BENTHIC DIVERSITY OF RIVER GOMTI IN RELATION TO THE PREVAILING ENVIRONMENTAL CONDITIONS IN LUCKNOW

P. K. Varshney, R. K. Agrahari*, S. K. Singh and A. K. Jain†
National Bureau of Fish Genetic Resources, Canal Ring Road, Dilkhusha, Lucknow - 226 002, India
**Rohtak Centre of Central Institute of Fisheries Education, Lahli, Via Anwal, Rohtak - 124 411, India*
†Fisheries Division, ICAR Research Complex for Eastern Region, ICAR Parisar, Patna – 800 014, India

ABSTRACT

To evaluate the benthic diversity of River Gomti in relation to the prevailing environmental conditions, four stations, *viz.*, Maa Chandrika Devi, Daliganj, Ambedkar Park and Aquaduct, were identified from upstream to downstream along the course of the river in Lucknow. Dissolved oxygen was low on many occasions at all the stations except Maa Chandrika Devi and chemical oxygen demand values were high. There was a gradual increase in mean nitrite and phosphate values from up to down stream. Benthic fauna was dominated by oligochaetes and chironomus larvae. Other groups reported were leeches, nematodes, sponges, crustaceans, pelycypodes, gastropodes and fish fry. Population density was exceptionally high at Daliganj (20,135 m^{-1}) followed by Ambedkar Park (5,199 m^{-1}) and Aquaduct (3,287 m^{-1}), and low at Maa Chandrika Devi (264 m^{-1}). Oligochaete genera common at all the four stations were *Lumbricillus, Limnodrillus, Branchiura, Chaetogaster, Nais* and *Tubifex*. Odonates were reported only from Maa Chandrika Devi while sponges were encountered at Daliganj and Aquaduct. On some occasions, fish fry were also found at Ambedkar Park and Aquaduct. Seasonally, maxima for population density were observed during pre-monsoon and minima during monsoon. The organic pollution indicator benthic species reported were tubificids, chironomids, culicoid larvae, *Lamellidens* sp., *Corbicula* sp., *Lymnaea* sp. and leech. Branchiurans, *Tubifex* sp. and *Chironomus* larvae were reported at all the stations. Filthy condition with foul smell throughout the length of the river coupled with poor water quality and appearance of indicator organisms at all the stations indicate that the river is under severe pollution stress due to anthropogenic discharges and it has reached an alarming stage.

Keywords: River Gomti, pollution, indicator species

INTRODUCTION

The disposal of wastes into the aquatic environment has long been an accepted fact, but it is being done without considering the possible consequences it may pose. The aquatic environment has a good deal of assimilation capacity but when the waste load exceeds the absorbing capacity, pollution becomes a serious problem. Today, aquatic pollution assumes a major challenge to man because the living resources form an essential source of animal protein. The rivers have become seriously vulnerable to pollution in industrialized cities leading to serious limitations to our harvesting food from the polluted environments. Lucknow city is an example of the conditions posed by increasing urbanization and industrialization. It has a population of about 3.68 million. The quantity of domestic sewage and industrial waste produced in Lucknow is about 325 million litres daily. At present, there is only one treatment plant of 42 million litres daily capacity located at Gaooghat to treat the sewage from Sarkata, Pata and Nagaria as well as Gaooghat itself. Therefore, a major portion of the sewage is discharged untreated at various places through five sewage pumping stations into the River Gomti.

Pollution completely disturbs the ecosystem by imposing considerable stress on aquatic life. In aquatic food chain, there is direct flow of energy from one level to the next trophic level. Any alteration at a particular level, therefore, is bound to affect the entire ecosystem.

The usefulness of benthos in pollution monitoring programme to ascertain river health is well established. There are several reasons why the benthos is used as an indicator of ecosystem change. First, the longevity of benthos provides long-term exposure to toxic substances. Second, they live in close contact with sediment which enhances their intimacy with many pollutants and last, the in-faunal organisms reflect the situation not only at the time of sampling but also during yester years. The studies made on benthos led to the development of indicator organism concept which is the presence of particular species among benthos. Oligochaetes are the ideal indicator organisms in and on bottom, and thus, give a good indication of the benthic realm of the river. Hence, the present study on zoo-benthic diversity of River Gomti in Lucknow was taken up.

MATERIAL AND METHODS

Four sampling stations were identified along the course of the river in Lucknow. The selection of two sampling stations was made in specific discharge dominated areas. While one station was upstream presuming a stress-free unpolluted environment, one station downstream was included in the recovery zone.

Maa Chandrika Devi

It is one of the most sacred temples in the city and is situated about 35 km from Lucknow on Sitapur road. On the auspicious new moon day of every

month, huge crowds gather in the form of a mela to worship Maa Chandrika Devi and offer prayers. The station is situated upstream of the river behind the temple. At this site, the width of the river is less and comparatively the depth is more. People come for picnic on this site on various occasions.

Daliganj

The station Daliganj is situated in the vicinity of the city close to Mohan Meakin, a distillery plant discharging the waste directly into the River Gomti. The quantum of the discharge is around 9.00 million litres daily. It is a fishermen locality. Washermen wash the clothes here on both the banks of the river. On this spot, the river bed is black in colour because of the decomposition of organic wastes discharged by the distillery, other adjoining plants and sewage. Hence, the area is badly affected and smelling foul. This locality is also utilized for defaecating by the local population. Hence, this station has been identified as dominated by industrial effluent apart from sewage.

Ambedkar Park

Ambedkar Park is situated on the bank of the River Gomti opposite the star hotel Taj Residency. Ambedkar Park was recently constructed by the Government of Uttar Pradesh and dedicated to the nation. It is one of the important and beautiful picnic spots. Upstream of this park at a distance of about 0.5 km, there is a cremation ground known as Bhainsa Kund. Close to this, city drains open into the river. River Gomti receives around 73 million litres of sewage from Jopling Road daily. Hence, the area is dominated with domestic sewage discharge and was identified for sampling.

Aquaduct

It is one of the peculiar spots on the River Gomti down stream in the outskirts of the city Lucknow. A barrage is constructed on the river at this spot. This area is utilized for recreation by the local people during holidays. This station has been identified as a recovery zone downstream.

Every month, samples were collected for environmental (water and sediment) and biological parameters. The parameters included temperature (air and water), pH, dissolved oxygen, CO_2, alkalinity, hardness and nutrients (NO_2^-, NO_3^- and PO_4^{3-}). Temperature, pH, CO_2 and dissolved oxygen were analyzed immediately in the field itself, while for the rest of the parameters, the water samples were collected in half-litre narrow-mouth polythene bottles.

Ekman grab of 0.1 m^2 area was used for the collection of benthic samples. The sediment collected by the grab was sieved through a 500-um standard sieve and preserved in 5% formalin and rose Bengal in wide-mouth polythene jars. Stained and preserved samples were labeled and brought to the laboratory for further analysis after Ward and Whipple (1959), Elefteriou and Holme (1984),

and APHA (1999). All the individuals belonging to the same species were identified and counted. The population density was, thus, estimated.

Environmental factors like air and water temperature, pH, dissolved oxygen, CO_2, alkalinity, hardness, nitrite, nitrate, phosphate and chemical oxygen demand in water were studied following the standard methods (APHA, 1999). Soil analysis was carried out every month for pH, $CaCO_3$, water retention capacity and organic carbon (APHA, 1999). The identification and analysis of benthos were made following the method of Ward and Whipple (1959), Needham and Needham (1962), Holme and McIntyre (1971), and Pennak (1978).

RESULTS AND DISCUSSION

The results of environmental parameters are presented in tables 1 and 2, and those of biological parameters in tables 3-7. The water temperature followed the trend of atmospheric

Table 1: Variation in water parameters of River Gomti at Lucknow

Parameter	Maa Chandrika Devi	Daliganj	Ambedkar Park	Aquaduct
Temperature (^{0}C)				
Air	11.00-37.00 (26.39)	15.00-36.00 (26.13)	14.00-33.00 (24.93)	14.00-30.00 (23.62)
Water	12.50-32.60 (23.20)	14.00-32.70 (24.03)	13.00-31.60 (23.10)	13.80-31.30 (22.00)
pH	7.50-8.40	7.20-8.20	7.20-8.00	6.90-7.90
DO (mg l^{-1})	3.60-7.70 (6.15)	0.80-6.26 (3.38)	0.40-7.37 (3.60)	0.20-8.23 (3.49)
CO_2 (mg l^{-1})	Nil-20 (7.80)	Nil-30 (8.18)	Nil-36 (8.02)	Nil-26 (7.40)
Alkalinity (mg $CaCO_3$ l^{-1})	100-360 (236. 80)	90-560 (282.05)	80-400 (238.35)	100-400 (237.78)
Hardness (mg $CaCO_3$ l^{-1})	80-340 (218.00)	98-420 (249.83)	80-328 (224.77)	130-340 (221.75)
Phosphate (mg l^{-1})	0.05-13.00 (2.40)	0.60-8.00 (2.72)	0.69-3.00 (2.55)	0.52-11.20 (3.31)
Nitrite (mg l^{-1})	0.06-6.90 (0.83)	0.02-5.23 (1.00)	0.02-8.77 (1.18)	0.01-6.19 (1.38)
Nitrate (mg l^{-1})	3.60-74.40 (22.70)	5.82-74.70 (30.60)	6.56-69.68 (26.08)	6.80-70.20 (23.45)
COD (mg l^{-1})	3.60-203.00 (36.05)	6.40-59.20 (21.34)	3.20-219.00 (37.35)	8.00-187.20 (34.70)

The values in parentheses are the averages.

Table 2: Variation in sediment parameters of River Gomti in Lucknow

Parameter	Maa Chandrika Devi	Daliganj	Ambedkar Park	Aquaduct
pH	6.60-8.20 (7.76)	6.30-8.00 (7.42)	5.20-8.20 (7.56)	6.00-8.50 (7.64)
$CaCO_3$ (%)	1.50-25.75 (9.78)	1.25-28.75 (10.62)	2.50-30.25 (12.75)	1.50-36.75 (13.36)
Water retention capacity (%)	24.00-46.60 (38.03)	29.00-57.00 (38.80)	17.00-40.00 (32.74)	29.00-59.00 (39.04)
Organic carbon (%)	0.07-1.00 (0.48)	0.08-2.04 (0.67)	0.07-1.20 (0.44)	0.07-1.40 (0.53)

The values in parentheses are the averages.

temperature. The mean pH showed a gradual decrease from upstream to downstream stations except Daliganj, which had an exceptionally low value (7.20). Mean dissolved oxygen was low at all stations from Daliganj downward. On many occasions, dissolved oxygen was less than 1.00 mg l^{-1}. The high organic load might have caused the depletion of oxygen. Mean dissolved oxygen value was higher (6.15 mg l^{-1}) at the upstream station Maa Chandrika Devi. High mean alkalinity (266.96 mg $CaCO_3$ l^{-1}) and hardness (288.07 mg $CaCO_3$ l^{-1}) were observed at Maa Chandrika Devi. Mean values of nitrite and phosphate showed increasing trend from upstream to downstream. Higher mean nitrate was noticed at Daliganj and Ambedkar Park probably because of the high organic load. Phosphate values were high during monsoon probably due to the runoff from agricultural fields. Chemical oxygen demand has been high in this river almost throughout the stretch (Varshney, 2006). The increasing trend of CO_2, PO_4^{3-} and NO_2^- from upstream to downstream as well as poor dissolved oxygen values represents the poor river condition due to the influx of sewage and industrial effluents. Varshney (1982) reported low dissolved oxygen coupled with higher concentrations of nutrients due to sewage and industrial wastes in the coastal waters of Mumbai. He also emphasized that the natural process of recovery occurs from inshore to offshore. The water quality of the river indicates that the river is under severe pollution stress both by sewage and industrial wastes. There was a gradual increase in mean $CaCO_3$ content of sediment from upstream to downstream. Sediment pH was comparatively high (7.76) at the upstream station Maa Chandrika Devi.

Dissolved organic matter in rivers, streams, lakes and ponds causes a steep rise in biochemical oxygen demand with the deoxygenation of water, resulting in the killing of zooplankton, nekton and fish. Suspended organic matter is more hazardous to fish as it gathers around each silt particle and this clogs the gills causing asphyxiation even though dissolved oxygen in water

Table 3: Benthic diversity (no. m^{-2}) of River Gomti at Lucknow
Station: Maa Chandrika Devi

Group	Oct. 2003	Nov. 2003	Dec. 2003	Jan. 2004	Feb. 2004	Mar. 2004	Apr. 2004	May 2004	June 2004	July 2004	Aug. 2004	Sep. 2004	Oct. 2004	Nov. 2004	Dec. 2004	Jan. 2005	Feb. 2005	Mar. 2005	Apr. 2005
Oligochaeta																			
Lumbricillus	--	--	30	--	--	--	--	--	--	--	20	--	--	10	10	10	--	--	10
Lumbriculus	--	10	20	--	--	20	--	--	--	--	--	--	--	--	10	--	10	--	--
Limnodrilus	--	10	--	--	--	10	--	--	--	--	--	--	--	--	10	10	20	--	--
Branchiura	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10	--	--	--	--
Chaetogaster	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	70	60	--	--
Nais	--	--	--	--	--	--	--	10	--	--	10	--	--	--	--	--	20	20	--
Tubifex	--	20	90	10	20	70	--	20	--	--	80	--	--	--	--	--	30	--	--
Unidentified	--	110	--	30	--	--	--	--	--	50	--	--	--	--	--	50	10	--	--
Chironomus	--	20	30	--	--	20	1370	--	--	--	--	--	--	--	--	30	690	550	--
Nematoda	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10
Pelecypoda																			
Lamellidens	--	--	70	10	30	30	40	10	--	60	30	50	20	20	30	10	--	20	50
Corbicula	--	10	30	10	--	--	10	--	20		10	--	--	30	50	10	20	50	20
Parrysia corrugata	--	--	--	--	--	--	--	--	--	20	10	--	--	--	--	--	10	10	30
Gastropoda	--	--	--	--	--	--	--	10	10	--	20	--	--	30	--	--	--	--	--
Crustacea	--	--	--	--	--	--	--	--	10	--	--	--	--	--	--	--	--	--	--
Diptera	10	--	--	--	10	20	100	10	--	--	--	--	--	--	--	--	80	20	--
Hirudinea	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10	--	--	--	--
Odonata	--	--	10	--	--	--	--	--	--	--	--	--	--	--	30	30	--	--	40
Total	**10**	**180**	**280**	**60**	**60**	**170**	**1520**	**60**	**40**	**130**	**180**	**50**	**20**	**90**	**160**	**220**	**950**	**670**	**160**

Table 4: Benthic diversity (no. m^{-2}) of River Gomti at Lucknow

Station: Daliganj

Group	Oct. 2003	Nov. 2003	Dec. 2003	Jan. 2004	Feb. 2004	Mar. 2004	Apr. 2004	May 2004	June 2004	July 2004	Aug. 2004	Sep. 2004	Oct. 2004	Nov. 2004	Dec. 2004	Jan. 2005	Feb. 2005	Mar. 2005	Apr. 2005
Oligochaeta																			
Lumbricillus	--	--	--	3000 50	4020	--	4000	10	480	340 3670	1400	-- 4690	40	340	62280 --	2680 53880	2320 18040	1240 8320	960
Tubifex		200	12000	50	200	1050	31200	200	2080	--	1600	10	4570	27540	--	--	--	--	69560
Pristina	20	--	1000	100	300	--	--	--	10	100	120	110	20	260	440	--	--	--	---
Nais	--	20	200	200	110	50	--	30	--	20	--	50	--	80	240	--	--	--	--
Dero	10	10	200	600	240	30	--	10	--	--	--	--	10	20	--	120	240	360	---
Branchiura	--	30	300	500	150	100	--	--	--	60	--	20	90	60	160	360	240	--	220-
Lumbriculus	--	--	--	400	980	--	800	--	30	260	180	100	--	20	440	2360	2000	680	--
Chaetogaster	--	20	2500	100	250	--	2000	--	250	20	600	--	10	--	--	240	40	--	480
Stylaria	--	10	200	40	400	20	--	--	--	210	--	160	--	--	520	2880	1240	840	80
Limnodrillus	--	--	450	200	150	50	3200	--	530	320	1200	--	160	--	--	560	--	--	1160
Unidentified	--	--	200		--	--	3200	--	120		1240		150	80					240
	--																		
Chironomus	20	50	550	2680	120	3490	920	1070	1230	440	--	80	--	--	320	360	3360	40	2520
Crustacea	--	10	50	--	--	--	--	--	--	--	--	50	--	--	--	--	--	--	--
Diptera	10	20	300	--	80	50	--	--	--	20	--	--	--	--	--	--	120	40	40
Nematoda	--	10	--	--	--	--	--	--	--	--	--	10	--	--	--	--	--	--	40
Porifera	--	--	--	--	--	170	--	--	--	--	--	--	--	--	--	--	--	--	--
Gastropoda	--	10	50	--	--	--	100	--	--	30	--	60	30	--	--	--	---	--	--
Total	**60**	**390**	**17800**	**7920**	**7000**	**5010**	**45420**	**1320**	**4730**	**5490**	**6340**	**5340**	**5080**	**28400**	**64400**	**63440**	**27600**	**11520**	**75300**

Table 5: Benthic diversity (no. m^{-2}) of River Gomti at Lucknow

Station: Ambedkar Park

Group	Oct. 2003	Nov. 2003	Dec. 2003	Jan. 2004	Feb. 2004	Mar. 2004	Apr. 2004	May 2004	June 2004	July 2004	Aug. 2004	Sep. 2004	Oct. 2004	Nov. 2004	Dec. 2004	Jan. 2005	Feb. 2005	Mar. 2005	Apr. 2005
Oligochaeta																			
Lumbricillus	20	--	10	--	--	--	--	--	--	--	--	--	--	70	160	--	60	2560	70
Limnodrilus	--	500	--	--	--	--	--	--	--	--	--	--	--	130	40	230	50	1120	210
Lumbriculus	--	300	--	--	--	--	--	--	--	--	--	180	--	50	80	--	30	800	--
Pristina	--	50	--	--	10	--	--	--	--	--	--	--	--	10	60	20	--	--	--
Tubifex	--	--	--	--	--	--	--	--	--	--	--	--	--	1520	8600	220	530	--	--
Naias	--	2820	--	--	30	--	10	70	90	--	50	1040	--	10	260	310	--	36900	--
Chetogaster	--	180	--	--	10	--	10	--	--	--	--	200	--	--	100	420	30	1280	1570
Stylaria	--	150	--	--	--	--	--	--	--	--	--	--	--	--	80	--	--	--	60
Branchiura	--	--	--	--	--	--	--	--	--	--	--	60	--	--	20	--	--	1880	20
Unidentified	--	--	--	--	--	--	--	--	--	--	--	--	--	--	480	230	10	640	20
Chironomus	--	400	10	--	--	430	20	--	30	100	20	22920	150	--	690	4920	70	760	--
Diptera	--	100	--	80	--	--		10	20	10	--	200	--	--	10	170	90	160	--
Hirudinea	--	--	--	--	--	--	--	--	--	10	--	--	--	--	10	--	--	--	--
Gastrparoda																			
Vivipara	--	50	--	--	60	--	--	--	10	10	40	--	--	--	--	20	--	--	--
Pomacea	--	20	--	--	--	--	--	30	--	20	--	--	--	60	20	10	--	40	--
Lymnaea	--	30	--	--	--	--	--	--	--	--	--	--	--	--	--	70	10	--	--
Pelycypoda	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10	--	--	--
Pisces	--	--	--	--	---	--	--	--	--	--	--	20	--	--	--	--	140	--	--
Total	**20**	**4600**	**20**	**80**	**110**	**430**	**40**	**110**	**150**	**150**	**110**	**24620**	**150**	**1850**	**10610**	**6630**	**1020**	**46140**	**1950**

Table 6: Benthic diversity (no. m^{-2}) of River Gomti at Lucknow

Station: Aquaduct

Group	Oct. 2003	Nov. 2003	Dec. 2003	Jan. 2004	Feb. 2004	Mar. 2004	Apr. 2004	May 2004	June 2004	July 2004	Aug. 2004	Sep. 2004	Oct. 2004	Nov. 2004	Dec. 2004	Jan. 2005	Feb. 2005	Mar. 2005	Apr. 2005
Oligochaeta																			
Lumbricillus	10	--	--	--	--	--	140	120	420	--	20	70	--	520	--	10	240	80	320
Branchiura	--	100	50	--	--	--	--	--	40	--	--	--	--	40	--	--	--	--	--
Limnodrillus	10	50	30	--	--	--	170	30	260	10	--	--	--	80	--	40	190	80	840
Nais	--	20	20	--	--	--	--	--	--	40	--	--	--	9610	--	60	--	130	--
Pristina	--	10	30	--	--	--	40	50	180	10	--	--	--	40	--	10	--	--	--
Dero	--	30	--	--	--	--	--	--	--	20	--	--	--	440	--	--	--	--	--
Tubifex	30	300	450	--	--	--	1140	40	2100	1330	--	--	--	120	--	40	1700	330	6640
Stylaria	--	--	--	--	--	--	30	300	--	--	--	--	--	--	--	--	30	--	120
Chaetogaster	--	--	70	--	--	--	80	--	20	--	--	--	--	--	--	--	200	90	280
Unidentified	--	--	50	--	--	--	320	--	40	--	--	--	--	--	--	--	--	--	400
Pelecypoda																			
Lamellidens	--	--	--	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pomacea	--	10	--	--	--	--	--	--	--	--	--	--	--	--	--	30	--	--	40
Chironomus	--	70	50	--	100	820	1830	14300	840	50	10	3300	--	120	160	10	--	4180	1430
Hirudinea (*Clepsine*)	--	--	--	--	--	20	--	--	--	--	--	--	--	--	--	--	--	--	10
Diptera	--	--	10	--	--	--	--	--	--	--	--	310	10	400	--	--	--	90	840
Porifera	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2400
Pisces (fry)	--	--	--	--	10	10	--	--	--	--	--	--	--	--	--	10	--	--	10
Total	**50**	**590**	**760**	**20**	**110**	**850**	**3750**	**14840**	**3900**	**1460**	**30**	**3680**	**10**	**11370**	**160**	**210**	**2360**	**4980**	**13330**

Table 7: Diversity indices of benthic organisms of River Gomti during 2003-05

Group/ Diversity	Shannon-Wiener	Simpson Dominance	McIntosh	Species Dominance	Simpson Reciprocal
Maa Chandrika Devi					
Oligochaeta	1.812	0.205	0.795	0.371	4.800
Diptera	0.273	0.834	0.166	0.912	1.090
Gastropoda	0.804	0.551	0.449	0.714	1.810
Odonata	1.090	0.195	0.805	0.330	5.120
Pelecypoda	0.849	0.218	0.782	0.628	4.500
Daliganj					
Oligochaeta	0.738	0.695	0.305	0.831	1.430
Diptera	0.139	0.940	0.060	0.970	1.060
Gastropoda	0.815	0.284	0.710	0.420	3.520
Coleoptera	0.980	0.540	0.460	0.500	1.850
Ambedkar Park					
Oligochaeta	0.868	0.648	0.352	0.804	1.500
Diptera	0.135	0.946	0.054	0.973	1.050
Gastropoda	0.322	0.321	0.679	0.400	3.100
Aquaduct					
Oligochaeta	0.959	0.607	0.393	0.777	1.640
Diptera	0.271	0.880	0.120	0.942	1.130
Gastropoda	0.792	0.238	0.762	0.346	4.200

may be above 5.00 mg l^{-1}. The sugar factory upstream discharges molasses and wastes into Gomti and every year, thousands of fish may be seen dead and floating downstream for miles. Although silt load in water may have little direct effect on man, the continuous silting of lakes, rivers and reservoirs shallow them. This problem has serious consequences.

The high concentrations of nutrients, especially NO_2^- and NO_3^- as well as chemical oxygen demand encountered during pre-monsoon may be due to precipitation and the low influx of effluents in summer. Phosphate values were high during monsoon probably due to runoff from agricultural fields. The high values of nutrients coincided with the high population density of benthos during pre-monsoon.

Benthic fauna (macrobenthos) form the major component of freshwater bodies and establish an important link in the food chain. It serves as food for most of the bottom-feeding fishes. The knowledge of their composition, abundance and distribution helps to evaluate its significance as fish food. Mean benthic population was exceptionally high at Daliganj (20135 m^{-2} followed by Ambedkar Park (5199 m^{-2}) and

Aquaduct (3287 m^{-2}), and low at Maa Chandrika Devi (264 m^{-2}). The number of oligochaete genera was seven at Maa Chandrka Devi, ten at Daliganj, and nine each at Ambedkar Park and Aquaduct.

The high population density at Daliganj was mainly contributed by oligochaetes and chironomid larvae. Numerically high population density of macrobenthos was observed in stressed localities compared to unpolluted environment off Versova (Mumbai) by Varshney *et al.* (1988).

The oligochaete genera common at all the stations are *Lumbricillus, Limnodrillus, Branchiura, Chaetogaster, Nais* and *Tubifex.* The genus *Lumriculus* was absent only at Aquaduct. The genera *Pristina* and *Stylaria* were present at all stations except Maa Chandrika Devi. The genus *Dero* was encountered only at Daliganj and Aquaduct. Some of the oligochaetes could not be identified.

The organic pollution indicator benthic species reported in River Gomti are *Branchiura, Tubifex, Chironomus*, culicoid larvae, *Lamellidens, Corbicula, Lymnaea* and leech. Out of these, the oligochaetes *Branchiura* and *Tubifex,* and the dipteran larvae of *Chironomus* were observed at all the stations. The bivalve *Lamellidens* sp. was encountered at Maa Chandrika Devi and Aquaduct, while *Corbicula* sp. was noticed only at Maa Chandrika Devi. Moza and Kolekar (2001) described these organisms as indicators of pollution for water quality in River Yamuna. They have also identified the genera *Branchiura, Tubifex* and *Chironomus* as pollution resistant or saprophilic organisms, and *Nais* as a pollution sensitive one. Varshney (1982) and Govindan *et al.* (1983) also noticed the dominance of worms in south Gujarat estuaries and the polluted coastal waters off Mumbai.

Odonata was reported only at Maa Chandrika Devi, while sponges were encountered at Daliganj and Aquaduct. In the benthic samples on some occasions, fish fry were also found at the stations Ambedkar Park and Aquaduct. Seasonally high populations of benthic organisms were noticed during pre-monsoon and low ones during monsoon. Low population during monsoon may be attributed to the disturbances in substrata due to the influx of rain water and the high values during pre-monsoon can be attributed to the stabilization of the bottom sediment gradually from post-monsoon onward till pre-monsoon.

Chironomids and oligochaetes were associated with clayey substratum. Damodaran (1973) and Varshney *et al.* (1988) also observed the assemblage of polychaetes in clayey bottom in the mud banks of Kerala coast and the coastal waters of Bombay, respectively. The Shannon-Wiener diversity index (H) of benthic organisms was less than 1.00 for oligochaetes, dipterans and gastropods for Daliganj, Ambedkar Park and Aquaduct. At Daliganj, the Shannon-

Wiener indices for coleopterans were also less than 1.00. At Maa Chandrika Devi, the Shannon-Wiener indices for dipterans (0.273), gastropods (0.804) and pelycypodes (0.849) were less than 1.00, while for oligochaetes (1.812) and odonates (1.090) it was more than 1.00. The Shannon-Wiener diversity index of less than one indicates a stressed environment.

The Simpson dominance index (D), McIntosh index and species dominance index for all the groups studied at all the stations were less than 1.00. Simpson reciprocal index was always more than one at all the stations for all the species. It was very high for gastropods (more than 3.00) at all the stations, while for oligochaetes (4.80), it was very high at Maa Chandrika Devi. The mean benthic population was high at Daliganj (20,135 m^{-2}), moderate at Ambedkar Park (5199 m^{-2}) and Aquaduct (3287 m^{-2}), and low at Maa Chandrika Devi (264 m^{-2}). Though the benthic density was on the higher side due to the presence of oligochaetes and chironomid larvae at Daliganj, Ambedkar Park and Aquaduct, these may not contribute to the food chain. The abundance of a particular group of organisms in a deteriorated and polluted environment may not transfer the energy to a higher trophic level. Poor benthic diversity associated with deteriorated water quality has created an alarming situation in River Gomti.

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