THE ECOLOGY AND FISHERY STATUS OF RIVER YAMUNA

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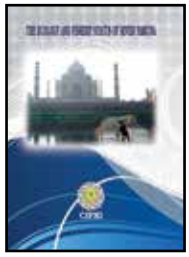

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Contents

Sl. No.	Chapters	Page No.
1.	**Introduction**	1
2.	**Physiography**	1
3.	**Geomorphology**	1
4.	**Tributaries of River Yamuna**	2
5.	**River Flow Characteristics**	3
6	**Uses of Yamuna River Water**	3
7.	**Pollution of Water**	4
	7.1 Domestic pollution	4
	7.2 Industrial pollution	5
	7.3 Agricultural pollution	5
	7.4 Sand mining	6
8.	**Encroachment over river bed and the flood plain**	6
9.	**Classification of the river stretch**	6
10.	**Habitat characteristics**	8
11.	**Fish and fisheries**	13
	11.1 Fish diversity	13
	11.2 Fish composition	13
	11.3 Distribution and relative abundance	14
	11.4 Trophic utilization by fishes	15
	11.5 Distribution of food & ornamental fishes	16
	11.6 Presence of exotic carps	16
	11.7 Conservation status	17
	11.8 Fish abundance - biomass assessment	20
12.	**Discussion**	30
13.	**Threats to river Yamuna**	30
	Alteration of flow	
	Pollution of water	
	Siltation and degradation of wetlands	
	Introduction of Exotic Species	
14.	**Conclusion**	31
15.	**References**	32

List of Tables

Table Number	Content
Table 1	Hydraulic structures on river Yamuna
Table 2	River water flow
Table 3	Abstraction of water from river Yamuna
Table 4	Physico-chemical parameters and land use pattern
Table 5	Mean values and range of environmental and land use variables (SD in parenthesis)
Table 6	Taxonomic list and abundance of fish species of river Yamuna

List of Figures

Figure Number	Content
Figures 1-6	Domestic pollution in the river
Figures 7-8	Industrial effluent drained into the river at Yamunanagar
Figures 9-10	Agricultural practices at Kulhal
Figures 11-12	Extraction of sand from river bed at Kulhal and Allahabad
Figures 13-14	Changing land use pattern at Yamunanagar
Figures 15-16	Map of river Yamuna and sampling spots
Figures 17-20	Habitat characteristics : Kulhal
Figures 21-24	Habitat characteristics : Dakpatthar
Figures 25-26	Habitat characteristics : Wazirabad
Figures 27-30	Habitat characteristics : Yamunanagar
Figures 31-34	Habitat characteristics : Agra
Figures 35-39	Variation in habitat parameters
Figures 40 -41	Family wise species abundance in river Yamuna

Figure Number	Content
Figure 42	Fish diversity and evenness of river Yamuna
Figure 43	Number of taxa and individuals recorded in Yamuna river
Figure 44	Hierarchical clustering of stations based on presence/absence of fish species indicating sites of similarity in fish species occurrence in Yamuna
Figure 45	Trophic status of fish species in river Yamuna
Figure 46	Comparative trophic level of fish species at different sites of river Yamuna
Figure 47	Distribution of food and ornamental fishes
Figure 48	Depicting the conservation status of fish of river Yamuna
Figures 49 -54	Fishing activities in River Yamuna
Figures 55 -60	Fish Catch from river Yamuna : Allahabad
Figures 61 -65	Fish Catch from river Yamuna : Wazirabad
Figures 66 -71	Fish Catch from river Yamuna : Yamunanagar
Figures 72 -77	Species abundance-biomass relationship at various stations along the river Yamuna
Figure 78	Relationship of Dissolved oxygen with fish abundance
Plates I - VII	Diversity of fish fauna of river Yamuna

Introduction

The river Yamuna is the largest tributary of the river Ganges. The river is revered for ages by the millions of people as it flows alongside the historical cities of Delhi, Vrindaban, Mathura and Agra . The river blends with the everlasting charms of the '*Taj Mahal*'.

It has a total catchment area of 3,66,223 km^2 spread over seven northern states. The Yamuna basin covers 42.5% of the total Ganga basin area and 10.7% of the highly fertile and high food grain yielding geographical land mass of India. The 1376 km long river from the source to its culmination in Ganges is a habitat for fish for approximately 1300 km stretch and supports a rich diversity of fish but exploitation of this resource takes place from Kalsi (junction of Tons and Yamuna) onwards on a small scale and from Tajewallah onwards on a large scale (Moza and Mishra 2003).

The river supports a rich diversity of fishe of commercial value (Moza and Mishra 2003; Mishra *et al*., 2007). But over the years the river has become highly polluted. The river water is extensively used for irrigation and receives heavy load of domestic and industrial wastes along its 1200 km journey through the states of Haryana, Delhi and Uttar Pradesh (Kazmi and Hansen, 1997; Mishra and Moza, 1997; Moza and Mishra, 2003; CPCB, 2005). All these factors have impacted the fisheries in the river as reflected by decline in fish catch, a discernible shift in fish species composition and an increasing presence of invasive fish species (Mishra *et al*.,2001, 2007; Vass *et al*., 2010). The systematic information on the diversity, community structure, impact of habitat alteration and ecological integrity assessment of the river is lacking. The present document presents the results of the study conducted during 2008-2010 in 1200 km stretch of the river from Dak Patthar to Allahabad to analyze the present status of the fish habitat, fish diversity, community structure and importance of the environmental factors in influencing the ecological integrity of the river.

2. Physiography

The ground elevation in the Yamuna River basin varies from about 6320 m above mean sea level (MSL) near Yamunotri Glacier to around 100 m above MSL near the confluence of Yamuna River with River Ganges at Allahabad. The topography of the Yamuna basin can be classified into three groups. They are Hilly Region – more than 600 m above MSL; Foot hills and Plateau region – 300 m to 600 m; Plains and valleys 100 m to 300 m above MSL.

On the basis of this topographic classification 11700 km^2 basin area (about 3.19%) can be classified as hilly, while the remaining is equally divided between plains and plateau regions with 161,231 km^2 and 172,917 km^2 respectively (CPCB, 2005).

The land use pattern in the Yamuna river catchment shows that the cultivable land in catchment is more than 60%, however, the land actually cultivated is about 52%. The forest land is only 12.5% in the catchment.

3. Geomorphology

The major soil type in the basin area is alluvial and covers about 42% of the basin area, followed by medium black soil 25.5% and mixed red and black soil 15%. The river

is dominantly aggradational in the plains and degradational around Kalpi in the WGP where it has incised reaches. The overall topography in the surrounding region is also of degradational nature. The amount and distribution of rainfall in space and in time directly controls the discharge variability in the river throughout the year, particularly during the monsoon months.

4. Tributaries of River Yamuna

In the upper Himalayan ranges of River Yamuna, four main rivers that join Yamuna are Rishi Ganga, which joins on the right bank of Yamuna, and Unta and Hanuman Ganga join on the left bank. In the lower Himalayan ranges the Yamuna River receives Kamal, Tons, Giri and Bata on its right bank and receives Aglag and Asan on its left bank. In the plains the tributaries Chambal, Betwa, Sindh and Ken join Yamuna on right bank and Hindon river joins River Yamuna in the left bank. The discharge of the tributaries Tons and Chambal to the main channel of river Yamuna is significant. (Table 1)

Table 1 Hydraulic structures on river Yamuna

SECTION	STATE	LENGTH (km)	TRIBUTARIES / DRAINS	DAM/BARRAGE	CANAL
Hills (Jamunotri – Hathnikund Barrage)	UK, UP, HP	172	Kamal, Giri, Tons, Asan	Dak Patthar Barrage, Asan Barrage	Dakpatthar Canal, Asan Canal
Upstream Delhi (Plains) (Hathnikund Barrage – Wazirabad Barrage)	Haryana, UP	224	Som nadi / Choti Yamuna Drain no. 2 and 8	Hathnikund Barrage	WYC and EYC
Delhi* (Wazirabad Barrage – Yamuna Barrage – Okhla Barrage)	Delhi	22	22 drains, Hindon Cut	Wazirabad Barrage, Yamuna Barrage	Agra canal
Downstream Delhi (Okhla Barrage-Confluence with Chambal)	UP, Haryana	490	Hindon, Bhuria Nala, Mathura – Vrindavan drain, Agra Drain	Okhla Barrage	Agra Canal, Gurgaon Canal
Revived Yamuna (Confluence with Chambal – Confluence with Ganga	UP	468	Chambal, Ken, Kali Sindh, Betwa	—	—
Total		1376			

WYC - Western Yamuna Canal, EYC - Eastern Yamuna Canal

5. River Flow Characteristics

River Yamuna carries almost 80% of total annual flow during monsoon period. The water flow reduces significantly during non-monsoon period accentuated by the diversion of water for irrigation and drinking purposes (CPCB, 2005).

Table 2 River water flow

Sites	Water velocity range (m/sec)	Depth (m)	Width (m)
Yamunanagar	0.14-0.21	0.5-2.45	140-260
Panipath	0.1-0.2	2.45-6.0	40-260
Delhi	0.15-0.17	3.6-5.05	84-255
Agra	0.12-0.2	1.3-2.8	80-150
Hamirpur	0.2-0.3	3.5-4.8	128-260
Allahabad	0.18-0.24	5.3-8.0	570-800

Diversion of water: Water from the river Yamuna has been diverted for power generation, irrigation and drinking water purposes at various places all along its length (Table 3).

6. Uses of Yamuna River Water

The river water is abstracted at different locations for varied uses. Substantial river water is abstracted at Hatnikund /Tajewala and Okhla. The percentage of water abstracted for varied purposes is as follows : Irrigation 94% Domestic Water Supply 4%; Industrial & Other uses 2% ; The annual abstraction at various location is depicted in Table 3.

Table 3 Abstraction of water from river Yamuna

Site	Structure	State	Purpose	Water abstraction and state of river
Dak Patthar	Barrage	UK	Power generation	Water diverted into canal
Asan	Barrage	UK	Power generation	Water diverted into canal
Hathnikund	Barrage	UP/ Haryana	Irrigation and drinking water	20,000 MLD of Water abstracted and diverted into WYC and EYC (No water flow downstream in dry season)
Wazirabad	Barrage	Delhi	Drinking water	1,100 MLD of water abstracted. Generally no water flow downstream in dry season
ITO bridge	Barrage	Delhi	Water supply to power plant	Water available mainly from drains
Okhla	Barrage	Delhi / UP	Water Supply into Agra Canal	5000 MLD of water abstracted between Wazirabad to Okhla .Generally no water flow downstream in dry season

Source: CPCB, 2000. WYC - Western Yamuna Canal; EYC - Eastern Yamuna Canal

7. Pollution of water

River Yamuna today is one of the most polluted rivers in the country. Domestic, agriculture as well as industrial pollution sources are mainly responsible for the present plight of the river.

7.1 Domestic Pollution:

Urban centres in the state of Uttarakhand (Dehradun), Haryana (Yamunanagar, Karnal, Panipat, Sonepat, Faridabad, Bhallabhgarh), UP (Saharanpur, Muzzafarnagar, Baghpat, Gaziabad, Noida, Mathura, Agra) and Delhi are the major sources of domestic pollution of the river. Increasing water requirement for domestic uses and the impact of resultant wastewater discharge in form of sewage (especially since the latter has not been efficiently treated and managed) on the receiving river has deteriorated the water quality.

Domestic uses that pollute the river include cattle wading, bathing, open defecation and washing of clothes in the river and the offerings and remnants of religious ceremonies performed in individual houses and in public places.(Figs.1-6)

Sources of domestic pollution in the river

1. Domestic waste discharge into Yamuna at Allahabad

2. Cloth washing at Allahabad

3.Ritual activities at Wazirabad

4. Effluent release Najafgarh nallah at Wazirabad

5.Cattle washing at Allahabad

6.Burning ghat at Agra

7.2 Industrial pollution:

Industrial pollution affects river water dissolved oxygen, pH, temperature, *etc* and adds heavy metals, phenolics and other organic pollutants According to CPCB (2000) there were 22 industrial units in Haryana, 42 units in Delhi and 17 units in Uttar Pradesh, which have been found to be directly discharging and polluting the river. These industries include paper, sugar, chemical, leather, distillery, pharmaceuticals, power *etc*. (Figs. 7-8)

7-8. Industrial effluent drained into the river at Yamunanagar

7.3 Agricultural pollution:

Agricultural pollution is mainly caused by agricultural residues, fertilizers and pesticides used in fields and the cattle (Figs. 9-10).

9-10. Agricultural practices at Kulhal

7.4 Sand mining :

The river bed is extensively exploited along the stretch for sand mining (Figs 11-12)


11-12. Extraction of sand from river bed at Kulhal and Allahabad

8. Encroachment over river bed and the flood plain

River bed and flood plains are part of an aquatic ecosystem with important ecological role of ensuring smooth river water flows, growth of requisite vegetation, ground water recharge as well as flood water regulation. Any encroachment on river bed or the flood plain resulting in a change in land use, results in hindering of one or all of the above functions (Figs 13-14).In Delhi, Zone o (6100 ha) and part of Zone P (3600 ha) (between the two embankments on west and east of the river adjacent to the Wazirabad barrage) has been identified as the river Yamuna spread over an area of around 97 sq km. Of this, 16 sq km is under water and the rest around 81 sq km is the river flood plain.


13-14. Changing land use pattern at Yamunanagar

9. Classification of the river stretch

Based on the geological and hydrological characteristics, the river Yamuna is classified into four distinct segments (GOI, 1993; CPCB, 2005):

1. Segment I/ Himalayan segment (157km) from Yamunotri to Hathnikund barrage. The major source of water in the segment is the melting glaciers.

2. Segment II/ Upper segment (224 km) from Hathnikund barrage to Wazirabad barrage. The main source of water in the segment is ground water accrual and contribution from few small tributaries.

3. Segment III /Delhi segment (22 km) between Wazirabad barrage and Okhla barrage. It receives water from 17 sewage drains of Delhi and also some water from Western Yamuna canal and Upper Ganga canal.

4. Segment IV/ (973 km) downstream of Okhla Barrage to confluence with river Ganga at Allahabad. The source of water is ground water accrual and the tributaries, Hindon, Chambal, Sridhar, Ken, Betwa *etc*.

To assess the current status of the environment and fishery of river Yamuna the present study was conducted during 2008 -10 along 1200 km stretch at 8 sampling stations selected on the basis of fishery and its habitat characteristics in all the four segments of the river (Fig. 15-16). These sites were Dakpathhar (Y1) and Kulhal (Y2) in segment I, Yamunanagar (Y3) and Panipat (Y4) in segment II, Wazirabad (Y5) in segment III, Agra (Y6), Hamirpur (Y7) and Allahabad (Y8) in segment IV of the main channel of the river.

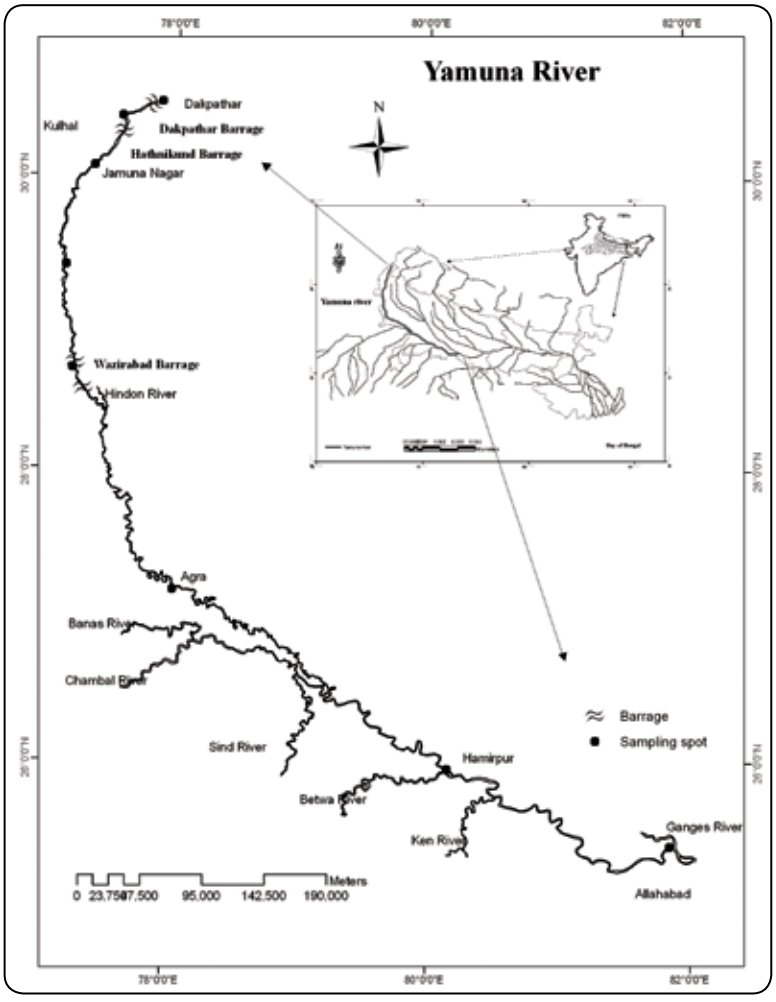


Fig 15. Map of river Yamuna

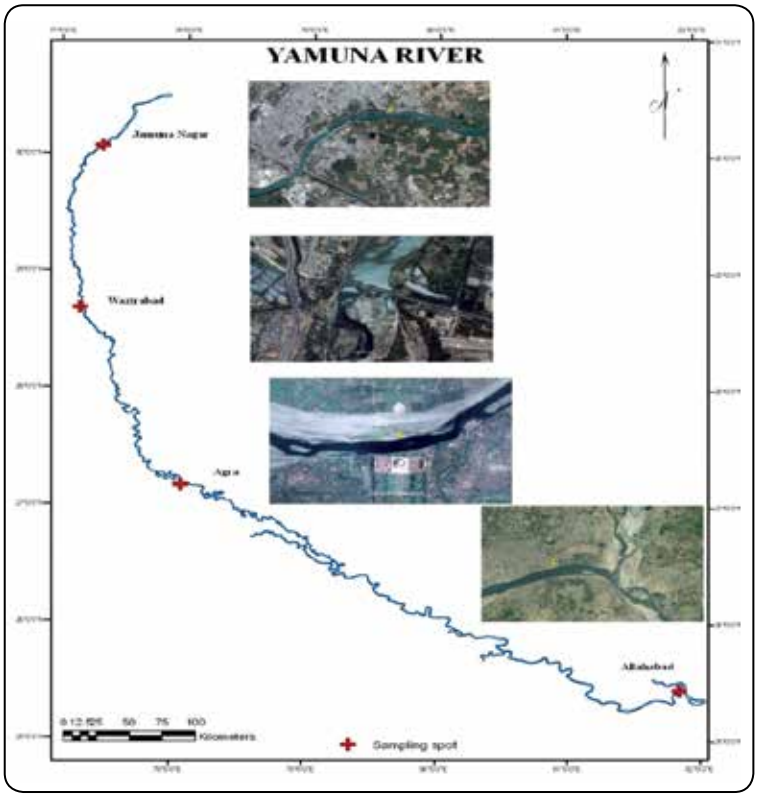


Fig 16. Map of river Yamuna and sampling spots

10. Habitat characteristics :

The habitat characteristics and environmental quality of the various stretches of the river studied are depicted in Figures (17-34) and Table 4.

Kulhal

17-18. River stretch at Kulhal


19-20. Lean period water at Kulhal showing substrate and riparian vegetation

Dakpatthar stretch




21-24. Substrate with boulder and gravels at Dakpatthar

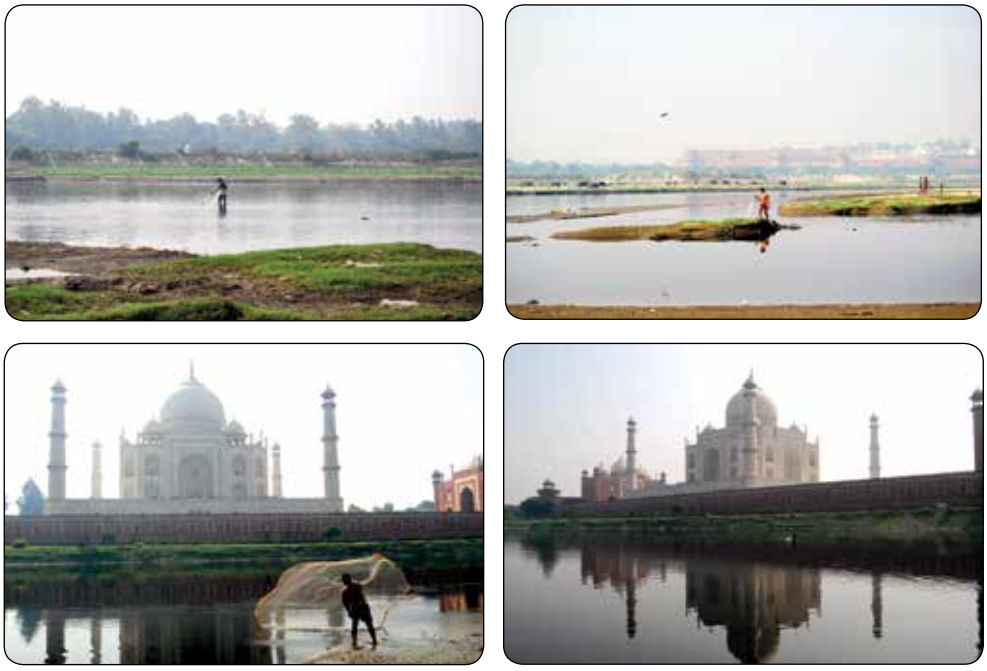
Wazirabad Stretch


25-26. Wazirabad Stretch downstream barrage Wazirabad Barrage

Yamunanagar stretch

27-30. Riparian vegetation Yamunanagar Anicut at Yamunanagar

Agra stretch



31-34. Agra stretch

Table 4: Physico-chemical parameters and land use pattern

Parameters	Dakpathar (Y1)	Kulhal (Y2)	Yamunanagar(Y3)	Panipath (Y4)	Wazirabad (Y5)	Agra (Y6)	Hamirpur (Y7)	Allahabad (Y8)
Physical parameters								
GPS Coordinates	30°30'04.45'' N 77°47'14.83''E Elevation:1497 ft	30°25'4.20'' N 77°36'44.57''E Elevation:1276 ft	30°03'27.25'' N 77°19'23.38''E	29°23'07.23'' N 77°09'05.42''E	28°38'03.54'' N 77°15'29.00''E	27°10'43.93'' N 78°02'45.46''E	25°57'47.22'' N 80°08'59.94''E	25°55'19.14'' N 81°50'37.75''E
CPUE (kg/h/person)	0.233	0.173	0.67	0.67	0.519	0.656	0.656	0.788
Width of channel(m)	270- 400	450- 750	160-280	60-285	84-260	80-170	130-280	550- 700
Mean depth (m)	1.0- 2.0	1.5 2.5	0.5 -2.5	2.4 – 6.0	3.5 -5.0	1.5 -3.0	3.5 -5.0	5.5 - 8.0
Substrate composition	Boulders 10%, pebbles 20%, gravels 40, sand 30%	Boulders 15%, pebbles 20%, gravels 35, sand 30%	Sand 55%, clay and others 45%	Sand 70%, clay and others 30%	Clay 85%, Others 15%	Sand 45%, Clay and others 65%	Clay 55%, Sand and others 45%	Clay 40%, Sand 60%
Bank cover	Covered with riparian vegetation	Covered with riparian vegetation	Covered with riparian vegetation and domestic houses	Covered with riparian vegetation and domestic houses	Covered with medium riparian vegetation	Covered with riparian vegetation and monuments	Covered with riparian vegetation and domestic houses	Covered with riparian vegetation and domestic houses
Land use								
Forest Vegetation	1	1	1	1	1	1	1	1
Crop land	0	0	0	0	0	0	0	0
Rangeland	1	1	1	1	1	0	1	1
Riprap	1	1	0	0	1	0	0	0
Factory	0	0	0	0	1	1	0	0
Domestic	1	1	1	1	0	0	1	1
Chemical parameters								
Water Temp (°C)	20.5	20.8	21.6	20.9	22.6	22.4	23.7	24.6
Turbidity (cm)	60	83	60	109	37	38	40	57
pH	7.4	7.7	8.1	8.0	7.7	7.6	8.1	8.1
DO (mgl^{-1})	8.9	9.8	8.1	7.5	3.7	3.4	7.6	7.3
Conductivity ($\mu S\ cm^{-1}$)	234	247	376	364	778	1143	591	417
TDS (mgl^{-1})	211	225	245	237	505	743	388	271
Stream Velocity ($m100\ sec^{-1}$)	28	27.6	17.5	14	16	20	23	21

Table 5 Mean values and range of environmental and land use variables (SD in parenthesis)

Variables	Mean	Range
DO (mg l^{-1})	7.04(2.31)	3.40-9.85
Turbidity (cm)	60.40(25.00)	37.00-109.00
Conductivity (µS cm^{-1})	519(310)	234-1143
TDS (mg l^{-1})	353.1(187.1)	211.3-743.0
Stream Velocity (m 100 sec^{-1})	20.89(5.12)	14.00-28.00
Water Temp. (°C)	22.14(1.47)	20.5-24.6
pH	7.84(0.27)	7.4-8.1
Depth (m)	3.23(1.86)	1.38-6.73
Domestic (Presence/absence)	0.75(0.46)	0-1
Rangeland (Presence/absence)	0.88(0.35)	0-1
Factory (Presence/absence)	0.25(0.46)	0-1
Riprap (Presence/absence)	0.38(0.52)	0-1

Soil texture showed dominance of sand (91-98 %).The substrate type varied from cobbles, boulders coarse sand upstream at Dakpatthar to sand and clay downstream at Allahabad (Table 5)

Among habitat variables, transparency, water velocity, pH, DO and depth varied considerably among the sites. Water velocity gradually decreased in the lower stretches of the river. DO was high at upper and lower stretches of the river Yamuna and very low (3.37-4.1 mg/l) in the middle stretch. Water transparency varied seasonally among the sites from very low (39.5 cm) to quite clear (109 cm) with moderate average (57.8 cm). Depth varied across the sites ranging from 1m in the middle stretch to 3.2 m in the lower stretch. The pH along the stretch ranged from 7.6 to 8.1. (Figs 35-39).

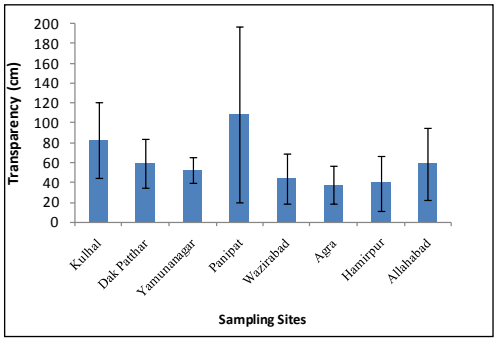


Fig.35

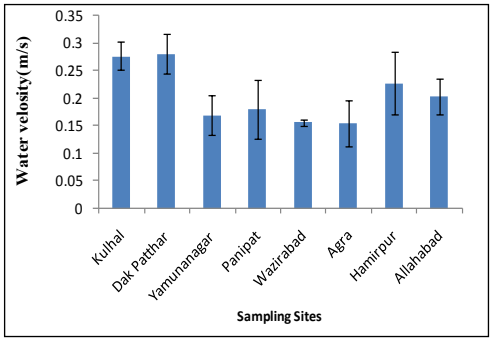


Fig.36

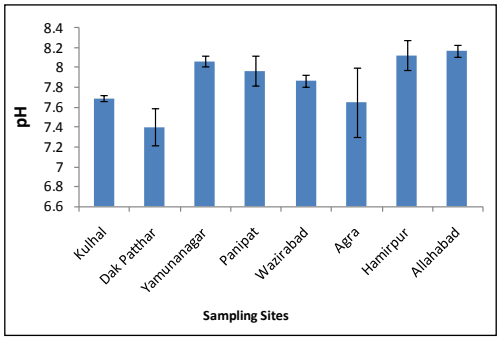


Fig.37

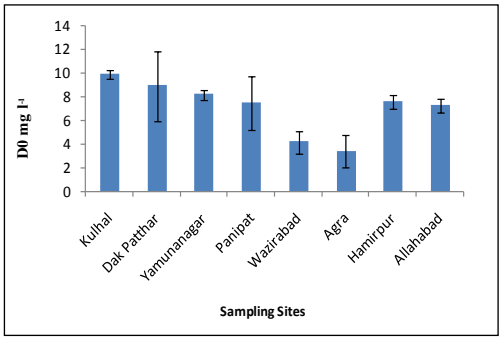


Fig.38

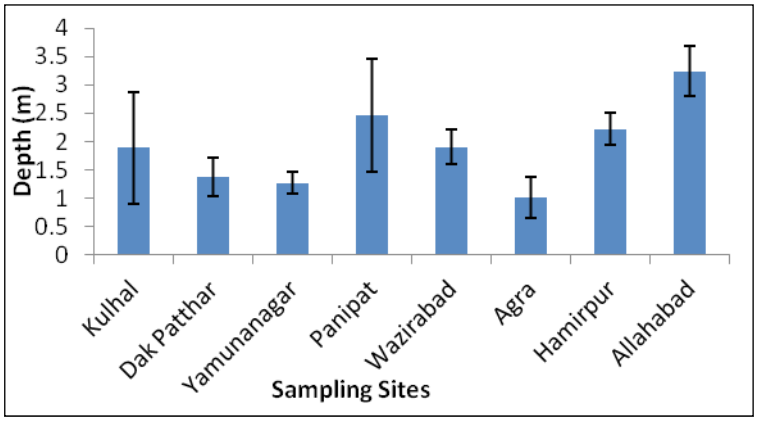


Fig.39

Figures 35-39 Variation in habitat parameters

11. Fish and fisheries

11.1 Fish diversity

93 fish species belonging to 23 families were recorded from fish sampled from different sites of the river (Table 6). The fishes were identified as per Jayaram, 1981. Talwar & Jhingran 1991,and Froese, et al, 2010. Photograps of the identified fishes are depicted in (PLATES I – VII)

11.2 Fish composition

Species of the family Cyprinidae (46.2%) were most dominant followed by Schilbidae (7.5%), Bagridae (6.5%) and Clupeidae (4.3%) (Fig. 40 -41). The relative abundance of fish studied is depicted in Table 6.

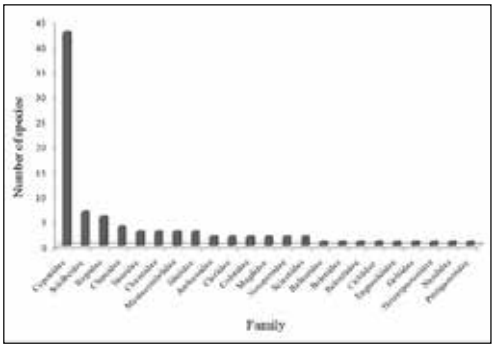


Fig.40

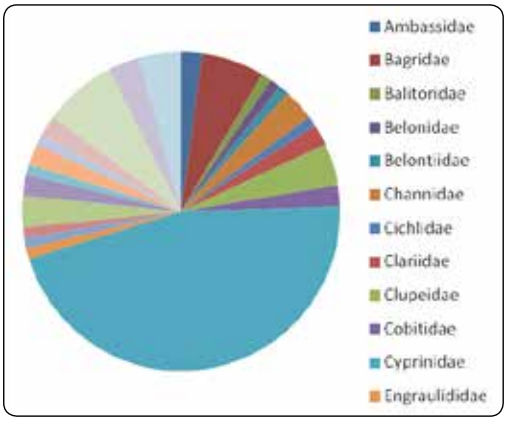


Fig.41

Figures 40 &41 Family wise species abundance in river Yamuna

Maximum number of species (62) was recorded in the lower stretch at Allahabad followed by Yamunanagar in the middle stretch. Dakpatthar sampling site located in the upper stretch, showed low species diversity index with good evenness of species but Agra site exhibited low ~~species diversity with low~~ evenness being dominated by only 7 species of which *Oreochromis niloticus* had a relative abundance of 64.4%. Sites (Y3-Y8) exhibited higher diversity index with low evenness of species (0.1-0.4) being dominated by 8-10 eurytopic species. The maximum and minimum fish species and numbers were recorded at Y8 and Y2 respectively (Fig. 42,43).

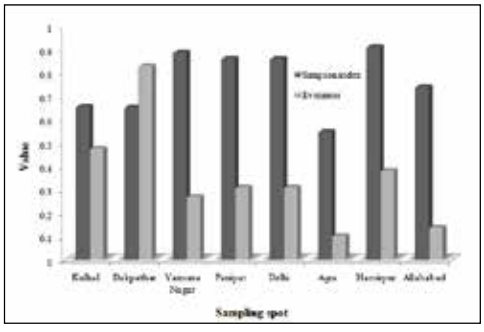


Fig. 42 Fish diversity and evenness of river Yamuna

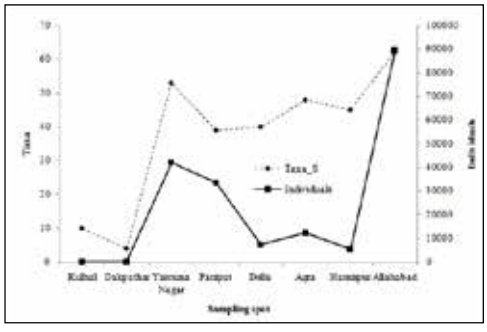


Fig. 43 Number of taxa and individuals recorded in Yamuna river

11.3 Distribution and relative abundance

The abundance of individuals of fish species across the sites showed a typical left skewed nature. This means that most of the species are relatively rare while a few species are dominant; 48 species had an abundance of about 250 individuals. 7 species with good relative abundance *viz*., *Puntius sophore*, *P. ticto*, *Barilius barila*, *Cirrhinus mrigala*, *Cyprinus carpio* and *Macrognathus pancalus* were recorded in majority of the sites (Table 6).

The highest species similarity (48%) was recorded between Yamunanagar - Panipat, followed by Delhi - Hamirpur (41%) and Yamunanagar - Allahabad (31%) (Fig. 44).

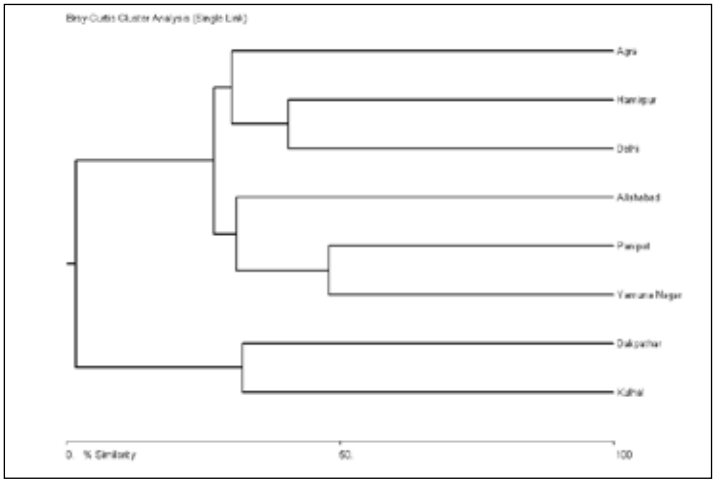


Fig.44 Hierarchical clustering of stations based on presence/absence of fish species indicating sites of similarity in fish species occurrence in Yamuna

11.4 Trophic utilization by fishes

A perusal of the figure 45 reveals that in the entire river stretch carnivores were dominant (47.87%) followed by omnivores (30.86%) and herbivores (21.27%). Carnivores were the predominant group (38.5-55%) in the fish assemblage of the lower stretch from Panipat to Allahabad whereas omnivores were the predominant group (35-75%) in the upper stretch from Dakpatthar to Yamunanagar. The maximum number of carnivore were recorded at Hamirpur (55.31%), Wazirabad (51.28%) and Agra (50%), while herbivore at Yamunanagar (32.07%) and Panipath (33.30%). Maximum number of omnivore were observed at Dakpathar (75%) (Fig. 46).

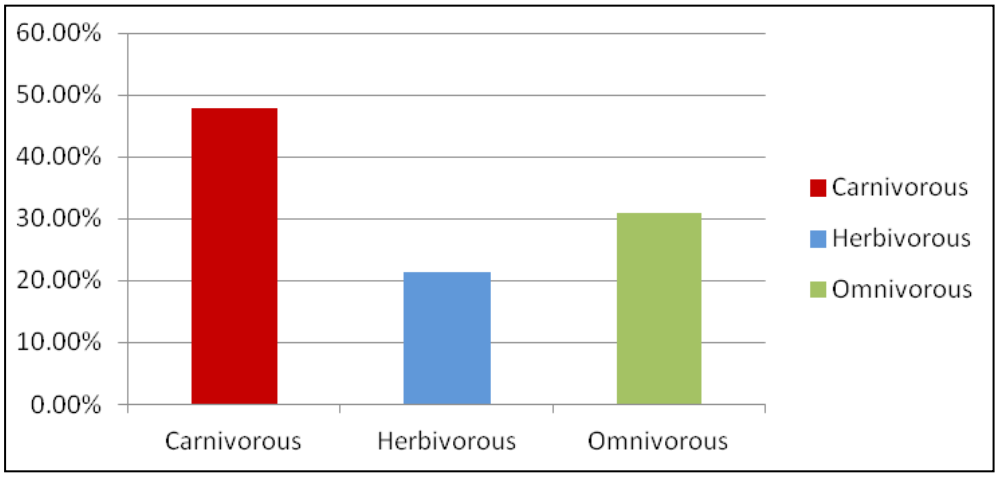


Fig 45 Trophic status of fish species in river Yamuna

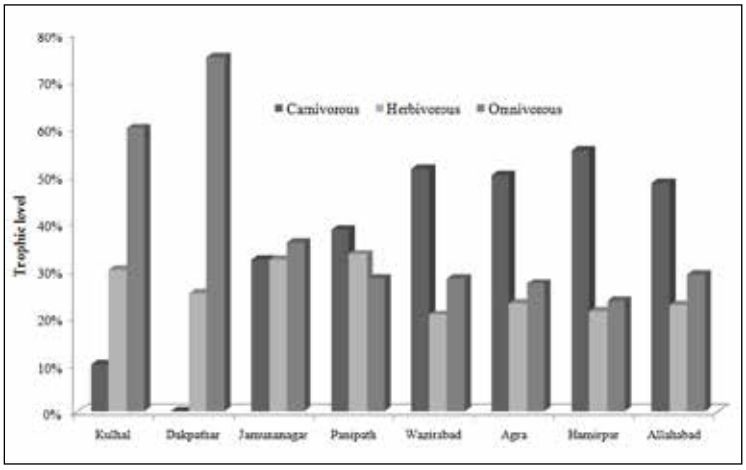


Fig.46 Comparative trophic level of fish species at different sites of river Yamuna

11.5 Distribution of food & ornamental fishes:

In various stretches of river Yamuna, maximum proportion of food fishes (65.95%) was observed followed by ornamental fish (27.65%) and sport fish (6.38%) (Fig 47).

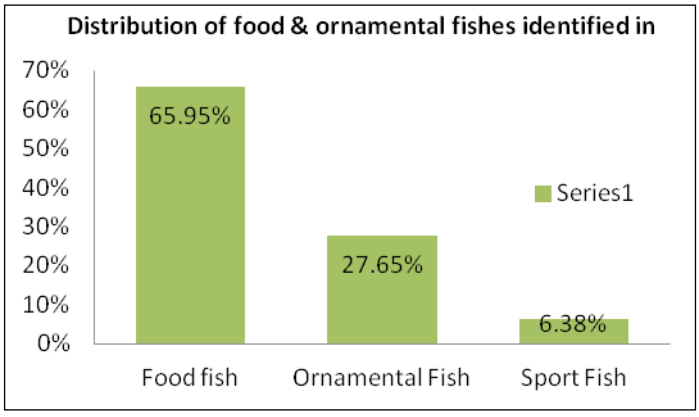


Fig.47 Distribution of food & ornamental fishes

Life history categorization of the 92 species recorded in the stretch (Y3-Y8) revealed 72 species to have periodic life history strategy, 10 opportunistic strategy and 12 equilibrium strategy. This middle stretch is dominated by small bodied periodic life history strategists, *viz. Salmopasia bacaila, Puntius sophore, A. morar, P. ticto B. barila, G. chapra. L. bata, C. garua, Gogangra viridescens, L. fimbriatus, G. manmina, Crossocheilus latiuslatius, C. laubuca, Osteobrama cotio cotio*, opportunistic strategists *O. niloticus* and *C. carpio* with and equivalent strategists *Sperata seenghala* and *C. marulius.*

11.6 Presence of exotics

Significant presence of *Oreochromis niloticus* and *Cyprinus carpio* is evident in majority of the stretches (Panipat, Delhi, Agra, Hamirpur and Allahabad) with mean relative abundance range of 0.6 to 9.9%. This trend of increasing exotic fishes in the

middle stretch of the river has earlier been reported by Anon (1994-2011), Mishra and Moza (1997), Moza and Mishra (2001). The present study showed the occurrence of exotics in greater numbers from a larger geographical area of the river.

11.7 Conservation status

Evaluation of the conservation status of fish species in river Yamuna as per IUCN criteria revealed 62 species of fishes to fall in the category of least concern followed by 19 species under not evaluated (NE), 8 species near threatened (NT), 2 species vulnerable (VU) and 1 species each in the lower risk near threatened (LRnt), endangered (EN) and data deficient category. (Fig 48)

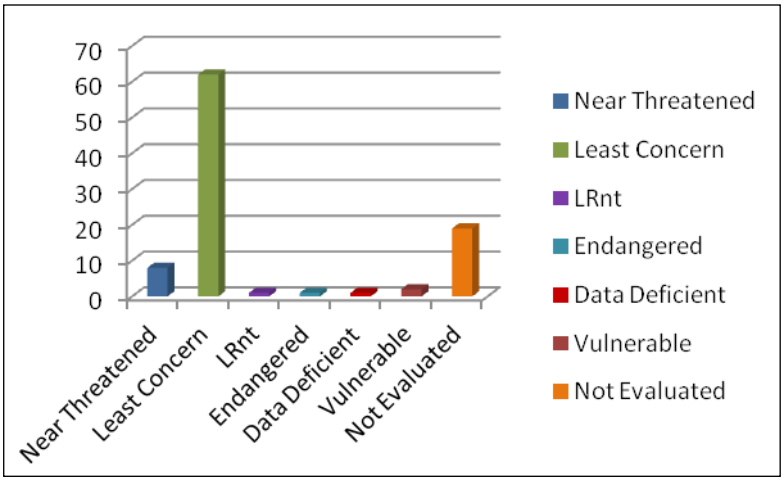


Fig.48: Depicting the conservation status of fish of river Yamuna

Fishing activities in River Yamuna (Figs 49- 54)

49-50. Kulhal and Dakpatthar


51-52. Yamunanagar


53-54. Agra Allahabad

Fish Catch from river Yamuna (Figs 55 – 71)

Allahabad

55. Miscellaneous fish

56. Tilapia

57. Cyprinus

58. Catfish

59-60. Gadusia chapra

Wazirabad

61-63. Tilapia

64. Puntius

65. *Tor tor*

Yamunanagar


66-67. Indian major carps & common carps




68-71. Assorted catch of fish

11.8 Fish abundance - biomass assessment

The study revealed that in Agra and Hamirpur the biomass curve passes over the abundance curve indicating more of large sized species than the miscellaneous fish groups of smaller size. While at other sites the biomass dominated over the abundance curve (Figs.72-77).

Abundance curves for fish faunal study at different sites of river Yamuna indicated undisturbed (unpolluted), moderately disturbed and grossly disturbed or polluted sites. Panipat and Delhi were relatively disturbed zones with biomass curve passing above the abundance curve. This is because of the dominance of opportunistic

species in contrast to large sized species due to degraded environment condition. High frequency of omnivores as well as exotics was recorded at these sites, which reflected poor water quality conditions. Whereas at Agra abundance curve showed less stressed condition being reflected by the high number of exotics, which also dominated in terms of biomass than any other species. As such the biomass curve is above the abundance curve. Thus, the recorded data are indicative of the degraded environment condition and gradual depletion of native species. Mention must be made on high pollution level of Yamuna river in Agra with very less dissolved oxygen level indicative of poor water conditions. While Hamirpur appeared to be undisturbed being evident from its abundance curves as well as from its biotic integrity.

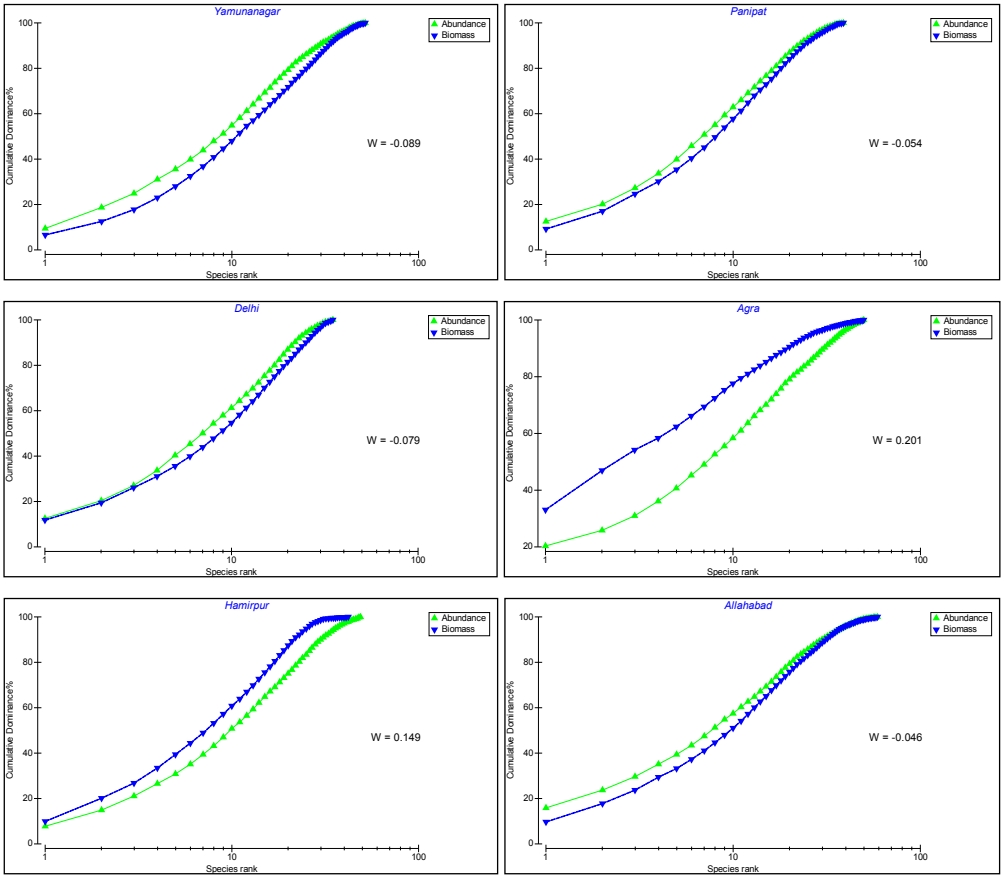


Fig. 72-77 Species abundance-biomass relationship at various stations along the river Yamuna

Among the physicochemical parameters, the variations in dissolved oxygen was recorded to be most critical. At suboptimal DO the abundance of fishes was observed to decrease (Fig. 78). Thus, in river Yamuna, DO can be inferred as the limiting factor for fish productivity especially at the stretches of Agra and Delhi where the aquatic environment is suboptimal for fisheries and require special effort to restore the stretches.

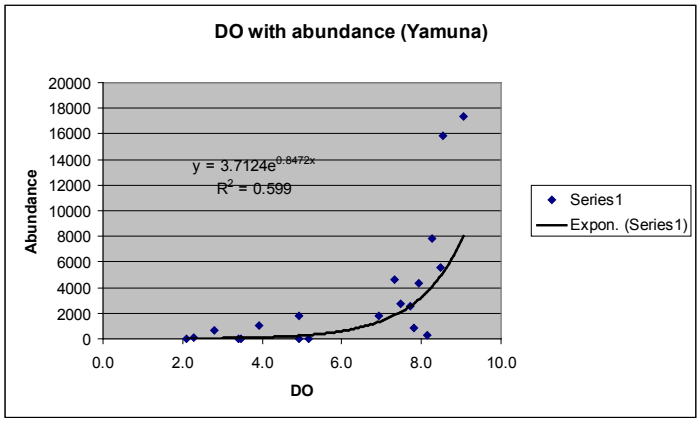


Fig. 78 Relationship of Dissolved oxygen with fish abundance

Diversity Of Fish Fauna Of River Yamuna

PLATE - I

Notopterus notopterus

Corica soborna

Gonialosa manmina

Gudusia chapra

Tenualosa ilisha

Amblypharyngodon mola

Aspidoparia morar

Barilius barna

Barilius bendelisis

Barilius vagra

PLATE - II

Catla catla

Chagunius chagunio

Chela laubuca

Cirrhinus mrigala

Cirrhinus reba

Crossocheilus latius latius

Ctenopharyngodon idella

Cyprinus carpio

Danio devario

Garra lamta

PLATE - III

Hypophthalmichthys molitrix

Labeo angra

Labeo bata

Labeo boga

Labeo dyocheilus

Labeo calbasu

Labeo fimbriatus

Labeo gonius

Labeo rohita

Osteobrama cotio

PLATE - IV

Parluciosoma daniconius

Puntius chola

Puntius conchonius

Puntius sarana

Puntius sophore

Puntius ticto

Raiamas bola

Salmophasia bacaila

Securicula gora

Tor putitora

PLATE - V

Nemacheilus botia

Lepidocephalus guntea

Mystus bleekeri

Mystus cavasius

Mystus vittatus

Rita rita

Sperata aor

Sperata seenghala

Ompok bimaculatus

Ompok pabda

Wallago attu

Ailia coila

PLATE - VI

Clupisoma garua

Eutropichthys murius

Eutropichthys vacha

Silonia silondia

Bagarius bagarius

Clarias batrachus

Clarias gariepinus (Exotic)

Heteropneustes fossilis

Xenentodon cancila

Chanda nama

Parambassis ranga

Johnius coitor

PLATE - VII

Johnius gangeticus

Nandus nandus

Oreochromis nilotica (Exotic)

Rhinomugil corsula

Sicamugil cascasia

Glossogobius giuris

Colisa fasciatus

Channa marulius

Channa punctatus

Channa striatus

Macrognathus pancalus

Mastacembelus armatus

12. Discussion

A scrutiny of the earlier records on the fish species of the river Yamuna (Sehgal, 1992; Moza and Mishra, 2001; Jhingran, 1975; Khan *et al.*, 1995; Mishra *et al.*, 2007) recorded 70 species. The present study recorded 93 species in the main channel of the river.

The trend of dominance of species of the family Cyprinidae observed in the present study is in consonance to the observation in other Indian and some tropical rivers of Southeast Asia (Bhatt, 2003; Raghavan *et. al.*, 2008; Sarkar *et al.*, 2009; Shanawaz *et al.*, 2010; De Silva *et al.*, 2007; Vass *et al.*, 2011).

The decline of the Indian major carps especially *C. mrigala* and dominance of small bodied cyprinids and fishes with opportunistic life history strategy like *O. niloticus, Puntius ticto, Chanda nama* and *C. carpio* is evident at some sites (Y6-Y8) of the river stretch. It reflects the ability of these species to colonize the altered habitat conditions prevailing in the river stretch since opportunistic strategists have a high demographic resilience. Research in other Asian rivers with long standing fisheries have revealed a tendency for large fishes with periodic type life-history strategists to be replaced by smaller species with opportunistic- type strategies (Arthington *et al.*, 2004) or with small bodied cyprinids.

The increasing presence of exotic fishes *C. carpio* and *O. niloticus* recorded from a larger geographical area in segment II and III of the river Yamuna reinforces the opinion of previous workers (Anon, 1994-2011; Mishra *et al.*, 2007; Vass *et al.*, 2011) that the species are gradually establishing themselves as a breeding population replacing the Indian major carps. Observation in the rivers of other countries (Kolar and Lodge, 2002) also indicated that reduced discharge alter the micro and macro habitat characters favouring the increase of non- indigenous species

13. Threats to river Yamuna

The major threats affecting the ecological integrity of River Yamuna identified during the investigation have been

(i) Alteration of the habitat of fish: The alteration of flow of river Yamuna has changed the habitat characteristics for fish and other aquatic organism. The disruption of the longitudinal and lateral connectivity of the river by diversion of the river water for power generation, irrigation and drinking water purposes at various places all along its length from the barrages at Dakpatthar, Asan, Hathnikund, Wazirabad, ITO bridge, and Okhla has altered the flow characteristics.

(ii) Pollution of water: The Ganga basin in general and the Yamuna basin in particular has a large proportion of the population concentrated in large urban centres, most of which do not have any sewerage and those with sewerage system do not have yet adequate capacity to treat domestic wastewaters. Therefore, enormous amounts of untreated or partly treated sewage are directly discharged in the river Yamuna in the urban centres along with industrial effluents and agrochemical pollutants (CPCB, 2005). As a result the water quality has deteriorated in these segments of the river. Since 1985, the Government has implemented the Ganga Action Plan to provide for interception and treatment of sewage in major cities along the River Ganga. This was later extended to many cities and smaller towns along River Yamuna (under the Yamuna Action Plan)

and other rivers in the Ganga basin (CPCB, 2005). Under present situation the river is not serving as an optimum habitat for fish.

(iii) Siltation and degradation of wetlands: All the segments of river Yamuna have been subjected to siltation, encroachment of river beds and the flood plains. This has resulted in a change in land use pattern hindering the ecological functions of the wetlands in the Yamuna basin.

(iv) Introduction of Exotic Species: Alteration of the habitat structure in river Yamuna has provided a favourable environment for the exotic species *Cyprinus carpio, Oreochromis niloticus, Clarius gariepinus* to colonise the river since 2003 resulting in decline of the valuable Indian major carps.

14. Conclusion

The management strategies for the fisheries of river Yamuna need to be viewed holistically. While maintaining sustainable production from the river it needs to be ensured that the maximum number of fisherfolk, traders and other support personnel make a reasonable living from the fish resource. The strategies advocated for effective management and conservation of fisheries in the river are summarised below:

Conservation efforts in the Yamuna basin necessitates a national approach to check deforestation in the Himalayan stretch of the river coupled with massive afforestation programme even along the plains to halt the soil erosion.

Commercial exploitation of Yamuna bed for extraction of stones/pebbles in upper segment of the river at Hathnikund, Doddopur, Tajewallah should not be allowed in order to preserve the breeding grounds and food web of the prized Mahseer fishery.

Programmes aimed at restoring the quality of river water and abating pollution, should evolve viable standards for various parameters, stretch-wise and to ensure that the standards are strictly adhered to by the agencies concerned, *viz.* industries, municipalities *etc.* There is also a need for direct monitoring of the ecosystem by the enforcing agency.

The indentified sanctuary areas between the two states *i.e.* Haryana and U.P. should not be leased. Strict imposition of mesh size along with fish size needs to be pursued earnestly by the concerned department.

One major concern demanding the attention of policy makers is the question of water allocations for maintaining ecological services. The collective management of rivers should ensure that interests of all its users including the fishers are protected in a sustained way.

Traditionally, the rivers are managed as common property resource. These have multiple uses for riparian area population. The residents of these areas cannot be excluded from its use, as they have the rights and duties in common property regime.

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Table 6. Taxonomic list and abundance of fish species of river Yamuna

	Species	Kulhal	RA	Dakpathar	RA	Yamunanagar	RA	Panipat	RA	Delhi	RA	Agra	RA	Hamirpur	RA	Allahabad	RA	Total	Total RA
1	*Aborichthyes elongatus*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	36	0.67	0	0.00	36	0.02
2	*Ailia coila*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	217	4.02	277	0.31	494	0.26
3	*Ailia punctata*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.02	0	0.00	1	0.00
4	*Amblypharyngodon mola*	0	0.00	0	0.00	780	1.85	58	0.17	0	0.00	12	0.10	0	0.00	22	0.02	872	0.46
5	*Aspidoparia jaya*	0	0.00	0	0.00	665	1.58	1254	3.76	0	0.00	0	0.00	0	0.00	12	0.01	1931	1.02
6	*Aspidoparia morar*	0	0.00	0	0.00	9141	21.68	3214	9.65	604	8.40	571	4.68	816	15.10	10383	11.59	24729	13.02
7	*Bagarius bagarius*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.02	16	0.30	41	0.05	59	0.03
8	*Barilius barila*	4	6.35	6	25.00	2141	5.08	2543	7.63	67	0.93	2	0.02	30	0.56	91	0.10	4884	2.57
9	*Barilius barna*	0	0.00	0	0.00	1154	2.74	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1154	0.61
10	*Barilius bendelisis*	2	3.17	0	0.00	500	1.19	0	0.00	0	0.00	0	0.00	73	1.35	0	0.00	575	0.30
11	*Barilius vagra*	0	0.00	0	0.00	10	0.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	10	0.01
12	*Botia lohachata*	0	0.00	0	0.00	23	0.05	0	0.00	0	0.00	15	0.12	0	0.00	0	0.00	38	0.02
13	*Catla catla*	0	0.00	0	0.00	3	0.01	56	0.17	0	0.00	10	0.08	2	0.04	0	0.00	71	0.04
14	*Chagunius chagunio*	0	0.00	0	0.00	380	0.90	0	0.00	0	0.00	5	0.04	11	0.20	82	0.09	478	0.25
15	*Chanda nama*	0	0.00	0	0.00	1762	4.18	10292	30.89	639	8.88	23	0.19	124	2.29	1254	1.40	14094	7.42
16	*Channa marulius*	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	18	0.15	279	5.16	24	0.03	322	0.17
17	*Channa punctatus*	0	0.00	0	0.00	152	0.36	0	0.00	0	0.00	23	0.19	2	0.04	3	0.00	180	0.09
18	*Channa striatus*	0	0.00	0	0.00	0	0.00	0	0.00	2	0.03	6	0.05	0	0.00	55	0.06	63	0.03
19	*Chela cachius*	0	0.00	0	0.00	529	1.25	351	1.05	0	0.00	0	0.00	0	0.00	0	0.00	880	0.46
21	*Chela laubuca*	0	0.00	0	0.00	1496	3.55	752	2.26	0	0.00	21	0.17	0	0.00	2050	2.29	4319	2.27
22	*Chitala chitala*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	1	0.02	0	0.00	2	0.00
23	*Cirrhinus mrigala*	1	1.59	0	0.00	7	0.02	518	1.55	4	0.06	116	0.95	63	1.17	181	0.20	890	0.47

24	*Cirrhinus reba*	0	0.00	0	0.00	1081	2.56	654	1.96	0	0.00	0	0.00	5	0.09	1	0.00	1741	0.92
25	*Clarias batrachus*	0	0.00	0	0.00	0	0.00	12	0.04	1	0.01	8	0.07	0	0.00	0	0.00	21	0.01
26	*Clupisoma garua*	0	0.00	0	0.00	0	0.00	0	0.00	19	0.26	73	0.60	565	10.46	2542	2.84	3199	1.68
27	*Colisa fasciata*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8	0.07	13	0.24	0	0.00	21	0.01
28	*Corica soborna*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	36	0.04	36	0.02
29	*Crossocheilus latius latius*	0	0.00	0	0.00	3494	8.28	303	0.91	38	0.53	3	0.02	1	0.02	24	0.03	3863	2.03
30	*Ctenopharyngodon idella*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00	1	0.00
31	*Danio devario*	0	0.00	0	0.00	0	0.00	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	2	0.00
32	*Eutropiichthys murius*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	130	2.41	61	0.07	191	0.10
33	*Eutropiichthys vacha*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	0.09	725	0.81	730	0.38
34	*Garra lamta*	0	0.00	0	0.00	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
35	*Glyptothorax telchitta*	0	0.00	0	0.00	0	0.00	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
36	*Glossogobius giuris*	0	0.00	0	0.00	330	0.78	89	0.27	358	4.98	71	0.58	50	0.93	57	0.06	955	0.50
37	*Gonialosa manmina*	0	0.00	0	0.00	0	0.00	502	1.51	36	0.50	130	1.07	7	0.13	4774	5.33	5449	2.87
38	*Gudusia chapra*	0	0.00	0	0.00	0	0.00	2180	6.54	0	0.00	0	0.00	236	4.37	5842	6.52	8258	4.35
39	*Heteropneustes fossilis*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.02	0	0.00	1	0.00
40	*Ilisha megaloptera*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.04	3094	3.45	3096	1.63
41	*Johnius coitor*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	9	0.17	738	0.82	747	0.39
42	*Johnius gangeticus*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	111	0.12	111	0.06
43	*Labeo angra*	0	0.00	0	0.00	93	0.22	15	0.05	0	0.00	0	0.00	0	0.00	0	0.00	108	0.06
44	*Labeo bata*	0	0.00	0	0.00	1017	2.41	1126	3.38	96	1.33	481	3.95	118	2.18	917	1.02	3755	1.98
45	*Labeo boga*	0	0.00	0	0.00	16	0.04	0	0.00	0	0.00	4	0.03	0	0.00	0	0.00	20	0.01
46	*Labeo boggut*	0	0.00	0	0.00	10	0.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	10	0.01

47	*Labeo calbasu*	0	0.00	0	0.00	31	0.07	0	0.00	105	1.46	85	0.70	45	0.83	156	0.17	422	0.22
48	*Labeo dero*	0	0.00	0	0.00	1233	2.92	0	0.00	0	0.00	12	0.10	123	2.28	0	0.00	1368	0.72
49	*Labeo dyocheilus*	0	0.00	0	0.00	31	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	31	0.02
50	*Labeo fimbriatus*	2	3.17	2	8.33	18	0.04	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	22	0.01
51	*Labeo gonius*	3	4.76	0	0.00	38	0.09	0	0.00	0	0.00	0	0.00	0	0.00	2	0.00	43	0.02
52	*L. pangusia*	0	0.00	0	0.00	57	0.14	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00	58	0.03
53	*Labeo rohita*	0	0.00	0	0.00	1	0.00	4	0.01	0	0.00	12	0.10	4	0.07	11	0.01	32	0.02
54	*Lepidocephalus guntea*	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	1	0.00
55	*Macrognathus aral*	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	0	0.00	1	0.00
56	*Macrognathus pancalus*	2	3.17	0	0.00	35	0.08	4	0.01	99	1.38	0	0.00	0	0.00	88	0.10	228	0.12
57	*Mastacembelus armatus*	0	0.00	0	0.00	36	0.09	0	0.00	35	0.49	157	1.29	47	0.87	486	0.54	761	0.40
58	*Mystus bleekeri*	0	0.00	0	0.00	36	0.09	0	0.00	8	0.11	0	0.00	0	0.00	3	0.00	47	0.02
59	*Mystus cavasius*	0	0.00	0	0.00	109	0.26	194	0.58	100	1.39	74	0.61	6	0.11	723	0.81	1206	0.64
60	*M. vittatus*	0	0.00	0	0.00	0	0.00	28	0.08	81	1.13	137	1.12	29	0.54	176	0.20	451	0.24
61	*Nandus nandus*	0	0.00	0	0.00	24	0.06	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00	25	0.01
62	*Nangra viridescens*	0	0.00	0	0.00	0	0.00	112	0.34	561	7.80	155	1.27	0	0.00	2952	3.30	3780	1.99
63	*N. punctata*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	12	0.22	0	0.00	12	0.01
64	*Nemacheilus botia*	0	0.00	0	0.00	64	0.15	360	1.08	86	1.20	5	0.04	2	0.04	20	0.02	537	0.28
65	*Notopterus notopterus*	0	0.00	0	0.00	0	0.00	1	0.00	0	0.00	67	0.55	0	0.00	7	0.01	75	0.04
66	*Ompok bimaculatus*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	1	0.00
67	*Ompok pabda*	0	0.00	0	0.00	0	0.00	17	0.05	0	0.00	2	0.02	0	0.00	0	0.00	19	0.01
68	*Osteobrama cotio cotio*	0	0.00	0	0.00	160	0.38	1468	4.41	176	2.45	22	0.18	20	0.37	118	0.13	1964	1.03
69	*Parambassis ranga*	0	0.00	0	0.00	8	0.02	0	0.00	254	3.53	8	0.07	0	0.00	25	0.03	295	0.16

70	*Parluciosoma daniconius*	0	0.00	0	0.00	75	0.18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	75	0.04
71	*Neotropius atherinoides*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01	0	0.00	0	0.00	1	0.00
72	*Puntius chola*	0	0.00	0	0.00	75	0.18	0	0.00	73	1.01	0	0.00	0	0.00	0	0.00	148	0.08
73	*Puntius conchonius*	0	0.00	0	0.00	585	1.39	324	0.97	5	0.07	0	0.00	0	0.00	0	0.00	914	0.48
74	*Puntius sarana*	0	0.00	0	0.00	24	0.06	0	0.00	300	4.17	14	0.11	0	0.00	1	0.00	339	0.18
75	*Puntius sophore*	4	6.35	12	50.00	8208	19.46	2475	7.43	795	11.05	249	2.04	280	5.18	2425	2.71	14448	7.61
76	*Puntius ticto*	35	55.56	0	0.00	1602	3.80	75	0.23	124	1.72	16	0.13	60	1.11	72	0.08	1984	1.04
77	*Raiamas bola*	0	0.00	0	0.00	240	0.57	24	0.07	0	0.00	0	0.00	0	0.00	12	0.01	276	0.15
78	*Rasbora daniconius*	0	0.00	0	0.00	0	0.00	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	2	0.00
79	*Rhinomugil corsula*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	20	0.16	39	0.72	401	0.45	460	0.24
80	*Rita rita*	0	0.00	0	0.00	18	0.04	0	0.00	3	0.04	65	0.53	116	2.15	163	0.18	365	0.19
81	*Salmophasia bacaila*	0	0.00	0	0.00	3968	9.41	3526	10.58	2246	31.22	419	3.44	955	17.67	43217	48.26	54331	28.61
82	*Salmophasia phulo*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.00	2	0.00
83	*Securicula gora*	0	0.00	0	0.00	33	0.08	0	0.00	0	0.00	18	0.15	0	0.00	26	0.03	77	0.04
84	*Setipinna phasa*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8	0.15	944	1.05	952	0.50
85	*Sicamugil cascasia*	0	0.00	0	0.00	0	0.00	0	0.00	7	0.10	0	0.00	34	0.63	803	0.90	844	0.44
86	*Silonia silondia*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	12	0.01	12	0.01
87	*Sperata aor*	0	0.00	0	0.00	6	0.01	3	0.01	0	0.00	33	0.27	66	1.22	361	0.40	469	0.25
88	*Sperata seenghala*	0	0.00	0	0.00	242	0.57	48	0.14	17	0.24	397	3.26	219	4.05	610	0.68	1533	0.81
89	*Tenualosa (Hilsa) ilisha*	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	68	0.08	68	0.04
90	*Tor putitora*	9	14.29	4	16.67	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00	15	0.01
91	*Wallago attu*	0	0.00	0	0.00	19	0.05	49	0.15	6	0.08	511	4.19	51	0.94	38	0.04	674	0.35
92	*Xenentodon cancila*	0	0.00	0	0.00	323	0.77	132	0.40	14	0.19	0	0.00	0	0.00	78	0.09	547	0.29

	Exotic species	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
93	*Hypophthalmichthys molitrix*	0	0.00	0	0.00	0	0.00	13	0.04	0	0.00	0	0.00	0	0.00	0	0.00	13	0.01
94	*Cyprinus carpio*	1	1.59	0	0.00	88	0.21	258	0.77	74	1.03	1	0.01	0	0.00	1240	1.38	1662	0.88
95	*Oreochromis niloticus*	0	0.00	0	0.00	0	0.00	280	0.84	152	2.11	8097	66.43	475	8.79	911	1.02	9915	5.22
96	*Clarius gariepinus*	0	0.00	0	0.00	0	0.00	0	0.00	2	0.03	0	0.00	0	0.00	0	0.00	2	0.00