

Pollution Assessment of a Segment of River Ganga in Uttarakhand

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Abstract: *The chemical and physical parameters of the river Ganga segment were observed in the present study. The segment of Uttarakhand in which river Ganga flows is taken as study area from Devprayag (Tehri Garhwal) to Har Ki Pauri (Haridwar). A total of 10 locations were selected and water samples were taken during winter season (February) and summer season (June). During the study it was noticed that the taste of the samples of both the months is agreeable and the odor of the samples of both the months is unobjectionable. In the month of February, the samples are clear whereas in the month of June, the samples are brown colored. In the month of February, the pH of the samples is falling within the desirable limit whereas in the month of June, it is not falling within the desirable limit. In both the months, electrical conductivity (EC) is falling within the desirable limit as prescribed by the World Health Organization.*

Keywords: Pollution, Ganga, River

1. Introduction

The Ganga basin accounts for a little more than one-fourth (26.3%) of the country's total geographical area and is the largest river basin in India, covering the entire states like Uttarakhand, Uttar Pradesh, Bihar, Delhi, and parts of Punjab, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh and West Bengal. The Ganga basin is bound in the north by the Himalayas and in the South by the Vindhyas. The main river stream (Fig. 1) originates in the Garhwal Himalaya (30°55'N, 79°07'E) under the name of the Bhagirathi. The ice-cave of Gaumukh at the snout of the Gangotri glacier, 4100 meters above sea level, is recognized as the traditional source of river Ganga. The river cuts its path through the Himalayas and flows a distance of about 205 km from Gaumukh and transverses through two districts of Uttarakhand state i.e. Uttarkashi and Tehri-Garhwal to reach Devprayag where another head stream, the Alaknanda, joins it to form Holy Ganga. The river Alaknanda is a major tributary of the river Ganga at Uttarakhand that begins at the confluence of the Satopanth and Bhagirath Kharak glaciers in Uttarakhand. The river Alaknanda meets Dhaul Ganga at Vishnuprayag, Nadakini at Nandaprayag, Pindar Ganga at Karnaprayag, Mandakini at Rudraprayag, flowing approximately a total length of 190 km before meeting Bhagirathi at Devprayag. These five confluences are called the PanchPrayag (Fig.2).

About ten percent of the rural and urban populations do not have access to regular safe drinking water and much more are vulnerable. Most of them depend on unsafe water sources to fulfill their daily desires. Several researchers have carried out studies on the water quality of rivers and streams. Kaushik (1963) carried a survey to analyze the water quality parameters by taking water from 100 wells located in Delhi. It was observed that total alkalinity was varied between 130 to 740 mg/l and also the concentration of nitrate, Sulfate and chloride were found between 23 to 457 ppm, 3.5 to 760 ppm and 12 to 1280 ppm. Singh and Sekhon (1976) analyzed 57 water samples located near a village in Ludhiana and Hoshiarpur district of Punjab in June and September month. The water sample was analyzed for nitrate concentration and

was found that 90% of the water samples have nitrate concentration less than 45 mg/l. Kumar (1983) performed a survey of several wells located in some parts of Uttar Pradesh for nitrate concentration and it was analyzed that the wells located in Badshapur, Mirzapur, Bangarmau, Birrdha have nitrate value more than 200 mg/l. The higher value of NO₃ was due to excessive use of nitrogen fertilizer. Srivastava *et al.* (1988) conducted a study by taking the sample of Sone River and checked collected samples. Mondal *et al.* (2005) studied untreated industrial effluent which when discharged to the surface caused groundwater pollution to very large extent in the rural part of the country. Choudhary *et al.* (2011) analyzed samples from Kerwa dam, Kolar dam and Kaliasote dam of Bhopal and found that all water quality parameters except hardness and COD of all the samples were within the permissible limit as described in water quality guidelines of WHO. Rao *et al.* (2011) collected sample from different locations near Tirupati Andhra Pradesh, they analyzed physicochemical parameters like pH, hardness, alkalinity, iron, calcium, nitrates, TS, TDS, TSS, DO, COD and BOD. Bajpayee *et al.* (2012) carried out study by taking 58 samples during pre and post monsoon season from Bankura District, west Bengal, India. It was seen from this study, the total dissolved solids and electric conductivity are physiochemical water quality parameters. Khawaja and Aggarwal (2012) collected 40 water samples from well in Aligarh city 20 water quality parameters and found the water is not suitable for domestic uses. Keeping the above factors in view the study was undertaken to analyze physicochemical water quality of river Ganga segment in Uttarakhand

2. Methodology

The river water samples were collected from ten places located between Devprayag (Tehri-Garhwal) to Har Ki Pauri (Haridwar). Table 1 represents the latitude and longitude of the locations from where the samples were collected. Route of river Ganga in India map is represented in Fig. 1. The major tributaries of river Ganga in Uttarakhand is shown in Fig. 2.

Table 1: Latitude and longitude of the sample collection locations

S. No.	Location	Latitude*	Longitude*
1	Bhagirathi (Devprayag)	30.146	78.597
2	Alaknanda (Devprayag)	30.145	78.598
3	Ghuret	30.139	78.597
4	Kauriyala	30.071	78.501
5	Atali	30.086	78.433
6	Shivpuri	30.136	78.392
7	Patna	30.127	78.353
8	Triveni ghat	30.102	78.299
9	Veerbhadra	30.069	78.286
10	Harki Pauri	29.956	78.170

* In Degree Decimal (DD) format



Figure 1: Route of river Ganga in India map



Figure 2: Major tributaries of river Ganga in Uttarakhand

Clean glass containers of one litre capacity were used to collect samples by grab sampling method from selected locations at either of banks. The samples were analyzed for various physicochemical parameters, namely Potential of Hydrogen (pH), Electrical Conductivity (EC), Total Dissolved Solids (TDS), hardness, calcium, acidity, alkalinity, chloride, carbon dioxide (CO₂) using standard methods (APHA, 1980). Taste, Color, Odor were determined on the spot while collecting the samples whereas the Potential of Hydrogen (pH), Electrical Conductivity

(EC), Total Dissolved Solids (TDS) of water samples were determined in laboratory directly with the help of pH meter, EC meter and TDS meter respectively. The taste of the samples was determined by drinking. The observation of the color of the samples was done visually. The odor of the samples was interpreted by inhaling. For determining Total dissolved Solids (TDS), Electrical Conductivity (EC) and Potential of Hydrogen (pH), digital testers were used by taking a 100 ml of water sample. The chemical analysis of collected samples were performed to estimate total alkalinity, total acidity, total hardness, calcium, chloride, free carbon dioxide (CO₂). The parameters were determined as per standard methods of water analysis specified by American Public Health Association (APHA), American Water Work Association (AWWA) and Water Pollution Control Federation (WPCF).

3. Results and Discussions

The river water samples collected in both the months, i.e. February and June, were analyzed for their physicochemical properties. Indian standard values of various physicochemical parameters, results of the samples collected in month of February and June are presented in Table 1 through Table 3.

Physicochemical Properties

The taste of the samples of both the months is agreeable. The odor of the samples of both the months is unobjectionable. In the month of February, the samples are clear whereas in the month of June, the samples are brown colored.

Table 1: Drinking water standard of BIS (IS 10500: 2012)

S. No.	Parameter	Drinking water quality standard (IS 10500: 2012)	
		Desirable limits	Permissible limits
1	Odor	Unobjectionable	-
2	Taste	Agreeable	-
3	pH	6.5-8.5	No relaxation
4	EC	600*	-
5	TDS	500	2000
6	TH	200	600
7	CaH	75	200
8	MgH	30	100
9	TAI	200	600
10	Cl	250	1000
11	FCO ₂	-	<50*

*World Health Organization (WHO) guidelines for drinking water quality

All values are in ppm except EC in µS/cm, pH in number

Potential of hydrogen (pH)

In the month of February, the pH of the samples varied from 7.4 to 7.6. The minimum observed value of the pH is 7.4 at Triveni ghat and Har ki Pauri whereas the maximum observed value is 7.6 at Bhagirathi (Devprayag), Alaknanda (Devprayag) and Ghuret (Table 2). The pH of the samples is falling within the desirable limit. In the month of June, the pH of the samples varied from 5.9 to 6.4. The minimum observed value of the pH is 5.9 at Triveni ghat whereas the maximum observed value is 6.4 at Alaknanda (Devprayag), Ghuret and Atali. The pH of the samples is not falling within the desirable limit (Table 3).

Electrical conductivity (EC)

In the month of February, the EC of the samples varied from 102 µS/cm to 158 µS/cm (Table 2). The minimum observed value of the EC was 102 µS/cm at Bhagirathi (Devprayag) whereas the maximum observed value is 158 µS/cm at Harki Pauri. In the month of June, the EC of the samples varied from 130 µS/cm to 180 µS/cm (Table 3). The minimum observed value of the EC is 130 µS/cm at Ghuret, Atali and Shivpuri whereas the maximum observed value is 180 µS/cm at Triveni ghat. EC of the samples of both the months is falling within the desirable limit as prescribed by the World Health Organization.

Total dissolved solids (TDS)

In the month of February, the TDS of the samples varied from 61 ppm to 95 ppm (Table 2). The minimum observed value of the TDS is 61 ppm at Bhagirathi (Devprayag) whereas the maximum observed value is 95 ppm at Harki Pauri. In the month of June, the TDS of the samples varied from 64 ppm to 89 ppm (Table 3). The minimum observed value of the TDS is 64 ppm at Shivpuri whereas the maximum observed value is 89 ppm at Triveni ghat. The TDS of the samples of both the months is falling within the desirable limit.

Total hardness (TH)

In the month of February, the total hardness of the samples varied from 67 ppm to 83 ppm. The minimum observed value of the total hardness is 67 ppm at Bhagirathi

(Devprayag) whereas the maximum observed value is 83 ppm at Harki Pauri (Table 2). The total hardness is falling within the desirable limit. In the month of June, the total hardness of the samples varied from 130 ppm to 210 ppm (Table 3). The minimum observed value of the total hardness is 130 ppm at Alaknanda (Devprayag) and Triveni ghat whereas the maximum observed value is 210 ppm at Veerbhadra. The total hardness of the samples is falling within the desirable limit except for Ghuret which is just at the desirable limit and for Veerbhadra which is above the desirable limit but is falling within the permissible limit.

Calcium hardness (CaH)

The main sources of calcium in natural water are various types of rocks, industrial waste and sewage. In the month of February, the calcium hardness of the samples varied from 38.9 ppm to 45 ppm (Table 2). The minimum observed value of calcium hardness is 38.9 ppm at Bhagirathi (Devprayag) whereas the maximum observed value is 45 ppm at Alaknanda (Devprayag). The Ca hardness of the samples is falling within the desirable limit. In the month of June, the calcium hardness of the samples varied from 60.0 ppm to 160.1 ppm. The minimum observed value of calcium hardness is 60.0 ppm at Ghuret whereas the maximum observed value of calcium hardness is 160.1 ppm at Kauriyala (Table 3). The calcium hardness of Ghuret is falling within the desirable limit and for all other places it is within the permissible limit.

Table 2: Physicochemical quality of river water in February

S. No.	Location	EC	pH	TDS	TAc	FCO ₂	Ca	TH	CaH	MgH	Mg	Cl	TAI
1	Bhagirathi (Devprayag)	102	7.6	61	36	2.8	15.6	67.0	38.9	28.0	6.8	5.5	59
2	Alaknanda (Devprayag)	108	7.6	65	25	3.0	18.0	80.0	45.0	35.0	8.5	5.5	71
3	Ghuret	108	7.6	65	20	3.0	16.0	73.0	39.9	33.0	8.0	5.5	63
4	Kauriyala	108	7.5	65	25	3.2	17.0	76.5	42.4	34.0	8.3	5.5	67
5	Atali	115	7.5	69	28	3.4	16.5	74.7	41.2	33.5	8.1	5.6	65
6	Shivpuri	123	7.5	74	30	3.2	16.6	76.3	41.6	34.7	8.4	5.6	66
7	Patna	138	7.5	83	24	3.3	16.8	78.0	42.0	36.0	8.7	5.0	68
8	Triveni Ghat	142	7.4	85	40	4.2	17.2	77.0	43.0	34.0	8.3	5.0	68
9	Veerbhadra	143	7.5	86	13	3.6	17.6	76.0	44.0	32.0	7.8	5.0	68
10	Harki Pauri	158	7.4	95	15	4.2	17.6	83.0	44.0	39.0	9.5	5.5	74

All values are in ppm except EC in µS/cm, pH in number

Table 3: Physicochemical quality of river water in June

S. No.	Location	EC	pH	TDS	TAc	FCO ₂	Ca	TH	CaH	MgH	Mg	Cl	TAI
1	Bhagirathi (Devprayag)	170	6.1	84	72	33.0	32.0	140	80.0	59.9	14.6	18.4	85
2	Alaknanda (Devprayag)	140	6.4	70	57	26.4	36.0	130	90.0	39.9	9.7	15.6	100
3	Ghuret	130	6.4	67	45	26.4	24.0	200	60.0	139.9	34.1	14.2	100
4	Kauriyala	150	6.3	74	47	44.0	64.1	140	160.1	-20.1	-4.9	17.0	100
5	Atali	130	6.4	65	50	6.6	48.1	190	120.1	69.9	17.0	35.5	100
6	Shivpuri	130	6.2	64	65	19.8	48.1	170	120.1	49.9	12.1	15.6	90
7	Patna	140	6.2	67	50	24.2	48.1	170	120.1	49.9	12.1	31.2	105
8	Triveni Ghat	180	5.9	89	87	61.6	48.1	130	120.1	9.9	2.4	21.3	125
9	Veerbhadra	150	6.0	72	25	28.6	56.1	210	140.1	69.8	17.0	25.5	95
10	Harki Pauri	140	6.1	76	30	19.8	48.1	180	120.1	59.9	14.6	14.2	105

All values are in ppm except EC in µS/cm and pH in number

Magnesium Hardness (MgH)

In the month of February, the magnesium hardness of the samples varied from 28.0 ppm to 39 ppm. The minimum observed value of magnesium hardness is 28.0 ppm at Bhagirathi (Devprayag) whereas the maximum observed value is 39 ppm at Harki Pauri (Table 2). The magnesium

hardness of Bhagirathi (Devprayag) is falling within the desirable limit and all other are falling within the permissible limit. In the month of June, the magnesium hardness of the samples varied from -20.1 ppm to 139.9 ppm. The minimum observed value of magnesium hardness is

20.1 ppm at Kauriyala whereas the maximum observed value is 139.9 at Ghuret (Table 3).

Total Acidity (TAc)

In the month of February, the total acidity of the samples varied from 13 ppm to 40 ppm. The minimum observed value of total acidity is 13 ppm at Veerbhadra whereas the maximum observed value is 40 ppm at Triveni ghat (Table 2). In the month of June, the total acidity of the samples varied from 25 ppm to 87 ppm. The minimum observed value of total acidity is 25 ppm at Veerbhadra whereas the maximum observed value is 87 ppm at Triveni ghat (Table 3).

Total Alkalinity (TAI)

In the month of February, the total alkalinity of the samples varied from 59 ppm to 74 ppm (Table 2). The minimum observed value of total alkalinity is 59 ppm at Bhagrathi (Devprayag) whereas the maximum observed value is 74 ppm at Harki Pauri. In the month of June, the total alkalinity of the samples varied from 85 ppm to 125 ppm (Table 3). The minimum observed value of total alkalinity is 85 ppm Bhagrathi (Devprayag) whereas the maximum observed is 125 ppm at Triveni ghat.

Chloride (Cl)

In the month of February, the chloride of the samples varied from 5 ppm to 5.6 ppm. The minimum observed value is 5 ppm at Patna, Triveni ghat and Veerbhadra whereas the maximum observed value is 5.6 ppm was found at Atali, Shivpuri and Balawali (Table 2). In the month of June, the chloride of the samples varied from 14.2 ppm to 35.5 ppm. The minimum observed value is 14.2 ppm at Ghuret and Harki Pauri whereas the maximum observed value is 35.5 ppm at Atali (Table 3). The chloride of the samples of both the months is falling within permissible limit.

Free Carbon dioxide (FCO₂)

In the month of February, the free carbon dioxide of the samples varied from 2.8 ppm to 4.2 ppm. The minimum observed value of free carbon dioxide is 2.8 ppm at Bhagrathi (Devprayag) whereas the maximum observed value is 4.2 ppm at Triveni ghat and Harki Pauri (Table 2). The free carbon of the samples is falling within the permissible limit prescribed by World Health Organization. In the month of June, the free carbon dioxide of samples varied from 6.6 ppm to 61.6 ppm. The minimum observed value of the free carbon dioxide is 6.6 ppm at Atali whereas the maximum observed value is 61.6 ppm at Triveni ghat (Table 3). Except for the Triveni ghat, all other locations are falling within the permissible limit.

4. Summary and Conclusions

River water has become one of the major sources of water to meet the requirements of domestic and irrigation purposes in India due to the easy availability and reliability since a number of dams, reservoirs, etc. are built on it. Water is also used for sanitation and waste disposal and not only for domestic and commercial purposes but also for industrial and irrigation purposes. The impurities are in the form of physical, chemical and biological parameters due to rapid industrialization, overpopulation and indiscriminate use of

chemicals in agriculture field. The major conclusions from the study are:

The taste of the samples of both the months is agreeable. The odor of the samples of both the months is unobjectionable. In the month of February, the samples are clear whereas in the month of June, the samples are brown colored. In the month of February, the pH of the samples is falling within the desirable limit whereas in the month of June, it is not falling within the desirable limit. In both the months, EC is falling within the desirable limit as prescribed by the World Health Organization. In both the months, TDS is falling within the desirable limit. In the month of February, the total hardness is falling within the desirable limit whereas in the month of June, it is falling within the desirable limit except for Ghuret which is falling just at the desirable limit and for Veerbhadra which is above the desirable limit but is falling within the permissible limit. In the month of February, the calcium hardness is falling within the desirable limit whereas in the month of June, it is falling within the desirable limit for Ghuret and for all other; it is falling within the permissible limit. In the month of February, the magnesium hardness of Bhagrathi (Devprayag) is falling within the desirable limit and all other are falling within the permissible limit whereas in the month of June. The total alkalinity in both the months is falling within the desirable limit. The chloride in both the months is falling within permissible limit. In the month of February, the free carbon dioxide is falling within the permissible limit prescribed by World Health Organization whereas in the month of June, except for Triveni ghat, all other locations are falling within the permissible limit.

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