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PHYSICO-CHEMICAL ANALYSIS OF RIVER GANGA AT VARANASI CITY IN UTTAR PRADESH, INDIA

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Abstract: *Physico-chemical Analysis of holy river ganga of Varanasi city (U.P.), India in month of February, 2016. Water samples were collected from seven different sites namely (S_1)- Gangamahal Ghat, (S_2)- Chedilal Ghat, (S_3)- Jain Ghat, (S_4)- Prabhu Ghat, (S_5)- Niranjini Ghat, (S_6)- Mahanirvini Ghat and (S_7)- Shivala Ghat. The range of observations are as under; pH of river water ranges between 7.0 to 7.8, Electrical conductivity from 0.45 to 0.58 dSm^{-1}, Cl from 1.50-4.0 mg L^{-1}, Ca+Mg from 23.50-27.50 mg L^{-1}, CO_3+HCO_3 from 2.80-4.20 mg L^{-1}, SO_4 from 16.00-36.00 mg L^{-1}, Na from 0.40-0.90 mg L^{-1}, K from 1.10-1.40 mg L^{-1}, TS from 800-1600 mg L^{-1}, DO from 5.30-7.30 mg L^{-1}, COD from 15.20-24.00 mg L^{-1}, NO_3 from 20.23 - 24.24 mg L^{-1} and SAR from 0.14-2.50. Regular monitoring of Ganga river water quality is necessary to have a check on surface water quality for the sake of human life & to maintain a balanced aesthetical value of religious.*

Keywords: *River Ganga, Water quality and Water resources etc.*

1. Introduction: The Ganges rises in the Garhwal Himalayas ($30^0$55N, $79^0$7E) under the name of Bhagirathi. The total length of Ganges river is about 2525 Km. The River Ganges is a part and parcel of everyday life in the city and it is one of the most sacred river in India, yet it is being polluted by many sources. The main townships of Uttarakhand and Uttarpradesh falling at bank of Ganges river are Rishikesh, Haridwar, Garhmukteshwar, Narora, Kannauj, Kanpur, Dalmau, Allahabad, Mirzapur, Varanasi, Ghazipur, Ballia and goes up to the Bay of Bengal in the Indian Ocean[1]. Today, over 29 cities, 70 towns, and thousands of villages extend along the Ganga banks. Nearly all of their sewage-over 1.3 billion litres per day-goes directly into the river, along with thousands of animal carcasses, mainly cattle [2]. Due to rapid population growth, agricultural and industrial developments, the quality of water in rivers is being degraded continuously making it unsuitable for various uses. An accurate and rational assessment for river water quality is required for determining the extent of usefulness of water bodies for various uses. Untreated waste water may contain different range of pathogens including bacteria, parasites, and viruses, toxic chemicals such as heavy metals and organic chemicals from agriculture, industrial and domestic sources [3, 4]. The present investigation is concerned in Varanasi city of Uttar Pradesh. The study of different water parameter is very important for understanding of the metabolic events in aquatic system. The parameters influence each other, therefore it has become obligatory to analyze important water parameters time to time which can indicate the favourable or unfavourable changes occurring in the ecosystem.

2. Materials and Methods

This chapter describes details of methodology used for the experiments performed during the course of the investigation. The area selected for the present study was River Ganga located in Varanasi city, month of February, 2016 for effective sampling its observation and analysis. Samples (Ganga River) was randomly collected at 1 m depth of 7 selected sites viz.

- **S_1**- Gangamahal Ghat
- **S_3**- Jain Ghat
- **S_5**- Niranjini Ghat

- **S_7-** Shivala Ghat
- **S_2-** Chedilal Ghat
- **S_4-** Prabhu Ghat
- **S_6-** Mahanirvini Ghat

Samples intended for chemical analysis must be collected during normal operating hours, 15 to 30 cm below the surface of the water or, where a reservoir is less than 30 cm deep, halfway between the surface of the water and bottom of the reservoir. Samples must be collected in an area that is not very frequented by bathers at the time of sampling. As per norm of the APHA[5]. It is also important to collect the sample in an area between the filtration system intake and water return. In the case of whirlpool baths, samples can be collected anywhere below the surface of the water. It is important to carefully follow the instructions provided by the manufacturer of the chemical test kits used. It is also essential that the hands of the person who is collecting the samples be extremely clean to prevent subsequent contamination (by sweat, chemical residues, etc.) when handling samples.

Table 1: Methods used for analysis of Physico-chemical parameters of river Ganga water at Varanasi city and Indian Standards (BIS) for Surface Water and their Permissible Limits. Source: APHA (1998).

Parameters	Methods	Indian Standards (BIS) (IS 10500:1991)
pH	pH meter	7.0-8.5
EC(dSm^{-1})	EC meter	0.50-5.00 (dSm^{-1})
Carbonate & Bicarbonate (mg L^{-1})	Titration Method	600 (mg L^{-1})
Nitrate (mg L^{-1})	Brucine Method	10-45 (mg L-1)
Chloride (mg/l)	A.O.A.C.	200-500 (mg L-1)
Sulphate (mg L^{-1})	Gravimetric Method	200-500 (mg L-1)
Na (mg L^{-1})	Flame Photometric method	20-200 (mg L^{-1})
K (mg L^{-1})	Flame Photometric method	12 (mg L^{-1})
Ca & Mg (mg L^{-1})	Titration Method	200 & 100 (mg L^{-1})
Total Solid (mg L^{-1})	Gravimetric Method	500-1500 (mg L^{-}1)
Dissolved Oxygen (mg L^{-1})	Winkler Method	6 (mg L^{-}1)
COD (mg L^{-1})	Winkler Method	250 (mg L^{-1})
Boron (mg L^{-1})	Calorimetric Curcumin Method	0.5-1.0 (mg L^{-1})
Sodium absorption ratio	Richards method	0.10-0.30

3. Results and Discussion

The present study evaluates the physico-chemical status of the Ganges River at Varanasi city. The estimation of 14 parameters (pH, EC, Cl^-, Ca^{2+} & Mg^{2+}, CO_3^{2-} & HCO_3^-, SO_4^{2-}, Na, K, TS, DO, COD, NO_3, B and Sodium absorption ratio.

3.1: pH: As depicted in the table 2, the pH values were found to be maximum 7.80 at Shivala Ghat and minimum PH 7.10 in Gangamahal Ghats. Alkaline range of pH in most of the water sample may be due to the general alkaline nature of the effluents being released into sampling sites/locations. From the table 3 we can know that there is a positive correlation of pH with Cl^-, CO_3^{2-} & HCO_3^-, Na, TS, DO and Sodium absorption ratio. Correlation between pH and calcium and magnesium is negative -0.70. This pH values having lower concentration as compared to BIS standards recommended. The different Ghats/Ganges was slightly above neutral making it's safe for drinking and other purposes [6].

3.2:.EC: As shown in the table 2 the maximum EC value (0.58 dSm^{-1}) was recorded at Shivala Ghat and minimum EC value (0.44 dSm^{-1}) was recorded at Prabhu Ghat. EC is significantly increasing at all sites to downstream. From the table 3 we can know that there is a positive correlation of EC with Cl, Ca^{2+} & Mg^2 and K. Correlation between EC and chloride is 0.67. The increased in EC values of water indicates that there is a source of dissolved ions in the vicinity. Higher the value of dissolved solids, greater the amount of ions in water. Increasing levels of conductivity and cations are the products of decomposition and mineralization of organic materials [6].

3.3: Chloride: As represented in the table 2 the chloride value of Ganga River is maximum at Shivala Ghat i.e 4.0 (mg L^{-1}) & minimum at Chedilal Ghat i.e 1.5 (mg L^{-1}). From the table 3 it can be concluded that there is a positive correlation of chloride with carbonate & bicarbonate, potassium, total solid and COD and sodium adsorption ratio. Chloride content can increase due to decomposition of organic matter. High concentration of chloride can also be contributed by mineral deposits, and industrial wastes, as well as domestic waste [7]. This Chloride values having lower concentration as compared to BIS standards recommended.

3.4: Calcium & Magnesium content (Ca^{2+} & Mg^{2+}): As represented in table 2, Gangamahal Ghat has the highest value of Calcium and magnesium content and Mahanirvini Ghat had

the minimum among these 7 Ghats. From the table 3 it can be concluded that there is a positive correlation of calcium & magnesium with Na, K, TS, COD and Boron. The correlation between calcium and magnesium and sodium is 0.02 [8]. This calcium & magnesium content values having lower concentration as compared to BIS standards recommended.

3.5:Carbonate & Bicarbonate (CO_3^{2-}& HCO_3^-): As represented in the table 2, the carbonate and bicarbonate value of Ganga River in maximum was 4.20 (mg L^{-1}) at Niranjini Ghat and minimum was 2.80 (mg L^{-1}) at Gangamahal Ghat. From the table 3 it can be concluded that there is a positive correlation of CO_3^- & HCO_3^- with DO, B and sodium absorption ratio. The carbonate values were found to be significant due to decomposition of organic matter [8]. High concentration of these can also be contributed by industrial wastes, as well as domestic waste. This Carbonate and bicarbonate values having lower concentration as compared to BIS standards recommended.

3.6: Sulphate (SO_4^{2-}): As represented in the table 2, the sulphate value of Ganga River water maximum was 36.0 (mg L^{-1}) at Jain Ghat and minimum was 16.0 (mg L^{-1}) at Mahanirvini Ghat. From the table 3 it can be concluded that there is a positive correlation of sulphate with DO, boron and sodium absorption ratio [9]. This sulphate values having lower concentration as compared to BIS standards recommended.

3.7: Sodium (Na): As represented in the table 2, the maximum sodium content value 0.9 (mg L^{-1}) was recorded at Chedilal Ghat and minimum Na value 0.40 (mg L^{-1}) was recorded at Niranjini Ghat. From the table 3 it can be concluded that there is a positive correlation of sodium with DO and Sodium absorption ratio. The correlation between sodium and TS is negative -0.71. The consistent in Na content values of water indicates that there is source toxicity is uniform [9]. This sodium concentration values having lower concentration as compared to BIS standards recommended.

3.8: Potassium (K): As represented in the table 2, the measure of Potassium value determines the quality of organic matter found in water. From the table 3 it can be recorded that there is a positive correlation of potassium with TS and COD. The maximum potassium concentration 1.5 (mg L^{-1}) was recorded at Gangamahal, prabhu and Nirinjini Ghat and minimum K value 1.2 (mg L^{-1}) was recorded at Chedilal and Jain Ghat [10]. Again after consistent analysis it is found that this value is lower than BIS standard reccomended.

3.9: Total Solid: As represented in the table 2, the total dissolved solid value of Ganga river maximum was 1600 (mg L^{-1}) at Gangamahal and mahanirvini Ghat and minimum was 800 (mg L^{-1}) at Jain and Niranjini Ghat. From the table 3 it can be concluded that there is a positive correlation of TS with COD and sodium absorption ratio. The largest amount of total solids adds to the highest turbidity and electrical conductivity [11, 12]. This total dissolved solid values having lower concentration as compared to BIS standards recommended.

3.10: Dissolved Oxygen (DO): Ganga river in minimum was 5.30 (mg L^{-1}) at Gangamahal Ghat and maximum was 7.3 (mg L^{-1}) at Shivala Ghat. From the table 3 we can know that the correlation of DO with sodium absorption ratio is positive. The DO values were found to be significantly different due to distinct sites [13]. These DO values have higher concentration as compared to BIS standards recommended. The different Ghats / Ganges having higher concentration of dissolve oxygen making it unsafe for drinking and other purposes.

3.11: Chemical Oxygen Demand (COD): As represented in the table 2, the measure of COD determines the quality of organic matter found in water. From the table 3 we can know that the correlation of COD with boron is positive. The COD was higher at Niranjini Ghat as compared to other Ghats. The maximum COD value 24.0 (mg L^{-1}) recorded at Niranjini Ghat, however the minimum mean COD value 17.6 (mg L^{-1}) was observed at Jain Ghat [14]. This chemical oxygen demand content values having lower concentration as compared to BIS standards recommended.

3.12: Nitrate (NO_3^{3-}): As represented in the table 2, the Nitrate concentration of Ganga river water maximum was 24.24 (mg L^{-1}) at Chedilal Ghat and minimum was 20.23 (mg L^{-1}) at Shivala Ghat [15, 16]. This nitrate concentration having lower concentration as compared to BIS standards recommended.

3.13: Sodium Absorption Ratio (SAR): As represented in the table 2 it is pretty much clear that Chedilal Ghat has highest value of sodium absorption ratio that is 0.25 and in Niranjini ghat the value is lowest this is 0.14. This value is calculated by taking calcium, sodium and magnesium in to consideration [17, 18]. This sodium absorption ratio values having lower

concentration as compared to BIS standards recommended.

Table 2: Physico-chemical parameter levels at different sites of the Ganga river at Varanasi city.

S.N.	Parameters	Locations of Different Ghats						
		S_1	S_2	S_3	S_4	S_5	S_6	S_7
1	pH	7.10	7.30	7.30	7.40	7.00	7.50	7.80
2	EC (dSm^{-1})	0.55	0.49	0.53	0.44	0.48	0.55	0.58
3	Chloride ($mg\ L^{-1}$)	3.20	1.50	3.50	2.80	2.90	4.00	2.50
4	Ca^{2+} & Mg^{2+} ($mg\ L^{-1}$)	27.50	27.00	25.50	25.00	26.00	23.50	24.50
5	CO_3^{2-} & HCO_3^{-} ($mg\ L^{-1}$)	2.80	3.20	3.80	2.80	4.20	4.00	4.00
6	SO_4^{2-} ($mg\ L^{-1}$)	17.50	21.00	36.00	19.00	24.0	16.00	27.50
7	Na ($mg\ L^{-1}$)	0.70	0.90	0.60	0.80	0.40	0.70	0.80
8	K ($mg\ L^{-1}$)	1.50	1.10	1.10	1.20	1.40	1.30	1.30
9	Total Solid ($mg\ L^{-1}$)	1600	1300	800	1200	800	1600	1400
10	DO ($mg\ L^{-1}$)	5.30	6.50	6.30	6.40	6.70	7.20	7.30
11	COD ($mg\ L^{-1}$)	22.40	20.00	17.60	19.20	24.00	22.40	15.20
12	NO_3^{3-} ($mg\ L^{-1}$)	21.40	24.24	21.47	21.40	22.35	22.14	20.23
13	Sodium absorption ratio	0.19	0.25	0.17	0.23	0.14	0.19	0.23

Here: S_1: Gangamahal ghat; S_2:Chedilal Ghat; S_3: Jain Ghat; S_4: Prabhu Ghat; S_5: Niranjini Ghat; S_6: Mahanirvini Ghat; S_7:Shivala ghat.

Table 3: Correlation between different physiochemical parameters of water sample

Correlations	**Different Ghats of Locations**											
	pH	EC	Cl	Ca^{2+} & Mg^{2+}	CO_3^{2-}& HCO^{3-}	SO_4^{2}	Na	K	TS	DO	COD	SAR
pH	1	-0.02	0.07	-0.70	0.33	-0.02	0.58	-0.38	0.41	0.61	-0.59	0.37
EC			0.67	0.30	-0.35	-0.14	-0.23	-0.14	0.40	-0.35	0.23	0.46
Cl				-0.30	0.04	-0.03	-0.61	0.23	0.06	-0.01	0.23	0.22
Ca^{2+} & Mg^{2+}					-0.67	-0.26	0.02	0.04	0.12	-0.77	0.41	-0.08
CO_3^{2-} & HCO^{3-}						0.43	-0.23	-0.38	-0.47	0.87	-0.15	0.36
SO_4^{2-}							-0.32	-0.52	-0.71	0.12	-0.61	0.36
Na								-0.29	0.57	0.08	-0.44	0.03
K									0.14	-0.25	0.57	-0.86
TS										-0.03	0.15	-0.11
DO											-0.14	0.20
COD												-0.35

4. Conclusion: On the basis of experimental findings it can be concluded that Shivala Ghat had higher pollution than other Ghats/Ganges, it may be attributed due to increased intensity of pH, EC, Carbonate, Bicarbonate, Sodium, Potassium, total solid and dissolved oxygen compare to other Ghats/Ganges. The water quality of the Ganga river can be improved to some level if immediate firm environmental surveillance is applied in order to check their compliance with environmental standards. The present infrastructure is not at all adequate to abate the pollution. The Ganga river water is mostly used for bathing purposes. In months of February of study period the Ganga water is found fit even for bathing. The strategies for resuscitating water quality of the Ganga river may include defensive and proactive approaches. Improvement in sewage network, enhancing sewage treatment capacities and preventing pollution load coming from tributaries are the measures under defensive approach which should be urgently executed.

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