ORIGINAL ARTICLE

The Physiochemical, Biological Quality and Seasonal Variability of River Ganges in Varanasi, Uttar Pradesh, India

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Abstract

Background: The Ganga River is a life-line, a symbol of purity and virtue for countless people of India. Nearly all the sewage, industrial effluent, runoff from chemical fertilizers and pesticides used in agriculture within the basin, and large quantities of solid waste, including thousands of animals carcasses and hundreds of human corpses are dumped in the river everyday which posed a considerable public health threat to the religious bathers and a large number of people living along the river who uses Ganges water for drinking and other household purposes. **Objective**: To assess the physiochemical and biological quality of river Ganges water and to study the seasonality pattern of pollution of River Ganges. **Materials and Methods**: Two points namely Samneghat and Rajghat (entry and exit point of Ganga into the city) were selected as the first and the last sampling stations, beside 8 other intermediate sampling stations to assess the physiochemical and biological quality of River Ganga water. The study was conducted from April 2013 to March 2014 and this period was crudely divided into three seasons viz Winter, Summer and Rainy season for the purpose of studying seasonality pattern of pollution. **Results**: As the river progress through city of Varanasi, Total dissolved solids (TDS), Chloride, Conductivity, Biochemical Oxygen Demand (BOD), Nitrate, Nitrite and Most Probable Number (MPN) increases, DO decreases progressively and Temperature and pH remain same. **Conclusion**: As far as quality of water with regard to recreational and industrial purposes are concerned, Ganges water may be considered useful but most of the parameters observed across different seasons indicates that it may not be used as potable water.

Keywords

Ganga River; Physiochemical; Biological; Seasonal variability

Introduction

The Ganga is a holy, symbol of purity and historical river of India. Ganga originates from the Gangotri glacier in Uttarakhand and enters Uttar Pradesh from Saharanpur when it starts flowing from south

to east. (1) In 2007, Ganga was ranked as one out of five most polluted rivers of the world. (2)

It serves water to drinking use and irrigation in agriculture to about 40% of India's population in 11 states. (2)

Water pollution is one of the serious public health hazards. Not only India but world is facing the problem of river pollution. Around 70% available water in India is polluted. The major responsible causes of pollution identified are domestic sewage, industrial and agricultural effluents. Out of which, wastes sewage constituting 84 to 92 percent of the waste water and other major source is industrial waste water which constitutes 8 to 16 percent. (4)

Although there are so many industries which pollute river Ganga but major load is being created by the domestic sewage that is untreated raw sewage which accounts for 1 million M3/day. (3)

Due to increasing population pressure, changing life style and growing trade activities pollution load is rising. It's really important to assess the present condition of the Ganges river.

Aims & Objectives

To assess the physio-chemical and biological quality of river Ganges.

Material & Methods

Study Type: A cross-sectional study. **Study Area:** The present study was carried out in Varanasi district.

Study Duration: The samples were collected at nearly weekly intervals from each sampling station between March 2013 to March 2014 so as to complete one sample from per Ghat per season.

Inclusion Criteria: While selecting the sampling stations, two points were specially taken care of:

A. Comparability with those studies conducted in past at River Ganges in Varanasi.
B. Relevance of the selected stations in the present-day context.

In order to fulfill the second condition, surveys were conducted to observe the extent of human activities at the bathing ghats and sewage discharge at different outfall points.

Parameters of the study: For this Present study following parameters were taken into account to cover physic-chemical (Temperature, pH, TDS, and Conductivity, DO, BOD, Chloride, Nitrate, and Nitrite) and bacteriological (MPN) aspect of the Ganga river.

Sampling Point: At each Sampling Station, three samples from the bathing Ghats were collected at the bank, about 15 meters away from the bank and at the midstream and half meter depth.

Sample Collection: Location of sampling points was based on sampling sites on the following characteristics.

University Ghat: entry point of river into the city.Bathing Ghat and Sewage Ghat: viz. AssiGhat, shivalaGhat, Rajendra Prasad Ghat, Trilochan and Pralhad Ghat to see the impact of human activity. Sewage Ghat: Assi, Shivala, Harishchandra, Rrajendra Prasad Ghat and Rajghat.

Funeral Ghat: Harishchandra.Rajghat: the exit point of river and most downstream point.

Time of Sampling: Samples were collected from 9 a.m. to 12.00 noon during winter and from 7:30 to 10:30 during the other seasons. Delay of maximum human activity at the bathing ghat by one and half to two hours during winter prompted the change in time of sampling. However, in a given season, samples were collected from a particular Station at a fixed time only during each visit (with a variation of ±30 minutes).

Technique of Collection: According to ICMR, 1996 guidelines three samples from the bathing Ghats were collected at the bank, about 15 meters away from the bank and at the midstream. But the samples from the opening of nalas were collected at about 2 meters downstream of the discharge point. The container was held at the bottom and the neck was plunged into the water at about 0.5 m depth, so as to avoid surface deposit which interferes with the results.

Thus, the neck of the bottle was turned slightly upwards, the mouth being towards the Current. When the bottle was full, it was raised above the surface and mouth Stoppard immediately. For bacteriological Samples the mouth of bottle and stopper were flamed with spirit lamp before collection to rule out the possibility of contamination the bottle were then dipped into the water at a depth of 0.5 meter, Stoppard Immediately.

Transport and Storage: All the sample collected and transported to the laboratory and stored at 8^0C-15^{o}C. Analysis of sample start as soon as sample reach the laboratory. If the pH of sample for bacteriological study is below 8.0, then they made alkaline by adding 4% NaOH to bring the pH above 8.0.

Physio-Chemical Analysis: Physiological parameters like temperature, pH and dissolved oxygen (DO) were estimated at the spot immediately after the

collection of samples and for further chemical analysis all the samples were brought to the laboratory and subjected to the analysis of Electric Conductivity (by conductivity meter), Chloride (by Mohr's method), TDS (by evaporation method and also checked by TDS meter), Nitrite (by diazotization method), Nitrate (by phenol disulfonic acid method), BOD (by incubating samples at 20 ºC for 5 days in BOD incubator), and MPN (by multiple tube method).

Results

Physio-chemical characteristics of River Ganges water are shown in table 1. As river progresses through city TDS, Chloride, Conductivity, BOD, Nitrate, Nitrite and MPN increases progressively, while DO decreases. At upstream samane ghat Nitrate was 0.161 ± 0.167 mg/L, while at most downstream Rajghat nitrate was 0.440± 0.281 mg/L. MPN concentration also showed rising trend with the progress of river in city. At upstream samaneghat MPN was 19055 ± 9303 mg/L, while at most downstream Raj ghat MPN was 31411 ± 11977 mg/L. The D.O. values lowest reading was 4.1 mg/L at Raj ghat and highest value was 8.9 mg/L at samane and shivala ghat. Though ghatwise there was no marked variation found in temperature and pH but maximum pH was 8.9 at Trilochan Ghat and minimum pH was 7.0 at Bhaidaini ghat. (Table 1)

Table 2 shows ghat-wise distribution of different parameters. Total solids varied from minimum 165 mg/L at RajenderaPrashad ghat in winter, to maximum 795 at trilochan ghat in monsoon. There was significant difference ($F = 5.534$, $p < 0.005$) found in ghatwise distribution of TDS. In this study conductivity at normal ghat was from 245 to 575 uS/cm, and at bathing and sewage ghat from 250 to 720 us/cm, while at cremation ghat from 265 to 680 uS/cm. There was significant difference observed in conductivity distribution at different ghat ($F= 3.543$, $p <0.03$). The minimum DO was 4.1 to 8.9mg/l at bathing and sewage ghat, maximum at normal ghat 5.14 mg/l to 8.9 mg/l, while at cremation ghat 4.5 mg/l to 8.9 mg/l. There was significant difference ($F=9.61$, $p=<0.0001$) observed in ghatwise DO in water. Normal ghat B.O.D. was from 2.5 mg/l to 7.8 mg/l and bathing and sewage ghat B.O.D. was 2.8 mg/l to 8.76 mg/l while cremation ghat BOD was 3.10mg/l to 7.75 mg/l, but no significant difference was observed. There was significant difference found in ($F= 5.029$, $p=0.009$) nitrite at different ghats. Taking MPN into account, there was significant difference observed in different ghats. (Table 2)

The seasonal variability is shown in table 3. The values of DO were highest during winter season and lowest during summer season with significant difference ($F = 54.7$, $p = <0.001$). Maximum BOD was during monsoon and minimum was during winter season and shows significant ($F= 437.22$, $p = 0.0001$) seasonal variation. Concentration of nitrate was maximum during summer while minimum during winter. There was significant ($F=71.037$, $p=0.0001$) difference in nitrate concentration during different season. In this study, MPN in summer was 14300 to 38800 /100ml, while in winter minimum from 7900 /ml to 30100 /100ml, and maximum in rainy season 21600 to 48300 / 100ml. There was significant difference observed ($F= 62.124$, $p < 0.0001$) in MPN in different season. (Table 3)

Discussion

As the river progresses through city there was no marked variation in temperature and pH of water.

It has been mentioned that the increasing pH appear to be associated with increasing use of alkaline detergents in residual areas and alkaline material from waste water in industrial areas. (5) Temperature and pH are found similar to the study done by A.K. Singh *et al* reported that temperature was maximum during summer and minimum during winter and pH ranges from 7.5 to 8. (6)

Smriti Dwivedi (1991) study shows TDS progressively increases as at university ghat 133- 318.4 and at raj ghat 320-600 mg/L and seasonal variation was marked as minimum in winter (133.6-352) and maximum during rainy (318.4 - 600.1) season which was as similar as in present study. (7)

The values of DO were highest during winter season and lowest during summer season (Table 3) as was also reported in a study by Kumari M *et. al*. (8) In present study DO was maximum during winter season and minimum during summer season as shown in table 3. The higher concentrations of DO were recorded during winter season mainly due to low turbidity & increased photosynthetic activity of the green algae found on the submerged stones and pebbles. As river progress through city DO decreases progressively. The trends observed in the present study is comparable with that observed in B.D. Tripathi *et al.* study showed there was a marginal decrease along the downstream. (9)

B. D. Tripathi and present study both shows similar increasing trend of BOD level as river flows into city (Table 1). As river progress through city Nitrate increased progressively, this showed increase sewage contamination, and bathing activity of man and animal at bathing ghat and cremation ghat waste discharge continuously in river. B.D. Tripathi *et al*. and present study both showed similar increase in nitrate level as river progress through city due to continuous pouring of untreated sewage. (9)

MPN concentration also showed rising trend with the progress of river in city. This study shows MPN in summer was 14300 to 38800 /100ml, while in winter minimum from 7900 /ml to 30100 /100ml, and maximum in rainy season 21600 to 48300 / 100ml. National River Conservation Directorate (NRDC) of the Government of India adopted standards in the year 2000 for ''river water quality bathing class'' rivers such as the Ganges of a maximum permissible FCC (faecal coliform count) level of 2500 MPN per 100 ml, but a ''desirable'' level of no more than 500 MPN per 100 ml. (10, 11) According to this criteria water in Ganga River in Varanasi was highly polluted.

Conclusion

Based on the results obtained in the study it can be concluded that Temperature, pH, Electrical Conductivity are within permissible level for recreational and industrial purpose while Nitrate and Nitrite are within desirable limit of drinking purpose. But DO, BOD and TDS (rainy season) are beyond permissible limit.

Recommendation

Strong action needed to be taken in this regard, otherwise after a lapse of time Ganga River will be only in books like river Saraswati.

Limitation of the study

It cannot be generalized as it was carried out only in Varanasi.

Relevance of the study

In the present study the quality of the Ganges water was assessed in keeping view of different parameters viz; physiochemical, biological Quality and seasonal Variability.

Authors Contribution

All authors contributed significantly in the study.

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Tables

TABLE 1 DISTRIBUTION OF PHYSIO-CHEMICAL AND BIOLOGICAL PARAMETERS AT SELECTED GHATS

GHAT	OVERALL MEAN AT EACH GHAT									
	Temperature	ph	TDS	Conductivity	Chloride	DO	BOD	Nitrite	Nitrate	MPN
SAMANE GHAT	24.64± 9.19	8.01± 2.84	323.33± 131.12	396.67± 172.54	31.37± 14.85	7.29± 2.64	4.52± 1.92	0.0011± 0.0010	0.1610± 0.1679	19056± 9303.66
ASSI GHAT	24.79± 9.30	7.83± 2.75	408.56± 173.50	473.33± 181.22	39.73± 16.44	6.14± 2.13	5.28± 2.16	0.0030± 0.0030	0.3010± 0.2561	25089± 10291.31
BHADAINI GHAT	24.86± 9.23	7.88± 2.70	315.89± 150.63	415.44± 183.43	32.69± 15.07	7.38± 2.72	5.16± 2.30	0.0014± 0.0013	0.1292± 0.1184	19656± 9964.97
SHIVALA GHAT	24.49± 8.74	7.76± 2.67	399.89± 165.68	488.89± 183.91	41.94± 17.68	6.32± 2.27	5.65± 2.40	0.0030± 0.0028	0.3159± 0.2532	26844± 10317.02
HARISHCHANDRA GHAT	24.96± 9.16	7.94± 2.55	506.67± 195.09	493.33± 196.32	34.50± 16.41	6.56± 2.41	5.57± 2.26	0.0028± 0.0025	0.3244± 0.2730	22211± 11266.78
RAJENDRA PRASAD GHAT	25.31± 9.51	8.14± 2.80	415.44± 181.11	484.44± 186.75	35.41± 16.49	6.24± 2.34	5.75± 2.42	0.0033± 0.0030	0.3179± 0.2443	26472± 10611.36
TRILOCHAN GHAT	25.42± 9.38	8.18± 2.76	497.11± 197.35	494.44± 194.61	36.59± 17.10	6.03± 2.23	5.93± 2.57	0.0035± 0.0030	0.3244± 0.2723	28156± 11502.94
TELIA GHAT	24.88± 8.99	8.14± 2.73	364.67± 165.56	426.67± 189.95	36.96± 17.53	6.99± 2.62	5.44± 2.28	0.0018± 0.0017	0.4039± 0.3370	23156± 11153.27
PRALHAD GHAT	25.06± 9.22	7.93± 2.55	434.78± 189.12	503.89± 200.51	45.28± 19.68	5.65± 2.06	6.02± 2.49	0.0045± 0.0041	0.3993± 0.2976	30189± 11618.21
RAJ GHAT	24.88± 9.22	8.02± 2.77	489.22± 184.21	522.78± 206.52	38.46± 17.37	5.79± 2.07	6.15± 2.47	0.0045± 0.0036	0.4409± 0.2811	31411± 11977.50

TABLE 2 SUMMARY STATISTICS OF WATER QUALITY PARAMETERS & TYPES OF GHATS

Type of ghat	Normal (Mean ±Std. Deviation)	Bathing and sewage ghat (Mean ±Std. Deviation)	Cremation ghat (Mean±Std. Deviation)	F	P
Temperature(^{O}C)	24.79 ±3.90	24.99 ±4.021	24.95 ±3.65	0.23	0.977
PH	8.09±0.42	8.08±0.44	8.05±0.39	0.037	0.964
TDS (mg/L)	334± 137.74	440± 168.00	506± 179.95	79.69	0.0001
DO(mg/L)	7.22±1.05	6.02±1.18	6.55±1.31	9.61	0.0001
BOD(mg/L)	5.03 ±1.71	5.67 ±1.95	5.42 ±1.81	1.041	1.041
Conductivity(uS/cm)	410.58 ±124.48	494.63 ±135.35	493.33 ±145.12	3.54	0.033
Chloride (mg/L)	33.67 ±13.22	39.57 ±14.20	34.50±14.23	1.81	0.169
Nitrate (mg/L)	0.231 ±0.259	0.349 ±0.278	0.324 ±0.293	1.68	0.191
nitrite(mg/L)	0.00143±0.00140	0.00363 ±0.00349	0.00280 ±0.00269	5.02	0.009
MPN (/100 ml)	20622±9613	28027±10735	22211±11332	4.91	0.010

TABLE 3 SEASONAL VARIABILITY IN WATER QUALITY PARAMETERS

Name of season	Summer (Mean ±Std. Deviation)	Winter (Mean ±Std. Deviation)	Monsoon (Mean ±Std. Deviation)	F	p
Temperature (^{O}C)	29.41±0.67	20.06 ±0.80	25.30±0.631	1313	0.0001
PH	8.16±0.41	8.03±0.41	8.04±0.46	0.878	0.419
TDS (mg/L)	336± 90.79	304 ± 116.10	605±95.56	79.69	0.0001
DO(mg/L)	5.20±0.71	7.48±0.88	6.62 ±0.93	54.7	0.0001
BOD(mg/L)	5.37 ±0.59	3.32 ±0.36	7.67±0.69	437.22	0.0001
Conductivity(uS/cm)	608.47 ±63.37	309.33 ±54.76	492.17 ±58.77	195.44	0.0001
chloride(mg/L)	55.47±6.33	29.49±4.22	26.91±5.62	250.67	0.0001
Nitrate (mg/L)	0.59±0.198	0.068 ±0.053	0.27 ±0.216	71.037	0.0001
Nitrite (mg/L)	0.00616 ±0.00315	0.00067 ±0.00049	0.00182 ±0.0012	64.408	0.0001
MPN (/100 ml)	22833 ±6307	16430 ±7576	36408 ± 7319	62.124	0.0001