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Pollution Status of Yamuna River, India - A National Concern

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Abstract

Water pollution is a global problem which poses a serious threat to humans, animals and aquatic species. The River Yamuna is the major source of water supply to Delhi. It is getting pollution due to household, industrial, agricultural waste, sewage discharge as well as religious activities. Heavy metals are one of the major pollutants which are harmful to human, animals and tend to bioaccumulate in food chain. Use of phytoremediation technique for removal of toxic metals is an ecofriendly and sustainable approach to control water or soil pollution. In this study we tried to depict the pollution status of Yamuna water and its control by phytoremediation. An investigation was conducted to study the physical, chemical and bacteriological analysis of water samples collected from three polluted sites of Yamuna River - Wazirabad, ITO and OKhla, compared to tap water, used as control. The results were analysed and match up to the standards laid by the Bureau of Indian Standards (BIS). For phytoremediation study, the three aquatic plants Eichhornia, Salvinia and Hydrilla were selected on the basis of their availability in Delhi's climatic conditions in Yamuna River. Our results clearly indicated that ITO water sample was the most polluted as the total dissolved solids, turbidity and total hardness were the highest in those samples. Among heavy metals, Arsenic (As) content was ten times higher beyond BIS permissible limit in Okhla sample. Chromium (Cr) content was the highest in Wazirabad, followed by ITO. Plant growth was higher in polluted water than control indicating the high tolerance of the plants to the stress level. Investigation for remediation of heavy metals by phytoremediation is still under progress.

Keywords: Water Pollution, River Yamuna, Phytoremediation, Sustainable Approach, Permissible Limit.

Introduction

With the rapid development of modern industries, water pollution has become a worldwide serious problem that endangers the environment and health of human[1]. The uncontrolled disposal of waste, process spillage, mining and smelting of metal ores, are majorly responsible for the contamination of water bodies[2].

The River Yamuna is considered as the largest tributary of River Ganga. Unfortunately, the urban centres, located on the banks of River Yamuna (including Delhi), are much polluted[3,4]. The prime reason for deterioration of Yamuna River water is that these stretches withdraw fresh water for different domestic, industrial, religious and agricultural activities[5,6], and in return dispose off the entire waste directly into it[7]. According to the report of Central Pollution Control Board (CPCB), there were about 359 industrial units, which discharge their effluents in Yamuna[8].

The objective of present work is to check and identify the most polluted site of Yamuna River in Delhi and to assess the physico-chemical parameters and heavy metal load of Yamuna water at the three different sites, i.e., Wazirabad, ITO and Okhla.

Phytoremediation is an effective, low-cost and environmentally friendly technology which is used to remove a large number of harmful organic and inorganic pollutants[9]. So, this study has also aimed to study the growth of aquatic plants in the polluted water and their role in controlling heavy metal pollution by phytoremediation. This approach will not only help to monitor the pollution level but will also assist in the implementation of remedy measures, which are needed to be taken in order to control water pollution. To project the entire safety standards, the different parameters of the collected water samples were compared with the literature data presented by Bureau of Indian Standards[10].

Materials and Methods

Site characterization and sample collection: Water samples were collected from three of the most polluted sites of Delhi. The sites were chosen for collection and samplings were Wazirabad, ITO and Okhla. The water samples were collected during the month of December in pre cleaned glass bottles from selected sites. Before sample collection, all bottles were washed with dilute acid followed by autoclave.

Physico-Chemical Analysis: All samples were analyzed for Colour, Odour, pH, Turbidity, Salinity, Electrical Conductivity

(EC), Total Dissolved Solids (TDS), Total Hardness (TH), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluoride, Sulphate, Iron (Fe), Manganese (Mn), Magnesium (Mg) Chromium and Arsenic (As).

Microbiological Analysis: All samples were analysed for the presence of total Coliforms, Faecal coliforms and Phytoplankton following the APHA's Standard Methods for the Examination of Water and Wastewater, 2012[11].

Selection of Plants: The plants selected for experimental study from pollution free sites were *Eichhornia*, *Salvinia* and *Hydrilla.* Collected plants were rinsed thoroughly in water before transferring into water tubs for experimental studies.

Experimental set up: *Eichhornia*, *Salvinia* and *Hydrilla* plants were collected from pollution free sites. The plants were washed carefully with tap water followed by distilled water before transferring to the experimental tubs. All the plants were allowed to grow in 35 liter plastic tubs with 20 litres of polluted water collected from Wazirabad, ITO and Okhla. The controlled conditions by growing plants in tap water were also maintained.

Biological treatment: The plants were allowed to grow in polluted water collected from three different sites (Wazirabad, ITO and Okhla). All the experiments for three different sites for each plant were maintained in triplicate in outdoor condition. The plants were taken out of the tubs after 30, 60 and 90 days and used for the estimation of plant growth. Water loss due to evaporation was maintained by regularly adding distilled water into the tubs.

Results and Discussion

Physico-Chemical Analysis and Heavy metals: High electrical conductivity indicates the total concentration of dissolved ions in water samples. Electrical conductivity of water collected from all the polluted sites was much higher than the permissible limit prescribed by the BIS which indicates high amount of dissolved solids (Table-1). Hardness of water is due to a number of dissolved multivalent metallic ions, mostly calcium and magnesium cations. Their presence adversely affects the capacity of this water sample to react with soap. Total dissolved solids (TDS) are an important parameter to check the quality of drinking water[11].

High concentration of dissolved solids gives a particular taste to the water, reduces water quality and causes scales build-up in pipes, valves and filters. Hardness and TDS values of water samples from all the sites showed higher values as compared to BIS permissible limit (Table-1). Fluoride, Magnesium and Sulphate were also higher as per the prescribe limit of BIS (Table-2). Such water cannot be used for domestic as well as industrial purposes and may cause many severe health problems, if it is used without treatment.

Microbiological Analysis: Faecal coliforms were detected in all three water samples indicating a direct correlation between the microbial contamination of groundwater and sewage access to the aquifers (Table-2). Significantly high concentrations of total coliforms and faecal coliforms have been reported in waters of Yamuna River at the Agra Canal mid and quarter stream in Delhi[12]. Sewage overflowing from the unlined drains, septic tanks, pit latrine in the study area could presumably be the main reason for contamination[13].

Among heavy metals, Arsenic content was ten times higher beyond BIS permissible limit in Okhla sample (Table-1). Though Chromium content was observed to be highest in Wazirabad, followed by ITO (Figure-1) and Manganese content in ITO followed by Okhla as per the BIS standard (Figure-2).

Table-1
Physico-chemical Parameters of Yamuna River water of three different sites

Water Sample	Physical Parameters							
	Temperature (°C)	pH		Conductivity		TDS		Salinity
				µs	% increase	ppm	% increase	ppm
Tap water	23.8	7.53	Nil	474 ± 0.58	Nil	337 ± 1.0	Nil	207 ± 1.0
Wazirabad water	17.8	7.50	Nil	764.7 ± 39.27	52.94%	542± 29.82	8.4%	328.3 ± 17.79
ITO water	17.2	7.23	Nil	1422.3 ± 5.51	184.46%	995 ± 2.52	99%	620.7 ± 5.51
Okhla water	17.5	7.55	Nil	921 ± 30.29	84.2%	660.67±21.08	32.13%	403.0 ± 12.17
BIS Permissible Limit	23.8	6.5-8.5		500-2000				

Biochemical Oxygen Demand and Chemical oxygen Demand: It indicates pollution status of Yamuna River water. The BOD level of Yamuna for different sites was 6, 16.6 and 10.6 mg/L for Wazirabad, ITO and Okhla respectively. It is quite high as per the permissible level i.e., 3 mg/L[10]. The COD level (indicator of the organic and inorganic pollutants in the water) was 24 mg/L in Wazirabd, 26 mg/L in ITO and 22 mg/L in Okhla (Table 2).

Table-2
Report on analysis of water samples from different sites of Yamuna River the parameters given here are beyond the permissible limit as given by BIS

S.No.	Parameters	BIS Permissible Limit	Wazirabad	ITO	Okhla	Tap water
1	Colour, Hazen units,	5	25	43	92	4
2	Odour	Agreeable	Foul Smell	Foul Smell	Foul Smell	Agreeable
3	Taste	Agreeable	Not Agreeable	Not Agreeable	Not Agreeable	Agreeable
4	Turbidity, NTU	1	14.8	22	4.72	2.21
5	Fluoride, (as F) mg/l, Max	1.0	0.54	0.71	0.70	0.42
6	Magnesium (as Mg), mg/l	30	21.6	43.68	27.36	20.64
7	Sulphate (as SO4) mg/l	200	55.57	126.56	71.73	56.76
8	Arsenic (as As), mg/l	0.01	Nil	Nil	10	Nil
9	Chromium (as Cr), mg/l	0.05	0.241	0.083	0.037	0.019
1	Manganese (as Mn), mg/l	0.1	0.092	0.342	0.181	0.180
11	BOD	--	6.0	16.6	10.6	Nil
12	COD	--	24.0	26.0	22	Nil
13	Total Coliform	0.0	$11x10^4$	$11x10^4$	$46x10^3$	0.0

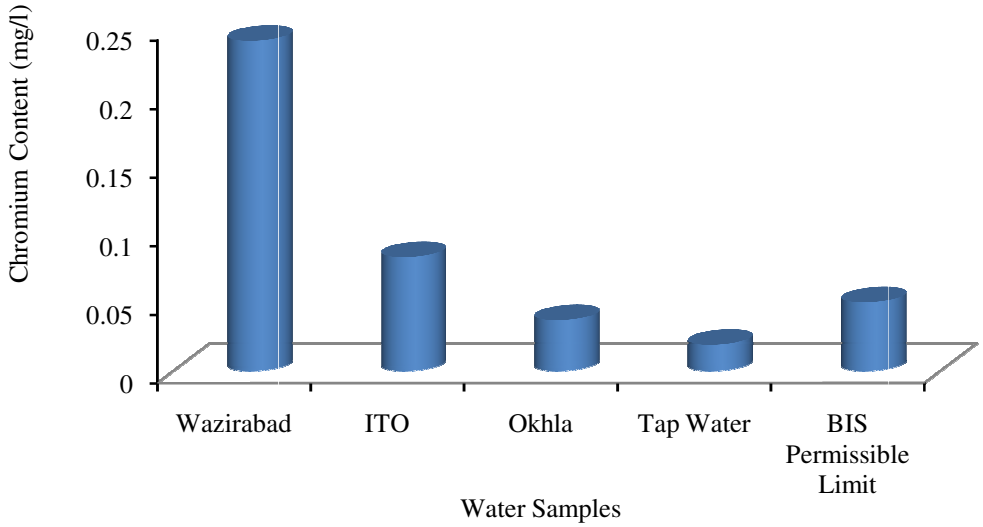

Figure-1
Analysis of Chromium concentration (mg/l) in Tap water and water samples collected from different sites by FAAS

Plant growth was higher in polluted water than control indicating the high tolerance and good accumulating capacity of the plants to the stress level (Figure- 3 to 5). Plant growth and proliferation is mainly determined by water quality and root microorganism which fix nitrogen for plants. Soluble salts of phosphorous and potassium also regulate growth and development of plants[14,15]. These plants showed high tolerance toward polluted water and can be used in Phytoremediation study to solve the water pollution problem.

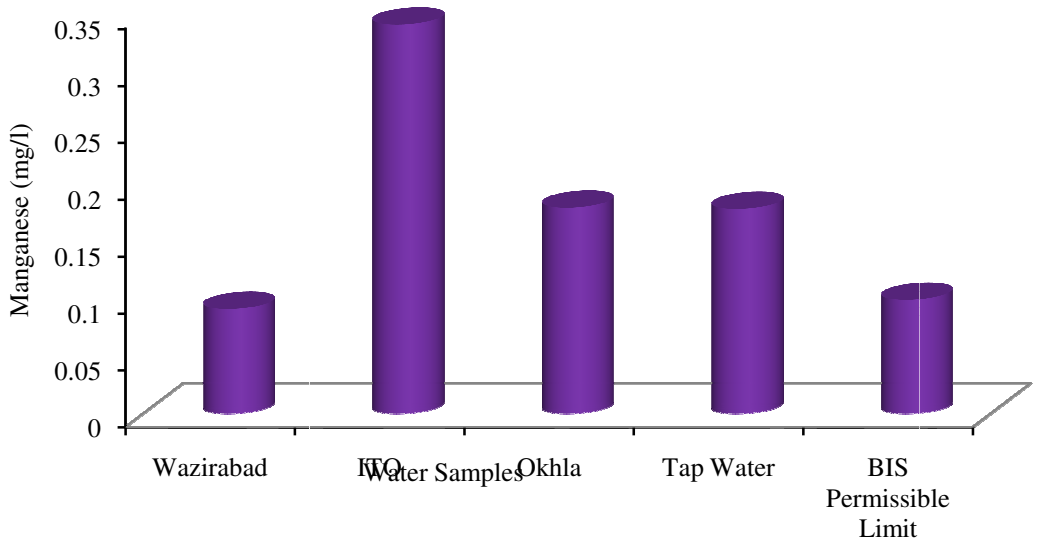

Figure-2
Analysis of Manganese concentration (mg/l) in Tap water and water samples collected from different sites by FAAS

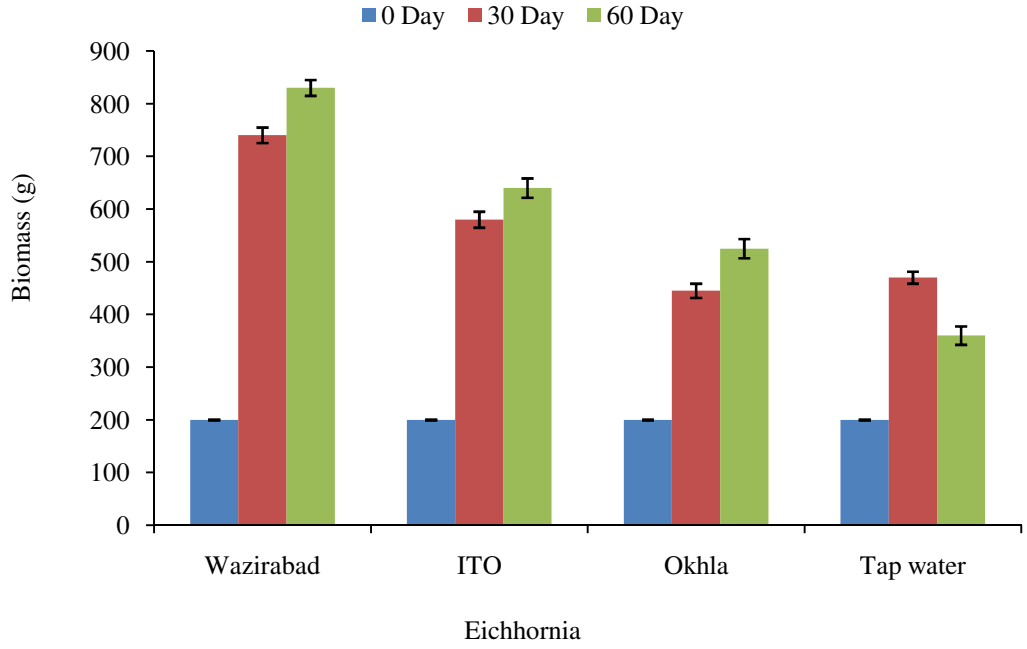

Figure-3
Growth of *Eichhornia* in terms of biomass showed tremendous increase from zero to 60 days in all polluted water samples, compared to control. Growth pattern = Wazirabad > ITO > Okhla

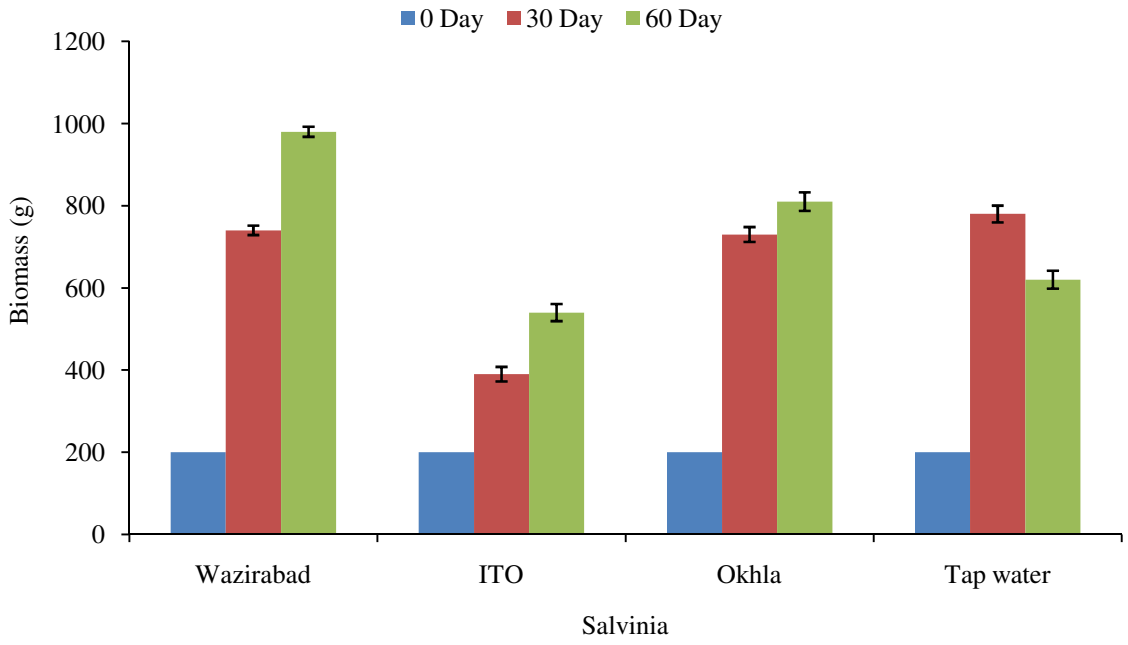

Figure-4
Growth of *Salvinia* in terms of biomass showed tremendous increase from zero to 60 days in all polluted water samples, compared to control. Growth of the plant was highest in Wazirabad followed by Okhla

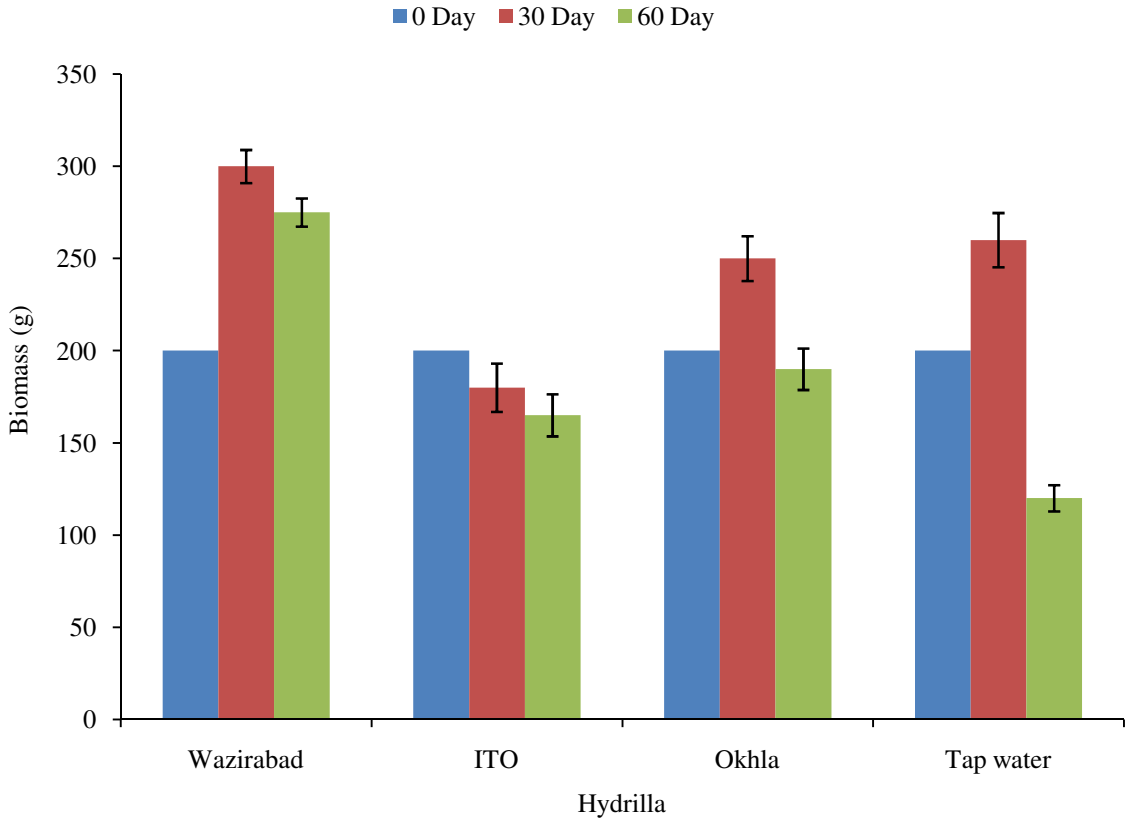

Figure-5
Growth of *Hydrilla* declined after 30 days in all water samples

Conclusion

This study assessed the physicochemical properties and heavy metal load of Yamuna River water from three different locations i.e. Wazirabad, ITO and Okhla of Delhi, during the month of December 2015. The detailed investigation of the parameters, which are not within the tolerance limits manifest the influence by the inflow of sewage, domestic and industrial waste in the water body which contributed tremendously to the high heavy metal contamination, dissolved solids and total hardness of the water samples. This bulk entering Yamuna, has a major influence on the chemistry and in turn on the bio-chemical aspects of the river. The results also reveal that the anthropogenic activities such as encroachments, construction activities, waste dumping etc. increased the total hardness of water up to a great extend. The major source of hardness gets into the water body from the industries and from the residential colonies. Among the different water samples treated ITO water is extremely polluted. Remarkably, little attention is given to the alarming loss of water source in Delhi. Hence, there is an urgent need to spread the awareness among people so that the pollution can be controlled by adopting effective and eco-friendly approach.

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