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Eco-status of Ramganga, Kali, Karmnasa, Yamuna, Ghagra and Gomti tributaries in middle stretch of river Ganga

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ABSTRACT

It is important to monitor tributaries of river Ganga for the sustainable development, as each tributary has its own water quality and productivity. For the present investigation the samples were taken from the River Ramganga, Kali, Karmnasa, Yamuna, Ghagra and Gomti, which are important tributaries of the river Ganga in middle stretch. Their water quality parameters like Temperature, pH, DO, BOD, Alkalinity, Specific conductivity, TDS, Hardness, Nutrients, Gross and Net productivity and Chloride were studied during winter and summer of 2017. Total dissolved solids carried by these tributaries were 275 ppm-Ramganga, 143 ppm -Ghagra, 282 ppm -Kali, 186 ppm -Karmnasa, 271 ppm -Gomti- and 294 ppm-Yamuna and Chloride was 54 ppm-Ramganga,38.3 ppm -Ghagra, 70ppm-Kali,48 ppm- Karmnasa, 55.8 ppm – Gomti, and-83.7 ppm Yamuna. Dissolved oxygen ranged from 7.6 to 11.2 ppm, and BOD ranged from 0.8 to 3.4ppm (Yamuna and Kali).Water temp. ranged from 15-21.8 (winter) and 30-36.2 (summer).Specific conductivity ranged from 230 ppm (Ghagra) to 763 (Yamuna). Plankton analysis revealed dominance of Bacillariophyceae in Ramganga, Ghagra, Karmnasa, Chlorophyceae in Gomti and Myxophyceae in Yamuna and Kali. Other planktonic groups were Euglenophyceae, Protozoa, Rotifera and Crustacea. Bacillariophyceae ranged from 21% (Ghagra) to 69.5 %(Karmnasa), Chlorophyceae from 6 (Karmnasa) to 57.8 (Gomti). Reduction in Bacillariophyceae and increase in Myxophyceae was remarkable feature in the river Yamuna as compared to previous studies. Average Myxophyceae contribution was recorded as, 40 % in Kali, 44% in Yamuna, 11 % In Ramganga, 15% in Karmnasa, 22% in Ghagra and 20% in Gomti Suggesting that all the rivers are passing through anthropogenic and environmental stress. Palmer pollution index was also higher for Yamuna and Kali rivers.

INTRODUCTION

The Ganga is the utmost significant river of India both from the point of view of its basin and cultural concern. The important arms of river Ganga are the Ramganga, the Gomati, the Ghaghara, the Gandak, the Kosi and the Mahanada. The river finally discharges itself into the Bay of Bengal near the Sagar Island. These tributaries are the small rivers of Ganga river basin. Their source of origin is different but they merge with the river at confluence points and affects water quality because each tributary carry its own water quality and ecology. As NMCG (National Mission for Clean Ganga) project was launched for cleaning of the river Ganga which was badly affected by discharge of industrial effluents, agricultural runoff and domestic waste. Therefore to clean Ganga it is necessary to clean whole Ganga river system (all small and big adjoining tributaries). Fishes and plankton are important as they indicate the ecological processes and the producer-consumer interactions (Dwivedi *et al.*, 2016). Exploitation of aquatic resources in river and streams are an economic activity governed by social needs and pressures (Dwivedi and Nautiyal, 2012; Mayank and Dwivedi, 2015 and Dwivedi *et al*., 2014).

Plankton being the primary producers, are the micro-organisms for fish food, also indicate water quality and productivity of the river. Nature of fauna and flora and water chemistry, just before mixing with the river Ganga, is presented in this paper. Yet it is in preliminary observation, even then, might be useful to improve the river Ganga in NMCG mission.

MATERIALS AND METHODS

Hydro biological samples were collected from the river Ramganga, Ghagra, Kali, Karmnasa, Gomti and Yamuna, just before the confluence with the river Ganga, during the year 2017 (summer and winter seasons). For plankton analysis fifty liters of water was filtered and fixed in 4% formaldehyde for further analysis (Welch, 1956) and water quality parameters were analyzed according to APHA (2010). The Pollution index was calculated according to Palmer (1969).

RESULTS AND DISCUSSION

Water quality

Water quality of the tributaries during winter is presented in Table-1**.** Air temperature in winter varied from 12.5 ^{0}C (Ramganga) to 27.3 ^{0}C (Yamuna) and water temp from 15^{0}C (Ramganga) to 21.8 ^{0}C (Yamuna). So air temp difference was 14.8^{0}C while water temp ,6.8^{0}C.Transperancy ranged from 16 Cm (Kali) to 45 Cm (Karmnasa), and pH from 7.7 (Karmnasa & Ghagra), to 8.2 (Kali). Alkalinity was maximum in Gomti followed by Karmnasa and Yamuna. Chloride was maximum in Yamuna (99.4 ppm) and minimum in Ghagra (11.36 ppm). Dissolved oxygen ranged from 7.6 ppm (Yamuna) to 11.2 (Kali). Specific conductivity ranged between 300.9 (Ghagra) to 763.4 (Yamuna), TDS 172.1 ppm (Ghagra) to 436.5 (Yamuna), BOD from 0.8 ppm (Ghagra) to 3.28 (Yamuna), and hardness from 172 ppm (Ghagra) to 244 ppm (Gomti). Silicate was maximum in river Karmnasa (5.2 ppm).

Water quality of the tributaries during summer is presented in Table-2. Air temperature was constant (22^{0}C while water temp varied slightly and ranged from 30^{0}C (Yamuna) to 36.2 ^{0}C (Karmnasa).Transparency ranged from 20 Cm (Kali) to 51 Cm (Ghagra), and pH from 7.3 (Gomti), to 7.8 (Yamuna & Ghagra). Alkalinity was maximum in Kali followed by Karmnasa and Gomti. Chloride was maximum in Ramganga (79.5 ppm) and minimum in (Kali). (48.2 ppm).Dissolved oxygen ranged from 7.6 ppm (Yamuna) to 9.2 (Kali, Ramganga). Specific conductivity ranged between 230 um (Ghagra) to 372 um (Kali, Ramganga), TDS from 101 ppm (Karmnasa) to 241 (Kali, Ramganga), BOD from 2.1 ppm (Ramganga) to 3.4(Ghagra),and hardness from 76 ppm (Ghagra)to 172 ppm (Karmnasa). Silicate was maximum in river Yamuna (5.7 ppm).

Plankton

During winter plankton abundance (Table3) was maximum in river Kali 2630 ul^{-1} followed by Ramganga (1480 ul^{-1}), Yamuna 750 ul^{-1}, Karmnasa 230 ul^{-1}, Gomti 160 ul^{-1} and Ghagra 60 ul^{-1}. Bacillariophyceae contribution ranged from 25% (Gomti) to 69.5% (Karmnasa), Chlorophyceae from 21.7 (Karmnasa) to 43.7% (Gomti), Myophyceae from 1.4% (Ramganga) to 31.2% (Gomti). Euglenophyceae was recorded in river Kali (9.5%) only. Crustaceans were present in the river Ramganga (2.8%) and Yamuna (16%). Rotifers were observed in Ramganga (3.4%), Kali (3.4%), and Yamuna (18.6%). While during summer season plankton abundance (Table4) was maximum in river Karmnasa 4650 ul^{-1} followed by Ramganga (2590 ul^{-1}), Gomti 1330ul^{-1}, Kali 940 ul^{-1} Yamuna 650 ul^{-1}, and Ghagra 600 ul^{-1}. Bacillariophyceae contribution ranged from 17% (Yamuna, Kali) to 56.1% (Karmnasa), Chlorophyceae from 6% (Karmnasa) to 57.8% (Gomti), Myophyceae from 9.8% (Gomti) to 75.5% (Kali and 73.8% Yamuna). Euglenophyceae was recorded in river Ramganga (2.3%) and Gomti 4.5% only. Crustaceans were present in the river Ramganga (1.9%),Gomti 2.3 % and Karmnasa (2.3%). Rotifers were observed in above three rivers and ranged from 0.8% (Ramganga) to 3% (Gomti). Protozoans were noticed in Ramganga only (2.7%). Dominant taxa of these tributaries were as follows-

1. *Ramganga*

Bacillariophyceae- *Cyclotella, Melosira, Nitzschia, Navicula*
Chlorophyceae- *Ankistrodesmus, Scenedesmus, Coelestrum, Actinastrum*
Myxophyceae- *Oscillatoria,Aphanezomenon*
Euglenophyceae-*Phacus, Lepocynclis*
Rotifera- *Brachionus*
Crustacea- *Ceriodaphnia*

2. *Ghagra*

Bacillariophyceae- *Melosira,*
Chlorophyceae- *Tribonema, Protococcus, Westella*
Myxophyceae- *Oscillatoria, Phormidium*

3. *Kali*

Bacillariophyceae- *Cyclotella, Melosira, Navicula, Nitzschia*
Chlorophyceae- *Tribonema, Scenedesmus, Ankistrodesmus*
Myxophyceae- *Oscillatoria, Aphanezomenon, Spirulina, Anabaena*
Rotifera- *Brachionus*

4. *Karmnasa*

Bacillariophyceae- *Melosira, Navicula*
Chlorophyceae- *Ankistrodesmus, Scenedesmus, Pediastrum*
Myxophyceae- *Oscillatoria, Phormidium, Merismopedia, Microcystis*
Crustacea- *Bosmina, Moina, Cyclops, Sida, Macrothrix*
Rotifera- *Brachionus*

5. *Gomti*

Bacillariophyceae- *Cyclotella, Melosira, Nitzschia,*
Chlorophyceae- *Coelestrum, Microspora ,Staurastrum*
Myxophyceae- *Anabaena, Phormidium*
Euglenophyceae- *Lepocynclis*
Crustacea- *Ceriodaphnia*
Rotifera- *Brachionus,Keratella*

6. *Yamuna*

Bacillariophyceae- *Cyclotella, Melosira, Nitzschia, Navicula*
Chlorophyceae-Oedogonium, *Ankistrodesmus*
Myxophyceae- *Anabaena, Phormidium, Merismopedia*
Rotifera- *Brachionus,Keratella*

Table 1: Winter Physico-chemical parameters of tributary

Parameters	Ramganga	Ghaghra	Kali	Karamnasa	Gomti	Yamuna
Air temp. (^{0}C)	12.5	26.5	24.6	26.2	27	27.3
Water temp. (^{0}C)	15	20.8	18.6	21.7	20.2	21.8
Transp. (c.m)	24	23	16	45.0	38	42.0
pH	7.8	7.7	8.2	7.7	7.9	7.8
CO_2 (ppm)	Nil	0	4	0	0	0
CO_3 (ppm)	6	7	Nil	9.0	38	9.0
HCO_3 (ppm)	110	142	216	218.0	236	204.0
Chloride (ppm)	28.4	11.36	92	17.04	45.44	99.4
D.O (ppm)	8.8	7.52	11.2	10.08	8.24	7.6
Sp. Cond. (µS)	543	300.9	564	475.9	560.4	763.4
TDS (ppm)	310	172.1	323	272	321.8	436.5
T. Hardness (ppm)	224	172	180	204.0	244	236.0
Calcium (ppm)	48.1	16.83	40.08	19.24	28.86	41.68
Magnesium (ppm)	25.2	31.57	19.4	37.88	41.76	32.03
Phosphate (ppm)	0.25	0.042	0.015	0.027	0.114	0.097
Silicate (ppm)	3.29	1.85	1.29	5.214	0.526	3.018
D.O.M (ppm)	2.7	0.98	5.78	0.79	1.95	2.7
G.P	Na	83.33	33	75.0	58.33	66.67
N.P		49.99	80	50.0	33	41.67
Respiration		40	56	30.0	30	30.0
B.O.D (ppm)	2.08	0.8	3.2	2.24	1.2	3.28

Table 2: Summer Physico-chemical parameters of tributary

Parameters	Ramganga	Ghaghra	Kali	Karamnasa	Gomti	Yamuna
Air temp.(^{0}C)	22	22	22	22	22	22
Water temp. (^{0}C)	31.9	33	33.4	36.2	32	30
Transp. (c.m)	21	51	20	32	20	36
pH	7.7	7.8	7,7	7.7	7.3	7.8
CO_2 (ppm)	14	0	0	0	0	0
CO_3 (ppm)	Nli	12	38	18	26	18
HCO_3 (ppm)	94	72	108	104	92	70
Chloride (ppm)	79.52	65.3	48.2	79.52	66.2	68
D.O (ppm)	9.28	8.2	9.28	8.16	8.7	7.6
Sp. Cond. (µS)	372	230	372	263	334	235
TDS (ppm)	241	114.1	241	101.3	222	152
T. Hardness(ppm)	76	148	120	172	84	96
Calcium (ppm)	14.4	22.4	22.4	19.24	17.6	16.0
Magnesium (ppm)	9.7	22.3	15.2	30.11	9.7	13.6
Phosphate (ppm)	0.073	0.05	0.16	0.153	0.07	0.511
Silicate (ppm)	1.94	3.85	2.15	1.016	2.91	5.756
D.O.M (ppm)	0.60	1.5	1.125	1.43	0.94	**3.30**
B.O.D (ppm)	2.1	3.1	2.4	2.8	2.6	2.8

Table 3: Winter plankton of tributaries

Groups	Ramganga	Ghaghra	Kali	Karamnasa	Gomti	Yamuna
Bacillariophyceae (u/l)	880	40	1350	160	40	210
%	59.4	66.6	56.7	69.5	25	28
Chlorophyceae (u/l)	490	20	600	50	70	170
%	33.1	33.3	25.2	21.7	43.7	22.7
Myxophyceae (u/l)	20	0	90	20	50	110
%	1.4	0	3.8	8.7	31.2	14.6
Euglenophyceae (u/l)	0	0	250	0	0	0
%	0	0	10.5	0	0	0
Crustaceans (u/l)	40	0	0	0	0	120
%	2.8	0	0	0	0	16
Rotifera (u/l)	50	0	90	0	0	140
%	3.4	0	3.8	0	0	18.6
Protozoa (u/l)	0	0	0	0	0	0
%	0	0	0	0	0	0
Total Plankton (u/l)	1480	60	2630	230	160	750

Table 4: Summer plankton of tributaries

Groups	Ramganga	Ghaghra	Kali	Karamnasa	Gomti	Yamuna
Bacillariophyceae (u/l)	860	130	160	3170	310	110
%	33.2	21.7	17	68.2	23.3	16.9
Chlorophyceae (u/l)	990	210	70	280	770	60
%	38.2	35	7.4	6	57.8	9.2
Myxophyceae (u/l)	540	260	710	970	130	480
%	20.8	43.3	75.5	20.9	9.8	73.8
Euglenophyceae (u/l)	60	0	0	0	60	14
%	2.3	0	0	0	4.5	0
Crustaceans (u/l)	50	0	0	130	20	0
%	1.9	0	0	2.3	1.5	0
Rotifera (u/l)	20	0	0	100	40	0
%	0.8	0	0	2.1	3	0
Protozoa (u/l)	70	0	0	0	0	0
%	2.7	0	0	0	0	0
Total Plankton (u/l)	2590	600	940	4650	1330	650

Table 5: Winter Palmer Pollution Index of Tributary

Genera	P.I.	Ramganga	Ghaghra	Kali	Karamnasa	Gomti	Yamuna
Synedra	2	P	P	P	P	A	P
Cyclotella	1	P	A	P	A	A	P
Navicula	3	P	P	P	P	P	P
Melosira	1	P	A	P	P	P	P
Nistzschia	3	P	A	P	A	P	P
Gomphonema	1	A	P	A	A	A	A
Ankistrodesmus	2	P	P	P	P	P	P
Closterium	1	A	A	P	A	A	A
Scnedesmus	4	P	P	P	P	P	P
Chlorella	3	P	A	P	A	A	A
Pandorina	1	A	A	A	A	A	A
Microcystis	1	P	A	P	A	P	P
Oscillatoria	5	A	A	P	A	P	A
Phormidium	1	P	A	P	P	P	P
Euglena	5	A	A	P	A	A	P
Lepocynclis	1	A	A	P	A	A	A
Phacus	2	A	A	P	A	A	A
Chlamydomonas	4	A	A	A	A	A	A
Total score		21	12	35	13	20	23

In the present study water quality parameters revealed that river Kali, Ramganga, Yamuna and Gomti were found as more polluted rivers while Karmnasa and Ghagra, as less polluted rivers. This observation is also confirmed by plankton analysis of tributaries. Palmer pollution index based on algal genera of these tributaries are presented in

Table 5 and 6. According to this index, score of River Kali, Ramganga, Yamuna and Gomti was recorded above twenty in the seasons, indicating that these rivers were found as polluted rivers .The load of total dissolve solids and chloride, carried by them, indicated that river Yamuna and Kali carrying maximum load (TDS and CL) to the river Ganga. While Ghagra and Karamnasa exhibited their score below 20. Earlier studies on pollution status of R. Gomti (Bhaskaran *et al.*, 1965) and river Kali (George *et al.*, 1965) depicted that both the rivers were heavily polluted since long by the discharge of paper factory, distillery sewage and other industries.

Table 6: Summer palmer pollution index of tributary

Genera	**P.I.**	**Ramganga**	**Ghaghra**	**Kali**	**Karamnasa**	**Gomti**	**Yamuna**
Synedra	2	P	P	A	A	P	P
Cyclotella	1	P	P	P	A	A	P
Navicula	3	P	A	A	P	P	P
Melosira	1	P	P	P	P	P	P
Nistzschia	3	P	A	P	A	P	P
Gomphonema	1	A	A	P	A	A	p
Ankistrodesmus	2	P	P	P	P	P	P
Closterium	1	A	A	A	A	P	P
Scnedesmus	4	P	P	P	P	P	P
Chlorella	3	A	A	P	A	A	P
Pandorina	1	A	A	A	A	A	P
Microcystis	1	A	P	P	P	P	P
Oscillatoria	5	A	P	P	P	P	P
Phormidium	1	P	P	P	P	P	P
Euglena	5	A	A	P	A	A	A
Lepocynclis	1	P	A	A	A	P	A
Phacus	2	P	A	A	A	A	A
Chlamydomonas	4	P	A	A	A	A	A
Total score		**24**	**17**	**27**	**17**	**24**	**29**

Abundance of Centric diatoms (*Melosira* sp.) and members of Chlorococcales as observed in our present study are characteristics of polluted waters (Hutchinson 1957). Bilgrami *et al.* (1985) recorded *Euglena*sps, *Oscillatoriasps, Microsystissps, Chlorella sp, Ankistrodesmussps, Scenedesmussps, Synedra ulna, Nitzschia* and *Navicula sp* from sewage polluted sites from the river Ganga between Patna to Farakka. Myxophyceae being developed luxuriantly in water, rich in organic load can be considered as pollution indicator or poor water quality (Ngodhe *et al.*, 2013). On the above basis Yamuna and Kali river tributary can be treated as polluted due to presence of 44% and 40% Myxophyceae respectively Qualitative and quantitative studies on plankton and physicochemical parameter were made on the river Yamuna (Chakraborty *et. al*, 1959; Ray *et al.*, 1966) in a few km above the confluence of the Ganga and Yamuna. Reduction in Bacillariophyceae and increase in Myxophyceae (Fig.1) was remarkable in the river Yamuna as compared to previous studied by Ray *et al.* (1966). This was subsequently followed by the workers of the CIFRI, Barracpore (Singh *et al.*, 2015) in a longer stretch of river Yamuna at Agra, Mathura, Etawa and Allahabad.

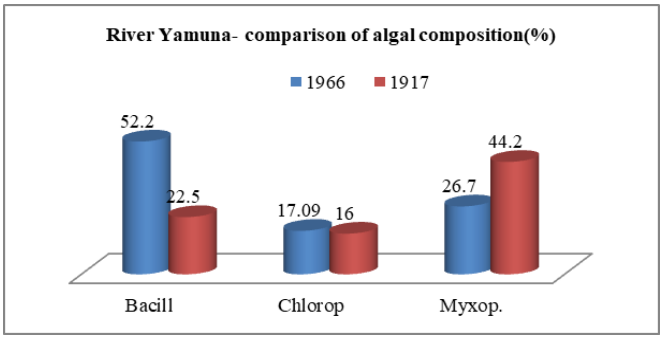

Fig. 1: Comparison of major algal groups of the river Yamuna at Allahabad

Zooplanktons were noticed in all the tributaries, mostly in summer season. River Yamuna revealed its maxima in winters (34.6%).Similarly; winter abundance of zooplankton in Yamuna was also reported by (Ray *et al.*, 1966). On the basis of Rotifers, as they are also indicator of aquatic pollution (Laal, 1993.), they were noticed in all the rivers except Ghagra river. So each tributary has its own water quality, algal composition, planktonic growth behavior, development of zooplankton, seasonality etc. When they join with the river Ganga, they will affect Ganga water quality definitely. Therefore to clean Ganga in a sustainable way, it is important to monitor its tributaries regularly.

CONCLUSION

Each tributary has its own water quality, algal composition, planktonic growth behavior, development of zooplankton, seasonality etc. When they join with the river Ganga, they will affect Ganga water quality. Water quality parameters revealed that river Kali, Ramganga, Yamuna and Gomti were found as more polluted rivers while Karmnasa and Ghagra, as less polluted rivers. River Yamuna and Kali carrying maximum load of total dissolved solids and Chloride to the river Ganga. This observation is also confirmed by plankton analysis of tributaries**.** Plankton analysis revealed dominance of Bacillariophyceae in Ramganga, Ghagra, Karmnasa, Chlorophyceae in Gomti and Myxophyceae in Yamuna and Kali. Abundance of Centric diatoms (*Melosira* sp.) and members of Chlorococcales as observed in our present study are characteristics of polluted waters.

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