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Biological Water Quality Assessment of the River Ganga (2017-18)

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1.0 INTRODUCTION

The Ganga is the biggest river in the Indian subcontinent in terms of water flow. The river has its origin in the Western Himalayan Ranges in the state of Uttarakhand, flows through the Gangetic plain of North India in Uttar Pradesh, Jharkhand, Bihar and finally falls into the Bay of Bengal (Sagar dweep) in West Bengal. The total length of Ganga is approximately 2,525 km, meeting a large number of tributaries viz., Yamuna, Ramganga, Pandu, Varuna, Gandak, Gomti, Kosi and many others on the way to Bay of Bengal.

The Ganga is a sacred river along every fragment of its length. The river has been proclaimed as the National river of India. All along its course, people drink and bathe in its waters. Ritual bathing at the bank of river in Haridwar and Allahabad during Kumbh Mela is of particular importance. The river's most famed fauna is the freshwater dolphin *Platanista gangetica gangetica*, the Ganges river dolphin, recently declared India's national aquatic animal. The Ganges River Catchment Basin covers an area of 390,000 sq miles (1,000,000 sq km) and supplies to one of the maximum populated areas in the world. The Ganga basin with its fertile soil is instrumental to the agricultural economy of the country. The Ganga and its tributaries provide a perennial source of irrigation to a large area. Along the banks of the river, the presence of swamps and lakes provide a rich growing area for crops such as legumes, chillies, mustard, sesame, sugarcane, and jute.

The Ganga is threatened from various sources of pollution and is cause of concern to the 400 million people who live close to the river. Sewage from many cities along the river's course, industrial waste and religious offerings wrapped in non-degradable plastics add large amount of pollution load to the river as it flows through densely populated areas. The problem is exacerbated by the fact that many poor people rely on the river on a daily basis for bathing, washing, and cooking. Pollution threatens not only humans, but also more than 140 fish species, 90 amphibian species and the endangered Ganges river dolphin.

Water quality of river Ganga is being monitored at various locations and assessed based on the physico-chemical and bacterial parameters (including BOD, COD, DO, temperature, pH, total coliforms, faecal coliforms etc.). Central Pollution Control Board (CPCB) is mandated with the responsibility of undertaking continuous Real Time Water Quality Monitoring (RTWQM)

of River Ganga at 36 locations. The installation of RTWQM stations at 36 locations was completed in 2017 and service provider had started providing data from all 36 locations with effect from 11.03.2017. Bio-monitoring team of CPCB under the guidance of Dr. Sanjeev Agrawal, In-Charge Bio-science Division has decided to undertake the biological water quality assessment at all 36 RTWQM locations along with 8 hydrology locations in Pre-monsoon as well as post monsoon.

Keeping in view, biological testing of River Ganga was initiated in April, 2017 and completed in June, 2017 at 44 RTWQM locations (Pre-monsoon phase). To see the seasonal change in biological water quality post-monsoon phase was carried out during December, 2017 to March, 2018. A complete list of locations with Latitude and Longitude is provided in Table 1-4.

Table 1: List of bio-monitoring locations in Uttarakhand

Sr. No.	Location Name	Location code	Site Description	Latitude (N)	Longitude (E)
1.	Haridwar Barrage (Ganga)	UK6	At Bhim gauda Barrage, First gate of Upper Ganga Canal	29.95854◦	78.17847◦
2.	Jagjeetpur STP U/S (Ganga)	UK8A	Upstream Jagjeetpur STP drain outlet	29.899040	78.141413
3.	Jagjeetpur STP D/S (Ganga)	UK8B	Near Ajeetpur village	29.887070	78.139573

Table 2: List of bio-monitoring locations in Uttar Pradesh

Sr. No.	Location Name	Location code	Site description	Latitude (N)	Longitude (E)
1.	Madhya Ganga Barrage	UP2	Madhya Ganga barrage, Bijnor	29.373889	78.040833
2.	Shukratal Ghat (Saloni River)	UP3	Bridge on Sukartal Ghat at Ban Ganga after confluence (a/c) Saloni river and before confluence (b/c) to River Ganga	29.491350	77.990090
3.	Bridge at Anupshahar (Ganga)	UP6	Road Bridge on River Ganga at Anupshar about 1 km u/s of bathing Ghat	28.365340	78.278355
4.	Barrage at Narora (Ganga)	UP8	Barrage at Narora on River Ganga	28.194925	78.403008
5.	River Ganga Kacchla Ghat	UP9	Road bridge on River Ganga near Kachla Ghat, Badaun	27.930736	78.857806
6.	Ramganga d/s of Moradabad	UP10	Bridge on Ramganga (d/s of Moradabad) at Shahbad on MDR53W	28.554944	79.049684
7.	Bridge on Kali River at Kanpur-Farrukhabad Road near Khudaganj	UP13	Bridge at Khudaganj, Kannauj d/s of River kali on bridge at Khudaganj, Kannauj	27.177257	79.676694

8.	Bridge at Ghatia Ghat on River Ganga	UP14	Ghatiya ghat bridge , Farrukhabad on River Ganga	27.398415	79.627510
9.	Bridge SH21 d/s Kannauj	UP16	Manimau bridge (Mehendi ghat), Kannauj on River Ganga a/c Ram Ganga & River Garra	27.010681	79.986332
10.	Bridge SH40 d/s Of Kannauj	UP17	Allahganj bridge, Farrukhabad on River ramganga	27.497972	79.696139
11.	Bridge at Bithoor	UP18	Pariyal bridge on River Ganga b/w Laxshman ghat & Hnuman ghat near Dhruv Teela, Bithoor,Kanpur	26.616412	80.273932
12.	Barrage U/S Kanpur	UP19	Ganga Barrage bridge, Kanpur on River Ganga	26.507240	80.317450
13.	U/s Bathing Ghat Kanpur (Deorighat) d/s Kanpur	UP24	River Ganga d/s Kanpur; Deorighat (Maharajpur)	26.378141	80.490793
14.	Bridge at KanpurI (Bridge at Shukla Ganj)	UP26	Railway bridge culvert at Bhauti on river Pandu / New Road-bridge on R. Ganga b/w Shuklaganj & Kanpur	26.467560	80.374147
15.	Bridge 2 at Kanpur NH25 (River Pandu)	UP29	Bridge on River Pandu (d/s of Kanpur), Bhingave (Hamirpur Road), Kanpur.	26.370381	80.307146
16.	Between Road rail bridge Bhruti near Panki (River Pandu)	UP29A u/s	Between Road rail culvert bridge Bhruti near Panki	26.461784	80.209589
17.	Bridge on River Ganga near Fatehpur (Asni Village)	UP32	Bridge on River Ganga at Ansi, Fatehpur / Bridge on river Pandu, Fatehpur	26.057378	80.906673
18.	Bridge d/s of tributaroy near Sirsa (pontoon bridge near Sirsa, Allahabad)	UP40	Pontoon bridge, Sirsa (Allahbad) on River Ganga	25.267700	82.093031
19.	Nalla at Allahabad 4	UP46	River Ganga d/s of discharge point Mawaiya nala (2.5mx0.5m) at Allahabad near Chitkahna Village	25.345649	81.921228
20.	Bridge on GT Road, Allahabad	UP47	Near Sangam before confluence with River Yamuna	25.437923	81.885484
21.	Varanasi Upstream	UP51	Ramnagar bridge upstream Varanasi near Ramana village	25.25574	83.027717
22.	Varanasi downstream (d/s Rajghat bridge)	UP53	Rail-Road Bridge at Rajghat (Malviva bridge), Varansi on River Ganga	25.322414	83.034520
23.	Bathing Ghat at Varanasi 1 (Puranapul)	UP54	Barrage on river Varuna 5-6 Km up stream/before confluence with River Ganga.	25.341712	83.023748
24.	Bridge on (river Gomti) tributary in Varanasi	UP55	Bridge on river Gomati b/c to Ganga at Rajwari, Varanasi U/s of River Gomati b/c to River Ganga	25.506829	83.140385

25.	Tribuatry at Rajwari (CCS Pump Canal Pumping station)	UP56	Bridge on Devkali Pump canal (Chaudhary Charan Singh Pump Canal), Jauhar ganj, Saidpur, Ghazipur D/s of River Ganga a/c River Gomati	25.537372	83.199939

Table 3: List of bio-monitoring locations in Bihar

Sr. No.	Location Name	Location code	Site description	Latitude (N)	Longitude (E)
1.	Dighaghat (Janardan Ghat) Patna	Bh7A u/s	River Ganga at Digha Ghat (U/s Patna) near rail bridge	25.653310	85.093393
2.	River Ganga at Fatuha	BH12C d/s	Kewratal ghat d/s Fatuha a/c Punpun River	25.509544	85.318221
3.	River Ganga at Malsalami	BH12	Near Patna Ghat, Malsalami	25.595747	85.244144
4.	River Ganga at Gandhi Ghat	(BH12a)	Gandhi Ghat behind NIT, Patna	25.622066	85.171140

Table 4: List of bio-monitoring locations in West Bengal

Sr. No.	Location Name	Location code	Site description	Latitude (N)	Longitude (E)
1.	1st inlet stream from west u/s of Ganga Nallah (Falgu River)	WB5	First Influent Stream from Weast on Bridge over NH34	24.504618	88.031789
2.	2nd inlet stream u/s of Ganga Nallah	WB6	Second influence stream from West	24.482660	88.056343
3.	Ganga river d/s Murshidabad (u/s Beharampore)	WB10	Road Bridge after Murshidabad, at Behrampore	24.099475	88.245433
4.	Ganga river d/s of Murshidabad (d/s of Behrampore)	WB11	Ganga watercourse d/s of Murshidabad / near under construction bridge	24.062227	88.228161
5.	Nalla opposite Ghat d/s of Srirampore	WB-22 d/s	River Ganga after c/s of Khardah Nallah at Ghat opposite d/s Srirampore/near WB21-22	22.719290	88.364127
6.	Ganga river Near Belgharia	WB23	Intake pumping Station of KMDA at Belgharia	22.670503	88.360044
7.	Nalla at Ballykhal	WB24 d/s	River Ganga after confluence of Nalla at Ballykhal near Bally bridge	22.653221	88.350386
8.	River Ganga near Howrah Bridge	WB27	Millennium Park	22.582878	88.348287
9.	River Ganga at Garden Reach	-	Garden Reach, behind CESC generating system near Surinam Ghat	22.549211	88.295512

2.0 METHODOLOGY

Bio-monitoring is the biological surveillance of benthic macro-invertebrate (BMI) communities dwelling in fresh water bodies. Benthic macro-invertebrates are of particular interest because they are a diverse group of long-lived, sedentary species that react strongly and often, predictably to changes in water quality. Taxonomic richness (Diversity Score) and composition (Saprobic Score) characterization of benthic macro-invertebrate communities is an effective method for assessing biological health of aquatic ecosystems.

2.1 Sample Collection and Preservation

Benthic macro-invertebrates sampling was carried out following the standard procedure developed in Biological laboratory, CPCB. The sampling process has been standardized according to the nature of substratum. In Uttarakhand stretch benthic macro-invertebrate sampling involved lifting and brushing of stones. In sandy river bed of Uttar Pradesh stretch net or sieve was placed firmly on river bed against river current and animals were collected into net or sieve after washing. In Bihar and West Bengal, where river bed consists of mud and silt, 5 grab samples were picked up by the shovel and samples were washed in sieve by river water and animals were picked up by forceps into tray. Unidentified specimens were preserved in formalin (4%) and brought to the laboratory for further identification.

2.2 Sample analysis

In the lab, animals were identified up to the generic level and their saprobic and diversity score was calculated. Based on the range of saprobic and diversity score values, CPCB has derived Biological Water Quality Criteria (BWQC) for water quality evaluation Table 5. This system has been developed after extensive field trials and calibration of all the saprobity and diversity information of different taxonomic groups of benthic animals collected from artificial and natural substratum of various water bodies to indicate changes in water quality to different grades of pollution level.

Table 5: Biological Water Quality Standards

Range of Saprobic Score	Range of Diversity Score	Water Quality	Water Quality Class	Indicator Colour
7 And More	0.2-1.0	Clean	A	Blue
6-7	0.5-1.0	Slight Pollution	B	Light Blue

3-6	0.3-0.9	Moderate Pollution	C	Green
2-5	0.4 –Less	Heavy Pollution	D	Orange
0-2	0-0.2	Severe Pollution	E	Red

3.0 SAPROBIC SCORE

This method involves a quantitative inventory of the presence of macro -invertebrate benthic fauna up to family/genus level of taxonomic precision. All possible families having saprobic indicator value are classified on a score scale of 1to 10 according to their preference for saprobic water quality. The families which are most sensitive to pollution are getting a score of 10 while the most pollution tolerant families are getting a score of 1 and 2. The other intermediately sensitive families are placed in between the scoring scale of 10 to1.

Enter different species within one family separately, and indicate abundancy as:

Abundance scale:

A = single (one individual)

B = scarce (2-10 individuals)

C = common (10-50 individuals)

D = abundant (50-100 individuals)

E = excessive (more than 100 individuals or only one species)

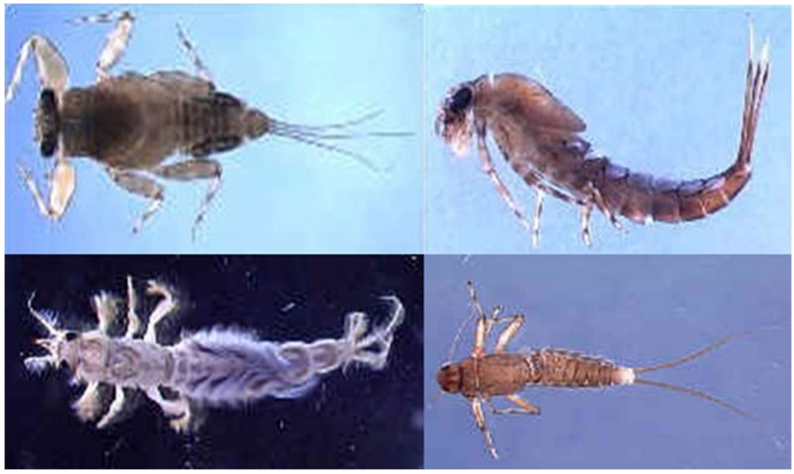
4.0 DIVERSITY SCORE

The evaluation of the benthic fauna diversity level can easily be done utilizing: the same animals collected for estimating the saprobic score. Take photograph of the living animals in the field for evidence. Since the method only involves a pair –wise comparison of sequentially encountered individuals and the differences of two specimens can easily be observed up to the genus/species level, no taxonomic skill is required.

First observed animal is always different and scored as 1 run. When the next observed animal is different from the last, a new run starts. The encounter of an individual which cannot be discerned for the last does not increment the number of runs. Size differences only do NOT change the run.

SAME RUN IS 0 (organism is same as the previous)

NEXT RUN IS 1 (organism is different from the previous)



A. Ephemeroptera

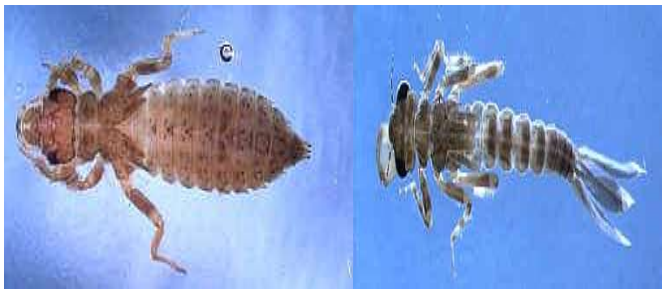
B. Trichoptera

C. Plecoptera

FIG.1: POLLUTION SENSITIVE TAXA

A. Coleoptera

B. Hemiptera



C. Odonata

FIG.2: POLLUTION INTERMEDIATE TAXA

A. Diptera

B. Mollusca

FIG.3: POLLUTION TOLERANT TAXA

5.0 FINDINGS OF BIOLOGICAL TESTING ALONG THE STRETCH OF 2255 KM:

5.1 Pre-monsoon Phase

In Uttarakhand, water quality assessment through Bio monitoring reflects gradual deterioration in water quality from clean water at Haridwar U/s (Bheemgauda Barrage) to moderate pollution at Haridwar D/s (after Jagjeetpur STP outfall) (Table 6). In Uttar Pradesh, out of 18 studied locations, biomonitoring data reflects slight pollution at 1 location i.e. Ghatia ghat at Farukhabad and severe pollution at Varanasi (old bridge). At remaining 16 locations the water quality reflects moderate pollution. In Uttar Pradesh, among 6 tributaries studied, water quality of Pandu river at Kanpur reflects severe pollution whereas water quality of remaining 5 tributaries indicate moderate pollution (Table 7). In Bihar, Ganga river water quality at all 4 monitoring locations reflects moderate pollution (Table 8). In West Bengal, biomonitoring data reflects moderate pollution at all Ganga River locations whereas, at Sirampore D/s the Ganga river water is slightly polluted (Table 9).

5.2 Post-monsoon Phase

In Uttarakhand, at Jagjeetpur STP biological water quality changes from moderate to heavy pollution (after Jagjeetpur STP outfall). Biological water quality at Haridwar Barrage found to be clean. This is the only location at entire stretch of River Ganga that comply with drinking water standards (Table 6). In Uttar Pradesh, out of 25 studied locations, 2 locations viz. bridge SH21 d/s Kannauj and River Pandu, Biological water quality were found to be in heavy pollution range. At remaining 23 locations the water quality reflects moderate pollution (Table 7). In Bihar, Ganga river water quality at all 4 monitoring locations reflects moderate pollution (Table 8). In West Bengal, biomonitoring data reflects moderate pollution at all the 9 locations (Table 9).

Fig. 4. Benthic Macroinvertebrates Sample Collection at River Ganga

5.3 Seasonal Variation in Biological Water Quality

1. In Uttarakhand, at Jagjeetpur STP u/s (UK 8a) water quality deteriorates from Slight to Moderate Pollution after monsoon while at Jagjeetpur STP d/s (UK 8b) water quality deteriorates from Moderate to Heavy Pollution after monsoon (Table 6).
2. In Uttar Pradesh, after monsoon, water quality deteriorates Slight to Moderate and from Moderate to Heavy Pollution at Bridge at Ghatia Ghat (UP14) and Bridge SH 21 d/s Kannauj (UP 16) respectively, water quality improves from Severe to Heavy and Severe to Moderate Pollution at Bridge 2 at kanpur NH25 (River Pandu) (UP29) and Bathing Ghat at Varanasi 1 (Puranapul) (UP 54) respectively (Table 7).
3. In Bihar, no seasonal variation in biological water quality was observed (Table 8).
4. In West Bengal, at one of the locations i.e. at Nalla opposite Ghat d/s of Srirampore (WB 22 d/s) water quality deteriorates from Slight to Moderate Pollution after monsoon (Table 9).

Table 6: Biological Water quality at bio-monitoring locations in Uttarakhand

Sr. No	Location Name	Location Code	Month of Sampling	Diversity Score	Saprobic Score	Biological Water Quality	Biological Water Quality Class
1.	Haridwar Barrage (Ganga)	UK6	April, 2017	0.60	7.16	Clean	A
			February, 2018	0.66	7.25	Clean	A
2.	Jagjeetpur STP U/S (Ganga)	UK8A	April, 2017	0.64	6.21	Slight Pollution	B
			February, 2018	0.77	5.94	Moderate Pollution	C
3.	Jagjeetpur STP D/S (Ganga)	UK8B	April, 2017	0.48	5.75	Moderate Pollution	C
			February, 2018	0.28	2.28	Heavy Pollution	D

Table 7: Biological Water quality at bio-monitoring locations in Uttar Pradesh

Sr. No	Location Name	Location Code	Month of Sampling	Diversity Score	Saprobic Score	Biological Water Quality	Biological Water Quality Class
1.	Madhya Ganga Barrage	UP2	May, 2017	0.54	5.47	Moderate Pollution	C
			December, 2017	0.77	4.3	Moderate Pollution	C
2.	Shukratal Ghat (Saloni River)	UP3	May, 2017	0.71	5.13	Moderate Pollution	C
			December, 2017	0.59	5.55	Moderate Pollution	C
3.	Bridge at Anupshahar (Ganga)	UP6	May, 2017	0.71	5.00	Moderate Pollution	C
			January, 2018	0.62	5.33	Moderate Pollution	C
4.	Barrage at Narora (Ganga)	UP8	May, 2017	0.66	5.25	Moderate Pollution	C
			January, 2018	0.66	4.31	Moderate Pollution	C
5.	River Ganga Kacchla Ghat	UP9	May, 2017	0.61	5.25	Moderate Pollution	C
			January, 2018	0.67	4.71	Moderate Pollution	C
6.	Ramganga d/s of Moradabad	UP10	May, 2017	0.45	4.40	Moderate Pollution	C
			January, 2018	0.43	4.56	Moderate Pollution	C
7.	Bridge on Kali River at Kanpur-Farrukhabad Road near Khudaganj	UP13	May, 2017	0.69	5.00	Moderate Pollution	C
		Location not included in Post-monsoon					
8.	Bridge at Ghatia Ghat on River Ganga	UP14	May, 2017	0.81	6.17	Slight Pollution	B
			February, 2018	0.40	5.09	Moderate Pollution	C
9.	Bridge SH21 d/s Kannauj	UP16	May, 2017	0.70	6.00	Moderate Pollution	C
			February, 2018	0.23	4.64	Heavy Pollution	D
10.	Bridge SH40 d/s Kannauj	UP17	May, 2017	0.56	4.47	Moderate Pollution	C
			February, 2018	0.60	5.10	Moderate Pollution	C
11.	Bridge at Bithoor	UP18	May, 2017	0.51	5.50	Moderate Pollution	C
			February, 2018	0.48	5.40	Moderate Pollution	C
12.	Barrage U/S Kanpur	UP19	May, 2017	0.82	4.71	Moderate Pollution	C
			February, 2018	0.70	4.77	Moderate Pollution	C

13.	U/s Bathing Ghat Kanpur (Deorighat) d/s Kanpur	UP24	May, 2017	0.76	4.76	Moderate Pollution	C
			February, 2018	0.68	4.76	Moderate Pollution	C
14.	Bridge at KanpurI (Bridge at Shukla Ganj)	UP26	May, 2017	0.80	5.28	Moderate Pollution	C
			February, 2018	0.60	5.15	Moderate Pollution	C
15.	Bridge 2 at Kanpur NH25 (River Pandu)	UP29	May, 2017	0.0	0.0	Severe Pollution	E
			February, 2018	0.29	4.0	Heavy Pollution	D
16.	Between Road rail bridge Bhruti near Panki (River Pandu)	UP29A u/s	May, 2017	0.0	0.0	Severe Pollution	E
			Location not included in Post-monsoon				
17.	Bridge on River Ganga near Fatehpur (Asni Village)	UP32	May, 2017	0.79	5.00	Moderate Pollution	C
			March, 2018	0.46	4.42	Moderate Pollution	C
18.	Bridge d/s of tributaroy near Sirsa (pontoon bridge near Sirsa, Allahabad)	UP40	May, 2017	0.71	5.14	Moderate Pollution	C
			March, 2018	0.67	5.4	Moderate Pollution	C
19.	Nalla at Allahabad 4	UP46	May, 2017	0.71	5.14	Moderate Pollution	C
			March, 2018	0.61	5.05	Moderate Pollution	C
20.	Bridge on GT Road, Allahabad	UP47	May, 2017	0.60	5.22	Moderate Pollution	C
			March, 2018	0.48	4.76	Moderate Pollution	C
21.	Varanasi Upstream	UP51	May, 2017	0.46	4.90	Moderate Pollution	C
			March, 2018	0.88	4.78	Moderate Pollution	C
22.	Varanasi downstream (d/s Rajghat bridge)	UP53	May, 2017	0.76	4.72	Moderate Pollution	C
			March, 2018	0.51	5.0	Moderate Pollution	C
23.	Bathing Ghat at Varanasi 1 (Puranapul)	UP54	May, 2017	0.06	1.67	Severe Pollution	E
			March, 2018	0.54	3.6	Moderate Pollution	C
24.	Bridge on (river Gomti) tributary in Varanasi	UP55	May, 2017	0.73	4.70	Moderate Pollution	C
			March, 2018	0.75	5.0	Moderate Pollution	C
25.	Tribuatry at Rajwari (CCS Pump Canal Pumping station)	UP56	May, 2017	0.63	5.43	Moderate Pollution	C
			March, 2018	0.84	5.09	Moderate Pollution	C

Table 8: Biological Water quality at bio-monitoring locations in Bihar

Sr. No	Location Name	Location Code	Month of Sampling	Diversity Score	Saprobic Score	Biological Water Quality	Biological Water Quality Class
1.	Dighaghat (Janardan Ghat) Patna	Bh7A u/s	June, 2017	0.63	4.93	Moderate Pollution	C
			March, 2018	0.85	5.29	Moderate Pollution	C
2.	River Ganga at Fatuha	BH12C d/s	June, 2017	0.72	5.20	Moderate Pollution	C
			March, 2018	0.49	4.64	Moderate Pollution	C
3.	River Ganga at Malsalami	BH12	June, 2017	0.79	4.5	Moderate Pollution	C
			March, 2018	0.73	4.82	Moderate Pollution	C
4.	River Ganga at Gandhi Ghat	(BH12a)	June, 2017	0.70	5.06	Moderate Pollution	C
			March, 2018	0.64	5.25	Moderate Pollution	C

Table 9: Biological Water quality at bio-monitoring locations in West Bengal

Sr. No	Location Name	Location Code	Month of sampling	Diversity Score	Saprobic Score	Biological Water Quality	Biological Water Quality Class
1.	1st inlet stream from west u/s of Ganga Nallah (Falgu River)	WB5	May, 2017	0.68	5.87	Moderate Pollution	C
			March, 2018	0.60	5.7	Moderate Pollution	C
2.	2nd inlet stream u/s of Ganga Nallah	WB6	May, 2017	0.74	5.41	Moderate Pollution	C
			March, 2018	0.87	4.82	Moderate Pollution	C
3.	Ganga river d/s Murshidabad (u/s Beharampore)	WB10	May, 2017	0.63	5.57	Moderate Pollution	C
			March, 2018	0.66	4.22	Moderate Pollution	C
4.	Ganga river d/s of Murshidabad (d/s of Behrampore)	WB11	May, 2017	0.66	5.76	Moderate Pollution	C
			March, 2018	0.56	5.57	Moderate Pollution	C
5.	Nalla opposite Ghat d/s of Srirampore	WB-22 d/s	May, 2017	0.57	6.30	Slight Pollution	B
			March, 2018	0.58	5.06	Moderate Pollution	C
6.	Ganga river Near Belgharia	WB23	May, 2017	0.62	5.37	Moderate Pollution	C

			March, 2018	0.55	4.96	Moderate Pollution	C
7.	Nalla at Ballykhal	WB24 d/s	May, 2017	0.56	5.17	Moderate Pollution	C
			March, 2018	0.56	4.93	Moderate Pollution	C
8.	River Ganga near Howrah Bridge	WB27	May, 2017	0.50	6.00	Moderate Pollution	C
			March, 2018	0.30	5.67	Moderate Pollution	C
9.	River Ganga at Garden Reach	WHG-1	May, 2017	0.09	6.00	Moderate Pollution	C
			March, 2018	0.60	5.25	Moderate Pollution	C

6.0 COMPARISON OF CURRENT FINDINGS (2017-18) WITH PREVIOUS STUDIES (2014-15 AND 2015-16)

Table 10: Bio-monitoring locations covered for biological water quality evaluation of River Ganga

States	2014-15	2015-16	2017-18	
			Pre-monsoon	Post- monsoon
Uttarakhand	06	07	03	03
Uttar Pradesh	38	39	25	25
Bihar	07	13	04	04
Jharkhand	--	04	--	--
West Bengal	15	23	09	09
Total Locations	**66**	**86**	**41**	**41**
			82	

The average biological water quality, as per the biological testing study of River Ganga conducted during past 3 consecutive years (2014-15, 2015-16 and 2017-18) in Uttar Pradesh, Bihar and West Bengal states remained the same i.e. moderately polluted. In Uttarakhand stretch, average biological water quality reflects deterioration in water quality from slight to moderate pollution (Table 11, 12 & 13).

Table 11: Bio-assessment of Ganga River Water Quality During 2014-15

State	No. of Locations	Diversity Score*	Saprobic Score*	Biological Water Quality	Biological Water

					Quality Class
Uttarakhand	6	0.49	6.03	Slight	B
Uttar Pradesh	38	0.66	4.97	Moderate	C
Bihar	7	0.65	5.21	Moderate	C
West Bengal	15	0.60	5.08	Moderate	C

**Based on average data*

Table 12: Bio-assessment of Ganga River Water Quality during 2015-16

State	No. of Locations	Diversity Score*	Saprobic Score*	Biological Water Quality	Biological Water Quality Class
Uttarakhand	8	0.67	6.26	Slight	B
Uttar Pradesh	39	0.64	5.02	Moderate	C
Bihar	13	0.64	5.17	Moderate	C
West Bengal	23	0.61	5.11	Moderate	C

**Based on average data*

Table 13: Bio-assessment of Ganga River Water Quality during 2017-18

State	No. of Locations	Diversity Score*	Saprobic Score*	Biological Water Quality	Biological Water Quality Class
Uttarakhand	3	0.57	5.76	Moderate	C
Uttar Pradesh	25	0.59	4.71	Moderate	C
Bihar	4	0.69	4.94	Moderate	C
West Bengal	9	0.58	5.42	Moderate	C

**Based on average data*

7.0 COMPARISON OF BIOLOGICAL WATER QUALITY OF RIVER GANGA (2014-18)

Table 14 revealed summary of comparison of Biological water quality of River Ganga during 4 rounds of biological testing in Uttarakhand stretch of the River Ganga, at Haridwar barrage (UK-6) biological water quality improves from Slight pollution to clean. However, downstream of Jagjeetpur STP outfall is one of the most impactful location on entire stretch where a gradual deterioration of water quality was observed from clean to heavy pollution in consecutive 4 years.

In Uttar Pradesh stretch, biological water quality is consistently moderately polluted in all the rounds during the period from 2014 to 2018 except River Ganga of mainstream in Kannuaj (UP 16) after confluence with 2 tributaries i.e. River Ramganga and Garra where river water is in Heavy Pollution range in Post-monsoon season during 2017-18. Tributaries such as Ramganga, Pandu, Varuna etc. were found to be more impactful locations with respect to biological water quality before confluence with the mainstream of River Ganga. Biological water quality of tributary River Ramganga d/s of Moradabad (UP 10) is found to be improved from Heavy (2014-16) to Moderate Pollution in the following year (2017-18). River Pandu was found to be biologically dead in the pre-monsoon sampling of 2017-18 (Severe Pollution) while oligochaetes colonization was observed in abundance (Total no. 256) after monsoon (Heavy pollution). Biological water quality of River Varuna was found to be improved from Severe to Moderate pollution after monsoon (2017-18). Subsequently, biological water quality of River Ganga after confluence with River Tons (UP 40) observed to be degraded from Slight (2014-15) to Moderate Pollution [2015-16; 2017-18 (pre- & post-monsoon)]. Biological water quality of River Ganga at Ghatia ghat, Farrukhabad (UP14) was found to be moderately polluted during 2014-15; 2015-16 & 2017-18 (Post-Monsoon) whereas in pre-monsoon season of 2017-18, it was found to be slightly polluted.

In Bihar, River Ganga at Gandhi ghat in Patna city (BH 12a) was in Heavy Pollution range during 2015-16 while all other locations in all rounds of bio-monitoring were consistently found moderately polluted.

In West Bengal, River Ganga downstream of Srirampore (WB 22 downstream) was found in Slight pollution range during 2017-18 (pre-monsoon) while all other locations in all rounds of bio-monitoring were consistently found in moderate pollution range.

Locational details attached at Annexure-I.

Table 14: Comparison of Biological Water Quality of River Ganga (2014-18)

Location City	Code	2014-15 (First Round)				2015-16 (Second Round)				2017-18 pre-monsoon				2017-18 post-monsoon			
		DS	SS	BWQ	BWQC	DS	SS	BWQ	BWQC	DS	SS	BWQ	BWQC	DS	SS	BWQ	BWQC
Haridwar	Uk6	0.79	6.5	Slight	B	0.68	6.28	Slight	B	0.6	7.16	Clean	A	0.66	7.25	Clean	A
Jagjeetpur	UK8a	-	-	-	-	7.5	0.8	Clean	A	0.64	6.21	Slight	B	0.77	5.94	Moderate	C
Jagjeetpur	UK8b	0.6	7.16	Clean	A	0.64	6.21	Slight	B	0.48	5.75	Moderate	C	0.28	2.28	Heavy	D
Bijnour	UP2	0.54	3.7	Moderate	C	0.77	4.17	Moderate	C	0.54	5.47	Moderate	C	0.77	4.3	Moderate	C
Muzaffarnagar	UP3	0.84	4.2	Moderate	C	0.78	4.93	Moderate	C	0.71	5.13	Moderate	C	0.59	5.55	Moderate	C
Anupshahr	UP6	0.89	5.09	Moderate	C	0.65	4.44	Moderate	C	0.71	5	Moderate	C	0.62	5.33	Moderate	C
Narora	UP8	0.77	4.54	Moderate	C	0.84	5.13	Moderate	C	0.66	5.25	Moderate	C	0.66	4.31	Moderate	C
Badaun	UP9	0.77	5.43	Moderate	C	0.8	5.3	Moderate	C	0.61	5.25	Moderate	C	0.67	4.71	Moderate	C
Muradabad	UP10	0.4	3.8	Heavy	D	0.4	4.25	Heavy	D	0.45	4.4	Moderate	C	0.43	4.56	Moderate	C
Khudaganj	UP13	0.56	5	Moderate	C	0.74	5.9	Moderate	C	0.69	5	Moderate	C	-	-	-	-
Ghatia Ghat	UP14	0.79	4.6	Moderate	C	0.61	5.27	Moderate	C	0.81	6.17	Slight	B	0.4	5.09	Moderate	C
Kannauj	UP16	-	-	-	-	-	-	-	-	0.7	6	Moderate	C	0.23	4.64	Heavy	D
Kannauj	UP17	-	-	-	-	-	-	-	-	0.56	4.47	Moderate	C	0.6	5.1	Moderate	C
Bithoor	UP18	0.71	5.78	Moderate	C	0.675	5	Moderate	C	0.51	5.5	Moderate	C	0.48	5.4	Moderate	C
Kanpur	UP19	0.78	5.33	Moderate	C	0.7	4.81	Moderate	C	0.82	4.71	Moderate	C	0.7	4.77	Moderate	C
Kanpur	UP24	0.7	5.5	Moderate	C	0.49	4.75	Moderate	C	0.76	4.76	Moderate	C	0.68	4.76	Moderate	C
Shuklaganj	UP26	-	-	-	-	-	-	-	-	0.8	5.28	Moderate	C	0.6	5.15	Moderate	C
Pandu River	UP29	0.46	4.72	Moderate	C	0.76	4	Moderate	C	0	0	Severe	E	0.29	4	Heavy	D
Pandu River	UP29A u/s	-	-	-	-	-	-	-	-	0	0	Severe	E	-	-	-	-
Fatehpur	UP32	0.73	4..80	Moderate	C	0.59	5.66	Moderate	C	0.79	5	Moderate	C	0.46	4.42	Moderate	C
Allahabad	UP40	0.61	6.2	Slight	B	0.54	4.28	Moderate	C	0.71	5.14	Moderate	C	0.67	5.4	Moderate	C
Allahabad	UP46	-	-	-	-	-	-	-	-	0.71	5.14	Moderate	C	0.61	5.05	Moderate	C
Allahabad	UP47	-	-	-	-	-	-	-	-	0.6	5.22	Moderate	C	0.48	4.76	Moderate	C
Varanasi	UP51	0.54	5.1	Moderate	C	0.5	5.42	Moderate	C	0.46	4.9	Moderate	C	0.88	4.78	Moderate	C
Varanasi	UP53	0.53	4.55	Moderate	C	0.47	5.3	Moderate	C	0.76	4.72	Moderate	C	0.51	5	Moderate	C
Varanasi	UP54	0.59	4.9	Moderate	C	0.68	4.9	Moderate	C	0.06	1.67	Severe	E	0.54	3.6	Moderate	C
Varanasi	UP55	0.64	5.6	Moderate	C	0.65	5.4	Moderate	C	0.73	4.7	Moderate	C	0.75	5	Moderate	C
Varanasi	UP56	-	-	-	-	-	-	-	-	0.63	5.43	Moderate	C	0.84	5.09	Moderate	C
Patna	Bh7A u/s	0.4	6.11	Moderate	C	0.66	5.25	Moderate	C	0.63	4.93	Moderate	C	0.85	5.29	Moderate	C

Patna	**BH12C d/s**	-	-	-	-	-	-	-	-	0.72	5.2	Moderate	C	0.49	4.64	Moderate	C
Patna	**BH12**	-	-	-	-	-	-	-	-	4.5	0.79	Moderate	C	4.82	0.73	Moderate	C
Patna	**BH12a**	0.76	5.08	Moderate	C	0.16	3.71	Heavy	D	0.7	5.06	Moderate	C	0.64	5.25	Moderate	C
Falgu River	**WB5**	-	-	-	-	0.81	5.6	Moderate	C	0.68	5.87	Moderate	C	0.6	5.7	Moderate	C
Falgu River	**WB6**	-	-	-	-	0.67	5.1	Moderate	C	0.74	5.41	Moderate	C	0.87	4.82	Moderate	C
Murshidabad	**WB10**	-	-	-	-	0.65	5.94	Moderate	C	0.63	5.57	Moderate	C	0.66	4.22	Moderate	C
Behrampore	**WB11**	0.7	4.65	Moderate	C	0.58	5.86	Moderate	C	0.66	5.76	Moderate	C	0.56	5.57	Moderate	C
Srirampore	**WB-22 d/s**	0.66	5.69	Moderate	C	-	-	-	-	0.57	6.3	Slight	B	0.58	5.06	Moderate	C
Belgharia	**WB23**	0.33	6	Moderate	C	-	-	No Collection	High Tide	0.62	5.37	Moderate	C	0.55	4.96	Moderate	C
Ballykhal	**WB24 d/s**	-	-	-	-	-	-	-	-	0.56	5.17	Moderate	C	0.56	4.93	Moderate	C
Howrah Bridge	**WB27**	-	-	-	-	0.38	6	Moderate	C	0.5	6	Moderate	C	0.3	5.67	Moderate	C
Garden Reach	**WHG-1**	-	-	-	-	-	-	-	-	0.09	6	Moderate	C	0.6	5.25	Moderate	C

DS- Diversity Score; SS- Saprobic Score; BWQ- Biological water quality w.r.t. pollution; BWQC- Biological water quality class

Note: Total 93 unique locations were covered during 2014-16.Out of which 66 locations were covered in first round and 86 locations were covered in second round.

Annexure-I

Locational Details of River Ganga

Sr. No.	Location Name	Location code
1.	Haridwar Barrage (Ganga)	UK6
2.	Jagjeetpur STP U/S (Ganga)	UK8a
3.	Jagjeetpur STP D/S (Ganga)	UK8b
4.	Madhya Ganga Barrage	UP2
5.	Shukratal Ghat (Saloni River)	UP3
6.	Bridge at Anupshahar (Ganga)	UP6
7.	Barrage at Narora (Ganga)	UP8
8.	River Ganga Kacchla Ghat	UP9
9.	Ramganga d/s of Moradabad	UP10
10.	Bridge on Kali River at Kanpur-Farrukhabad Road near Khudaganj	UP13
11.	Bridge at Ghatia Ghat on River Ganga	UP14
12.	Bridge SH21 d/s Kannauj	UP16
13.	Bridge SH40 d/s Of Kannauj	UP17
14.	Bridge at Bithoor	UP18
15.	Barrage U/S Kanpur	UP19
16.	U/s Bathing Ghat Kanpur (Deorighat) d/s Kanpur	UP24
17.	Bridge at KanpurI (Bridge at Shukla Ganj)	UP26
18.	Bridge 2 at Kanpur NH25 (River Pandu)	UP29
19.	Between Road rail bridge Bhruti near Panki (River Pandu)	UP29a upstream
20.	Bridge on River Ganga near Fatehpur (Asni Village)	UP32
21.	Bridge d/s of tributaroy near Sirsa (pontoon bridge near Sirsa, Allahabad)	UP40
22.	Nalla at Allahabad 4	UP46
23.	Bridge on GT Road, Allahabad	UP47
24.	Varanasi Upstream	UP51
25.	Varanasi downstream (d/s Rajghat bridge)	UP53
26.	Bathing Ghat at Varanasi 1 (Puranapul)	UP54
27.	Bridge on (river Gomti) tributary in Varanasi	UP55
28.	Tribuatry at Rajwari (CCS Pump Canal Pumping station)	UP56
29.	Dighaghat (Janardan Ghat) Patna	Bh7A upstream
30.	River Ganga at Fatuha	BH12c downstream
31.	River Ganga at Malsalami	BH12
32.	River Ganga at Gandhi Ghat	BH12a
33.	1st inlet stream from west u/s of Ganga Nallah (Falgu River)	WB5
34.	2nd inlet stream u/s of Ganga Nallah	WB6
35.	Ganga river d/s Murshidabad (u/s Beharampore)	WB10
36.	Ganga river d/s of Murshidabad (d/s of Behrampore)	WB11
37.	Nalla opposite Ghat d/s of Srirampore	WB-22 downstream
38.	Ganga river Near Belgharia	WB23
39.	Nalla at Ballykhal	WB24 downstream
40.	River Ganga near Howrah Bridge	WB27
41.	River Ganga at Garden Reach	WHG-1

8.0 CONCLUSION

It can be concluded that various physico-chemical and bacterial parameters (including BOD, COD, DO, temperature, pH, total coliforms, faecal coliforms etc.) provide only the momentary account of water quality i.e. water quality that prevails at that particular time of monitoring. Biological monitoring, on the other hand, has much longer dimension since the aquatic biota can be affected by chemical and/or hydrological events that may have lasted only a few days, some months or even years before monitoring was carried out. Bio-monitoring of River Ganga at/ near Real Time Water Quality Monitoring Stations thus indicated that in Uttarakhand, Jagjeetpur STP outlet is adding a lot of pollutants as observed by change in biological water quality from B to C class downstream to STP outlet. In Uttar Pradesh, 2 major tributaries namely River Pandu and River Varuna are increasing pollution load of mainstream of River Ganga as found to be severely polluted before their confluence point. On mainstream of River Ganga although none of the locations were found to be severely polluted but most are in moderate pollution range. Therefore, efforts must be made to control the pollution so that all locations may comply with at least 'B' class water quality.

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