



Studies of Selected Water Quality Parameters of River Ganges at Patna, Bihar

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Abstract: The study was carried out for a period of only two seasons (Pre-monsoon and Post-monsoon) in a year. The physicochemical parameters such as pH, Electrical conductivity (EC), Alkalinity, Total Solids (TS), Hardness, Chloride, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) & Most Probable Number (MPN) were evaluated at selected sites of River Ganga. The river is subjected to severe domestic and sewage pollution at two selected sites of Patna. At sampling site, I and II physicochemical parameters were not found to be within the safe limits of drinking water as World Health Organization WHO (1984). But at sampling site II chloride were found within the safe limits. At sites, I & II water sample was not found good quality showing that the River Ganga has moderately polluted. The present studies indicate that increase water pollution levels in the River Ganga present near urban environment due to discharge of various types of wastewater/ sewage/ effluents.

Keywords: Electrical conductivity, Alkalinity, Total Solids, Hardness, Chloride, Dissolved Oxygen, Biological Oxygen Demand & Most Probable Number.

1. Introduction

Water pollution is an acute problem in all the major rivers of India (Bhargava, 1987). The quality of river water as determined by its physical and chemical constituents is of great importance in determining its suitability for a certain use such as public water supply, irrigation, industrial application etc (Dwivedi and Pathak, 2007). The detailed survey of river revealed that small areas as well as large areas which fall in the way of river, dump and toxic wastes in the river. This has caused severe pollution in the river to the extent that its water is posing threat to the survival of aquatic flora and fauna. Anthropogenic activities like discharge of sewage effluents, wastewater from houses, toxic metals as well as metal chelates from different sources and also indiscriminate use of heavy metal containing fertilizers and pesticides in agriculture resulted in deterioration of water quality rendering serious environmental problems posing threat to human beings and sustaining biodiversity (Lantzy and Mackenzie, 1979; Nriagu, 1979; Ross, 1994). Singh and Rai (2003)

studied the impact of the industrial effluents and domestic sewage on river Ganga at Allahabad and reported that all the pollution parameters are beyond the permissible limits and unfit for human consumption. Tiwari (2004) studied the pollution potential of River Pandu contaminated heavily by the discharge of various industrial effluents. Gupta and Pankaj (2006) studied the eutrophication and heavy metal pollution in river Ganga and Gomti with reference to human activity.

1.1 About River Ganga

In general, over 29 cities, 70 towns, and thousands of villages extend along the River 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. Another 260 million liters of industrial waste is added to this by hundreds of factories along the rivers banks. Municipal sewage constitutes 80 percent by volume of the total waste dumped into the Ganga, and industries contribute about 15 percent. The majority of the Ganga pollution is organic waste, sewage, trash, plastic from surface

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runoff, food items, domestic wastes and human/animal remains. An estimated 80% of all health problems and one-third of deaths in India are attributable to water-borne diseases. The industrial pollutants also a major source of contamination in the Ganga. A total of 146 industries are reported to be located along the river Ganga between Rishikesh and Prayagraj. On its 1,560-mi (2,510-km) course in plains, Ganga flows southeast through the Indian states of Uttar Pradesh, Bihar and West Bengal. River Ganga passes from some of the most populous cities of India including Kanpur, Allahabad, Varanasi, Patna and Kolkata.

2. Materials and Methods

2.1 Study area

The present study was confined to the surrounding areas of Site I (including *Pahalwan Ghat and Bans Ghat*) and Site II (including *Krishna Ghat and Gandhi Ghat*) of Patna where huge masses of devotees offer holy dip, local people do perform bathing, washing the clothes and discharge of local wastes throughout the year.

2.2 Collection of Samples

Water samples were collected once in pre-monsoon & post-monsoon seasons during, 2010 from two

selected sites of the River Ganga. The samples were collected from a depth of 1 foot below the surface of river using the plastic containers (500ml). Samples were collected from two places of each sampling site, randomly and mixed thoroughly. Water samples were stored in the icebox to retard the biochemical activities. Collection of samples took place between the hours of 9 am to 11.30 am. The samples were analyzed as per standard methods mentioned in (APHA, 1995). The standards reagents used in analysis were prepared using double distilled water. Nine water quality parameters namely pH, EC, Alkalinity, Total Solids, Hardness, Chloride, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) & Most Probable Number (MPN) were monitored at the ISM, Dhanbad. In Fig. 1 sampling sites are shown on the map and Fig. No 2 shows the simple Bathing Ghat of River Ganga in Patna.

2.3 Methodology

The aim of this study is to describe the trend and variations of the selected water quality parameters of the river. The study also aims to ascertain the levels of the quality parameters and in the absence of any detectable impact from any source, may serve as baseline values (Singh *et al.*, 2007). The water quality test methods are shown in Table 1.

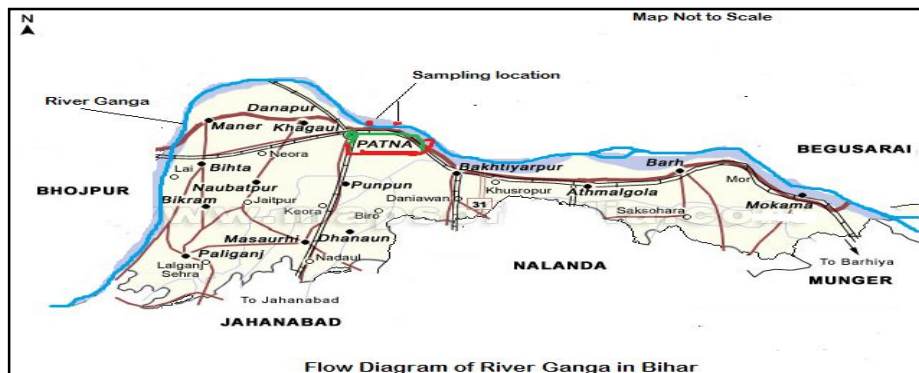


Fig. 1. Location of sampling sites in River Ganga (Red marked).



Fig. 2. A Simple View of Bathing Ghat (Ganga) in Patna, Bihar.

Table 1. Water Quality Test Methods.

S. No	Parameters	Units	Test Method
1	pH	-	Electrometric
2	Electrical Conductivity	$\mu\text{S/cm}$	Electrometric
3	Total Solids	mg/l	Electrometric
4	Alkalinity	mg/l	Titration and Electrometric
5	Hardness	mg/l	Titration EDTA
6	Chloride	mg/l	Titration
7	Dissolved Oxygen	mg/l	Winkler method with Azide Modification
8	Biological Oxygen Demand	mg/l	5 days incubation
9	**Most Probable Number/100 ml	mg/l	Lactose broth method

**In the most probable number (MPN) test, tubes of lactose broth are inoculated with water samples measuring 10ml, 1ml, and 0.1ml. During incubation, coliform organisms produce gas. Depending upon which tubes from which water samples display gas, an MPN table is consulted and a statistical range of the number of coliform bacteria is determined. The MPN test is very easy to perform and interpret, but it does not determine the exact number of bacteria as the standard plate count does.

Table 2. Site Wise Observed Values of Different Water Quality Parameters with their W.H.O Standards.

Parameters	Site I		Site II		WHO Standards (1984)
	Pre-monsoon season	Post-monsoon season	Pre-monsoon season	Post-monsoon season	
	Range	Range	Range	Range	-----
pH	8.1-8.4	7.3-8.2	8.4-8.7	6.8-7.3	7.0-8.5
Electrical conductivity ($\mu\text{mho/cm}$)	431-453	416-427	505-532	497-514	--
Alkalinity (mg/l)	177-185	166-171	197-203	184-193	120.0
Total solids (mg/l)	817-943	615-672	947-976	598-621	500.0
Hardness (mg/l)	168-172	161-165	189-198	131-153	100.0
Chloride (mg/l)	158-164	184-194	181-211	209-219	250.0
Dissolved oxygen (mg/l)	7.1-7.5	7.7-8.2	6.8-7.2	7.2-7.7	5.0
BOD (mg/l)	6.1-6.6	4.7-4.9	5.8-6.3	5.2-5.7	6.0
MPN/100 ml	2150-2343	1850-1951	1700-1767	1445-1634	< 4

3. Results

The range values of the River Ganga water quality parameters of the present study are presented in Table 2 and discussed on the basis of only pre-monsoon and post-monsoon seasons in brief. The odour was unobjectionable and taste agreeable at the selected sites.

4. Discussions

4.1 pH

The pH is one of the most important factors which influence aquatic life of any water body. The pH is generally affected by organic and inorganic solutes present in water. In the present study, pH ranges from 8.1 to 8.4 in pre-monsoon & 7.3 to 8.2 in post-monsoon seasons at site I. At site II, pH ranges from 8.4 to 8.7 in pre-monsoon, & 6.8 to 7.3 in post monsoon seasons. It has been seen that pH values are higher in summer than other seasons. Maximum values of pH during summer may be due to increased photosynthesis of the algal blooms resulting in the precipitation of carbonates of calcium and magnesium from bicarbonates (Prakash *et al.*, 2007).

4.2 Electrical conductivity (EC)

The electrical conductivity is a measurement of capability of water to transmit electric current in water bodies. It represents the total concentration of soluble

salts/mineral salts in water (Trivedy and Goyal, 1986), thereby making it sour and unsuitable for drinking. In the present study, the EC varies from 431-453 $\mu\text{mho/cm}$ in pre-monsoon & 416-427 $\mu\text{mho/cm}$ in post-monsoon seasons at site I. At site II, 505-532 $\mu\text{mho/cm}$ in pre-monsoon & 497-514 $\mu\text{mho/cm}$ in post-monsoon seasons as shown in Table 2. The narrow variation of EC can be due to the existing lithology of the region of the River Ganga.

4.3 Alkalinity

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 (Bhargava, 1982). In the present investigation, the alkalinity at site I ranged between 177-185mg/l in pre-monsoon season and 166-171mg/l in post monsoon seasons. The values at site II ranged between 197-203mg/l in pre-monsoon and 184-193 mg/l in post monsoon seasons. Alkalinity at the two sites was above the desirable limit prescribed for drinking water which is 120mg/l (WHO, 1984). The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body (Abassi *et al.*, 1999; Jain *et al.*, 1997). The high values of alkalinity may also be due to increase in free carbon dioxide in the River Ganga which ultimately results in the increase in alkalinity at site I & site II.

4.4 Total Solids (TS)

TS have great implications for the control of biological and physical wastewater treatment processes. The largest amount of total solids adds to the highest turbidity and EC value in the river water. TS at site I varied from 817-943mg/l (pre-monsoon period) and 615-672mg/l (post-monsoon period). At site II ranged between 947-976mg/l (pre-monsoon) and 598-621mg/l (post-monsoon period). The measurement of TS can be useful as an indicator of the effects of runoff from urban and agricultural areas. The increased TS was attributed to soil erosion in the nearby catchment and massive contribution of suspended solids from domestic effluents or local sewage.

4.5 Hardness

In general, hard water has no known effect on human health but is unsuitable for domestic uses. Hardness mainly depends upon the *dissolved salts* present in water. 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. Hard water is safe for drinking, cooking and other household uses, but it can cause problems. Hardness of water is due to the concentration of multivalent metallic ions of calcium and magnesium. In the present study, it is found that hardness ranges from 168mg/l to 172mg/l (pre-monsoon period) and 161-165mg/l (post-monsoon period) at site I. At site II, ranges from 189 mg/l to 198mg/l (pre-monsoon period) and 131-153mg/l (post-monsoon period). The trend of variation is non-uniform at all the sites. The hard water causes health effect on digestive system and forming of calcium oxalate in urinary bladder. The water hardness on selected study sites of River Ganga was higher during summer months which might have caused increased concentration of salts by excessive evaporation. In Table 3, Classification of Hard Water is shown.

Table 3. Classification of Hard Water

S. No.	Concentration as CaCO ₃	Indication
1	0 to 60 mg/l	Soft water
2	60 -120 mg/l	Moderately hard water
3	120 -180 mg/l	Hard water
4	>180 mg/l	Very hard water

Chloride (Cl⁻¹) 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 groundwater by weathering. The chloride ion is highly mobile and is transported to closed basins. The main source of chloride in surface water and groundwater is due to atmospheric precipitation, animal feeds, septic tanks, use of inorganic fertilizers and landfill leachate. In this study, the chloride contents were ranged from 158-164mg/l (pre-monsoon seasons), and 184-194mg/l (post-

monsoon seasons) at site I. The value ranges from 181-211mg/l (pre-monsoon seasons), and 209-219mg/l (post-monsoon season) at site II. Chloride content was lower than the accepted limit of 250mg/l at two selected sites in River Ganga. Chlorides in River Ganga waters can be attributed to discharge of local effluents or domestic sewage disposal which may result in moderate increase in levels of chlorides. The present observation finds support with the work of Singh *et al.*, 2007.

4.6 Dissolved Oxygen

DO levels in surface water body indicate the ability to support aquatic life. The high DO values means the rate of oxygen replenishment in water is greater than the oxygen utilization. Adequate DO is necessary for good water quality. DO levels between 5.0 and 8.0mg/l are satisfactory for survival and growth of aquatic organisms. In the present investigation, the DO contents were ranged from 7.1-7.5mg/l (pre-monsoon seasons) and 7.7-8.2mg/l (post-monsoon seasons) at site I. The value ranges from 6.8-7.2mg/l (pre-monsoon seasons) and 7.2-7.7mg/l (post-monsoon season) at site II. The low value was found in pre-monsoon period due to decreased solubility of oxygen in summer months and vice versa.

4.7 Biological Oxygen Demand (BOD)

BOD is the amount of oxygen required by the living organisms (microbes) in the utilization or stabilization of organic matter. In other words, the BOD is the amount of oxygen required by the microorganisms during their growth in wastewater. It is very important indicator of the organic pollution status of a water body. The Unpolluted water has BOD value of 3mg/l or less and industrial wastewater has BOD value 25000mg/l. The value of BOD in the present study was highest on site I as compared to site II (seen in Table 2). The value of BOD was more in pre-monsoon seasons and indicates that the river can be slightly polluted at different Ghats. The higher values were recorded due to organic waste discharges from various sources. Almost similar results were observed by (Bhargava, 1982; Rao, 1992; Shukla, 1989) for the Ganga river water.

4.8 Most Probable Number (MPN)

Generally, *total coliform bacteria* refer to the entire coliform group. These bacteria are abundant in soil, decaying vegetation, animal fecal matter and raw surface water. They are not normally present in deep groundwater and properly treated surface water. In addition to *fecal coliform bacteria* refers to a subgroup of coliform bacteria many of which are found in the intestines of warm-blooded animals, including humans. *E. coli* is the primary fecal coliform of interest. The presence of these bacteria in a water supply should be taken very seriously as they may well be accompanied by disease bacteria that are transmitted in animal feces.

The value of MPN in the present study was highest (2150-2343mg/l, pre-monsoon season; 1850-1951mg/l post-monsoon) on site I as compared to site II which values ranges from (1700-1767mg/l, pre-monsoon; 1445-1634mg/l post-monsoon) as shown in Table 2. In the present study, the maximum number of total coliform was in the month of April to June. The minimum number was recorded in the month of December and January. The high value in the present study may be attributed to the presence of bacterial load from the nearby surrounding areas (Fecal matter) and due to this reason, the River Ganga is absolutely unfit for drinking and unhealthy for bathing. Such higher value of MPN is also supported from the studies of other researchers (Bhargava, 1982; Rao 1992; Shukla, 1989).

5. Conclusions

It may conclude that the general characteristics of water from the study area is alkaline in nature with more total solids as well as above saturated with dissolved oxygen. The parameters chlorides are well within the permissible limits of drinking water quality standards. In addition to some selected parameters are slightly higher limits prescribed by (WHO, 1984) and not tolerable for household and commercial purposes. Slightly higher Hardness, DO, BOD and MPN values in Ganga river water is unfit for drinking purpose at selected sites. However, high pH, TS, Hardness, DO, BOD and MPN values suggest purification may be necessary for domestic consumption. Strict legal action should be taken against those who contaminate the River Ganga by waste dumping or discharges of local effluents.

Acknowledgment

The authors would like to thank Ministry of Human Resource Development (MHRD), New Delhi, Govt. of India, for providing financial support in the form of JRF and SRF to carrying out this research work. The authors would like to thank the Director Prof. T. Kumar, ISM, Dhanbad and HOD/ESE, ISM, Dhanbad for providing the laboratory facility for analytical works. The efforts of Lopa Mudra (B. Tech Student, ISM) are also highly appreciated in this research paper. The assistance received from Ranjan Kumar Singh during collection of samples is acknowledged. Sincere thanks also go to the two anonymous referees for their constructive comments.

References

- [1]. Bhargava, D.S. (1987). Nature and the Ganga. *Environmental Conservation*, 14(4):307-318.
- [2]. Dwidevi, S.L. and Pathak, V. (2007). Studies of Water Quality of Mandakini River in Chitrakoot for Irrigation Purposes. *IJEP*, 27: 761-764.
- [3]. Lantzy, R.J. and Mackenzie, F.T. (1979). Atmospheric Trace Metals Global Cycles and Assessment of Man's Impact. *Geochimica et Cosmochimica Acta*, 43, 511-525.
- [4]. Nriagu, J.O. (1979). Global Inventory of Natural and Anthropogenic Emissions of Trace Metals to the Atmosphere. *Nature*, 279: 409-411.
- [5]. Ross, S.M. (1994). Toxic Metals in Soil Plant Systems, Wiley Chichester, U.K.
- [6]. Singh, S.K. and Rai, J.P.N. (2003). Pollution Studies on River Ganga in Allahabad District. *Pollution Research*, 22:469-472.
- [7]. Tiwari, D. (2004). Pollution Potential of the Wastes Polluting River Pandu. *Nature Env. Polln. Techno.*, 3:219-221.
- [8]. Gupta, A.K. and Pankaj, P.K. (2006). Comparative Study of Eutrophication and Heavy Metal Pollution in Rivers Ganga and Gomti with reference to Human Activities. *Nature Env. Polln. Techno.*, 5:229-232.
- [9]. APHA (1985). Standard Methods for Examination of Water and Wastewater, 16th American Public Health Association, Washington, DC.
- [10]. Singh, R.P., Nath, S., Prasad, S.C. and Verma, H. (2007). Monitoring of Variation in Water Quality of River Ganga at Sangam in Allahabad. *IJEP*, 27 (8):680-688.
- [11]. Prakash, J.W., Aamon, J. and Regini, G.S. (2007). Water Quality Assessment of Thirparappu Reservoir, Kanyakumari. *IJEP*, 27 (8): 733-736.
- [12]. Bhargava, D.S. (1982). Usefulness of Ganga. *J. Indian Water Works Assoc.*, 14(3):239-241.
- [13]. Trivedy, R.K. and Goyal, P.K. (1986). Chemical and Biological Methods for Water Pollution Studies. Env. Publications, Karad, 35-96.
- [14]. WHO (1984). *Guidelines for Drinking Water Quality*, Volume I, Geneva.
- [15]. Abassi, S.A., Khan, F.J., Sentilevelan, K. and Shabuden, A. (1999). A study on the sewage disposal on water quality of Harmu river in Ranchi city, Jharkhand, India. *Indian J. Env. Health*, 41(3):176 -183.
- [16]. Jain, C.K., Bhatia, K.K.S and Vijay, T. (1997). Groundwater Quality in Coastal Region of Andhra Pradesh. *Indian J. Env. Health*, 39 (3):182-192.
- [17]. Rao, S.N., Chaubey, R. and Srinivasan, K.V. (1990). Ganga Water Quality in Bihar. *Indian J. Env. Health*, 32:393-400.
- [18]. Shukla, S.C., Tripathi, B.D., Rajanikant, V., Deepa Kumari and Pandey, V.S. (1989). Physicochemical and Biological Characteristics of River Ganga from Mirzapur to Ballia. *Indian J. Env. Health*, 31(3):218-227.
- [19]. http://www.jcranmer.com/lab_prempn.html.