Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2018, 10(7): 145-150

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Assessment of Major Ion Chemistry and Spatial Variation of Water Quality of Ganga River of Uttarakhand, India

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ABSTRACT

The Physicochemical analysis of Ganga river has been carried out at Gangotri (the origin point) to Ganga river at Haridwar district. Water samples have been collected from upstream, midstream and downstream of Ganga river of Uttarakhand. Ionic balance was calculated, the error in the ionic balance for majority of the samples were within 5%.

The abundance of various ions in the sample was in order of HCO3(63.8 mg/l)> Ca (19.2 mg/l) > Mg (5.9 mg/l) Na (3.05 mg/l) > Cl (1.6 mg/l) > K (0.5 mg/l). The pH value were ranged from 6.2 to 7.5 with a mean value of 6.5. The EC were ranged from 89 µs/cm to 485 µs/cm with a mean value of 166.2 µs/cm. The physicochemical parameter of water quality were compared with Bureau of Indian Standard (BIS 2012) and found that all the parameter were under permissible limit of standards (BIS 10500). (Ca+Mg) - (Na+K) values were plotted against HCO3-(Cl+SO4) to characterize the water samples. In most of the samples, the water is Ca-Mg-HCO3 type. The water samples from Gangotri to Loharingapala were of Ca-Mg-Cl-SO4 type.

Hot Spot Matrix have also been calculated for identifying the location of severe water quality deterioration site where immediate control measures are needed to restore and to preserve the water quality. As per trilinear diagram of (Ca+ Mg), Na and K most of the samples falls towards the apex of (Ca + Mg) while in trilinear of HCO3 , Cl and NO3 all the samples falls towards the apex of HCO3 indicating dominance of carbonate weathering in ganga river.

Keywords: Hydrochemistry; Drinking water; Water pollution; Water quality

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INTRODUCTION

Water is one of the valuable natural resources and the quality of water is of vital concern for the mankind since it is directly link with human welfare. Fresh water is necessary for healthy living [1,2]. Industrialization and urbanization causing deterioration of surface and ground water quality in various part of the world. Untreated effluent and municipal solid waste is directly thrown on water catchment area [3-8]. The world is facing problems with a wide variety of pollutants both inorganic and organic in nature. Rivers receive huge quantities of untreated sewage, agricultural runoff (pesticides, fertilizer etc.), street washouts (oil, asphalt, sediment and many types of heavy metals). The characterization of river water quality is a tool to understand the water quality in its catchment area [9,10]. River Ganga is a trans-boundary river of India and Bangladesh [11-15]. It is the largest water resource available to India and due to anthropogenic activities in the Gangetic plain, the Ganga water quality has been severely deteriorated for many years. Water quality of Himalayan Rivers has been steadily deteriorating over several decades due to anthropogenic activities, dumping of treated or untreated effluents, poor structured sewerage and drainage system, etc . [16-20]. The knowledge of hydro-chemistry is essential in order to understand suitability of water for drinking and irrigation purposes and sustainability of water resources for consumption of future generations [21-24] . The study on water quality has been done by various researcher in many places. [25-29]

The water of all these rivers serves as the major source for drinking and irrigation purposes in region of Uttarakhand. Therefore, to restore the vitality and water quality of all these rivers, proper water resource planning programme should be developed.

STUDY AREA

The present study area cover river Ganga from Gangotri to Haridwar of approximate length of 254 Km starting from Gangotri to Bishanpur (Haridwar).

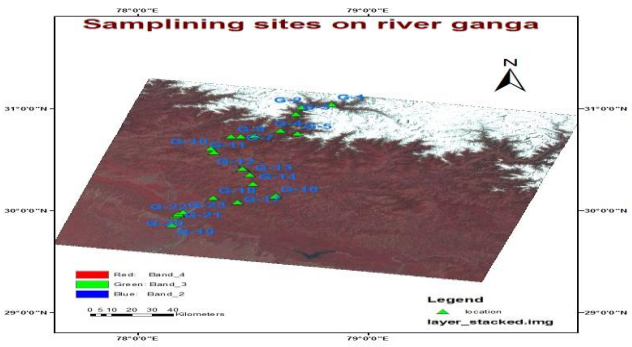

Figure 1. Sampling location at Ganga river Material and Method

MATERIAL AND METHODS

The water quality analysis was performed as per standard method [30] at National Institute of Hydrology, Roorkee laboratory (An ISO 9001-2008 Certified). The pH, conductivity and TDS were analyzed at the sampling locations with the help of pH meter, conductivity meter and TDS meter. The alkalinity, hardness, chloride, calcium and magnesium were by titration methods. Iron was analyzed with the help of UV Spectrophotometer. Ionic balance was calculated, the error in the ionic balance for majority of the samples was within 5%. The sampling location map of Ganga river has been prepared with using SOFTWARE USED-Arc GIS 9.3 and Surfer 9.

RESULT AND DISCUSSION

The physiochemical analysis of various ions are presented in table 1. The pH value in the study area were ranged from 6.2 to 7.5 with a mean value of 6.5 (Table 1). The total dissolve solid (TDS) were ranged from 57mg/l to 311 mg/l with a mean value of 106 mg/l and found under permissible limit of BIS standard (IS 10500) of drinking water quality. The alkalinity were ranged from 33 mg/l to 401 mg/l with a mean value of 63.8 mg/l. The spatial variation of variation of EC, alkalinity, 89mg/l to 485 mg/l with a mean value of 166 mg/l and alkalinity from 33mg/l to 401 mg/l with a mean value of 63.8 (Table 1) mg/l. The spatial variation of EC, alkalinity, hardness and calcium were shown in contour map of river Ganga (Figure 2, 3, 4, and figure 5)[31-33].

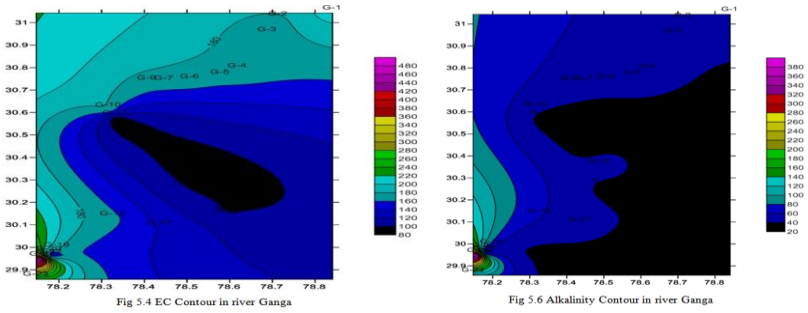

Figure 2. Contour map of river Ganga showing spatial variation

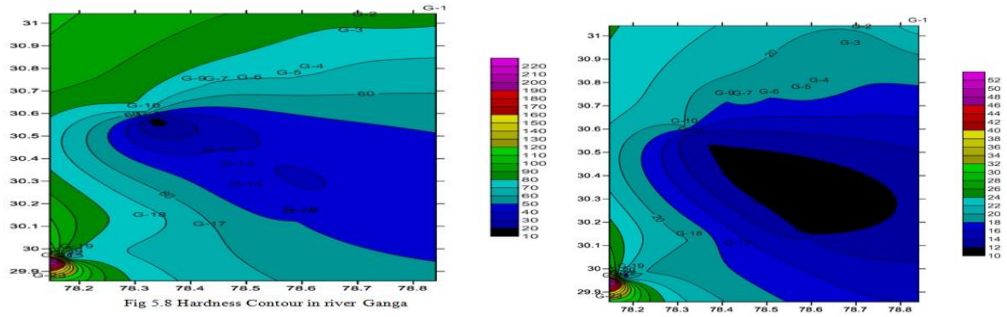

Figure 3. Contour map of river Ganga showing spatial variation of Hardness and Calcium

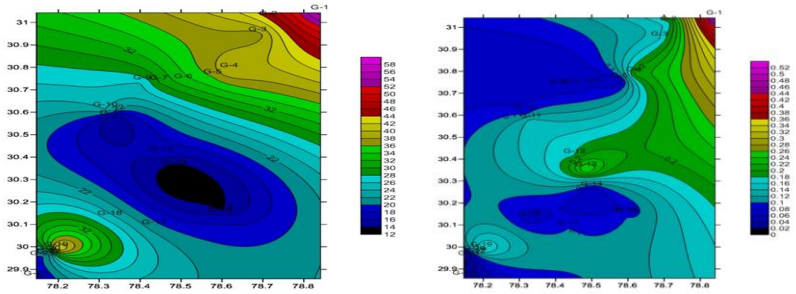

Figure 4. Contour map of river Ganga showing spatial variation of Sulphate and Iron

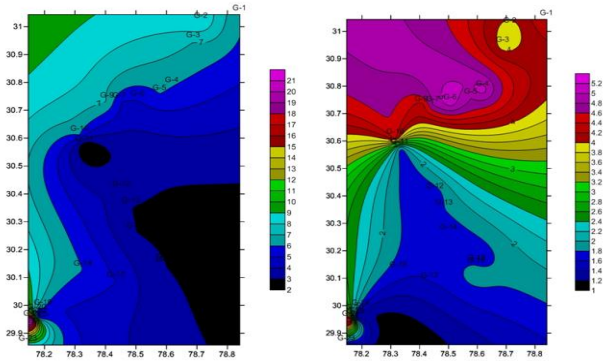

Figure 5. Contour map of river Ganga showing spatial variation of Magnesium and Sodium

(Ca+Mg)-(Na+K) values were plotted against HCO3-(Cl+SO4) to characterize the water samples (Figure 6 Chadda diagram). Most of the samples, the water were of Ca-Mg-HCO3 type. The water samples from Gangotri to Loharingapala were of Ca-Mg-Cl-SO4 type.

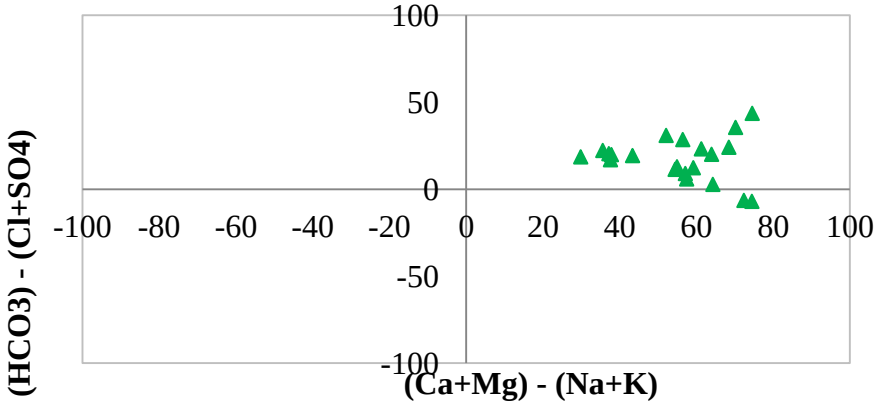

Figure 6. Chaddha Diagram

Hot Spot Matrix is use to identifying that location where water Quality is worst and need immediate control measures to restore and Retreat and Preserve the water Quality again (Table 1). These sites are those sites which are directly affected by any point source of pollution. To restore and preserve water quality of such location need frequent supervision monitoring and continuous surveillance.
In order to restore the water Quality of such location identification of source of pollution is first essential step. Following equation has been used for identifying Hot Spot Matrix.

Priority Number = 10 (LE) +5 (MV) +ME

Where, ME-Mean Value Exceeded, MV-Maximum Value, LE-Limit Exceeded.
Where, 10 and 5 are Weightage factors
The location which got highest Priority number that will be considered as Hot Spot.
Priority Number =Not Applicable, if at least 1 Parameter is not exceeded Limit Value.

Highest Priority number is-32 at G-21 (Khadkhadi) means it is most Sensitive location and required frequent, monitoring (Table 2). Deviation at Khadkhadi may be due to discharge of partially treated sewage into the river Ganga from Jagjeet pur Sewage treatment plant. There is immediate need to increase treatment capacity of the STP by introducing more units. Also care taken to Nallas, which discharge into the river directly although such Nallas are few.
The bicarbonate was found to be most dominant ions (63.8 mg/l) followed by Ca (19.2 mg/l) The abundance of various ions in the study area were in the order of HCO3> Ca (1 > Mg > Na > Cl > K

CONCLUSION

The hydrochemistry of the study area indicated bicarbonate was the most dominant ion followed by calcium, magnesium, sodium, chloride and potassium. All parameter of water quality were under permissible limit of BIS standards (2012). The water samples were of Ca-Mg-HCO3 category in most of the sampling location of Ganga river.

Table 1 : Physicochemical parameter and their comparison with BIS Standard (IS 10500:2012)

SN	Parameter	Range	Mean Value	Required acceptable limit (IS 10500 : 2012)	Permissible limit in absence of alternate source (IS 10500 : 2012)
1	pH	6.2 - 7.5	6.5	6.5 to 8.5	No relaxation
2	EC (µs /cm)	89 - 485	166	NA	
3	TDS (mg/l)	57-311	106.6	500	2000
4	Alkalinity (mg/l)	33-401	63.8	200	600
5	Hardness (mg/l)	14-224	71.7	200	600
6	Cl (mg/l)	0.2 -7.4	1.6	250	1000
7	NO_3 (mg/l)	3.1 -18	7.8	45	No relaxation
8	SO_4 (mg/l)	57 -311	106.6	200	400
9	Na (mg/l)	1.2 - 5.1	3.05	NA	
10	K (mg/l)	0.5 - 2	1.2	NA	
11	Ca (mg/l)	11.1 - 52.1	19.2	75	200
12	Mg (mg/l)	2.1 to 22.2	5.9	30	100
13	Fe (mg/l)	0.02 to 0.05	0.12	0.3	No relaxation

Table 2. Hot Spot Matrix

Location Code	pH.	EC (µs /cm)	Alkalinity (mg/L)	Hardness (mg/L)	Cl (mg/ L)	NO3 (mg/ L)	Na (mg/ L)	K (mg /L)	Ca (mg/ L)	Mg (mg/ L)	Fe (mg /L)	TDS (mg/l)	SO4 (mg/ l)	L E	M E	M V	Priority No
G-1	5.9	ME	51	ME	0.2	7	ME	ME	ME	ME	LE	ME	MV	1	7	1	22
G-2	5.8	ME	43	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	0	11	0	11
G-3	6.2	ME	41	ME	0.8	ME	ME	ME	18	ME	ME	ME	ME	0	9	0	9
G-4	6.2	ME	47	ME	0.8	5.3	MV	ME	ME	ME	ME	ME	ME	0	8	1	13
G-5	ME	ME	47	70	1.4	1.3	ME	ME	ME	ME	0.06	ME	ME	0	8	0	8
G-6	6.4	ME	45	68	0.4	4.8	MV	ME	18	5	0.08	ME	ME	0	4	1	9
G-7	6.6	ME	46	68	ME	6.6	ME	MV	ME	5	0.07	ME	ME	0	6	1	11
G-8	6.7	ME	47	ME	ME	6.6	ME	MV	ME	ME	0.06	ME	ME	0	8	1	13
G-9	6.4	ME	51	ME	1.2	ME	ME	ME	18	ME	0.07	ME	ME	0	8	0	8
G-10	ME	ME	47	ME	2	7	ME	ME	20	ME	0.09	ME	24	0	7	0	7
G-11	ME	89	33	14	0.2	ME	1.7	1.1	12	2	0.15	57	14	0	2	0	2
G-12	ME	96	34	43	0	ME	1.7	1.3	11	4	0.18	61	17	0	2	0	2
G-13	6.4	94	55	41	1.2	3.1	1.8	1.1	11	3	0.27	60	13	0	0	0	0
G-14	ME	100	34	43	1.4	4.8	1.7	1.1	12	3	0.06	64	12	0	1	0	1
G-15	ME	99	35	42	0.4	4	1.6	1	11	3	0.08	63	14	0	1	0	1
G-16	ME	111	38	49	1.2	4.8	2	1	14	3	0.1	71	17	0	1	0	1
G-17	ME	139	52	61	ME	5.7	1.6	0.8	17	5	0.1	ME	21	0	3	0	3
G-18	ME	166	61	ME	ME	11	1.7	0.8	20	ME	0.07	ME	25	0	5	0	5
G-19	ME	ME	ME	ME	ME	MV	1.6	0.7	21	ME	0.19	MV	ME	0	7	2	7
G-2-0	ME	135	52	57	0	4.8	1.7	0.9	16	4	0.1	88	20	0	1	0	1
G-21	MV	MV	LE	MV	MV	5.3	5	0.5	MV	MV	0.02	ME	20	1	2	4	32
G-22	ME	160	47	ME	ME	ME	1.2	0.7	ME	5	0.08	102	20	0	5	0	5
G-23	ME	217	ME	ME	ME	ME	1.4	0.5	ME	ME	0.02	86	17	0	7	0	7
Mean Values	6.2 8888	127. 8181 8	45.3	50.5454 54	0.8	5.47 3333 3	1.9	0.88 461 5	15.6 4285	3.81 8181	0.09 736 8	72.4 4444	18				

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