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Irrigation Water Quality Assessment of River Ganga in Haridwar with Adjoining Areas

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ABSTRACT

The holy River Ganga at Haridwar is largely affected by that effluent from various industries and untreated sewage disposed from insufficient sewage treatment plants. Along with that the pilgrims that take holy dip in the pious river throughout the year, all these situations worsens the condition a lot. The quality and quantity of surface water in a river basin is influenced by natural factors such as rainfall, temperature and weathering of rocks and anthropogenic changes that curtail natural flow of the river, or alter its hydrochemistry. A study related to water quality indexing of River Ganga was conducted for four months, and four sampling stations were selected for physico-chemical parameters. WQI of the River during the study period was 46.03 which fall in the good water quality. DO values ranged from 10.32-13.24 mg/l, BOD values were 1.08-3.66 mg/L, COD ranged from 5.50-11.50 mg/L. Other physico-chemical parameters were observed well in the range.

KEYWORDS: *Ganga, Haridwar, adjoining, areas, hydrochemistry, physico-chemical, parameters*

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INTRODUCTION

River Ganga is a perennial river connected to several glaciers in the Himalayan mountain. In its initial course the river Alakhnanda and Bhagirathi meet at Dev Prayag and after their confluence, the resulting river is known as Ganga. The Dev Prayag is approximately 70.0 Km along from Haridwar - the off taking point of the Ganga canal. The contribution of Alaknanda is approximately 66% and river Bharigathi is 34% in the River Ganges. The total catchment area of the river Ganga above Haridwar is approximate 20,000.00 Sq Km in Himalayan Mountains. This river is the life line of large fertile agricultural track of the adjoining districts on its both banks. The economy of the inhabiting farmers mainly depends on the irrigation water which is supplied from the river Ganga. Originally the Ganga Canal irrigates the Doab region between the Ganges River and the Yamuna River in India. The canal is primarily an irrigation canal, although parts of it were also used for navigation, primarily for its construction materials. Separate navigation channels with lock gates were provided on this system for boats to negotiate falls. Originally constructed from 1842 to 1854, for an original head discharge of 6000 ft³/s. The Upper Ganges Canal has since been enlarged gradually for the present head discharge of 10,500 ft³/s (295 m³/s). The canal system irrigates nearly 9,000 km² of fertile agricultural land in ten districts of Uttar Pradesh and Uttarakhand. Today the canal is the source of agricultural prosperity in much of these states, and the irrigation departments of these states actively maintain the canal against a fee system charged from users. The canal is administritatively divided into the Upper Ganges Canal the Lower Ganges Canal which constitutes several branches. The Upper Ganges canal is the original Ganges Canal, which starts at the Bhimgoda Barrage near Har ki Pauri at Haridwar, traverses Bahadrabad, Roorkee and flows to Uttar Pradesh. With increase in population and gap between demand and supply, the canal system has also increase throughout the world for maximum approach to freshwater. The Ganga basin accounts for a little more than one-fourth (26.3%) of the country’s total geographical area and is the biggest river basin in India, covering the entire states of Uttarakhand. The Ganga Canal emerging out from Ganga basin has great ritual importance among pilgrims and tourists at Haridwar, Uttarakhand, India. The Canal is being polluted due to mass bathing, washing, disposal of sewage, industrial waste and these human activities are deteriorating its water quality. To determine the impact of these activities, Ganga Canal water quality at three major sites at Bhimgoda Barrage and Roorkee, Haridwar has been analyzed for various physico-chemical pollutants and compared with water quality standards for improved understanding.[1,2]

Site 1—The site is situated near Kaudiyala, located at 30°4′25.15″ N to 78°30′5.39″ E. It is the victim of human disturbances to some extent, and receives waste from cattle washing, vehicle washing, idol immersion, cremation, and nirmalya immersion, and is also used for fishing activities and boating in this area.

Site 2—The site Shivpuri is located at 30°8′7.78″ N to 78°23′27.27″ E, representing a lotic that is less disturbed by various anthropogenic activities, although tourist activities in the area are increasing day by day. The site receives waste from sewage, clothes washing, vehicle cleaning, idol immersion, animal washing, fishing and several other activities to a minimal extent.

Site 3—The site Rishikesh is situated at 30°4′59.57″ N and 78°17′26.54″ E. Many human disturbances to the river water can be seen there due to Rishikesh being a holy place, and people from all over the country and from abroad come here for religious purposes. Overpopulation and contact with the Ganges are the main reasons for river water pollution here.

Site 4—The site Haridwar is an ancient city and an important Hindu pilgrimage site in Uttarakhand state, where the river Ganges exits the Himalayan foothills. The largest of several sacred ghats (bathing steps), har Ki Pauri hosts a nightly Ganges Aarti (river-worshipping ceremony), in which tiny flickering lamps are floated off the steps. Worshipers fill the city during major festivals like the annual Kanwar Mela. During this time, pollutants in the water can be observed due to their natural quality and color.

Site 5—The site Bhogpur village is located downstream about 20 km towards South Haridwar district. Agriculture and animal husbandry are the main professions of the residents of this village, who completely depend on river water. Different agricultural processing, irrigation, deforestation, etc., processes are the largest human interventions on the water of the Ganges at this site, resulting in more contamination compared to other sites.[3,4]

Discussion

The analyzed water parameters were Temperature, pH, DO, COD, BOD, $CaCO_3^-$, $CaCO_3$, Turbidity, EC, TDS, Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, F^-, and Fe^{2+}. We analyzed pH, DO, Temperature and Turbidity at the sample collection spot. The samples were collected in a sterilized PVC bottle and stored in an icebox to reduce the occurrence of changes in the water characteristics. Water temperature is a very important parameter, because it influences the biota in a water body by affecting activities such as behavior, respiration, and metabolism. The temperature values rangeed from 15.85 to 16.04 °C. It was observed that the temperature was higher during the summer, followed by rainy and winter seasons. pH measures the nature of water in terms of whether it is basic (>7) or acidic (<7). In the present study, the highest and lowest pH were observed to be 8.45 and 7.05 at sample sites 5 and 1, respectively. High water pH in the summer may be attributed to the use of free carbon dioxide in algal photosynthesis, resulting in high algal populations. Dissolved oxygen plays a significant role in supporting aquatic life and evaluating the freshness of water. The highest DO was found at site 4, and the lowest at site 3, i.e., 10.28 and 9.11 mg/L, respectively. A suitable amount of DO is required in water for aquatic life like fish and other organisms, and to maintain the diversity of all forms of life, but excess amounts indicate a degradation in the quality of water.[5,6]

River Ganga in Haridwar

BOD is the amount of oxygen required during the metabolization of organic matter, which is essential to aquatic ecosystems. The water at the sampled sites on the Ganges had a maximum alkalinity of 219.42 mg/L during the course of this study, decreasing gradually moving towards the upper course. The hardness of the water was found to have a maximum value of 309.8 mg/L and a minimum value of 110.12 mg/L, at sample sites 5 and 1, respectively. The Ganges water contained a maximum chemical oxygen demand of 8.86 mg/L, followed by a gradual decrease to a minimum value of 6.11 mg/L. Some parameters, like total alkalinity ($CaCO_3^-$), total hardness ($CaCO_3$), and turbidity were found to be above the desirable limits; this is because of increasing human intervention resulting from floating population, domestic sewage, the addition of nutrients, agricultural runoff, and organic matter in water. The EC of water is a direct indication of its total dissolved salts, and is used for measuring the total concentration of soluble salts in water. Our testing results showed that at the sampling sites, the concentration of EC was always below the desirable limit.[7,8] Although high degrees of anthropogenic activities such waste disposal, sewage, and agricultural runoff are present at sites 3, 4, and 5, EC was found to have a good content, which may be due to water flowing towards the lower course, because EC fluctuates due to water flow. Total dissolved solids (TDS) primarily consist of inorganic salts like chlorides, sulphates, bicarbonates, carbonates, magnesium, sodium, potassium, phosphates, and nitrates of calcium, iron, etc. The values of TDS, in increasing order, were 227.08, 221.68, 344.83, 525.31, and 598.65 mg/L at sample sites 1, 2, 3, 4, and 5, respectively. The value of TDS at all sites was below the BIS desirable limit of l000 mg/L. the concentrations of calcium (Ca^{2+}), sodium (Na^+) and potassium (K^+) were also found to be below the desirable limit as recommended by the BIS standard. However, the values of magnesium (Mg^{2+}), chlorides (Cl^-), fluoride (as F^-), and ferrous iron (Fe^{2+}) were found to be above the desirable limit at some sites, such as 4 and 5. These parameters were found in higher proportions in these locations because of the increased pollution load due to sewage and agricultural runoff in the river water.[9,10]

Details of site-wise physicochemical parameters and their QWI (mean ± sd) during the observation.

Parameters	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Min.	Max.
Temperature	°C	15.85 ± 2.36	16.56 ± 3.21	15.92 ± 1.25	16.85 ± 3.54	16.04 ± 2.54	14.25	17.46
pH		7.05 ± 0.25	7.31 ± 0.32	7.38 ± 0.51	8.31 ± 0.65	8.45 ± 0.45	7.3	8.3
Dissolved Oxygen (DO)	mg/L	9.12 ± 1.25	9.44 ± 1.74	9.11 ± 0.95	10.28 ± 1.24	10.09 ± 1.02	7.51	11.54
COD	mg/L	7.23 ± 1.31	6.11 ± 1.27	8.5 ± 1.41	8.86 ± 1.44	8.27 ± 1.12	5.64	9.52
BOD	mg/L	2.38 ± 0.24	2.37 ± 0.32	2.97 ± 0.41	2.57 ± 0.11	2.92 ± 0.42	1.87	3.52

Total Alkalinity ($CaCO_3^-$)	mg/L	145.14 ± 24.2	111.32 ± 10.5	178.32 ± 25.6	195.11 ± 12.8	219.42 ± 25.2	109.95	242.9
Total hardness ($CaCO_3$)	mg/L	110.12 ± 11.5	131.43 ± 9.32	226.34 ± 32.7	306.62 ± 35.28	309.8 ± 31.5	101.21	158.61
Turbidity	NTU	34.32 ± 4.51	29.41 ± 5.32	32.24 ± 7.54	21.51 ± 4.51	25.21 ± 6.21	24.2	36.85
Electrical conductivity (EC)	µS/m	225.8 ± 8.74	210.47 ± 9.65	221.21 ± 12.35	205.5 ± 18.54	201.7 ± 17.41	185.71	248.91
Total dissolved solids (TDS)	mg/L	227.08 ± 15.2	221.68 ± 18.4	344.83 ± 21.4	525.31 ± 34.7	598.65 ± 35.5	208.29	632.1
Calcium (Ca^{2+})	mg/L	19.25 ± 4.82	19.36 ± 5.54	18.11 ± 4.32	15.58 ± 3.67	17.36 ± 4.51	15.37	22.65
Magnesium (Mg^{2+})	mg/L	85.32 ± 6.27	80.65 ± 6.89	88.69 ± 7.27	57.3 ± 5.74	61.41 ± 6.32	55.4	99.58
Sodium (Na^+)	mg/L	78.21 ± 4.74	69.14 ± 5.47	72.41 ± 6.85	54.24 ± 7.32	65.31 ± 5.74	42.32	95.47
Potassium (K^+)	mg/L	1.54 ± 0.22	1.21 ± 0.09	1.25 ± 0.23	0.58 ± 0.81	0.98 ± 0.05	0.5	2.05
Chlorides (Cl^-)	mg/L	113.25 ± 9.32	102.45 ± 7.32	175.43 ± 8.64	190.14 ± 12.95	252.54 ± 13.74	100.37	378.52
Fluoride (as F^-)	mg/L	0.92 ± 0.32	0.76 ± 0.08	1.13 ± 0.08	1.37 ± 0.074	1.71 ± 0.121	0.71	2.1
Ferrous iron (Fe^{2+})	mg/L	0.13 ± 0.02	0.1 ± 0.002	0.26 ± 0.03	0.41 ± 0.04	0.67 ± 0.07	0.09	0.78
Water Quality Index (WQI)		74.45	70.97	99.79	121.61	135.98	61.78	147.45

Results

The present study was an attempt to investigate the impacts of human interactions and activities on water quality. A complex presumption was taken into consideration that the changing land use phenomena due to human intervention may responsible for deteriorating the quality of the water in the upper course of the river Ganges. For the same water, samples were collected to test the physico-chemical properties at predefined stations by considering places where minimal and maximal degrees of human intervention can be observed, including construction, tourism, deforestation, and cultivation. GIS techniques were used to prepare land use mapping and change detection to perform a spatial correlation with water quality index. The results revealed that out of the five selected sampled sites, three (sites 3, 4, and 5) were under human effects, and high degrees of human engagement in land modification such road construction, habitation, religious gatherins, deforestation and cultivation imposed maximal pressure on the river water directly or indirectly, resulting in the water quality also being found to be in poor to very poor condition. The spatial autocorrelation also exhibited a highly positive correlation, with a value of 0.8455. The present investigation also evidenced that temporary changes in land use and human interaction with the natural system have a great impact on surface water quality, resulting in deterioration of the water quality index, making water unfit for irrigation and other uses.[11,12]

Our study findings demonstrate that spatial and temporal investigation using GIS and multivariate statistical techniques could offer an overview of the relationship between land use and water quality. Our study findings also show that GIS has great efficacy for the correlation and analysis of spatial relationships from small to large scale. It is evidenced that public interventions play a great role in changing land features, as well as surface water quality. Therefore, it is of keen interest to plan some management strategies that could serve as remedial measures with respect to the pollution levels in the upper Ganges River, making the water of an acceptable standard for drinking and other uses.[13,14]

Conclusions

The following suggestions could be effective in this regard:

1. Site-based water quality analysis in our study indicates that agricultural land use and human gatherings for religious purposes affect water quality. Therefore, water restoration in critical areas should be employed to improve the quality.
2. Deforestation should be strictly restricted and the local community should be engaged in preserving the forest, which could improve the nutrient composition in the water and enrich the overall quality of the water.[15,16]

3. The major pollutants in the river in the study area are derived from human waste and agricultural effluent. Therefore, it is essential to develop effective sewage conveyance systems and efficient water treatment plants in affected and critical areas.[17,18]
4. Large human gatherings and bathing are the main issues at Rishikesh (site 3) and Haridwar (site 4), due to religious practices. Therefore, Government measures should be implemented to reduce the public interventions in the water.
5. Last but not least, more public concern, awareness and active participation should require at the local level to save the water and enrich the quality of life.[19,20]

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