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ABSTRACT

According to water discharge and water flow rate Ganga is the third largest river, next to Amazon and Congo in the earth. In this work we tried to find out the difference of ganga river water quality between upper course and delta course with respect to physico-chemical parameters, biologically significant few ion concentrations, status of coliform bacteria present. TDS, salinity, turbidity, conductance, alkalinity etc. are found greater in delta course compared to upper course. The dissolved oxygen level was foundhigher for upper course of the river. Hardness remains almost constant throughout the river flow. The coliform bacteria found is significant.

Keywords**:** *Ganga, Physico-chemical parameters, Ions, Upper course, Delta course*

INTRODUCTION

Upper course of river Ganga is the mountain course of river within the state Uttarakhand. Delta course denotes the path of river within West Bengal, i.e., Farakka to Gangasagar. River Ganga originated from western Himalaya within the Uttarakhand state of India, and is 2525 KM long. The river flows through the states Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. The Ganges is threatened by severe pollution, these poses a danger not only to humans but also to animals; the Ganges is home to approximately 140 species of fish and 90 species of amphibians. The river also contains reptiles and mammals, including critically endangered species such as the Gharial and South Asian river dolphin1. After flowing for 256.90 KM distance through Himalayan valley, the Ganges emerges from the mountains at Rishikesh, then debouches onto the Gangetic Plain at the pilgrimage town of Haridwar. This part is called upper flow of the river Ganga. From Farakka to Sagar island the river flows 408 km and known as Bhagirathi-Hooghly river or delta flow of river. The major cities at the bank of river Ganga are Kannauj, Farukhabad, Kanpur, Prayagraj or Allahabad,Chunar, Mirzapur, Varanasi, Ghazipur, Ara, Patna, Chapra, Hajipur, Mokama, Munger, Sahibganj, Rajmahal, Bhagalpur, Ballia, Buxar, Simaria, Sultanganj, Farakka, Murshidabad, Baharampur, Katwa, Nabadwip, Santipur, Chakdah, Naihati, Barrackpore, Kolkata and Howrah. These cities eject huge sewage water within the river during its flow. The major industrial towns of Unnao and Kanpur, situated on the banks of the river with the predominance of tanning industries add to the pollution[2]. According to official standards, water safe for bathing should not contain more than 500 fecal coliforms per 100 ml[3]. Sewage from many cities along the river's course, industrial waste and religious offerings wrapped in non-degradable plastics add large amounts of pollutants to the river as it flows through densely populated areas. Varanasi, a city of one million people that many pilgrims visit to take a "holy dip" in the Ganges, releases around 200 million litres of untreated human sewage into the river each day, leading to large concentrations of fecal coliform bacteria[4]. However, the riverine ecology has become highly disturbed because of the high degree of pollutionand it is noteworthy that the biological pollutant also shared some part of the total pollutant[5]. As the human beings residing in the area of the bank of the river Ganga, poor septic system leads to contribute biological contaminants to streams through surface or groundwater flows. Total coliform counts are the most widely used bacteriological procedures for water quality assessment and indeed is vital as the water of the “Ganga” is used for consumption either as drinking water or for house

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hold use. Hence the present study is aimed to compare the presence of total coliform group of bacteria in the upper and lower basin of the river "Ganga".

SAMPLING AND STUDY DESIGN

Sampling*:*

Sampling was done in different locations. In upper course sampling and onsite measurements were done in Rishikesh and Haridwar of Uttarakhand. In delta course sampling and onsite measurements were carried out at six sampling sites namely Baharampore, Nabadwip, Santipur, Naihati, Barrackpore and Princep Ghat, Kolkata. On site measurements were carried out from boat and samples were collected from mid-depth of river using expert swimmer.

Microbiological assessment:

Microbiological assessment was performed by sampling 100 ml of water from each site namely Rishikesh and Haridwar (Upper basin), Berhampur, Nabadwip, Shantipur, Naihati, Barrackpore and Princep Ghat (Lower basin). Microbial samples were collected in sterilized glass bottles for corresponding sampling sites and assessed according to the guideline of APHA[6]. Precisely, 5 tube most probable number (MPN) test was performed to determine the total coliform present in the sample. Briefly the method as follows; 10 ml, 1 ml and 0.1 ml of each sample was added to different test tube containing 10 ml of sterile Lauryl tryptose broth (LSB; Hi-media, India) with an inverted durham's tube in each tube. The sets of tube for each sample were incubated for 24 hr at 37ºC. Formation of acidic environment or gas accumulation in any tube is indicative for the positive result.

Determination of physico-chemical variables:

The sodium ion concentrations and potassium ion concentrations were measured at the Environmental Chemistry Research Laboratory, Barrackpore Rastraguru Surendranath College, Barrackopre, North 24 Parganas, WB, using Systronics (India) made Flame photometer 128 μC. Chloride, nitrate, ammonium and calcium concentrations are measured using Systronics (India) Limited made ion meter model number SYS-460 at Environmental Chemistry Research Laboratory, Barrackpore Rastraguru Surendranath College, Barrackopre, North 24 Parganas, WB. Total Dissolved Solid (TDS), pH, Temperature, conductance and salinity were measured using EUTECH made Multi-parameter PCSTestr 35 at the Environmental Chemistry Research Laboratory, Barrackpore Rastraguru Surendranath College, Barrackopre, North 24 Parganas, WB. Ion free, Redistilled water, prepared at laboratory, were used for all the analysis. All the measurements were carried out between 14° - 20°C.

Results

Table 1: Physico-chemical Parameters Recorded during January 2021 for River Ganga

Location	pH	Conductance mho/cm	Hardness ppm	TDS ppm	DO mg/l	Salinity ppm	Turbidity (NTU)	Total Alkalinity (ppm)
Rishikesh (14.4ºC)	8.67	144.6	67.18	101	9.7	67.9	2.8	72
Haridwar (15.3ºC)	8.68	243	106.70	168	10.4	114	1.9	108
Baharampur (18.5ºC)	8.50	385	144.248	273	9.3	183	12.65	202
Nabadwip (19.2ºC)	8.70	388	146.224	276	7.8	185	11.6	212
Santipur (18.9ºC)	8.56	388	146.224	284	10.3	184	24.4	215
Naihati (19.7ºC)	8.37	395	154.128	280	5.8	189	33.7	229
Barrackpore (19.9ºC)	9.7	398	154.128	283	5.9	191	28.8	206
PincepGhat (19.2ºC)	8.51	402	146.224	288	8.8	193	31.4	210

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Table 2.: Biologically Significant Ion Concentrations Recorded during January 2021 for River Ganga

Location	$CO_3^{=}$ mg/l	HCO_3^- mg/l	Na^+ mg/l	K^+ mg/l	NO_3^- mg/l	Ca^{2+} mg/l
Rishikesh (14.4°C)	2.4	82.96	7.03	4.79	151	54
Haridwar (15.3°C)	4.8	122	11.47	4.85	151	97
Baharampur (18.5°C)	2.4	198	41.01	8.94	75	117
Nabadwip (19.2°C)	4.8	248.88	38.83	8.42	92	170
Santipur (18.9°C)	3.6	209	41.35	9.23	69	164
Naihati (19.7°C)	8.4	215	45.58	10.16	131	166
Barrackpore (19.9°C)	3.6	244	40.71	12	90	112
PrincepGhat (19.2°C)	2.4	206	40.75	8.79	15	74

Table 3: Presence of Coliform group of bacteria in different sites of the river Ganga during January 2021. The MPN test was performed using 5 tube multiple tube fermentation.

Location	Positive Tubes in Sample Concentration (10 ml, 1 ml and 0.1 ml)	MPN Index 100 mL^{-1}	95% Confidence Limits		WHO standard count 100 mL^{-1}[9]
			Lower	Upper	
Rishikesh	1-1-0	4	1	15	3
Haridwar	2-3-0	12	5	29	3
Berhampur	5-4-2	220	100	580	3
Nabadwip	5-4-2	220	100	580	3
Shantipur	5-4-2	220	100	580	3
Naihati	5-5-5	>1600	700	-	3
Barrackpore	5-5-5	>1600	700	-	3
Princep Ghat (Kolkata)	5-5-5	>1600	700	-	3

The upper course of river Ganga is the mountain course within the state Uttarakhand. The delta course is actually the path of the river within West Bengal, i.e., Farakka to Gangasagar. From long ago the river Ganga is used by human civilization for water transportation, fishing, water source for irrigation, bathing, swage and industrial discharge, cremation etc. It has been estimated that about 350 fish species live in the entire Ganges drainage, including several endemics[5]. From the Table 1 it is clear that pH remains above 8 throughout the river course, i.e., river water is slightly alkaline. The hardness of river water is low in upper course but around 150 ppm in delta course. TDS values found low in upper course but around 280 ppm in West Bengal course. Dissolve oxygen value remain high in upper course (Table 1) but relatively low in delta course. Salinity and turbidity are lower in upper course of river when the river flows through Uttarakhand. From Table 2 it is found that nitrate concentration gradually decreases with increasing rivers course length. Sodium, potassium and calcium lower in upper course but higher for delta course. Bicarbonate ions are also found higher during delta course compared to that in mountain course. Total coliform counts from the eight sampling sites are presented in the Table 3. The lowest coliform count of 4 MPN 100 mL^{-1} was observed in Rishikesh while the counts exceeded >1600 MPN100 mL^{-1} in Naihati, Barrackpore and Princep Ghat (Kolkata), though in Berhampur Nabadwip and Santipur, the count limited to 220 MPN mL^{-1} and 12 MPN mL^{-1} in the sample of Haridwar.

DISCUSSION

The Ganges suffers from extreme pollution levels[7]. After the cremation of the deceased at different ghats the bones and ashes are thrown into the Ganges. However, in the past thousands of

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uncremated bodies were thrown into the Ganges during cholera epidemics, spreading the disease. Even today, holy men, pregnant women, people with leprosy or chicken pox, people who have been bitten by snakes, people who have committed suicide, the poor, and children under 5 are not cremated at the ghats but are left to float free, in order to decompose in the waters. In addition, those who cannot afford the large amount of wood needed to incinerate the entire body, leave behind a lot of half burned body parts. The physico-chemical parameters and ions found at different sites can be represented by following graphical diagrams.

Fig. 1: Comparison of pH data for different sampling sites

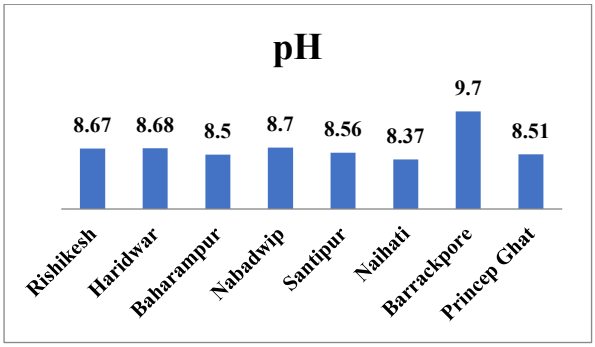

Fig. 2: Comparison of Conductance data for different sampling sites

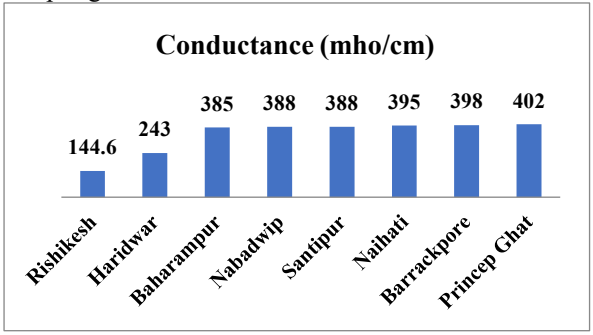

Fig. 3: Comparison of Hardness data for different sampling sites

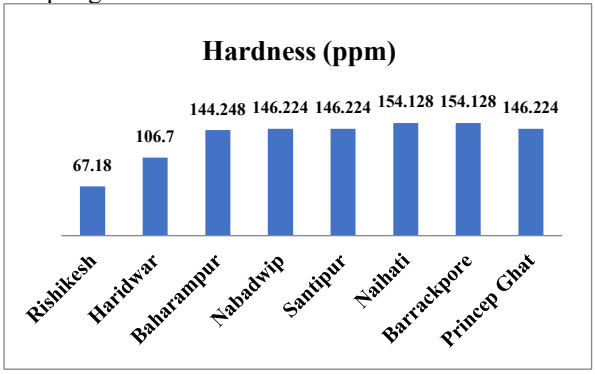

Fig. 4: Comparison of TDS data for different sampling sites

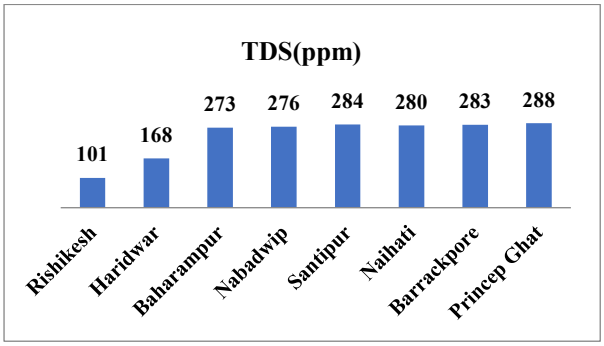

Fig. 5: Comparison of Dissolved Oxygen data for different sampling sites

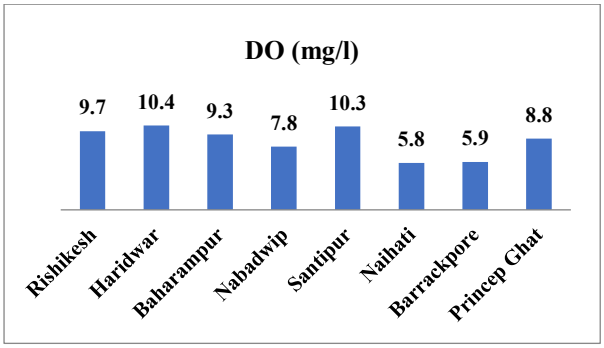

Fig. 6: Comparison of Salinity data for different sampling sites

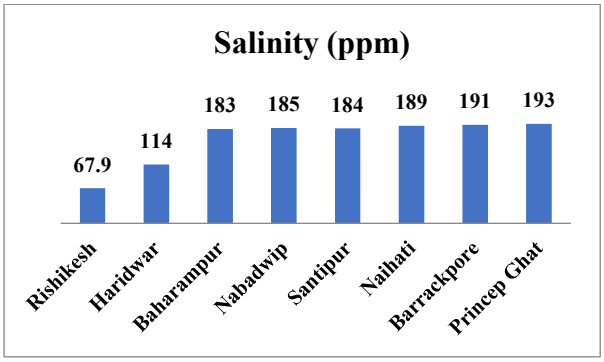

Fig. 7: Comparison of Turbidity data for different sampling sites

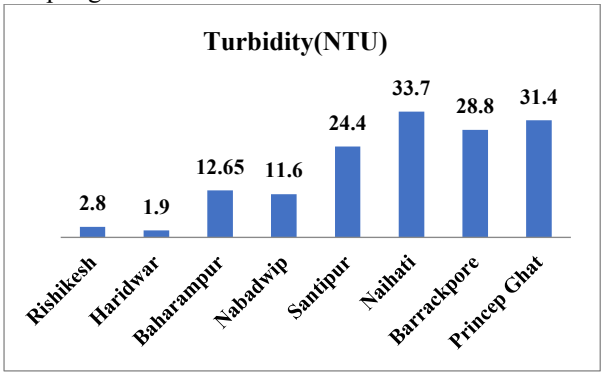

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Fig. 8: Comparison of Total Alkalinity data for different sampling sites

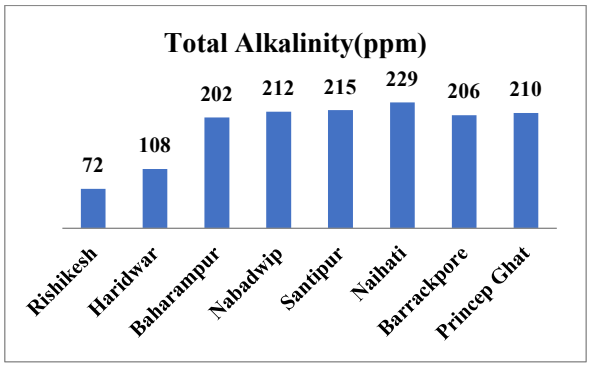


Fig. 9: Comparison of carbonate ion concentration data for different sampling sites

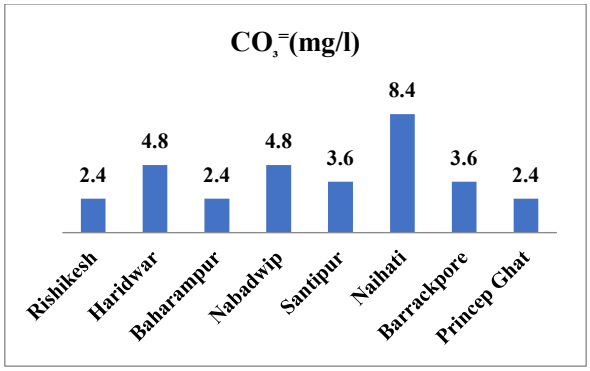


Fig. 10: Comparison of bicarbonate ion concentration data for different sampling sites

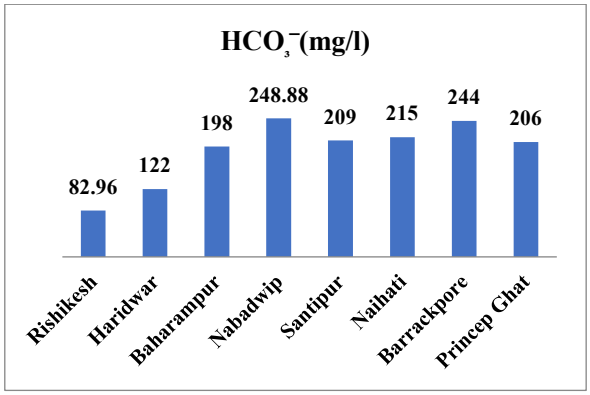


Fig. 11: Comparison of sodium ion concentration data for different sampling sites

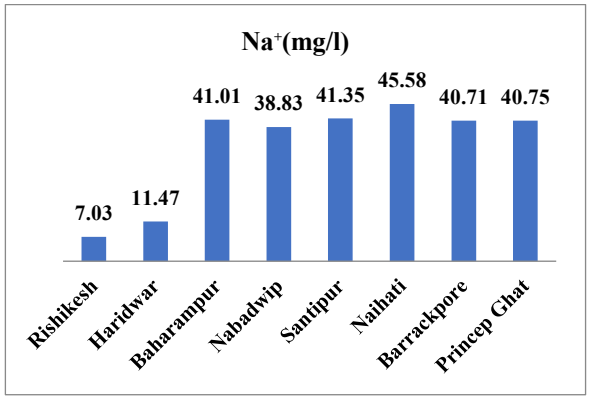


Fig.e 12: Comparison of potassium ion concentration data for different sampling sites

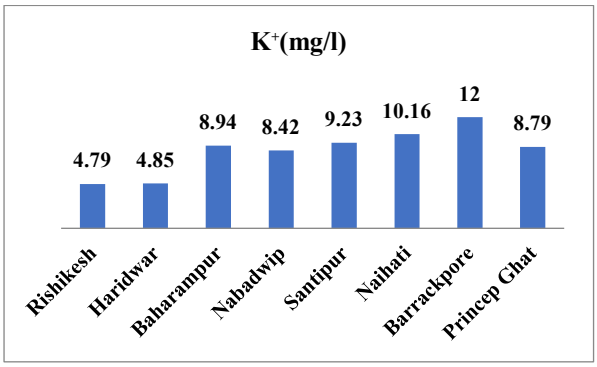


Fig. 13: Comparison of nitrate ion concentration data for different sampling sites

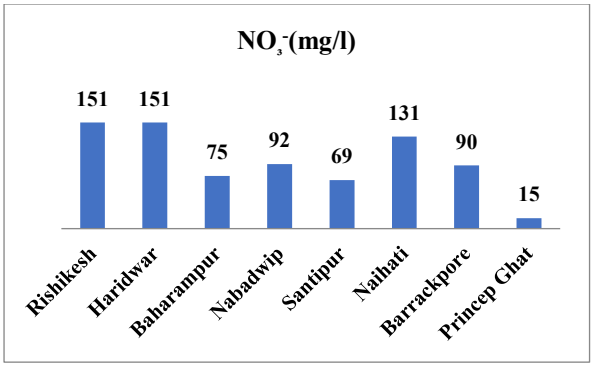
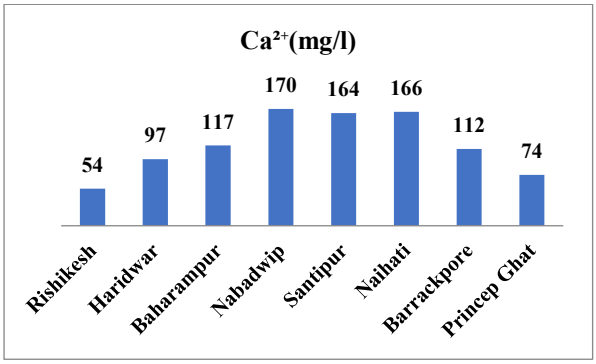


Fig. 14: Comparison of calcium ion concentration data for different sampling sites



Throughout this course of river water pH is constant and around 8.5 (Table 1, Figure 1). The low hardness in upper course is due to low calcium and magnesium carbonates and bicarbonate salts within dissolve water. This is also evident from calcium, carbonate and bicarbonate ions concentration reported in Table 2, Figure 9, Figure 10 & Figure 14. Results obtained from TDS measurements indicates low level of sewage, industrial waste and pollutants discharge within the river Ganga within the state Uttarakhand. The major sewage, industrial waste and pollutant discharge take place from the states Uttar Pradesh, Bihar and Jharkhand, so TDS value moves around 288 ppm within West Bengal course (Figure 4). Relatively

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higher dissolve oxygen in upper course and lower in the delta course is the clear indication of higher level of pollutant present within rivers delta course or West Bengal course (Figure 5). In the delta course salinity two to three times than that in upper course of river(Figure 6). This is due to dissolution of salts during rivers flow and effluents mixing from big towns within the rivers middle course. Turbidity of any river is low in its upper course and maximum in lower course. For the river Ganga the trend of turbidity is usual (Figure 7). Interestingly with distant travelled or course length the nitrate ion contained of river water gradually decreases (Figure 13). Perhaps the nitrate ions are used to oxidised organic pollutants during rivers course. Anyway, the amount of nitrate ion remains above WHO limit for drinking water (45mg/litre) before the river reach Kolkata. In Kolkata the nitrate ion contains in river Bhagirathi water is found 15mg/litre. It is evident from Table 2 bicarbonate, sodium, potassium and calcium content is largely higher in delta course of river due to addition of these ions in rivers middle course (Figure 10, Figure 11, Figure 12 & Figure 14). The results of the total coliform counts for eight sampling sites of the river Ganga were exceeded the WHO standard limit of 3 coliform/100 mL. It is a striking feature that as the river water ran from upper basin to lower basin, the tendency of growth of the coliform bacteria became higher. This phenomenon can be justified as the water entered in the lower basin (mostly flat terrain) of the running path of the river, river bank is highly densely populated and urbanised which in turn discharge a vast amount of house hold contaminant in to the river as compare to the upper basin which is barely populated. Moreover, coliform bacteria are considered as fecal contaminant of several animals and human beings and as the lower basin of the Ganga is highly exposed to the developing as well as developed urbanization, resulting poor septic system causes higher number of coliform group accumulation and growth in the river. The result supports the findings of Sengupta et al.[8] stated that rivers near populated areas are more prone to bacterial contamination as the area receive surface runoff from agricultural and pasture land, animal wastes and effluent runoff discharges from the industrial and plantation. Furthermore, the results of this study showed that the coliform count of the river was exceeded than the WHO standard[9], either of its' basin indicating that the Ganga is becoming increasingly polluted as untreated sewage and agricultural runoff discharges into the water which is not safe for consumption before treatments. Evans et al.[10] stated that urbanization leads to overpopulated growth which is the main contributor to water pollution cases globally which can be attributed by our study specifically in the lower basin of the Ganga where urbanization is very salient feature. Thus, concerning the overgrowth of coliform, special care is utmost important for water-based recreational activities as pollutants may lead to gastrointestinal infections, diarrhoea, dysentery, typhoid fever, and other forms of infections.

CONCLUSION

Rivers are considered as the lifeline of human civilization. Most of the ancient civilization were firmly associated with the river, even now leading modernized urbanization developed in the river bank as the river is considered as large fresh water reservoir around the globe. The Ganga is such a river of the India involved in important urbanization considering its use in irrigation, house hold (cooking, bathing), Industry etc. Water quality has been a subject of great concern. In this study a baseline approach has been made to assess the water quality of the Ganga considering its running path i.e. upper basin and lower basin by physicochemical and microbiological perspectives. Upper basin of the river was found relatively safer than the lower (delta) basin either of the study perspectives where most of the physicochemical variables are lower in concentration in the upper course of the river and notably higher in lower course of the river. It is noteworthy that faecal coliform also significantly higher and far beyond the permissive limit in the lower basin. Considering the importance of the Ganga in Indian scenario, the study shows a great concern and particularly the lower basin is widely polluted. Hence, Governments and policy makers have to be highly aware to minimize the pollution level of the river.

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