



e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE



Impact of human activities on Ganga River water during Kanwar Mela 2024 in Rishikesh-Haridwar region, Uttarakhand, India

Nitish Kumar^{1*} and Hafeezur Rehman²

¹Graduate Institute of Biomedical Engineering, National Chung Hsing University, Taichung - 40227, Taiwan, Republic of China

²Department of Chemistry, Gurukula Kangri (Deemed to be University) Haridwar, Uttarakhand - 249404, India

*Corresponding author's E-mail: snitish366@gmail.com

ARTICLE HISTORY

Received: 24 March 2025

Revised received: 25 May 2025

Accepted: 05 June 2025

Keywords

Anthropogenic activity

Mass bathing

Microbiological parameter

Physico-chemical parameter

Water quality

ABSTRACT

The present investigation was conducted to study the water quality of the Ganga River during Kanwar Mela 2024 concerning physicochemical and microbiological characteristics in the Rishikesh-Haridwar region. Water samples were collected from fifteen designated sites, including six in Rishikesh, seven in Haridwar, and two outlet points—one from the main river stream and one from the Ganga canal. Among all sites, Har ki Pauri Ghat (HKP) exhibited the highest average levels of several key indicators of pollution: TDS (125.04 ± 34.18 mg/l), pH (7.52 ± 0.14), alkalinity (94.06 ± 10.31 mg/ml), total hardness (117.56 ± 16.43 mg/ml) BOD (2.41 ± 0.58 mg/l), COD (7.41 ± 0.87 mg/l). This site also recorded the lowest average level of DO (9.81 ± 0.63 mg/l) and the highest microbial contamination, with total coliform (2008.81 ± 188.25 MPN/100ml) and *E. coli* (884.8 ± 57.62 MPN/100ml), marking it as the most polluted location. The second most polluted site, Purnanand Ghat (PG) in Rishikesh, showed the highest concentration of fluoride (0.10 ± 0.09 mg/l). These findings indicated that mass bathing and associated religious activities during the Kanwar Mela significantly impacted the water quality of the Ganga River, particularly in densely visited pilgrimage zones, contributing to elevated levels of pollution. The outcomes of this study underscore the urgent need for robust water quality monitoring, public health risk assessment, and the implementation of sustainable water management policies during mass gatherings to protect the ecological integrity of the river and safeguard the health of millions who rely on it for religious, domestic, and agricultural purposes.

©2025 Agriculture and Environmental Science Academy

Citation of this article: Kumar, N., & Rehman, H. (2025). Impact of human activities on Ganga River water during Kanwar Mela 2024 in Rishikesh-Haridwar region, Uttarakhand, India. *Archives of Agriculture and Environmental Science*, 10(2), 297-302, <https://dx.doi.org/10.26832/24566632.2025.1002016>

INTRODUCTION

Water is the most crucial thing for humans and the ecosystem; without it, we cannot assume the origin or survival of life. Rivers are the major source of fresh water, and the banks of rivers are the most probable natural habitats for the survival and growth of any civilization (Kumar & Chopra, 2012; Kumar *et al.*, 2018; Singh & Singh, 2007). The Indian civilization is preferably developed in the vicinity of the river's banks. Therefore, the role of rivers in Indian people's lives is very sacred; many social activities and religious events are performed at the banks of rivers

(Yasir & Srivastava, 2016). The Ganga River is the most sacred river that rises at the foot of Gangotri Glacier in the Himalayan Mountains at Gomukh (Haritash *et al.*, 2016; Kumar *et al.*, 2018). Ganga River starts to flow in the plain at Haridwar (pilgrimage town), and some of its water diverts into the Ganga canal through a dam for irrigation. Many religious festivals and fairs like Kumbh Mela, Ardha Kumbh, Somvati Amavasya Mela, Kanwar Mela, and Ganga Dashara are held at Haridwar, in which millions of people gather to participate in different ritualistic activities. The festival Kanwar Mela is organized every year in July at Haridwar. During Kanwar Mela, millions of devotees

partake in this auspicious festival and take a dip in the holy river (Kumar *et al.*, 2018; Yadav & Bhatia, 2020). The reason behind this mass gathering is that people believe that a dip in the holy River at this particular time absolves all their sins (Haritash *et al.*, 2016). The assemblage of devotees, visitors, and sadhu (holy man) performs different anthropogenic activities like *achman*, mass bathing, washing, etc., and has a non-eco-friendly effect on the environment. To do this, the contamination of river water is a major threat during such types of festivals and ritualistic activities.

While these gatherings are of immense religious and cultural value, they exert significant anthropogenic pressure on the river ecosystem. Activities such as mass bathing, ceremonial washing, and disposal of ritualistic materials can introduce organic and microbial pollutants into the river water. Studies have shown that such events lead to a deterioration in water quality, increasing the concentration of suspended solids, biological oxygen demand (BOD), chemical oxygen demand (COD), and microbial contaminants (Singh & Singh, 2007; Khandi & Srivastava, 2016). These pollutants pose serious public health risks, including outbreaks of waterborne diseases such as cholera, jaundice, typhoid, and skin infections. The river water is effectively resolving the drinking water crisis of the wider population. The preservation of water sources and real-time monitoring of water quality have drawn the attention of the scientific community during the last decade. The assessment of deviation in water quality of sacred rivers, holy water bodies, and streams has been made by the researcher on time to time and concludes that the regular monitoring of these water sources is necessary to ensure the availability and quality of water for drinking and irrigation purpose (Simeonov *et al.*, 2003; Kansal *et al.*, 2013; Mohamed & Ahmed, 2011; Haritash *et al.*, 2016; Oladeji *et al.*, 2017). Despite various studies on Ganga water quality, limited attention has been paid to the immediate and localized impacts of specific mass gatherings like the Kanwar Mela, especially in the Rishikesh–Haridwar region, which serves as the initial inter-

action point between the river and the plains. Moreover, most existing studies focus either on broader spatiotemporal trends or on mega-events like the Kumbh Mela, thereby leaving a gap in understanding the specific effects of annual festivals like Kanwar Mela on river water quality.

This study aims to assess the physicochemical and microbiological impacts of mass bathing and associated anthropogenic activities on the water quality of the Ganga River during the Kanwar Mela 2024 in the Rishikesh–Haridwar region. The study also incorporated two outlet locations to evaluate the overall influence of the mass gathering on the downstream water quality of the Ganga River. By evaluating water samples collected from multiple strategic locations along the river, this research seeks to quantify pollution levels and identify the most affected sites, thereby providing scientific evidence for environmental management, public health advisories, and policy making.

MATERIALS AND METHODS

Site description

Rishikesh and Haridwar are also called the “twin national heritage cities” situated in the Shivalik Hills region. Due to the religious significance of these holy cities and to know about how the mass gathering of pilgrims affects the water quality of the Ganga River during Kanwar Mela 2024, the six sampling sites viz., Laxman Jhula (LJ), Muni Ki Reti (MKR), Ram Jhula (RJ), Purnanan Ghat (PG), Triveni Ghat (TG), and Sai Ghat (SG) at Rishikesh region and seven sampling sites viz., Haripur Kla Ghat (HKG), Sarvanand Ghat (SG), Bhimgoda Barrage (BB), Har Ki Pauri (HKP), Chandi Ghat (CG), Prem nagar Ashram Ghat (PAG) and Dasheshwar Mahadev Temple (DMT) at Haridwar were selected for the collection of Ganges water samples at the months of March and April (Figure 1). The two sampling sites viz., Shyampur Kangri (SK) and Bahadradab Town (BT) were also selected as outlet points of both the Ganga River (main stream) and Ganga Canal.

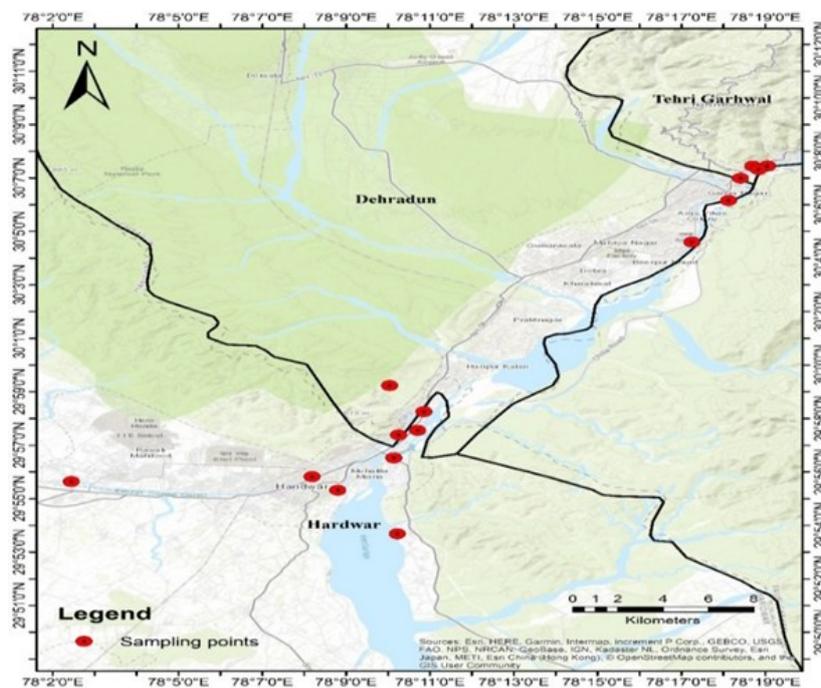


Figure 1. Sampling sites at Rishikesh-Haridwar region.

Collection of samples and analysis parameters

For physico-chemical analysis, the water samples were collected in one-liter pre-cleaned HDPE bottles, and 100 ml autoclaved bottles were used for microbial analysis, separately. The water samples were collected every week in July, and the depth of the collection point was maintained at 30 – 40 cm to minimize undesirable intervention. The important parameters viz., total dissolved solids (TDS), pH, chlorides (Cl^-), total hardness, alkalinity, nitrate (NO_3^{2-}), sulphate (SO_4^{2-}), fluoride (F^-), calcium (Ca), magnesium (Mg), iron (Fe), dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) were performed for physicochemical analysis and most probably number (MPN)/100ml of *E. coli*. and total coliform were calculated for microbial analysis. All parameters were analyzed following the standard methods (BIS, 2021 and APHA, 2022).

Statistical analysis

The average value and standard deviation (SD) were calculated with the help of MS Excel 2016.

RESULTS AND DISCUSSION

The physicochemical characteristics of Ganga River water during Kanwar Mela 2024 at Laxman Jhula (LJ), Muni Ki Reti (MKR), Ram Jhula (RJ), Purnanan Ghat (PG), Triveni Ghat (TG), and Sai Ghat (SG) at Rishikesh region are shown in Table 1. While, seven sampling sites viz., Haripur Kla Ghat (HKG), Sarvanand Ghat (SG), Bhimgoda Barrage (BB), Har Ki Pauri (HKP), Chandi Ghat

(CG), Prem nagar Ashram Ghat (PAG) and Dasheshwar Mahadev Temple (DMT) at Haridwar region including two others sampling sites viz., Shyampur Kangri (SK) and Bahadrabad Town (BT) are shown in Table 2.

TDS and turbidity

All natural waters contain some dissolved solids due to the leaching and dissolution of rocks and soil. The value of total dissolved solids (TDS) was recorded at different sampling sites (Table 1). During Kanwar Mela, the maximum average value of TDS (125.04 ± 34.18 mg/l) was found at Har Ki Pauri Ghat (HKP), which was well within the permissible limit (500 mg/l). Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. The maximum average value of turbidity was found to be 4.3 ± 3.25 NTU at Muni Ki Reti (MKR). Which was under the permissible limit (5 NTU). Bhutiani et al. (2012) also reported higher values of TDS and turbidity in the water of the Ganga River at Haridwar during Kumbh Mela 2010.

pH

pH is the negative logarithm of the molar concentration of hydrogen ions. For drinking water Permissible limit of pH is 6.5 – 8.5 pH. During Kanwar Mela, the maximum average value of pH was found to be 7.52 ± 0.14 at Har ki Pauri (HKP). Which was within the range of permissible limits as per BIS standards (BIS, 2021).

Table 1. Water quality assessment of river Ganga at Rishikesh region during Kanwar Mela-2024.

Parameter	Sampling site at Rishikesh region					
	MKR	LJ	PG	RJ	TG	SG
TDS	97.41±17.1	112.70±32.12	115.58±22.02	106.3±32.10	97.42±17.1	98.87±21.65
pH	7.42±0.12	7.44±0.12	7.47±0.15	7.46±0.13	7.44±0.14	7.43±0.14
Turbidity (NTU)	4.30±3.25	3.60±2.71	3.76±2.49	2.88±2.83	3.08±2.42	3.29±3.08
Total Hardness (mg/l)	92.50±22.3	112.50±53.03	112.20±51.25	99.31±30.97	100.6±19.01	96.19±29.50
Alkalinity (mg/l)	75.31±24.03	90.12±58.07	88.5±56.54	86.81±35.85	80.75±20.75	80.31±22.58
Ca (mg/l)	24.18±8.93	28.7±15.18	28.75±5.94	24.55±6.60	27.83±5.98	23.87±6.71
Mg (mg/l)	7.79±3.71	9.98±5.12	10.55±4.92	9.92±4.77	7.56±3.23	8.87±4.24
Cl^- (mg/l)	13.5±3.8	16.5±6.18	15.94±6.63	17.25±5.05	16.56±4.42	17.69±6.36
F^- (mg/l)	0.06±0.05	0.07±0.07	0.10±0.09	0.08±0.03	0.08±0.03	0.09±0.04
Nitrate (mg/l)	2.85±2.05	2.83±1.81	2.76±2.02	2.61±2.36	2.95±2.55	2.61±2.43
Sulphate (mg/l)	25.63±4.24	26.63±7.42	29.75±8.07	26±4.6	25.75±4.59	26.13±4.19
DO (mg/l)	8.92±0.38	9.21±0.54	9.18±0.43	9.23±0.78	9.61±0.52	9.32±0.46
BOD (mg/l)	2.21±0.12	1.28±0.22	2.19±0.27	1.33±0.13	1.71±0.54	2.20±0.26
COD (mg/l)	5.11±0.83	5.29±1.11	5.42±0.93	5.39±1.11	5.35±1.22	6.33±1.07
Iron (mg/l)	0.18±0.15	0.19±0.15	0.17±0.19	0.17±0.19	0.18±0.21	0.19±0.19
<i>E. coli</i> (MPN/100 ml)	316.6±67.03	294.15±45.67	518.39±38.72	276.38±36.48	288.8±56.67	386.83± 86.48
Total coliform (MPN/100 ml)	1011.24±351.18	1418.24±50.07	1608.3 ±3 61.84	1453.86±538.20	1508.125±402.92	1358.81± 168.25

Values are mean ± SD of replicates; Laxman Jhula (LJ), Muni Ki Reti (MKR), Ram Jhula (RJ), Purnanan Ghat (PG), Triveni Ghat (TG), Sai Ghat (SG).

Alkalinity, hardness, and chloride

The alkalinity of natural water represents the presence of carbonates, bicarbonates, and hydroxide and some amount of salt of weak acids. In the present study, the maximum average value of Alkalinity (94.06 ± 10.31 mg/ml) and total Hardness (117.56 ± 16.43 mg/l) were recorded at Har Ki Pauri Ghat (HKP). The maximum average value of chloride (17.69 ± 6.36 mg/l) was observed at Sai Ghat (SG), respectively. Kumar & Chopra (2012) also observed similar patterns of water quality characteristics of the abandoned Old Ganga Canal at Haridwar (Uttarakhand) India.

Calcium, magnesium, and iron

The elements like calcium and magnesium are attributed to the hardness of natural water. During Kanwar Mela, the maximum average value of calcium (37.45 ± 35.29 mg/l) and magnesium (12.74 ± 4.77 mg/l) were measured at Haripur Kila Ghat (HKG) and Bahadradab Town (BT), respectively. This was within the maximum permissible limit of 100 mg/l of BIS, similar to calcium (BIS, 2021). Generally, the heavy metals are present in natural water at very low concentrations. They are typically introduced to surface waters as waste from human activities. As per BIS standards, the ranges of 0.3 mg/l and 1.0 mg/l have been suggested as desirable and permissible limits, respectively, for iron metal (BIS, 2021). The maximum average value of iron in Ganga River water samples was found to be 0.24 ± 0.14 mg/l at Chandi Ghat.

DO, BOD, and COD

Dissolved oxygen is the amount of oxygen that depends upon the physicochemical and biochemical activity of a water body. The Central Pollution Control Board (CPCB) suggested that the desirable limit for DO is > 5 mg/l. The minimum average value of DO was found to be 8.89 ± 0.40 mg/l at Har Ki Pauri Ghat (HKP). During the Mela period, the maximum average value of BOD and COD was found to be 2.41 ± 0.58 mg/l and 7.41 ± 0.87 mg/l, at Har Ki Pauri Ghat. The BOD was still in the range of the permissible limit (< 3 mg/l) provided by the CPCB. Likewise, Bhutiani *et al.* (2012) also found the same trend in the COD value of the Ganga River.

Nitrate, sulphate, and fluoride

In the present study, during Kanwar Mela, the maximum average values of Ions were noted to be Nitrate (2.95 ± 2.55 mg/l) at Triveni Ghat (TG), sulphate (29.75 ± 8.07 mg/l), and fluoride (0.1 ± 0.09 mg/l) at Purnanan Ghat (PG). All three ions were observed well within the permissible limits according to BIS standards for the above-mentioned ions. These Ions also have low concentrations, as earlier reported by Kumar & Chopra (2012).

Microbiological profile of Ganga river water

Bacterial parameters, such as total coliform (TC) and *E. coli*, which serve as indicators of coliform pollution, are very important when human health is the prime concern. *E. coli* bacteria are found in the intestinal tract of human beings. The enzyme substrate method performed the microbial test as a most probable number (MPN) index. This is an index of the number of bacteria. The maximum average values of total coliform

(TC) and *E. coli* during Kanwar Mela were noted to be 2008.81 ± 188.25 MPN/100ml and 884.8 ± 57.62 MPN/100ml, respectively, at Har Ki Pauri Ghat (HKP). It exceeded the minimum permissible limit (50 MPN/100ml). It is likely due to the mass bathing, dirt, fungi, bacteria, contamination, sweat from bodies, urination, and due to breath. Kumar *et al.* (2018) also reported the changes in water quality characteristics of the Ganga River water due to the huge mass gathering.

Table 2. Water quality assessment of river Ganga at Haridwar region including two outlets during Kanwar Mela-2024.

Parameter	Sampling site at Haridwar region									
	HKG	SAG	BB	HKP	CG	PAG	DMT	SK	BT	
TDS	124.26±30.72	104.02±32.92	104.37±30.7	125.04±34.18	111.4±35.85	116.13±35.67	102.12±30.47	117.99±21.94	110.99±34.80	
pH	7.46±0.15	7.50±0.13	7.44±0.11	7.52±0.14	7.43±0.11	7.49±0.12	7.45±0.12	7.50±0.13	7.50±0.13	
Turbidity (NTU)	2.0±1.89	2.81±2.99	3.75±4.01	3.71±4.03	2.41±1.87	3.38±4.46	3.6±4.34	2.83±3.25	3.25±3.59	
Total Hardness (mg/l)	115.72±47.74	106.69±18.75	105.31±21.07	117.56±16.43	113.87±18.72	103.06±15.72	117.56±16.43	114.75±9.85	110±24.19	
Alkalinity (mg/l)	86.81±46.9	83.86±12.26	75.19±2.95	94.06±10.31	83.38±23.18	76.86±9.76	94.06±10.31	92.56±7.29	81.94±27.99	
Ca (mg/l)	37.45±35.29	27.26±7.40	30.3±12.35	32.89±16.48	28.94±6.48	29.85±9.22	32.89±16.48	32.14±18.20	26.67±9.66	
Mg (mg/l)	11.50±6.12	11.37±3.06	11.01±5.83	11.69±1.46	12.09±3.75	9.28±3.88	11.69±1.46	11.82±2.64	12.74±4.77	
Cl ⁻ (mg/l)	16.0±5.67	14.54±4.28	16.56±3.13	14.75±3.01	16.25±4.13	17.31±4.66	14.75 ± 3.01	14.63±4.0	15.19±6.35	
F ⁻ (mg/l)	0.08±0.05	0.07±0.04	0.06±0.04	0.08±0.05	0.09±0.05	0.07±0.04	0.08±0.05	0.07±0.05	0.07±0.05	
Nitrate (mg/l)	1.17±0.47	1.73±0.76	1.81±0.85	2.37±0.75	1.84±0.27	2.36±1.13	2.37±0.75	1.89±0.61	2.4±1.15	
Sulphate (mg/l)	29.5±9.40	26.13±4.61	27.63±3.58	29.61±4.32	28.75±3.69	28.0±2.14	29.61±4.32	29.25±3.41	28.95±5.23	
DO (mg/l)	9.11±0.73	9.23±0.44	9.81±0.63	8.89±0.40	9.18±0.48	9.54±0.49	8.89±0.40	9.35±0.43	9.05±0.74	
BOD (mg/l)	2.20±0.55	1.83±0.31	1.61±0.43	2.41±0.58	1.81±0.38	2.05±0.36	2.41±0.58	1.75±0.43	1.89±0.37	
COD (mg/l)	5.36±0.79	5.93±0.87	5.30±0.44	7.41±0.87	7.28±1.32	6.11±1.31	7.41±0.87	6.97±1.97	6.30±1.10	
Iron (mg/l)	0.1±0.04	0.17±0.08	0.17±0.11	0.17±0.11	0.24±0.14	0.15±0.11	0.17±0.11	0.14±0.08	0.12±0.05	
<i>E. coli</i> (MPN/100 ml)	293.19±73.26	384.26±84.05	345.88±112.89	884.8±57.62	194.94±42.14	319.36±75.83	884.8±57.62	526.49±84.05	465.09±101.46	
Total coliform (MPN/100 ml)	1596.56±601.39	1573.19±600.70	1011.24±351.18	2008.81±188.25	1035±451.17	1260.08±434.23	2008.81±188.25	1132.64±507.48	1464.86±437.60	

Values are mean ± SD of replicates; Haripur Kila Ghat (HKG), Sarvanand Ghat (SG), Bhimgoda Barrage (BB), Har Ki Pauri (HKP), Chandi Ghat (CG), Prem nagar Ashram Ghat (PAG), Dashedwar Mahadev Temple (DMT).

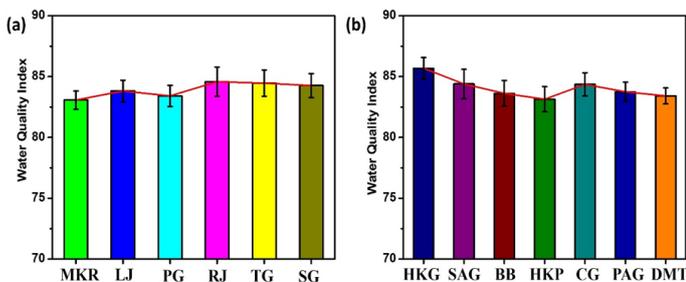


Figure 2. WQI of Ganga River; (a) Rishikesh region (b) Haridwar region excluding outlets.

Assessment of Water Quality Index (WQI)

The Water Quality Index (WQI) is used to assess river water contamination. It simplifies the overall health of water quality into a single numerical value, making it easier to compare different water bodies and select appropriate treatment methods to address specific issues. This led the present study to examine the spatial and temporal variations in water quality across the Ganga River basin. Ramakrishnaiah *et al.* (2009) classified the Ganga River as having either good or excellent water quality. "Good" indicates a slight level of threat or impairment, while "excellent" signifies water quality that is virtually free from threats or impairments, closely resembling natural or pristine conditions. Based on this qualification, we can predict that the water quality of the Ganga River was "Good" during the Kanwar Mela as shown in Figure 2. Even though the water is classified as "good," basic treatment is still advisable for safe human consumption. The classification does not guarantee microbiological safety, which is often the primary concern in drinking water.

Conclusion

This study presents a detailed assessment of the impact of the Kanwar Mela 2024 on the water quality of the Ganga River in the Rishikesh–Haridwar region, using a suite of physicochemical and microbiological indicators. The results demonstrate that the large influx of pilgrims, mass bathing, and associated ritualistic activities during this religious event significantly altered the river's water quality at multiple locations. Among the fifteen sampling sites, two locations—Har Ki Pauri Ghat (HKP) in Haridwar and Purnanand Ghat (PG) in Rishikesh—were identified as the most adversely affected. At HKP, water samples exhibited the highest concentrations of several pollution indicators: TDS (125.04 ± 34.18 mg/L), BOD (2.41 ± 0.58 mg/l), COD (7.41 ± 0.87 mg/l), and microbial loads such as total coliform (2008.81 ± 188.25 MPN/100 ml) and *E. coli* (884.8 ± 57.62 MPN/100 ml). The site also recorded the lowest mean dissolved oxygen (9.81 ± 0.63 mg/l), a key indicator of aquatic health. PG, the second most impacted site, reported the highest fluoride level (0.10 ± 0.09 mg/L), further suggesting elevated anthropogenic influence in this area. Significant deviations in turbidity, chloride content, total hardness, and other water quality parameters were also observed during the Mela period, indicating an overall decline in water quality. The findings underscore the vulnerability of riverine systems during mass religious gatherings and the necessity for implementing scientifically informed, preventive measures to

minimize ecological degradation. It is recommended that awareness campaigns be initiated to educate pilgrims about environmentally responsible behaviour, along with the deployment of temporary sanitation facilities, real-time water monitoring systems, and strict regulation of effluent discharge during such events. This study not only contributes to the growing body of literature on human-induced water pollution but also offers practical insights for the formulation of sustainable river basin management policies, especially during high-pressure events like the Kanwar Mela.

ACKNOWLEDGEMENT

Uttarakhand Jal Sansthan, Dehradun and Gurukula Kangri (Deemed to be University), Haridwar are gratefully acknowledged for providing necessary instrument facility.

DECLARATIONS

Author contribution statement

Conceptualization: N.K and H.R.; Methodology: N.K and H.R.; Software and validation: N.K.; Formal analysis and investigation: N.K.; Resources: H.R.; Data curation: N.K and H.R.; Writing—original draft preparation: N.K.; Writing—review and editing: N.K and H.R.; Visualization: H.R.; All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.

Consent for publication: All co-authors gave their consent to publish this paper in AAES.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: No supplementary data is available for the paper.

Funding statement: No external funding is available for this study.

Additional information: No additional information is available for this paper.

Open Access: This is an open access article distributed under the terms of the Creative Commons Attribution Non-commercial 4.0 International License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) or sources are credited.

Publisher's Note: Agro Environ Media (AESA) remains neutral

about jurisdictional claims in published maps, figures and institutional affiliations.

REFERENCES

- APHA. (2022). Standard Methods for the Examination of Water and Wastewater. American Public Health Association, 24th edition, Washington, DC: APHA Press; 2023. <https://www.standardmethods.org/24theditioncitation>
- BIS. (2021). Bureau of Indian Standards Specification for drinking water. IS: 10500:2012, Amendment No. 3. *Bureau of Indian Standards*, New Delhi, India. <https://www.scribd.com/document/656107401/10500A3>
- Bhutiani, R., Tyagi, P., & Ruhela, M. (2012). Assessment of water quality of River Ganges during Kumbh Mela 2010. *Environment Conservation Journal*, 13(3), 165–169. <https://doi.org/10.36953/ECJ.2012.130327>
- Haritash, A. K., Gaur, S., & Garg, S. (2016). Assessment of water quality and suitability analysis of river Ganga in Rishikesh, India. *Applied Water Science*, 6(4), 383–392. <https://doi.org/10.1007/s13201-014-0235-1>
- Kansal, A., Siddiqui, N. A., & Gautam A. (2013). Assessment of heavy metals and their interrelationships with some physico-chemical parameters in eco-efficient rivers of Himalayan Region. *Environmental Monitoring and Assessment*, 185(3), 2553–63. <https://doi.org/10.1007/s10661-012-2730-x>
- Khandi, R. M., & Srivastava, S. (2016). Impact of tourism on water quality characteristics of Lidder Stream at Pahalgam, (J&K), India. *Archives of Agriculture and Environmental Science*, 1(1), 37–42. <https://doi.org/10.20935/AcadEnergy7556>
- Kumar, V., & Chopra, A. K. (2012). Hydrological characteristics of abandoned Old Ganga Canal at Haridwar (Uttarakhand) India. *Journal of Chemistry and Pharmaceutical Research*, 4(11), 4774–4782. <https://api.semanticscholar.org/CorpusID:54929608>
- Kumar, V., Kumar, S., Srivastava, S., Singh, J., & Kumar, P. (2018). Water quality of River Ganga with reference to physico-chemical and microbiological characteristics during Kanwar Mela 2017, at Haridwar, India: A case study. *Archives of Agriculture and Environmental Science*, 3(1), 58–63. <https://doi.org/10.26832/24566632.2018.030108>
- Mohamed, S., & Ahmed, A.W. (2011). Water pollution and riverbank filtration for water supply along River Nile, Egypt. In: *Riverbank Filtration for Water Security in Desert Countries*, 5C. Ray and M. Shamrukh (eds.), 1–25. https://doi.org/10.1007/978-94-007-0026-0_2
- Oladeji, S. O. (2017). Evaluation of nickel levels in wastewater, soil and vegetable samples grown along Kubanni stream channels in Zaria, Kaduna State, Nigeria. *Archives of Agriculture and Environmental Science*, 2(3), 141–147. <https://journals.aesacademy.org/index.php/aaes/article/view/02-03-02>
- Ramakrishnaiah, C.R., Sadashivaiah, C., & Ranganna G. (2009). Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State, India. *E-Journal of Chemistry*, 6(2), 523–530. <https://doi.org/10.1155/2009/757424>
- Singh, M., & Singh, A. K. (2007). Bibliography of environmental studies in natural characteristics and anthropogenic influences on the Ganga River. *Environmental Monitoring and Assessment*, 129, 421–432. <https://doi.org/10.1007/s10661-006-9374-7>
- Simeonov, V., Stratis, J. A., Samara, C., Zachariadis, G., Voutsas, D., Anthemidis, A., Sofoniou, M., & Kouimtzi, T. (2003). Assessment of the surface water quality in Northern Greece. *Water Research*, 37, 4119–4124. [https://doi.org/10.1016/S0043-1354\(03\)00398-1](https://doi.org/10.1016/S0043-1354(03)00398-1)
- Yadav, S., & Bhatia R.K. (2020). Assessment of mass bathing on River Ganga water quality during Kumbh Mela 2019 in Prayagraj, Uttar Pradesh, India. *International Research Journal of Engineering and Technology*, 7(7), 4757–4762. <https://doi.org/10.1016/j.jgsd.2022.100750>
- Yasir & Srivastava, S. (2016). Monitoring of ground water quality in the province of district Dehradun, (Uttarakhand), India. *Archives of Agriculture and Environmental Science*, 1(1), 43–48. <https://journals.aesacademy.org/index.php/aaes/article/view/aaes-01-01-06>