Assessment of Physico-Chemical Parameters of River Ganga at Baba Ghat, Kanpur

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Abstract
The Ganga River is one of the most important river of India has served as the cradle of Indian civilization, is increasingly threatened by contamination from industrial effluent, agricultural runoff and urban discharge. However, rapid industrialization, accelerated urban expansion, and unsustainable anthropogenic practices have exerted unprecedented pressure on this fragile system. The present study assessed the seasonal variation in physico-chemical parameters of the river Ganga at the Kanpur. Samples were collected from river Ganga at the confluence of the drain at Baba Ghat in year 2023 to assess the magnitude and characteristics of pollution. The collected samples were analyzed for different physico-chemical parameters viz: Temperature, pH, conductivity, Turbidity, Alkalinity, T.D.S, BOD, COD, Cl^-, SO_4 and Cr. The overall mean values of these parameters during the study period were observed as Temperature (26.99±6.22^{0}C), pH (7.98±0.33), Conductivity (339±61.32 µs/cm), Turbidity (109.86±145.32NTU), Alkalinity (160.45±38.43mg/L), Total dissolved solids (203.22±55.65mg/L), Biological oxygen demand (7.8±4.27mg/L), Chemical oxygen demand (27.91±7.30 mg/L), Chloride (65.14±21.18mg/L), Sulphate (52.07±15.80 mg/L) and Chromium (0.27±0.08mg/L). This extensive research presents a comprehensive approach to Ganga River assessment, and it emphasizes the urgent need for multi-dimensional indices, standardized monitoring protocols and developing industrial, institutional and public co-ordination.

Key words: Physico-chemical parameters, Civilization, Contamination, Unsustainable and Fragile system.
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Introduction

River Ganga is an ecological, social and economic lifeline for dwellers of Indo-Gangetic plain. It is one of the most important river of India. The Ganga river basin spread over 8, 62, 769 km^2 and drains about 26% of the geographical area of India (Central Water Commission-WRIS,2014)[3]. The Bhagirathi River and Alakhnanda river confluence at Devprayag, Uttarakhand and combined watercourse take the name of Ganga. During its course of 2525 km from Gomukh glacier to Bay of Bengal (Harijan *et al.,* 2003)[6] it traverses through 29 most populated cities, 70 townships and more than 1000 villages of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal (Khwaja *et al.,* 2001)[9]. Kanpur (25^0, 26^{0}latitude, 79^{0}31'-80^{0}34' longitude) one of the largest industrial and densely populated metro-politant city of Uttar Pradesh is situated along the bank of river Ganga. The pollution influx in Ganga is alarming. The city, with an estimated population of 4,270,000 lakh, generates 450 million liter of municipal wastewater and other solid waste every day. The untreated municipal wastewater by 16 major drains and one bypass channel at Jajmau contributes to the pollution load of Ganga. The drains either discharge into river Ganga directly or they discharge indirectly through tributaries which ultimately discharge into river Ganga. The wastewater coming from different industries, domestic channels and agricultural washouts is constantly discharged into river partial or without any treatment. The ghats situated along bank of river Ganga are regularly used for bathing, cremation, fishing and navigation. Such activities also add nuisance and deteriorate the pristine purity and quality of river Ganga. Rivers constitute critical natural waterways of global significance, serving as primary sources of fresh water for domestic consumption, industrial activities, and agricultural irrigation (Faith., 2006)[5]. The Ganga river's polluted water adversely affects agricultural productivity in the surrounding areas (Singh *et al.,* 2023)[15]. Aquatic ecosystems are increasingly subjected to pollution due to the expansion of industrial corridors, enhanced nutrient loading and intensified anthropogenic activities, particularly in developing countries (Kumar and Pal, 2010)[10]. Industrial effluents contribute significantly to the pollution of aquatic systems and have potential to alter the physical, chemical, and biological characteristics of receiving water bodies (Sangodoyin, 1991)[12]. Industries represent major sources of environmental pollution, and industrial wastewater typically comprises sanit1ary effluents, process waste from manufacturing operation, wash waters, and relatively uncontaminated discharges from heating and cooling activities. Several studies have recognized the water Quality Index (WQI) as a reliable and comprehensive measure for assessing river water quality in both Indian and International context (Brown *et.al.,* 1970)[2] (Horton, 1965)[7] (Tyagi *et. al.,* 2013)[16] and Cude., C.G., 2001)[4]. Regular monitoring the health of river Ganga is vital for water security, biodiversity conservation, and sustainable development. It also integrates hydrology, water quality and ecological processes. This study has been carried out to analyze physico-chemical parameters and assess the impact of discharge of pollution load on the river Ganga.

Material and Methods

Study Area- The district of Kanpur is situated on the right bank of river Ganga in a large and relatively flat alluvial plain in the state of Uttar Pradesh between $25^0$26' North latitude and $79^0$31' to $80^0$34'longitude. The place has characteristic sub-tropical climate. There are distinct climatic variations during different parts of the year.

Sample collection and Analysis

The physico-chemical analysis is of prime consideration to assess the quality of water. In view to assess totality of lotic water attributes, assessment of water quality has to be representative of water in time and space. All river water samples were collected in a fixed time, date and place for various calendar months in the year 2023. Accordingly, samples were selected in the river Ganga at the confluence point of the drain at Baba Ghat to assess the magnitude and characteristic of pollution. The water samples were collected using 5-liter plastic bucket fastened with rope. The collected samples were transferred into pre-washed and rinsed plastic or glass bottles then transported to laboratory on the same day to avoid any unpredictable changes in physico-chemical parameters. The collected sample were analysed for a total: 11 physico-chemical parameters like Temperature, pH, Conductivity, Turbidity, Alkalinity, Total dissolved solids, Biochemical oxygen demand, Chemical oxygen demand chloride, Sulphate and Chromium as per standard methods for examination of water and wastewater (APHA AWWA WEF-2012)[1].

Results and Discussion

Temperature is a critical parameter that directly influences chemical reactions in water as well as bio-chemical processes in living organisms (Kumar *et al.,* 2010)[10]. Results show that temperature increases from February to September and it gradually decreases from October to January. The temperature recorded maximum 35^0C in month of June and minimum 16.5^0C during January with year mean value of 26.99±6.22. (Graph-1 and table-1)

pH of the aquatic system is an important indicator of the water quality. To determine the water quality pH of water is necessary as it affects the chemical reactions as solubility and metal toxicity (Khanna *et al.,* 2005)[8]. During the course of study, it was recorded that pH was always alkaline at Baba Ghat. A perusal of table 1 monthly variance in pH of Ganga River water at Baba Ghat recorded in various months with mean 7.98±0.33 of the year. The maximum pH was recorded in month of November 8.5 and minimum in month of May 7.4. (Graph-2 and table-1)

Conductivity measurement gives rapid and practical estimate of variation in the dissolved mineral content of water. The annual mean value of electrical conductivity was recorded 339±61.32 µs/cm. The maximum and minimum value of conductivity is 424.22 µs/cm in month of July and 248.56 µs/cm in month of January. However, conductivity shows a marked degree of fluctuation during different months. (Graph-3 and table-1)

Turbidity serves as critical parameter in evaluating the suitability of water for domestic, industrial, and ecological purposes, and its monitoring is essential for effective water resource management. During study annual mean value was 109.86±145.32. The minimum and maximum value of turbidity is 18.41 NTU in month of January and 470.24 NTU in month of August. (Graph-4 and table-1)

Higher value of Total Alkalinity during winter indicates greater ability of river water to support algal growth and other aquatic life in this season (Singh *et.al.* 2010)[14]. During month of July and August low value of TA was possibly due to dilution of river water with rainwater. Result shows that minimum and maximum TA recorded 116.48mg/L in the month of August and 241.16 mg/L in the month of December with annual mean value 160.45±38.48. Seasonally the value was highest in the winter followed by summer and monsoon. (Graph-5 and table-1)

Total dissolve solids refer to the matter either filtrate or infiltrate that remains as residue upon evaporation at defined temperature. TDS is particularly useful in the analysis of industrial wastewater. It signifies the inorganic pollution load of any water system (Usha *et.al.,* 2008)[17]. The annual mean value of TDS at Baba Ghat was 203.22±55.65 with minimum and maximum value 137.80 mg/L in month of December and 306.91 mg/L in the month of July. (Graph-6 and table-1)

While study BOD was found minimum 3.6 mg/L in the month of January and maximum 17.2 mg/L in the month of June, with an annual mean of 7.8±4.27. BOD was found higher than the permissible limit of 2 mg/L as Central Pollution Control Board guideline throughout the year. (Graph-7 and table-1)

Chemical oxygen demand is an important parameter for assessing the level of organic pollution in water, as it reflects the quantity of oxidizable organic matter present. Therefore, COD serves as a reliable indicator of organic pollution in surface water bodies (King *et.al.,* 2003).[13] During the study period, the annual mean concentration of COD was 27.91±7.30 mg/L. The minimum COD value 18.9 mg/L was recorded in December, while the maximum value 41.5 mg/L was observed in May. (Graph-8 and table-1)

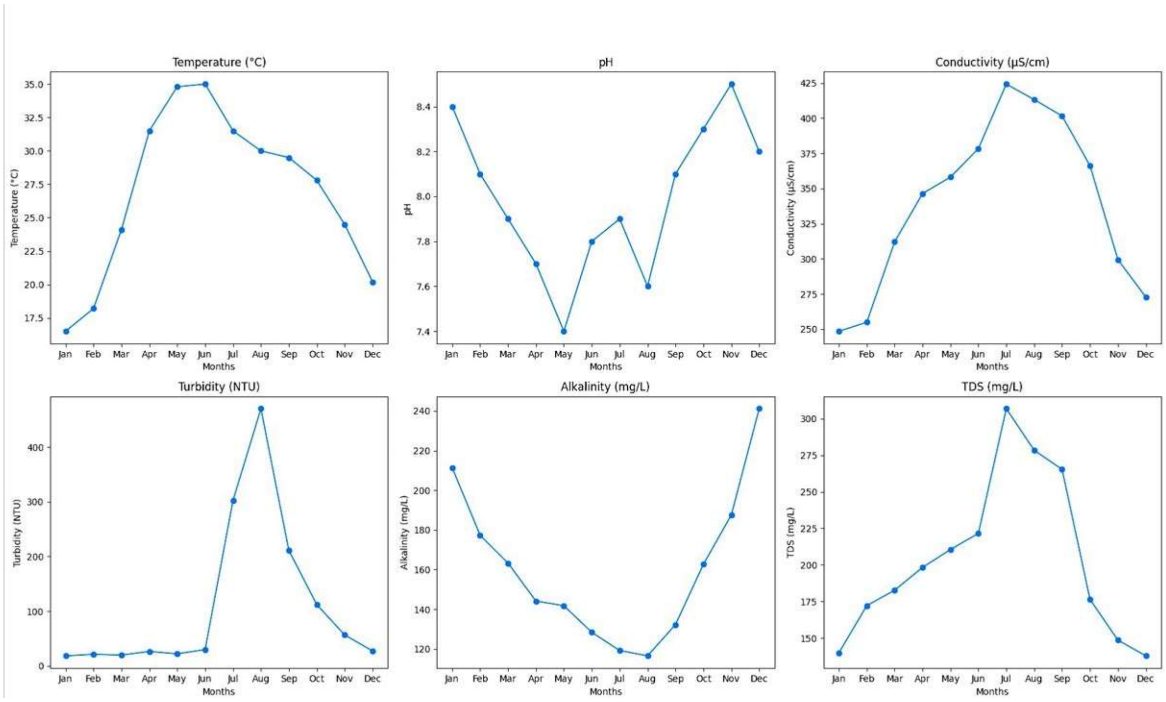
Chloride concentration in the river Ganga at Baba Ghat exhibited marked seasonal variation. The minimum concentration 31 mg/L was recorded in September, while the maximum concentration 111 mg/L occurred in June. The annual mean chloride concentration during the study period was 65.14±21.81 mg/L. (Graph-9 and table-1)

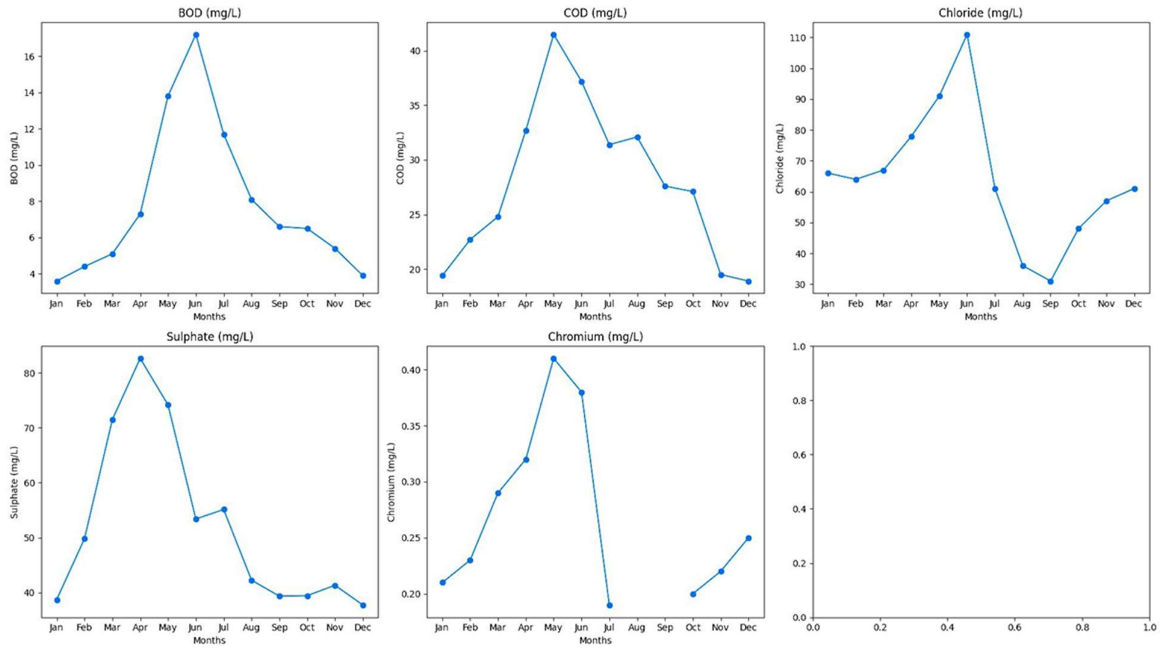
Although Sulphate concentration exhibited a progressive increase in the year 2023, the values consistently remained within the prescribed desirable limits throughout the study period. During study, the annual mean concentration of sulphate was 52.07±15.80 mg/L. The minimum sulphate concentration of 37.15 mg/L was recorded in December, while the maximum concentration 82.62 mg/L was observed in April. (Graph-10 and table-1)

The primary source of Chromium concentration in water bodies include effluents from industries such as electroplating, leather tanning, textile dyeing, metallurgy, and pigment manufacturing industries. Elevated concentration of Chromium adversely affects aquatic organisms. In humans, chronic exposure of chromium containing water is responsible for dermatological disorders, gastrointestinal irritation, liver and kidney damage, and carcinogenic effects. (Graph-11 and table-1)

Table -1 Physico-chemical analysis of Ganga River water from January 2023 to December 2023 on Baba Ghat Civil Lines, Kanpur-U.P.

Collection Month	Temperature (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	Alkalinity (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)	Cl^- (mg/L)	SO_4 (mg/L)	Cr (mg/L)
JAN	**16.5**	8.4	**248.56**	**18.41**	211.36	139.83	**3.6**	19.4	66	38.73	0.21
FEB	18.2	8.1	254.91	21.26	177.27	172.15	4.4	22.7	64	49.82	0.23
MARCH	24.1	7.9	312.16	19.84	163.25	182.72	5.1	24.8	67	71.47	0.29
APRIL	31.5	7.7	346.45	26.52	144.12	198.31	7.3	32.7	78	**82.62**	0.32
MAY	34.8	**7.4**	358.12	22.10	141.78	210.56	13.8	**41.5**	91	74.16	**0.41**
JUNE	**35.0**	7.8	378.35	29.87	128.36	221.62	**17.2**	37.2	**111**	53.39	0.38
JULY	31.5	7.9	**424.22**	302.61	119.17	**306.91**	11.7	31.4	61	55.13	**0.19**
AUG	30.0	7.6	413.16	**470.24**	**116.48**	278.44	8.1	32.1	36	42.27	0.0
SEPT	29.5	8.1	401.54	211.16	132.25	265.37	6.6	27.6	**31**	39.36	0.0
OCT	27.8	8.3	366.21	112.28	162.64	176.41	6.5	27.1	48	39.45	0.20
NOV	24.5	**8.5**	299.45	56.67	187.52	148.56	5.4	19.5	57	41.34	0.22
DEC	20.2	8.2	272.81	27.31	**241.16**	**137.80**	3.9	**18.9**	61	**37.15**	0.25
Mean	26.99	7.98	339	109.86	160.45	203.22	7.8	27.91	65.14	52.07	0.27
SD±	± 6.22	± 0.33	± 61.32	± 145.32	± 38.43	± 55.65	± 4.27	± 7.30	± 21.81	± 15.80	± 0.08


Temperature (°C)
pH
Conductivity (µS/cm)
Turbidity (NTU)
Alkalinity (mg/L)
TDS (mg/L)
Months
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



"Graphs show various annual fluctuations in the physico-chemical properties of River Ganga water at Baba Ghat, Civil Lines, Kanpur."

Conclusion

Karl persons correlation analysis was employed to examine the interrelationship among various physico-chemical parameters of the river Ganga water during the study period (2023). The correlation coefficient (r) revealed several significant positive and negative associations, indicating the influence of seasonal variation and pollution sources on water quality.

Water temperature exhibited a strong positive correlation with BOD (BOD; r=0.85) and COD (COD; r=0.91), suggesting that higher temperature enhance microbial activity and organic matter decomposition. Conversely, temperature showed a strong negative correlation with total alkalinity (r=-0.82), indicating dilution and buffering effects during cooler periods.

pH demonstrated a significant negative correlation with COD (r=-0.87) and chromium (Cr; r= -0.81), implying that increased solubility and mobility of heavy metals and organic pollutants.

Electric conductivity showed a strong positive relationship with TDS (TDS; r= 0.90), confirming that conductivity is largely governed by dissolve ionic constituents in the river.

Turbidity exhibited a strong positive correlation with TDS (r=0.79) and conductivity (r=0.71), reflecting increased suspended and dissolved matter during high runoff and monsoon periods, Total alkalinity displayed a strong negative correlation with conductivity (r=-0.88) and TDS (r=-0.88), indicating the inverse relationship between buffering capacity and dissolved pollutant load. A strong positive correlation was observed between BOD and COD (r=0.88), suggesting a common origin of biodegradable and non-biodegradable organic pollutants. Chloride showed a significant positive correlation with chromium (r=0.88), pointing towards anthropogenic inputs such as domestic sewage and industrial effluents. Sulphate also exhibited moderate to strong positive correlation with COD (r=0.58) and Cr (r=0.66), indicating its association with organic and metal pollution sources

Overall, the correlation analysis highlights the dominance of anthropogenic activities and seasonal hydrological variations in controlling the water quality of river. The strong interdependence among organic pollution indicators, dissolve solids and heavy metals emphasizes the need for continuous monitoring and effective pollution management strategies.

Table -2 Karl pearson correlation coefficient in different physico-chemical parameters of water sample

Parameter	**Temperature**	**pH**	**Conductivity**	**Turbidity**	**Alkalinity**	**TDS**	**BOD**	**COD**	**Chloride**	**SO_4**	**Chromium**
Temperature	1.00										
pH	-0.70	1.00									
Conductivity	0.85	-0.53	1.00								
Turbidity	0.32	-0.26	0.71	1.00							
Alkalinity	-0.82	0.66	-0.88	-0.58	1.00						
TDS	0.68	-0.57	0.90	0.79	-0.88	1.00					
BOD	0.85	-0.64	0.63	0.13	-0.67	0.54	1.00				
COD	0.91	-0.87	0.72	0.22	-0.79	0.61	0.88	1.00			
Chloride	0.38	-0.38	-0.07	-0.60	-0.10	-0.12	0.67	0.51	1.00		
SO_4	0.46	-0.69	0.13	-0.29	-0.37	0.13	0.36	0.58	0.54	1.00	
Chromium	0.63	-0.81	0.25	-0.47	-0.39	0.14	0.66	0.76	0.88	0.66	1.00

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