildew. Copper ions are highly toxic to fish, so care must be taken with the dosage. The very low concentrations of copper sulphate used to control most species of algae also inhibit the growth of bacteria such as *Escherichia coli*. Copper is particularly adsorbed or fixed in the soil, making it one of the less displaceable heavy elements. The amount of copper decreased considerably in every experimental set up displaying its considerable phytoremediation by water hyacinth.

Chromium compounds are commonly used as tanning agents, textile pigments and preservatives, antifouling paints, wood preservatives, metal finishing, and in electroplating. The toxic nature of chromium depends upon its valency state: Cr (VI) is more toxic than Cr (III), because of its solubility. Contamination of soil and groundwater due to the use of chromium in various anthropomorphic activities has become a serious source of concern to plant and animal scientists over the past decade (Sunadaramoorthy*et al.,* 2010). The bioabsorption of chromium in the present study was found to be significant in only one sample.

Conclusion

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The accumulation of heavy metals by*Eicchornia crassipes* provides an advantage for phytoremediation over other methods which are more costly and not environment friendly. Therefore, there is a need to improve the possibilities of accumulation of heavy metals in aquatic plants. Heavy metals become a primary concern than other environmental pollutions because heavy metals cannot be destroyed by degradation. The remediation process of contaminated soils, groundwater, and surface water by heavy metals needs some methods to remove the metals from contaminated areas. Several methods are being used for removing the pollutants from the contaminated environments. Remediation techniques can be used for removing heavy metals from contaminated ground water are extraction and treatment by activated carbon adsorption, microbes use, air stripping, chemical, biological, biochemical and biosorptive treatment technologies The use of some of these remediation techniques requires a high cost, a long time, logistical problems, and technical complexity. Therefore, alternative solution is needed for heavy metals removing from the environment. Bioremediation or phytoremediation is an innovative and promising technology available for removal of heavy metals and recovery of the heavy metals in polluted water.

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