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RESEARCH ARTICLE

ASSESSMENT AND ENHANCEMENT OF PHYTOREMEDIATION STUDIES OF CONTAMINATED YAMUNA WATER USING *HYDRILLA VERTICILLATA*

*Talad Khan, Harihar and Samuel Gorden Singh

Department of Botany, St. John's College, Agra- 282002, Uttar Pradesh, India

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***Corresponding Author:**
Talad Khan

ABSTRACT

The present study was carried out to analyze the physicochemical parameters and heavy metal of Yamuna water from Agra near Taj Mahal. Heavy metals persist as major pollutants in water bodies. Phytoremediation, the green technology is a cost effective and an in situ method for remediation of pollutants. Present study is an integrated approach towards efficient removal of physicochemical parameters and toxic heavy metals from polluted Yamuna water using *Hydrilla verticillata* with different treatment of EDTA and EGTA. Physicochemical parameters and heavy metals investigated in present study include pH, Electrical conductivity, TDS, Dissolved oxygen, BOD, COD, Pb, Zn, Ni. In this research three tubs were used as control (without amendments) and 9 tubs were used in triplicate for each treatment T1, T2, T3 on 30 days of experimental period. The accumulation of Pb was found more 9.28 ppm in roots copared to the stem and leaves of *Hydrilla verticillata* in T3. The accumulation of Zn and Ni were found 7.21 ppm and 6.3 ppm in roots on T3. Result shows that *Hydrilla verticillata* is a potential hyperaccumulator and suitable for Pb, Zn and Ni accumulation.

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INTRODUCTION

Rivers are an essential source of fresh water along which ancient developed. River Yamuna is one of India's famous rivers in the national capital city, New Delhi. Several large and small cities are also located along its entire stretch from Yamunotri to the Ganga River at Prayagraj. Rivers are considered a significant source of potable water that fulfills all human requirements and ecology balance. Rapid urbanization, industrialization and increase population result in the discharge of a considerable amount of sewage, industrial effluents and agricultural runoff being released to rivers and water bodies that pollutes almost all the river and water sources of country (Barejee *et al*. 2014; Barde *et al*. 2015; Sharma *et al*. 2015). Many studies have been conducted on various rivers of the country as well as on Yamuna River regarding the change in the physicochemical parameters due to many factors such as temporal, spatial, seasonal, environmental variations and even small modifications due to the choice of sampling sites (Khaiwal *et al*. 2003; Maheshwari *et al*. 2011; Gupta *et al*. 2013; Rout *et al*. 2015; Dubey 2015). The point sources of pollution are sewage and wastewater as non-point sources are inorganic fertilizer in agricultural fields and animal manure responsible for nutrient enrichment in river water (Eliku and Leta 2018). Yamuna water pollution is one of the most serious problems faced by man today. Since Yamuna water is the vital concern for mankind and essential for man, animal and aquatic. It is the universal enabling chemical which is capable of dissolving or carrying in suspension of a variety of toxic materials from heavy flux of sewage, industrial effluents, domestic and agricultural waste. That is why it is of special interest to study the Yamuna water pollution.

Heavy metals being very toxic to human and aquatic life decide the pollution index of water and soil. The heavy metals in the aquatic ecosystem are high in concentration due to industrial effluents, refuse and sewage. The Yamuna River water in the Delhi region, assessing the seasonal variation of heavy metals concentration. The concentration was high in summer compared to winter values. The values of Pb, Cd, Cr, Cu, Zn and Co were found within permissible limits (Kaur *et al*. 2012). All the previous studies show that the Yamuna River's water is continuously polluted beyond the entire limit for the last many decades. The problem is much more severe when the rivers flow through highly polluted areas as in such areas people directly uses the river water for their daily needs, agricultural and industrial use. There are many heavy metal remediation processes available like phytoremediation, absorption, adsorption, and filtration. The phytoremediation potential of numerous plant species has been recognized and considered as hyperaccumulators if they are capable of accumulating potentially phytotoxic elements to concentrations 50-500 times higher than average plants (Lasat 2000). Many aquatic plants have the ability to bio-accumulate pollutants such as toxic heavy metals and nutrients, in large quantities and effectively remediate wastewater containing various inorganic and organic pollutants including heavy metals, pesticides, nutrients, oils, POPs etc. The macrophytes exhibits absorption of the pollutants at different rates and efficiencies because it depends on the concentration of pollutant, duration of exposure and other factors including environment conditions (pH, temperature etc.), physico-chemical properties of contaminants (solubility, pressure etc.), abundance, biochemical composition, habit and species (Anand *et al* 2017).

Macrophytes produce metal-binding cysteine-rich peptides (phytochelatins) to detoxify metals by forming complexes with them, under the pollution stress. The phytoremediation ability of several macrophytes such as water hyacinth (*Eichhornia crassipes*), duckweed (*Lemna* spp.), water lettuce (*Pistia stratiotes* L.), vetiver grass (*Chrysopogon zizanioides*), water spinach (*Ipomoea aquatica*), bulrush (Typha), common reed (*Phragmites australis*), etc. and microalgae including *Chlorella vulgaris* were utilized for the treatment of different types of wastewater by many researchers. Many macrophytes are excellent tools for phytoremediation approach, because these universally available aquatic plants have the excellent ability to survive in adverse conditions and high colonisation rates (Aisien *et al*. 2015). To enhance the phytoremediation efficiency, many methods, including agricultural strategies and chemical agents, have been examined (Brown *et al*. 1995; Hammer and Keller 2003; Koopmans *et al*. 2008). Various chelators such as EDTA, EGTA, organic acid, citric acid, or nicotianamine may be helping the translocation of metal cations through the xylem. EDTA is one of the most applied chelating agents. As EDTA have drawbacks like high toxicity, persistent nature in the environment and expensiveness (Wuana & Okieimen 2011).The present investigation was carried out to assess as physicochemical parameters and heavy metals of Yamuna water of Agra near Taj mahal and the plant used for this study was *Hydrilla verticillata.*

MATERIALS AND METHODS

Collection and analysis of water sample: water samples were collected from Yamuna River at Agra near the Taj Mahal in the first week of March 2022. These samples were collected in the pre sterilized plastic container and brought to the laboratory and kept at 25 degree Celsius for further analysis. Collected sample were analyzed for their different physicochemical parameters and heavy metals by the standard methods. Physicochemical parameters like pH, EC, TDS, BOD, COD, Dissolved oxygen and heavy metals like Zn, Pb, Cd were analyzed during the study. Collection of plant sample: Young plant sample was collected from Yamuna River of Agra. Plant use for this study was *Hydrilla verticillata* and rinsed with distilled water to remove all the dirt.

Figure 1. Sampling Site

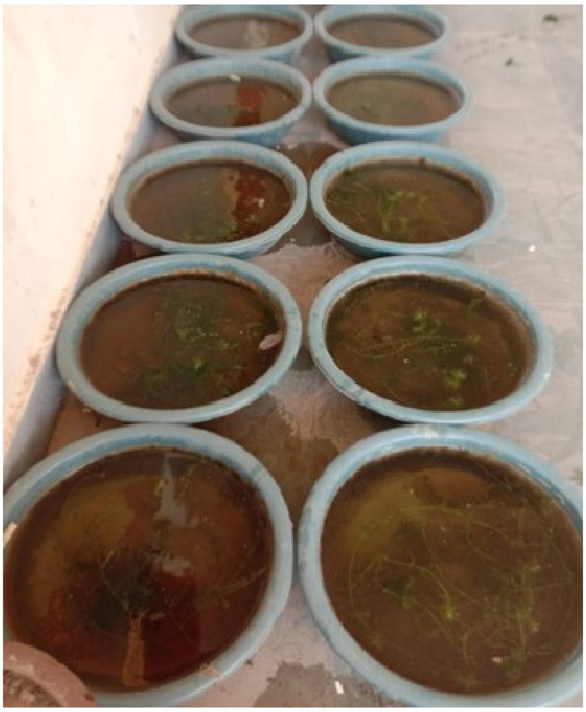


Figure 2. Experimental Setup

There after 2 weeks acclimatization period were set to stabilize the plant. Experimental detail: The experiments were carried out in plastic tubs with 5 liter capacity in which the acclimatized plant were kept with collected water samples. In the present experiment three tubs were used as control (without amendments) and nine tubs were used for each treatments as replicates of different amendments

Experimental setup

Control = Polluted water + Hydrilla verticillata + without amendments
T1 = Polluted water + Hydrilla verticillata + 1 gm EDTA
T2 = Polluted water + Hydrilla verticillata + 1 gm EGTA
T3 = Polluted water + Hydrilla verticillata + 1 gm EDTA + 1 gm EGTA

After 45 days of treatment, the plants were harvested and washed with water until free of soil and then three times with deionized water. Plants shoot and root were dried for 48 at 70 degree Celsius and further air dried. The samples were then ground into fine powder and used for the analysis of heavy metal metals and physicochemical parameters and heavy metals in treated water samples were also determined by standard method as suggested by APHA 2012.

STATISTICAL ANALYSIS

All the experiments were performed in three replicates for each treatment. Data presented here are mean and standard deviation.

RESULTS AND DISCUSSION

Physicochemical parameters and heavy metals of initial and treated water samples. The initial value of pH in the water sample was found to be 8.5 i.e. basic in nature. During the present study, pH at different amendments showed marked variation. pH value was recorded 8.2 for control (without amendment), 7.6 for T1 (EDTA), 7.9 for T2 (EGTA) and 7.2 for T3 (EDTA + EGTA) . Maximum pH was recorded in T3. The electrical conductivity concentration in initial water sample was 1207 µs/cm. This value was reduced drastically to 1077 µs/cm after 30 days of treatment with EDTA. Value was recorded highest (1190 µs/cm) in control condition and lowest (943 µs/cm) in T3. For determining the concentration of Zn, Ni, and Pb in water collected from control, T1, T2, T3 are summarized in table.

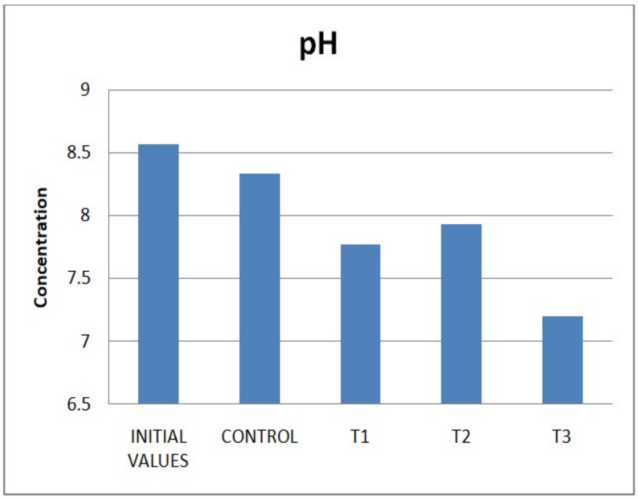
Table 1. Presence of physicochemical parameters and heavy metals of initial and treated water samples

PARAMETERS	INITIAL VALUE	Control	T1	T2	T3
pH	8.5±0.1523	8.3±0.152	7.6±0.152	7.9±0.208	7.2±0.2
EC (µs/cm)	1207±2.51	1190±3.055	1077±3.055	1108±6.506	943±4.358
TDS mg/l	1010±3.055	984±5.859	863±3.511	905±4.358	715±4.163
DO mg/l	4±0.2	4.46±0.251	5.43±0.251	4.9±0.115	5.9±0.1
BOD mg/l	20±1.527	17±1.527	13±1..527	15±1.527	11±1.53
COD mg/l	115±3	96±1.527	75±2.516	84±3.605	73±2.082
HEAVY METALS					
Zn mg/l	0.3423±0.0049	0.305±0.007	0.212±0.005	0.232±0.002	0.183±0.004
Ni mg/l	0.545±0.0032	0.397±0.005	0.297±0.003	0.377±0.002	0.254±0.005
Pb mg/l	0.652±0.004	0.506±0.005	0.363±0.0032	0.475±0.003	0.275±0.0036

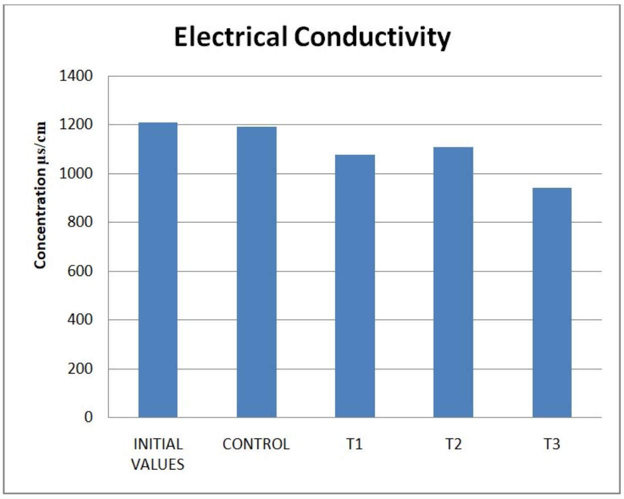
Table 2. Metals accumulation in plant parts (ppm)

	ROOT				SHOOT				LEAVES			
heavy metals	Control	T1	T2	T3	Control	T1	T2	T3	Control	T1	T2	T3
Zn	2.54	6.2	4.32	7.21	2.32	4.4	3.6	5.21	1.78	3.6	2.5	4.98
Ni	2.6	4.5	3.6	6.3	1.78	3.85	2.63	4.71	2.41	4.78	3.7	5.21
Pb	3.21	7.42	5.73	9.28	2.73	4.63	3.81	6.2	3.1	5.8	4.7	7.4

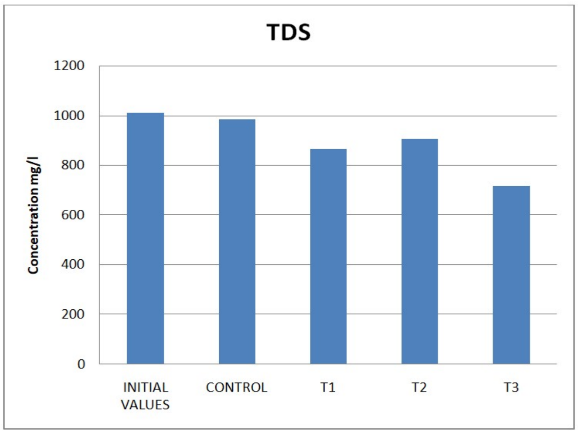
Graphical representation of physicochemical parameters of initial and treated Yamuna water



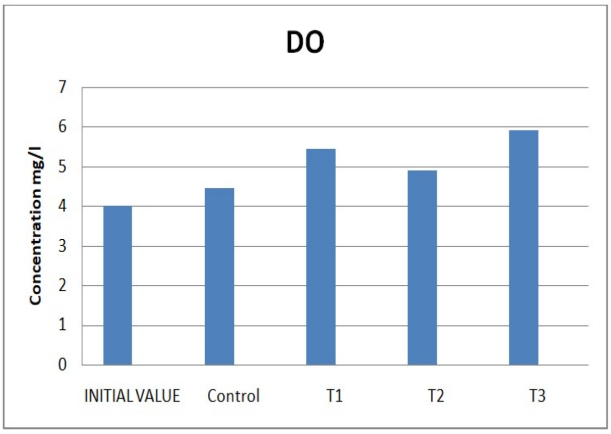
Graph 1



Graph 2



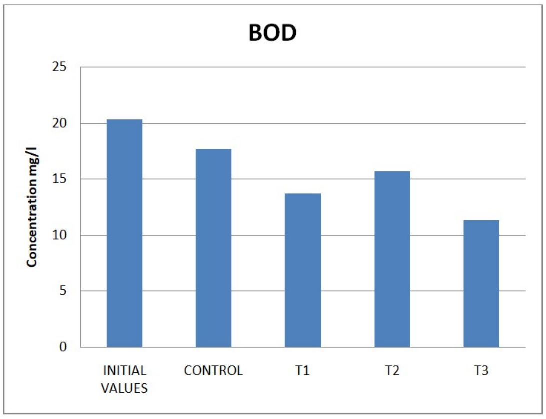
Graph 3



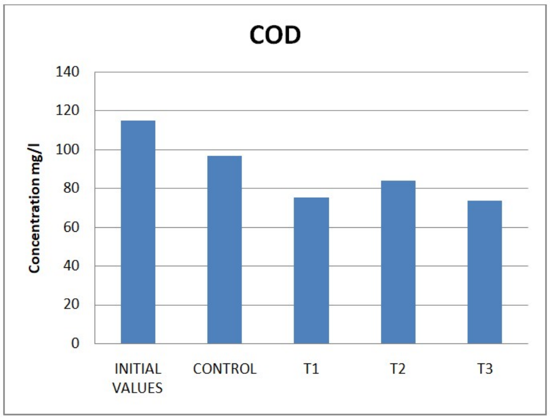
Graph 4

The initial mean values of Zn, Ni, Pb were 0.3423 mg/l , 0.545 mg/l, 0.652 mg/l respectively. This value decreased in all the treatments. The maximum reduction of Zn 0.183 mg/l, Ni 0.254 mg/l and Pb 0.275 mg/l were recorded in T4and minimum reduction of Zn 0.305 mg/l, Ni 0.397 mg/l, Pb 0.506 mg/l were recorded in control condition.

Accumulation of heavy metals in plant parts: The concentration of heavy metals accumulation by the plant parts from different treatments are presented in table 2. Generally metals concentration in plant root was higher as compared to plant stem and leaves. *Hydrilla verticillata* had great accumulation in root part than stem and leaves. Highest concentration of Zn7.21ppm was observed in the root part of *Hydrilla verticillata* on T3 and lowest root concentration of Zn was

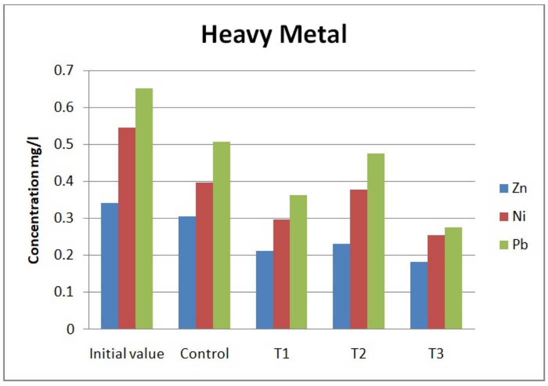


Graph 5

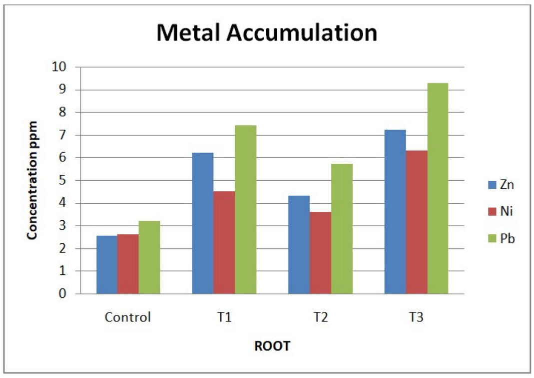


Graph 6

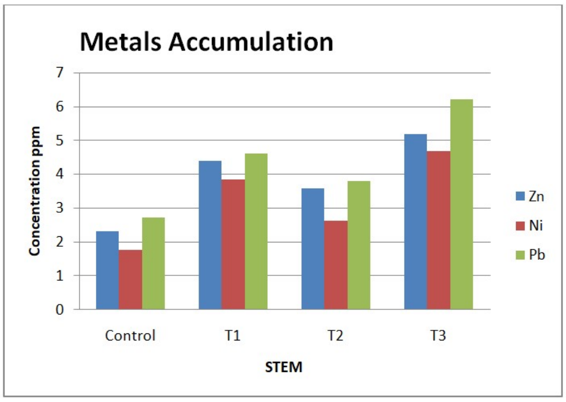
Graphical representation of Heavy metals of initial and treated Yamuna water



Graph 8.1



Graph 8.2



Graph 8.3

reported in control condition and 6.2 ppm, 4.32 ppm were also reported in T1, T2 respectively. For shoot and leaves accumulation highest concentration of Zn 5.21 ppm and 4.98 ppm were found on T4 and lowest shoot and leaves concentration 2.32 ppm and 1.78 ppm in control. Ni accumulation observed in root stem and leaves was 2.6 ppm, 1.78 ppm and 2.41 ppm in control, 4.5 ppm, 3.85 ppm, 4.78 ppm in T1 and 3.6 ppm, 2.63 ppm, 3.7 ppm in T2 respectively. Highest accumulation of Ni 6.3 ppm, 4.71 ppm, 5.21 ppm was observed in root, stem, leaves of *Hydrilla verticillata* on T4. In the present research shows that Pb concentration in all the parts of *Hydrilla verticillata* was higher as compared to Zn and Ni. Highest Pb accumulation 9.28 ppm and lowest 3.21 ppm was observed in root.

CONCLUSION

The study has revealed that the selected plant *Hydrilla verticilltа* was able to reduce the concentration of the identified physicochemical parameters such as pH, Electrical conductivity, TDS, Dissolved oxygen, BOD, COD and heavy metals like Zinc, Ni and Pb in water from Yamuna River. In this study root of the selected plant showed comparatively greater uptake for all the heavy metals than other parts. The accumulation of heavy metals was more in the root than in stem and leaves. The addition of EDTA and EGTA to the treatment increased plant uptake of heavy metals especially leads. In summary, the addition of EDTA and EGTA to contaminated Yamuna water can enhance the heavy metal uptake and reduced all the physicochemical parameters except DO in Yamuna water.

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