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HEAVY METAL CONTAMINATION AND THEIR ANALYSIS OF YAMUNA RIVER WATER IN THE VICINITY OF NATIONAL CAPITAL OF INDIA

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ABSTRACT

The Yamuna River is one of the major tributaries of the river Ganga originated in the Himalayas and flowing through a varied geological terrain. The present study was focused on heavy metal analysis in different regions of Delhi including rural, semi-rural and urban areas. The water sample was taken from six different locations and analyzed for pH, EC, BOD, DO along with heavy metal analysis. The results show that the Yamuna River water is alkaline in nature and the dissolved oxygen concentration is within the permissible limit except in the Nizamuddin area. The BOD was found to vary from 12.4 to 124.5mg/l which was higher than the permissible limit. Heavy metal analysis shows that Fe, Cu, Cr, and Zn lie below their permissible limit while Ni, CN, Pb and Co lies above the permissible limit of BIS. The present work highlights the pollution load of heavy metals in the river Yamuna and also advocates an urgent attention towards minimizing the health risk of people residing not only along the riverbanks and surrounding regions but also for city population.

Keywords: Yamuna River Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Heavy Metals.

INTRODUCTION

Water is the requisite and leading stipulation of life and is generally available in Rivers, Lakes, Ponds and Dams. It is used for various purposes such as drinking, irrigation and power supply etc. The usual source of drinking water is from streams, rivers, wells and boreholes which are usually not treated. The quality of water generally refers to the component of water, which is to be present at the optimum level for suitable growth of plants and animals (1,2). The river Yamuna is known as the sub basin and largest tributary of River Ganga. It is also a scared river of India which covers around 40.14% of total Ganga River Basin (3,4). It flows through the seven different states of India such as Uttarakhand, Himachal Pradesh, Uttar Pradesh, Haryana, Delhi, Rajasthan and Madhya Pradesh as well as in the plain areas it has many branches such as Hindon, Chambal, Sind, Betwa and Ken. The river serves many large numbers of urban centres and industrial towns including Sonepat, Baghpat, Delhi, Noida, Faridabad, Mathura, Agra, Etawah, etc where it receives a large amount of domestic and industrial wastewater (3,5).The number of rivers have been used beyond carrying capacity to dilute wastes generated by the cities flanking them. These rivers can also be used for discharging industrial, domestic and agricultural wastes, cleaning, bathing, open defecation, immersion of dead bodies, idols and other religious activities (5-7). As a result of these industrial and domestic discharges the Yamuna River is getting polluted day by day. The pollution level gets worse when River Yamuna leaves National Capital Territory of Delhi. This region cover only 1% of the river's total catchment area but it contribute more than 50% of the pollutants in the River Yamuna (6,7). In addition to this, rapid urbanization and population growth in fast growing cities leading to industrialization possess a major threat of Heavy metal pollution for India's rivers flowing through these cities (8,9). The water quality monitoring of River Yamuna has indicated significant presence of several heavy metals in its water (10). These heavy metals polluted the River Yamuna at various segments or location due to the untreated industrial discharge, lead battery-based industrial units, vehicular pollution, sewage discharge and surface run-off from contaminated areas (11-13). Monitoring of heavy metal contamination is important because increased concentration of heavy metals in potable water increases the threat to human health and to the environment due to biological magnification (15).

EXPERIMENTAL

Sample collection:

The samples were collected from 22km Delhi stretch of Yamuna from Baghpat to Okhla barrage covering two semi urban, two rural and two urban areas. Total six samples were taken from these areas using one litre polyethylene bottles for collection of samples. Prior to sample collection, all bottles were washed with dilute acid followed by distilled water and were dried in an oven. Before taking water samples, the bottles were rinsed three times with the water to be collected. At each sampling location, water samples were collected in duplicate. Water samples for DO and BOD determination were collected in BOD bottles (non-reactive borosilicate glass bottles of 300 ml capacity). Analysis of water samples was conducted immediately after collection to avoid unpredictable changes in water sample. The concentrations of heavy metals were determined in all samples by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). It is a standard laboratory analytical tool for metal analysis.

The details of sample collection are with their abbreviations are given in Table 1.

Table 1: Location of Sample Site at Different Regions of Delhi

S. N.	Sample collection Area	Latitude/Longitude	Abbreviation
1	Baghpat	28° 56′ 35″ N/77° 12′ 04″ E	A
2	Pachahira	28° 48′ 02″ N/77° 12′ 18″ E	B
3	Nizamuddin	28° 36′ 02″ N/77° 15′ 44″ E	C
4	Okhla	28° 32′ 36″ N/77° 18′ 52″ E	D
5	Manjhawali	28° 22′ 11″ N/77° 29′ 17″ E	E
6	Chhainssa	28° 15′ 27″ N/77° 28′ 08″ E	F

RESULTS AND DISCUSSION

pH Analysis: The pH analysis at different region was performed using pH meter. From the analysis it was observed that the Yamuna River water was alkaline in nature having a pH 7.2 to 8.8. The results show that all the aquatic organisms are affected by the change in pH as most of their metabolic activities are pH dependent (9,11). For the sustainable aquatic life the optimal range of pH is 6.5 to 8.2. These Results show that Yamuna River water is not suitable for aquatic organism. The pH value of different region is given in Table 2.

Table 2: pH, BOD, COD and DO analysis in Yamuna Water sample at different regions of Delhi

Sample Area	pH	Conductivity (μS/cm)	DO (mg/l)	BOD (mg/l)	COD (mg/l)
A	7.2	3124	1.7	124.5	234.1
B	7.6	2787	2.9	88.7	198.5
C	8.4	680	9.5	12.4	30.1
D	8.3	985	7.6	29.5	64.1
E	7.9	1934	4.9	52.8	108
F	7.7	2576	4.1	60	143.7

The increase in pH is due to the discharge of industrial waste and other organism in the Yamuna River. However, in the lock down period a decrease in pH was observed due to the reduction of industrial activities, the non-functioning of essential commercial units, and prevailing weather conditions. The concentration of pH was also correlated with the primary water quality criteria for bathing water and designated best usable water quality criteria of India. The variability of pH outside this range physiologically put stress on numerous species and may affect decreased reproduction and growth, attack of disease, or even death. Hence beyond the optimum value of pH can adversely affect the biological diversity in water bodies.

Conductivity Analysis:

The conductivity analysis shows that the conductivity of Yamuna River varies from 680 to 3124 µS/cm. The maximum conductivity was observed in the **A** while minimum in **C** (as shown in Table 2). Discharges into the streams are capable of changing the conductivity depending on their makeup. A failing sewage system raises the conductivity because of the higher presence of chloride, phosphate, and nitrate.

Dissolved Oxygen (DO) Analysis:

DO is most useful water quality constraint on which aquatic life depends. The DO was varying from 1.7 to 9.5 mg/l at different regions (as shown in Table 2). The estimated DO results were compared with standard values and observed that most of the DO levels were within the permissible limit of 5mg/l except at C and D region. In these regions DO level was high due to the increasing discharge and waste water plants.

Biological Oxygen Demand (BOD) level and Chemical Oxygen Demand (COD) Level

The quality of Yamuna water is measured by Biological Oxygen Demand (BOD) which affects the quantity of dissolved oxygen in the given water sample. As the BOD level increases in Yamuna water due to dead plants, discharge of industrial/domestic effluents, the oxygen availability in water sample also decreases for aquatic life. As a consequence, the effect of less oxygen availability putting aquatic life under stress, suffocation and could be lethal. The BOD was found to vary from 12.4 to 124.5 mg/l (As shown in Table 2). The BOD data was also compared with primary water quality and observed that the BOD levels are much higher than the permissible limit (3 mg/l) which affects the biological process and hence reduces the biological diversity in streams (14).

COD was also measured for all the samples. It measures the amount of dissolved matter in water susceptible which are going to oxidised and responsible for DO level reduction. The higher concentration of COD in the water sample lowers the oxygen availability which creates a harmful effect on the aquatic life. The COD was varying from 30 to 234.1 mg/l at different regions (as shown in Table 2). The increase COD in Yamuna water was due to increasing industrial/domestic effluents, wastewater treatment plants, failing septic systems; and urban storm water runoff.

Heavy metal analysis:

Heavy metals such as Ni, Fe, Co, Cu, Pb, Zn, Cr, CN was analysed in the Yamuna river water at different locations and the data is given in Table 3 and Fig. 1. From the analysis it was observed that the heavy metals Fe, Cu, Cr and Zn lie below their permissible limit while Ni, CN, Pb and Co lie above the permissible limit of BIS. The Ni concentration is found to be high in all regions, Co is found to be high in **C** to F regions and Pb concentration is out of the permissible limit in E and F region. The mean concentration of heavy metals was in the range of 22 to 1591.3μg/L at different regions. The cumulative concentration was in the range of 1652 to 3174μg/L and found to be maximum at **C** region. The higher concentration of Pb was due to wastewater from the disposal of storage batteries, industrial gases and liquid effluents, sugarcane, and paper industries.

Table 3: Heavy Metal Concentration at different Regions of Delhi

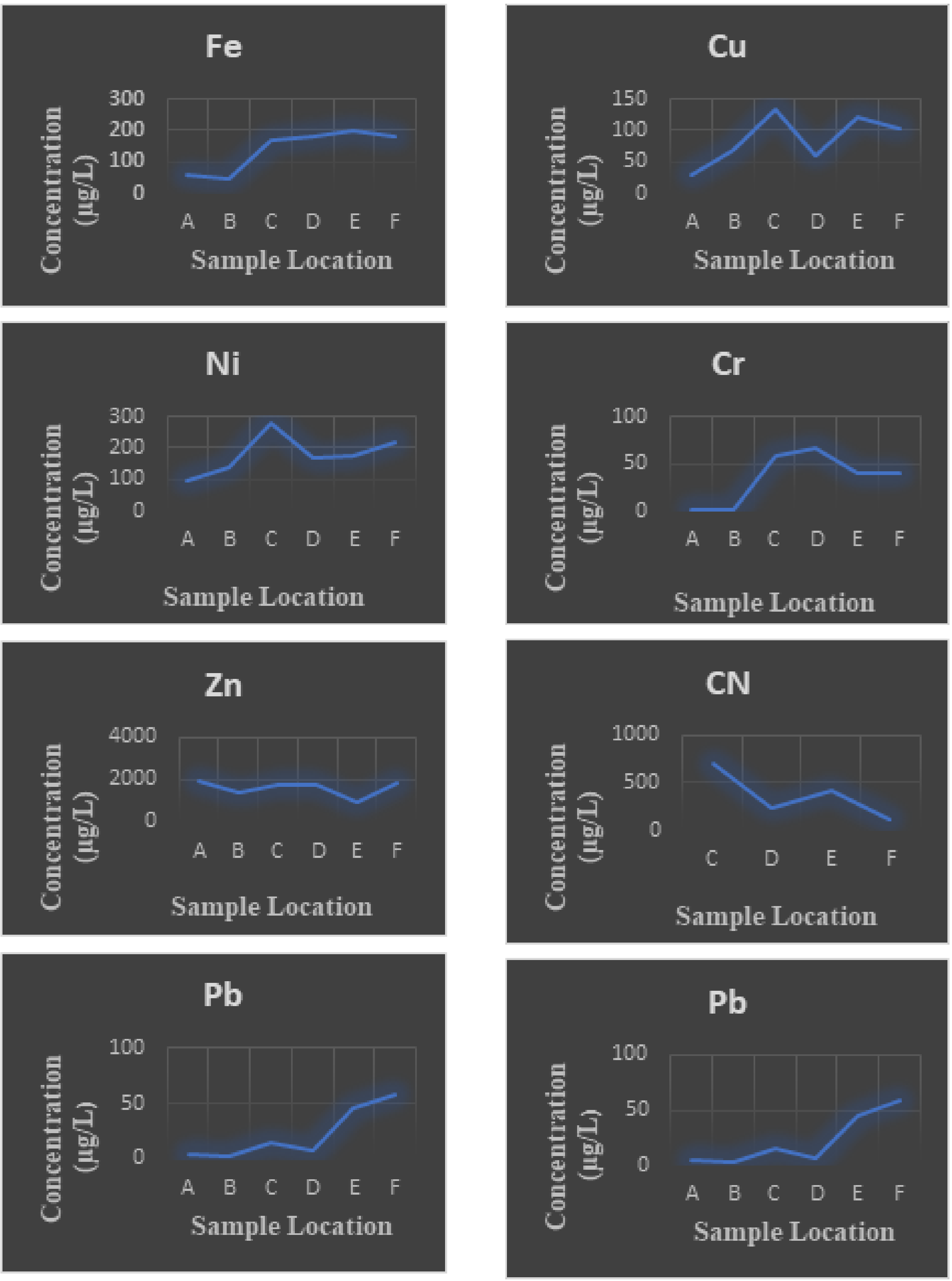
Sample Location	Heavy Metal Concentration (μg/L)								Cumulative Concentration
	Fe	Cu	Co	Zn	Pb	CN	Ni	Cr	
A	60	30	3	1957	4	NA	96	1	2151

B	45	70	5	1389	3	NA	138	2	1652
C	170	135	75	1732	15	710	278	59	3174
D	180	60	15	1730	7	243	167	66	2468
E	198	120	19	910	45	415	175	40	1922
F	184	103	55	1830	58	110	220	39	2599
Mean Concentration	139.5	86.3	28.67	1591.3	22	246.3	179	34.5	2327.67

These heavy metals are continuously discharged into the river by highly toxic heavy metals effluents of a wide range of industries including electroplating, dyeing, paper manufacturing, and sugarcane located on the banks of river. Sewage discharge treated, partially treated, or untreated generally carrieslead, cadmium, and chromium because it is very much difficult for sewage treatment plants (STPs) to remove metals. As results, these heavy metals polluted the Yamuna River at a very high extent and also cause various health related issue. Therefore, it is necessary to remove all the toxic metals or to decrease the concentration of these heavy metals in the River Yamuna at different regions of Delhi.

Figure 1: Concentration of Heavy metals at different Regions of Delhi

CONCLUSION



The present study was focused on heavy metal analysis at different regions of Delhi. The Results heavy metals are polluting the River Yamuna at a very speedy rate. The concentration of Ni was found to be high in all the regions while the cumulative concentration of heavy metals was maximum at Nizamuddin area. Zn, Fe, and Cu concentrations in all analyzed samples of the study area were low while Ni and CN were found to be high. The high concentration of Ni, Pb, and CN was probably due to waste from the landfill, metal industry wastes, and auto-waste. As a result, the water quality in Delhi is highly polluted due to addition from sewage waste and input from agricultural areas and unsuitable for the human uses. Hence, the water quality index technique along with nutrient elemental ratio is a useful tool for the overall assessment of water quality of a water body.

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Conflict of Interest:

The author(s) declares no conflict of interest.

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