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Study of Water Quality of Ganga River and Its Suitability for Mass Ritualistic Bathing before Kumbh Mela-2021 at Haridwar in Uttarakhand, India

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Abstract: *Kumbh Mela, an important festival that involves bathing in river was held on the bank of the river Ganga at Haridwar, India during January14th - April 27th, 2021. Dissolved oxygen (DO) in river Ganga ranged as 5.8-8.9 mg/l, pH: 7.7-7.9, biochemical oxygen demand (BOD): bdl-1.4 mg/l, and fecal coliform: 330-35000 MPN/100 ml. River Ganga was meeting bathing water quality criteria with respect to pH, DO and BOD at all eight monitoring locations however all monitoring locations except two locations namely Triveni Ghat, Rishikesh and downstream Har ki Pauri, Haridwar were meeting the bathing water quality criteria w.r.t. fecal coliform.*

Key Words: *Mass bathing, water quality, sewage treatment, Kumbh Mela-2021*

1. INTRODUCTION

Water is the most important essential commodity required by all forms of life on earth to survive. The freshwater bodies such as rivers and lakes are chief resources of water to meet the daily demand of water supply for domestic, industrial, and agricultural purposes. India is naturally supported by several rivers, lakes, and wetlands. The Ganga River basin is the largest amongst river basins in India, and the fourth-largest in the world. It has important socio-economic and environmental values and is the lifeline of more than 45% of the Indian population. River Ganga covers approximately 2525 km with a basin size of 1320 thousand km^2. It originates in the state of Uttarakhand at Gaumukh (30°362 N; 79°042 E) in the snout of the Gangotri glacier as Bhagirathi River in the Himalayas at an elevation of 4356 m. The river attains the name Ganga at Devprayag, where Alaknanda joins Bhagirathi and enters the Gangetic plains at Haridwar at an elevation of 300 m above mean sea level.

Kumbh Mela, an important 12-yearly religious Hindu social gathering festival in India, involves a holy dip (bathing) in the river. It is celebrated every twelve years at four river bank pilgrimage sites in India: (i) Prayagraj (on sangam of rivers Ganga and Yamuna) in Uttar Pradesh; (ii) Haridwar (on river Ganga) in Uttarakhand; (iii) Nashik (on river Godavari) in Maharashtra; and (iv) Ujjain (on river Shipra) in Madhya Pradesh. Kumbh Mela-2021 in year 2021 was held on the bank of river Ganga at Haridwar in the state of Uttarakhand of India during January 14th - April 27th, 2021. Considering the importance of maintenance of water quality of river Ganga during mass ritualistic bathing at Haridwar during Kumbh Mela, monitoring of river Ganga, its tributaries and connecting drains in Rishikesh-Haridwar stretch and sewage treatment plants installed at Rishikesh, Dehradun and Haridwar was carried out during December 2nd - 9th, 2020 before the commencement of Kumbh Mela. Many researchers have assessed and reported the water quality of river Ganga in Rishikesh and Haridwar but a comprehensive assessment of water quality along with the pollution load exerted by the drains and status of sewage treatment has not been carried out. Therefore, to address the paucity of data, the objectives of this study were: (i)

to assess the water quality of river Ganga (with respect to bathing criteria) and its tributaries in Rishikesh to Haridwar stretch in Uttarakhand before Kumbh Mela; (ii) to assess the pollution load due to drains discharging sewage in river Ganga; and (iii) to assess the status of sewage treatment in Rishikesh, Haridwar and Dehradun.

2. MATERIALS AND METHODS

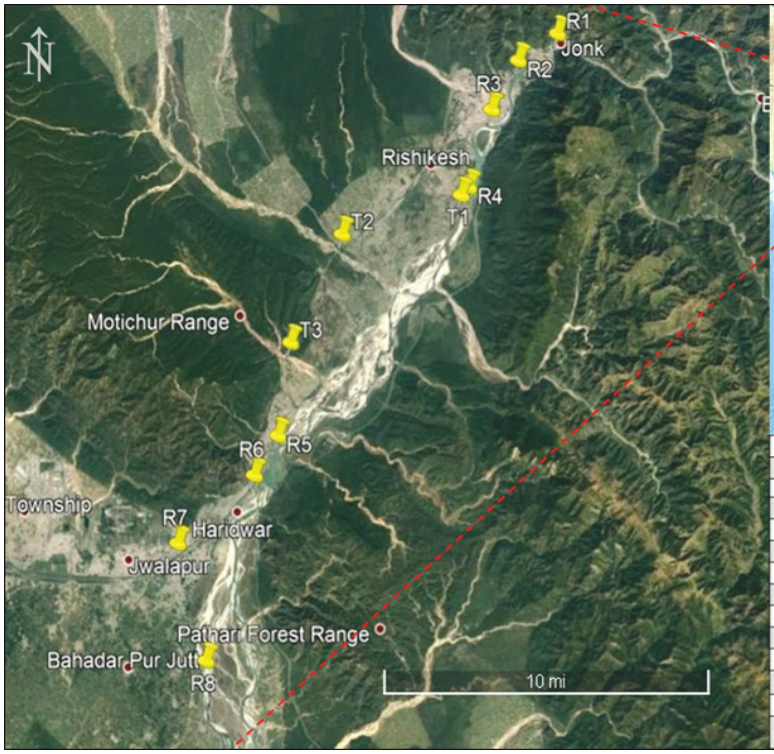
2.1 Description of Study Area

Haridwar is located in the southwestern part of Uttarakhand State of India and lies between 29°42'-30°9' N latitude and 77°58' E - 77°46' E longitude. To ensure the water quality of river Ganga in Haridwar during Kumbh Mela, eight locations were selected in Rishikesh and Haridwar to assess the water quality of river Ganga. Apart from river Ganga, three locations on tributaries (Song, Rambha and Chandrabhaga) before the confluence with river Ganga in Rishikesh-Haridwar stretch were also selected to assess the pollution load exerted by tributaries on river Ganga (Fig. 1 & Table 1). River Song receives the wastewater (treated/ untreated) from Dehradun city through the river Bindal Rao. River Rambha is a tributary of river Ganga & have confluence with river Ganga at downstream of the Pashulok Barrage.

To assess the pollution load on river Ganga in Haridwar and Rishikesh in Uttarakhand, eight drains discharging wastewater into river Ganga were also monitored. In Rishikesh, four monitored drains were Chandreshwar Nagar drain, Triveni Ghat Drain, IDPL STP drain and Lakkarghat STP drain and four monitored drains in Haridwar were Kassavan drain, Pandeywala drain, Matri Sadan Nala, Jagjeetpur STP drain. Out of these eight drains, three drains are outlets of sewage treatment plants that carry treated sewage and five drains are tapped to STPs. Sewage treatment plants in Rishikesh, Haridwar and Dehradun discharging treated effluent into river Ganga and its tributaries were selected. Treated sewage quality of six STPs in Rishikesh, five in Haridwar and seven in Dehradun was evaluated.

2.2 Sample Collection and Analysis

Grab samples of river water were collected using polypropylene bottles from 30 cm below the water surface (CPCB, 2017). The pH and conductivity were measured using a pH meter and conductivity meter, respectively and color was measured onsite using a color comparator. The samples for chemical oxygen demand, chloride, phosphate, ammonia were collected in pre-washed polypropylene bottles. Samples for dissolved oxygen (DO), biochemical oxygen demand (BOD), total and fecal coliform were collected in glass bottles. Sampling bottles for total coliform (TC) and fecal coliform (FC) bacteria analysis were pre-sterilized with 70 % v/v ethanol before use. Samples for DO



Name of monitoring location	Code	Latitude	Longitude
Monitoring locations on river Ganga			
Upstream Tapovan, Rishikesh	R1	30.1334	78.3319
Ram Jhula, Rishikesh	R2	30.1227	78.3115
Triveni Ghat, Rishikesh	R3	30.1027	78.2971
Pashulok Barrage, Rishikesh	R4	30.0709	78.2846
Upstream Haridwar barrage	R5	29.9705	78.1837
Har ki Pauri, Haridwar	R6	29.9544	78.1711
Muni Ghat, Singh Dwar Bridge	R7	29.9271	78.1311
Downstream Haridwar	R8	29.8783	78.1442
Monitoring locations on tributaries of river Ganga meeting in Rishikesh to Haridwar stretch			
River Rambha before confluence with river Ganga	T1	30.0677	78.2805
River Song before confluence with river Ganga	T2	30.0529	78.2189
River Chandrabhaga before confluence with river Ganga	T3	30.0087	78.1912

Fig. 1: *Map showing water quality monitoring locations on river Ganga and its tributaries (Song, Rambha and Chandrabhaga) in Rishikesh-Haridwar stretch*

Table 1: Physico-chemical and biological properties of water in river Ganga and its tributaries (Song, Rambha and Chandrabhaga) in Rishikesh-Haridwar

Name of location	Code	Coordinates		Parameters										
		Latitude	Longitude	DO	pH	Conductivity	Color	BOD	COD	Cl^-	PO_4-P	NH_3-N	TC	FC
River Ganga														
Upstream Tapovan, Rishikesh	R1	30.1334	78.3319	8.6	7.7	138	bdl	bdl	05	10	bdl	bdl	1700	1400
Ram Jhula, Rishikesh	R2	30.1227	78.3115	8.7	7.7	140	bdl	bdl	05	09	bdl	bdl	4900	1700
Triveni Ghat, Rishikesh	R3	30.1027	78.2971	8.5	7.7	156	bdl	bdl	07	08	bdl	bdl	92000	35000
Pashulok Barrage, Rishikesh	R4	30.0709	78.2846	8.2	7.7	200	bdl	1.1	05	12	bdl	bdl	24000	1300
Upstream Haridwar barrage	R5	29.9705	78.1837	8.0	7.9	206	bdl	1.2	07	12	bdl	bdl	3300	1100
Har ki Pauri, Haridwar	R6	29.9544	78.1711	8.4	7.8	151	bdl	bdl	07	08	0.09	bdl	1700	330
Muni Ghat, Singh Dwar Bridge	R7	29.9271	78.1311	5.8	7.8	193	bdl	1.0	09	09	0.07	bdl	5400	3500
Downstream Haridwar	R8	29.8783	78.1442	8.9	7.9	194	bdl	1.4	11	12	bdl	bdl	2400	1300
Tributaries of river Ganga meeting in Rishikesh to Haridwar stretch														
River Rambha before confluence with river Ganga	T1	30.0677	78.2805	2.8	7.3	457	bdl	4.0	14	18	0.22	1.24	92000	92000
River Song before confluence with river Ganga	T2	30.0529	78.2189	6.4	7.7	545	bdl	2.6	12	16	0.06	bdl	14000	1700
River Chandrabhaga before confluence with river Ganga	T3	30.0087	78.1912	Dry at confluence point with river Ganga										

Notations: bdl- Below detection limit; DO- Dissolved oxygen, BOD- Biochemical oxygen demand, COD- Chemical oxygen demand, Cl^-- Chloride, PO_4-P- Phosphate, NH_3-N- Ammoniacal nitrogen, TC Total coliform, FC Fecal coliform; All values are expressed in mg/l except pH, conductivity (µmho/cm) and TC/FC (MPN/100 ml)

Table 2: Tapping status of drains discharging wastewater in river Ganga in Rishikesh-Haridwar stretch of Uttarakhand (India)

Name of drains	Coordinates		Tapping status	Diversion to sewage treatment plant
	Latitude	Longitude		
Kassavan drain	29.9202	78.1095	Tapped	18 MLD Sarai Jwalapur STP
Pandeywala drain	29.9211	78.0974	Tapping provision was found damaged	14 MLD Sarai Jwalapur STP
Matri Sadan Nala	29.9088	78.1397	Tapped	68 MLD Jagjeetpur STP
Jagjeetpur STP drain	29.8982	78.1412	STP outlet	-
Chandreshwar nagar drain	30.1074	78.3080	Insufficient tapping was found	7.5 MLD Chandreshwar Nagar STP
Triveni Drain	30.1032	78.2982	Tapped	26 MLD Lakkarghat STP
IDPL STP drain	30.0552	78.2657	STP outlet	-
Lakkarghat STP drain	30.0439	78.2479	STP outlet	-

were preserved with $MnSO_4$ and NaN_3. After collection, the samples were transported to the laboratory in an ice-box and analyzed using standard protocols (APHA, 2017).

Wastewater samples from drains (using grab sampling technique) were collected before the confluence point of the drain with the river Ganga. The pH and color were analyzed onsite and samples for chemical oxygen demand, total dissolved solids (TDS), total suspended solids (TSS), chloride, nitrate-nitrogen, ammoniacal nitrogen, phosphate and sulfate were collected in pre-washed polypropylene bottles. Samples for biochemical oxygen demand, total and fecal coliform were collected in glass bottles. After collection, samples were transferred to the laboratory in an ice-box and analyzed using standard protocols (APHA, 2017).

Grab samples of the treated effluent from sewage treatment plants were collected. The pH was analyzed onsite, samples for COD and TSS were collected in pre-washed polypropylene bottles. Samples for BOD and FC were collected in glass bottles. After collection, samples were transferred to the laboratory in an ice-box and analyzed using standard protocols (APHA, 2017).

2.3 Flow Measurement in Drains

The flow of wastewater in drains was measured by the Ball-float method. Instantaneous flow in drains was calculated as

$$Flow\ (Q) = A \times V$$

Where: Q was measured in m^3/sec; A is the average cross-sectional area of flow in m^2; V is the average velocity of flow in m/sec.

The average cross-sectional area of flow was calculated as

$$Average\ cross-sectional\ area\ of\ flow\ (A) = W \times D$$

Where: the average cross-sectional area of flow was measured in m^3/sec; W and D are width and depth of the flow measured in meters.

Width, Depth, and average surface velocity are measured thrice and average values were considered for further calculation of flow.

As flow velocity is not identical in the entire cross-section of the drain, suitable correction factors were applied so that flow is not exaggerated/over-estimated (Subramanya, K., 2009). A factor of 0.8 was used for averaging velocity and flow width. Therefore, the resulting factor (0.8 × 0.8) ~ 0.65 was considered for flow calculation in natural drains (CPHEEO, 2013).

2.4 Statistical Analysis

Hierarchical cluster analysis (HCA) was performed to cluster monitoring locations on the basis of normalized dataset of water quality parameters (pH, conductivity, DO, BOD, COD, chloride, phosphate, TC and FC) using average linkage (between groups) with Euclidean distances as measure of similarity. All statistical calculi were performed using software SPSS, IBM statistics version 21.0 package.

3. RESULTS AND DISCUSSION

3.1 River Water Quality

The water quality parameters in river Ganga ranged as DO: 5.8-8.9 mg/l, pH: 7.7-7.9, conductivity: 138-206 µmho/cm, color: below detection limit (bdl), BOD: bdl-1.4 mg/l, COD: 5-11 mg/l, chloride: 8-12 mg/l, phosphate: bdl-0.09 mg/l, ammoniacal nitrogen: bdl, TC: 1700-92000 MPN/100 ml and FC: 330-35000 MPN/100 ml.

The Ministry of Environment, Forest and Climate Change, Government of India vide notification dated 25/09/2000 notified the primary water quality criteria for bathing water (water used for organized outdoor bathing) as: pH must be between 6.5 and 8.5, DO ≥ 5 mg/l, BOD ≤ 3 mg/l and FC ≤ 2500 MPN/100 ml (MoEF&CC, 2000). With respect to these notified water quality criteria, the water quality of river Ganga in the stretch from Rishikesh to Haridwar was meeting bathing water quality criteria w.r.t. pH, DO and BOD at all monitoring locations, however; all monitoring locations except two locations namely R3 (Triveni Ghat, Rishikesh) and R7 (downstream Har ki Pauri, Haridwar) were meeting the bathing water quality criteria w.r.t. fecal coliform. The physico-chemical and biological properties of the river Ganga in Rishikesh-Haridwar stretch are shown in Table 2.

Three tributaries of the river Ganga in Rishikesh i.e., Chandrabhaga, Song and Rambha were also monitored before the confluence with river Ganga. River Chandrabhaga was found dry at the confluence with river Ganga. River Song was meeting the bathing water quality criteria w.r.t. pH, DO, BOD and FC. River Rambha was not meeting the bathing water quality criteria w.r.t. DO, BOD and FC (Table 1). River Rambha receives wastewater from the AIIMS Rishikesh campus and Barrage colony, Pashulok and nearby Ashrams, hotels and colonies in Rishikesh.

The color of water affects the penetration of sunlight into the river depth thus, impacts the photosynthesis process in the river. The pH regulates the carbonate complexation, metal dissolution in river water. The pH of water in rivers is influenced by various biological, physical and geochemical processes such as photosynthesis, respiration of plants, CO_2 pressure equilibrium with the atmosphere, degradation of organic matter, geological and mineral background, and pollution. The maintenance of optimum pH in river water is also required for the sustenance of aquatic life (Matta et al., 2017).

The DO indicates the quality of river water as it plays a pivotal role in controlling the diversity of aquatic fauna and indicating the effect of waste discharge into the river (Haritash et al., 2016). The DO concentration in a river regulates significant processes for the sustenance of aquatic life because its concentration and regulatory elements in river water governs the ecosystem health, eutrophy, and biogeochemical responses. The DO content in the river decreases by the discharge of organic waste into the river. Moreover, inorganic substances such as H_2S, ammonia, nitrite, ferrous iron, and certain oxidizable substances also lead to a decrease of DO content in the water.

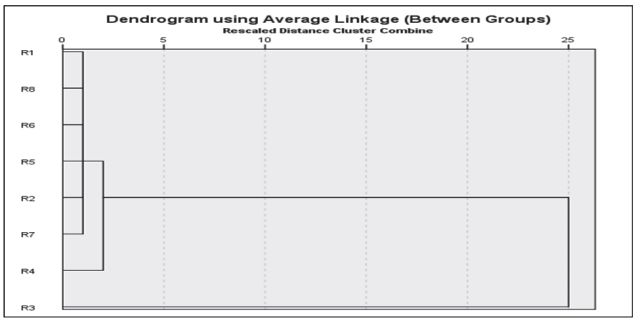


Fig. 2: *Dendrogram using average linkage (between groups) representing hierarchical clustering of water quality monitoring locations on river Ganga*

(a)

(b)

Fig. 3: (a) *Damaged tapping provision at Pandeywala drain and* ***(b)*** *Wastewater from Pandeywala drain mixing with Ganga canal*

In river water, BOD shows the biodegradable fraction of the organic load. The BOD and COD quantify the degree of organic pollution in a river. The BOD takes the biodegradable portion into account while the COD measures both biodegradable and non-biodegradable pollution as well. In a river, the discharge of untreated/partially-treated municipal and industrial wastewater builds up high levels of BOD and COD which decreases progressively at the downstream side of the river (Matta et al., 2017).

The presence of FC in aquatic environments may indicate that the water has been contaminated with the fecal material of humans or other animals. The reason for the presence of FC in river water could be (i) direct discharge of untreated sewage; (ii) fecal bacteria remaining in the treated wastewater, and (iii) open defecation on the banks of the river (Haque, et al., 2016).

HCA is a method to statistically identify the group of similarly behaving samples. Hierarchical cluster of monitoring locations on river Ganga is shown in Fig. 2. The first cluster has two groups: the first group contains R1, R2, R3, R4, R5, R6 and R7 whereas the second one includes R3 (River Ganga at Triveni Ghat, Rishikesh). The results revealed that River Ganga at Triveni Ghat, Rishikesh (R3) formed a different cluster from all other monitoring locations on river Ganga which could be due to high TC and FC. Thereafter, sub-groups formed R4 (River Ganga at Pashulok Barrage, Rishikesh) as a different cluster which could be due to high count of TC in river water.

3.2 Pollution Load Due to Drains

Eight drains (Rishikesh-04 and Haridwar-04) connecting to river Ganga in the stretch from Rishikesh to Haridwar downstream were monitored. All eight drains carried domestic sewage. Out of four drains in Rishikesh, two drains namely Triveni drain and Chandreshwar Nagar drain were tapped and two drains namely IDPL STP drain and Lakkarghat STP drain were STP outlets. The tapping status of drains is shown in Table 2. Out of two tapped drains, seepage from one drain namely the Triveni drain was observed and insufficient tapping provision at one drain namely Chandreshwar Nagar drain was observed. Chandreshwar Nagar drain was partially tapped to 7.5 MLD Chandreshwar Nagar STP and approximately 11 MLD untreated wastewater was being discharged through the drain to river Ganga along with treated wastewater from 7.5 MLD STP.

The wastewater properties in drains ranged as pH: 6.8-7.0, color: 15-42 Hazen, BOD: 5.9-13 mg/l, COD: 26-62 mg/l, TDS: 268-384 mg/l, TSS: 31-135 mg/l, chloride: 26-36 mg/l, nitrate: 0.48-2.73 mg/l, ammoniacal nitrogen: 3.8-7.9 mg/l, phosphate: 0.65-1.56 mg/l, sulphate: 35-208 mg/l, TC: 16×10^4 - 22×10^6 and FC: 92×10^3 - 14×10^6 MPN/100

Table 3: Characteristics of wastewater discharged by drains into river Ganga in Rishikesh and Haridwar in India

Locations	Coordinates		Parameters												
	Latitude	Longitude	pH	Color	BOD	COD	TDS	TSS	Cl^-	NO_3-N	NH_3-N	PO_4-P	SO_4	TC	FC
Pandeywala Drain Pumping Station (Tapping point), Haridwar	29.9211	78.0974	6.8	42	13	62	384	31	36	0.98	7.9	1.56	208	16×10^5	16×10^5
Untreated sewage of Chandreshwar STP reaching river Ganga	30.1074	78.3080	6.8	21	12	42	316	135	26	0.48	7.4	0.89	131	22×10^6	14×10^6
Treated + Untreated sewage of Chandreshwar STP reaching River Ganga at Chandreshwar Nagar	30.1074	78.3080	7.0	27	7.9	26	352	63	30	2.73	4.5	0.78	46	46×10^4	46×10^4
Lakkarghat STP Drain near Rajkiya Polytechnic, Garhi Shyampur	30.0439	78.2479	6.8	15	5.9	28	268	34	28	2.46	3.8	0.65	35	16×10^4	92×10^3

Notations: BOD- Biochemical oxygen demand, COD- Chemical oxygen demand, TDS- Total dissolved solids, TSS- Total suspended solids, Cl^-- Chloride, NO_3-N- Nitrate-Nitrogen, NH_3-N- Ammoniacal nitrogen, PO_4-P- Phosphate, SO_4- Sulphate, TC- Total coliform, FC- Fecal coliform; All values are expressed in mg/l except pH, color (Hazen) and TC/FC (MPN/100 ml)

Table 4: Properties of treated effluent of sewage treatment plants in Rishikesh, Haridwar and Dehradun

Region	Name and installed capacity of sewage treatment plants	Coordinates		Parameters				
		Latitude	Latitude	pH	BOD	COD	TSS	Fecal coliform
Rishikesh	Tapovan STP (3.5 MLD)	30.1332	78.3307	7.2	3.9	19	38	68
	Swarg Ashram STP (3 MLD)	30.1146	78.3106	6.8	1.1	13	bdl	1100
	Muni Ki Reti STP (5 MLD)	30.1147	78.2833	7.1	3.7	25	bdl	39000
	Chandreshwar Nagar STP (7.5 MLD)	30.1099	78.3076	7	bdl	2	bdl	46000
	IDPL STP (14 MLD)	30.0638	78.2653	7	8.7	67	38	92000
	Lakkarghat STP (26 MLD)	30.0569	78.2620	6.9	2.1	10	bdl	110
Haridwar	Jagjeetpur (68 MLD)	29.8990	78.1388	6.8	2.6	12	bdl	130000
	Jagjeetpur (27 MLD)	29.9015	78.1375	7.1	2.4	11	bdl	4900
	Jagjeetpur (18 MLD)	29.9015	78.1375	6.9	1.7	14	bdl	4900
	Sarai Jwalapur (18 MLD)	29.8935	78.0893	7.2	1.4	11	21	22
	Sarai Jwalapur (14 MLD)	29.9004	78.1376	6.9	10	68	34	70000000
Dehradun	Kargi STP (68 MLD)	30.2846	78.0151	7.4	2.1	14	bdl	4400
	Mothorowala STP - Old (20 MLD)	30.2624	78.0426	7.1	1.5	9	bdl	12000
	Mothorowala STP - New (20 MLD)	30.2624	78.0426	7	3.8	18	bdl	bdl
	Indira Nagar STP (5 MLD)	30.2927	77.9982	7.4	2.3	17	bdl	7.8
	Jakhan STP (1 MLD)	30.3578	78.0580	7.5	1.3	10	bdl	930
	Salawala STP (0.71 MLD)	30.3406	78.0527	7.2	9.5	60	24	68000
	Vijay Colony STP (0.42 MLD)	30.3440	78.0394	7.2	3.6	32	44	bdl
Sewage discharge norms*				5.5 - 9.0	10	50	20	Des-100 Per : 230

Note: The installed sewage treatment capacity was 59 MLD at Rishikesh, 145 MLD at Haridwar and 115.13 MLD in Dehradun;
**Sewage discharge norms prescribed by Hon'ble National Green Tribunal vide order dated 30.04.2019 in O.A. No. 1069/2018*

ml. Before confluence with river Ganga, the characteristics of wastewater in Chandreshwar Nagar drain showed BOD - 7.9 mg/l, COD - 26 mg/l, color - 27 Hazen, and FC - 46×10^4 MPN/100 ml (Table 3).

In Haridwar, out of four monitored drains, three drains are tapped namely Kassavan drain, Matri Sadan drain and Pandeywala drain and one drain namely Jagjeetpur STP drain is STP outlet. Out of three tapped drains, one drain namely the Matri Sadan drain was found dry. Seepage in one drain namely the Kassavan drain was observed. Tapping provision at one drain namely Pandeywala drain was found damaged and wastewater (BOD-13 mg/l, COD-62 mg/l, FC-16×10^5 MPN/100 ml) was reaching to river Ganga (Fig. 3). Solid waste dumping along the drain was also observed.

3.3 Sewage Treatment in the Catchment Area of River

Six STPs in Rishikesh, five in Haridwar and seven in Dehradun were monitored. The installed sewage treatment capacity was 59 MLD at Rishikesh, 145 MLD at Haridwar and 115.13 MLD in Dehradun. The characteristics of treated effluent from sewage treatment plants in Rishikesh, Haridwar and Dehradun are shown in Table 4. Sewage discharge norms in India prescribed by Hon'ble National Green Tribunal, Government of India vide order dated 30.04.2019 in O.A. No. 1069/2018 are pH: 5.5 - 9.0, BOD: 10 mg/l, TSS: 20 mg/l, COD: 50 mg/l; total nitrogen: 10 mg/l, total phosphorus (for discharge into ponds and lakes): 1 mg/l, FC: desirable limit: 100 MPN/100 ml and permissible limit: 230 MPN/100 ml (NGT, 2019).

In Haridwar, treated effluent from all the sewage treatment plants was meeting the discharge norms for pH and BOD prescribed by Hon'ble National Green Tribunal vide order dated 30.04.2019 in O.A. No. 1069/2018. In Rishikesh, one STP namely 26 MLD Lakkarghat STP (New) and in Dehradun, two STPs namely 20 MLD Mothorowala STP (New) STP and 5 MLD Indira Nagar STP were found complying w.r.t. the discharge norms prescribed by National Green Tribunal for pH, BOD, COD, TSS and FC. Disinfection system was installed at all the sewage treatment plants in Rishikesh, Haridwar, and Dehradun however at four sewage treatment plants in Dehradun namely 20 MLD Mothorowala STP (Old), 5 MLD Indira Nagar STP, 1 MLD Jakhan STP and 0.71 MLD Salawala STP, disinfection system was found non-operational but temporary arrangements were made for disinfection of treated sewage.

4. CONCLUSIONS

The water quality of river Ganga was assessed at eight locations in Rishikesh and Haridwar which was meeting bathing water quality criteria with respect to pH, DO and BOD at all eight monitoring locations however all monitoring locations except two locations namely R3 (Triveni Ghat, Rishikesh) and R7 (downstream Har ki Pauri, Haridwar) were meeting the bathing water quality criteria w.r.t. fecal coliform. It was observed that the sewage treatment plants in Dehradun, Rishikesh and Haridwar were not meeting the prescribed discharge standards by the National Green Tribunal, Government of India. The study recommends that zero overflows from tapped drains must be ensured. The sewage treatment plants must be regularly inspected to ensure their proper functioning to maintain the water quality of river Ganga during religious congregations at Haridwar, India.

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