

# A study on physico-chemical Characteristics to assess the pollution status of river Ganga in Uttarakhand

Gagan Matta\*

Department of Zoology and Environmental Science

Gurukula Kangri University, Haridwar (Uttarakhand), India

\*Corresponding author: E-mail: drgaganmatta@hotmail.com

## Abstract

The present study was undertaken to appraise impact of pollution on River Ganga at Rishikesh with two different sites i.e. Site 1 (Shivpuri) control site and Site 2 (Pashulok Barrage) with loads of pollution from dense commercialized waste water discharging areas from Rishikesh. While monitoring samples were collected monthly (2011-2012) from sampling sites to evaluate relative differences in physico-chemical properties of river water such as Temperature (8.14%) higher, Turbidity (29.39%) higher, Transparency (13.93%) lower, Velocity (4.34%) lower, Total solids (27.40%) higher, pH (1.40%) higher, Dissolved Oxygen (6.20%) lower, Free CO<sub>2</sub> (11.76%) higher and Total Hardness (18.83%) higher at site 2 in comparison to Site 1. The mean values of these parameters were compared with WHO and ISI standards. Significant differences ( $p < 0.05$ ) was found in Turbidity, Total solids (TS), pH, Dissolved Oxygen (DO), Free CO<sub>2</sub> and Total Hardness (TH) with sampling stations. Turbidity on both sites was observed above the permissible limit but, was found much higher on Site 2 in comparison to Site 1 due to pollution in Rishikesh.

**Keywords:** physico-chemical Characteristics, Ganga River water, pollution, Shivpuri, Pashulok Barrage

## INTRODUCTION

River Ganga occupies a unique position in the cultural ethos of India. Millions of Hindus accept its water as sacred and count as river of faith, devotion and worship. River Ganga (Ganges) has originated from two headwaters at an altitude of about 6000 m in the Garhwal Himalaya, it flows through the Sivalik hills and entered the plains at Haridwar. Flowing towards south, meandering over several hundred kilometers in the Indo-Gangetic plains in Uttar Pradesh, Bihar and West Bengal, with surface water availability (446 million acre feet) and the annual flow of freshwater in the river (142.6 million m<sup>3</sup>), it nourishes the mostly dense populated regions of the world. Over 29 cities, 70 towns and thousands of villages extend along the Ganga banks depends on River Ganga basin from agriculture to domestic, commercial to industrial use. During its over 2,525 km journey from Gangotri to Ganga Sagar (Bay of Bengal), there are complex, nested sets of challenges that intimidate the very existence of this revered river by millions of Indians. Not only is the river a vital resource for agriculture and industry, it also holds an iconic status in India's cultural heritage (Das et al. 2012 and M.H.A 2012).

But in the last three decades the Ganges basin is among the most heavily populated areas in the world with an average density of 520 persons per square kilometer. After independence pressure of advancement in industry, urbanization and population growth have posed higher contamination to water quality of River Ganga. In the process, this invaluable resource was reduced to a convenient means of waste disposal. Wastewater such as municipal sewage is a major culprit followed by industrial effluents and agricultural run-off. The river is also a site for religious bathing (Kanvar mela, Kumbh mela *etc.*), washing and watering of animals and the disposal of human and animal corpses. Including all these activities, tourism is also an important factor, promoting higher pollution load to River Ganga. Permanent restructuring of the river and its environment was the result of variety of construction activities and replacement of a natural environment by a new built environment with variety of far reaching and long lasting result, in term of existing biological species and physical conditions in the area (Matta, 2010, Matta et al., 2011, Bhadula et al. 2014).

Keeping in view the above scenario the present study has been undertaken to assess the impact of monthly variation on concentration of physico-chemical parameters and impact of the different pollutants discharged into river water, as well as to explore the relative pollution status of the River Ganga.

## MATERIALS AND METHODS

**Study area:** The present study has been carried out in Rishikesh to examine pollution status of River Ganga, located in newly carved state of Uttarakhand. Rishikesh is extended from latitude 30°07' in the north to longitude 78°19' in the east. It has an average elevation of 372 meters. Rishikesh had a population of 59,671 as per 2001 census of India. During this study period physico-chemical parameters of River Ganges were studied. Water samples were taken from two locations in Rishikesh in foot hills of Garhwal Region of Uttarakhand. The sampling

locations are depicted in Fig. 1. Site 1 (Shivpuri), is control site for the study 18 Km away from Rishikesh, a naturally ecosystem, a well know tourist spot popular for river rafting and beach camping and. Just next to sampling location, highly tourist spot is available for river rafting with domestic or commercial setups. Site 2 (Pashulok Barrage – 22Km from Shivpuri) is located in outer part of Rishikesh. After crossing all over from Rishikesh, River Ganga flows from this sampling site. Fig. 1 shows highly commercial areas with loads of pollution and waste water discharge. Located on River Ganga towards south of Rishikesh in Dehradun district, Uttarakhand, India with low water level in winter season in comparison to summer and monsoon season. The velocity and water level at Pashulok Barrage depends on seasonal variability. The barrage covers entire pollution load of Rishikesh city and tourism. In a run-of-the-river scheme, the main purpose of the barrage is to divert water into a canal on the east bank of the river which feeds water to the Chilla Power Plant downstream at 29°58'34"N 78°13'11"E, 4 km (2 m) upstream of Haridwar. Therefore, comprehensive river water quality monitoring program is becoming a necessity in order to safeguard public health and to protect the valuable and vulnerable fresh water resources (Kannel et al. 2007 and Singh 2014).



Figure.1. Showing the view of Shivpuri (Site 1- control site) and (Site 2 - Pashulok Barrage)

**Samples collection and analysis:** The water samples were collected on monthly basis for the period of one year from Nov 2011 to Oct 2012. Water samples were collected using a clean plastic bucket, transferred to clean plastic bottles and transported to the laboratory on ice and stored in a deep freezer (-20°C) till analysis. Samples were collected in triplicate from each site and average value for each parameter was reported. The physical parameters like pH, Temperature, DO, Transparency, Velocity, and Free CO<sub>2</sub> are recorded on the spot and other chemical parameters like Turbidity, TS, and TH are recorded in the Laboratory which were determined using standard methods (APHA 2005).

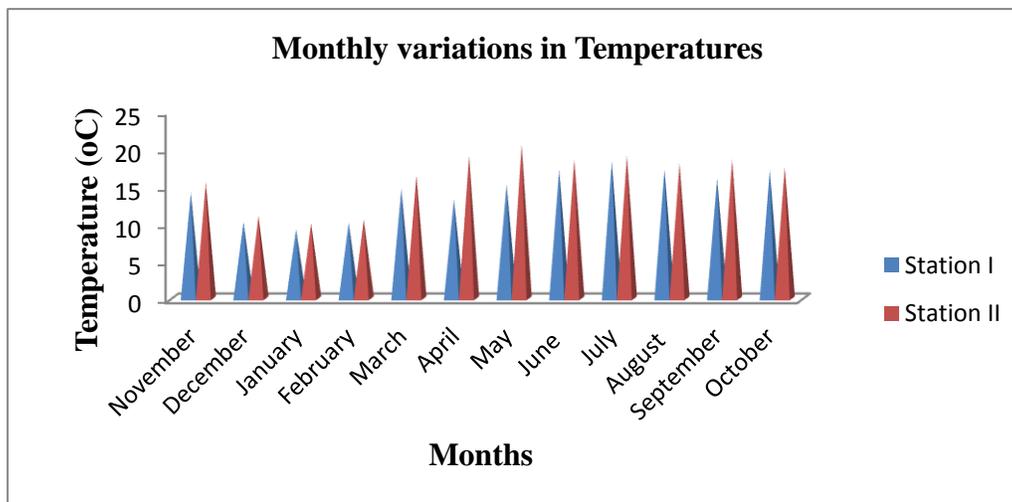
**Statistical Analysis:** In statistical analysis, a correlation developed between parameters by using Karl Pearson's coefficient of correlation for data analysis of Ganga River water to measure the variations between Site 1 and Site 2 parameters. MS Excel was used to measure the Mean and Standard deviation (SD) of the data.

## RESULTS AND DISCUSSION

The physico-chemical characteristics of Site 1 (Shivpuri) control site and Site 2 (Pashulok Barrage) sampling sites are appended in Table (1) and Fig. 2, 3 and 4. The water quality analysis of Ganga River showed that Site 2 was highly polluted because of the influx of sewage and domestic wastes in comparison to Site 1.

**Temperature:** Temperature is one of the most important parameters that influence almost all the physical, chemical and biological properties of water and thus the water chemistry. It never remains constant in rivers due to changing environmental conditions (Kumari et al. 2013). In present study the mean maximum temperature (16.20°C ± 3.67) of Ganga River was recorded at Site 2 in comparison to site 1, which was recorded to be (14.37 °C ± 2.97). The minimum temperature was recorded in the month of January at site 1 and maximum was recorded in the month of July at site 2. Maximum values of temperature might be due increasing rates of pollution and wastewater discharged at Site 2 (Fig. 2). Temperature is known to influence the pH, alkalinity and DO concentration in the

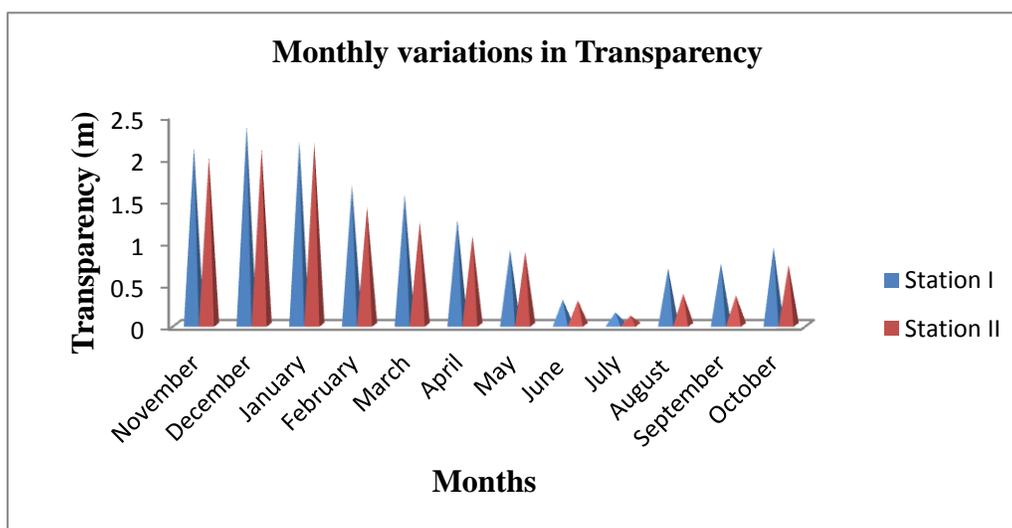
water. Bhadula et al. (2014) reported 8.04% increase in temperature between two sites of Sahastradhara stream at Dehradun District. The overall lowest and highest mean values of temperature were observed 10.7°C and 21.7°C in the month of January and June at the Site 1 and Site 2, respectively. Among the three selected sites the Site 1, happens to be first site therefore has been treated as reference site. It can also be recorded here that normally there are no tourists at Site 1.



**Figure.2.** Showing monthly variations in temperatures (°C) of Site 1 and Site 2

**Turbidity:** The Turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as lay or slit, finely divided organic matter, plankton and other microscopic organisms. Turbidity of water is an important parameter, which influences the light penetration inside water and thus affects the aquatic life (Verma and Saksena 2010; Tambekar et al. 2013). During the present study maximum turbidity was recorded with Site 2 (165.56 JTU) in comparison to Site 1, that was found to be (126.29 JTU). The minimum turbidity was recorded in the month of January at Site 1 and maximum in the month of July at Site 2.

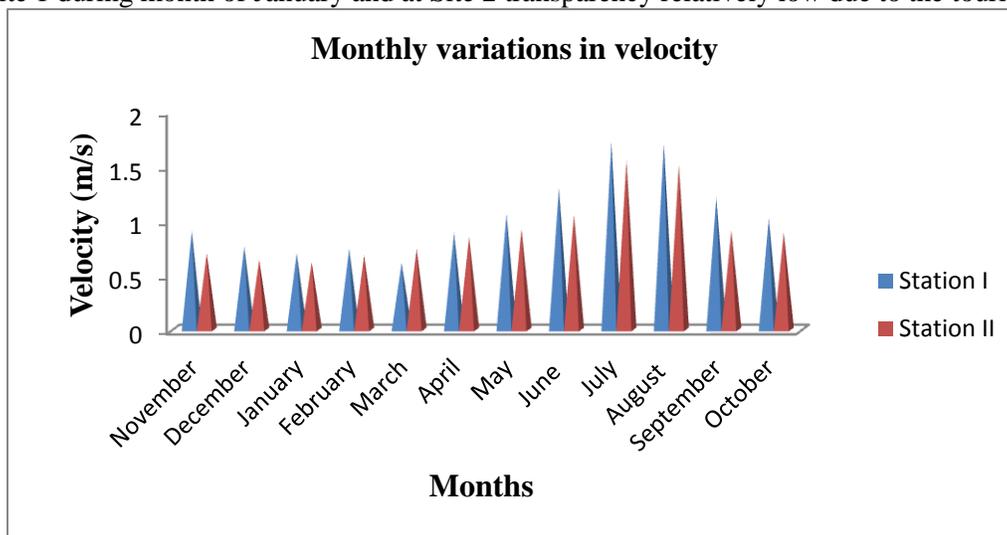
Recent study done by Joshi et al. 2009 reported that turbidity in the River Ganga at Haridwar was lowest during winter season. From summer season onwards the water became turbid due to melting of snow and rains. The maximum turbidity 608.15 JTU was observed in monsoon season and minimum 19.15 JTU was observed in winter season from water samples collected from five spots sampling site A (Bhooma Niketan), sampling site B (Jai Ram Ashram), Sampling site C (Har-Ki-Pauri), sampling site D (Prem Nagar Ashram) and sampling site E (Pul Jatwara).



**Figure.3.** Showing monthly variations in transparency (m) of Site 1 and Site 2

**Transparency:** Transparency is a measure of how clear the water is. It is important, because aquatic plants need sunlight for Photosynthesis. The clearer the water, the deeper sunlight will penetrate. Transparency has direct

bearing on the light penetration of water and depends upon suspended matter and dissolved colored substances. In the present study lowest mean value of transparency was recorded (1.05m) with Site 2 as compared with Site 1 (1.23m). The lower transparency at Site 2 is due to higher pollution load. The higher values were exhibited during winter and summer months, whereas lower values were found in monsoon season (Fig. 3). (Sharma et al. 2010) reported highest values 47cm was at bathing ghat of Sapt rishi during III<sup>rd</sup> Royal Bath, while the lowest value 14 cm was found at the bathing ghat of Prem Nagar during fourth Royal bath at Haridwar. Bhadula et al. (2013) reported overall lowest and highest mean value of transparency were observed 1.0cm and 45.7cm in the month of August and January at the Site 2 and Site 1, respectively of Sahasradhara stream. The study reveals that a relative comparison in transparency showed comprehensive variation in water quality. The maximum transparency was found at the Site 1 during month of January and at Site 2 transparency relatively low due to the touristic activities.



**Figure 4. Showing monthly variations in velocity (m/s) of Site 1 and Site 2**

**Velocity:** The velocity was found to be directly proportional to the flood level and also with gradient of the river stretch. The water level and its velocity started increasing from winter season onwards due to melting of snow at the place of origin of the river. Flow can affect the river's ability to assimilate pollutants; larger, swiftly-moving streams and rivers can receive pollutants with a diminished negative effect. Smaller rivers with low flow have less of a capacity to dilute and degrade potentially harmful pollutants (EPA 2012).

During the present study the mean velocity of River Ganga at Site 2 was recorded to be (0.92m/s) in comparison to Site 1, which was found to be (1.05m/s). Maximum velocity of River Ganga was observed in the month of July and August at both the sites, but lower velocity was observed at Site 2 in comparison to Site 1 (Fig. 4). This might be due to climatic conditions in which water level and its velocity started increasing from winter season onwards due to melting of snow at the place of origin of the river. Joshi et al. (2009) also reported the maximum velocity 2.18 m/s of the Ganga at Haridwar was recorded in monsoon season and the minimum velocity 0.39m/s were observed in winter season.

**Total solids:** Total solids (TS) are the combination of total suspended solids (TSS) and total dissolved solids (TDS). The effect of presence of TS is due to silt and organic matter. In the present study maximum TS (397.34 mg/l  $\pm$  322.23) was recorded at Site 2 in comparison to Site 1. Higher values of TS were recorded in the month of July and August at Site 2, which reflects more pollution due to discharge of whole city sewage at this site. Recent studies done by Raja et al. 2008 reported higher level of TS (570.00 mg/l  $\pm$  155.2) at Chinthamani Road Bridge than upper anicut and grand anicut sites of River Kaveri, Tiruchirappalli. Tambekar et al. (2013) also reported Wardha river water sample in pre- monsoon, monsoon and post-monsoon was found to be in the range of 260- 360, 480- 510, 350- 431 mg/l along with concentration of average value with 95% CL value was found to be 283+13.5, 495+11, 385+29 mg/l respectively. The effect of presence of TS is due to silt and organic matter. The maximum value of TS was recorded in monsoon season.

**pH:** Aquatic organisms are affected by pH, because most of their metabolic activities are pH dependent. Optimal pH range for sustainable aquatic life is pH 6.5-8.2. pH of an aquatic system is an important indicator of the water quality and the extent pollution in the watershed areas (Kumar et al. 2011).

During the present study the overall highest mean value of pH were observed ( $7.91 \pm 0.21$ ) at Site 2 in comparison to Site 1, which was recorded to be ( $7.83 \pm 0.23$ ). There was not much fluctuation recorded in pH values. The highest pH were recorded in the months winter and summer seasons than rainy seasons. Higher value of pH in summer season may be due to influx of sewage effluents disposal and low level of water. Recent studies done by Joshi et al. 2009 reported the pH of the Ganga River at Haridwar was slightly alkaline ranged from 7.06 to 8.35.

**Dissolved Oxygen:** DO is a factor which determines whether the biological changes are brought about by aerobic or anaerobic organisms. It reflects the physical and biological processes prevailing in the water. The oxygen present in water can be dissolved from air or produced by photosynthetic organisms. Oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reductant such as hydrogen sulphide, ammonia, nitrites, ferrous iron, etc. (Singh 2012). In the present study DO reduces during the summer season as compared to winter and monsoon months it may be due to higher temperature, oxygen demanding wastes, inorganic reductant and seasonal variation. In the present study the overall lowest and highest mean value of dissolved oxygen was observed 8.92 mg/l at Site 2 and 9.51mg/l at Site 1. The lowest value at Site 2 indicates load of pollution in comparison to Site 1.

Mishra and Tripathi (2007) reported the mean value of the dissolved oxygen ranged between 1.8 to 5.9 mg/l in River Ganga in Varanasi. Highest DO at the Site 5 where minimum discharge of effluent and human activities. Lowest DO at the Site 1 where maximum discharge of sewage effluent from the town. Verma (2013) reported that W. Ramganga River in Kumaun Himalaya, India had highest DO 10.72 mg/l content in month of December, whereas the lower DO 7.6 mg/l. content was recorded in the month of July due to increase in temperature in summer months.

**Free CO<sub>2</sub>:** Carbon dioxide is vital in the life of plants and microorganisms. It is produced due to respiration of aquatic organisms. Free CO<sub>2</sub> in the present study was recorded maximum ( $1.33 \text{ mg/l} \pm 0.61$ ) at Site 2 in comparison to Site 1, which was observed ( $1.19 \text{ mg/l} \pm 0.52$ ). The lower values of Free CO<sub>2</sub> were observed in the month of Nov to February and higher values were recorded in the month of June to September at Site 2. The increase in carbon dioxide level during these months may be due to decay and decomposition of organic matter due the addition of large amount of sewage, which was the main causal factor for increase in carbon dioxide in the water bodies.

Joshi et al. (2009) reported that free carbon dioxide in the Ganga water was invariably present throughout the year. It fluctuated from 1.15 mg/l in winter season to 5.39 mg/l in rainy season. The free carbon dioxide was found to be maximum in monsoon season and minimum in winter season.

**Total hardness:** The hardness of water is not a pollution indicator parameter but indicates water quality mainly in terms of Ca<sup>2+</sup> and Mg<sup>2+</sup>, bicarbonate, sulphates, chloride, and nitrates. Water with less than 75 mg/l-1 of CaCO<sub>3</sub> is considered soft and above 75 mg/l-1of CaCO<sub>3</sub>as hard (Kumar et al. 2010; Singh and Chodhary, 2013). It is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies (Mitharwal et al. 2009). During the present study maximum TH ( $58.10 \text{ mg/l} \pm 8.35$ ) was recorded at Site 2 in comparison to Site 1, which was found to be ( $49.22 \text{ mg/l} \pm 8.36$ ).

**Correlation (r) between different parameters:** In the present study the correlation coefficient (r) between every parameter for Site 1 and Site 2 is shown in Table.2 and Table.3 in the form of correlation matrix. Correlation coefficient (r) between any two parameters, x & y is calculated for parameter such as pH, turbidity, TH, DO, Free CO<sub>2</sub> and TS for Ganga River water. The water turbidity has been found to show positive correlations with TS and Free CO<sub>2</sub>, whereas TS have positive correlations with Free CO<sub>2</sub> at both Site 1 and Site 2. The pH has positive correlation with DO at Site 1, whereas pH has positive correlation with TH at Site 2. DO shows positive correlation with Free CO<sub>2</sub> and TH at both Site 1 and Site 2. There is a strong positive correlation ( $r=0.943/0.938$ ) between turbidity and TS at Site 1/Site 2. There was also observed significant ( $p < 0.05$ ) positive correlation ( $r=0.959/0.927$ ) between DO and Free CO<sub>2</sub> at both Site 1 and Site 2. TS and DO showed a highly significant ( $p > 0.05$ ) negative correlation ( $r=-0.818/0.795$ ) at both Site 1 and Site 2.

Table.1.Monthly fluctuation in physico-chemical characteristics during 2011 – 2012 in Rishikesh

Site 1						
Months	Turbidity (JTU)	Total Solids (mg/l <sup>1</sup> )	pH	DO (mg/l <sup>1</sup> )	Free CO <sub>2</sub> (mg/l <sup>1</sup> )	Total Hardness (mg/l <sup>1</sup> )
November	52.31	72.16	7.9	10.12	0.58	55.21
December	20.17	57.31	7.8	11.25	0.37	50.12
January	9.26	42.34	7.9	11.36	0.46	58.63
February	10.21	50.13	8.1	11.23	0.68	50.21
March	17.29	198.72	7.8	9.68	1.02	64.45
April	46.72	241.61	7.8	9.34	1.23	48.25
May	141.56	260.52	8.1	9.04	1.39	55.35
June	233.64	371.22	8.2	8.43	1.58	42.14
July	365.24	868.12	7.5	8.15	1.76	33.25
August	335.41	761.66	7.4	8.02	1.78	44.25
September	201.32	645.49	7.6	8.63	1.71	50.12
October	82.32	173.12	7.8	8.81	1.69	38.64
Mean±SD	126.29± 123.24	311.87± 278.33	7.83± 0.23	9.51± 1.17	1.19± 0.52	49.22± 8.36
Site 2						
November	55.61	75.23	7.7	9.36	0.69	56.25
December	26.41	86.54	7.9	10.15	0.32	53.17
January	14	75.4	7.9	10.5	0.5	60.08
February	15.2	123.4	8	9.59	0.79	64.81
March	25.6	365.21	7.8	9.11	1.37	59.23
April	55.72	285.64	7.9	8.51	1.4	60.21
May	185.45	300.21	8.2	8.5	1.57	72.45
June	265.79	589.24	8.4	8.1	1.62	68.95
July	480.51	979.44	7.8	8.1	1.98	60.24
August	445.86	815.71	7.7	8.11	1.95	48.31
September	295.39	810.82	7.7	8.32	1.9	45.63
October	121.19	261.23	7.9	8.66	1.92	47.89
Mean±SD	165.56 ± 169.41	397.34 ± 322.23	7.91 ± 0.21	8.92 ± 0.82	1.33 ± 0.61	58.10 ± 8.35
IS	10	-	6.0-9.0	3	-	300-600
WHO	05	-	6.5-9.2	6	0.5-2.0	500

Table.2.Correlation coefficient (r) values between physico-chemical parameters of Ganga River at Site 1

Physico-chemical Parameter	Turbidity	Total Solids	pH	DO	Free CO <sub>2</sub>	Total Hardness
Turbidity	1.00					
Total Solids	0.943*	1.00				
pH	-0.516	-0.692	1.00			
DO	-0.832	-0.818	0.420	1.00		
Free CO <sub>2</sub>	0.797	0.806	-0.402	0.959*	1.00	
Total Hardness	-0.673	-0.580	0.321	0.573	-0.627	1.00

\*Correlation is significant at p &lt; 0.05

Table.3.Correlation coefficient (r) values between physico-chemical parameters of Ganga River at Site 2

Physico-chemical Parameter	Turbidity	Total Solids	pH	DO	Free CO <sub>2</sub>	Total Hardness
Turbidity	1.00					
Total Solids	0.938*	1.00				
pH	-0.093	-0.157	1.00			
DO	-0.771	-0.795	-0.111	1.00		
Free CO <sub>2</sub>	0.766	0.816	-0.012	0.927*	1.00	
Total Hardness	-0.172	-0.221	0.769	0.020	-0.182	1.00

\*Correlation is significant at p &lt; 0.05

While assessing the various parameters, it was found that the water quality of River Ganga is not satisfactory. High turbidity can significantly reduce the aesthetic quality of Ganga River water, having disastrous ecological changes, harmful impact on recreation and tourism. It can increase the cost of water treatment for drinking and food processing. It can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function. Keeping in mind increasing urbanization and pollution loading of rivers, necessary measures should be taken to reduce future contamination loads from entering the river. The study establishes that sewerage, solid and liquid waste contaminants of organic nature are the prime sources of pollution. This will improve its carrying capacity. To improve the quality of water, sewage treatment plants are essential. The analysis report clearly indicates that the water after treatment can be reused in irrigation. Results also indicate that the Ganga River with such overloaded situation cannot sustain any further sewage discharge. If proper alternative arrangements like sewage treatment before discharge are not made then the situation may be alarming to the inhabitants in the study area and to the downstream as well. Thus, adequate attempts have to be made to treat the waste water before discharging it to the water bodies to keep the marine environment healthy.

## REFERENCES

- Aenab AM, Evaluating water quality of Ganga river within Uttar Pradesh state by water quality index analysis using C++ Program, *Civil and Environmental Research*, 3, 2013, 57-65.
- APHA, Standard methods for the examination of water and wastewater (21st Edn), Washington, D.C., American Public Health Association, 2005.
- Bhadula S, Sharma V, Joshi BD, Impact of Touristic Activities on Water Quality of Sahashtradhara Stream, Dehradun. *International Journal of ChemTech Research*, 6, 2014, 213-221.
- Das P, Tamminga KR, The Ganges and the GAP: An Assessment of Efforts to Clean a Sacred River, *Sustainability*, 4, 2012, 1647-1668.
- EPA, A report on Water: Monitoring & Assessment, 2012.
- Joshi DM, Bhandari NS, Kumar A, Agrawal N, Statistical analysis of physicochemical parameters of water of river Ganga in Haridwar district. *Rasayan Journal of Chemistry*, 2, 2009, 579-587.
- Kannel PR, Lee S, Lee Y, Kanel SR, Khan SP, Application of water quality indices and dissolved oxygen as indicator for river classification and urban impact assessment. *Environmental Monitoring and Assessment*, 132, 2007, 93-110.
- Kumar A, Bisht BS, Joshi VD, Singh AK, Talwar A, Physical, Chemical and Bacteriological Study of Water from Rivers of Uttarakhand. *Journal of Human Ecology*, 32, 2010, 169-173.
- Kumar V, Arya S, Dhaka A, Minakshi & Chanchal, A study on physico-chemical characteristics of Yamuna River around Hamirpur (UP), Bundelkhand region central India. *International Multidisciplinary Research Journal*, 1, 2011, 14-16.
- Kumari M, Mudgal LK, Singh AK, Comparative Studies of Physico-Chemical Parameters of two Reservoirs of Narmada River, MP, India. *Current World Environment*, 8, 2013, 473-478.
- Matta Gagan, Bhadauriya Gaurav and Singh Vikas, Biodiversity and Sustainable Development: A Review. *ESSENCE – Int J for Env Rehab and Conser*, 2(1), 2011, 72 – 80.
- Matta Gagan, Freshwater: Resources and Pollution. *Env Con J*, 11 (3), 2010, 161-169.
- Ministry of Home Affairs, Census of India, 2001; Government of India: New Delhi, India, 2001. <http://censusindia.gov.in/> (accessed on 24 July 2012).
- Mishra A, Tripathi BD, Seasonal and Temporal variations in physico-chemical and bacteriological characteristics of river Ganga in Varanasi. *Current World Environment*, 2, 2007, 149-154.
- Mitharwal S, Yadav RD, Angasaria RC, Water Quality analysis in Pilani of Jhunjhunu District (Rajasthan). *Rasayan Journal of Chemistry*, 2, 2009, 920-923.

Raja P, Amarnath AM, Elangovan R, Palanivel M, Evaluation of physical and chemical parameters of river Kaveri, Tiruchirappalli, Tamil Nadu, India. *Journal of Environmental Biology*, 29, 2008, 765-768.

Sharma V, Bhadula S, Joshi BD, Impact of Mass Bathing on water quality of Ganga River during Maha Kumbh-2010. *Nature and Science*, 10, 2012, 1-5.

Singh L, Choudhary SK, Physico-chemical characteristics of river water of Ganga in middle Ganga plains, *International Journal of Innovative Research in Science, Engineering and Technology*, 2(9), 2013, 4349-4357.

Singh J, Gangwara RK, Khare P, Singh AP, Assessment of physico-chemical properties of water: River Ramganga at Bareilly, U.P. *Journal of Chemical and Pharmaceutical Research*, 4, 2012, 4231-4234.

Singh P, Studies on seasonal variations in physico-chemical parameters of the river Gomti (U.P.) India. *International Journal of Advanced Research*, 2, 2014, 82-86.

Tambekar P, Morey PP, Batra RJ, Weginwar RG, Physico-chemical parameter evaluation of water quality around Chandrapur District Maharashtra, India. *Journal of Chemical and Pharmaceutical Research*, 5, 2013, 27-36.

Verma A, Current status of physico-chemical characteristics and biological factor of W, Ramganga river in kumaun Himalaya, India. *International Journal of Current Microbiology and Applied Science*, 2, 2013, 114-123.

Verma AK, Saksena DN, Impact of Pollution on Sewage Collecting River Kalpi (Morar) Gwalior (M.P.) with special reference to Water quality and Macrozoobenthic fauna, *Asian J. Exp. Biol. Sci.*, 1, 2010, 155-161.