Ecodynamics and Fishery Status of Upper Stretch of River Yamuna and Associated Canals

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ECODYNAMICS AND FISHERY STATUS OF UPPER STRETCH OF RIVER YAMUNA AND ASSOCIATED CANALS

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PREFACE

River Yamuna, also called Kalindi in some areas, is the largest tributary of Ganga having a run of 1376 km draining an area of 3,66,223 sq.km. Its catchment area of 3,425,848 km^2 is spread over 7 Northern States.

Yamuna basin has been well developed from time immemorial. Great civilizations from Mahabharat (Kurukshetra, Indraprastha (Delhi), Mathura) to Moghul (Agra) to Maratha times (Indore, Gwalior) all dwelt within its catchment area. Presence of all these civilizations show that Yamuna basin was well developed with regard to agriculture, industrialization and urbanization.

Resources of upper Yamuna have been utilized from mid historical periods of Ferozshah Tughlak times. He was the first to utilize Yamuna water for irrigation. A 160 km long canal from Tajewallah to present Hissar district of Haryana was carved in his regime. Mughal king Akbar extended the canal right up to Delhi. In 19^{th} Century Britishers rebuilt the irrigation system by constructing Tajewallah barrage in 1899 and carving 2 main irrigation canals, Western and Eastern Yamuna Canal, the former irrigating present day Haryana and the latter Western U.P. All this shows that Yamuna in upper reaches has been subjected to maximum manipulations, which has affected its inbuilt capacity to cleanse itself.

River Yamuna has been monitored by several agencies since early eighties and nineties because of its utility and deteriorated conditions. The studies were mainly related to water quality and pollutional load, but fishery resources of Yamuna and the effect of environmental constrains on this resource were not known.

This work presents the result of investigations carried out by scientists of Karnal Centre of CIFRI from 1995 to 1999. The investigations give a complete picture of present environment (soil texture and quality of river bed, water quality), community organization of various biotic forms, fish fauna, fishery resources and its economics of upper Yamuna and its canals.

I am sure, the comprehensive account on environment and fishery of upper Yamuna river and its canals unknown so far, would be of immense use for planners and development authority of "Yamuna Action Plan".

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CONTENTS

INTRODUCTION

1.1 The Yamuna

Yamuna is the second most important river of India, 1376 Km. long having a total catchment area of 3,425,848 Km^2, spread over seven Northern states. The river originates from Yamunotri Glacier situated on the western slope of Banderpunch peak of Himalayas at an elevation of 6387 m asl, passes through Tehri Himalayas of Uttaranchal, Haryana, Delhi, Utterpradesh before joining Ganga at Allahabad (100 m asl), in between draining an area of 3,66,223 Km^2 (CPCB 89-90).

Based on geological and hydrological characteristics, Yamuna is classified into five distinct segments (GOI, 1993); i) Himalayan segment, ii) upper segment, iii) Delhi segment, iv) eutrophic segment, v) diluted segment.

Himalayan Yamuna extends from origin to Tajewallah barrage, covering a distance of 172 Km, has a catchment area of 8280 km^2 which falls within Uttarkashi (Tehri region) and Dehradoon districts of Uttranchal and Sirmaur district of Himachal Pradesh. Many rivulets and tributaries join main river in this segment, important being Rishi Ganga, Kuntar, Hanuman Ganga in uppermost region and Tons, Giri, Asan, Lakhnar Amalnanda in lower region.

Along the lower region Lakhnar, Amalnanda and Tons meet Yamuna above Dakpather barrage at various points within greater Himalayas, while Giri and Asan join it along Shiwalik Himalayas and Doon valley range. Amongst all these tributaries Tons is largest. Yamuna contains more water in this zone due to high rainfall (150cm) and is characterized by has an average flow of 116-645 kilo liters, average depth of 1.75 to 3 m. steep gradient of 59 m/km in Greater Himalayas and 11.3 m/km in Shiwalik Himalayas (CPCB 89-90). Anthropogenic activity starts from this zone itself and is caused due to manoeuvring of river for power generation and irrigation. Two barrages Dakpathar (1960) and Tajewallah (1899) [Tajewallah assisted by Hathnikund barrage (1999)] and weirs at Kattapather and Ponta Saheb have been constructed for the purpose.

Upper segment of Yamuna extends from Tajewallah/ Hathnikund to Wazirabad barrage, covering a distance of 224 km, forming boundary between Haryana and Western U.P. Big cities like Saharanpur, Yamunanagar, Muzzafar nagar, Panipat are situated along its course, but all these cities are 20-25 km away from its banks and only three main drains one each from Panipat, Sonipat and Bhagpat enter into it carrying municipal effluents. Maximum abstraction of water resource takes place in this zone due to formation of two irrigation canals, namely Western Yamuna Canal (WYC) and Eastern Yamuna Canal (EYC) (Fig.-2). The river in this zone is very sluggish, having an average flow of 9.8 to 38 Kilo liters and has average depth of 0.5 to 2.5 m, average width of 40 to 175 m and a gradient of 0.3 km/m only (CPCB 89-90).

Ecology of Yamuna changes drastically from Delhi onwards under the impact of various types of effluent load. Delhi segment, 22 km stretch between Wazirabad and Okhla barrage is highly polluted (B.O.D. 160 M.T day (GOI 1993) due to offloading of 20 big drains and minimum water flow. The river remains as isolated entity barring monsoons, although Yamuna gets some water through Hindon cut in this region, but that water is mainly transmitted to "Agra Canal" above Okhla barrage. The river flow during monsoons varies between 25-616 Kilo liter has average depth of 1.25 to 3.5m and average width of 125-175 m (CPCB 89-90).

Eutrophic segment, 490 km stretch between Okhla barrage to Chambal confluence harbours thickly populated cities like Mathura, Agra, Etawah discharging their domestic and industrial effluents mainly through 20 nallas, 1 from Shahdra (after Okhla barrage), 8 from Mathura, 10 from Agra and 1 from Etawah (GOI 1993). A tributary- Hindon joins Yamuna in this segment at Dadri (dist. Gautam Budh nagar U.P.) yet flushing by this dose not help in recovering capacity due to lifting of its resources into Hindon cut above barrage.The flow rate of Yamuna along this stretch has been 2.5-692 kiloliters, has gradient of 0.22 to 0.08m/km only, average depth of 0.88-1.75m (CPCB 89-90).

Diluted segment, 468km stretch of Yamuna between Chambal confluence (Panchnada) to Ganga confluence (Allahabad) receives maximum water supply from 4 main tributaries namely Chambal, Sind, Betwa and Ken. Amongst the 4, Chambal is the largest having 5-10 times more water flow than Yamuna and has a catchment area of 1,39,785 km^2 almost half of total Yamuna basin (CPCB 89-90). Maximum induction of water and minimum pollutional load (only 6 drains, 1 from Etawah and 5 from Allahabad) help in assimilation capacity of river. The river has an average depth of 1.75 to 6m, average width of 200-375m and attains flow rate of 214-5843m/sec (GOI 1993) thereby making it diluted segment.

1.2 Objectives of the present investigations

River Yamuna has been evaluated thoroughly for its ecological characteristics especially water quality status by agencies like Central Pollution Control Board (89-90). Central Water Commission, Govt. of India (1993); but fishery resources of Yamuna and affect of environmental constrains on this resource has not been assessed comprehensively so far.

Yamuna was known to be holding fish along 1050 km stretch only (Sehgal 1992) mainly within middle and lower segment, which have been evaluated by CIFRI and documented by Jhingran (1975), Mishra and Moza (2001) and Moza & Mishra (2001). No scientific database regarding fish and fish food resources existed for the upper stretch above Delhi. The stretch acquires importance where in Yamuna waters are diversified into a network of irrigation canals. These canals on one hand affect growth and recruitment of fish but on the other hand sustain substantial fishery also, therefore evaluation of river and canals was imperative to

have i) scientific data-base of fish resources and its environment in upper Yamuna ii) carrying capacity of canals, their contribution to fishery resources as well as impact on river system. Keeping in mind above objectives, CIFRI carried out work on "Ecodynamics and fishery status of upper stretch of river Yamuna and its associated canals" from 1995 to 1999.

1.3 Plan of work and area of study

A. River

Observations on the ecological status of the river appox. 150km were taken from 4 sites namely i) Hathnikund above barrage (reference zone), ii) Kalanour, (between Yamunanagar and Saharanpur, U.P.), iii) Badoli (between Karnal and Shamlee, U.P.), iv) Sanoli (between Panipat and Kairana U.P.) (Fig. 1).

B. Canals

Observations on ecodynamics of canal system encompassed the evaluation of 3 canals.

i) Western Yamuna Canal (WYC)
ii) Sutlej Yamuna Link Canal (SYL)
iii) Eastern Yamuna Canal (EYC)

An approximately 150 km stretch of western Yamuna Canal was evaluated at 6 stations depending on inflow of effluents and other canals. 3 stations were taken up at Yamunanagar At, (OF), before (AOF) and after (BOF) the influx of nalla containing effluents. 2 stations at Karnal before and after its link with SYL. 1 station at Panipat.

SYL had 1 station prior to its link with WYC.
EYC was estimated at 2 stations, one at Saharanpur and one at Phulkeri (dist. Muzzafarpur) (Fig. 1). No effluent discharge was observed in this canal.

Fish Resources

Upper stretch of Yamuna forms boundary between Haryana and western U.P., but fishing rights vest with Haryana Government, as such fishery of this stretch is being disposed off mainly within Haryana from 3 landing centres namely Yamunanagar, Karnal and Panipat. One more subsidiary centre at Kairana (dist. Muzzafarnagar, U.P.) was observed during the tenure. Estimate Data from Kairana and Panipat were pooled for current observations and are termed as Panipat Resources.

Evaluation of fishery resources was done by enumeration of daily arrivals at above 4 mentioned stations. Each station was surveyed for 4 days per month, i.e. 2 days per fortnight.

Canals

Western Yamuna canal (WYC) too has its fish disposal stations along the 3 main centres mentioned above. Enumeration of its resources for approximately same

stretch as river was also done on the pattern of riverine system. The produce of SYL at Karnal was being disposed off along with that of WYC, as such the fish estimates at Karnal encompasses both WYC and SYL. Eastern Yamuna Canal does not hold sufficient fishery. Only intermittent fishery on individual basis for individual consumption was observed in its upper segment. Since no commercial fishery existed in this canal no resource evaluation could be done.

2. OBSERVATIONS

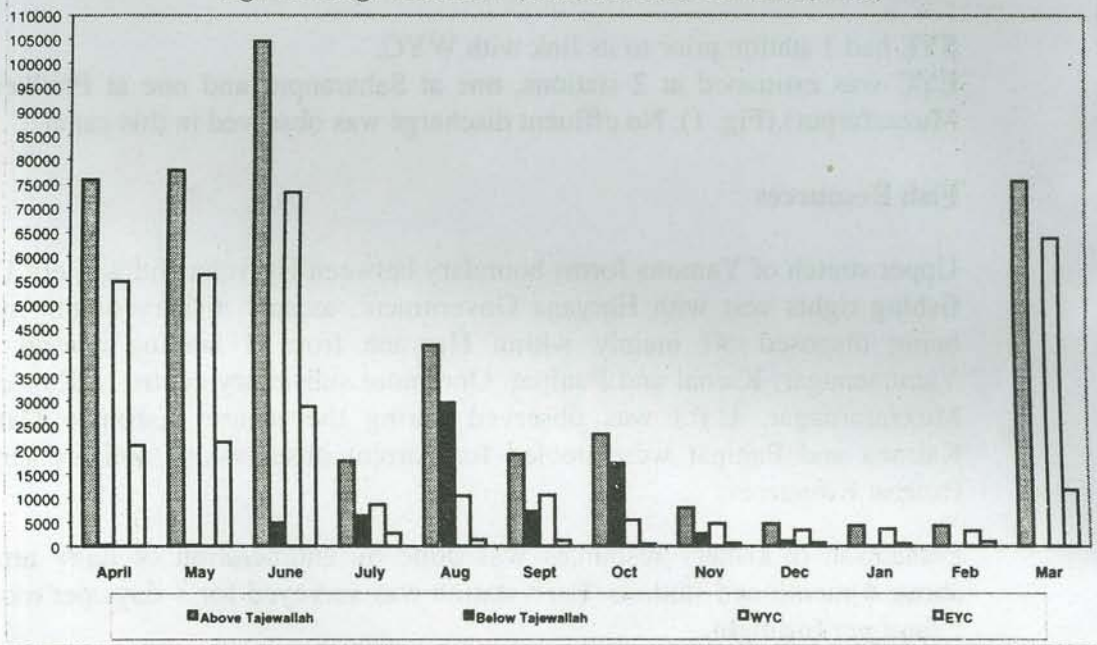
RIVER

2.1 Environmental constraints.

Environmental constraint within upper Yamuna were mainly water abstraction. Water abstraction in the region has been going on for the last century since 1899 from Tajewallah barrage, wherein 2 canals, western Yamuna Canal (WYC) and Eastern Yamuna Canal (EYC) were carved out. Amongst the two WYC is 646 km long, irrigates Haryana and contains 1/3rd of water resources (280 Cusses). EYC irrigates western U.P. is 266 km long and contains 2/3rd of water resources (63 cusses) (GOI 1993).

In order to find out the magnitude of diversion of resources during study period, documentation of amount of water released from Tajewallah barrage into canals and river was done and is depicted in Fig. 2.

Fig. 2 Average water flow (cusecs) in river Yamuna (97-99)



2.2 Soil texture (Table 1 a)

River bed of upper Yamuna is primarily sandy in texture having sand in the range of 70.52-74.76%, silt in the range of 17.74-18.56% and clay in the range of 7.35-

11.55%. The bed soil shows original ustorthents character only at Hathnikund, thereafter soil changes gradually due to changed pattern of water course and land use.

2.3 Soil characteristics (Table 1a) Upper Yamuna has slightly alkaline soil reaction with pH almost uniform (7.33-7.23) depicting no externeous effect. Presence of near similar range of free calcium carbonate (3.42-3.18%) corroborates with pH values.

Availability of phosphorus (2.64-2.18 mg/100g) and nitrogen content (27.22-23.39 mg/100g) showed moderate presence within the entire segment, but the high values at Hathnikund depict it as high productive zone comparatively as observed in production values.

Specific conductance of bed soil was slightly high at Hathnikund (257.5) and Sanoli 256.87 µmhos/cm) compared to rest of the stretch, which may be due to active mining activities-Removal of building material and construction of barrage at former and removal of sand at latter site.

Percentage of organic carbon reduces as river flows downwards from Hathnikund (0.36%) to Sanoli (0.25%), showing poor water retention capacity in lower segment.

2.4 Water quality (Table 2 a)

Water characteristics like temperature, transparency and oxygen content differentiate upper Yamuna into two portions (i) Hathnikund and (ii) Rest of the stretch.

Hathnikund zone with seasonal fluctuations of temperature from low of 15°C (winter) to high of 25°C (summer) and relatively high dissolved oxygen content of 12 mg/l (winter) to 7.36 mg/l (summer) classify into cold water sub temperate having clear waters upto bottom (winter, summer) to 28.5 cm transparency (post-monsoons).

Other limno-chemical characters reveal upper Yamuna alkaline having low amplitude of variation, pH varies between 7.46 to 7.74. Water contains high D.O. of 7.75-9.34 mg/l and low free CO_2, 2.25-2.9 mg/l except at Badoli, Karnal (5.02 mg/l) which may be due to easy putrefication of organic compounds because of low water current, depth and high transparency (46.6 cm).

Water temperature (20.68-23.3°C), alkalinity (118.7-142.3 mg/l), dissolved organic matter (2.65-4.0 mg/l), chloride content (9.53-9.9 mg/l) and mineral content especially magnesium (2.17-4.34 mg/l) increase gradually as Yamuna flows from mountainous zone (Hathnikund) to plains. But contrary to this specific conductivity shows decreased values from 263.7 (Hathnikund) to 237.4 µmhos/cm (Sanoli). The high concentration of dissolved salts at Hathnikund and Kalanour may be due to heavy churning of river bed at these 2 sites for formation of barrage and bridge respectively and also due to ingress of tributaries at former site.

Perusal of last 4 years data showed that river although not exhibiting much variation in water characteristics still the onslaught of deterioration has initiated in upper segment. Average temperature around Hathnikund has increased from 18.5 (95-96) to 22.9°C (98-99), pH, alkalinity and mineral content has decreased from 95-96 to 99 (Table 2a), which may be due to deforestation and construction of new barrage at this site.

2.5 Gross primary production (Table 2 a)

Gross primary production along upper Yamuna was highest at Sanoli, 119.38 followed by Hathnikund 102.6 $mgC/m^2/hr$, the least being in Kalanour-Badoli (Karnal) stretch, ranging between 84.1-69.9 $mgC/m^2/hr$. Analysis of 4 year data reveals that there is not much change in carbon production value in river, only that seasonal variation exists in Hathnikund zone. Production being maximum 94-150 $mgC/m^2/hr$ during winter.

The ratio between gross and net production varies between 0.45 (Hathnikund) to 0.66 (Sanoli), thereby indicating that river has high productivity value at Sanoli (Panipat) zone which is also observed by plankton and fish biomass.

2.6 Plankton (Table 3 a)

The average standing crop of total plankton in upper Yamuna was 308 u/l showing a gradual increase down the gradient. It being 273 u/l at Hathnikund, 289 u/l at Kalanour, 329 u/l at Badoli and 380 u/l at Sanoli. Variation in abundance and composition has been found to be in accordance with productivity and water quality. Phytoplankton contributed maximum (95.79-90.49%) towards total population. Major groups contributing were bacillariophyceae (68.20-44.33%), chlorophyceae (25.53-18.71%), myxophyceae (3.0-21.08%) in order of abundance.

Zooplankton occupied only 3.25- 8.11% of total population being maximum (8.11%) at Sanoli and minimum 3.25% at Hathnikund. Amongst zoplanktons, rotifers were present all along upper Yamuna, while rest of the groups started appearing from Kalanour onwards (Table 3a).

Sectorial variation of contributing groups was observed in river. At Hathnikund main contributing groups were bacillariophyceae (68.22%) and chlorophyceae (25.53%), while rest of the stretch had presence of all planktonic groups (Table 4a), thereby indicating water enrichment in lower segment.

The decrease in percentage of bacillariophyceae from 68.22 to 44.33% and increase in myxophyceae from 3.0 to 21.08% between Hathnikund to Sanoli and existence of cladocerans (0.88-1.50%) and copepods, (0.47-4.33%) between Kalanour to Sanoli too indicate water enrichment to small extent (Table 3a). Planktonic fauna present along upper Yamuna has been depicted in Table 4a.

2.7 Periphyton (Table 5 a)

Average periphyton concentration was very high in river, it being 1428 u/cm^2. The density increased from 1160 at Hathnikund to 1616 u/cm^2 at Sanoli.

Periphyton composition like plankton showed sectorial variation. Bacillariophyceae decreased from 81.90% at Hathnikund to 45.15% at Sanoli, while myxophyceae increased from 1.24 to 20.89% down the gradient. Chlorophyceae was almost equally present forming 16.86 to 22.32% of total population. Presence of desmidaceae (1.20-3.70%) and protozoans (1.75-12.12%) in Periphyton assemblage (Table 6a) in lower zone show water enrichment as Yamuna flows into plains.

The periphyton flora was represented mainly by *Diatoma, Frustulia, Tabellaria, Cocconeis, Navicula, Synedra* among bacillariophyceae. *Spirogyra, Trochschia* and *Cladophora* among chlorophyceae, *Oscillatoria, Sprilulina* and *Nostoc* among myxophyceae.

2.8 Macrozoobenthos (Table 6 a)

Macrozoobenthic population varied between 412 to 66 u/m^2. The maximum density of 412 u/m^2 at Hathnikund may be due to shallow clean waters, stony bed and river soil having highest organic carbon (Table 1 a). The minimum, 66 u/m2 at Badoli (Karnal) may be due to high sand and low clay percentage in soil texture (Table 1 a). Benthic population was mainly present during post-monsoon to winter especially at Hathnikund.

Population composition showed sectoral difference. Plecoptera (0-7.5%), Ephemeroptera (0.5.56%) and Hemiptera (2.0-6.25%) were present only in Hathnikund-Kalanour segment. Abundance of shrimps (0-20.55%) at Kalanour may be due to presence of shelter in the form of marginal shrubs along the river banks at this site.

Diversity of macrozoobenthos at various sites in upper Yamuna (Table 7a) show that species confined to reference zone were *Nymphula, Ephemerella, Ephemera* and *Plea* sp., as such these classify as Saprophobic forms (non tolerant species) in context to Yamuna basin.

2.9 Surface Insects (Table 9)

Upper Yamuna harboured insect population along its banks throughout the stretch due to minimum water flow and shallow depth especially between December to May. The density ranged between 2-18 u/m^2 being highest at Hathnikund (18) and Sanoli (15 u/m^2). The middle segment Kalanour to Badoli had only 2-7 u/m^2.

Maximum diversity in population was exhibited at Hathnikund, having nymphs of Ephemeroptera (12.5%), Odonata (12.5%), Hemiptera (31.98%), Coleoptera (1.25%) and miscellaneous while rest of the stretch had nymphs of odonata (4.0-

20.0%) and Coleoptera only (11.0-43.3%). Shrimps in the range of 4.0-20.53% were also confined to this zone only.

2.10 Macrovegetation (Table 8 a)

Macrophytes were mostly present between winter to pre-monsoon .Biomass varied from 15.96 (Hathnikund) to 1.0 gm/m^2 (Sanoli).

Macrophytes like other biotic components showed sectoral variation. Population at Hathnikund was made up of *Chara* (46.65%), *Potomogeton* (48.3%) and *Ceratophyllum* sp. (4.5%). Charophytes were dominant during winter and *P. crispus* during pre-monsoon. Middle segment between Kalnour to Badoli had dominance of marginal weeds (92.5-38.5%), while Sanoli had only *Potomogeton* sp. (100%).

Dominance of charophytes especially in winter (80%) at Hathnikund envisage the zone as fresh water as charophytes all over are present mostly in fresh shallow water bodies and are considered as index of purity.

2.11 Macrophyte associated fauna

Yamuna had high density of associated fauna at Hathnikund site and exhibited highest diversity than rest of stretch (Table 9).

FISH AND FISHERY

2.12 Fishery spectrum :- The observations on the faunistic survey and fish landings from market arrivals between Hathnikund to Panipat showed presence of 55 fish species, belonging to 17 families of which 40 are of commercial significance (Annexure I).

2.13 Fish diversity :- Fish population within upper Yamuna show restriction in distribution of certain species due to thermal regime. Indian trouts, Mahseer, some minor carps and cobitids are present mainly between Hathnikund and Yamunanagar zone of river having temperature gradiation between 15-25 °C River below Yamunanagar hold warm water fishery mainly. As far as abundance within a population is concerned, fishery of this stretch classify into following 4 categories as per NBFGR, having 1 Endangered, 6 Vulnerable, 3 Indeterminate and 10 Rare species.

Fish-diversity in upper Yamuna

Endangered species	:*Ompok pabda*
Vulnerable species	: *Tor tor, T. putitora, L. dero, L. dyocheilus, P. sarana* (carps), *Bagarius bagarius* (catfishes)
Indeterminate species	: *Silonia silondia, Eutropiichthys vacha, Xenentodon cancila.*

Rare species : *Noemacheilus botia*
Barilius bola
B. barila
B. bendelisis
Rasbora daniconius
Gadusia chapra
Osteobrama cotio
Sisor rhabdophorus
Mystus cavasius
Macrognathus aculeatus

2.14 Fishery resources :- River Yamuna from uplands was observed to contain fish right from Kalsi (where it leaves Greater Himalayas), but large scale commercial exploitation exists from Tajewallah /Hathnikund onwards (where it leaves Shiwalik Himalyas).

Fish biomass (Table 10)

Total estimated fish biomass from open water systems (both river + WYC) was 157.92 t varying between 39.27 t (95-96) to 40.43 t (98-99), having an average production of 39.475 t/yr, not showing much change in total biomass (Table 10), but annual trend in market arrivals from March 1995 to February 1999 showed that IMC and big size catfishes were on decline from 4.27 to 2.99 t and from 12.96 to 5.86 t respectively. Miscellaneous groups (comprised all groups except main groups) and common carp showed regular increase from 11.08 to 15.79 t and from 1.92 to 4.88 t respectively. Minor carps and Mahseer fishery showed erratic presence during the tenure (Table 12). The reason being the large scale disturbances in their habitat due to construction of barrage at Hathnikund during this period.

a) Annual trend in fish catch (River) (Table 11a). To find out the production potential of river and canal on comparative basis, evaluation of fishery from both the resources was done separately but simultaneously for a period of 2 years 97-99.

Fish catch during the period ranged between 21.78 t to 24.18 t having average production of 22.98 t/year. Sectorial abundance (Table 12a) showed that Panipat sector with 15.54 t/year yield was most productive and Karnal with 1.13 t/year least productive.

Low production at Karnal was due to maximum siltation and low water column between Kalanour to Karnal, which cause depletion in food web especially benthic organisms (only 66 u/m^2) and loss of breeding grounds as depicted elsewhere.

High produce at Panipat was mainly due to trash fish, *Chela* , *Puntius* etc. which perhaps can withstand ecodegradation and also due to fishing techniques adopted

in this segment-use of Chatti Jal, made of mosquito net dragged along the river bed where in almost all small size fishes are caught.

b) Fish catch composition (Table 12a). Major fishery within river was formed by agglomeration of various groups termed as other group forming 56.13% of total biomass. Main fish groups formed subsidiary contribution towards total population (Table 14a). Largest being cat fishes (14.23%), followed by minor carps (11.69%), IMC (6.64%) and common carps (5.20%).

Fish composition depicted sectorial variation, Uppermost segment-Yamunanagar contained commercially valuable fishes like, minor carps (21.45%), large size catfishes (18.46%). IMC (13.15%) and Mahseer (9.03%). Thereafter individual fishery behaved differently IMC contribution decreased from 13.15 to 3.67%; minor carps from 21.45 to 7.82%, Mahseer from 9.03-0.93%, while the contributing percentage of Mahseer and minor carps may be affected due to thermal regimentation but that of IMC was surely due to less availability of water and siltation of river bed, as this group of fishes under conducive environment can withstand broad range of temperature.

Amongst IMC, *L. calbasu* was dominant and present throughout the stretch. *C. mrigala* and *L. rohita* were present equally. *C. catla* was least represented present mainly at Yamunanagar (Table 14a) thereby showing that *C. catla* needs sufficient water column to thrive than other three species of IMC. Amongst large catfishes, *M. seenghala* and *W. attu* were of same magnitude and equally present. *B. bagarius* was less and mostly confined to Yamunanagar , while *R. rita* was present from Karnal onwards.

The stretch showed presence of exotics mainly common carp, both species *C. c. communis* and *C.c. specularis*. Invasion of common carp into Yamuna may be due to accidental entry during floods from the ponds at high altitude, where its culture is taken up on large scale, but its gradual increases show that fish is now sustaining in the system. The other two genera *C. idella* and *A. nobilis* showed occasional presence (Table 12a).

2.15 Length-frequency distribution (Table 13)

Length frequency estimation of commercial fishes showed that IMC were present mostly in IInd group. *L. calbasu* being dominant (62.3%) in this group followed by *L. rohita* (51.0%) and C. catla (50%). Minimum presence of *C. catla* (7.2%) in Ist group showed its poor recruitment.

Minimum presence 8.5% of *L calbasu* in IIIrd group shows that although this carp has efficient recruitment (29.2% in Ist group) than rest of carps, but it does not grow beyond a point.

Highest presence of 30.3% of Ist group Mahseer in Yamunanagar segment of river show recruitment in this specified area and its presence upto IV stage (2.1%) clearly show the zones suitable for this fishery.

2.16 Spatio-temporal variation in availability of spawn

Percentage of desirable spawn ranged from 36.10 (95-96) to 2.0% (96-97) at Jadoli and Kundaghat, both in Karnal segment of river. Spawn was observed only in receding phase.

Amongst desirable spawn almost 26% was comprised of minor carps like *L. bata* , *L. gonius, L. dero* and *C. reba.*

Drastic decline of spawn during 96-97 may have been due to 2 reasons i) Inconsistent monsoon ii) diversion of water above Tajewallah due to initation of construction of Hathnikund barrage in this year.

2.17 Fish Price Spread :

a) **Fish marketing :-** Fish disposal was of Ist channel at Yamunanagar, II channel at Panipat/Kairana and IIIrd channel at Karnal and is summarized as below.

CENTRE	CHANNEL
Yamunanagar	- Ist Fisher-Contractor cum Retailer-Consumer
Panipat/Kairana	-IInd Fisher-Wholesale cum commission agent-Retailer-Consumer
Karnal	-IIIrd Fisher-Contractor-Commission agent-Retailer-Consumer

b) **Fish price spread (Table 14)**

The fish price spread from fishers' point of view was almost same at Yamunanagar (63.89%), Panipat and Kairana (63.26%), but much low at Karnal (16.68%) mainly due to presence of extra intermediary at this site. The average wholesale price ranged between Rs.17.33 at Karnal to Rs. 29.89 at Kairana. The Retail price also followed similar trend with maximum Rs. 43.33 at Kairana and minimum Rs.26.00 at Karnal.

Higher price spread was observed for some miscellaneous (other) group. It was mainly due to the fact that contractors consider these as non-commercial and renumerate the fisher cheaply, but some of these like *N. chitala, Eel,* Murrels, *E. vacha* fetch very high price more than catfishes.

The over all market price for different categories of fishes evident during the tenure is given in table 14.

2.18 Fishing equipment

Crafts :- Fishing crafts are non mechanised and range from Rubber Tyres to small boats. Tyres are used in and around Hathnikund area where current is swift.

Gears :- Gears show localisation in their use. The main gears operative in upper Yamuna are.

1. Line and Hooks
2. Rope-loop system
3. Gill net
4. Cast net
5. Fry drag net(Chatti Jal)
6. Roak fishing

1. **Line & Hooks:** Line and Hooks is used mostly between winter to pre-monsoon, when water is clear and current is comparatively slow.

2. **Rope-loop system:** This type of fishing is done where current is swift, depth low generally around barrages. 100-150 meter nylon thread having 100 loops is spread by a person along the current in river by means of light weight sinkers.

3. **Gill/Cast net:** Operative in river at places having sufficient water volume, generally above Yamunanagar and in rest of Yamuna during monsoons only.

4. **Fry drag net:** The net is like any other drag net but made of mosquito cloth, having fine mesh size, was generally used after Kalanour site during non-rainy season when river has less water column.

5. **Roak fishing:** Roak fishing was observed during winter around Panipat segment of river. In this type of fishing, course of water was obstructed across the river by sand bags or any other alternative material to hamper water flow and create pond like conditions. Fry drag net is used to salvage the fishery above the obstruction. This type of fishing practice is very harmful, because along with small size fishery like *Chela, Chanda, Puntius,* fingerlings of commercial fishery as well as shrimp fishery also get salvaged, thereby affecting recruitment process.

Table 1a. Texture of bed soil of upper Yamuna during 1997-99.

Parameters	Hathnikund		Kalanaur (Y.nagar)		Badoli (Karnal)		Sanoli (Panipat)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Sand (%)	70.52	70.85-69.55	72.94	74.05-71.82	74.76	73.9-74.23	74.56	75.55-73.57
Silt (%)	18.25	17.62-18.87	18.56	17.17-19.95	18.58	18.94-18.22	17.74	17.47-18.0
Clay (%)	11.55	11.52-11.58	8.50	8.77-8.23	7.35	7.16-7.55	7.70	6.98-8.43
pH	7.33	7.2-7.47	7.33	7.2-7.47	7.33	7.16-7.5	7.23	7.07-7.4
Organic carbon (%)	0.36	0.28-0.44	0.27	0.28-0.27	0.26	0.29-0.24	0.25	0.17-0.34
Sp. cond. (µmhos/cm)	257.5	277-238.1	207.23	198.75-215.72	205.42	183.33-227.5	256.87	267.25-246.5
Free calcium carbonate (%)	3.42	3.64-3.21	3.23	3.56-2.90	3.21	3.48-2.94	3.18	3.33-3.03
Avl. Nitrogen (mg/100gm)	27.22	21.6-32.85	21.38	18.22-24.55	24.38	25.36-23.4	23.39	21.37-25.42
Avl. Phosphorus (mg/100gm)	2.64	2.87-2.42	2.27	2.45-2.1	2.6	3.26-1.95	2.18	2.27-2.1

Table 2a. Water characteristics of upper Yamuna during 1995-1999

Station		W. temp. (o^C)	Trans. (cm)	pH	D.O. (mg/l)	Free CO_2 (mg/l)	T. alkalinity (mg/l)	Calcium (mg/l)	Magn. (mg/l)	Sp. cond. (µmhos/cm)	Primary Productivity	
											GP	NP
Hathnikund	Av.	20.68	21	7.5	9.34	2.45	118.7	31.89	2.17	263.7	102.6	46.5
	Range	18.5-22.9	Clean-28.5	8.0-6.99	7.37-12	0-4.5	122.6-100.5	36.87-26.92	2.88-1.46	219-369		
Kalanour (Y.nagar)	Av.	22.5	39.4	7.46	7.75	2.25	140.6	29.44	2.73	257.4	84.1	48.3
	Range	20.6-23.8	43.5-36.1	8.03-6.91	6.64-9.1	0.6.6	147.3-94.2	29.92-28.97	1.46-4.0	195.5-300.5		
Badoli (Karnal)	Av.	22.2	46.6	7.74	8.8	5.02	151.2	42.26	3.96	249.2	69.9	57.7
	Range	18.9-24.3	53.8-31.1	8.1-7.37	7.09-10.0	0-10.6	177.3-123.3	43.28-41.24	3.13-4.8	198.4-290.5		
Sanoli (Panipat)	Av.	23.3	31.8	7.71	9.01	2.9	142.3	31.52	4.34	234.7	119.3	78.83
	Range	22.6-24.3	37.1-21.6	7.44-8.0	8.05-9.64	1.1-6.0	112.6-181.5	30.99-32.06	1.74-6.95	206.3-250.5		

Table 3a. Plankton density and composition in upper Yamuna during 1995-99

Density	Hathnikund			Kalanaur (Yamunanagar)			Badoli (Karnal)			Sanoli (Panipat)		
Mean (ul^{-1})	237			289			327			380		
Range (ul^{-1})	175-297			187-369			312-358			338-406		
Composition	Sp. No.	Mean	Range	Sp. No.	Mean	Range	Sp. No	Mean	Range	Sp. No.	Mean	Range
Bacillariophyceae	12	68.22	55.6-78.9	13	54.85	48.8-59.9	14	48.74	36.64-64.12	13	44.33	40.33-5.51
Chlorophyceae	5	25.53	19-31.3	5	23.92	19.8-26.2	9	18.71	16.02-20.1	7	23.74	10.56-29.09
Myxophyceae	1	3.0	Nil-6.4	3	9.45	5.4-17.1	8	19.87	11.85-29.08	6	21.08	11.20-36.37
Desmidiaceae	-	0	-	1	2.0	3.5-7.10	2	4.42	8.0-9.61	1	1.34	Nil-4.23
Dinophyceae	-	-	-	2	2.98		2	4.0		2	1.40	
Prorozoa	-	0	-	-	-	-	-	-	-	-	-	-
Rotifera	1	3.25	Nil-7.3	3	3.02	Nil-6.4	2	3.37	Nil-5.45	2	2.28	Nil-3.60
Cladocera	-	-	-	1	0.88	Nil-3.5	1	0.50	Nil-1.31	2	1.50	Nil-3.35
Copepoda	-	-	-	2	2.90	Nil-5.4	1	0.47	Nil-1.87	2	4.33	1.55-11.2

Table 5a. Periphyton distribution in upper Yamuna

Population Density	Hathnikund			Kalanaur (Yamuna Nagar)			Badoli (Karnal)			Sanoli (Panipat)		
Mean (ucm^{-2})	1160			1428			1508			1616		
Range (ucm^{-2})	300-3830			263-3058			288-3912			363-4124		
Plankton Composition	Sp. No	Mean	Range	Sp. No	Mean	Range	Sp. No	Mean	Range	Sp. No	Mean	Range
Bacillariophyceae	14	81.90	68.39-91.70	10	68.50	61.98-75.80	5	61.59	56.60-66.66	8	45.15	31.81-51.79
Chlorophyceae	2	16.86	8.30-31.70	4	22.32	18.42-24.2	5	20.28	Nil-34.80	3	20.64	27.50-34.40
Myxophyceae	1	1.24	Nil-3.72	2	4.71	0.0-14.07	3	14.43	3.70-22.22	4	20.89	10.20-31.82
Desmidaceae	-			1	2.64		2	3.70		1	1.20	
Protozoa	-			1	1.75		-			3	12.12	

Table 4a. Plankton Population Recorded in River Yamuna

	Hathnikund	Kalanaur	Badoli	Sanoli
BACILLARIOPHYCEAE				
Diatoma	+	+	+	+
Achnanthes	+	+	-	+
Melosira	+	+	+	+
Surirella	+	-	-	-
Frustulia	+	+	+	-
Tabellaria	+	+	+	+
Cocconeis	+	+	+	+
Navicula	+	+	+	+
Nitzschia	+	+	+	-
Cyclotella	+	-	-	+
Eunotia	+	-	-	-
Fragillaria	+	+	+	-
Cymbella	-	+	+	+
Calonies	-	+	+	-
Meridion	-	+	+	+
Amphora	-	+	+	+
Stauroneis	-	-	+	-
Synedra	-	-	+	+
Gyrosigma	-	-	-	+
Gomphonema	-	-	-	+
CHLOROPHYCEAE				
Trochiscia	+	+	+	-
Spirogyra	+	+	+	+
Ulothrix	+	-	+	+
Tetraspora	+	-	-	-
Cladophora	+	+	+	-
Characium	-	+	+	+
Coelastrum	-	+	-	-
Actinostrum	-	-	+	-
Cystodinium	-	-	+	-
Clasterioplis	-	-	+	-
Ankistrodesmus	-	-	+	+
Batryococcus	-	-	-	+
Kirchneriella	-	-	-	+
Pediastrum	-	-	-	+
DESMIDS				
Cosmarium	-	+	+	+
Staurastrum	-	-	+	-
MYXOPHYCEAE				
Oscillatoria	+	+	+	+
Spirulina	-	+	+	+

Microcystis	-	+	+	+
Gomphorphaeria	-	-	+	-
Phormidium	-	-	+	+
Nostoc	-	-	+	+
Merismopedia	-	-	+	+
Coelosphaerium	-	-	+	-
DINOPHYCEAE				
Peridinium	-	+	+	+
Ceratium	-	+	+	+
ROTIFERA				
Monostyla	+	+	-	+
Keratella	-	+	+	-
Nothalca	-	+	+	-
Brachionus	-	-	-	+
COPEPODA				
Cyclops	-	+	+	+
Nauplii	-	+	-	+
CLADOCERA				
Bosmina	-	+	+	+
Daphnia	-	-	-	+

Table 6a. Distribution of Benthic forms in upper Yamuna during 1995-99.

Population density	Hathnikund			Kalanaur (Yamunanagar)			Badoli (Karnal)			Sanoli (Panipat)		
Mean (um^{-2})	412			124			66			276		
Range (um^{-2})	46-801			83-257			5-97			58-577		
Population Composition	Sp. No.	Mean %	Range %	Sp. No.	Mean %	Range %	Sp. No.	Mean %	Range %	Sp. No.	Mean %	Range %
Plecoptera	1	2.8	0-7.5	-	-	-	-	-	-	-	-	-
Ephemeroptra	3	4.03	Nil-5.56	1	1.0	Nil-3.51	-	-	-	-	-	-
Odonata	-	-	-	-	-	-	2	4.16	Nil-16.46	2	2.85	Nil-11.40
Hemiptera	3	2.0	Nil-28	3	6.25	Nil-25	-	-	-	-	-	-
Coleoptera	3	7.38	Nil-28	1	1.5	Nil-3.57	1	1.4	Nil-4.16	1	1.04	Nil-4.16
Chironomus sp.	1	26.65	Nil-42.14	1	25.0	Nil-50	1	12.58	Nil-25	1	23.66	Nil-48
Other Dipteran	1	15.49	0-42.14	1	25.0	0-50	-	-	-	-	-	-
Gastropods	2	12.5	Nil-49.95	2	3.75	Nil-12.5	3	20.83	Nil-50	4	37.06	Nil-71.42
Pelecypoda	-	-	-	2	3.75	Nil-12.5	-	-	-	2	6.7	Nil-24.28
Annelids	1	2.0	Nil-8.0	1	12.35	Nil-25	2	35.53	Nil-83.33	2	7.14	Nil-21.42
Shrimps	-	-	-	2	6.10	0-20.55	-	-	-	-	-	-

Table 7a. Macrobenthic Population Recorded in Upper Yamuna

	Hathnikund	Kalanaur	Badoli	Sanoli
Placoptera				
Nymphila	$+^{S}$	-	-	-
Hydropsyche	$+^{W}$	-	-	-
Ephemera sp	$+^{W}$	-	-	-
Baetis simplex	-	$+^{W}$	-	-
Coleoptera				
Berosus larvae	-	$+^{W}$	-	-
Psephenus sp	$+^{W}$	-	-	-
Bagous sp	+	-	-	-
Laccotrephes	-	-	$+^{S}$	$+^{S}$
Haliplus sp	+	-	-	-
Odonata				
Gomphus sp	-	-	$+^{S}$	$+^{S}$
Enallagona sp	-	-	$+^{M}$	$+^{M}$
Hemiptera				
Plea sp	$+^{W}$	$+^{W}$	-	-
Nepha sp	+	+	-	-
Gerris sp	+	+	-	-
Chironomus sp	+	+	+	+
Diptera				
Triogma sp	+	-	-	-
Dixa sp	-	$+^{PM}$	-	-
Chironomids				
Shrimps	-	$+^{P,M\&W}$	-	-
Annelids				
Tubifex tubifex	+	+	+	+
Aeolosoma sp	-	-	+	+
Mollusca				
Lymnaea sp	+	+	-	-
Glessula sp	-	-	+	+
Planorbis sp	+	+	-	-
Viviperus bengalensis	-	-	+	+
Melonia straitella	-	-	+	+
Physa sp	-	-	-	+
Corbicula regularis	-	+	-	+
Lamellidens sp.	-	-	-	+
Indonia sp.	-	-	-	+
Machrochlyamys sp.	-	+	-	-

Note: Presence of certain Zoobenthos in specific period is given in superscript
W = Winter, S = Summer, PM = Post Monsoon, M = Monsoon.

Table 8a. Macrophyte distribution in upper Yamuna during 1995-99

	Hathnikund		Kalanaur (Y.nagar)		Badoli (Karnal)		Sanoli (Panipat)	
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Biomass (dry wt.) gm/m^2	15.95	Nil-24.5	5.5	Nil-16.0	5.76	Nil-17.5	1.0	Nil-2.0
Composition (%)								
Chara sp.	46.65	13.3-80.0	---	---	---	---	---	---
Ceratophyllum echinatum	4.5	Nil-9.0	---	---	---	---	---	---
Potamogeton crispus	48.3	10-86.6	5.0	Nil-10.0	23.94	20-27.88	100	Nil-100
Vallisenria spiralls	---	---	2.5	Nil-5.0	11.25	Nil-22.5	---	---
Hydrilla sp.	---	---	---	---	14.68	Nil-29.37	---	---
Marginal weeds	---	---	92.5	85.0-100	38.5	Nil-77.0	---	---

Table 9. Insect population present in Yamuna and its canals as epiphytic forms and as surface dwellers

	River				Canal		
Insect Groups	**Hathnikund**	**Kalanaur**	**Badoli**	**Sanoli**	**WYC**	**SYL**	**EYL**
Lepidoptera							
Nymphula larvae	+	-	-	-	-	-	-
Trichoptera							
Caddis fly larvae	+	-	-	-	-	-	-
Ephemeroptera							
Ephemerella nymphs	+	-	+	-	+	+	+
Baetis nymphs	-	-	+	+	+	+	+
Hemiptera							
Plea sp.	+	+	+	+	+	+	+
Belostoma sp	-	-	+	-	+	-	-
Diplonychus annulatum	-	-	+	+	-	-	-
Notonecta sp	-	-	-	-	+	-	-
Corixa hieroglyphica	-	-	+	-	+	+	+
Garris sp.	+	+	+	+	+	+	+
Laccotrophes robustus	-	-	-	-	+	-	-
Limnometra micronecta	-	-	-	-	-	+	+
Coleoptera							
Halipus sp	+	-	-	-	-	-	-
Berosus indicus	-	+	-	+	+	+	-
Regimbartea attenutta	-	-	-	+	-	+	+
Cybistus sp	+	+	-	-	+	+	+
Laccpphilus sp.	-	+	+	-	-	+	+
Ranatra filiformis	-	-	+	-	+	+	+
Hydrophilus sp	-	-	-	-	+	+	+
Eretes sp	-	-	-	-	-	+	+
Rhantaticus sp	-	-	-	-	+	+	+
Odonàta							
Epicordulia sp.	+	-	-	-	-	-	+
Enallogoma sp	+	-	+	+	-	+	+
Gomphidae nymphs	+	-	+	-	+	+	+
Diptera							
Dixa pupa	+	-	-	+	+	+	-
Chronomus tendipis (pupa & larva)	-	-	-	+	Occasional	+	+
Culex nymphs & larva	-	-	-	-	+	+	-
Elliptera sp	-	-	-	-	-	+	-
Acari							
Water mite	-	-	-	-	-	+	-

Annelida							
Leech	+	-	-	-	+	+	+
Shrimps	-	+	+	+	+	+	+
Mollusca							
Planurbis	+	+	-	-	-	-	+
Lymneae	+	+	-	-	-	+	+
Valvata	-	+	+	-	+	+	+
Gyraulus sp	-	+	+	+	+	+	+
Melanies stritella	-	-	-	-	+	+	-
V. bengalensis	-	-	-	+	+	+	-
Physa sp	-	-	-	-	+	-	-
Carbicula sp	-	+	-	+	+	+	+

Table 10. Year-wise estimated fish landing from river Yamuna and associated Canals (WYC), for the year 1995-96 to 1998-99.

Years	1995-96		1996-97		1997-98		1998-99	
Fish groups	**(t)**	**(%)**	**(t)**	**(%)**	**(t)**	**(%)**	**(t)**	**(%)**
Major carps	4.27	10.87	4.48	10.98	2.82	7.52	2.99	7.41
Minor carps	3.64	9.26	6.5	15.93	8.38	22.40	5.46	13.50
Exotic carps								
C. carpio	1.92	4.89	1.83	4.46	3.23	8.68	4.88	12.09
H. molitrix	0.05	0.13	0.09	0.22	-	-	0.05	0.12
C. idella	-	-	0.02	0.05	0.02	0.05	0.02	0.04
A. nobilis	-	-	-	-	0.08	0.21	0.03	0.07
Mahseer	1.77	4.51	0.12	0.29	0.74	1.98	3.77	9.37
Large size catfishes	12.96	33.0	7.31	17.92	6.05	16.16	5.82	14.42
Murrels	3.48	8.86	1.94	4.75	0.44	1.17	1.56	3.85
Others	11.18	28.48	18.5	45.35	15.65	41.83	15.79	39.05
Total	**39.27**		**40.79**		**37.41**		**40.43**	

Table 11a. Year-wise estimated landing of river Yamuna for the year 1997-99

Years	**1997-98**		**1998-99**	
Groups	(t)	(%)	(t)	(%)
IMC	1.24	5.69	1.81	7.48
Minor carps	2.53	11.62	2.92	12.07
Exotic carps				
C. carpio	0.71	3.25	1.68	6.94
H. molitrix	-	-	-	-
C. idella	0.02	0.09	-	-
A. nobilis	-	-	0.03	0.12
Large scale Catfishes	2.80	12.85	3.74	15.46
Mahseer	0.33	1.51	1.12	4.63
Murrels	0.17	0.78	0.32	1.32
Other groups	13.98	64.18	12.56	51.94
Total	**21.78**		**24.18**	

Table 12a. Species-wise average landing and their percentage composition at Various centres during the period 1997-1999 in river Yamuna.

Species	Yamunanagar		Karnal		Panipat		Total	
	(t)	(%)	(t)	(%)	(t)	(%)	(t)	(%)
Major carps								
C. mrigala	0.58	4.60	-	-	0.32	1.03	0.90	1.96
C. catla	0.25	1.98	-	-	0.02	0.06	0.27	0.59
L. rohita	0.20	1.58	-	-	1.90	0.79	0.79	1.72
L. calbasu	0.63	4.99	0.25	11.06	0.68	1.09	1.09	2.37
Sub-total	**1.66**	**13.15**	**0.25**	**11.06**	**1.14**	**3.67**	**3.05**	**6.64**
Minor carps								
L. bata	1.48	11.72	0.11	4.86	1.15	3.70	2.74	5.96
L. gonius	0.62	4.91	0.03	1.32	0.13	0.41	0.78	1.69
L. dyocheilus	0.29	2.29	0.01	0.44	0.27	0.86	0.57	1.24
L. dero	0.24	1.90	0.02	0.88	0.45	1.44	0.71	1.54
C. reba	0.08	0.63	0.05	2.20	0.44	1.41	0.57	1.24
Sub-total	**2.71**	**21.45**	**0.22**	**9.70**	**2.44**	**7.82**	**5.37**	**11.69**
Exotic carps								
C. carpio	0.82	6.51	0.17	7.52	1.40	4.51	2.39	5.20
H. molitrix	-	-	-	-	-	-	-	-
C. idella	0.02	0.06	-	-	-	-	0.02	0.04
A. nobilis	-	-	0.03	1.33	-	-	0.03	0.07
Sub-total	**0.84**	**6.57**	**0.20**	**8.85**	**1.40**	**4.51**	**2.44**	**5.31**
Mahseer	1.14	9.03	-	-	0.29	0.93	1.43	3.11
Catfishes								
M. aor	0.06	0.48	-	-	0.05	0.16	0.11	0.24
M. seenghala	0.86	6.81	0.05	2.21	2.34	7.53	3.25	7.07
W. attu	1.41	11.17	0.05	2.21	1.72	5.53	3.18	6.92
Sub-total	**2.33**	**18.46**	**0.10**	**4.42**	**4.11**	**13.22**	**6.54**	**14.23**
B. bagarius	0.52	4.19	0.03	1.32	0.19	0.61	0.74	1.61
Murrel	0.28	2.21	0.10	4.42	0.21	0.67	0.59	1.28
Other groups	3.14	24.88	1.36	68.17	21.30	68.53	25.80	56.13
Total	**12.12**		**2.26**		**31.08**		**45.96**	
Annual biomass	**6.31**		**1.13**		**15.54**		**22.98**	

Table 13. Length frequency percentage of culturable carps and catfishes from river Yamuna and associated canals during 1996-99

Groups	Length (mm)		Percentage							
	Carps	Cat fishes	C. mrigala	C. catla*	L. rohita	L. calbasu	T. putitora	C. carpio	M. seenghala	W. attu
I	0-305	0.279	26.2	7.2	19.0	29.2	30.3	28.9	15.4	9.3
II	306-500	280-457	49.2	50.0	57.0	62.3	53.1	61.9	39.8	19.1
III	502-660	458-635	24.0	43.8	24.0	8.5	14.5	9.2	12.7	26.2
IV	661-762	636-762	-	-	-	-	2.1	-	14.5	32.0
V	763-864	763-864	-	-	-	-	-	-	2.1	8.4
VI	865-above	865-above	-	-	-	-	-	-	2.5	4.9

*** NB: The number of C. catla recorded for the 3 years only 16.**

Table 14 Average price for fish catch from different water resources during project period.

S.No	Category/ source of fish	Type of Price	Centre			
			Yamunanagar	Karnal	Panipat	Kairana
A	River					
1	Carps	Wholesale	25.38	19.40	26.95	24.23
		Retail	34.96	26.00	35.05	34.93
2	Catfish	Wholesale	50.43	22.50	42.48	41.14
		Retail	65.96	37.50	57.02	55.23
3	Miscellaneous	Wholesale	18.72	14.33	21.14	19.87
		Retail	32.66	21.67	31.84	34.42
4	Riverine catch	Wholesale	28.62	17.33	28.83	29.89
		Retail	40.32	26.00	41.09	43.23
B	WYC & Other water bodies					
1	Carps	Wholesale	22.83	27.72	24.44	-
		Retail	37.78	40.66	38.93	-
2	Catfish	Wholesale	39.97	41.55	33.07	-
		Retail	58.17	61.33	50.94	-
3	Miscellaneous	Wholesale	22.31	25.29	24.38	-
		Retail	34.52	36.16	47.83	-
4	WYC & Other sources	Wholesale	27.15	30.02	27.16	-
		Retail	40.00	43.76	47.02	-

CANAL SYSTEM

2.19 Environmental influences

Environmental influences within canal system markedly prominent mainly in Western Yamuna Canal. WYC at Yamunanagar receives direct influx of industrial waste from i) biggest paper pulp factory of India ii) Sugar distillery mills through a Nalla. The canal also gets flushed mainly by Bhakra canal and Sutlej-Yamuna Link (SYL) Canal around Karnal. The assessment of canal from Yamunanagar to Panipat cover approximate 150 km .

The Eastern Yamuna canal observed between Saharanpur to Shamlee- approximate 150 km had no outward influence. Ecology of canal system was as follows.

2.20 Soil characteristics (Table 1b)

Western Yamuna Canal: Soil characteristics delineate WYC loosely into 3 zones i) AOF Yamunanagar, where canal bed was predominantly sandy in texture having 76.55% of sand and only 7.54% of clay. Alkaline pH 6.42 to 7.42 having moderate availability of nitrogen, 26.0 mg/100g and phosphorus 2.32 mg/100g and low value of specific conductance 201.92µmhos/cm, resemble more less river bed characteristics.

ii) Presence of 20.98% silt, 332.73 µmhos/cm of conductance and near neutral soil pH 6.92-7.15 at OF Yamunanagar indicate changes although slight caused in canal bed due to induction of effluents. The effect remains up to Karnal especially in subtle characteristics.

iii) The 3rd zone is after the induction of SYL between confluence to Panipat. The canal bed too was sandy in texture (71.02% of sand) but has sufficient silt (18.0%) and clay (10.98%). pH value of 7.34, slight high value of organic carbon (0.44%), available nitrogen (30.15 mg/100g) and phosphorus (2.8 mg/100g) depict the zone having influence of SYL.

Sutlej Yamuna Link Canal (SYL): SYL showed high percentage of clay having 9.87%, organic carbon 0.42%, available nitrogen 30.04 mg/100g thereby having conducive substrata for high productivity.

Eastern Yamuna Canal (EYC): EYC bed is alkaline, pH 7.25-7.34 had high percentage of sand, 75.63%, reasonable silt 14.6-16.08% and clay 9.7-8.01%. Specific conductance of 241.04-247.5 µmhos/cm, low than WYC (Table 1b) show it having less organic load comparatively.

Presence of 2.86 mg/100g of phosphorus and 34.16 mg/100g of nitrogen show sufficient nutrient enrichment within the canal and if exploited properly can help to produce quality fish.

2.21 Water quality (Table 2b)

WYC: WYC water quality characteristics indicate that WYC barring stressed zone (OF-BOF Yamunanagar) has conducive environment for fishery purpose. The water was alkaline in all seasons having pH range of 7.41 to 7.74, sufficient dissolved oxygen, 7.02 –8.5 mg/l, optimum alkalinity, 88-119.15 mg/l. Mineral content, free CO_2 content was slightly higher than river (Table 2a) due to sustained effect of effluents and presence of macrophytes. The specific conductance range of 201.18-245.1 µmhos/cm in non-stressed zone indicate recovery of canal water due to flushing and continuous flow.

The stressed (OF-BOF Yamunanagar) zone under the influence of effluents has slightly acidic to near neutral water, pH in the range of 6.13 to 7.03.

The quality of dissolved oxygen decrease upto 2.1 mg/l, carbon dioxide content increases upto 16.0 mg/l, dissolved organic matter, 6.63 mg/l, specific conductance (326.05-591.4 µmhos/cm) and mineral content, calcium, magnesium, chloride (Table 2b) all show enhancement at OF site from initial values of AOF site.

The effect of stress was observed upto Karnal site having comparatively low D.O., 7.02 mg/l, high free CO_2, 6.95 mg/l and high conductance 265.78 µmhos/cm.

SYL (Table 2b): SYL waters with pH value of 7.29-7.81, dissolved oxygen concentration of 5.8-11.67 mg/l, total alkalinity of 72.5-125.3 mg/l and optimum availability of minerals (Table 2 b) in water phase seems to be most conducive for fishery. The high concentration of free CO_2, 6.2 mg/l in this canal may be due to presence of macrophytes in large number.

EYC (Table 2b): Physical characteristics of EYC waters do not vary much from non-stressed WYC zone. The water was alkaline, pH ranging between 7.31-7.76, had comparatively adequate dissolved oxygen, 9.27-9.34 mg/l.
Low nutrient load of magnesium (1.67-3.16 mg/l) may be hampering the trophic status of this canal.
High conductance of 413.4 µmhos/cm at Saharanpur may be due to washings from basin brought in by the seasonal tributaries at EYC Head especially Son and Pathrala.

2.22 Primary production (Table 2b)

Gross primary production of WYC in general between 91.23 (confluence) to 105.28 $mgC/m^2/hr$. The values were less 74.43 $mgC/m^2/hr$ at OF site indicating the zone under stress.

Carbon production value at SYL was 102.0 mgC/m^2/hr. The ratio between net and gross production was too high, 0.56 at SYL than WYC (0.18-0.50) denoting it comparatively productive.

The carbon production values within EYC ranged from low of 81.2 to high 129.02 mgC/m^2/hr.

2.23 Plankton (Table 3b)

Western Yamuna Canal: The average standing crop of plankton was 378 u/l, slightly higher than river. The productivity showed gradual increase from 246 u/l (AOF, Yamunanagar) to 381 u/l (Panipat) through a high of 448 u/l at BOF Yamunanagar under the influence of effluents.

Phytoplankton contributed maximum 92.07 to 96.9% and zooplankton meager, 3.09-7.93% towards total planktonic population.

Planktonic composition along WYC was in accordance with water quality. AOF Yamunanagar not subjected to effluent load showed dominance of bacillariophyceae (60.0%) followed by chlorophyceae (18.73%) among phytoplanktons and rotifers (4.48%) among zooplanktons.

The OF-BOF stretch subjected to effluent load showed dominance of myxophyceae (54.98-38.02%) decrease in abundance of bacillariophyceae (37.56-38.31%) and chlorophyceae (2.87-13.59%).

The sustained effect of pollutants upto Karnal was shown by presence of myxophyceae (24.55%), protozoa (2.33%) at this site.

Presence of zooplankton especially cladocerans 0.26-2.13% and copepods 0.36-2.08% all along WYC show its waters organically rich than river.

SYL: SYL not subjected to effluents in immediate vicinity, having slow water flow and eathern embankments had high planktonic density of 469 u/l. The population contributed by bacillariophyceae (46.52%), chlorophyceae (24.67%), myxophyceae (13.35%), dinophyceae (6.01%) and desminds (5.0%) in order of abundance.

EYC :- Standing crop of plankton within EYC on an average was 237 u/l ranging between 200-275 u/l, dominated by bacillariophyceae (79.1-54.7%). Minimum presence of myxophyceae (6.5%) that too in lower segment of canal only and absence of zooplankters like protozoa and cladocera from whole canal and that of copepods (Table 3b) from upper section of this canal signify that EYC is free from any untoward effluents and has cleaner water than WYC.

The plankton fauna present in canal system has been depicted in Table 3b.

2.24 Periphyton (Table 5b)

Average periphyton concentration within WYC was quite high ranging between 2126 to 1292 u/cm^2 barring effluent affected zone, where the concentration decreased to 151-875 u/cm^2.

Bacillariophyceae in the range of (59.13-70.98%) was dominant at non-stressed sites and myxophyceae (54.17%) at effluent loaded sites. Quantitative and qualitative abundance of periphyton flora depicted profound response towards effluent load.

SYL: SYL had highest periphyton concentration of 2768 u/cm^2. Population exhibited great diversity (Table 5b) may be due to i) conducive condition of both water and soil ii) slow current iii) unlined nature of canal. The effect persisted up to confluence site of WYC having periphyton concentration of 1844 ucm^{-2}.

EYC: Periphyton concentration within EYC was comparatively low, 263-319 ucm^{-2} mainly due to i) lined nature of canal ii) fast inconsistent water flow.
Periphyton like plankton had dominance of bacillariophyceae 73.85-62.50% and minimum presence of myxophyceae 6.60-15.5% depicting is having clean environment than WYC.

2.25 Macrozoobenthos (Table 6b)

WYC: Macrozoobenthic population of WYC was high compared to river. It ranged between 191-681 u/m^2 at unstressed sites and 762-2292 u/m^2 at stressed sites. Population at latter sites increased under the impact of sugar distillery effluents causing organic enrichment conducive for chironomid and tubificids which were in abundance along this stretch (Table 6b).

Population along canal was composed of many groups. But species diversity within a group was restricted, thereby exhibiting environment constrains. Presence of Ephemeroptera nymphs at selected sites (AOF &CON) depict these comparatively clean.

SYL: SYL had substantial macrobenthic population of 347 u/m^2 present throughout the year. Contributory percentage of various groups towards population depict it eutrophic in character but not polluted.

EYC: Benthic population within EYC was comparatively low, 50-33 u/m^2 mainly due to sandy texture and more disturbance in canal bed due to frequent manipulation of water flow in this canal.

Distribution of benthic organisms (Table 6b) within various canals exhibited response to externeous effluents. Presence of *Ephemerella, Libellula nymphs* and *Haliplus* within upper segment of EYC and AOF of WYC only having clean waters (Table 2b) denote these two as non-tolerant organisms or saprophobic forms.

Presence of *Baetis simplex, Atherix sp., Triogma sp., Aelosoma, Chaetogaster, Lymaea sp., Valvata, Parreyscia sp.* present at upper EYC, AOF Yamunanagar and diluted portion of WYC and SYL show these organisms present both in fresh as well as mildly polluted waters.

Presence of *Gomphus nymphs, Berosus larvae, Viviparus* sp. in both fresh (EYC Saharanpur) mildly polluted (confluence site) and grossly polluted (OF-BOF stretch) sites (Table 6b) show these organisms having wide range of tolerance hence can be delineated as saproxenic species.

Incidence of *Branchiura, Dixid, Culicoid* and *Chaoborus larvae* only along stressed zone of WYC (Table 6b) and bloom of *Chironomous, Tubifex, Limnodrillus* at OF-BOF sites of WYC show there can withstand sufficient amount and type of population, hence can be categorized as pollution resistanct or saprophilic forms.

2.26 Surface Insects

WYC :- Surface Insect density within canal was in the range of 1-25 u/m^2. It being low (1-3 u/m^2) upto WYC Karnal, under the impact of effluents. Density raised to 25 u/m^2 at Panipat under the impact of SYL.

SYL :- SYL had surface Insect density of 19 u/m^2, present in all seasons.

EYC :- Surface Insects showed seasonal and sectoral variation. At upper segment, these were present only in pre-monsoon (6 u/m^2) formed exclusively by *Libellula nymphs* at lower segment present during winter only (7 u/m^2) formed by many groups mainly Hemiptera.

Insects present along canal system are shown in Table 9.

2.27 Macrovegetation (Table 8b)

WYC :- Macrophytes along WYC were present at AOF-Yamunanagar and then from confluence onwards rest of the stretch being devoid of it under the impact of effluents. The biomass ranged between 1.66 to 15.0 g/m^2 (dry wt.) being highest at confluence (diluted segment) and lowest at WYC Karnal (stressed segment).

SYL had high biomass of macrovegetation, 61.44 g/m^2 (dry wt.).

EYC had low macrovegetation density of 5.0-2.5 g/m^2 only during post-monsoons.

Dominance of *Vallisneria* (52.33%) and *Ceratophyllum echinatum* (13.3%) at AOF-Yamunanagar and subsequent decrease in other portions of canal (Table 8b) depict these two plants can not withstand much of effluent load.

Presence of *Potomogeton pectinatus* throughout the canal (Table 8b) exhibit the plant has wide range of pollution tolerance.

FISH AND FISHERY

2..28 Fishery spectrum: Observations on market arrivals of canal fishery show presence of all fishes found in river (Annexure –I). In addition following fishes were also observed occasionally.

1. Silver carp, *H. molitrix*
2. Magur, *C. batrachus*
3. Singhi, *H. fossilis*

Fish diversity: Fish population within canal shows extension of Eurythermal cold-water fishes only up to Karnal unlike river where these extend occasionally to Panipat.

2.29 Fish biomass (Table 11b) Amongst canals, commercial fishing exists only in WYC. Fishery does exist in SYL, but since SYL joins WYC at Karnal, the produce from both is marketed together and designated as WYC fishery.
Fish biomass from canal ranged between 15.63 t (97-98) to 16.23 t (98-99), having an average production of 15.93 t/year. The low fish biomass in canal irrespective of maximum availability of water (Fig. 2) and food (Table 3-6 a & b) than river may be due to repeated fish kills observed along Yamunanagar-Karnal zone due to industrial discharge in canal.

Sectoral abundance (Table 12b) within canal depicted high production of 7.08 t/year at Karnal, although the segment is under the influence of unwanted effluents (Table 2 b). This is because availability of fish produce in Karnal zone was not true reflection of its productivity because the catch comprise the produce from SYL also, Decrease in productivity of canal at Panipat (2.09 t) may be due i) prolonged effect of pollution load. ii) Concrete lining of canal in the region. iii) Less fishing efforts and iv) Low recruitment rate of fishery due to nature of canal (deep lined, more water flow).

Fish catch composition (Table 12b) Canal fishery was not dominated by any particular group like riverine fishery (Table 12a). All groups contributed substantially towards total population, largest being minor carps (26.79%) followed by exotic carps (18.42%), large size catfishes (16.75%), Mahseer (9.67%) and IMC (8.66%), but irrespective of above observations, the single fish dominant in canal was common carp (both varieties) forming 17.95% of total population between 5.03% (Yamunanagar) to 32.42% (Karnal). High incidence of common carp at Karnal may be due to conducive environment for breeding within SYL canal for this fishery.

Preview of catch composition among canal showed that Mahseer (20.95%) and minor carps (44.55%) mostly eurythermal variety was present predominantly at Yamunanagar, the reason being that Yamunanagar catch of canal encompass the canal Head and place around Dodoopur region both these places situated at the foot hills of Shiwalik Himalayas, natural habitat of above two groups.

Perusal of data also show presence of quality fish in canal than river. Indian major carps no doubt least contributory still its population percentage was more than river (Table 12a) which shows that the canal can be exploited by various means like cage culture etc. for this fishery

Distribution of IMC along canal was unlike river. The canal had almost equal presence of *L. calbasu* (3.08%) and *C. mrigala* (3.45%). *L. rohita* (1.82%) and *C catla* (0.31%) were least represented.

Fish price spread (Table 14)

The price spread for different categories of fish across sampled centers followed no uniform pattern with maximum fishers' share for catfish (61.84%) and miscellaneous fishes (58.17%) at Yamunanagar in channel 1 and for carps at Panipat (56.5%). The minimum share of fishers' for all the categories of fish was at Karnal, evidently due to inclusion one more intermediary the contractor.

The wholesale-cum-commission agents received 5.10-6.99% of retail price in case of miscellaneous fish at Panipat and Karnal respectively. Similar to riverine catch the fixed rate of commission resulted in low variation in their share. The contractors existing only at Karnal received 44.04-45.46% of consumer rupee.

The overall price for different categories of fishes evident during the tenure is given in table 14.

3. CONCLUSION

The present study in upper Yamuna upto Sanoli (Panipat) has indicated the river more or less clean, devoid of any pollutional effect as far as water quality and fish food organisms are concerned, but contrary to it fishery prevalent in river is not of good quality mainly in the region below Tajewallah barrage as this portion of river is subjected to i) heavy water abstraction due to manoevuring of water resources for irrigation and power generation , ii) sedimentation due to deforestation in catchment areas.

Water abstraction has decreased the available water volume in river which has resulted in habitat loss of biotic communities mainly macrozoobenthos and fish especially quality fish as was evident by assessing the contributory percentage of IMC within river.

Yamunanagar zone having catchment area from above barrage (existence of sufficient water column) to Kalnaour contain 13.15% of IMC, the group decrease gradually to 3.67% at Panipat having low water volume (caused due to diversification of resources) and no reprieve from this. Contrary to it canal (WYC) which is subjected to good amount of industrial effluents at Yamunanagar, causing even occasional fish kills, the IMC contribution does not vary much between Yamunanagar (7.99%) to Panipat (8.35%) because canal gets flushed continuously by sufficient water.

Sedimentation coupled with water abstraction result in desertification of river bed, blanketting the soil-water interface, thus loss of productivity and breeding grounds as was evident by meager percentage of desirable spawn between Kalanour to Badoli (Karnal).

Loss of habitat and breeding grounds due to manipulation (Hathnikund barrage formation) of river resources was evident by the rise in contributing percentage towards total population of mahseer from 1.51 to 4.63% in river and from 2.6 to 16.45% in Western Yamuna Canal between 97-98 to 98-99 (construction period) and its subsequent reduction to 3.11% in river and 9% within canal latter on. Enhancement during construction period was due to continuous movement of this fishery in search of shelter and food, decrease was due to lose of breeding grounds/brood stock.

Annual rise in auctioning amount and paucity of fishable stock in the stretch has caused irrational methods of fishing (Rope loop system, Chatti Jal, Roak fishing) by the fishermen, which has affected the process of recruitment and paucity of food mainly for cat fish fishery. 68.8% of Panipat catch comprised of small sized fishery which could have been utilized by big size cat fish fishery to some extant.

Perusal of 4 years data show that upper Yamuna as well as WYC sustain exotic fishery mainly common carp. Invasion of this fishery may have been accidental

but gradual rise from 4.89 to 12.02% within the tenure show that fish is getting conducive environs for its sustenance and growth. Small but continuous presence of *C. idella*, *H. molitrix* and *A. nobilis* within river and canal show their existence in the system.

Study of canal system indicates that out of 3 canals, Western Yamuna canal is polluted due to induction of industrial effluents at Yamunanagar. The effect of effluents persists upto Karnal causing occasional fish kills which may be the reason for low fish produce of only 15.93 t/year compared to 22.98 t/year of river, almost a decrease of 30.67% irrespective of the fact that canal has sufficient available water and food resources.

The comparative low fish produce of 2.09 t/year in diluted segment of canal (Panipat) compared to 6.75 t/year at Yamunanagar and 7.08 t/year at Karnal, envisage the importance of breeding facilities for sustainance of any fishery. Yamunanagar zone of canal encompassing Dodoopur area get inducted by some seasonal Nallas, providing breeding facilities especially to IMC, minor carps and Mahseer. SYL with maximum submerged weeds form good breeding ground for common carp forming 32.42% of total population at Karnal, but Panipat with lined narrow deep nature of canal has no such facility in the vicinity.

Comparative perusal of fish population within river and canal show that canal contains quality fish than river (8.66% of IMC and 26.79% minor carps) as such can be used for cage culture purposes.

In situ evaluation of fish produce both in river and canal under the impact of ecodegradation in former and pollutional load in latter envisage the importance of combination of factors for the production of sustainable fishery.

Availability of water resources, food and productivity along Eastern Yamuna Canal denote it conducive for fish propagation.

4. RECOMMENDATIONS FOR CONSERVATION AND SUSTANANCE OF FISHERIES IN UPPER YAMUNA

Sustenance of one of the richest resource of fish germ plasm and to bridge the gap between production and demand, especially of those fishes which are not cultured but are greatly sought after, it is imperative to conserve the capture fisheries resources within Yamuna sub basin of Ganga system.

4.1 Eco-conservations

Ecoconservation in the Yamuna basin necessitates a national approach extending beyond state boundaries. The alarming rate of deforestation in neighbouring hill states of Utteranchal and Himachal needs an immediate check coupled with massive afforestation programme even along foot hills to halt the soil erosion.

Commercial exploitation of Yamuna bed for extraction of stones/pebbles in upper most segment at Hathnikund, Doddopur, Tajewallah should not be allowed as it affects breeding grounds and food web especially of Mahseer fishery.

The problem of pollution within canal system especially WYC has assumed serious dimensions causing occasional fish kills. It is therefore necessary by the concerned authority-Haryana Pollution Control Board to exercise immediate check on dumping of untreated effluents at Yamunanagar.

Ranching of upper Yamuna may also be done by mixture of eurythermal cold water minor carps also, but prior to this breeding biology of these carps in this habitat needs to be worked out.

Restructuring of the leasing stretches, leaving identified Sanctuary area beyond the preview of commercial fishing by both the states, adjoining Sanctuary area i.e. Haryana and U.P.

Strict imposition of mesh size along with fish size needs to be pursued earnestly by the concerned department.

Transfer of fishery rights from various departments like Revenue, Irrigation, Gram Panchayat, Forestry to state fisheries departments to overcome lack of co-ordination.

Leasing of Yamuna on 3 year tenure instead of 1 year tenure and make the contractor party to ranching programme by the state fisheries department as it will ensure the success of the programme and help in diminising the unethical practises adopted by contractor to get maximum yield within minimum period.

For stabllization of fishery within Yamuna especially Mahseer, Haryana Fisheries needs to review its policy of regular enhancement of Revenue resources for at least 3 years mainly at Yamunanagar district because high contract money involved leads to poaching by the contractor.

For restoration of over all fish population auctioning of Yamuna may be stopped for 1-2 years with strict vigil on fishing.

4.2 SUSTENANCE AND DEVELOPMENT OF FISHERIES

River Yamuna forms backbone of capture fisheries for the state of Haryana and Western U.P. The scope for sustenance and development rests on both the states and can be done by following short term/long term strategies.

Short term measures :

1) Complete ban on fishing by i) Fry drag net (Chatti jal) and ii) Roak type.

2) Stringent measures required to over look fish catch at Doddopur during closure of canals. Juvenile fishery of Mahseer as well other commercial species caught ,be transplanted to main river.

3) Immediate ban on auctioning of upper Yamuna by Haryana fisheries department for at least 2 to 3 years to restore the population or to go away with the practise of annual enhancement.

4) Closed season to be observed by both states simultaneously to avoid poaching.

Long terms measures :

The river zone from Kelasar to Hathnikund barrage extending laterally to Dodoopur be notified as Mahseer Sanctuary by the Haryana Fisheries department with the consent of U.P. fisheries, other-wise unabated fishing from opposite bank may prove futile exercise .

A systematic survey for Mahseer spawn within incoming rivulets like Som and Pathrala and in isolated patches of river during receding phase. This would help to determine availability of spawn and if found productive.the spawn can be salvaged for ranching of the system.

Artiopagation of Mahseer by the spawners of the region may also be taken up to utilize the natural habitat of this fish in upper Yamuna.
Cage culture of commercial fishes may be taken up into main Western Yamuna Canal to augment production.
Utter Pradesh Fisheries department should earnestly induce IMC seed into EYC to utilize its resources.

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Table. 1b. Texture of bed soil of Yamuna canals (WYC & EYC) during 1997-99

		Western Yamuna Canal							Eastern Yamuna Canal	
		Yamunanagar			Karnal			Panipat	Saharan.	Phulkeri
		AOF	OF	BOF	WYC	SYL	CON			
Sand (%)	Mean	76.55	70.37	75.23	73.40	73.11	76.55	71.02	75.63	75.83
	Range	81.10-72.0	72.28-68.45	80.28-70.17	74.8-72.0	76.7-69.52	79.54-73.55	67.27-74.77	76.37-74.9	80.96-70.7
Silt (%)	Mean	15.91	20.98	16.86	18.81	17.02	15.16	18.0	14.60	16.08
	Range	11.7-20.12	19.02-22.95	12.85-20.88	19.66-17.97	13.76-20.48	13.3-17.02	19.8-16.2	11.87-17.32	12.74-19.42
Clay (%)	Mean	7.54	8.65	7.91	7.79	9.87	8.29	10.98	9.77	8.09
	Range	7.2-7.88	8.7-8.6	6.87-8.95	5.54-10.03	9.54-10.20	7.16-9.43	12.93-9.03	11.76-7.77	6.3-9.88
pH	Mean	7.3	7.03	7.1	7.25	7.25	7.31	7.34	7.33	7.25
	Range	7.2-7.4	6.9-7.15	7.0-7.2	7.13-7.3	7.1-7.4	7.2-7.44	7.27-7.42	7.2-7.47	7.13-7.37
Sp. cond. (µmhos/cm)	Mean	201.9	332.73	221.5	299.19	273.24	246.66	248.55	241.04	247.05
	Range	195.1-208.7	280.75-384.72	160-283	276.16-322.22	266.7-279.7	225.4-267.9	231.35-265.75	232.7-249.3	234.45-259.66
Organic carbon (%)	Mean	0.29	0.31	0.29	0.25	0.42	0.28	0.44	0.38	0.28
	Range	0.24-0.35	-	0.26-0.33	0.20-0.31	0.36-0.48	0.28-0.29	0.34-0.54	0.27-0.50	0.25-0.31
Free cal. Carbonate (%)	Mean	3.28	3.24	3.08	2.84	3.35	2.79	3.44	3.42	2.72
	Range	2.76-3.81	2.64-2.85	2.6-3.56	2.72-2.97	2.96-3.75	2.67-2.92	3.09-3.79	2.87-3.97	2.58-2.82
Aval. Niteogen (mg/100g)	Mean	26.0	26.76	24.66	28.06	30.04	26.67	30.15	34.16	26.97
	Range	25-27	25.17-28.35	23.7-25.9	25.96-30.17	29.45-30.63	25.95-27.4	26.4-33.9	29.9-38.4	24.3-29.65
Aval. Phosphorus (mg/100g)	Mean	2.32	2.62	2.27	2.6	2.62	2.52	2.89	2.77	2.86
	Range	2.0-2.65	2.12-3.1	2.15-2.4	2.4-2.9	2.32-2.93	2.35-2.7	2.3-2.47	2.32-3.23	2.5-3.2

Table :2b Water characteristics of Yamuna Canals (WYC & EYC) during 1995-1999 (Annual Average).

Station		W. temp. (o^C)	Trans. (cm)	pH	D.O. (mg/l)	Free $C0_2$ (mg/l)	T. alkalinity (mg/l)	Sp. cond. (µmhos/cm)	Calcium (mg/l)	Magn. (mg/l)	Primary Productivity	
											GP	NP
Y. nagar AOF	Av.	22.54	38.96	7.46	8.5	2.9	114.4	206.63	34.3	3.66	95.86	52.95
	Range	20.8-24.57	16.5-55.6	6.78-7.9	7.46-9.7	0-46	88.5-135.3	165.75-233.3	27.72-40.88	1.57-5.76		
OF	Av.	23.68	18.7	6.82	3.72	7.3	164.9	591.4	35.27	5.53	-	-
	Range	21.6-24.9	10.5-29.8	6.13-7.3	2.1-5.33	4-10.6	109.3-215.2	378.3-824.5	35.22-35.33	1.36-9.7		
BOF	Av.	23	25.5	7.03	6.39	8.9	137.1	326.05	37.13	4.16	74.43	45.31
	Range	22.5-23.7	20-37	6.64-7.6	5.49-7.32	4.0-16.0	111.5-171.3	283-385	30.17-44.09	1.07-7.25		
WYC Karnal	Av.	22.12	34.01	7.44	7.02	6.95	111.11	265.78	39.09	5.43	97.97	47.71
	Range	20.33	23.30-50.25	7.15-7.84	5.06-8.28	3.9-19.6	100-118.66	204.25-361.6	34.48-43.7	3.3-7.57		
SYL Karnal	Av.	22.8	32.45	7.53	8.67	6.2	99.8	205.7	29	5.19	102.0	57.22
	Range	20-24.4	23.8-40.2	7.29-7.81	5.8-11.6	3.5-10.3	72.5-125.3	177.5-264.6	23.24-34.76	3.06-7.33	9	
Confluence Karnal	Av.	22.2	32.84	7.41	7.24	7.13	88.88	245.1	29.54	5.95	91.23	45.86
	Range	20.2-24.4	27.2-43.57	7.22-7.6	4.64-8.4	3.55-10.2	61.3-124	172.5-411.6	29.16-29.92	2.81-9.09		
WYC Panipat	Av.	22.63	36.15	7.74	8.45	3.22	119.15	201.18	29.11	5.3	105.2	50.88
	Range	21-24.12	20.6-45	7.34-8.11	7.04-9.3	0-7.0	83.5-147	88.7-117.75	28.32-29.9	1.81-8.79	8	
EYC Sharanpur	Av.	21.6	27	7.31	9.27	3.05	74.05	413.4	34.96	1.67	81.2	49.67
	Range	-	23.25-30.75	7.26-7.37	9-9.54	2.5-3.6	67.2-80.9	358.5-468.75	34.08-35.85	1.54-1.80		
EYC Phulkheri	Av.	23.8	33.8	7.76	9.34	9.5	94.25	169.2	28.34	3.16	129.0	80.8
	Range	22.6-25	22-45.6	7.46-8.07	9.28-9.4	6.1-12	74.5-114	150.2-188.2	27.78-28.91	1.43-4.89	2	

Table: 3b Plankton density and distribution in Yamuna Canals (WYC & EYC) during 1995-99.

Population Density	Western Yamuna Canal							Eastern Yamuna Canal	
	Yamunanagar			Karnal			Panipat	Saharanpur	Phulkheri
	AOF	OF	BOF	WYC	SYL	CON.			
Mean (ul^{-1})	346	355	448	353	469	372	381	200	275
Range (ul^{-1})	238-500	125-592	200-550	312-411	416-538	325-438	325-452	175-225	225-325
Population composition (%) and species number ( )									
Bacillariophyceae	60.0 (16)	37.56 (11)	38.31 (9)	44.14 (12)	46.52 (12)	48.59 (12)	42.64 (8)	79.1 (16)	54.7 (8)
Chlorophyceae	18.73 (6)	2.87 (6)	13.59 (10)	17.76 (7)	24.67 (9)	23.65 (6)	20.36 (5)	20.9 (5)	20.7 (4)
Myxophyceae	11.24 (5)	54.98 (7)	38.02 (6)	24.55 (5)	13.35 (5)	14.82 (5)	26.54 (4)	1.0 (1)	6.5 (1)
Desmidaceae	1.41 (1)	0.92 (1)	0.89 (1)	5.56 (1)	5.52 (1)	3.0 (1)	3.0 (1)	2.9 (1)	9.4
Dinophyceae	2.47 (2)	-	1.0 (1)	-	6.0 (2)	6.31 (2)	3.05 (1)	-	
Protozoa	1.05 (1)	-	0.36 (1)	2.33 (1)	-	-	-	-	-
Rotifera	4.48 (3)	0.26 (1)	5.45 (2)	5.25 (4)	1.81 (2)	1.78 (1)	4.06 (4)	-	-
Cladocera	-	0.26 (1)	1.14 (1)	0.15 (1)	2.13 (1)	-	-	-	-
Coepoda	0.38 (1)	2.08 (1)	0.64 (1)	0.36 (1)	-	1.85 (1)	0.35 (1)	-	8.7 (2)

Table- 5b Periphyton distribution in Yamuna Canal (WYC & EYC)

Population density		Western Yamuna Canal							Eastern Yamuna Canal	
		Yamuna Nagar			Karnal			Panipat	Saharanpur	Phulkeri
		AOF	OF	BOF	WYC	SYL	CON			
Mean (ucm^{-2})		2126	151	875	1320	2768	1844	1292	263	319
Mean (ucm^{-2})		300-5691	138-163	238-2186	363-3285	538-7143	313-4781	365-3112	250-375	263-375
Population Composition (%)										
Bacillariophyceae	**Sp. No.**	10	2	5	6	18	6	7	17	9
	Mean	60.80	41.12	54.84	67.30	67.51	70.98	59.13	73.85	62.50
Chlorophyceae	**Sp. No.**	5	1	1	4	2	2	4	3	2
	Mean	27.59	4.71	9.83	11.83	13.18	10.64	18.97	19.35	20.38
Myxophyceae	**Sp. No.**	2	5	3	5	4	4	3	2	2
	Mean	10.48	54.17	20.66	19.68	11.57	14.42	18.34	6.60	15.52

Table: 4b: Plankton Population recorded in Yamuna Canals (WYC, SYL & EYC)

	Yamunanagar			Karnal			Panipat	EYC	
	AOF	OF	BOF	WYC	SYL	CONF		Saharanpur	Phulkeree
Bacillariophyceae									
Eunotia	+	-	+	-	-	-	-	+	-
Fragillaria	+	+	-	+	-	-	-	-	+
Eucocconeis	+	-	-	-	-	-	-	-	-
Amphora	+	-	+	+	-	-	-	+	+
Stauroneis	+	-	-	-	-	-	-	+	-
Cymbella	+	+	+	-	+	-	-	+	+
Caloneis	+	+	-	+	-	+	-	-	-
Melosira	+	-	-	+	-	+	+	+	-
Cyclotella	+	-	-	-	-	-	-	+	-
Meridion	+	+	+	+	+	-	+	+	+
Diatoma	+	+	+	+	+	+	+	+	+
Cocconeis	+	+	-	+	-	+	+	+	+
Achnanthes	+	+	-	-	-	+	-	-	-
Navicula	+	+	+	+	+	+	+	+	+
Frustulia	+	-	+	+	-	-	-	+	+
Nitzschia	+	-	-	+	+	+	-	+	+
Gyrosigma	-	+	-	+	+	-	-	-	+
Tabillaria	-	+	+	+	+	+	+	+	+
Synedra	-	+	+	-	+	+	-	+	-
Gurirella	-	-	-	-	+	-	-	-	-
Amphipleura	-	-	-	-	+	+	-	-	-
Gomphonema	-	-	-	-	-	+	+	+	-
Chlorophyceae									
Cyclodinium	+	+	+	+	-	+	+	-	-
Spirogyra	+	+	+	-	+	+	+	+	+
Cladophora	+	-	+	-	+	-	-	+	-
Coelastrum	+	-	+	-	+	-	-	+	-
Trochscia	+	+	+	-	-	-	+	+	+
Zygnema	-	+	-	-	-	-	-	-	-
Ulothrix	-	+	-	+	-	+	+	+	-
Characium	+	+	+	+	+	+	-	-	+
Actinostrum	-	-	+	-	+	-	-	+	-
Batricoccus	-	-	+	-	-	-	-	-	-
Characiopsis	-	-	+	-	-	-	-	-	-
Ankistrodesmus	-	-	-	+	-	+	+	+	-
Closterum	-	-	-	+	-	-	-	-	-
Pediastrum	-	-	-	+	-	-	-	-	-
Kirchneriella	-	-	-	-	-	+	-	-	-
Batryococcus	-	-	-	-	+	-	-	-	-

Senedesmus	-	-	-	-	+	-	-	-	-
Chaetophora	-	-	-	-	-	-	+	-	-
Cruceigenia	-	-	-	-	-	-	-	+	-
Myxophyceae									
Microcystis	+	+	+	+	+	+	+	+	-
Nostoc	+	+	+	+	-	-	-	-	-
Oscillatoria	+	+	+	+	+	+	+	+	+
Spirulina	+	+	+	+	+	+	+	+	+
Merismopedia	+	-	+	-	+	+	-	-	-
Phormidium	-	+	+	-	+	+	+	+	+
Stigonema	-	+	-	-	-	-	-	-	-
Polycystis	-	+	-	+	-	-	-	-	-
Desmidaceae									
Cosmarium	+	+	+	+	+	+	+	+	-
Dinophyceae									
Ceratium	+	-	+	-	+	+	+	-	-
Peridinium	+	-	-	-	+	+	+	+	-
Rotifera									
Keratella	+	+	+	+	-	-	+	-	-
Monostyla	+	-	+	+	-	-	+	-	-
Brachionus	+	-	-	+	+	-	+	-	-
Notholca	-	-	-	+	+	+	+	-	-
Copepoda									
Cyclops	-	-	+	+	-	+	-	+	-
Nauplius larva	+	+	-	-	-	-	+	+	-
Cladocera									
Daphnia	-	-	-	+	+	-	-	-	-
Bosmina	-	-	+	-	-	-	-	-	-
Diaphanosoma	-	+	-	-	-	-	-	-	-
Protozoa									
Rhizodinium	+	-	-	-	-	-	-	-	-
Acfinosphaerium	-	-	+	-	-	-	-	-	-
Difflugia	-	-	-	+	-	-	-	-	-
Arcella	-	-	-	-	-	-	-	-	-

Table :6b Distribution of Benthic forms in Yamuna Canals (WYC & EYC) during 1995-99

	Western Yamuna Canal														Eastern Yamuna Canal			
	Yamunanagar						Karnal						Panipat					
Population density	AOF		OF		BOF		WYC		SYL		CON.				Saharanpur		Phulkheri	
Mean (u/m^2)	191		1824		762		2292		347		681		508		50		33	
Range (u/m^2)	24-608		Nil-6116		123-4661		231-4661		68-650		142-1058		33-1217		Nil-100		Nil-66	
	Sp. No.	%	Sp. No.	%	Sp. No.	%	Sp. No.	%	Sp. No.	%	Sp. No.	%	Sp. No.	%	Sp. No.	%	Sp. No.	%
Ephemeroptera	1	1.0	-	-	-	-	-	-	1	1.8	1	1.8	-	-	2	6.25	-	-
Odonata	1	3.5	-	-	-	-	2	10.26	-	-	1	2.6	-	-	2	6.23	-	-
Colepotera	3	10.3	2	4.74	2	6.27	1	0.11	-	-	1	2.25	-	-	-	-	-	-
Diptera a) *Chironomus*	1	29.9		12.5		19.82		27.23		28.98	1	15.17	1	13.49	1	21.87	1	25.0
b) Other Diptera	2	4.0	2	8.0	1	8.0	2	17.0	2	16.36	3	29.0	1	5.32	-	-	-	-
Gastropods	2	9.51	-	-	3	17.57	2	6.3	10	26.54	1	2.15	6	12.80	2	21.0	2	12.0
Pelecypoda	1	1.81	1	0.25	1	1.0	-	-	2	3.61	2	8.03	2	28.56	2	35.0	2	25.0
Annelida a) Tubificids	1	7.12	1	15.63	1	40.12	1	38.71	1	18.98	2	37.71	1	23.93	-	-	1	12.0
Other Annelids	2	6.2	2	6.2	2	7.22	-	-	4	2.23	-	-	2	10.0	-	-	-	-
Misc.	-	-	-	3.1	-	-	-	-		1.5		1.63		5.0	-	-		25.0

Table. 7b. Macro Zoobenthic population recorded in Yamuna canals

	WYC							EYC	
	Yamunanagar			Karnal			Panipat	Saharan.	Phulkeri
Ephemeroptera	**AOF**	**OF**	**BOF**	**WYC**	**SYL**	**CON**			
Ephemerella nymph	-	-	-	-	-	-	-	+	-
Baetis simplex	+	-	-	-	$+^{S}$	$+^{S}$	-	+	-
Odonata									
Libellula nymphs	+	-	-	-	-	-	-	+	-
Gomphus nymphs	-	-	-	+	-	+	-	+	-
Ophiogompus sp	-	-	-	+	-	-	-	-	-
Coleoptera									
Halipus	$+^{W}$	-	-	-	-	-	-	-	-
Dytiscus sp	+	+	+	-	-	-	-	-	-
Berosus larvae	+	+	+	+	-	$+^{W}$	-	-	-
Diptera									
Athrix sp	$+^{W}$	-	-	-	-	-	-	-	-
Triogma sp	+	-	-	-	-	-	-	-	-
Tabanus sp	-	-	-	-	-	+	+	-	-
Culicoides larvae	-	+	-	-	-	-	-	-	-
Chronomus sp	$+^{W}$	+	+	+	+	+	+	+	+
Dixid pupa	-	+	+	+	+	+	-	-	-
Chaoborus	-	-	-	+	+	+	-	-	-
Annelids									
Aelusoma sp	+	-	-	-	-	-	-	-	-
Chaetogaster sp	+	-	-	-	-	-	-	-	-
Branchiura sp	-	+	+	+	-	-	-	-	-
Limnodrillus sp	-	+ Bloom	-	+	+	-	-	-	-
Tubifex tubifex	+	+	+	+	+	+	+	-	+
Leech	-	-	-	-	+	+	-	-	-
Shrimps	-	-	-	-	-	$+^{PM}$	$+^{PM}$	-	-
Water nematodes	-	+	-	-	-	-	-	-	-
Mollusca									
a) Gastropods									
Lymnaea sp	+	-	-	+	+	-	-	+	-
Viviparus bengalensis	-	-	+	-	+	+	+	-	-
Valvata sp	+	-	-	-	+	-	-	+	-
Amnicola sp	-	-	+	-	+	-	+	-	-
Glessula sp	-	-	-	-	+	-	+	-	-
Melania straitella	-	-	+	+	+	-	+	-	+
M. scabra	-	-	-	-	-	-	+	-	-
Faunus ater	-	-	-	-	+	-	-	-	-
Physa sp	-	-	-	-	+	-	-	-	-
Planorbis sp	-	-	-	-	+	-	-	-	-
Gyraulus conbexicula	-	-	-	-	+	-	-	-	-
b) Bivalvia									
Parreysis sp	+	-	-	-	-	-	-	+	-
Corbicula straitella	-	+	+	-	+	+	+	+	+
C. regularis	-	-	-	-	-	+	+	-	+
Sphaerium sp	-	-	-	-	+	-	-	+	-

Presence of certain Zoobenthos in specific period given in super script
W = Winter. S = Summer. PM = Post Monsoon

Table :8b Macrophyte distribution in Yamuna Canal (WYC & EYC) during 1995-99

		Western Yamuna Canal					Eastern Yamuna Canal	
		Yamunanagar	Karnal			Panipat	Saharanpur	Phulkheri
		AOF	WYC	SYL	CON.			
Biomass (dry wt.) gm/m^2	Range	1.25-3.0	Nil-5.0	52.5-73.0	Nil-73.0	Nil-23.75	Nil-10	Nil-5
Composition (%)								
Charra sp.	Range	---	---	Nil-3.5	---	---	---	---
Ceratophyllum echinatum	Range	Nil-26.6	---	---	Nil-5.0	---	---	---
Potamogeton pectinatus	Range	Nil-50.5	Nil-2.0	Nil-13.9	60-100	---	Nil-70.0	---
Potamogeton richardsonii	Range	---	Nil-60.0	50-60	---	50-70	---	---
Vallisneria sp.	Range	50-100	Nil-20	Nil-5.0	Nil-5.0	---	Nil-20.0	---
Hydrilla sp.	Range	---	Nil-5.0	5.0-50.0	Nil-5.0	---	---	---
Eichhornia crassipes	Range	---	Nil-10.0	---	Nil-10	15-50	---	---
Marginal weeds	Range	Nil-26.6	--	---	Nil-15.0	Nil-15.0	Nil-10.0	Nil-70.0
Misc.	Range	---	Nil-3.0	Nil-13.0	---	---	---	Nil-30.0

Note :- No macrophyte observed along OF and BOF stretch of WYC in any season during the observed period.

Table:11b -Year-wise estimated landing of river WYC for the year 1997-99

Years	1997-98		1998-99	
Species	(t)	(%)	(t)	(%)
Major carps				
IMC	1.58	10.10	1.18	7.27
Minor carps	5.85	37.42	2.54	15.65
Exotic carps				
C. carpio	2.52	16.12	3.20	19.71
H. molitrix	-	-	0.05	0.30
C. idella	-	-	0.02	0.12
A. nobilis	0.08	0.51	-	-
Large scale Catfishes	3.25	20.83	2.12	13.06
Mahseer	0.41	2.62	2.67	16.45
Murrels	0.27	1.72	1.24	7.64
Other groups	1.67	10.68	3.21	19.77
Total	**15.63**		**16.23**	

Table : 12b : Species-wise average landing and their percentage composition at Various centres during the period 1997-1999 in Western Yamuna Canal

Species	Yamunanagar		Karnal		Panipat		Total	
	(t)	%	(t)	%	(t)	%	(t)	%
Major carps								
C. mrigala	0.32	2.36	2.51	3.60	0.27	6.44	1.10	3.45
C. catla	0.05	0.37	0.05	0.35	-	-	0.10	0.31
L. rohita	0.19	1.14	0.36	2.54	0.03	0.72	0.58	1.82
L. calbasu	0.52	3.85	0.41	2.90	0.05	0.98	0.98	3.08
Sub-total	**1.08**	**7.99**	**1.33**	**9.39**	**0.35**	**8.35**	**2.76**	**8.66**
Minor carps								
L. bata	0.59	4.36	1.51	10.66	0.05	1.19	2.35	6.75
L. gonius	0.47	3.48	0.35	2.48	-	-	0.82	2.57
L. dyocheilus	3.09	22.87	0.21	1.48	-	-	3.30	10.35
L. dero	1.64	12.14	0.21	1.48	-	-	1.85	5.80
C. reba	0.23	1.70	0.16	1.013	0.03	0.71	0.42	1.32
Sub-total	**6.02**	**44.55**	**2.44**	**17.23**	**0.08**	**1.90**	**8.74**	**26.79**
Exotic carps								
C. carpio	0.68	5.03	4.59	32.42	0.45	10.74	5.72	17.95
H. molitrix	0.01	0.07	0.04	0.28	-	-	0.05	0.16
C. idella	0.02	0.15	-	-	-	-	0.02	0.06
A. nobilis	0.07	0.52	0.01	0.07	-	-	0.08	0.25
Sub-total	**0.78**	**5.77**	**4.64**	**32.77**	**0.45**	**10.74**	**5.87**	**18.42**
Mahaseer	2.83	20.95	0.25	1.77	-	-	3.08	9.67
Catfishes								
M. aor	-	-	0.20	1.41	0.04	0.95	0.24	0.75
M. seenghala	0.38	2.81	0.79	5.58	1.74	41.53	2.91	9.31
W. attu	0.66	4.89	0.98	6.92	0.54	12.89	2.18	6.85
Sub-total	**1.04**	**7.70**	**1.97**	**13.91**	**2.32**	**55.37**	**5.33**	**16.73**
Murrels	1.08	7.99	0.22	1.55	0.21	5.01	1.51	4.73
B. bagarius	0.32	2.36	0.14	0.98	0.01	0.23	0.47	1.48
Other groups	0.36	2.66	3.17	22.38	0.77	18.37	4.30	13.49
G. Total	**13.51**		**14.16**		**4.19**		**31.86**	
Average	**6.75**		**7.08**		**2.09**		**15.93**	

FISH SPECIES RECORDED FROM UPPER STRETCH OF YAMUNA BETWEEN (HATHINIKUND-PANIPAT)

I ORDER : CLUPEIFORMES

Sub-order : Clupeoidei
Family : Clupeidae

1. *Gadusia chapra* (Ham.)

Sub-order : Notopteroidei
Family : Notopteridae

2. *Notopterus chitala*
3. *Notopterus notopterus*

II ORDER : CYPRINIFORMES

Family : Cyprinidae
Sub-family : Abramidinae

4. *Chela bacatila* (Ham.)
5. *Chela laubuca* (Ham.)

Sub-family : Rasborinae

6. *Baroilius bola* (Ham.)
7. *Barilius barila* (Ham.)
8. *Rasbora daniconius* (Ham.)
9. *Rarilius bendelisis* (Ham.)

Sub-family : Cyprininae

10. *Tor putitora* (Ham.)
11. *Tor tor*
12. *Puntius sarana* (Ham.)
13. *Puntius sophore* (Ham.)
14. *P. ticto* (Ham.)
15. *P. punjaabensis* (Ham.)
16. *Catla catla* (Ham.)
17. *Cirrhinus* mrigala (Ham.)
18. *Cirrhinus reba* (ham.)
19. *Labeo rohita* (Ham.)
20. *Labeo calbasu* (ham.)

21. *Labeo dero* (Ham.)
22. *Labeo dyocheilus* (McClland)
23. *Labeo gonius* (Ham.)
24. *Labeo bata* (Ham.)
25. *Osteobrama cotio cotio* (ham.)
26. *Ctenopharyngodon idella* (Val.)
27. *Hypopthalmichthys molitrix* (Val.)
28. *Aristichthys nobilis*
29. *Cyprinus carpio communis*
30. *Cyprinus carpio specularis*

Family : Cobitidae

31. *Noemacheilus botia* (Ham.)

III ORDER : SILURIFORMES

Family : Bagridae

32. *Mystus aor* (Ham.)
33. *Aorichthys seenghala* (Sykes)
34. *M. cavasius* (Ham.)
35. *M. tengara* (Ham.)
36. *Rita rita* (Ham.)

Family : Sisoridae

37. *Bagarius bagarius* (Ham.)
38. *Sisor rhabdophorus* (Ham.)

Family : Siluridae

39. *Ompak pabda* (Ham.)
40. *Wallago attu* (Schneider)

Family : Schilbeidae

41. *Eutropiichthys vacha* (Ham.)
42. *Silonia silondia* (Ham.)

Family : Heteropneustidae

43. *Heteropneustes fossilis* (Bloch)

Family : Clariide

44. *Clarias batrachus* (Linnaeus)

IV ORDER : BELONIFORMS

Family : Bedlonidae

45. *Xenentodon canciula* (Ham.)

V ORDER : CHANNIFORMES

Family : channidae

46. *Channa marulius* (Ham.)
47. *C. punctatus* (Bloch)
48. *C. striatus* (Bloch)

VI ORDER : PERCIFORMES

Family : Nandidae
49. *Nandus nandus*
Family : Ambassîdae
50. *Chanda nama* (Ham.)
51. *Chanda ranga* (Ham – Buch)
Family : Anabantidae
52. *Colisa fasciata* (Schn)
Family : Goboidae
53. *Glossogobius giurius* (Ham.)

VII ORDER : MASTACEMBELIFORMES

Family : Mastacembelidae
54. *Mastacembelus armatus* (Lacepedae)
55. *M. pancalus* (Ham.)

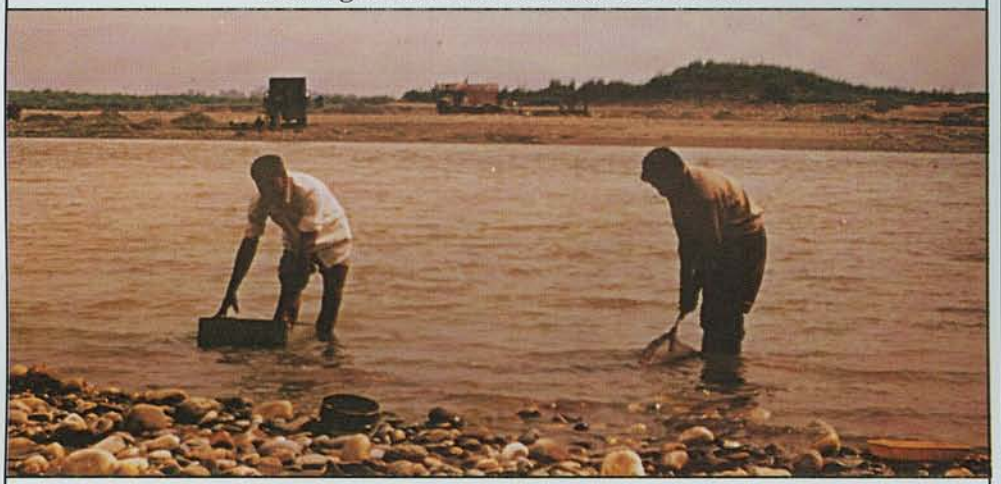
Table : Fish-diversity in upper Yamuna

Endangered species	:	*Ompok pabda*
Vulnerable species	:	*Tor tor, T. putitora, L. dero, L. dyocheilus, P. sarana* (carps), *Bagarius bagarius* (catfishes)
Indeterminate species	:	*Silonia silondia, Eutropiichthys vacha, Xenentodon cancila.*
Rare species	:	*Noemacheilus botia* *Barilius bola* *B. barila* *B. benedelisis* *Rasbora daniconius* *Gadusia chapra* *Osteobhrama cotio* *Sisor rhabdophorus* *Mystus cavasius* *Macrognathus aculeatus*

Tube fishing from Upper Yamuna

**Presence of weeds in Upper Yamuna during winter.
River transparent upto bed**

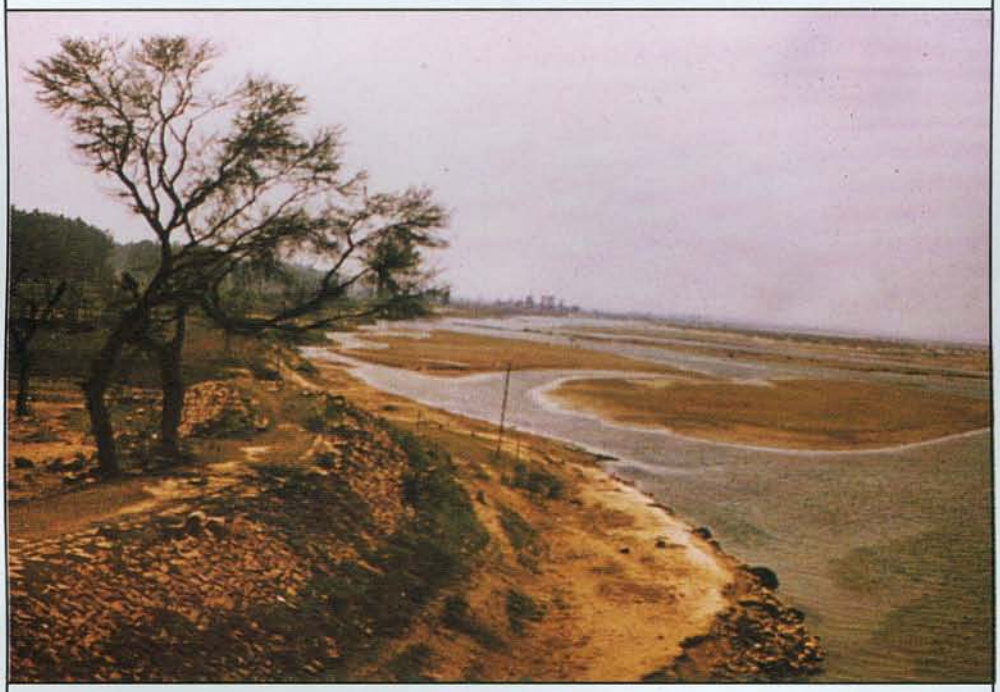
Anthropogenic activity (Barrage construction) around Hathnikund area causing destruction of Mahseer habitat



Surber sampling undertaken for collection of benthic macro invertebrates at Hathnikund

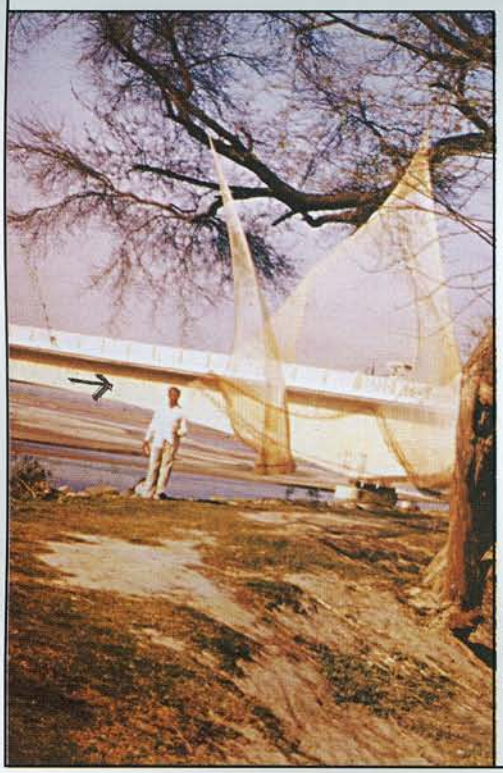
***Tor putitora* from upper Yamuna**

River Yamuna at Kalanour (Y-nagar). Note siltation of river bed



River Yamuna at Badoli (Karnal). Note low depth and high silt load

Roak fishing in river at Panipat



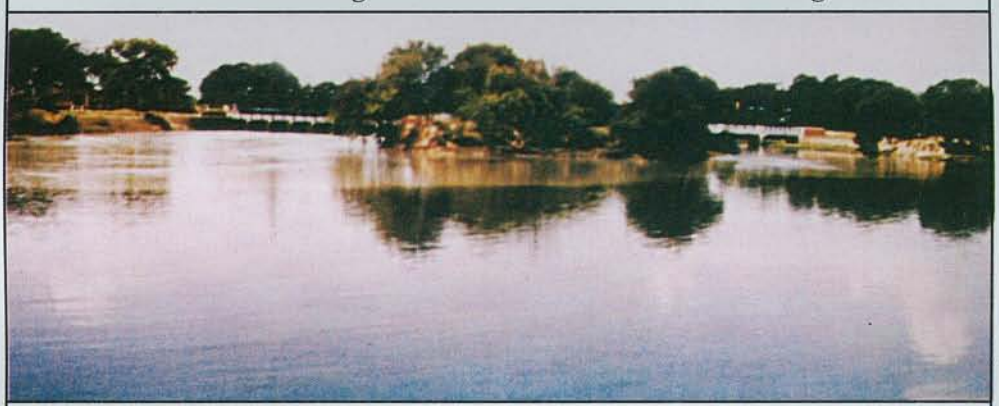
Formation of closed enclosure within river (→) use of Chattijal at Panipat

**Western Yamuna canal (WYC) at Tajewallah Headwater.
Note the amount of water within canal**

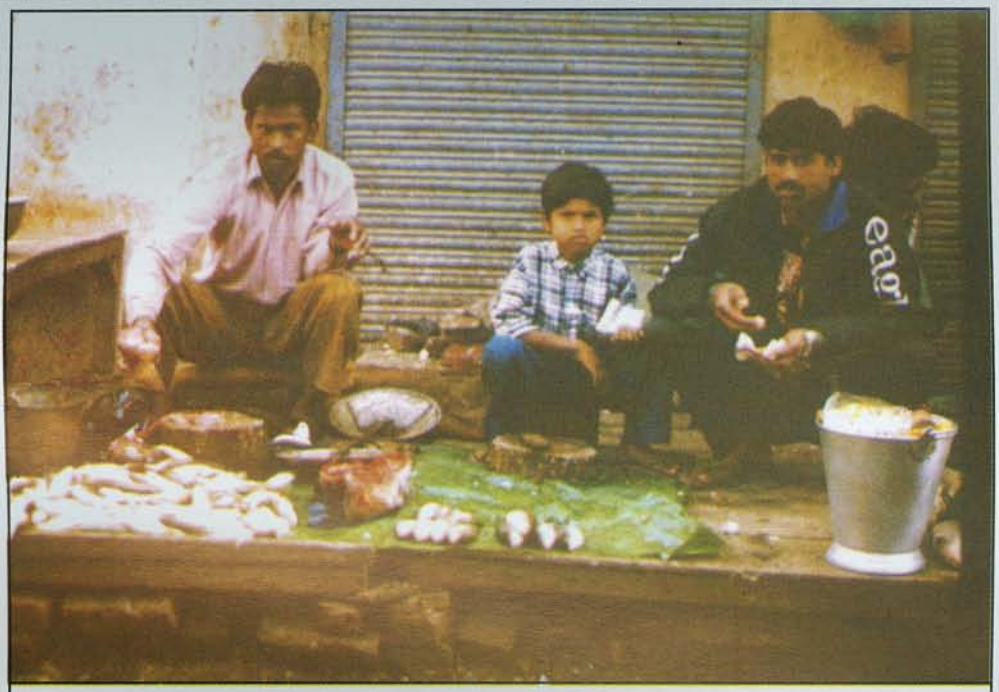
Presence of effluents in WYC at Y-nagar site

Sutlej Yamuna link (SYL) canal at Karnal having earthen embankments and less inflow of water

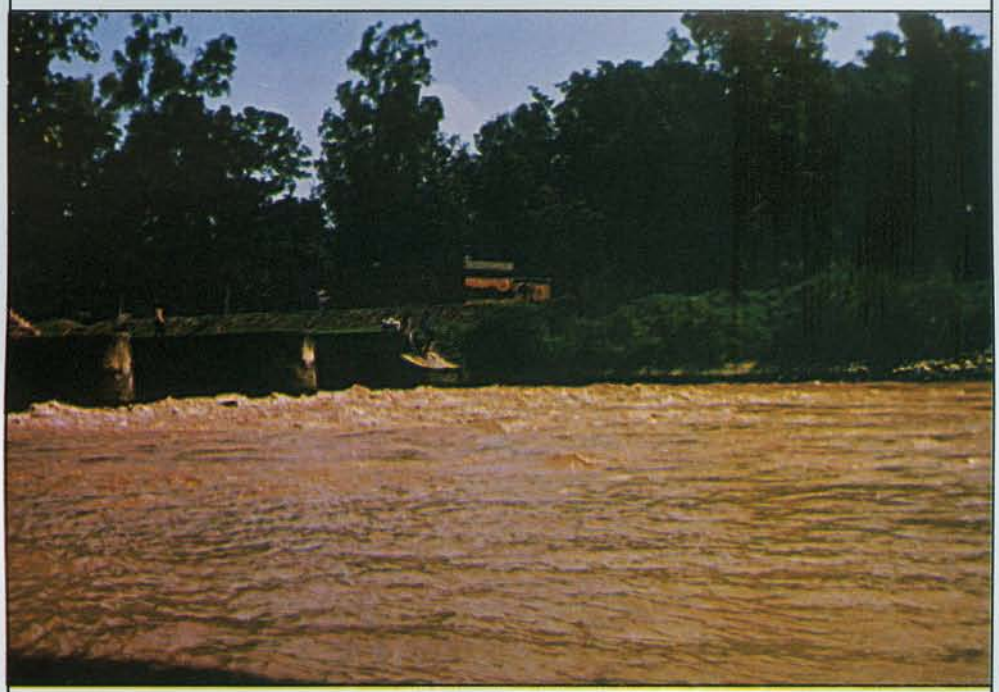
Bharka canal having lined embankments and fast flowing water



Confluence site (Karnal) where WYC, SYL and Bharka join



Landing centre at Panipat



Eastern Yamuna canal (EYC) at Saharanpur. Note the fast flowing water