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Heavy Metals (Cd, Cu and As) Accumulation by Aquatic Plant along with Gomti River, Lucknow (U. P.)

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ABSTRACT

The aquatic plants have a great importance to the removal of heavy metals from the contaminated river water. In this study the heavy metals (Cd, Cu and As) were evaluated in aquatic plants like *Ranunculus sceleratus*, *Hydrilla virticillata*, *Botumusumbelatus* and *Sagittaria japonica* collected from the 15 sites along with Gomti river, Lucknow (U. P.), Heavy metals enters into the river through the discharge of domestic sewage, industrial effluents, municipal waste water etc., The concentration of Cu was found maximum followed by Cd and least was As for all selected plants at all sites. The highest accumulation of Arsenic, Cadmium and Copper was found in *Hydrilla virticillata* (0.172±0.005 μg g−1 DW), *Sagittaria japonica*(1.62±0.02 μg g−1 DW) and *Botumus umbelatus* (2.08±0.07 μg g−1 DW) respectively. However, the lowest concentration of all these heavy metals was observed in *Ranunculus scleratus* sp. The results of this study to give the information in relation to aquatic plants growing in polluted water, which accumulates heavy metals. These findings provide are an opportunity for the removal of toxic heavy metals from the use of aquatic plants in phytoremediation and treating water bodies.

1) INTRODUCTION

Aquatic plant species are well known for substantial component of primary production in water bodies. The Heavy metal pollution are increasing due to rapid industrialization, urbanization and other developmental activities. These heavy metals can enter into the water bodies through domestic sewage, industrial effluents, agricultural, wastewater, urban runoff, paper and pulp mills sewage, distilleries and other sources. Aquatic plants have the ability to remove or accumulate heavy metal such as Copper (Cu), Nickel (Ni), Arsenic (As), Cadmium (Cd) etc. from water bodies. The accumulation of heavy metals in aquatic plants depends on metal speciation and the species of plant. *R. sceleratus*, *H. verticillata*, *B. umbellatus* and *S. japonica* are aquatic plants, and grow in water or in shallow water, could accumulate heavy metals like Cd, Cu, Fe, As, Zn, Hg, Cr etc. in their different parts such as leaves, flower, stem and roots from the polluted sites and hence, it can be used for phytoremediation [1, 2].

The heavy metal such as Cr, Cd, Ni, Zn, Pb, Co, Mn, Cu, Fe etc., found in large quantities in Gomti river water, causes serious hazardous effects on surrounding soil, water, and other living organisms. The presence of heavy metal in potable waters, domestic waste and industrial effluents are a subject of serious concern due to the toxic properties of these materials. Industrial effluents are generally loaded with the trace elements such as chromium, lead, copper, zinc and iron [3]. Aquatic plants are used in water quality studies to monitor heavy metal and other pollutants of aquatic ecosystem [4]. All industries of distillery, milk industry and vegetable oil, pouring effluent directly into Gomti and besides this domestic waste water are also discharge into the River Gomti. Drains are the main source of water pollution particularly for rivers flowing within the city carries industrial waste water and sludge, domestic waste, sewage and medicinal waste results in pouring the water quality [5].The extent to which these drains pollute the water quality of river Gomti in Lucknow city. The water pollutants include sewage, variety of both organic and inorganic pollutants including oils, greases, plastics plasticizers, metallic wastes, suspended solids, phenols, acids, greases, salts, dyes, cyanides, DDT and some heavy metals like Cu, Cr, Cd, Hg, Pb are also discharged from industries [6]. Many sources of heavy metals including tannery, sugar, beverages, paints, chemicals, fertilizers, batteries, automobiles, factories, cement thermal power plants, petroleum refineries, food processing units, and sewage disposal water.

The aim of this study was to evaluate the capacity of selected aquatic plants grown in the water of Gomti river near Lucknow, with regard to the accumulation of heavy metals (As, Cd and Cu).

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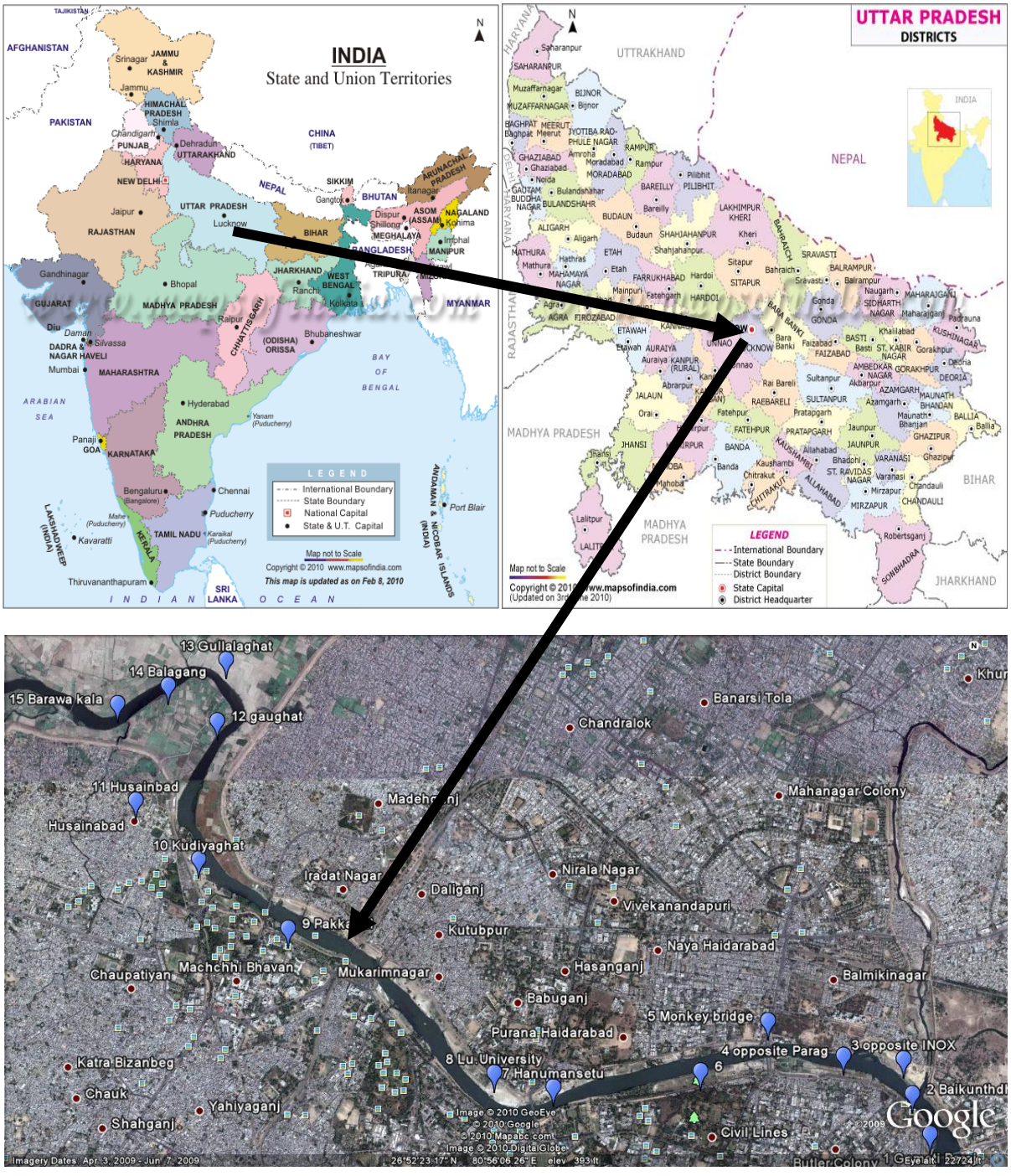
2) MATERIAL AND METHODS

Study Area: The Gomti originates from Gomat Taal which formally known as Fulhaar jheel, near MadhoTanda, Pilibhit, India. It extends 900 km (560 miles) through Uttar Pradesh and meets the Ganges River near Saidpur, Kaithi in Ghazipur. After a distance of 240 km, the river gomti is entering the city of Lucknow and covers a distance of 12 Kms by passing through it. There are about 25 drains passing through the city, which pour sewage into the Gomti, which is not yet treated. An area of 2528 sq km^2, Lucknow latitude from 26°30′ to 27°10′N and longitude 80°30′ to 81°13′Eand located at an elevation of 123 meters above sea level. This city was known by the name of Awadh during ancient times. Aquatic plants were collected from 15 sampling sites, located near **1.** Gomti barraj **2.** Baikunth dham **3.** Opposite INOX **4.** Opposite parag **5.** Monkey Bridge **6.** Laxman mela maidan **7.**Hanuman setu **8.** Lucknow University **9.** Pakkapul **10.** Husainbad **11.** Kudiyaghat **12**. Gaughat **13.** Gualalaghat **14.** Balaganj and **15.** Barawa Kala after monsoon season in clean plastic bags for the analysis of heavy metal accumulation from Gomti river in Lucknow (Fig 1).

Plant collection and analysis: Four aquatic plants namely *Ranunculus sceleratus Hydrilla virticillata*, *Botomus umbellatus and Sagittaria japonica* were collected from all 15 sample sites this study.

Ranunculus sceleratus is an aquatic plant species, and also

Figure1: Map of sampling sites (15 Km stretch) along with Gomti River, Lucknow.



known as buttercup. It is native to North America and Eurasia. It grows in wet and moist habitat, including ponds and riverbanks. Stems are 80cm tall, glabrous, hollow, branching above, easily broken, and herbaceous, roots are fibrous. The leaves are divided into three leaflets. Flowering takes place in May to August and flower has three to five yellow petals.

Hydrilla virticillata is an aquatic, submerged perennial plant, belong to the family Hydrocharitaceae, generally rooted to bottom and survive in a free-floating state and native to the warmer areas of Asia and inhibits native species where it is grow. It is found in lakes, rivers, and ponds. The height of plant is depending on the depth of the water, it can grow very rapidly in favourable conditions.

Botomus umbellatus is the sole genus in the monogenetic plant family Butomaceae. The plant is a rhizomatous, hairless and perennial aquatic plant. It is native to Eurasia and grows on the slowly moving water down to about 3 m depth. Its flower is pink in colour. It is an endangered species due to the dwindling of its habitat.

Sagittaria japonica is a perennial aquatic plant, and grow in wet soil and in shallow water, North American native plant**,** roots are being tuberous, fibrous, and stoloniferous (running); the leaves submerged and ribbon-like, floating or erect. It is often late spring before they awaken, the blossoms following during late summer.

All collected plants were carefully washed with tap water and finally with double distilled water to remove sediment and other foreign part objects adsorbed on plant surface. Plant samples were cut into small pieces and oven dried at 80^{o}C for 72 hands homogenized using mortar and pestle. 1gm of plant sample was digested with conc. HNO_3 and conc.$HCIO_4$ in a ratio of 3**:**1 v/v. It was initially heated slowly on a hot plate until frothing ceased and further heated continuously until the solution becomes clear and white fumes of $HCIO_4$ appeared [7]. The digested samples were diluted with 0.65% of 1N HNO_3 distilled water then filtered through a 0.45µm nitrocellulose membrane filter paper. Metal (Cd, As, Fe and Cu) concentrations in the prepared samples were analyzed with a flame atomic absorption spectrometer. All plant samples were analyzed in three replicates. Metal accumulation in collected aquatic plants was calculated by using formula given below:

Metal Concentration (µg/g) = X (Y × V / W

Where,

X= Reading of sample in ppm on AAS

Y= Reading of Blank sample in ppm on AAS

V= Final volume of Digested samples

W= Dry weight of the sample in gm.

3) RESULTS

3.1 Arsenic

Concentration of As in *R. sceleratus, H. virticillata, B. umbelatus* and *S. japonica*are presented in **Table 1**. The highest concentration of As was found in the *H. virticillata* with a value of 0.172±0.005 (µg g−1 dry weight) at sampling site 3 (Opposite INOX) and lowest concentration of As was found in *R. scleratus* with a value of 0.102±0.011 (µg g−1 dry weight) at site 6.

3.2 Cadmium

The highest concentration of Cd in all aquatic plants was observed in the *S. Japonica* with a value of 1.62±0.02 (µg g−1 dry weight) at sampling site 1 (Gomtibarraj). However, the lowest concentration of Cd was found in the *R. scleratus* showing a value of 0.22±0.02 (µg g−1 dry weight (**Table 1).**

3.3 Copper

The concentration of Cu in the all plants from the each site ware observed. However, the highest metal concentration was measured in the *B. umbelatus* with a value of 2.08±0.07 (µgg−1 dry weight) and the lowest concentration of Cu was found in *R. scleratus* with a value of 1.02±0.05 (µg g−1 dry weight) (**Table 1**).

4) DISCUSSION

Although heavy metals are an essential component of the aquatic ecosystem (all heavy metals cannot be essential), which are required for growth of plants, but their higher concentrations are toxic to all life forms. However, the least polluted sites should have been taken as control as well as plant absorbed heavy metals. The concentrations of Cd in all aquatic plants in the Gomti river were found to be generally low except ***S. japonica***. The Cd accumulation by aquatic plants was detected from station 1 to 15.In this study we found Cd concentration is maximum 1.62±0.02 (µg g−1 dry weight) in ***S. japonica*** at **Station 1** (Gomti barraj). So this plant may use for the removal of heavy metals from water.Copper concentration was detected in low concentrations (1.02±0.05to 2.08±0.07µg g−1 dry weight) in selected aquatic plants for all sites. Theconcentrations of metals vary considerably between different plant species.The ***H. virticillata*** and ***B. umbellatus*** have more effectively accumulated comparatively higher level of arsenic. *H. verticillata* has been tested for the uptake and remediation of arsenic, copper,lead, zinc and chromium from water by Elankumaran, 2003 and Dixit, 2010 [8, 9].The highest accumulation of As was found in ***H. virticillata*** with a value 0.172±0.005 (µg g−1 dry weight) at sampling site 7 (Hanuman setu) and 15 (Barawakala). The ability of heavy metal accumulation by ***H. virticillata*** and ***B. umbellatus*** is relatively higher than other studied plants so, hence they may be used as phytoremediator for these heavy metals. Study revealed that the ***H. virticillata*** has a strong ability to accumulation of As and ***S. japonica***for Cd and ***B. umbelatus*** for Cu metals from the polluted water, and might be useful in remediation of metal-contaminated water bodies. Some aquatic plants including *Hydrilla verticillata, Echornia crassipes* and *Bacopamonnieri* have been extensively studied by several authors and have been found to accumulate high level of Cr, Cu, Ni and Pb [10, 11]. So it is widely used in phytoremediation.

5) CONCLUSION

The present study revealed that the heavy metal accumulation in aquatic plants presents in Gomti River in Lucknow. Aquatic plants are very important for the accumulation of heavy metals from the polluted water bodies. However, the heavy metal accumulation capacity depends species to species of plant. ***H. virticillata, B. umbellatus*** and ***S. japonica*** is the best accumulator of arsenic, cadmium and copper respectively and might be useful in remediation of metal-contaminated water bodies.

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Table 1: Mean concentration and Standard deviation (SD) of As, Cd and Cu (μg g−1 dry weight) in plants collected from selected sampling sites of Gomti River, Lucknow (U.P.)

Sites	*H. virticillata*			*S. japonica*			*B. umbelatus*			*R. scleratus*		
	As	**Cd**	**Cu**	**As**	**Cd**	**Cu**	**As**	**Cd**	**Cu**	**As**	**Cd**	**Cu**
1	0.17±0.002	0.94±0.04	1.34±0.07	0.14±0.005	1.53±0.02	1.38±0.02	0.14±0.002	0.54±0.02	1.63±0.04	0.12±0.002	0.44±0.02	1.12±0.04
2	0.15±0.003	0.90±0.04	1.30±0.06	0.15±0.004	1.62±0.02	1.64±0.04	0.15±0.002	0.46±0.02	1.48±0.11	0.11±0.003	0.38±0.05	1.14±0.04
3	0.17±0.005	0.72±0.04	1.16±0.05	0.13±0.002	1.34±0.03	1.62±0.04	0.15±0.003	0.48±0.02	1.38±0.05	0.11±0.005	0.36±0.04	1.24±0.10
4	0.15±0.003	0.66±0.02	1.22±0.05	0.13±0.002	1.22±0.09	1.66±0.02	0.15±0.002	0.82±0.02	1.32±0.04	0.12±0.003	0.34±0.03	1.22±0.04
5	0.14±0.007	0.70±0.07	1.28±0.05	0.13±0.005	1.27±0.02	1.84±0.07	0.14±0.001	0.69±0.01	1.42±0.05	0.12±0.007	0.38±0.04	1.10±0.05
6	0.14±0.011	0.76±0.07	1.40±0.06	0.14±0.006	1.22±0.05	1.65±0.09	0.15±0.003	0.48±0.06	1.36±0.05	0.10±0.011	0.28±0.04	1.60±0.06
7	0.15±0.011	0.78±0.06	1.42±0.10	0.15±0.005	1.40±0.04	2.00±0.07	0.15±0.003	0.86±0.03	2.08±0.07	0.13±0.011	0.44±0.04	1.44±0.10
8	0.13±0.006	0.75±0.01	1.36±0.02	0.15±0.002	1.53±0.04	1.92±0.02	0.13±0.033	0.76±0.04	1.62±0.07	0.11±0.006	0.42±0.06	1.52±0.05
9	0.14±0.002	0.70±0.05	1.38±0.01	0.13±0.003	1.51±0.03	1.74±0.01	0.14±0.004	0.72±0.03	1.68±0.01	0.12±0.002	0.36±0.05	1.42±0.04
10	0.13±0.005	0.68±0.05	1.98±0.06	0.13±0.001	1.44±0.04	1.92±0.02	0.15±0.003	0.70±0.05	1.70±0.02	0.12±0.005	0.32±0.05	1.32±0.06
11	0.14±0.003	0.71±0.07	1.68±0.06	0.13±0.003	1.34±0.06	1.65±0.06	0.16±0.002	0.68±0.07	1.90±0.04	0.12±0.003	0.36±0.02	1.38±0.03
12	0.13±0.002	0.62±0.04	1.44±0.05	0.13±0.002	1.12±0.03	1.82±0.09	0.15±0.003	0.31±0.02	1.58±0.03	0.11±0.002	0.22±0.02	1.02±0.05
13	0.13±0.004	0.78±0.04	1.44±0.02	0.13±0.004	1.14±0.04	2.08±0.06	0.15±0.007	0.36±0.03	1.34±0.04	0.11±0.004	0.32±0.02	1.26±0.03
14	0.14±0.008	0.82±0.07	1.78±0.05	0.14±0.003	1.30±0.02	1.88±0.06	0.14±0.002	0.54±0.03	2.04±0.02	0.12±0.008	0.32±0.04	1.34±0.03
15	0.14±0.002	0.80±0.05	1.86±0.05	0.16±0.004	1.32±0.03	1.94±0.03	0.14±0.002	0.66±0.04	2.00±0.03	0.13±0.004	0.34±0.03	1.42±0.10

Table 2: Mean concentrations, standard deviation and range of As, Cd and Cu (μg g−1 dry weight) in complete plants collected from 15 selected sites of Gomti River, Lucknow (U.P.)

Species	**As**		**Cd**		**Cu**	
	Mean	Range	Mean	Range	Mean	Range
R. sceleratus	0.12±0.007	0.102-0.127	0.35±0.06	0.22-0.44	1.30±0.24	1.02-1.52
H. virticillata	0.14±0.013	0.129-0.172	0.74±0.08	0.70-0.94	1.47±0.24	1.22-1.86
B. umbellatus	0.15±0.007	0.132-0.163	0.60±0.16	0.31-0.86	1.64±0.26	1.32-2.08
S. japonica	0.14±0.006	0.126-0.147	1.35±0.15	1.12-1.62	1.78±0.21	1.38-2.08

The mean concentration, standard deviation and range of the heavy metal (As, Cd and Cu) on the basis of whole plant were collected from the 15 sites is presented in Table1. The concentrations of Cd (μg g−1 dry weight) in all aquatic plants in Gomti River were found to be generally low except *S. japonica.*