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Water quality of river Ganga along Ghats in Allahabad City, U. P., India

Ruby Pandey*, Divya Raghuvanshi and D. N. Shukla

Bhargava Agricultural Laboratory, Department of Botany, University of Allahabad, Allahabad, Uttar Pradesh, India

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ABSTRACT

In present study, an extensive investigation of physico-chemical parameters of water samples of river Ganga at Allahabad was carried out. For this, three sampling sites were selected along river Ganga at Allahabad depending upon their pollution index and usage viz: Phaphamau (S1), Daraganj Ghat (S2) and Sangam (S3). Five samples of water were collected during January 2014 to March 2014 at an interval of 15 days from these sites. The observed values of different physico-chemical parameters like pH, Temperature, Electrical conductivity (EC) , Turbidity, Total Hardness (TH), Chloride , Total Dissolved Solids (TDS), Total Alkalinity (TA), Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) of samples were compared with standard values recommended by world health organization (WHO). According to result obtained by analyzing various physico-chemical parameters of Ganga river in Allahabad city, maximum BOD was recorded at S1 and minimum at S3 whereas maximum DO was observed at S3 and minimum at S1. On the basis of our experimental result it was found that the values of turbidity, pH, BOD, TH, TA were highest at S1. Reason of high level of pollution at Phaphamau is attributed to the disposal of untreated sewage and industrial wastewater and cremation of dead bodies. Regular monitoring of River Ganga water quality is necessary to have a check on surface water pollution for the sake of healthy living of human. Correlation coefficients were calculated between different pairs of parameters to identify the highly correlated and interrelated water quality parameters.

Keywords: Physico-chemical properties, Allahabad, Ganga, Correlation.

INTRODUCTION

Ganga is a trans-boundary river of Asia which flows through India and Bangladesh. The 2,525 km (1,569 mi) river rises in the western Himalayas in the Indian state of Uttarakhand, and flows south and east through the Gangetic Plain of North India into Bangladesh, where it empties into the Bay of Bengal. Ganga is the most sacred and worshipped river of Hindus, is now one of the most polluted river of the country. Today, over 29 cities, 70 towns, and thousands of villages extends along the Ganga banks. Nearly all of their sewage - over 1.3 billion liters per day - goes directly into the river, along with thousands of animal carcasses, mainly cattle [1]. Another 260 million liters of industrial waste are added to this by hundreds of factories along the rivers banks. Domestic and industrial wastewater constitute as a constant polluting source, whereas surface runoff is a seasonal phenomena mainly controlled by climate [2].

Allahabad is located in the southern part of the state of Uttar Pradesh, at 25°27′N 81°50′E25.45°N 81.84°E, it is an old and unique city in India where two big rivers of the country namely Ganga and Yamuna carrying various industrial effluents have a confluence. Numerous industries and cities in India are located on both sides of these rivers. The industrial effluents as well as domestic sewage/wastes are disposed in these rivers either with partial or no pre-treatment and hence increasing concentration of different kinds of pollutants including that of heavy metals in the riverine water [3]. The indiscriminate dumping and release of wastes containing wide variety of organic and inorganic pollutants including solvents, oils, grease, plastics, plasticizers, phenols, heavy metals, pesticides and

suspended solids are hazardous substances into rivers might lead to environmental disturbance which could be considered as a potential source of stress to biotic community.

In the present paper an attempt has been made to analyze the changes within 15 days interval from January-March (in the 2014 year) period, on the physiochemical properties of water of river Ganga at three selected sampling sites *viz*: Phaphamau, Daraganj Ghat and Sangam. The water of river Ganga at aforesaid site was analyzed for Temperature, pH, Alkalinity, Dissolved Oxygen, Biological Oxygen Demand, Total Dissolve Solid, Chloride, Turbidity, Total Hardness, and Electrical Conductivity.

MATERIALS AND METHODS

This Chapter describes details of methods used for experiments, performed during analysis of water samples. Selection of effective sampling sites is first important point for observation and analysis of various physico-chemical parameters. Temperature of water samples were recorded on the sampling sites immediately with the help of Celsius thermometer. DO was fixed on sampling sites with Manganous sulphate and alkaline Potassium iodide solution. There are following three selected sampling sites:

- **S1**- Phaphamau
- **S2**- Daraganj Ghat
- **S3**- Sangam

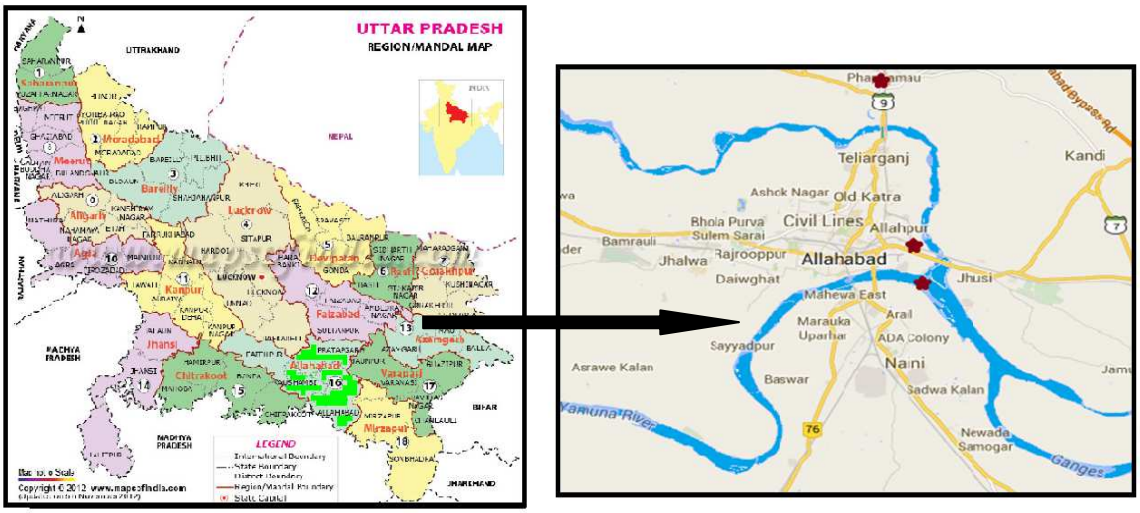

Figure 1: Map of Uttar Pradesh showing Allahabad city and an enlarged view of Allahabad city showing study sites

Source: www.mapsofindia.com and www.googlemaps.com, Map not to scale. *Represents sampling sites.*

Table 1: Methods used for Analysis of Physico-chemical parameters of River Ganga Water of Allahabad City in year of 2014

S.N	Parameters	Method
1.	pH	pH meter
2.	Temperature ^{0}C	Thermometer
3	EC (µS/cm)	Conductivity meter
4.	Turbidity (NTU)	Nephelometer
5.	Total Hardness (mg/L)	Titration Method
6.	Chloride (mg/L)	Titration Method
7.	Total Dissolved Solids (mg/L)	Gravimetric Method
8.	Total Alkalinity (mg/L)	Titration Method
9.	Dissolved Oxygen (mg/L)	Winkler Method
10.	Biological Oxygen Demand (mg/L)	Winkler Method

Table 2: WHO Standard of physico-chemical parameters

S.N	Parameters	Drinking Water WHO Standards	
		HDL	MPL
1.	pH	6.5-8.5	No relaxation
2.	Temperature^{0}C	-	-
3.	EC (µS/cm)	-	-
4.	Turbidity (NTU)	5	10
5.	Total Hardness (mg/L)	300	600
6.	Chloride (mg/L)	250	1000
7.	Total Dissolved Solids (mg/L)	500	2000
8.	Total Alkalinity (mg/L)	200	600
9.	Dissolved Oxygen (mg/L)	2	6
10.	Biological Oxygen Demand (mg/L)	-	6

[HDL: Highest Desirable Limit; MPL; Maximum Permissible Limit]

RESULTS AND DISCUSSION

3.1 Temperature (^{0}C)

The present investigation reveals that the temperature increases more rapidly within given interval period i.e. 15 days, at the site -1 due to major disposal of untreated sewage and industrial effluents, which rise the temperature maximum at 30.5^{0}C on the 60th day of investigation period .i.e. on 7 March.

Table 3: Samples was Collected at different Months, Date, Days of Intervals and Temperature (^{0}C)

Month	Date	Day	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
January	10/01/2014	1st	23.2	20.65	20.4
January	24/01/2014	15th	25.4	23.5	22.3
February	7/02/2014	30th	26.05	24.3	24.3
February	21/02/2014	45th	28.9	26.1	26.2
March	7/03/2014	60th	30.5	28.5	28.1

3.2 pH values

The present investigation reveals that highest values of pH .found at site- 2 within taking time period, whereas site-3 have minimum pH values in comparison to both sites and it increases with time. The values of pH increases from January-March may be due to increased photosynthesis of the algal blooms resulting into the precipitation of carbonates of calcium and magnesium from bicarbonates [4]. This pH values having higher concentration as compared to WHO standards recommended

Table 4: Changes in pH at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	8.17	8.29	8.06
15th	8.45	8.49	8.28
30th	8.75	8.65	8.50
45th	8.63	8.56	8.41
60th	8.70	8.60	8.57

3.3 EC (µmho/cm)

It represents the total concentration of soluble salts/mineral salts in water [5], thereby making it sour and unsuitable for drinking. The present investigation reveals that 1st day of taking time period i.e. on 10 January EC has maximum values, and it decreases with passes time period i.e. it minimum at 60th day of time period (7 March). The narrow decrement of EC can be due to the unexisting litho logy of the region of the River Ganga.

Table 5: Changes in EC at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	412	532	542
15th	403	529	542
30th	401	522	539
45th	396	513.50	535
60th	392	508.10	528

3.4 Turbidity (NTU)

Turbidity is measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more suspended solids in water, the murkier it seems and the higher the turbidity. It is considered as a good measure of the quality of water. Results shown that site-1 have highly turbid in compare to other sites due

to extremely runoff from industrial and agricultural site. This Turbidity values having higher concentration as compared to WHO standards recommended.

Table 6: Changes in turbidity at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	9.80	9.20	7.30
15th	11.90	11.30	8.50
30th	10.20	11.10	8.10
45th	11.40	11.90	8.80
60th	11.50	11.30	8.50

3.5 Hardness (mg/L)

Hard water is water that contains high levels of dissolved calcium, magnesium and other mineral salt such as iron. High amount of dissolved minerals in the water causes more the water hard. Hardness of water is due to the concentration of multivalent metallic ions of calcium and magnesium. Results shown that site-1 is highly hard in compare to other sites. This Hardness values having lower concentration as compared to WHO standards recommended.

Table 7: Changes in hardness at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	145	145	136
15th	142	130	118
30th	128	130	116
45th	123	128	110
60th	129	123	114

3.6 Chloride (mg/L)

Chloride ion is one of the major anions found in water and are generally combined with calcium, magnesium or sodium. Chlorides are leached from various rocks into soil and ground water by weathering. The chloride ion is highly mobile and is transported to closed basins. Results shown that chloride ion maximum found at site-1in compare to Daraganj and Sangam sites. This Chloride values having lower concentration as compared to WHO standards recommended.

Table 8: Changes in concentration of chloride ion at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	15.80	15.10	13.00
15th	18.30	18.50	16.0
30th	19.20	14.30	13.20
45th	20.10	20.00	17.10
60th	16.50	15.70	14.30

3.7 TDS (mg/L)

TDS is measure of the combined content of all organic and inorganic substances contained in a liquid in molecular, ionized or micro-granular suspended form. It is an important parameter for water quality. Results shown that site-1 contains maximum TDS due to huge discharges of industrial effluents without or partial pre-treatment. This TDS values having lower concentration as compared to WHO standards recommended.

Table 9: Changes in TDS at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	250	238.20	250.50
15th	250	255.50	280.50
30th	255	250.20	260.30
45th	260	270	265.10
60th	280.6	270.50	270.60

3.8 Alkalinity (mg/L)

It is the quantitative capacity of water sample to neutralize a strong acid to a pH Increase dilution of river water may be responsible for lower values of alkalinity in rainy seasons [6]. The present investigation reveals that site-1 has highest alkalinity values and at site-3 shows minimum values whereas site-2 reveals intermediate values of alkalinity. The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body [7, 8]. The high values of alkalinity may also be due to decrease in free carbon dioxide in the River Ganga by which bicarbonate ions converted into carbonate ,which ultimately result

in the increase in alkalinity at site -1 in comparisons to other both sites. This Alkalinity values having lower concentration as compared to WHO standards recommended.

Table 10: Changes in alkalinity at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	142	134	120
15th	150	150	134
30th	169	160.30	149
45th	153	155.50	136
60th	248	150	146

3.9 DO (mg/L)

The measurement of DO gives a ready assessment of purity of water. The amount of dissolve oxygen is a measure of the biological activity of the water masses and is widely used in water quality studies and routine operation of water reclamation facilities. Results reveal that Sangam has maximum DO due to maximum flow rate of water than other sites. The DO values having higher concentration as compared to WHO standards recommended.

Table 11: Changes in DO at different ghats of Allahabad within take time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	6.70	7.90	9.00
15th	5.80	6.30	8.00
30th	5.30	5.90	7.80
45th	5.10	5.80	7.60
60th	5.80	6.20	7.30

3.10 BOD (mg/L)

BOD is the quantity of oxygen required by bacteria and other microorganisms during the biochemical degradation and transformation of organic matter present in wastewater under aerobic condition. It is valuable parameter for assess of water quality. Results shown that site-1 has maximum pollutional index in compare to other sites.

Table 12: Changes in BOD at different ghats of Allahabad within taken time period

Days	S1-Phaphamau	S2-Daraganj Ghat	S3-Sangam
1st	5.70	5.50	4.20
15th	4.30	3.80	2.60
30th	4.00	3.90	2.60
45th	5.80	4.50	3.00
60th	5.40	5.20	3.10

Table (13) depicts the correlation matrix among various water quality parameters. It revealed that DO showed negative correlation with almost all parameters, thus it can be served as a single index of water quality, as with rise in the value of most of these parameters decreases the DO concentration **[9].**

Table 13: Correlation matrix among the various physico-chemical parameters (significant level at 0.05)

Parameter	Temperature	pH	EC	Turbidity	TH	Chloride	TDS	TA	DO	BOD
Temperature	1									
pH	.679	1								
EC	-1.000*	-.666	1							
Turbidity	.606	.995	-.592	1						
TH	.711	.999*	-.698	.990	1					
Chloride	.865	.956	-.855	.924	.968	1				
TDS	.991	.770	-.989	.706	.798	.923	1			
TA	.971	.835	-.967	.779	.859	.960	.994	1		
DO	-.818	-.978	.807	-.953	-.986	-.996	-.887	-.932	1	
BOD	.771	.991	-.759	.974	.996	.987	.848	.901	-.997*	1

CONCLUSION

On the basis of experimental findings it can be concluded that S1-Phaphamau site had higher pollution index than other Ghats/Ganges, it may be attributed due to increased intensity of Turbidity, pH, BOD, Hardness, Alkalinity, Chloride compare to other Ghats/Ganges.

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