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Floral and Faunal Diversity in Lower Ganga

Varanasi to Farakka

GRB EMP : Ganga River Basin Environment Management Plan

by

Indian Institutes of Technology



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Preface

In exercise of the powers conferred by sub-sections (1) and (3) of Section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has constituted National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Government for effective abatement of pollution and conservation of the river Ganga. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin: Environment Management Plan (GRB EMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin Environment Management Plan (GRB EMP) by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. Memorandum of Agreement (MoA) has been signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This report is one of the many reports prepared by IITs to describe the strategy, information, methodology, analysis and suggestions and recommendations in developing Ganga River Basin: Environment Management Plan (GRB EMP). The overall Frame Work for documentation of GRB EMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRB EMP. Dedicated people spent hours discussing concerns, issues and potential solutions to problems. This dedication leads to the preparation of reports that hope to articulate the outcome of the dialog in a way that is useful. Many people contributed to the preparation of this report directly or indirectly. This report is therefore truly a collective effort that reflects the cooperation of many, particularly those who are members of the IIT Team. Lists of persons who have contributed directly and those who have taken lead in preparing this report is given on the reverse side.

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1. Introduction

The river Ganga comprises a lotic water series, which originates at Gaumukh and flows down to Gangasagar traversing a distance of 2525 km. During its course through eleven states, the river receives numerous tributaries (with characteristic quality, pollution load and biota) including Bhilangana, Alaknanda, Ram Ganga, Kali, Yamuna, Gomti, Ghagra, Gandak, and Kosi.

A thorough review of a large number of studies available in the form of student's project reports and theses, reports produced through sponsored, consultancy, investigatory and Environment Impact Assessment studies, published papers/articles in journals/ conference/ workshop/ symposia proceedings, books, news paper articles, etc. has led to collection of fragmented information on ecology and biodiversity in the Ganga Basin. The information is in different time domain and isolated stretches largely governed by the period of the study and the proximity of a river stretch/water body to the investigating institutions, organizations or individuals involved in the study. Due to lack of definitive bio-monitoring programme like river water quality monitoring programmes by the Central Pollution Control Boards, State Pollution Control Boards and National River Conservation Directorate, the analysis is based on extrapolation and interpolation of scattered, mostly qualitative data/information.

The entire stretch of the river Ganga (main stem) can be viewed into three segments:

- A. Upper Ganga \approx **294** km Gaumukh to Haridwar
- B. Middle Ganga \approx **1082** km Haridwar to Varanasi
- C. Lower Ganga \approx **1134** km Varanasi to Ganga Sagar

(The Upper Ganga Segment for all practical purposes and studies carried out, starts at Gangotri as the terrain between Gaumukh to Gangotri is essentially devoid of biota due to hostile conditions)

These three segments not only differ in their geomorphology, ecology and rheology but are different in terms of issues that need to be addressed (refer report 001_GBP_IIT_GEN_DAT_01_Ver 1_Dec 2010). Considering this, floral and faunal diversity of the main stem of Ganga is reported in a series of four reports. This report covers the fresh water zone of lower Ganga stretch from Varanasi to Farakka (LG-A). The lower Ganga comprises of a fresh water zone (Varanasi to Farakka) 701 km (LG-A) and estuarine zone (Farakka to Gangasagar) 286 km (LG-B). The LG-A zone spreads through three states *viz.* Uttar Pradesh, Bihar, West Bengal and includes five important towns, Varanasi, Buxar, Patna, Bhagalpur and Farakka (Figure 1).

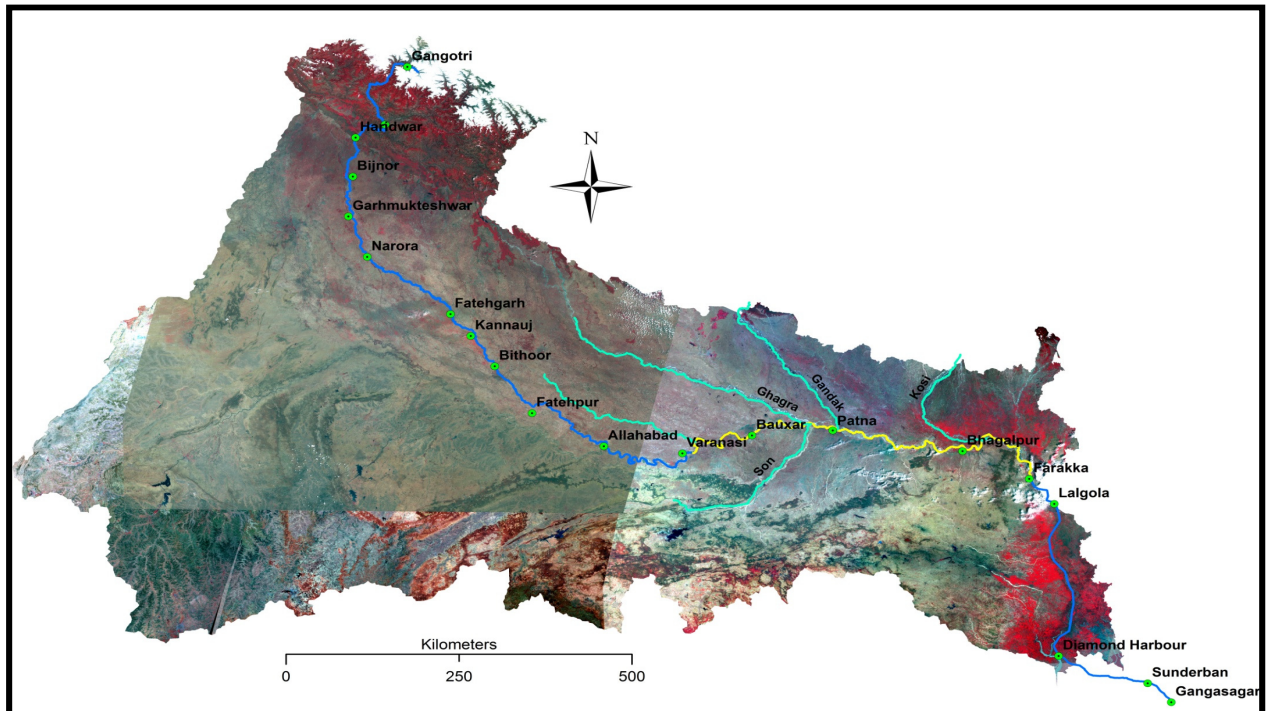


Figure 1: Ganga in lower fresh water zone (LG-A) and their major tributaries

(* The LG-A zone represented from yellow and green colour, respectively)

This stretch is characterized by the presence of number of tributaries. Downstream of Varanasi, the Varuna joins the Ganga on the left bank at Khalispur. The river then flows to Ghazipur, where it joins the united stream of two major tributaries, the Sai and the Gomti. Further downstream, the Ganga receives the Basu Nadi on the left and the Karamnasa on the right bank at Narbatpur. Before reaching Buxar, Ganga is joined by the Thora on the right bank. It then enters Bihar passing through Ballia. At the Uttar Pradesh-Bihar border the Ghagra which is formed by the confluence of Sarada, Sarju, Gori and Kali joins the Ganga on the left bank.

In Bihar the Ganga receives the Sone, Gandak and Punpun. The Gandak, which originates from Nepal is formed by seven holy Gandakis and join the Ganga on the left bank at Hazipur. After passing through Patna it receives water from the Patna canal and the combined stream of the Punpun, Morhan, and Dordhan at Fatuha and moves to Munger. The united stream of the Harohar, Dhanayan, Mohani, and Dharhara river joins on the right bank and the Barhi Gandak on the left bank. Then on its way to Bhagalpur, the Ganga receives the Man and Jumania river on the right bank. Downstream of Bhagalpur, the Kosi joins Ganga at Kursela on the right bank and then the river enters West Bengal (Mathur, 1991).

The river bed of this region is sandy in nature with 80-90% sand and low percentage of silt and clay. But from Bhagalpur to Farakka, the sand contribution declines considerably with 54-69% sand and substantial increase in silt content. Sand bed is indicator of low aquatic productivity. This is compensated by the nutrient flow from the basin. Due to the confluence of number of tributaries water velocity in this stretch is high. The slope of the river Ganga is appreciably

reduced from Varanasi to Farakka due to silting. In this region sediment load is very high and the substrate is silt over sand (Mathur, 1991).

Like middle Ganga this stretch of lower Ganga also supports good growth of biological communities due to the presence of nutrients, higher temperature and clean water with high velocity. Good solar radiation also supports the primary productivity. The biodiversity in this stretch is very similar to middle Ganga and that it does not vary significantly at different stretches. Thus the fresh water zone of lower Ganga has been considered a single stretch (LG-A) from Varanasi to Farakka.

2. Biological Profile

The data of biological communities has been taken from biological profile of the Ganga and ecological imbalance of the Ganga river system and consists of phytoplankton, zooplankton, zoobenthos including macro-invertebrates, fish and higher vertebrates specially Gangetic dolphin (Sreenivasaprasad, 1991; Bilgrami, 1991; Ray, 1998; Neseemann *et al.* 2011).

2.1. Phytoplankton

Phytoplankton constitutes the main autotrophic component of Ganga river. They are microscopic, free floating and belong to ten classes of algae of which Cyanophyceae, Bacillariophyceae, and Chlorophyceae, comprises 93% of the taxa. The other seven classes are Euglenophyceae, Chrysophyceae, Dinophyceae, Xanthophyceae, Cryptophyceae, Rhodophyceae and Synurophyceae. The most productive stretches of the river Ganga are middle and lower. A representation of taxa and percent composition of various classes of algae reported from fresh water zone (LG-A) of the Ganga river are shown in Figure 2 and 3, respectively.

The diatoms constitute the major group in upper Ganga, while diatoms, green algae and blue green algae in that order represent the dominant group in the middle Ganga and green algae, diatoms and blue green algae predominate in the lower Ganga. In addition, the lower Ganga also includes the other seven classes as well. The species richness of total taxa could be represented as:

Chlorophyceae (91) > Bacillariophyceae (81) > Cyanophyceae (78) > Euglenophyceae (8) > Chrysophyceae, Xanthophyceae (3) > Dinophyceae, Rhodophyceae (2) > Cryptophyceae, Synurophyceae (1)

**(The number in parenthesis represents number of taxa)*

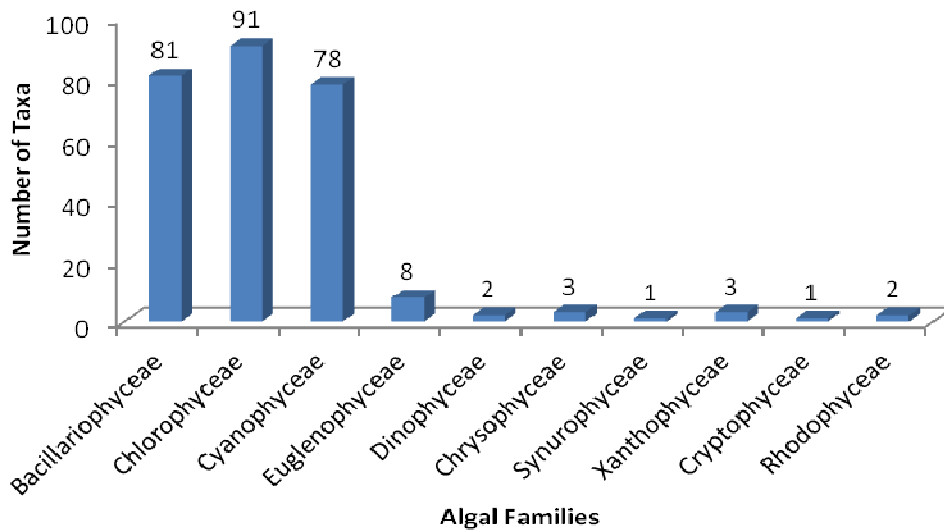


Figure 2: Changing pattern of algal dominance in lower Ganga (LG-A)

A compendium of algae reported in different stretches is given in the Appendix I.

The most common genera of Bacillariophyceae are *Amphora*, *Cymbella*, *Fragillaria*, *Gomphonema*, *Melosera*, *Navicula*, *Pinnularia*, *Surirella*, *Synedra*; Cyanophyceae are *Anabaena*, *Aphanocapsa*, *Chroococcus*, *Lyngbya*, *Merismopedia*, *Microcystis*, *Oscillatoria*, *Phormidium*, *Spirulina*; Chlorophyceae are *Chlamydomonas*, *Closterium*, *Crucigenia*, *Cosmerium*, *Pediastrum*, *Scendesmus*, *Ulothrix*, *Spirogyra*, Euglenophyceae are *Euglena*, *Phacus*; Chrysophyceae is *Dinobryon*; Synurophyceae is *Synura* and Dinophyceae are *Ciratium* and *Peridinium*.

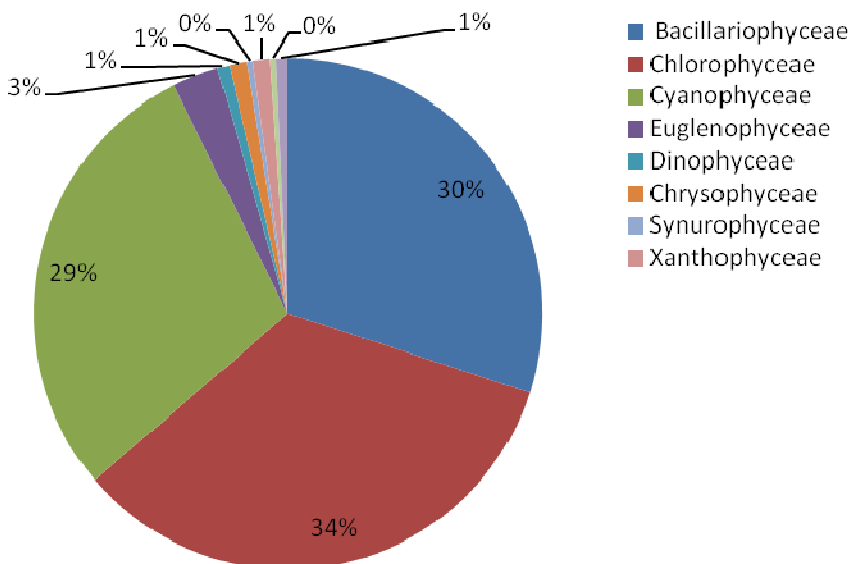


Figure 3: Distribution of various classes of algae in lower Ganga (LG-A)

2.2. Zooplankton

Zooplankton comprises of Protozoans, Rotifers and Crustaceans (Copepods and Cladocerans). In this stretch all groups are represented though are low in specific composition. In normal routine biomonitoring surveys when plankton samples are collected through plankton nets (bolting silk) protozoans escape and are not caught. For them, either Sedgwick rafter funnels or centrifuge usage is desired. The complete list of zooplankton and its distribution is mentioned in Appendix II and Figure 4. The distribution of zooplankton in LG-A along with important genera is:

Protozoa (Total taxa reported 8 under 5 genera): *Acella*, *Centropyxis*, *Diffflugia*, *Paramecium*, *Vorticella*

Rotifera (Total taxa reported 26 under 12 genera): *Asplanchna*, *Brachionus*, *Euchlanis*, *Filinia*, *Keratella*, *Iecane*, *Monostyla*, *Polyarthra*, *Rotaria*, *Synchaeta*, *Testudinella*, *Trichocera*

Cladocerans (Total taxa reported 13 under 8 genera): *Alona*, *Bosmina*, *Bosminopsis*, *Ceriodaphnia*, *Daphnia*, *Diaphanosoma*, *Moina*, *Simocephalus*

Copepoda (Total taxa reported 5 under 4 genera): *Cyclops*, *Diaptomus*, *Mesocyclops*, *Neodiaptomus*

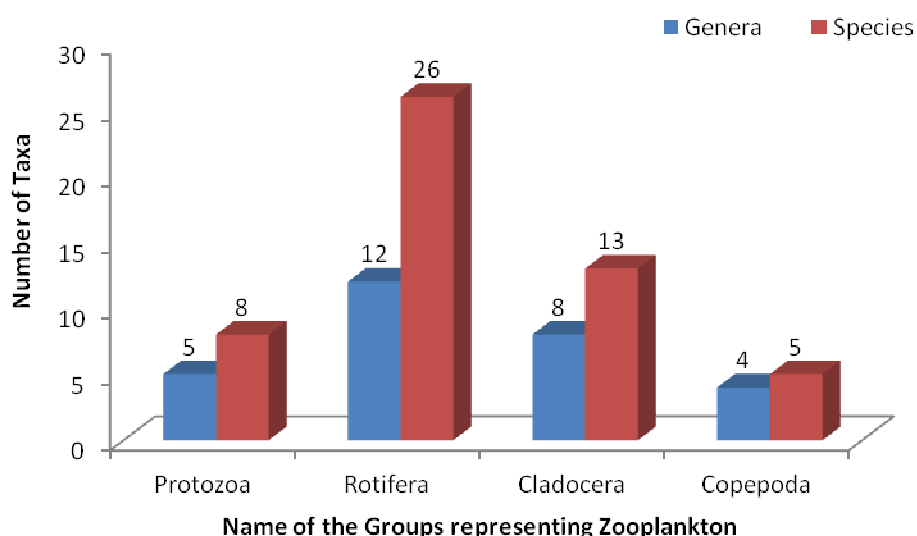


Figure 4: Distribution of Genus/Species in zooplankton

2.3. Zoobenthos and Macro-invertebrates

The Ganga is a natural repository of a wide range of fauna. Besides fish, higher vertebrates and zooplankton some other animals constitute a link of operative food chain in the system. They include zoobenthos and macro-invertebrates. A large number of insects, annelids, crustaceans and molluscs have been reported in the entire stretch depending largely on the type of substratum. Hard substratum consisting of boulders, cobbles, stone and pebbles support breeding places of insect larvae. In the upper Ganga and some parts of middle Ganga where substratum is hard and stony and at places mixture of sandy and stony largely

supports insect larvae of families of Plecoptera, Trichoptera, Ephemeroptera, Odonata and Diptera. Later part of middle and lower Ganga with soft substratum and accumulation of lignocellulosic materials supports insects of order Diptera, Coleopteran, and Hemiptera. In addition soft substratum supports Annelids, Nematodes and Molluscs.

The benthic community of lower Ganga (LG-A) is reported to be very rich in diversity and high in abundance in the region around Patna. Ninety five invertebrate taxa have been recorded including Annelids, Molluscs, Insects and Crustaceans which included 12 taxa of marine originated families also (Nereididae, Nephtheidae, Ozobranchidae, Stenothyridae, Arcidae, Psammobiidae, Mysidae, Corallanidae and Hymenosomatidae) (Nesemann *et al.* 2011). The percent and group wise distribution are shown in Figure 5 and 6.

The data reveals a high representation of Annelids (21%), Molluscs (36%), Insects and others Arthropods (43%). The Molluscs (46 taxa) of which Gastropods are represented by 26 taxa and Pelecypoda by 20 taxa. Among Annelids Nesemann *et al.* (2011) reported, Oligochaetes 14 taxa which are predominant over Polycheates (3 taxa) and Hirudinea (9 taxa). Order Mysida, Isopoda, Decapoda and Insecta represented Arthropods. The Insecta was however, more than other Arthropods constituted with Odonata, Trichoptera, Lepidoptera, Diptera, Heteroptera, Coleoptera (Nesemann *et al.* 2011). A list of zoobenthos recorded by Bilgrami (1991) and Nesemann *et al.* (2011) in lower stretch is given in Appendix III.

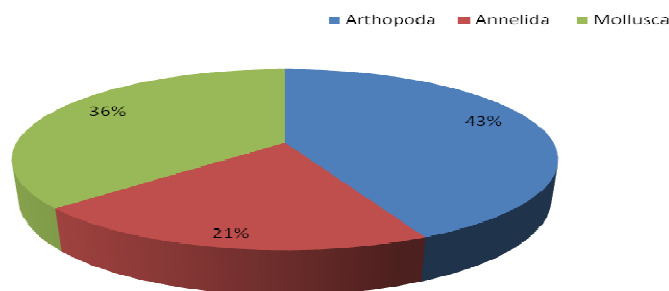


Figure 5: Distribution of zoobenthos in lower Ganga (LG-A)

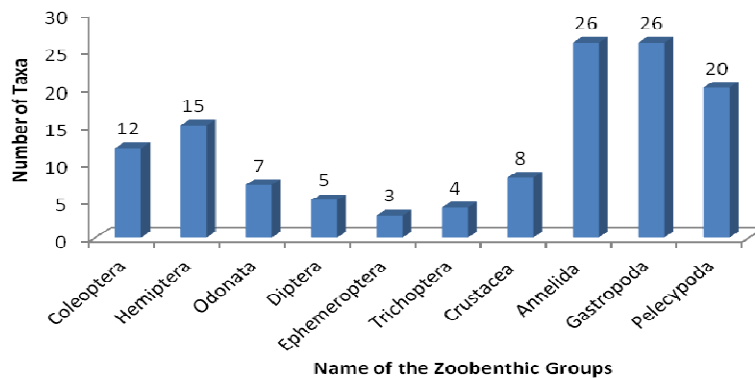


Figure 6: Distribution of zoobenthos in lower Ganga (LG-A)

Twelve species of macro invertebrates present at Patna belong to marine-originated (primary brackish) water families:

Family	Species
Nereididae	<i>Namalycastis indica</i>
Nephtheidae	<i>Nephtys oligobranchia</i>
Ozobranchidae	<i>Ozobranchus shipleyi</i>
Stenothyridae	<i>Stenothyra ornata, Gangetia miliacea</i>
Arcidae	<i>Scaphula celox, S. deltae</i>
Pammobiidae	<i>Novaculina gangetica</i>
Mysidae	<i>Gangemysis assimilis</i>
Stenothyridae	<i>Tachaea spongillicala</i>
Hymenosomatidae	<i>Hymenicoides carteri, Neorhynchoplax spp.</i>

Neemann et al. (2011)

2.4. Fish

The lower Ganga from Varanasi to Farakka is one of the largest productive stretch for the inland catch fisheries. This is also borne out by the fact that out of nine important fish catch centers located on the river Ganga five are located on this stretch viz. Varanasi, Buxar, Ballia, Patna and Bhagalpur. This stretch supports 121 species belonging to 36 families out of a total of 179 species reported in the fresh water zone of river Ganga (UG-1 to LG-A). Thirty five commercially important fishes are included in the taxa along with six invasive species. Every third fish caught belongs to the family Cyprinidae. The important fish reported are the four Indian major carps viz. *Labeo rohita*, *L. calbasu*, *Catla catla*, and *Cirrhina mrigala*, some other carps viz. *Labeo dero*, *Cirrhina reba*, *Labeo bata*, Cat fish *Ailia coila* and other fish *Puntius sophore*. A complete list of the fishes recorded is given in the Appendix IV along with their families. Out of four exotic (invasive fishes), *Cyprinus carpio* (Chinese carp) and *Oreochromis niloticus* (Tilapia) grows luxuriantly in the stretch. The relative abundance of various fish families are depicted below:

Cyprinidae (40 sp.) > Sisoridae, Bagridae (9 sp. each) > Channidae (5 sp.) > Clupeidae, Cobitidae, Schilbeidae, Siluridae (4 sp. each) > Chandidae, Mestacembelidae, Sciaenidae (3 sp. each) > Ambassidae, Engraulidae, Gobiidae, Mugilidae, Notopteridae, Pangasiidae, Tetraodontidae, Osphronemidae (2 sp. each) > Anabantidae, Anguillidae, Badidae, Balitoridae, Belonidae, Chacidae, Cichlidae, Clariidae, Heteropneustidae, Latidae, Megalopidae, Muraenidae, Nandidae, Osphronemidae, Polynemidae, Sillaginidae, Synbranchidae (1 sp. each).

Tenulosa ilisha which at one time was a prominent commercially important fish prior to the construction of Farakka barrage in 1975 has now become a rarity. *Tenulosa* is not able to migrate upstream for breeding upto Varanasi due to physical barriers at Farakka dam. At Patna the total catch of *Tenulosa ilisha* before and after the construction of Farakka barrage has gone down from 12.9% to 0.17% while at Lalgola the fish catch which was about 92.02% of *Tenulosa* has a mere 16.8% representation now.

Among other important fishes are *Sperata aor*, *Sperata seenghala*, *Silonia silondia*, *Wallago attu*, *Bagarius bagarius*, *Rita rita*, *Eutropiichthys vacha*, *Ompak bimaculatus*, *Notopterus notopterus* and *Notopterus chitala*. A graphic representation of families with species recorded is shown in Figure 7.

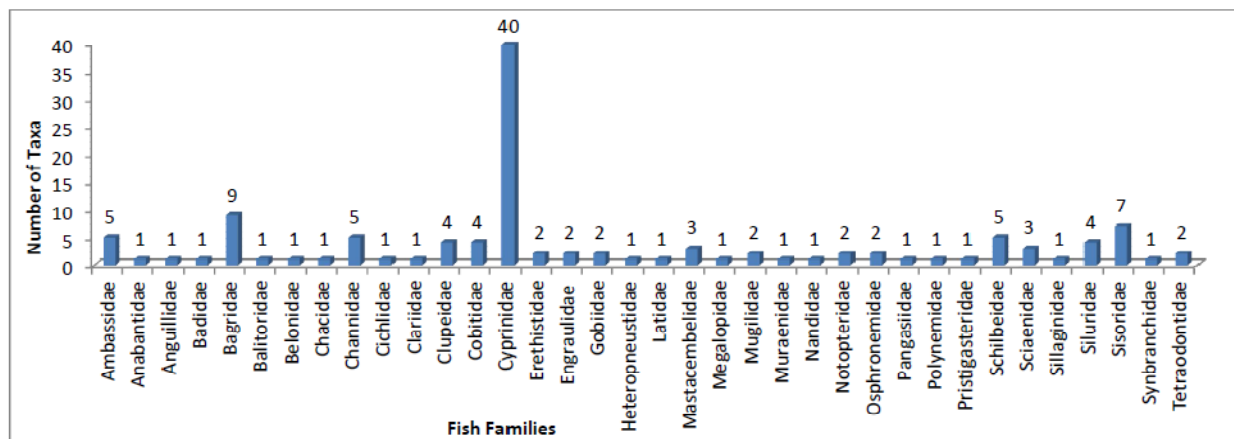


Figure 7: The distribution of fishes of Lower Ganga (LG-A)

Aristichthys nobilis, *Ctenopharyngodon idella*, *Hypophthalmicus molitrix*, *Clarias gariepinus*, other invasive species have also been reported as stray catch by Singh *et al.* (2010).

It has been reported in the annual reports of central Inland Fisheries Research Institute (CIFRI) and other documents that due to water obstruction in the upper Ganga, water abstraction in middle Ganga and rampant pollution by treated and untreated domestic and industrial wastes the fish catch has been reduced drastically and the yield rate kg/km at Patna and Bhagalpur along with all other centers has gone down drastically.

The most characteristic fish of the reach in addition to *Tenualosa ilisha* are Indian major carps. (Jhingran, 1974, 1975, 1989, 1991; Jhingran and Ghosh, 1978; Jhingran and Pathak, 1988; Payne *et al.* 2003; Rao, 1995; Sehgal, 1973; Sinha and Prasad, 1988; Singh *et al.* 2010; Vass *et al.* 2010).

2.5. Higher vertebrates

Beside the preponderance of fish species in this zone, an aquatic mammal, Gangetic dolphin *Platanista gangetica gangetica* has been reported to be present in this stretch. Indian Gangetic Gharyals *Gavialis gangeticus* has been reported in Hooghly river. Salt water crocodile *Crocodylus porosus* has however, been reported in the deltaic region. Number of fresh water turtles has been reported in between Varanasi to Farakka.

As per existing reports, dolphin population has been reported in the lower Ganga are given below:

Allahabad to Buxar (425 km)	172 d/s Survey Sinha <i>et al.</i> (2000)
Buxar to Manihari Ghat (500 km)	24 d/s Survey Unpublished Data Dec. 2004
Farakka feeder canal (38 km)	21d/s Survey Sinha <i>et al.</i> (2000)

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Appendix I

List of phytoplankton in lower Ganga from Varanasi to Farakka

Bacillariophyceae

<i>Achnanthes delicatula</i>
<i>A. microcephalla</i>
<i>Achnantheidium clevei</i>
<i>Amphora</i> sp.
<i>A. ovalis</i>
<i>A. veneta</i>
<i>Asterionella japonica</i>
<i>Caloneis</i> sp.
<i>Chaetoceros</i> sp.
<i>Cocconeis placentula</i>
<i>Cyclotella</i> sp.
<i>Cymatopleura</i> sp.
<i>Cymbella</i> sp.
<i>C. microcephala</i>
<i>C. turgida</i>
<i>C. turgidula</i>
<i>C. tumida</i>
<i>C. ventricosa</i>
<i>Diatoma elongatum</i>
<i>D. vulgare</i>
<i>Eunotia</i> sp.
<i>Fragillaria</i> sp.
<i>F. intermedia</i>
<i>Gomphonema constrictum</i>
<i>G. clevei</i>
<i>G. intricatum</i>
<i>G. lanceolata</i>
<i>G. parvulum</i>
<i>G. sphaerophorum</i>
<i>G. subclavatum</i>
<i>Grammatophora</i> sp.
<i>Gyrosigma</i> sp.
<i>G. distortum</i>
<i>G. scalproides</i>
<i>Hantzschia</i> sp.
<i>Leptocylindrus</i> sp.

Bacillariophyceae

Mastogloia sp.*Meridian* sp.*Melosira ambigua**Navicula* sp.*N. cincta**N. cryptocephala**N. cuspidata**N. gracilis**N. gregaria**N. minima**N. mutica**N. salinarum**N. viridula**Nitzschia* sp.*N. acicularis**N. amphibia**N. communis**N. filiformis**N. gandersheimiensis**N. gracilis**N. linearis**N. palea**N. parvula**N. perspicillata**N. rostellata**N. sigma**N. subtilis**N. thermalis**Pinnularia* sp.*P. interrupta**P. nobilis**P. viridis**Pleurosigma* sp.*P. angulatum**Sellaphora pupula**Surirella* sp.*S. elegans**Synedra* sp.

Bacillariophyceae*S. acus**S. rumpens**S. ulna**Tabellaria* sp.*T. flocculosa**Thalassiosira* sp.*Terpsinoe* sp.**Chlorophyceae***Actinastrum hantzschii**Ankistrodesmus* sp.*A. falcatus**A. spiralis**Bulbochaete* sp.*Chaetophora* sp.*Chara wallichii**Chlamydomonas mirabilis**Chlorella* sp.*C. vulgaris**Chlorococcum* sp.*Chodatella* sp.*Cladophora* sp.*C. glomerata**Closteriopsis* sp.*Closterium* sp.*C. acutum**C. calosporum**C. cynthia**C. ehrenbergii**C. leibleinii**C. nematodes**C. rostratum**C. tumidulum**Cosmarium* sp.*C. auriculatum**C. blyttii**C. ctenoideum**C. galeritum**C. gostyniense*

Chlorophyceae

*C. isthmochondrum**C. pseudobroomei**C. pseudopyramidatum**C. sublatereundatum**C. tenue**Coelastrum cambricum**C. microporum**Crucigenia crucifera**Cylindrocapsa* sp.*Desmidium* sp.*Dictyosphaerium* sp.*Dictyosphaerium pulchellum**Enteromorpha* sp.*Euastrum* sp.*E. carinatum**Eudorina* sp.*Gloeotaenium loitlesbergerianum**Golenkinia radiata**Hydrodictyon* sp.*H. reticulatum**Kirchneriella* sp.*K. contorta**K. obese**Microspora* sp.*Nitella acuminata**Oocystis elliptica**Oedogonium* sp.*Pandorina morum**Pediastrum* sp.*P. duplex**P. simplex**P. tetras**Protococcus* sp.*Schroederia planctonica**Selenastrum* sp.*Scenedesmus* sp.*S. abundans**S. arcuatus*

Chlorophyceae*S. armatus**S. bijugatus**S. dimorphus**S. falcatus**S. quadricauda**Sorastrum spinulosum**Sphaeroplea* sp.*Spirogyra* sp.*S. affinis**S. borgeana**S. hyaline**S. inflata**S. maravillosa**S. paludosa**S. setiformis**S. singularis**Stigeoclonium* sp.*Tetraedron minimum**Treubaria triappendiculata**Ulothrix* sp.*U. zonata**Volvox* sp.*Zygnema* sp.**Cyanophyceae***Anabaena* sp.*A. circularis**A. cylindrica**A. fertilissima**A. laxa**A. orientalis**Anabaenopsis arnoldi**Anacystis montana**Aphanocapsa* sp.*Aphanothece* sp.*A. microscopica**A. pallida**Arthrospira* sp.*A. jeneri*

Cyanophyceae

*A. tenuis**Aulosira fertilissima**Calothrix elenkini**C. fusca**Chroococcus minor**C. turgidus**Cylindrospermum* sp.*C. licheniforme**Gloeocapsa* sp.*G. quaternata**Gloeotrichia echinulata**Lyngbya* sp.*L. gracilis**L. heironymusii**L. limnetica**L. magnifica**L. confervoidis**Mastigocladus* sp.*Merismopedia aeruginea**M. elegans**M. glauca**M. punctata**Microcoleus* sp.*M. chthonoplastes**Microcystis aeruginosa**M. flosaquae**M. protocystis**Myxosarcina* sp.*Nostoc* sp.*N. linckia**Nodularia* sp.*N. spumigena**Oscillatoria* sp.*O. amphibia**O. chilensis**O. chlorine**O. formosa**O. limosa*

Cyanophyceae*O. proteus**O. princeps**O. raciborskii**O. subbrevis**O. tanganyikae**O. tenuis**O. willei**Phormidium* sp.*P. calcicola**P. inundatum**P. purpurascens**P. uncinatum**Pseudanabaena schmidlei**Raphidiopsis curvata**Rivularia aquatic**Schizothrix* sp.*Spirulina gigantea**S. major**S. meneghiniana**S. subsalsa**Symploca* sp.*Synechococcus elongatus**Synechocystis* sp.*S. aquaticus**Trichodesmium* sp.*Tolypothrix* sp.**Euglenophyceae***Euglena* sp.*E. acus**E. oxyuris**E. proxima**E. viridis**Heteronema* sp.*Phacus* sp.*P. caudatus***Dinophyceae***Ciratium* sp.*Peridinium* sp.

Chrysophyceae

Chrysococcus sp.

Dinobryon sp.

D. sertularia

Synurophyceae

Synura sp.

Xanthophyceae

Tribonema sp.

T. bombycinum

Voucheria sp.

Cryptophyceae

Chroomonas sp.

Rhodophyceae

Batrachospermum sp.

Compsopogon sp.

Appendix II

Zooplankton of the lower Ganga from Varanasi to Farakka

Protozoa	<i>Arcella</i> sp.	Cladocera	<i>Alona</i> sp.
	<i>A. discoides</i>		<i>A. dentifera</i>
	<i>Centropyxis aculeta</i>		<i>Bosmina</i> sp.
	<i>C. ecornis</i>		<i>B. longirostris</i>
	<i>Diffugia</i> sp.		<i>Bosminopsis</i> sp.
	<i>D. oblonga</i>		<i>Ceriodaphnia</i> sp.
	<i>Paramecium</i> sp.		<i>C. rigaudi</i>
	<i>Vorticella</i> sp.		<i>Daphnia lumholtzi</i>
Rotifera	<i>Asplanchna</i> sp.		<i>D. carinata</i>
	<i>A. peroodonota</i>		<i>Diaphanosoma excisum</i>
	<i>Brachionus angularis</i>		<i>Moina</i> sp.
	<i>B. caudatus</i>		<i>M. brachiata</i>
	<i>B. calyciflorus</i>		<i>Simocephalus</i> sp.
	<i>B. diversicornis</i>	Copepoda	<i>Cyclops</i> sp.
	<i>B. falcatus</i>		<i>Diaptomus</i> sp.
	<i>B. forficula</i>		<i>Mesocyclops leuckarti</i>
	<i>B. quadridentatus</i>		<i>M. hyalinus</i>
	<i>B. rubens</i>		<i>Neodiaptomus</i> sp.
	<i>Euchlanis dilatata</i>		
	<i>Filinia longiseta</i>		
	<i>F. terminalis</i>		
	<i>Keratella</i> sp.		
	<i>K. cochlearis</i>		
	<i>K. tropica</i>		
	<i>K. serrulata</i>		
	<i>Lecane elasma</i>		
	<i>Monostyla</i> sp.		
	<i>M. bulla</i>		
	<i>M. closterocerca</i>		
	<i>Polyarthra vulgaris</i>		
	<i>Rotaria</i> sp.		
	<i>Synchaeta</i> sp.		
	<i>Testudinella</i> sp.		
	<i>Trichocera multicornis</i>		

Appendix III

Zoobenthos of the lower Ganga from Varanasi to Farakka

Coleoptera*Berosus indicus**B. pulchellus**Cybister tripunctatus**Dineutes spinosus**Guignotus pradhani**Haliplus pulchellus**Hydrophilus olivaceus**Laccobius sp.**L. anticatus**L. purvulus**Laccophilus chinensis**Regimbartia attenuata***Hemiptera***Amphiops sp.**Anisops sardea**Belostoma sp.**Canthydrus sp.**C. lactabilis**Corixa heiroglyphica**C. promontoria**Diplonychus annulatum**Gerris fossarum**Hydrometra sp.**Laccotrephes griseus**Micronecta merope**Notonecta sp.**Plea frontlis**Ranatra filiformes***Odonata***Asiagomphus sp.**Cordulegaster sp.**Ischnura delicata**I. senegalensis**Macrogomphus sp.**Paragomphus lineatus**Potomarcha obscura***Diptera***Anopheles sp.**Chironomus sp.**Clinotanypus sp.**Culex sp.**Monopelopia sp.***Ephemeroptera***Baetis sp.**Cloeon sp.**Ephemerella sp.***Trichoptera***Glossosoma sp.**Hydropsychidae sp.**Limephilus sp.**Triaenodes sp.***Crustacea***Barythelphusa lugubris**Caridina sp.**Gangemysis assimilis**Hymenicoides carteri**Macrobrachium sp.**Neorhynchoplax sp.**Parathelphusa martensi**Tachaea spongillicola***Annelida***Alboglossiphonia pahariensis**A. weberi**Allonais paraguayensis**Asiaticobdella birmanica**Aulodrilus pigueti**Aulophorus indicus**Barbronia weberi**Branchiodrilus semperi**Branchiura sowerbyi*

Annelida

Chaetogaster limnaei
Dero pectinata
Glyphidrilus gangeticus
Limnodrilus hoffmeisteri
Nais sp.
N. bretscheri
Namalycastis indica
Nephtys oligobranchia
N. polybranchia
Odontobdella krishna
Ozobranchus shipleyi
Perionyx excavatus
Placobdelloides fulvus
Pristina acuminata
P. biserrata
Salifa biharensis
S. lateroculata

Mollusca**Gastropoda**

Amnicola sp.
Assiminia sp.
Bellamyia bengalensis
Brotia costula
Digoniostoma pulchella
Ferrissia baconi
F. verruca
Gangetia miliacea
Glessula sp.
Gyraulus convexiusculus
Haitia mexicana
Hydrobia sp.
Indoplanorbis exustus
Lymnaea sp.
L. acuminata
Mekongia crassa

Gastropoda

Melania tuberculata
Melanoides tuberculatus
Pila globosa
Planorbis sp.
Quickia bensoni
Stenothyra ornate
Thiara granifera
T. lineata
T. scabra
T. tuberculatus

Pelecypoda

Corbicula assamensis
C. aurea
C. bensoni
C. regularis
C. striatella
Lamellidens consobrinus
L. corrianus
L. marginalis
Novaculina gangetica
Parreysia caerulea
P. corugata
P. favidens
P. lima
P. occata
P. olivaria
P. pachysoma
Pisidium clarkeanum
P. nevillianum
Scaphula celox
S. deltae

Appendix IV

Fishes of the lower Ganga from Varanasi to Farakka

Species	Families
<i>Ailia coila</i>	Schilbeidae
<i>Anabas testudineus</i>	Anabantidae
<i>Amblypharyngodon mola</i>	Cyprinidae
<i>Anguilla bengalensis</i>	Anguillidae
<i>Aspidoparia jaya</i>	Cyprinidae
<i>A. morar</i>	Cyprinidae
<i>Badis badis</i>	Badidae
<i>Bagarius bagarius</i>	Sisoridae
<i>Barilius bendelensis</i>	Cyprinidae
<i>B. bola</i>	Cyprinidae
<i>Botia dario</i>	Cobitidae
<i>B. dayi</i>	Cobitidae
<i>B. lohachata</i>	Cobitidae
<i>Catla catla</i>	Cyprinidae
<i>Chaca chaca</i>	Chacidae
<i>Chagunius chagunio</i>	Cyprinidae
<i>Chanda baculis</i>	Ambassidae
<i>C. nama</i>	Ambassidae
<i>C. ranga</i>	Ambassidae
<i>Channa orientalis</i>	Channidae
<i>C. gachua</i>	Channidae
<i>C. marulius</i>	Channidae
<i>C. punctatus</i>	Channidae
<i>C. striatus</i>	Channidae
<i>Chela atpar</i>	Cyprinidae
<i>C. bacaila</i>	Cyprinidae
<i>C. laubuca</i>	Cyprinidae
<i>Cirrhinus mrigala</i>	Cyprinidae
<i>C. reba</i>	Cyprinidae
<i>Clarias batrachus</i>	Clariidae
<i>Clupisoma garua</i>	Schilbeidae
<i>Colisa chuna</i>	Osphronemidae
<i>C. fasciata</i>	Osphronemidae
<i>Cyprinus carpio</i>	Cyprinidae
<i>Danio devario</i>	Cyprinidae
<i>D. rerio</i>	Cyprinidae
<i>Erethistes hara</i>	Sisoridae

Species	Families
<i>E. pusillus</i>	Sisoridae
<i>Esomus danricus</i>	Cyprinidae
<i>Eutropiichthys vacha</i>	Schilbeidae
<i>Gacata cenia</i>	Sisoridae
<i>G. gagata</i>	Sisoridae
<i>Garra annandalei</i>	Cyprinidae
<i>G. gotyla gotyla</i>	Cyprinidae
<i>Glossogobius giuris</i>	Gobiidae
<i>Goniolosa manmina</i>	Clupeidae
<i>Gobiopterus chuno</i>	Gobiidae
<i>Gudusia chapra</i>	Clupeidae
<i>G. variegata</i>	Clupeidae
<i>Hara hara</i>	Sisoridae
<i>Heteropneustes fossilis</i>	Heteropneustidae
<i>Ilisha motius</i>	Pristigasteridae
<i>J. coitor</i>	Sciaenidae
<i>Johnius gangeticus</i>	Sciaenidae
<i>Labeo bata</i>	Cyprinidae
<i>L. boga</i>	Cyprinidae
<i>L. boggut</i>	Cyprinidae
<i>L. calbasu</i>	Cyprinidae
<i>L. dero</i>	Cyprinidae
<i>L. fimbriatus</i>	Cyprinidae
<i>L. gonius</i>	Cyprinidae
<i>L. pangusia</i>	Cyprinidae
<i>L. rohita</i>	Cyprinidae
<i>Lates calcarifer</i>	Latidae
<i>Lepidocephalus guntea</i>	Cobitidae
<i>Lycodontis tile</i>	Muraenidae
<i>Macrognathus aral</i>	Mastacembelidae
<i>M. pancalus</i>	Mastacembelidae
<i>Mastacembelus armatus</i>	Mastacembelidae
<i>Megalops cyprinooides</i>	Megalopidae
<i>Monopterusuchia</i>	Synbranchidae
<i>Mystus bleekeri</i>	Bagridae
<i>M. cavasius</i>	Bagridae
<i>M. gulio</i>	Bagridae
<i>M. menoda</i>	Bagridae
<i>M. tengara</i>	Bagridae
<i>M. vittatus</i>	Bagridae
<i>Nandus nandus</i>	Nandidae

Species	Families
<i>Nangra nangra</i>	Sisoridae
<i>N. punctata</i>	Sisoridae
<i>Nemacheilus botia</i>	Balitoridae
<i>Notopterus chitala</i>	Notopteridae
<i>N. notopterus</i>	Notopteridae
<i>Ompok bimaculatus</i>	Siluridae
<i>O. pabda</i>	Siluridae
<i>O. pavel</i>	Siluridae
<i>Oreochromis niloticus</i>	Cichlidae
<i>Osteobrama cotio</i>	Cyprinidae
<i>Oxygastor gora</i>	Cyprinidae
<i>Pama pama</i>	Sciaenidae
<i>Pangasius pangasius</i>	Pangasiidae
<i>Parambassis ranga</i>	Ambassidae
<i>Polynemus paradiseus</i>	Polynemidae
<i>Pseudoambassis ranga</i>	Ambassidae
<i>Pseudotropius atherinoides</i>	Schilbeidae
<i>Puntius chola</i>	Cyprinidae
<i>P. chrysopterus</i>	Cyprinidae
<i>P. conchoniis</i>	Cyprinidae
<i>P. sarana sarana</i>	Cyprinidae
<i>P. sophore</i>	Cyprinidae
<i>P. ticto</i>	Cyprinidae
<i>Rasbora daniconius</i>	Cyprinidae
<i>Rhinomugil corsula</i>	Mugilidae
<i>Rita rita</i>	Bagridae
<i>Salmostoma bacaila</i>	Cyprinidae
<i>S. phulo</i>	Cyprinidae
<i>S. untrahi</i>	Cyprinidae
<i>Sciamugil cascasia</i>	Mugilidae
<i>Securicula gora</i>	Cyprinidae
<i>Setipinna brevifilis</i>	Engraulidae
<i>S. phasa</i>	Engraulidae
<i>Sillaginopsis panijus</i>	Sillaginidae
<i>Silonia silondia</i>	Schilbeidae
<i>Sisor rabdophorus</i>	Sisoridae
<i>Sperata aor</i>	Bagridae
<i>S. seenghala</i>	Bagridae
<i>Tenulosa ilisha</i>	Clupeidae
<i>Tetraodon cutcutia</i>	Tetraodontidae

Species	Families
<i>T. fluviatilis</i>	Tetraodontidae
<i>Wallago attu</i>	Siluridae
<i>Xenentodon cancila</i>	Belonidae