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A Review on the Physicochemical Properties of Ganga River Water from India and Bangladesh

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Abstract

Millions of people depend on the Ganga River for their livelihood. But the unlimited demands of human beings and their activities had fallen down the quality of Ganga water. The present study reviewed the physicochemical properties of Ganga River water with a particular emphasis on heavy metals. The properties assessment of river water revealed that it is not drinkable along most of its stretch. The level of dissolved oxygen is lower in most study locations of the Ganga River. The Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values indicate serious concerns about aquatic ecosystems and human health risks. Several types of heavy metals, some of which are hazardous, are transported into the river body in several ways. Growing industrial development, urbanization, e-waste disposal, effluent discharge, and sewage deteriorate the water quality. This review presents the pollution status of the river higher in the downstream region of the river system due to the tendency of pollutants to accumulate in the lower part of the river. However, it is now essential to take adequate measures to recover water quality in the mighty Ganga River.

Keywords: *Dissolve Oxygen (DO), Biological Oxygen Demand (BOD), Heavy Metals.*

Introduction

Ganga is one of the largest transboundary rivers in the Indian Sub-continent, having recreational, economic and environmental values. About 450 million people get water from it for their daily maintenance (Sankhla *et al.,* 2018). Water is an indisputable precious natural resource that exists on the earth, essential for the survival of living organisms. But it becomes a matter of concern that the quality of Ganga water is deteriorating daily. Intensive agricultural practices, urbanization, industrialization and the growing population are responsible for the discharge of obsessive industrial, municipal and domestic wastewater into river systems, causing severe deterioration of water quality (Matta *et al.,* 2020, Adbarzi *et al.,* 2020).

Ganga originates from the Gaumukh ice cave of the Gangotri stretch, a place in the Uttarakhand State of Himalayan (Figure 1). Regarding ocean water supply, the world's third largest river is Ganga. The contribution of the river is significant as it serves as an ideal habitat

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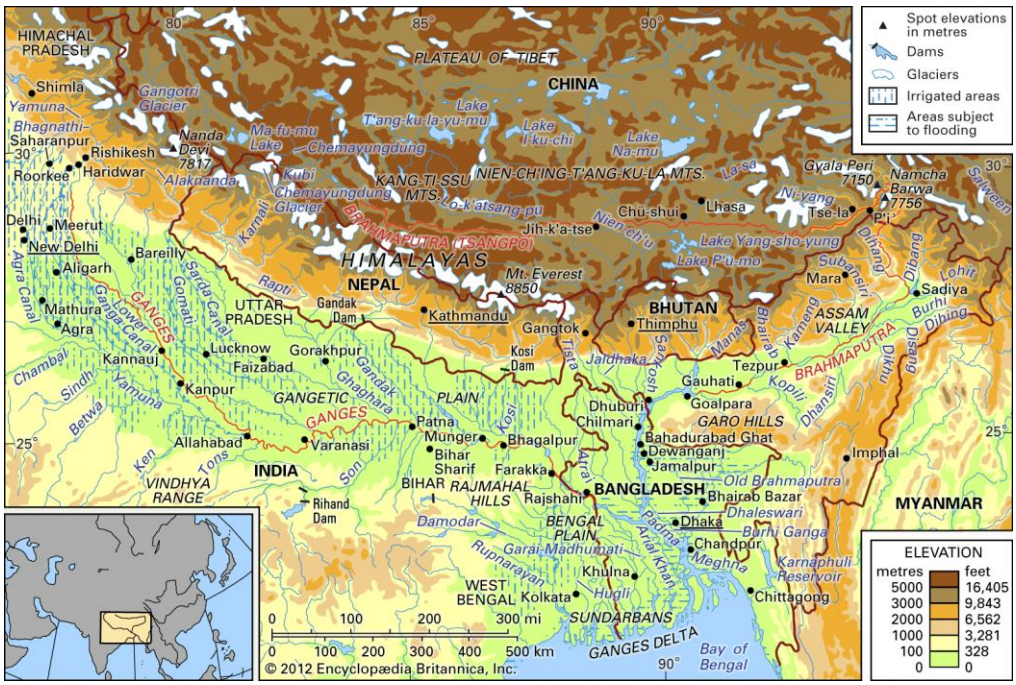

Figure 1: Ganga River Basin in India and Bangladesh

for many rare species, make fertile floodplains suitable for the cultivation of crops. But the pollution status of river Ganga is consistently increased, and large quantities of chemical fertilizers, pesticides, and insecticides used for improving crop production mix up with river water, causing Ganga pollution. The synergistic interaction of municipal and industrial wastewater discharge into the river, limited government initiatives, and lack of proper water quality infrastructure make the river water immensely polluted (Lakhera *et al.*, 2023).

Access to good quality fresh water is essential to maintain public health and social development. World civilization is remarkably connected with the river system, where most civilizations developed by centring a river. Rivers serve as a source of water resources for households, agriculture and industries and provide food, habitat and a medium of transport for several organisms. Most industries develop near the river bank and discharge industrial waste into the river. That's why it is essential to monitor water quality periodically when people use it for domestic purposes (Haque *et al.*, 2020).

Most organic and inorganic pollutants enter the river from sewage, industrial effluent, and agricultural runoff. Inorganic contaminants, heavy metals, are a genuine issue because of their persistent nature and bioaccumulation capacity. Both natural and anthropogenic sources are responsible for causing metal pollution in the river system. Several types of industries like tanneries, battery industries, steel plants, thermal power plants, and pesticides from farming industries dispose of poorly treated effluents into the river water, enhancing heavy metal concentration in Ganga (Haque et al., 2020). Natural processes like weathering and mineralogy are causing metal pollution in the environment. Some trace elements like Zn, Cu,

Fe, Ni, Al, Mg, and Mn are essential micronutrients for living organisms, but some metals like Hg, As, Cr, and Pb have carcinogenic effects. Anthropogenic sources of heavy metal contributed more comparing natural activities like weathering of rocks and leaching (Matta *et al.,* 2020).

Recently it was observed that the value of Dissolved oxygen (DO), Chemical Oxygen Demand (COD), and Biological Oxygen Demand had risen daily. The hardness of river water has also been observed to be highest in recent years. The concentration of ions like nitrate, nitrite, phosphate and sulfate was also higher. According to the report of the Central Pollution Control Board (CPCB) of India, the Ganga River water has lost its quality for drinking purposes even from its origin at Gangotri ice cave (Soni *et al.,* 2022, Shing *et al.,* 2023).

The river water and its surrounding area are now severely polluted due to both point sources and nonpoint sources pollution. A considerable amount of nutrients comes from agricultural runoff, mainly nitrate and phosphorus, which enhances algal blooms, leading to eutrophication, damaging water quality, and severely affecting the surrounding area's biodiversity. So, monitoring river water quality regularly and taking protective measures regarding the current pollution status is necessary. This study aims to review critically the quality of Ganga River water.

Physicochemical properties of Ganga River Water

The physicochemical properties of water play an essential role in maintaining ecosystem services, regulating the global biogeochemical cycle and the good and well-being of human health. Water quality must be examined based on its purpose. The physicochemical properties of the Ganga River water at different places are shown in Table 1. Kambuj *et al.,* 2019 assessed the quality of Ganga River water in Haridwar district, India. They took samples from five areas, two sites near the mining region. They found the highest pH values in monsoon season and the lowest in summer; the pH range was recorded (6.80 to 7.89). The author reported the higher pH range in monsoon due to the free available CO_2. Electric conductivity indicates dissolved ions present in the water body. The authors recorded electric conductivity between (130.95 and 215.67) ($\mu S\ cm^{-1}$). Dissolve Oxygen (DO) is an essential parameter for determining the pollution level of the water body. The range of DO records (7.30-8.15) mg/L. The desirable limit of dissolved oxygen is 5 mg/L as per BIS standards. The author reported that the Biological Oxygen Demand (BOD), Total Dissolved Solid (TDS) and K vary from (1.0-2.17) mg/L, (26.25-368.00) mg/L, and (1.72-2.56) mg/L respectively.

Singh *et al.,* 2023 studied the middle Ganga valley of North India and reported pH (7.10 to 7.30) mg/L, EC (0.47-0.49) mg/L, DO (5.80-7.30) mg/L, COD (16.0-22.4) mg/L, NO_3^- (25.27-29.6) mg/L and, K (1.10-1.40) mg/L. The authors recorded this observation for the Ganga River in the Ghats of Varanasi district of Uttar Pradesh, India, from January to March 2019.

Table 1 shows that the pH value varied from place to place, ranging from (6.80-9.01). The highest pH value was found (8.27 to 9.01) downstream of Ganga River, Jajmau. The author reported higher pH during summer due to free oxygen from the photosynthesis of the algal bloom. The highest values of EC were recorded at the lower Ganges River at Hardinge Bridge

point, and the values varied from 174.07 to 360.69 μS $cm^{-1,}$ which falls within the permissible limit of WHO and BSI standards (Haque *et al.*, 2020).

Table: 1 Physio-chemical parameter levels at different locations of the Ganga River

Study Areas	pH	EC (μS cm^{-1})	DO mgL^{-1}	BOD mgL^{-1}	TDS mgL^{-1}	COD mgL^{-1}	TSS mgL^{-1}	NO_3^- mgL^{-1}	K mgL^{-1}	Reference
Mining area of Ganga River at district Haridwar.	6.80 to 7.89	130.95 to 215.67	7.30-8.15	1.0-2.17	26.25-368.00	-	-	-	1.72-2.56	Kamboj *et al.*, 2019
Middle Ganga Valley of North India.	7.10 to 7.30	0.47-0.49	5.80-7.30	-	-	16.0-22.4	-	25.27-29.6	1.10-1.40	Singh *et al.*, 2023
Upper Ganga channel	7.9 to 8.0	146-1832	4.60-8.3	1.2-10	-	18.1-22.9	-	-	-	Singh *et al.*, 2021
Downstream of Ganga River, Jajmau	8.27 to 9.01	346.6 to 546.03	0.43 to .93	0.63 to 1.04	288 to 692.8	288 to 692.8	453-2980	-	-	Singh *et al.*, 2020
Uttar Pradesh, India	8.32-8.36	-	7.7-8.2	4.1-4.5	90-100	28-34	-	-	-	Sharma *et al.*, 2019
Upper Ganga Channel ,Uttarakashi to Roorkee	-	-	7.46-11.92	0.71-2.94	4.48-232	2.71-9.01	12.6-1163	-	-	Matta *et al.*, 2020
Upper Ganges River near Haridwar, Uttarakhand	7.05-8.5	201.7-225.8	9.11-10.28	2.37-2.97	208.29-598.65	6.11-8.86	-	-	-	Maurya *et al.*, 2021
The lower Ganges River at Hardinge Bridge point	7.80-8.48	174.07-360.69	7.27-11.18	-	-	-	-	<0.03-11.65	-	Haque *et al.*, 2020
Ganga River at Hapur District Uttar Pradesh, India.	7.93-8.49	85.10-395.00	7.04-8.38	1.61-3.10	51.40-234.0	40-160	-	-	-	Kumar *et al.*, 2019
The River Ganga at Rishikesh, Uttarakhand, India	7.85-8.02	-	8.10-8.83	2.47-2.92	201.3-250.25	5.04-6.13	199.5-258.25	-	-	Lakhera et al., 2023

Dissolved Oxygen (DO) is an essential parameter for determining water quality. The dissolved oxygen value ultimately indicates the quality of water and its usefulness. The highest DO value was observed at the Upper Ganges River near Haridwar, Uttarakhand, and the values recorded 9.11 mg/L to 10.28 mg/L and the lowest DO values recorded (0.43 to .93) mg/L downstream of the Ganga River, Jajmau. From the observation, it was concluded that the water quality of downstream Ganga River is much more polluted than the upper portion. This may be due to the tendency of pollutants to accumulate in the downstream region of the river.

The biological oxygen demand (BOD) measures the amount of O_2 bacteria and other microbes required to break organic matter into more specific products. The observations of the present study show that the highest BOD value (113.14-234.44) mg/L was reported in Uttar Pradesh, India and the lowest BOD value (0.63 to 1.04) mg/L downstream of Ganga River, Jajmau. But simultaneously, the highest level of COD (chemical oxygen demand) was observed downstream of the Ganga River, Jajmau.

Total Dissolved Solids (TDS) and Total Suspended Solid (TSS) were recorded (288 to 692.8) mg/L and (453-2980) mg/L, respectively, downstream of Ganga River, Jajmau. The parameters studied in this study showed that the lower portion of the Ganga River is much more polluted than the upper regions.

Metal Concentration of Ganga River Water

The concentration of metals in the Ganga River Water at different places is shown in Table 2. In this study, a total of 11 metals, namely Zn, Pb, Mn, Fe, Cu, Al, Ni, Cd, Mg, Co, and Cr were reported, most of them are essential nutrients for a certain level, and some are hazardous to the environment and human health.

Zinc (Zn) is one of the most essential and abundant transition metals in nature, and the deficiency of Zn has many adverse effects on primary productivity. The highest value of Zn recorded (148 to 255) (µg/L) at Ganga River Water at Haridwar city of Uttarakhand, India. Zinc is necessary for die-casting metal, paints, rubber, and other alloys. It is important to note that the river's downstream portions have higher concentrations of heavy metals than the upstream regions might be due to agricultural runoff and other human-induced pollution (Subudhi *et al.,* 2023).

Lead (Pb) was reported higher at Ganga River Water in Kanpur, India. Lead is a carcinogenic compound hazardous to human health and destroys the nervous system. The maximum concentration was recorded for Manganese (Mn) (44.0-85.6) µg/L. Nickel (Ni) was recorded higher at Ganga River Water at Kanpur, India, and the values range from (12.4-238.7) µg/L. It is commonly used in domestic products such as stainless steel, Ni–Cd batteries, and other alloys. There is a chance to increase the discharge of Ni from sewage discharge (Matta *et al.,* 2020).

Kumar *et al.,* 2019 studied the Ganga River Water from Rishikesh to Brijghat and found Zn (10.10) µg/L, Pb (0.622-5.59) µg/L, Mn (13.47-330.59) µg/L, Fe (369.36-5405.7) µg/L, Cu (2.28-26.0) µg/L, Ni (2.78-22.32) µg/L, Cd (0.11-1.25) µg/L, and Cr (1.90-10.32) µg/L. Consumption of Ganga Water containing heavy metals like Cd, Pb and Cr can potentially cause nerve bladder carcinoma in eastern Uttar Pradesh and Western Bihar of India.

Table: 2 Metal Concentration at different regions of Ganga River

Study Area	Concentration of heavy metals (µg/L)											Reference
	Zn	Pb	Mn	Fe	Cu	Al	Ni	Cd	Mg	Co	Cr	
Ganga River Water from Gangotri to Roorkee	13.90-74.10	1.0-7.90	1.90-70.00	21.50-7028	1.30-34.6	0.70-6.20	1.10-5.80	0.80-5.70	1875.4-4874.2	0.50-5.20	-	Matta *et al.,* 2020
Ganga River Water at Haridwar City of Uttarakhand	148-255	5.0-5.67	44.0-85.6	266-1050	139-188	1.03-4.56	10.5-40.1	2.1-3.64	-	21.4-49.1	63-195	Subudhi *et al.,* 2023
Ganga River Water from Haridwar to Gangasagar	BDL-2.80	BDL-8.10	0.40-989.9	50.0-467	3.90-9.40	15.3-278.6	BDL-6.20	-	-	BDL-2	0.40-6.10	Dhiman *et al.,* 2023
Ganga River Water from Rishikesh to Brijghat	10.10	0.622-5.59	13.47-330.59	369.36-5405.7	2.28-26.0	-	2.78-22.32	0.11-1.25	-	-	1.90-10.32	Kumar *et al.,* 2019
Ganga Water from 12 different zones	26.23-39.43	2.9-6.917	2.80-6.23	5289.4-5496.5	3.183-4.36	1.22-2.84	2.23-48.58	1.64-3.37	3000-3609	2.58-4.19	-	Matta *et al.,* 2018
Ganga Water from 10 different Locations	32.83-42.68	2.23-5.48	2.57-4.51	5222.6-5565.4	2.98-5.21	1.38-2.42	2.39-2.91	2.42-2.83	3742.0-3749.9	2.39-6.35	-	Matta et al., 2020
Ganga River Water at Kanpur, India	54.18-213	21.85-166.6	18.2-35.69	836-8074	23.6-256.3	-	12.4-238.7	BDL-2.92	-	0.53-3.4	27.85-372.0	Singh *et al.,* 2020

* Abbreviations: BDL indicates below the detection limits

Iron (Fe) is an essential micronutrient for plant growth and is crucial in regulating numerous cellular processes. The bioavailability of Fe depends on the pH of the water. The present review shows the highest concentration of Fe is (5222.6-5565.4) (µg/L), and the lowest values range from (50.0-467) (µg/L) at Ganga River Water from Haridwar to Gangasagar. For Copper (Cu), the concentrations were recorded (139-188) (µg/L) at Ganga River Water in Haridwar City of Uttarakhand, India. Higher Iron concentration in the Ganga River system is attributed to large-scale human activities such as domestic waste discharge, agricultural runoff, construction sites and industrial releases (Matta *et al.,* 2018). The access of Cu comes to the river body mainly from agricultural runoff, as it is a vital component of pesticides. It is also used for various purposes, including roofing, cooking utensil, production of alloys, and electrical wiring.

This review observed that heavy metal concentrations vary from season to season, place to place. Most of the authors reported that heavy metal concentrations are higher during the summer may be due to the increased evaporation rate and decreasing river flow.

Conclusion

The Ganga River is a lifeline for millions of people. It provides water for life, food, amenity, and habitat for billions of organisms. However, due to the growing demand of human beings, industrialization, urbanization, and other anthropogenic activities make the river water polluted day by day. This review study concluded that the physicochemical properties of the Ganga River water indicate it is not fit for potable use. The Dissolve Oxygen (DO) level is lower, making the river system unsuitable for the survival of aquatic organisms. The concentration of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), and Total Dissolved Solids (TDS) remained higher in the river water. Moreover, heavy metal, especially Pb, Cd, and Cr, makes the water hazardous to the environment and human health. It is time to take necessary actions to maintain Ganga River water quality for sustainable use.

References

Matta, G., Nayak, A., Kumar, A., K., Kumar, P., Kumar, A., Tiwari, A. T., Naik, P.K., (2020) Evaluation of Heavy Metals Contamination with Calculating the Pollution Index for Ganga River System. *Taiwan Water Conservancy*, 68(3). Doi: 10.6937/TWC.202009/PP_68(3).0005

Sankhla, S.M., Kumari, M., Sharma, K., Kushwah, R.S., Kumar, R. (2018) Heavy Metal Pollution of Holy River Ganga: A Review. *International Journal of Research*, 5(1)

Adbarzi, S. S. M., Tripathi, P., Choudhary, K. K., Kant, R., & Tripathi, V. (2020). Assessment of physico-chemical properties of pre and post-treated wastewater of Prayagraj region and its effect on nearby Ganges river. Vegetos, 33(2), 258–264. doi:10.1007/s42535-020-00103-y

Lakhera, K., Tripathi, DM., Semwal, N., Pandey, N., Madan, S., & Rayal, R. (2023). Impacts of the seasonal variation on the water quality of the river Ganga at Rishikesh, Uttarakhand : Physicochemical assessment. *Biochem. Cell. Arch*. 23, 617-621. DOI: https://doi.org/10.51470/bca.2023.23.1.617

Haque, M. M., Niloy, N. M., Nayna, O. K., Fatema, K. J., Quraishi, S. B., Park, J.-H., … Tareq, S. M. (2020). Variability of water quality and metal pollution index in the Ganges River, Bangladesh. Environmental Science and Pollution Research. doi:10.1007/s11356-020-10060-3

Soni, R., Pal, A. K., Tripathi, P., Jha, P. K., and Tripathi, V. (2022) Physicochemical analysis of wastewater discharge and impact on Ganges River of major cities of North India. *Water Supply*, 22(6), 6157. doi: 10.2166/ws.2022.185

Singh, Y. V., Bharteey, P. K., Singh, K., Borah, S.R., Kumar, A., Pal, S. and Barla, F.X. (2023) Assessment of Water Quality in Ganga River Ghats of Varanasi District, Uttar Pradesh, India. *International Journal of Environment and Climate Change*, 13(5), 231-239.

Kamboj, N., Kamboj, V. (2019) Water quality assessment using overall index of pollution in riverbed-mining area of Ganga-River Haridwar, India. *Water Science*, 33(1), 65-74, doi: 10.1080/11104929.2019.1626631

Singh, Y. V., Bharteey, P. K., Singh, K., Borah, S. R., Kumar, A., Pal S., Barla, F. X. (2013) Assessment of Water Quality in Ganga River Ghats of Varanasi District, Uttar Pradesh, India. *International Journal of Environment and Climate Change*, 13(5), 231-239.

Singh, V. K., Kumar, D., Singh, S. K., Pham, Q. B., Linh, N. T. T., Mohammed, S., & Anh, D. T. (2021). Development of fuzzy analytic hierarchy process based water quality model of Upper Ganga river basin, India. *Journal of Environmental Management*, 284, 111985. doi:10.1016/j.jenvman.2021.111985

Singh, V., Ngpoore, N. K., Chand, J., & Lehri, A. (2020). Monitoring and assessment of pollution load in surface water of River Ganga around Kanpur, India: A study for suitability of this water for different uses. *Environmental Technology & Innovation*, 100676. doi:10.1016/j.eti.2020.100676

Matta, G., Nayak, A., Kumar, A., & Kumar, P. (2020). Water quality assessment using NSFWQI, OIP and multivariate techniques of Ganga River system, Uttarakhand, India. Applied Water Science, 10(9). doi:10.1007/s13201-020-01288-y

Maurya, P K., Ali, S A., Alharbi, R S., Yadav, K K., Alfaisal, F M., Ahmad, A., Ditthakit, P., Prasad, S., Jung, U K., & Jeon B H. (2021) Impacts of Land Use Change onWater Quality Index in the Upper Ganges River near Haridwar, Uttarakhand: A GIS-Based Analysis. *Water*, 13, 3572. https://doi.org/10.3390/w13243572,