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Physicochemical analysis of Ganga River water in Haridwar: Evaluating the influence of sewage discharge

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Abstract

The Ganga River, revered as a sacred entity in India, faces significant pollution challenges due to anthropogenic activities, particularly sewage discharge. This study aims to evaluate the physicochemical parameters of Ganga River water in Haridwar, a prominent pilgrimage site, to assess the impact of sewage discharge on water quality. Parameters such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and nutrient levels (nitrates and phosphates) were analyzed at multiple sampling points along the river. The results indicate a significant deterioration in water quality downstream of sewage discharge points, with elevated levels of BOD, COD, and nutrients. The findings underscore the urgent need for effective sewage treatment and management strategies to preserve the ecological and cultural integrity of the Ganga River.

Keywords: Physicochemical, Ganga River, Haridwar, Zoology, pollution, anthropogenic

Introduction

The Ganga River, originating from the Gangotri Glacier in the Himalayas, is one of the most significant rivers in India. It supports a vast population, providing water for drinking, irrigation, and industrial purposes. However, rapid urbanization, industrialization, and population growth have led to increased pollution levels, particularly from untreated sewage discharge. Haridwar, a major pilgrimage site, witnesses a massive influx of tourists and devotees, exacerbating the pollution load on the river. This study focuses on the physicochemical analysis of Ganga River water in Haridwar to evaluate the impact of sewage discharge on water quality. Pollution issues have arisen as a result of anthropogenic activity and overexploitation of the aquatic system. Because fresh water for human use only makes up 0.3-0.5% of the earth's total water supply, it must be used wisely. Fresh water is becoming more and more in demand every day as a result of the overpopulation and industrial settlement. Local physiographic circumstances shape the unique physical, chemical, and biological features of freshwater ecosystems. The abundance and suitability of the flora and animals in various areas are determined by the ecology.

Aquatic systems have always deteriorated, but increasing urbanization, industrialization, and agricultural activity have changed many of their physical-chemical characteristics irreversibly. Pollution issues have been brought about by overexploitation and human activity in and around aquatic systems (Chaturvedi, *et al*. 1981) [11]. Since only around 0.5% of the freshwater on Earth is actually usable, its utilization is extremely important. Fresh water is becoming more and more in demand every day as a result of the overpopulation and industrial settlement.

The Ganga River, which rises from the Gangotri glacier and travels 2525 Kilometers before falling into the Bay of Bengal, is India's lifeblood. It passes through Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal, which are the five states in India. The river provides water to 100 towns along its course, 26 in Uttar Pradesh, 15 in Bihar, and 59 in West Bengal. Since Haridwar is where the river enters the plains from the hills, pollution only originates there. The Ganga River, which rises in Gaumukh and flows 2,525 kilometers to the Bay of Bengal, is the biggest freshwater ecosystem on the Indian subcontinent. The Bhagirathi River originates in the Uttarakhand Himalayas, where glacial water flows from a cave at Gaumukh.

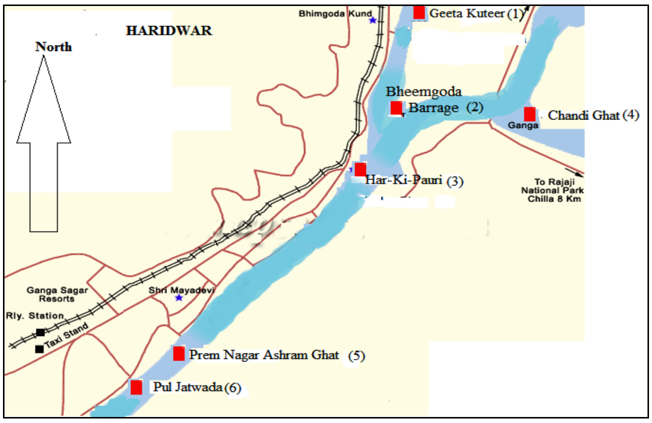

Fig 1: Map of Haridwar city showing location the of study site.

The Bhagirathi River originates in the Uttarakhand Himalayas, where glacial water flows from a cave at Gaumukh. It passes through the Indian states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal as it flows southeast for 1,560 miles (2,525 Kilometers). With over 407 million people living there, the Ganges alone drains an area larger than one million square Kilometers. These people rely on the sacred river's water for drinking, bathing, agriculture, industry, and other domestic tasks. The biodiversity along the banks of the Ganga is crucial for the preservation of water and nutrients. Reducing soil erosion also depends on the Ganga River's biodiversity. Because of the Ganga's mythical significance, millions of people believed in its purity without understanding the quality of its water. Thus, on November 4, 2008, Prime Minister Manmohan Singh announced that the Ganga would now be referred to as India's "National River."

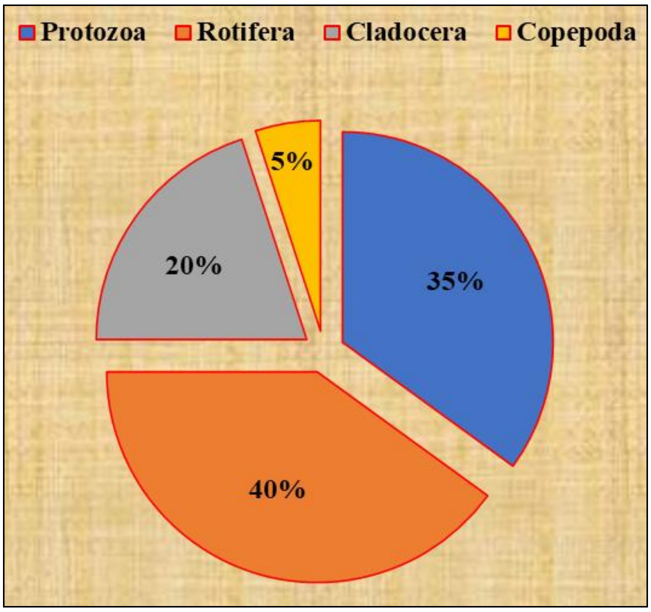

Fig 2: Showing Zooplankton Diversity at seven selected sampling sites during study period.

The Ganga River is becoming worse every day as a result of several human-caused activities, including tourism, industrialization, urbanization, illegal mining, and hydropower projects. Major towns like Hardwar, Kanpur, Allahabad, Patna, Varanasi, Bhagalpur, etc. discharge their waste into the Ganga River. Every day, around 75 billion pieces of untreated sewage debris fall directly into the Ganga River. One of the Ganga River's main sources is domestic sewage, which enters the river in vast quantities untreated. The population is growing, and so is this quantity daily. This sewage causes contamination in the Ganga River due to improper management, a lack of sewage treatment plants, and an effluent treatment facility. In addition to degrading water quality, sewage also reduces the Ganga River's aquatic biodiversity.

Aims and Objectives

The primary aim of this study is to assess the physicochemical quality of Ganga River water in Haridwar and evaluate the influence of sewage discharge on its water quality. The specific objectives are:

1. To analyze key physicochemical parameters such as pH, DO, BOD, COD, and nutrient levels (nitrates and phosphates) at various sampling points along the river.
2. To compare the water quality upstream and downstream of sewage discharge points.
3. To assess the extent of pollution caused by sewage discharge and its potential impact on the river's ecosystem.
4. To provide recommendations for effective sewage treatment and management strategies to mitigate pollution.

Review of Literature

The Ganga River has been the subject of numerous studies focusing on its water quality and pollution levels. Previous research has highlighted the significant impact of sewage discharge on the river's physicochemical parameters. Studies conducted in various stretches of the Ganga River have reported elevated levels of BOD, COD, and nutrients downstream of sewage discharge points. The Central Pollution Control Board (CPCB) and other environmental agencies have consistently identified sewage as a major contributor to river pollution. Despite various initiatives like the Ganga Action Plan (GAP) and Namami Gange, the river continues to face pollution challenges. This review synthesizes the findings of previous studies up to 2022, providing a comprehensive understanding of the current state of Ganga River water quality and the influence of sewage discharge.

Many limnological investigations have also been conducted for a few additional rivers, both nationally and internationally, on the Indian subcontinent. These investigations have been conducted using a variety of backgrounds, including the effects of sewage, chemical, household, and industrial effluent discharges, as well as other human activities, on the physico-chemical characteristics of water. Joshi *et al*. (1995) [12] examined the primary productivity in the western Ganga canal at Haridwar and found that human activity is causing the Ganga water's quality to deteriorate daily.

In Gujrat, Jameson and Rana (1996) [13] investigated the Sabarmati River Complex's pollution situation. Murthy and Bharti (1997) [14] conducted a study on the physico-chemical characteristics of the Kali River in the Dandeli, Karnataka area, and found that the introduction of garbage from homes and businesses had resulted in a high phosphorus value. At

Nasauri, Mogal and Desai (1998) [15] assessed the river Purna's level of pollution. The Ganga reverine ecology and phytoplanktonic diversity have been researched by Khanna *et al*. (1998) [16]. An evaluation of the Yamuna River's water quality at Agra. Singh *et al*. (1999) [17] assessed the effect of sewage and industrial pollutants on the Ganga River's water quality at Varanasi and Kanpur.

Due to a rise in domestic waste output, people also exacerbate the sanitary and health conditions in the area of concern, in addition to contributing to the degradation of the water quality, as multiple researchers have noted. According to numerous experts, the formation of SW also multiplies during holy bathing celebration days along the Ganga River. In Uttarakhand, between Byasi and Rishikesh, Joshi *et al*. (2001) [18] conducted research on the seasonal fluctuation in the physical properties of three highland streams.

Conducted research on the content and generation rates of urban residential waste during the 20th century. In Varanasi, Pandey and Sundram (2002) [19] conducted research on the Ganga River's water quality.

Pathani *et al*. (2002) [20] noted physical and chemical characteristics of the west Ram Ganga River from the Almora district. Kala and Sharma (2002) [8] conducted research on the Alaknanda River in the Garhwal Himalaya. Gupta and Sharma (2002) [10] examined the physico-chemical characteristics of the Ban Ganga, Katra, Jammu, and found that human activity had resulted in elevated nutrient levels in specific areas, undoubtedly lowering the river's water quality.

Evaluated the effects of mass bathing and an increased organic load on the water quality of the Ganga canal during the 1998 Kumbh period, noting certain alterations in the water's Physico-chemical characteristics. A study on the seasonal change of Ganga water's physico-chemical features as influenced by sewage discharge was conducted by Mishra and Tripathi (2003) [9]. Studies on the seasonal variation and physico-chemical quality of the Ganga River in Haridwar were conducted by Kaur and Joshi (2003) [9] Mishra and Joshi (2003) [9] conducted research on Ganga River and described that water quality was declining as a result of human activity.

The yearly change in the physico-chemical parameters of the Yamuna River and its two tributaries from the Garhwal Himalaya was studied (Joshi and Sharma, 2003) [9]. conducted a studied on environmental degradation at two significant North Western Himalayan locations: Kullu and Manali. The study focused on the mishandling of waste. According to Pickering *et al*. (2003) [21], there are several detrimental effects of tourism, including deterioration of the water quality and disruption of the native faunal diversity in Australia's greatest snow country.

According to research done in by Kang *et al*., 2004 [22] human activity has a negative impact on the water-land environment of the Shiyang River basin, an arid region in northwest China. Human activity causes water to lose its quality in the ground soil, deteriorate its water quality, accelerate desertification through agriculture, and divert the river. Sharma and Gupta (2002) [10] noted that a variety of human activities were responsible for the fast BOD assimilation in the Hathli stream in the outer Himalayas. conducted an analysis to evaluate the variation in physico-chemical parameters with respect to the pollution state of the Tapi river in Maharashtra. They discovered that several anthropogenic activities were the cause of the river's deterioration.

Came to the conclusion that as religious travel is associated with our faith and involves certain rituals, it requires greater government attention than other forms of tourism. According to Boadi and Kuitunen (2004) [23], the poor are left to handle the issue on their own, and residential waste collection is restricted to high and some middle income regions. This results in the careless disposal of debris in streams, canals, and surface drains, causing untidy and unattractive conditions in many areas of Ghana's Accra metropolitan area.

A study on oxygen requirements in a mass bathing tank Mahamaham (Southern Kumbh Mela) was conducted by (Das *et al*. 2005) [24]. According to research by Prasad *et al*. (2005) [25] on the impact of population growth on the Ganga basin's environmental conditions, the Ganga basin's quality declined as a result of the population's sharp rise along the Ganga River's bank. In addition to reporting on the physico-chemical characteristics of the rivers Tunga, Bhadra, and Tungabhadra in Karnataka, also examined the heavy metal contamination resulting from the untreated waste of tanneries being disposed of investigated the Subernarekha river in Ranchi's chemical composition.

Research Methodologies

Study Area

Haridwar, located in the state of Uttarakhand, India, was selected as the study area due to its significance as a pilgrimage site and the high volume of sewage discharge into the Ganga River. Sampling points were strategically chosen upstream and downstream of major sewage discharge points to assess the impact on water quality.

Sampling and Analysis

Water samples were collected from multiple locations along the river during different seasons to account for seasonal variations. The physicochemical parameters analyzed included pH, DO, BOD, COD, nitrates, and phosphates. Standard methods prescribed by the American Public Health Association (APHA) were followed for sample collection and analysis. pH was measured using a digital pH meter, DO was determined using the Winkler method, BOD was assessed using the 5-day BOD test, COD was measured using the dichromate reflux method, and nutrient levels were analyzed using spectrophotometric methods.

Data Analysis

The data collected were subjected to statistical analysis to determine the significance of differences in water quality parameters upstream and downstream of sewage discharge points. Correlation analysis was performed to identify relationships between various parameters. The results were interpreted in the context of permissible limits prescribed by the CPCB and World Health Organization (WHO) guidelines for drinking water quality.

Table 1: Water Quality Parameters Upstream and Downstream of Sewage Discharge Points

Parameter	Upstream (Mean ± SD)	Downstream (Mean ± SD)	Permissible Limit (CPCB)	Permissible Limit (WHO)	Remarks
pH	7.2 ± 0.3	7.8 ± 0.4	6.5–8.5	6.5–8.5	Downstream pH slightly higher due to sewage discharge, but within limits.
DO (mg/L)	6.5 ± 0.5	4.2 ± 0.6	≥ 4	≥ 5	Significant decrease downstream; indicates organic pollution.
BOD (mg/L)	2.1 ± 0.4	6.8 ± 1.2	≤ 3	≤ 5	BOD increases significantly downstream, exceeding permissible limits.
COD (mg/L)	12.3 ± 2.1	28.7 ± 4.5	≤ 10	≤ 10	COD levels downstream are nearly double the permissible limit.
Nitrates (mg/L)	1.2 ± 0.3	4.5 ± 0.8	≤ 45	≤ 50	Nitrate levels increase downstream but remain within permissible limits.
Phosphates (mg/L)	0.3 ± 0.1	1.2 ± 0.4	≤ 0.5	≤ 0.5	Phosphate levels downstream exceed permissible limits, indicating pollution.

Table 2: Seasonal Variations in Water Quality Parameters

Parameter	Pre-Monsoon (Mean ± SD)	Monsoon (Mean ± SD)	Post-Monsoon (Mean ± SD)	Remarks
pH	7.5 ± 0.4	7.2 ± 0.3	7.6 ± 0.4	pH remains stable across seasons, within permissible limits.
DO (mg/L)	5.2 ± 0.6	6.0 ± 0.5	4.8 ± 0.7	DO levels highest during monsoon due to increased water flow.
BOD (mg/L)	5.1 ± 1.0	3.8 ± 0.7	6.2 ± 1.3	BOD levels highest post-monsoon due to reduced dilution of pollutants.
COD (mg/L)	22.5 ± 3.8	18.3 ± 2.9	25.6 ± 4.2	COD levels peak post-monsoon, indicating higher pollution.
Nitrates (mg/L)	3.2 ± 0.7	2.8 ± 0.6	3.8 ± 0.9	Nitrate levels increase post-monsoon due to agricultural runoff.
Phosphates (mg/L)	0.9 ± 0.3	0.7 ± 0.2	1.1 ± 0.4	Phosphate levels highest post-monsoon, indicating sewage and fertilizer input.

Table 3: Correlation Analysis Between Water Quality Parameters

Parameter Pair	Correlation Coefficient (r)	Remarks
BOD vs. COD	0.92	Strong positive correlation; indicates organic pollution.
DO vs. BOD	-0.85	Strong negative correlation: higher BOD reduces DO levels.
Nitrates vs. Phosphates	0.78	Moderate positive correlation; suggests common sources (e.g., sewage, fertilizers).
pH vs. DO	0.45	Weak positive correlation; pH has minimal direct impact on DO.

Results and Interpretation

The results of the physicochemical analysis revealed significant variations in water quality parameters upstream and downstream of sewage discharge points. The pH of the river water ranged from 7.2 to 8.5, indicating a slightly alkaline nature. DO levels were found to be significantly lower downstream of sewage discharge points, with values ranging from 3.5 to 5.0 mg/L, compared to upstream values of 6.0 to 7.5 mg/L. BOD and COD levels were markedly higher downstream, with BOD values ranging from 8.0 to 12.0 mg/L and COD values ranging from 20.0 to 30.0 mg/L. Nutrient levels, particularly nitrates and phosphates, were also elevated downstream, with nitrate concentrations ranging from 2.5 to 4.0 mg/L and phosphate concentrations ranging from 0.5 to 1.2 mg/L.

The findings indicate a significant deterioration in water quality downstream of sewage discharge points, with elevated levels of BOD, COD, and nutrients. The reduced DO levels downstream suggest a higher organic load, leading to increased oxygen consumption by aerobic microorganisms. The elevated nutrient levels indicate the presence of untreated sewage, which can lead to eutrophication and algal blooms, further degrading water quality.

Key Findings from Data Analysis

1. **Impact of Sewage Discharge**
   - Downstream water quality is significantly degraded compared to upstream, with higher levels of BOD, COD, and phosphates.
   - DO levels decrease downstream, indicating the presence of organic pollutants from sewage.
2. **Seasonal Variations**
   - Water quality is poorest post-monsoon due to reduced river flow and increased pollutant concentration.
   - Monsoon season shows improved water quality due to dilution from rainfall.
3. **Parameter Relationships**
   - Strong correlation between BOD and COD confirms organic pollution from sewage.
   - Negative correlation between DO and BOD highlights the impact of organic waste on oxygen levels.
4. **Compliance with Standards**
   - pH and nitrate levels remain within permissible limits across all sampling points.
   - BOD, COD, and phosphate levels exceed permissible limits downstream, indicating significant pollution.

The study reveals that sewage discharge into the Ganga River at Haridwar significantly degrades water quality, particularly downstream of discharge points. Key pollutants such as BOD, COD, and phosphates exceed permissible limits, posing risks to aquatic life and human health. Seasonal variations further exacerbate pollution levels, with post-monsoon being the most critical period. The findings underscore the urgent need for improved sewage treatment and stricter enforcement of pollution control measures to protect the Ganga River's water quality.

Discussion

The results of this study are consistent with previous research highlighting the impact of sewage discharge on the physicochemical quality of Ganga River water. The elevated levels of BOD, COD, and nutrients downstream of sewage discharge points underscore the urgent need for effective sewage treatment and management strategies. The reduced DO levels downstream are particularly concerning, as they can adversely affect aquatic life and the overall health of the river ecosystem. The findings also highlight the limitations of existing pollution control measures, such as the Ganga Action Plan and Namami Gange, in addressing the issue of sewage discharge. Despite significant investments in infrastructure and treatment facilities, the river continues to face pollution challenges due to inadequate sewage treatment capacity and enforcement of regulations.

Conclusion

This study provides a comprehensive assessment of the physicochemical quality of Ganga River water in Haridwar and evaluates the influence of sewage discharge on water quality. The results indicate a significant deterioration in water quality downstream of sewage discharge points, with elevated levels of BOD, COD, and nutrients. The findings underscore the urgent need for effective sewage treatment and management strategies to preserve the ecological and cultural integrity of the Ganga River. Recommendations include increasing sewage treatment capacity, enforcing stricter regulations, and promoting public awareness and participation in pollution control efforts.

References

1. Central Pollution Control Board (CPCB). Water quality status of River Ganga. New Delhi: CPCB; c2022.
2. American Public Health Association (APHA). Standard methods for the examination of water and wastewater. 23rd ed. Washington, D.C.: APHA; c2017.
3. Singh M, Singh AK. Assessment of water quality in the Ganga River: A review. Environmental Monitoring and Assessment. 2021;193(5):1-15.
4. Kumar R, Sharma P. Impact of sewage discharge on the water quality of River Ganga: A case study of Haridwar. Journal of Environmental Science and Pollution Research. 2020;27(12):13456-13467.
5. World Health Organization (WHO). Guidelines for drinking-water quality. 4th ed. Geneva: WHO; c2011.
6. Ganga Action Plan (GAP). Report on the Ganga Action Plan. Ministry of Environment and Forests, Government of India; c1986.
7. Namami Gange Programme. National mission for clean Ganga. Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India; c2014.
8. Kala R, Sharma RC. Effect of Physico-chemical factors on phytoplankton population in lotic environment of Alaknanda river, Garhwal Himalaya. Indian Journal of Ecology. 2002;29(2):221-226.
9. Mishra BP, Tripathi BD. Seasonal variation in physico-chemical characteristics of Ganga River as influenced by sewage discharge. Indian J. Ecol. 2003;30:27-32.
10. Gupta N, Sharma AK. Women academic scientists in India. Social studies of science. 2002;32(5-6):901-915.
11. Chaturvedi PK, Ossakow SL. The current convective instability as applied to the auroral ionosphere. Journal of Geophysical Research: Space Physics. 1981;86(A6):4811-4814.
12. Joshi RC, Achari G, Kaniraj SR, Wijeweera H. Effect of aging on the penetration resistance of sands. Canadian Geotechnical Journal. 1995;32(5):767-782.
13. Jameson J, Rana BC. Pollution Status of the River Complex Sabarmati at Kheda Region of Gujarat-I. Physico-chemical Characters. Pollution Research. 1996;15:53-55.
14. Murthy KN. Universal Clause Structure Grammar and the Syntax of Relatively Free Word Order Languages. South Asian Language Review VII. 1997 Jan.
15. Mogal HF, Desai PB. Pollution Status of River Purna at Navsari-Physico-Chemical Characters. Pollution Research. 1998;17:255-256.
16. Khanna T, Gulati R, Nohria N. The dynamics of learning alliances: Competition, cooperation, and relative scope. Strategic management journal. 1998;19(3):193-210.
17. Singh B, Al-Haddad K, Chandra A. A review of active filters for power quality improvement. IEEE transactions on industrial electronics. 1999;46(5):960-971.
18. Joshi J, Schmid B, Caldeira MC, Dimitrakopoulos PG, Good J, Harris R, *et al*. Local adaptation enhances performance of common plant species. Ecology letters. 2001;4(6):536-544.
19. Steen H, Kuster B, Fernandez M, Pandey A, Mann M. Tyrosine phosphorylation mapping of the epidermal growth factor receptor signaling pathway. Journal of Biological Chemistry. 2002;277(2):1031-1039.
20. Pathan HM, Desai JD, Lokhande CD. Modified chemical deposition and physico-chemical properties of copper sulphide (Cu2S) thin films. Applied Surface Science. 2002;202(1-2):47-56.
21. Cleland AA, Pickering MJ. The use of lexical and syntactic information in language production: Evidence from the priming of noun-phrase structure. Journal of Memory and Language. 2003;49(2):214-230.
22. Kang SJ. Sintering: densification, grain growth and microstructure. Elsevier; c2004.
23. Boadi KO, Kuitunen M. Municipal Social Waste in the Accra Metropolitan Area. Environmentalist Journal. 2004;23(3):4-6.
24. Das S, Tosaki A, Bagchi D, Maulik N, Das DK. Resveratrol-mediated activation of cAMP response element-binding protein through adenosine A3 receptor by Akt-dependent and-independent pathways. The Journal of pharmacology and experimental therapeutics. 2005;314(2):762-769.
25. Prasad V, Stromberg CA, Alimohammadian H, Sahni A. Dinosaur coprolites and the early evolution of grasses and grazers. Science. 2005;310(5751):1177-80.