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Journal of Advanced Scientific Research

Available online through http://www.sciensage.info/jasr

ISSN
0976-9595
Research Article

WATER QUALITY ASSESSMENT OF GANGA CANAL SYSTEM

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ABSTRACT

Canal system is one of major requirement of modern civilization for the sustainable utilization of water in river basins. Ganga canal is one such example of canal system created on River Ganga Basin in India; originate at Bhimgoda Barrage, Haridwar. Current study is focused on Ganga canal to assess the physico-chemical parameters during 2011 – 2012 at Haridwar (Uttarakhand) with Bhimgoda Barrage (Site 1 -Control Site) and Bahadrabad (Site 2 – sampling site). During investigation maximum Turbidity (233.8 ±104.60 JTU), Total Solids (933.00 ±216.44 mgl^{-1}) and minimum Velocity (0.93 ±0.355 ms^{-1}), Free CO_2 (1.85 ±0.14 mgl^{-1}) and Transparency (0.22 ±0.15 m) were recorded in monsoon season at site 2. While maximum pH (8.1 ± 0.1), Total Hardness (84.38 ±4.65 mgl^{-1}) and Dissolved Oxygen (8.64 ± 1.02 mgl^{-1}) were recorded in summer season at Site 2 in comparison with Site 1. The mean values of these parameters were compared with WHO and ISI standards and found significant differences ($p<0.05$) in the mean values of Turbidity, Total solids (TS), pH, Dissolved Oxygen (DO), Free CO_2 and Total Hardness (TH) with sampling Sites. The Turbidity of both the Site 1 and 2 was recorded above the permissible limit, but higher at site 2 in comparison to Site 1. The values of the studied parameters were more during rainy season and summer season at Site 2 as compared with Site 1. The results indicated that most of the physico-chemical parameters from Ganga canal system were within or at margin in comparison to permissible limit of ISI and WHO for drinking water and therefore, may be suitable for domestic purposes, but it require noticeable consideration due to extreme changes in climate and increase in pollution.

Keywords: Water quality, Ganga Canal, Haridwar, Physico-Chemical characteristics

1. INTRODUCTION

Water is very essential to all forms of lives from very micro-organisms to very complex systems of plants, animals and human being. Its purity varies from place to place in nature. Today pollution is one of the biggest problems of water quality degradation in the River Ganga and its tributaries increasing from year to year due to the increase pollutant loads particularly from commercial and domestic sources, sewage discharge and industrial effluent [1, 2]. The quality of water is not only essential for the survival of mankind but also it is directly or indirectly linked with human welfare, culture and economy [3]. But unfortunately freshwater has become a meagre to commodity due to over exploitation and pollution. Growing population and its necessities has lead to the decline of surface and subsurface water quality. The importance of water to get a good quality/quantity crop growth is very well known; it is one of the prime requirements for agricultural practices about which farmers have always been concerned. India is a land of farmers and agriculture is the foundation of Indian economy [4]. 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 [5]. 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 [6]. To determine the impact of these activities, Ganga Canal water quality at two sites at Bhimgoda Barrage and Bahadrabad, Haridwar has been analyzed for various physico-chemical pollutants. The present study deals with the Ganga Canal of River Ganga in Haridwar. This canal system irrigates the Doab region lying between River Ganga and River Yamuna in India.

2. MATERIAL AND METHOD

2.1. Study Area

The present study has been carried out in Haridwar to examine pollution status of Ganga canal, located in newly carved state of Uttarakhand. Water samples were taken from two locations in Haridwar. The sampling locations are depicted in Fig. 1. Site 1 (Bhimgoda barrage), is control site for the study. Bhimgoda Barrage is situated at Har Ki Pauri, Haridwar on the river Ganga. The primary purpose for the barrage is irrigation but it also serves to provide water for hydroelectric power production and control floods. The area behind the barrage is known as the Neel Dhara

Bird Sanctuary and is a popular destination for various water birds and tourists. Next site 2 is Bahadrabad, a place few meters before the barrage (this barrage feed water to a power plant situated in Bahadrabad) and because of this water flow at this sampling site is slow relative to other sampling sites here. Human activity like bathing and cleaning is very common phenomenon at this site. This site is at a distance of 17.5 KM from Bhimgoda Barrage. Here, the floor of the canal is sandy and depth is not so high.

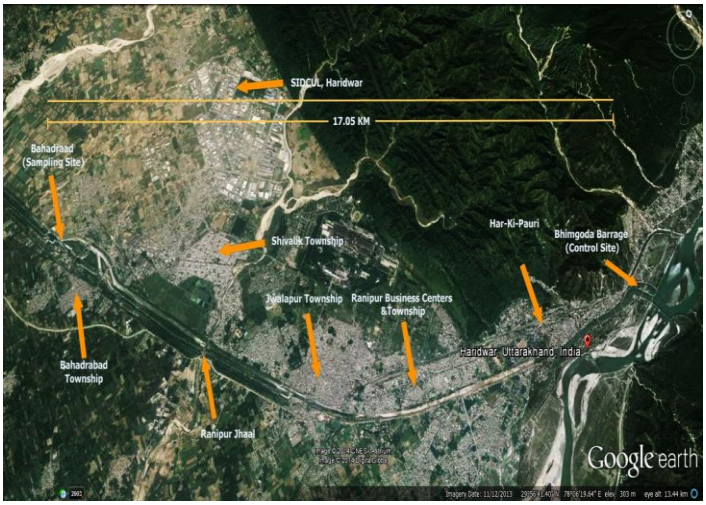

Fig. 1: Map showing the view of Bhimgoda Barrage (Site 1- control Site) and (Site 2 - Bahadrabad)

2.2. Locations

Bhimgoda Barrage (Control Site) (29^0 57' 26.66" N - 78^0 10' 33.84" E), is just 1 KM from the world famous Hindu Pilgrimage Har – Ki – Pauri. It is the point where the Ganga Canal System originates.

Bahadrabad (29^0 54' 36.30" N - 78^0 01' 58.48" E), 500 meters from the barrage towards Govindpur Road activities like discharge of sewage, bathing and cleaning is very common phenomenon. At this point water flows after crossing the various point and non-point pollution sources from Haridwar city and outer areas. This site is at a distance of 17.5 KM from Bhimgoda Barrage.

2.3. Sampling and Analysis

Field sampling was carried out seasonally 2011-2012. Given the fact that water quality of the Ganga canal had been strongly influenced by discharge of sewage from various locations, bathing and cloth washing activities, discharge of industrial effluent and commercial waste water was regarded as the primary principle to choose certain sampling sites. Sampling was done in three different seasons viz. winter, summer and monsoon for the period of one year from 2011 to Oct 2012. Water samples were collected using a clean plastic bucket, transferred to clean plastic bottles and transported to the laboratory on ice and stored in a deep freezer (-20°C) till analysis. Samples were collected in triplicate from each site and average value for each parameter was reported. The physical parameters like pH, Temperature, DO, Transparency, Velocity, and Free CO_2 are recorded on the spot and other chemical parameters like Turbidity, TS, and TH are recorded in the Laboratory which were determined using standard methods [7]. Data obtained subjected to statistical analysis, while developing correlation between parameters by using Karl Pearsons coefficient of correlation for data analysis of Ganga canal water quality to measure the variations between Site 1 and Site 2 parameters.

2.4. Statistical Analysis

In statistical analysis, a correlation developed between parameters by using Karl Pearsons coefficient of correlation for data analysis of Ganga river water to measure the variations between Site I and Site II parameters. MS Excel, 2000 was used to measure the Mean and Standard deviation (SD) of the data.

3. RESULTS AND DISCUSSION

The physico-chemical characteristics of Site 1 (Bhimgoda Barrage) control Site and Site 2 (Bahadrabad) sampling sites are appended in Table1 and Fig. (1-3). The water quality analysis of Ganga canal showed that Site 2 was highly polluted because of the incursion of sewage, industrial effluent, commercial and domestic wastes in comparison to Site 1.

3.1. Temperature

The most common physical assessment of water quality is the measurement of temperature. Temperature impacts both the chemical and biological characteristics of surface water. Temperature is known to influence the pH, alkalinity and DO concentration in the water [8]. In present study the mean maximum temperature (19.67 ±3.22) of Ganga River was recorded at Site 2 in summer season as compared with Site 1 (Fig. 2). Maximum values of temperature might be due increasing rates of pollution and wastewater discharged at Site 2. During a study [9] reported water temperature of river Ganga at Gazipur ranged from a minimum of 17 ± 0.55°C at site- I in January 2006 to a maximum of 33.90 ± 0.58°C at site - III in the month of June 2006. Seasonally the values were highest in summer season followed by rainy and winter season.

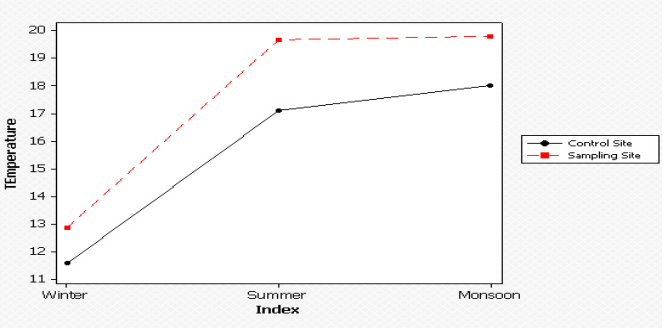

Fig. 2: Seasonal variation of temperature between control site and sampling site.

3.2. Turbidity

The Turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as lay or slit, finely divided organic matter, plankton and other microscopic organisms. Turbidity of water is an important parameter, which influences the light penetration inside water and thus affects the aquatic life [10, 11]. During the present study maximum turbidity was recorded with Site 2 (233.8 ±104.60 JTU) in monsoon season as compared with Site 1, while minimum turbidity was observed in winter season (Table 1).

3.3. Transparency

Transparency is a measure of how clear the water is. It is important, because aquatic plants need sunlight for Photosynthesis. The clearer the water, the deeper sunlight will penetrate. Transparency has direct bearing on the light penetration of water and depends upon suspended matter and dissolved colored substances [12]. In the present study lowest mean value of transparency was recorded (0.22 ±0.15m) with Site 2 in monsoon season as compared with Site 1. The lower transparency at Site 2 is due to higher pollution load. The higher values were exhibited during winter and summer months, whereas lower values were found in monsoon season (Fig. 3).

Highest values was 47cm at bathing ghat of Sapt rishi during IIIrd Royal Bath, while the lowest value 14cm was found at the bathing ghat of Prem Nagar during fourth Royal bath at Haridwar [13]. Overall lowest and highest mean values of transparency were observed 1.0cm and 45.7cm in the month of August and January at the Site 2 and Site 1, respectively of Sahashtradhara stream [14]. The study reveals that a relative comparison in transparency showed comprehensive variation in water quality. The maximum transparency was found at the Site 1 during month of January and at Site 2 transparency relatively low due to the touristic activities.

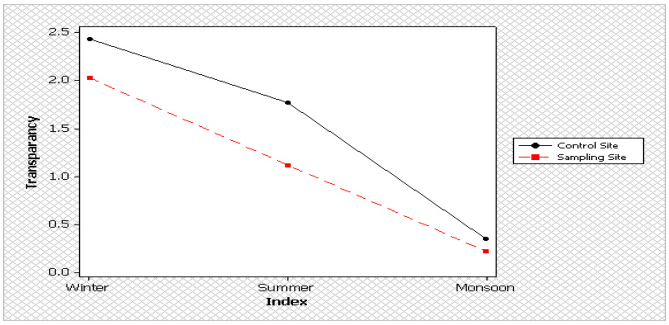

Fig. 3: Seasonal variation of transparency between control site and sampling site

3.4. Velocity

The velocity was found to be directly proportional to the flood level and also with gradient of the river stretch. The water level and its velocity started increasing from winter season onwards due to melting of snow at the place of origin of the river. Flow can affect the river's ability to assimilate pollutants; larger, swiftly-moving streams and rivers can receive pollutants with a diminished negative effect. Smaller rivers with low flow have less of a capacity to dilute and degrade potentially harmful pollutants [15].

During the present study the maximum mean velocity of River Ganga at Site 2 was recorded to be (1.72 ±0.557ms^{-1}) in monsoon season as compared with Site 1. Maximum velocity of River Ganga was observed in monsoon season at both the sites, but lower velocity was observed at Site 2 in comparison to Site 1 (Fig. 4). This might be due to climatic conditions in which water level and its velocity started increasing from winter season onwards due to melting of snow at the place of origin of the river. The maximum of velocity was 2.18 m/s at Ganga in Haridwar, recorded in monsoon season and the minimum velocity 0.39m/s was observed in winter season [16].

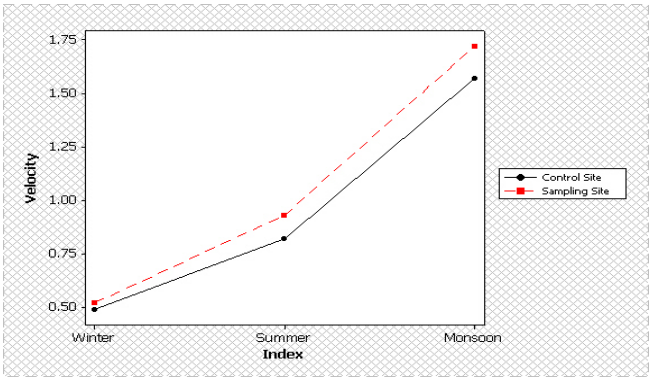

Fig. 4: Seasonal variation of velocity between control site and sampling site.

3.5. Total solid

Total solids (TS) means the total amount total suspended solids (TSS) and total dissolved solids (TDS) in particular sample. The TS are composed of carbonates, bicarbonates, chlorides, phosphates, calcium, magnesium, sodium, potassium, manganese, organic matter, salts and other particles. The effect of presence of TS is due to silt and organic matter [17]. In the present study maximum TS (933.00 ±216.44 mgl^{-1}) was recorded at Site 2 in monsoon season as compared with Site1 (Table 1). Higher values of TS were recorded in monsoon season at Site 2 reflects more pollution due to discharge of whole city sewage at this site. Maximum TS (336.86 ± 149.53 mgl^{-1}) in water quality of Ganga river water recorded at Haridwar in monsoon season than summer and winter seasons [18].

3.6. pH

pH is considered an important chemical parameter that determines the suitability of water for various purposes. pH of water important for the biotic communities because most of the aquatic organism are adapted to an average pH. Optimal pH range for sustainable aquatic life is pH 6.5-8.2. pH of an

aquatic system is an important indicator of the water quality and the extent pollution in the watershed areas [19, 20].

During the present study the overall highest mean value of pH were observed (8.1 ± 0.1) at Site 2 in comparison to Site 1. There was not much fluctuation recorded in pH values (Table 1). The highest pH was recorded in the summer seasons than winter and rainy seasons. Higher value of pH in summer season may be due to influx of sewage effluents disposal and low level of water. Recent studies done by Joshi et al. 2009 reported the pH of the Ganga River at Haridwar was slightly alkaline ranged from 7.06 to 8.35.

Table1. Physico-chemical parameters of Ganga river water at Site-I (Bhimgoda barrage) and Site-II (Bahadrabad)

Seasons	PHYSICO-CHEMICAL PARAMETERS OF BHIMGODA BARRAGE (CONTROL SITE) SITE-1					
	TURBIDITY (JTU)	TS (mgl^{-1})	pH	DO (mgl^{-1})	F.CO_2 (mgl^{-1})	TH(mgl^{-1})
Winter	18.91 ±18.52	151.17 ±12.26	7.78 ± 0.17	10.74± 0.42	0.95 ± 0.07	58.02± 5.44
Summer	35.79 ±26.26	189.89 ±51.04	7.63 ± 0.06	9.73 ± 0.52	1.36 ± 0.15	62.27± 4.85
Monsoon	164.31 ±63.30	502.128±250.47	7.5 ±0.16	8.53 ± 0.43	1.48 ± 0.17	75.8 ± 6.20
Seasons	PHYSICO-CHEMICAL PARAMETERS OF BHADARABAD SITE-2					
	TURBIDITY (JTU)	TS (mgl^{-1})	pH	DO (mgl^{-1})	F.CO_2 (mgl^{-1})	TH(mgl^{-1})
Winter	23.98 ±24.09	162 ±16.07	7.9 ± 0.14	10.08 ± 0.731	1.12 ±0.07	64.71 ±1.70
Summer	47.31 ±32.02	213.5 ±28.52	8.1 ± 0.1	8.64 ± 1.02	1.72 ±0.21	69.91 ±1.68
Monsoon	233.8 ±104.60	933.00 ±216.44	7.76 ± 0.18	7.89 ±0.46	1.85 ±0.14	84.38 ±4.65
IS	10	-	6.0-9.0	3	-	300-600
WHO	05	-	6.5-9.2	6	0.5-2.0	500

Table 2. Correlation coefficients (r) of physico-chemical parameters of Ganga river water at Site-I (Bhimgoda barrage)

	Turbidity	TS	pH	DO	F.CO_2	TH
Turbidity	1.000					
TS	0.984	1.000				
pH	-0.897	-0.894	1.000			
DO	-0.933	-0.931	0.996	1.000		
F.CO_2	0.750	0.746	-0.965	-0.937	1.000	
TH	0.992	0.992	-0.945	-0.971	0.826	1.000

Table 3. Correlation coefficients (r) of physico chemical parameters of Ganga river water at Site-II (Bahadarabad)

	Turbidity	TS	pH	DO	F.CO_2	TH
Turbidity	1.000					
TS	0.999	1.000				
pH	-0.747	-0.774	1.000			
DO	-0.824	-0.800	0.240	1.000		
F.CO_2	0.712	0.682	-0.066	-0.985	1.000	
TH	0.988	0.980	-0.635	-0.902	0.813	1.000

3.7. Dissolved Oxygen

Dissolved Oxygen is one of the important parameter in water quality assessment. Its presence is essential to maintain variety of forms of life in the water and the effect of waste discharge in a water body are largely determined by the oxygen balance of the system. It can be rapidly removed from the wastewaters by discharge of the oxygen demanding waste. Inorganic reducing agents such as H2S, ammonia, nitrite, ferrous iron and certain oxidizable substances also tend to decrease dissolved oxygen in the water [21, 22].

In the present study DO reduces during the summer season as compared to winter and monsoon months it may be due to higher temperature, oxygen demanding wastes, inorganic reductant and seasonal variation. In the present study the overall lowest and highest mean value of dissolved oxygen was observed (7.70 mgl^{-1}± 0.23) at Site 2 in comparison to Site 1. The lowest value at Site 2 indicates load of pollution in comparison to Site 1 (Table 1). Ganga water contained highest dissolved oxygen during winter season, followed by a gradual decrease to its lowest values during monsoon season [23]. The higher concentrations of DO were recorded during winter season mainly due to low turbidity and

increased photosynthetic activity of the green algae found on the submerged stones and pebbles. The maximum 12.10 mg/L oxygen content of water was recorded in winter season (Jan 2007) at site 3 and minimum 7.14 mg/L at site 2 during monsoon season (July 2008)

3.8. Free CO_2

Carbon dioxide is vital in the life of plants and microorganisms. It is produced due to respiration of aquatic organisms. Free CO_2 in the present study was recorded maximum (1.85 $\pm$0.14 mgl^{-1}) at Site 2 in comparison to Site 1. The lower values of Free CO_2 were observed in winter season and higher values were recorded in monsoon and summer season at Site 2 (Table 1). The increase in carbon dioxide level during these months may be due to decay and decomposition of organic matter due the addition of large amount of sewage, which was the main causal factor for increase in carbon dioxide in the water bodies.

Free CO_2 in the Ganga water was invariably present throughout the year [23]. The Free CO_2 was found to be maximum range (1.85-2.01 mgl^{-1} in monsoon season and minimum during winter season.

3.9. Total Hardness

The hardness of water is not a pollution indicator parameter but indicates water quality mainly in terms of Ca^{2+} and Mg^{2+}, bicarbonate, sulphates, chloride, and nitrates. Water with less than 75 mg^{-1} of CaCO3 is considered soft and above 75 mg^{-1} of $CaCO_3$ as hard [8, 24]. It is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies [25]. In the present study maximum TH (84.38 $\pm$4.65 mgl^{-1}) was recorded in monsoon season at Site 2 in comparison to Site 1 (Table 1). This was in accordance with the results who reported that seasonal behaviors of TH were more or less similar at all the sites [24]. It was lowest at Site 1 (90 ppm) in summer season and even highest at site 1 (200 ppm) in winter and monsoon of Ganga River water at Bhagalpur (Bihar), India respectively. This was due to result from poor dilution owing to low precipitation rate.

TH of four different Sites of the River Ganga in Haridwar city (Site 1: Harkipauri, Site 2: Birla ghat, Site 3: Mayapur and Site 4: Singhdwar) for a period of 1 year. The maximum (163.52 mg^{-1}) hardness of water was recorded at second Site and the minimum (60.00 mg^{-1}) in comparison to other three sites [26].

3.10. Correlation (r) between different parameters

In the present study the correlation coefficient (r) between every parameter for Site 1 and Site 2 is shown in Table 2 and 3 in the form of correlation matrix. Correlation coefficient (r) between any two parameters x & y is calculated for parameter such as pH, turbidity, TH, DO, Free CO_2 and TS for Ganga River water. The Ganga river water turbidity has been found to show positive correlations with TS, Free CO_2 and TH, TS have positive correlations with Free CO_2 and TH, pH showed positive correlation with DO and F.CO_2 have positive correlation with TH at both the Site I and II. There is a strong positive correlation (r=0.984/0.999) between turbidity/TS and (r=0.992/0.988) between Turbidity/TH and at Site 1/Site 2. There was also observed significant ($p < 0.05$) positive correlation (r=0.826/0.813) between Free CO_2 and TH at both Site I and II. TS and DO showed a highly significant ($p > 0.05$) negative correlation with F.CO2/TH (r=−0.937/-0.971) at Site I and (r=−0.985/0.902) at Site II.

4. CONCLUSION

Haridwar is known as "Holy Place" as it is famous for pligrimage. The main source of Ganga riverwater contamination is from domestic, human & industrial. The quality of water is depleting rapidly withthe change in human life style *i.e.*, massive industrialization, construction activities, utilization of agricultural land and forest land for other developmental purposes. It was concluded that the water quality of River Ganga is not satisfactory. High turbidity and TS can significantly reduce the aesthetic quality of Ganga River water, having a harmful impact on recreation and tourism. It can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function. Keeping in mind increasing urbanization and pollution loading of rivers, necessary measures should be taken to reduce future contamination loads from entering the river. The study establishes that sewerage, solid and liquid waste contaminants or organic nature are the prime sources of pollution. The analysis report clearly indicates that the water after treatment can be reused in irrigation. Results also indicate that Ganga River with such overloaded situation cannot sustain any further sewage discharge. If proper alternative arrangements like sewage treatment before discharge are not made then the situation may be alarming to the inhabitants in the study area and to the downstream as well. Hence regular water quality monitoring and strict law enforcement is desirable to develop a strategy to control the environmental hazards due to these elements and to recover environmental security of River Ganga.

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