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Evaluation of Physico-chemical Characteristics of Ganga Canal at Haridwar

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Abstract: Ganga Canal is being used for ritual bathing, washing of clothes, domestic needs and irrigational purposes. These activities are leading to degradation in its water quality day by day and thus, month by month and site by site. In order to assess the monthly and spatial variations, water samples of Ganga Canal from its origin to exit point at Haridwar, Uttarakhand, India were assessed for physico-chemical water quality characteristics. These water samples were collected from five sampling sites namely Bhimgoda Barrage, Haridwar (origin point); Premnagar Ashram Ghat, Haridwar; Pathari Power Plant, Bahadrabad; Rail Bridge, Roorkee and Uttam Sugar Mill Limited, Narsan (exit point). Total 15 water quality characteristics namely pH, EC, TDS, turbidity, total hardness, alkalinity, bicarbonate, chloride, sulphate, nitrate, fluoride, sodium, potassium, calcium and magnesium were analyzed on monthly basis from March, 2014 to August, 2014. The values of turbidity and fluoride in analyzed water samples exceeded their respective permissible limits as per Bureau of Indian Standards (BIS), 2012 specifications. Magnesium was detected more than its desirable limit at three study sites namely S-3, S-4 and S-5. Moreover, the water quality assessment of Ganga Canal was found to be excellent for irrigation purpose with respect to three irrigation water quality parameters viz. Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) and Sodium Percent (Na%). The results emphasized need of regular assessment and proper monitoring of Ganga Canal water for maintaining its water quality and subsequently, health of local population along with millions of tourists and pilgrims at Haridwar.

Key words: Ganga canal, water quality, irrigation water quality, Haridwar.

Introduction

Haridwar has great significance in terms of Ganga River and other religious places for tourists and pilgrims not only from different parts of the country but also from abroad. It helps in generating revenue for the state as well. The Ganga Canal originates from Ganga River at Bhimgoda Barrage, Haridwar and, subsequently, becomes lifeline of Haridwar district for meeting out drinking and irrigational needs. The water of Ganga Canal is also used for mass bathing, offering worship related materials, washing of clothes, etc.

Water quality of a water body basically depends on its physical and chemical characteristics (Kamboj & Aswal, 2015). These water quality characteristics determine its fitness/suitability for different purposes. The characteristics of water constantly change due to anthropogenic and geogenic activities (Canter et al., 1987; Choudhury et al., 2014). Anthropogenic activities have led to deterioration in its water quality by altering

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several physico-chemical parameters. When solid and/or liquid wastes get mixed with aquatic system, it becomes polluted due to change in its composition (Kamboj et al., 2015). In addition, untreated/partially treated domestic and municipal sewages, agricultural run-off, street run-off, etc. getting mixed at different places are also degrading its water quality day by day.

The Ganga basin was comparatively free from anthropocentric activities till 1940 but it became a disposal site for agricultural, industrial and sewage wastes after independence (Singh, 2010). Pace of modernization and increasing industrialization, urbanization, agriculture and other human activities are among serious aspects for causing Ganga Canal water pollution and resulted deterioration in its water quality. Domestic and untreated/partially treated sewage along with industrial wastewater have become constant source of pollution, whereas surface run-off is a seasonal phenomena mainly controlled by climate and rainfall (Singh et al., 2004). Various unwarranted activities viz. toilets within submergence area of Ganga during monsoon season, open defecations, disposal of untreated domestic and municipal liquid wastes, disposal of garbage, etc. also affect its water quality (Bhutiani et al., 2016).

Accelerated activities by humans such as intensive agriculture, urbanization and industrialization contribute to water deterioration (Cachada et al., 2012). Unmanaged discharges of sewage and industrial effluents, regular practice of washing of clothes and bathing in Ganges causes deterioration in their ecology and water quality (Matta et al., 2015). A study by Bhutiani et al. (2015) reported that spirituality of Ganga water has been endangered due to unregulated human activities viz. discharges of domestic sewage, untreated/partially treated municipal discharge and industrial wastes, disposal of dead bodies, soil erosion, deforestation, excessive use of fertilizers and pesticides, unplanned and unmanaged use of agricultural land practices, ritual bathing during Ardh Kumbh, Maha Kumbh, pilgrimage, etc. In addition, cultural and religious tourism on the banks of Ganga along with heavy influx of tourists and river rafting activities have been one of the significant causes of changes in its water quality (Farooquee et al., 2008).

The literature survey on Ganga Canal water quality inferred that none of the study has been undertaken for various physico-chemical parameters at five significant locations along the stretch from its origin to exit in Uttarakhand.

Therefore, present study of evaluation of Ganga Canal water in Haridwar was undertaken with the objective to determine the updated factors responsible for changes in its water quality. Besides, keeping in view of non-availability of water quality data regarding suitability of Ganga Canal water from origin of Ganga Canal to its exit in Uttarakhand state for irrigation purpose has also been evaluated and presented in the paper.

Materials and Methods

Study Area

The collection of water samples was carried out on temporal basis from five different sites viz. Bhimgoda Barrage, Haridwar (origin point); Premnagar Ashram, Haridwar; Pathari Power Plant, Bahadrabad; Rail Bridge, Roorkee and Uttam Sugar Mill Ltd., Narsan (exit point) of Ganga Canal in Uttarakhand state of India for a period of six months from March, 2014 to August, 2014. The details of all the sampling sites along with their co-ordinates and elevation above mean sea level (MSL) are given in Table 1. The study area map is depicted under Figure 1.

Table 1: Sampling sites of Ganga Canal, Haridwar along with their co-ordinates and elevation above mean sea level (MSL)

S.N.	*Name of sampling sites*	*Sampling sites code*	*Latitude/Longitude*	*Elevation above MSL (m)*
1.	Bhimgoda Barrage, Haridwar	S-1	N 29º 60′ 25.9″/E 08° 14′ 28.1″	275
2.	Premnagar Ashram Ghat, Haridwar	S-2	N 29º 55′ 48.8″/E 78º 08′ 10.3″	266
3.	Pathari Power Plant, Bahadrabad	S-3	N 29º 55′ 41.5″/E 78º 02′ 24.7″	240
4.	Rail Bridge, Roorkee	S-4	N 29° 50′ 59.4″/E 77° 52′ 49.0″	244
5.	Uttam Sugar Mill Limited, Narsan	S-5	N 29° 44′ 00.7″/E 77° 51′ 30.9″	242

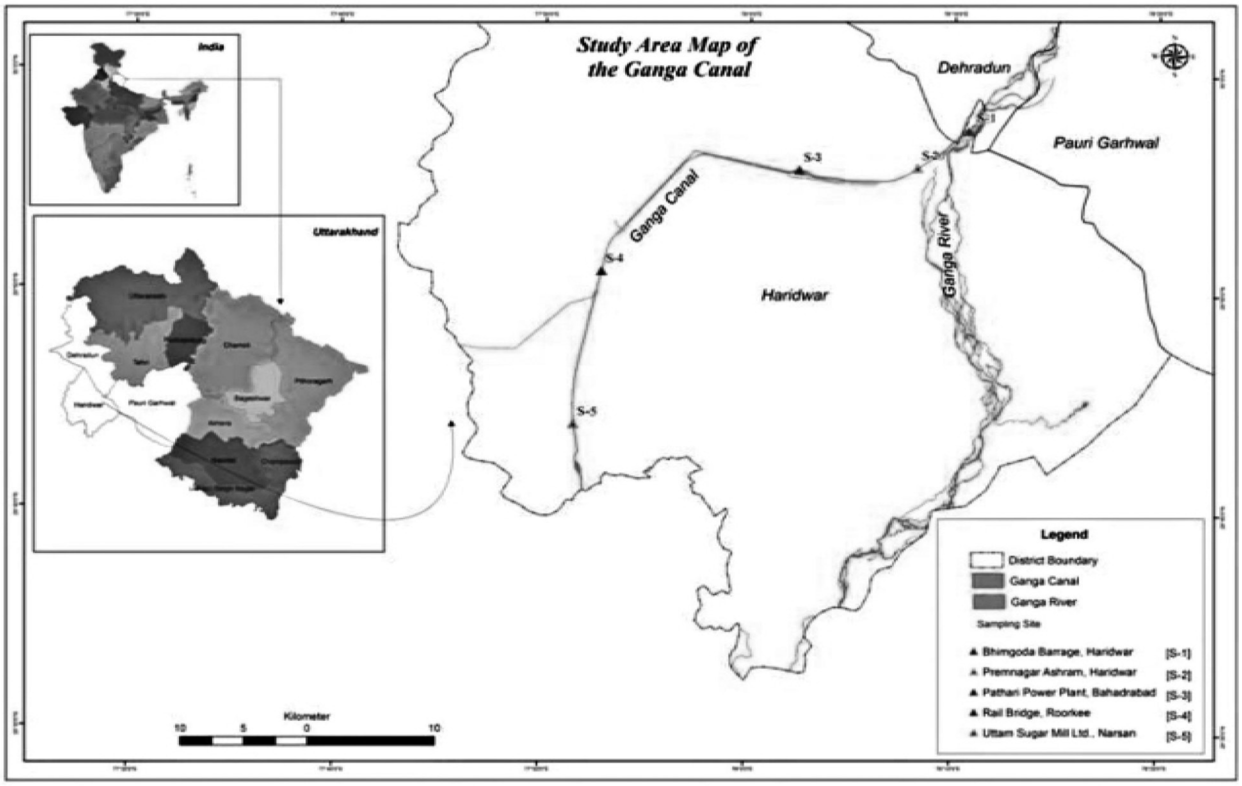

Figure 1: Study area map of Ganga Canal at Haridwar District.

Methodology for Sampling, Preservation and Analysis

The water samples for 15 physico-chemical analysis of pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, total hardness, alkalinity, bicarbonate, chloride, sulphate, nitrate, fluoride, sodium, potassium, calcium and magnesium at five sites were collected applying grab sampling method. The process of preservation, transportation and analysis of collected water samples from sampling site to laboratory were performed by adopting standard methods and protocols of BIS (2012) and APHA (2012). The bicarbonate concentration was calculated by multiplying alkalinity with 1.22 (Seth et al., 2013).

Irrigation Water Quality

A total of three irrigation water quality parameters viz. sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and sodium percent (Na%) have been determined and compared with IS: 11624 (1986 Reaffirmed 2001) and IS: 3025 (Part 45) (1993 Reaffirmed 2003 & 2014) standards. The calculation of SAR, RSC and Na% was done for each of the studied site in order to get significant information regarding spatial variation in irrigation water quality of Ganga Canal and also to assess the suitability of its water for irrigation purpose.

The detailed procedure adopted for calculating these three irrigation water quality parameters are provided below.

1. Sodium Adsorption Ratio (SAR)

SAR is used for assessing sodium hazard in relation to calcium and magnesium concentrations (Richards, 1954). It was computed by using the equation developed by Richards (1954).

2. Residual Sodium Carbonate (RSC)

The RSC is used to quantify the effect of carbonate and bicarbonate ions (Eaton, 1950). It was calculated through the equation developed by Eaton (1950).

3. Sodium Percent (Na%)

Excess amount of sodium in water reacts with soil, which in turn reduces soil permeability and supports either little or no plant growth (Wilcox, 1955). Therefore, analysis of Na% is necessary for consideration of suitability of water for irrigation purpose. Na% was calculated by using the formulae as earlier used by Ravikumar et al. (2013) and Seth (2015). Na% can also be calculated by using the formulae given under IS 3025 (Part 45): 1993.

Results and Discussion

The statistically analyzed data of 15 water quality variables at all five sampling sites namely S-1, S-2, S-3, S-4 and S-5 of Ganga Canal, Haridwar from March, 2014 to August, 2014 is given under Table 2 and described in detail hereunder.

pH

The prescribed desirable limit of pH for drinking water is 6.5-8.5 (BIS, 2012). However, minimum pH value (6.69) was observed at site S-4, while it was maximum (8.10) at S-1 site. During the monitoring of Ganga Canal, pH value did not fluctuate in a wider range from their mean value at any of the study site.

EC

The BIS (2012) has not specified the limit for electrical conductivity in drinking water. However, WHO (2004) has set its desirable and permissible limits as 500 µS/cm and 1500 µS/cm, respectively. Minimum electrical conductivity (187.6 µS/cm) was recorded at S-1 site, while 595.4 µS/cm was recorded as maximum at site S-5.

TDS

Minimum TDS (121.4 mg/L) was recorded at S-1 site, whereas maximum (384.3 mg/L) was noted at site S-5. Therefore, it was found well below the desirable limit (500 mg/L) as per BIS, 2012.

Turbidity

Turbidity is occurred due to suspended solid materials such as clay, silt, colloidal organic matter, phytoplankton and other microscopic organisms (Dorner et al., 2007). High value of turbidity is usually associated with high level of disease causing micro-organisms e.g. bacteria and parasites (Udousoro and Umoren, 2014). The highest turbidity was found at site S-5 as 468.3 NTU, whereas its lowest value was obtained as 11.8 NTU at S-1 site. The lower turbidity was even found well above the permissible limit (5 NTU) as per BIS, 2012 specifications. Khanna (2004) also obtained higher turbidity (217.13 NTU) at Muneshwar Ghat during monsoon season of 1999-2000.

Total Hardness

Minimum and maximum hardness were observed as 64 mg/L at S-5 site and 181 mg/L at S-4, respectively. These values were observed within desirable limit (200 mg/L) of BIS, 2012.

Alkalinity

The value of alkalinity ranged from 53 mg/L to 176 mg/L during study period. Its minimum concentration was recorded at site S-1, while maximum was at S-4 site. These values were also observed well below to the desirable limit (200 mg/L) of BIS, 2012.

Bicarbonate

Minimum bicarbonate was found as 64.66 mg/L at site S-1, whereas it was maximum as 214.72 mg/L at S-4 site during the study. There is no specific limit of BIS for bicarbonate ion in drinking water. However, WHO (2004) has prescribed its permissible limit as 240 mg/L. As per WHO limit, the bicarbonate concentration was also found below the limit.

Chloride

In present study, maximum chloride was obtained as 21.8 mg/L (site S-5). While, it has minimum value at S-4 site (0.6 mg/L). These concentrations were also observed well below the desirable limit of 250 mg/L (BIS, 2012).

Sulphate

The sulphate concentration was observed as 12 mg/L (minimum) at three sites namely S-1, S-2 and S-5, while it was found maximum (48 mg/L) at S-5 site. All these values were recorded well below to the specified limit of BIS, 2012.

Nitrate

In present study, nitrate at S-5 site was detected as 0.2 mg/L (minimum) and 26.7 mg/L (maximum), respectively. These values were also observed well within the desirable and permissible limit of BIS.

Fluoride

Fluoride usually occurs in minerals and geo-chemical deposits and gets released into sub-soil water bodies by slow natural degradation of fluorine contained rocks (Rakshit, 2004). Fluoride pollution occurs in the environment either through geogenic or anthropogenic source (Cengeloglu et al., 2002). The fluoride was not detected at any of the study site during July and August, whereas 2.09 mg/L was detected as maximum fluoride at S-1 site. It was observed well above to the permissible limit (1.50 mg/L) as per BIS, 2012. Further, site S-2 has also recorded higher concentration as 1.57 mg/L, which also exceeded permissible limit of BIS (2012). Fluoride is a necessary element for human health and its

Table 2: Statistical data of 15 water quality variables of Ganga Canal, Haridwar at five sites from March, 2014 to August, 2014

S.N.	*Water quality parameter*	*BIS: 10500 (2012)*		*S-1*				*S-2*				*S-3*				*S-4*				*S-5*			
		DL	*PL*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*
1.	**pH**	6.5 - 8.5	No Relax	7.76	8.10	7.89	0.12	7.19	8.05	7.69	0.29	6.88	7.82	7.47	0.38	6.69	7.78	7.40	0.46	6.93	7.76	7.49	0.38
2.	**EC, µS/cm**	500*	1500*	187.6	392.3	280.4	70.4	192.3	451.2	274.4	97.1	200.0	508.5	285.8	113.3	218.6	573.6	304.7	136.8	215.5	595.4	301.5	146.1
3.	**TDS, mg/L**	500	2000	121.4	253.2	181.0	45.3	124.2	291.1	177.1	62.7	129.0	328.2	184.6	73.1	141.4	370.4	196.8	88.3	139.3	384.3	194.7	94.3
4.	**Turbidity, NTU**	1	5	**11.8**	**392.3**	144.7	181.0	**12.6**	**396.8**	152.6	189.5	**13.1**	**418.5**	159.7	197.0	14.3	**447.8**	170.7	210.6	**14.5**	**468.3**	180.1	221.4
5.	**Total Hardness, mg/L**	200	600	79	132	108	21	82	148	102	23	72	172	104	37	88	181	108	36	64	157	94	32
6.	**Alkalinity, mg/L**	200	600	53	114	85	21	58	138	84	32	57	166	86	40	68	176	92	42	66	152	86	33
7.	**Bicarbonate, mg/L**	-	240*	64.66	139.08	103.50	25.24	70.76	168.36	102.48	38.49	69.54	202.52	105.33	48.97	82.96	214.72	111.63	51.05	80.52	185.44	105.12	40.13
8.	**Chloride, mg/L**	250	1000	1.1	6.1	3.2	2.1	0.8	8.4	4.4	3.1	1.2	13.9	5.4	4.7	0.6	12.3	4.6	4.8	1.2	21.8	6.0	7.9
9.	**Sulphate, mg/L**	200	400	12	32	20	7	12	29	18	6	15	25	19	5	13	42	23	11	12	48	22	13
10.	**Nitrate, mg/L**	45	No Relax	0.5	6.1	3.3	2.3	0.6	9.6	2.9	3.6	1.4	5.0	3.4	1.5	0.7	5.4	3.4	1.9	0.2	26.7	6.6	10.1
11.	**Fluoride, mg/L**	1.0	1.5	BDL	**2.09**	0.65	0.96	BDL	**1.57**	0.52	0.70	BDL	0.19	0.10	0.08	BDL	0.23	0.14	0.08	BDL	0.17	0.12	0.08
12.	**Sodium, mg/L**	-	200*	2.418	6.514	3.969	1.509	2.736	5.941	3.913	1.276	1.806	7.617	3.786	2.007	2.298	5.727	3.930	1.090	2.574	5.411	3.508	1.114
13.	**Potassium, mg/L**	-	12*	0.288	1.876	0.883	0.702	0.014	1.565	0.834	0.712	0.189	0.794	0.436	0.236	0.372	1.876	1.072	0.661	0.093	0.989	0.557	0.340
14.	**Calcium, mg/L**	75	200	18.842	41.830	30.608	8.871	17.662	44.138	27.521	9.476	18.620	40.074	27.282	7.255	21.496	49.092	29.018	10.424	22.860	52.149	30.229	11.099
15.	**Magnesium, mg/L**	30	100	5.720	14.065	7.994	3.081	5.748	20.148	9.212	5.559	5.336	31.190	11.457	9.737	5.920	33.141	12.086	10.591	5.659	34.705	11.731	11.333

DL: Desirable Limit, PL: Permissible Limit, Min: Minimum, Max: Maximum and SD: Standard Deviation

*WHO, 2004 Specifications

Bold values indicate more than permissible limit deficiency and overexposure both lead to adverse effects in teeth and bones of the users (Azizullah et al., 2011).

Sodium

BIS (2012) has not set any specification for sodium concentration in drinking water, however WHO (2004) has affixed its permissible limit as 200 mg/L. Sodium concentration did not exceed its specified limit at any of the studied site. Its minimum and maximum values were detected at S-3 and varied from 1.806 mg/L to 7.617 mg/L during the study.

Potassium

Similar to the sodium, BIS (2012) has also not framed any specification for potassium concentration in drinking water, however WHO (2004) has set its permissible limit as 12 mg/L. Potassium was also recorded well within its standard limit, which fluctuated between 0.014 mg/L (S-2 site) and 1.876 mg/L (S-1 and S-4 sites).

Calcium

Minimum calcium value was found as 17.662 mg/L at site S-2, while it was detected maximum as 52.149 mg/L at S-5 site. BIS (2012) have specified maximum desirable and permissible limits for calcium concentration in drinking water as 75 mg/L and 200 mg/L, respectively. However, its both least and highest concentrations were detected well below to the specified desirable limit.

Magnesium

The lowest value of magnesium (5.336 mg/L) was recorded at site S-3, whereas S-5 site had its highest value (34.705 mg/L) during the study. Three sites namely S-3, S-4 and S-5 contained higher magnesium values, which exceeded its desirable limit (30 mg/L) as per BIS (2012) specifications. However, all the values were observed well within its permissible limit (100 mg/L).

Status of Ganga Canal Water and Its Suitability for Irrigational Purpose

The Ganga Canal water was also assessed for irrigational purpose on the basis of three irrigation water quality parameters namely SAR, RSC and Na%. The irrigation water quality data is presented under Tables 3-5 and using this data Figures 2-4 have been drawn to represent their fluctuations with respect to different sites and discussed below.

Sodium Adsorption Ratio (SAR)

The SAR was specifically computed to determine the suitability of Ganga Canal water at Haridwar district for irrigation purpose. To assess the suitability for irrigation purpose at all five sampling sites, SAR value was calculated by using the data of Na^{+}, Ca^{2+} and Mg^{2+} cations analyzed and their SAR data is provided in Table 3 and have been compared with IS: 11624 (1986) for irrigation water.

All five sampling sites of Ganga Canal were found within the scale of below 10 meq/L as per the BIS standards and fall in the class of low sodium (low risk of sodium) and classified as 'Excellent' water quality for irrigation purpose (Figure 2). Maximum SAR value was computed as 0.058 meq/L (sites S-1 and S-2), while its minimum calculated concentration was 0.048 meq/L (site S-5). The prominent reason of lower SAR values was lesser quantity of sodium, calcium and magnesium ions in the assessed water samples.

Table 3: Sodium adsorption ratio (SAR) in Ganga Canal water

S.N.	*Location*	*Sampling site code*	*Calculated SAR values (meq/L)*	*SAR specification*	*Classification of water category**
1.	Bhimgoda Barrage, Haridwar	S-1	0.058	Below 10	Excellent
2.	Premnagar Ashram, Haridwar	S-2	0.058	-Do-	Excellent
3.	Pathari Power Plant, Bahadrabad	S-3	0.054	-Do-	Excellent
4.	Rail Bridge, Roorkee	S-4	0.055	-Do-	Excellent
5.	Uttam Sugar Mill Ltd., Narsan	S-5	0.048	-Do-	Excellent

*Ravikumar et al., 2013

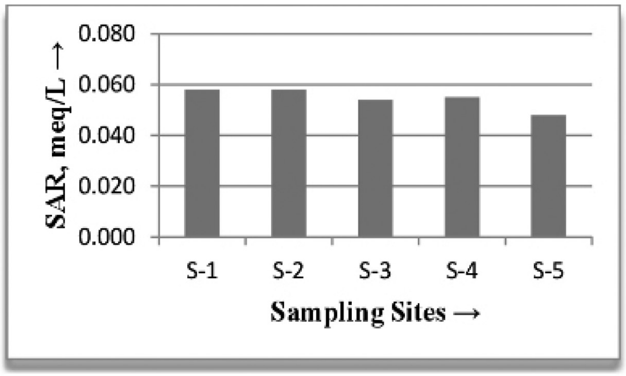

Figure 2: Sodium Adsorption Ratio (SAR) in Ganga Canal water.

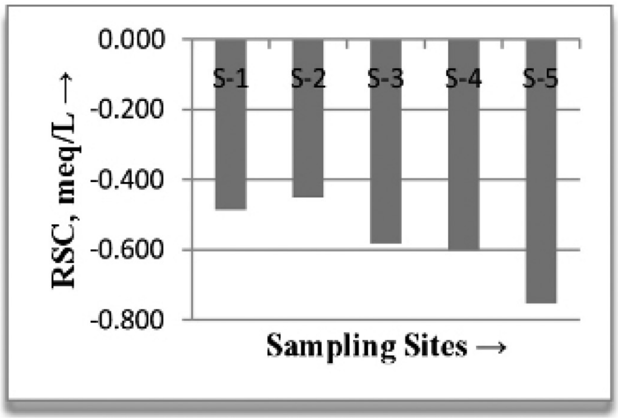

Figure 3: Residual Sodium Carbonate (RSC) in Ganga Canal water.

Residual Sodium Carbonate (RSC)

The RSC provides significant information about hazardous effects of carbonate and bicarbonate ions on water quality for agricultural purpose. The five sampling sites of Ganga Canal have been assessed by calculating RSC value and depicted in Table 4.

RSC concentration in all analyzed water samples of Ganga Canal during the study was found much lower (less than 0) as compared with its BIS (1986) specification (1.5 meq/L) and also fall under the 'Excellent' category of irrigation water quality. The highest value of RSC (-0.451 meq/L) was calculated at site S-2, while it was recorded as -0.753 meq/L (least) at S-5 site as shown through Figure 3. Therefore, the water at all selected sites was found suitable for irrigation purpose with respect to RSC.

Sodium Percent (Na%)

The Na% in soil is considered essential for determining the suitability of water for irrigation. It has been recommended that in order to avoid the harmful effects of sodium ion on soil, the Na% should not exceed 60 meq/L in irrigational water.

The Na% was also calculated for assessing suitability of Ganga Canal water at five sampling sites for checking suitability for irrigation purpose during the study. Na% (Table 5) in all the analyzed water samples lies under the scale (less than 20) and, therefore, classified with 'Excellent' water quality to meet out irrigation demand. Maximum value of Na% was noted (1.209 meq/L) at S-4 site. However, 0.614 meq/L (least Na%) was noted at S-3 site (Figure 4).

Conclusion

Out of 15 drinking water quality characteristics, only two water quality parameters viz. turbidity and fluoride were found to be exceeded than their respective permissible limits as per BIS standards. Higher turbidity values might be indicated by soil run-off, bathing, laundering, silt, sand dredging, micro-organisms and wastewater

Table 4: Residual sodium carbonate (RSC) in Ganga Canal water

S.N.	*Location*	*Sampling site code*	*Calculated RSC values (meq/L)*	*RSC specification*	*Classification of water category**
1.	Bhimgoda Barrage, Haridwar	S-1	-0.486	Below 1.5	Excellent
2.	Premnagar Ashram, Haridwar	S-2	-0.451	-Do-	Excellent
3.	Pathari Power Plant, Bahadrabad	S-3	-0.583	-Do-	Excellent
4.	Rail Bridge, Roorkee	S-4	-0.602	-Do-	Excellent
5.	Uttam Sugar Mill Ltd., Narsan	S-5	-0.753	-Do-	Excellent

*Ravikumar et al., 2013

Table 5: Sodium percent (Na%) in Ganga Canal water

S.N.	*Location*	*Sampling site code*	*Calculated Na% values (meq/L)*	*Na% specification*	*Classification of water category**
1.	Bhimgoda Barrage, Haridwar	S-1	1.121	Less than 20%	Excellent
2.	Premnagar Ashram, Haridwar	S-2	1.088	-Do-	Excellent
3.	Pathari Power Plant, Bahadrabad	S-3	0.614	-Do-	Excellent
4.	Rail Bridge, Roorkee	S-4	1.209	-Do-	Excellent
5.	Uttam Sugar Mill Ltd., Narsan	S-5	0.692	-Do-	Excellent

*Ravikumar et al., 2013 and Seth, 2015

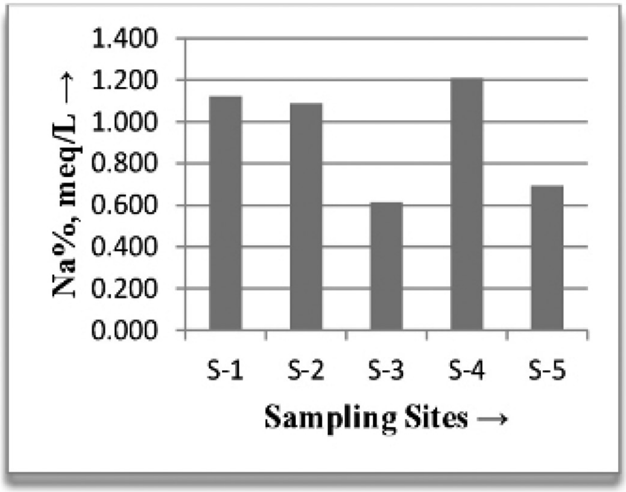

Figure 4: Sodium percent (Na%) in Ganga Canal water.

discharges. However, higher concentration of fluoride could be inferred due to leaching from fluoride bearing minerals, industrial wastes and agricultural fertilizers. Magnesium was detected more than its desirable limit at three study sites. The assessment of Ganga Canal for irrigational water quality parameters namely SAR, RSC and Na% inferred that its water is suitable for meeting irrigational requirements owing to 'Excellent' grade. Present study emphasized the significance of regular monitoring in order to assess the present status of Ganga Canal water quality and determining the suitability of its water for drinking and other domestic needs along with irrigation purpose as per BIS norms.

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Calendar of Events

9th International Conference on Environmental Engineering and Applications (ICEEA 2018)
10th to 12th July 2018
Amsterdam, The Netherlands
Website: http://www.iceea.org/
Contact person: Ms. Lydia. Liu
Organized by: CBEES

3rd International Conference on Water Pollution and Treatment (ICWPT 2018)
10th to 12th July 2018
Amsterdam, The Netherlands
Website: http://www.icwpt.net/
Contact person: Ms. Luna Huang
Organized by: CBEES

8th International Conference on Environmental and Agriculture Engineering (ICEAE 2018)
26th to 28th July 2018
Singapore
Website: http://www.iceae.org/
Contact person: Ms. Zero Jiang
Organized by: CBEES

International Conference on Environment and Ocean Engineering (ICEOE 2018)
6th to 8th August 2018
Taipei, Taiwan
Website: http://www.iceoe.org/
Contact person: Ms. Luna Huang
Organized by: CBEES

International Conference on Water Conservation & Management WC2EM-2018
10th to 12th August 2018
Bali, Indonesia
Website: https://inwascon.org.my/wc2em/
Contact person: Nur Farwizah
Organized by: INWASCON, MALAYSIA

The INTESDA 3rd Asian Symposium on Water, Sanitation and Hygiene - WASH 2018
2nd to 3rd September 2018
Tokyo, Japan
Website: http://intesda.org/water-sanitation-hygiene-symposium/
Contact person: The WASH 2018 Team
Organized by: INTESDA

4th International Conference Water Resources and Wetlands
5th to 9th September 2018
Tulcea, Romania
Website: http://www.limnology.ro/wrw2018/abstract.html
Contact person: Petre Bretcan
Organized by: Romanian Limnogeographical Association