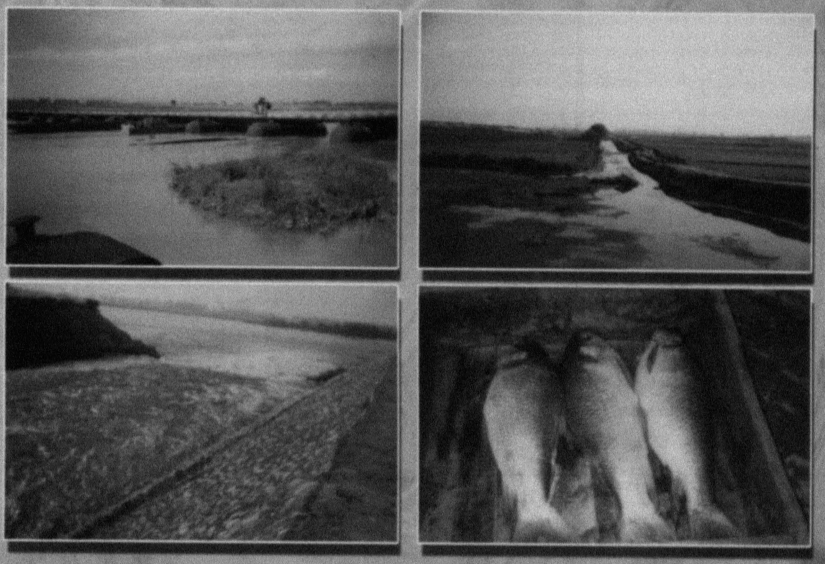
Diamond Jubilee Year
2007

RIVER BEAS
ECOLOGY AND FISHERY



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ECOLOGY AND FISHERY

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FOREWORD

River Beas the second most important tributary of Indus System so far India is concerned is 460 km long from its source, Rohtang Pass within North-Western Himalaya to its culmination with river Sutlej at Hari-ke-Pattan in the plains of Punjab (Distt. Amritsar). It has catchment area of 12,130 km^{-2} and drains 25900 km^2 of 2 Indian states. The river has maximum run off 295 km within H.P and 165 km in Punjab.

River Beas has been considered sacred from times immemorial. It was known as Arjikiya in Vedic times. The importance of this river to Indian civilization is gauged from the fact that all important sages like Narda, Vashist, Vishwamitra, Prashar, Kanav, Parsuram and Vyasa (after whom river got renamed as Vyas) meditated on its banks (their temples exist till today) and gave rise to a harmonious social hill culture which developed and prospered with passage of time in its vallies like Kullu, Nagar and Kangra.

Presence of all these civilizations show that Beas basin has been well developed, prosperous and its resources utilized judiciously from times immemorial. But the resource utilization underwent sea change after independence due to greater need for overall development to meet the aspirations of burgoing population.

The rhitherone zone of Beas within Himalaya has been maneuvered particularly for generation of energy by formulation of two dams, **Pandoh** and **Pong** on it and diversion of its resources to river Sutlej through **Beas-Sutlej Link Canal**. The potomoan zone within plains has been exploited for irrigation by carving of Canals (Shah Nehar Canal & Mukerian Hydal) from it.

These large scale changes in river has affected ecology and fishery of this basin as shown by the studies conducted from time to time within Himalayan zone i.e. two reservoirs and adjoining drainage, but how the ecology thereby productivity and biodiversity of the system has changed within the potomoan zone within plains has not been evaluated at all although it is good source of revenue to the exchequer and provide livelihood to many people related to fishery business.

This work presents the results of investigation carried over on Potomoan zone of river Beas between 2002-2005 by the scientists of Karnal Centre of CIFRI. The investigations give complete picture of present environment (water abstraction, pollution source and load) Ecology (soil texture, river bed quality, water quality and organization of various biotic forms), Fish diversity, Fishery resources and its economics. I am sure comprehensive account of environment and its impact on fishery within plains of Punjab, unknown so far, would be of immense use to planners and development authority mainly Punjab State Fisheries.

DIRECTOR
CIFRI

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CONTENTS

INTRODUCTION

1.1 River Beas

Beas an important contributory river of the Indus System is the only tributary of the system confined to India. The river 460 km long originates from two sources, Beas Kund (4060 m asl) on the South and a caveran, Beas Rishi on the right of Rohtang Pass at an elevation of 4350 m asl within North-Western Himalaya. The two streams meet at Palchan village, 10 km north of Manali to form river Beas.

The river was known as Arjiki in pre-mahabarat times and then onwards as Vipasa to ancient Indians. The present name Beas is thought to be a corruption of the word Vyas, the name of saint Vyasa, the author of great epic Mahabharata, who meditated on its banks.

The catchment area of the river, 12130 km^{-2} is spread within Himachal Pradesh (H.P) and it drains, 25900 km^{-2} of 2 states, H.P. and Punjab, having maximum run of 300 km in former and 165 km in latter. The river is steep in Head waters and first 120 km have average fall of 1 in 40. Downstream it decreases rapidly 1 in 500 in Beas Valley.

Along its course especially within Hiamalyan zone river is fed by numerous streams. The main being Parbati, Spin, Malana Nala in the east; the Solang , Manalsu, Sujion, Phojal, Sarvati in the west. In district Mandi it is joined by the Tirthan, Hansa, Bakhli, Jiuni, Suketi, Panddi, Son and Bather from North side. In Kangra district, river is fed by the Kunah, Maseh, Khairan and Man from South and the Binwa, Neugal, Banganga, Gej, Dehr, Chakki from North side. The Northern and Eastern tributaries are perennial and snowfed, being drainage from southern slopes of Dhauladhar chain of mountains while southern are seasonal with the result flow rate within river fluctuates widely. It being maximum during monsoon and minimum during winter. Total mean annual run off of Beas is 16,763 million cumecs (Sehgal, 1989) which is being utilized extensively for various purposes as the waters of the river are allotted to India along with that of river Sutlej and Ravi under Indus water treaty between India and Pakistan.

The river is subjected to first manipulation at village Pandoh in Mandi district within H.P. where it is dammed into **Pandoh reservoir**, the earth cum rock fill dam, 74.37 m high involving placement of 1.58 million cumecs of water and simultaneously a major chunk of its resources, 4716 cumecs of water diverted to river Sutlej through **Beas-Sutlej Link canal** in the form of tunnel (12.38 km long, 8.15 m. wide) and lined canal (11.8 km long, 9.14 m dia)- longest Hydroelectric tunneling project in the country so far. The river is again damed at village Pong in Kangra district to form **Pong reservoir**, again a earth cum rock fill reservoir having water spread area between 6000-24000 ha. These changes allow the resources to be utilized for multipurpose activity mainly power generation.

After leaving Pong Dam, river enters plains of Punjab at Talwara (Distt. Hoshiarpur) where it is immediately subjected to further manipulation for irrigation by carving a Canal-**Shah Nehar Canal** where in water in the range of 4170-8611 cusecs is diverted , depending upon the season, leaving only 4.53-6.88% of available water downstream between April-September and 12.18-39.0% between October-March thereby denying the river natural monsoon flushing.

The river with depleted water resources takes a loop like course till it reaches Mirthal (Distt. Gurdaspur) in between traversing through foot hills of Himachal –Nurpur.

In district Gurdaspur river regains some water resources made available from river Ravi through another Link Canal-**Ravi Beas Link** originating from Modhopur and a tributary **Chakki** coming

from north side joining it around Mirthal and by another tributary Sarri joining at village Vhed Pattan. The river regains its resources fully at village Terrikein (Distt. Hoshiarpur) through reinduction of Shah Nehar Canal. Thereafter river flows unrestricted for approximately 100 km to its culmination with Sutlej near village lohian at Hari-Ke-Pattan(confluence of 3 districts, Amritsar, Kapurthala and Firozpur)in between it receives many small Nallas amongst which two are important, an effluent loaded channel-**Chakwal Nalla** at village Chakwal (Distt. Hoshiarpur) below Terrikein and a seasonal tributary **Kali or West Bein** around its culmination point at Harike (Fig. 1 & 2).

1.2 Objectives of the present investigation

River Beas contains enough fish resources throughout its course right from Himalayan zone to its culmination. Large scale manipulations has affected ecology and fishery of this river as shown by the studies carried over from time to time in the rhitherone zone within Himalaya (Sehgal, 1974b; Tandon and Sharma, 1976; Sehgal and Sarkar, 1989; Dhanze and Dhanze, 1998). The reservoir zone within Himalaya has also been studied (Sehgal, 1983; Kumar, 2002). A comprehensive investigation on ecology and fishery of Pong dam was carried over by CIFRI under project FA/A/7.

But the ecology and fishery of Potomoan zone of river which sustain enough commercial fishery and is subjected to extraneous pressures like water abstraction and pollution load has not been studied in detail so far. Some piece meal observations done on different aspects so far are, Spawn prospecting availability in 1966 by CIFRI below Beas bridge. Water quality by CPCB (95-96) conducted during 1993 between Mirthal to Beas bridge only and by PPCB (1995) during 1988 to 1992. Ecological evaluation by Toor *et al*, (1993) and Bath *et al*. (1998) has been confined to Harike only. No information exists on the total ecology and fishery resources of Beas nor is there any account of impact of environment on the fishery of Beas within plains of Punjab.

Hence a need was felt to have scientific data base on fish resources, fish catch estimate, fish diversity and impact of external influence on this resource and how best to preserve it as it provides good source of revenue to the exchequer and livelihood to many people.

Keeping in mind above objectives, CIFRI through its Karnal Centre carried out work on "Assessment of Ecology, Biodiversity, Production potential of Indus river System" within plain of Punjab. "Evaluation of ecology and fish community structure of river Beas" is part of the programme carried over between 2002-05.

1.3 Plan of work and area of study

Observations carried over were based on three pronged approach.

i) Environmental factors influencing Beas.

ii) Ecological status of Beas.

iii) Fishery status of Beas.

ENVIRONMENTAL CONSTRAINS

Two externous factors :

i) water abstraction and ii) pollutant effluents influence the Beas.

Water abstraction : Data regarding release of water downstream barrage and within Shah Nehar Canal/Mukerian Hydal was collected at Head Work of Talwara barrage from Irrigation department of Bhakra Beas Management Board (BBMB) on daily basis for 3 years. Day to day

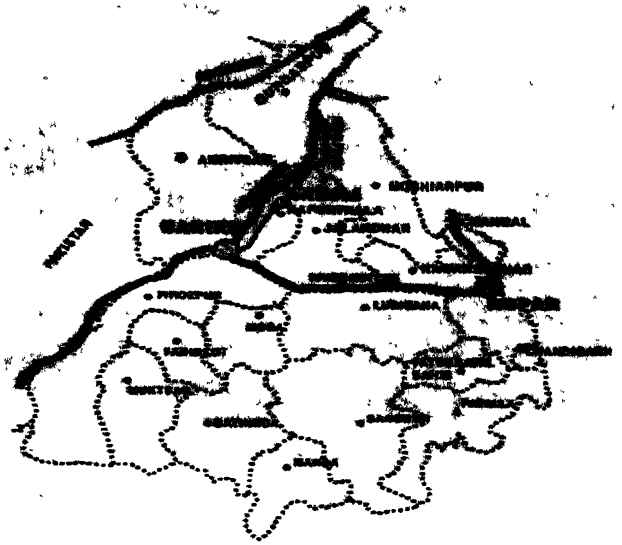


Fig. 1 : Contributory tributaries of Indus System within Punjab

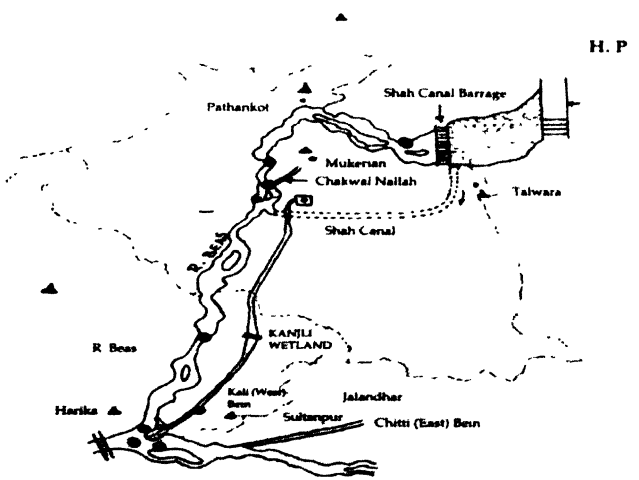
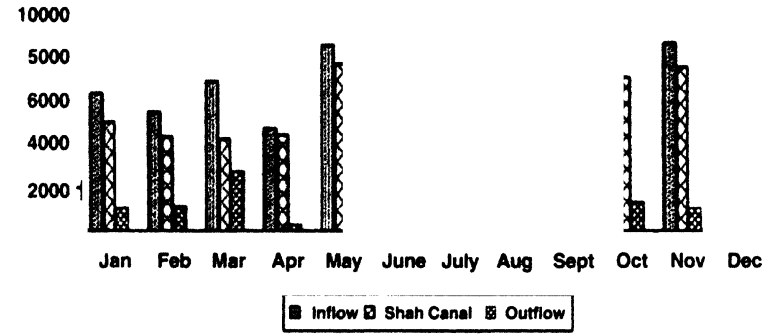


Fig. 2 : Diagramatic representation of Beas R. showing sites ◉ and sampling centres ▲

data was compiled on monthly basis. Average monthly data was drawn from 3 years observations between 2002-05 (Fig. 3).

Fig. 3 : Average water released (cusecs) in Beas between 2002-2005



Pollutional Impact : Beas within plains of Punjab is subjected to many Nallas both on western bank (distt. Sri Hargobindpur) and on eastern bank (distt. Hoshiarpur) receiving the municipal effluents of Pathankot, Beas and Goindwal city directly and of Mukerian city through drain as observed currently, as well as reported by PPCB (1995); but amongst all, the one on eastern bank-**Chakwal Nalla** is a major source of industrial pollution bringing in effluents mainly from **Paper, pulp and sugar distillery industry** of industrial town of Mukerian.

The other source is a tributary on western bank-**West Bein or Kali Bein** which brings in municipal effluents of Kapurthala district mainly. Hence the ecological status of these two was studied in detail in order to ascertain their impact on river thereby on its fishery.

Pollutional impact was assessed from the status of soil texture, water quality, B.O.D. and C.O.D. load of Chakwal Nalla at Village Chakwal before its fall into river and that of Kali Bein at village Alluwal before its merger with Beas.

Beas in addition to these effluents is also subjected to wash off of pesticides and fertilizers used extensively in Punjab, on an average 172 kg/ha compared to national average of 72 kg/ha PPCB (1995). The evaluation of which is beyond the purview of present study.

Ecological evaluation (Soil texture and quality, water quality, B.O.D. and C.O.D, food availability at various tropic levels)Ecological status of river approximately 165 km was assessed from sites having 8 stations (i) Talwara (reference zone) (ii) Mukerian, having 3 stations AOF before the inflow of Chakwal Nalla, OF, at the induction of Nalla; BOF, below outfall. (iii) Beas Bridge (iv) Harike having 3 station (a) Beas before culmination with Sutlej (b) Sutlej before culmination with Beas (c) Confluence, meeting point of both rivers (Fig. 2).

Fishery evaluation

River Beas is exploited commercially for its fish resources. The river is auctioned annually by Punjab Fisheries department generally in the month of September. Fishing is carried round the year barring 2 months- July& August, observed as closed season. The catch procured is disposed off at nearest landing centre, being six in this case namely (i) Talwara (ii) Pathankot (iii) Mukerian (iv) Amritsar (v) Sultanpur (vi) Harike (Fig. 2).

Evaluation of fishery resources was done by enumeration of daily arrivals at above 6 mentioned stations. Each station was surveyed for 2 days per month. Average catch estimated was assessed by taking account of yearly catch between 2002-2005. Average monthly catch was assessed by computing the catch of particular month for concerned years. Total catch per year was assessed by adding the catch for each month barring closed period of 2 months. Fish diversity was assessed by noting down fish composition at each landing centre.

OBSERVATIONS

2. Environmental Constrains

2.1 Water Abstraction : River Beas is subjected to water abstraction for an approximate 60-65 km stretch within plains, out of which first 30-35 km between Talwara to Mirthal coursing along foot hills of Shivalik Himalaya face acute shortage due to maximum diversion of its resource. Next 30 km between Mirthal to Mukerian (Terrikein village) contain substantial water level due to flow of **Ravi-Beas Link Canal and Chaki tributary.**

Annual discharge rate commuted for 3 years (Table 1) indicate that abstracted zone has almost no water, only 300-377 cusecs i.e. 3.53-6.88% of actual water available upstream (4680-9058 cusecs) for 6 months of the year between April-September. During October-March this zone contains 12.28-39.07% of available upstream resource (5421-8583 cusecs).

Comparative annual discharge down the barrage between 2002-05 showed no substantial variation below barrage at Talwara even during monsoon.

Approximate 100 km stretch of Beas within plains do not face resource crunch because of gaining most of its resources due to re-induction of Shah Canal, but even this induction of water resource into Canal and its subsequent re-induction is regulated by the water released from Pong dam. Amount of water released from Pong dam above Talwara barrage, diversion of this resource and water released below barrage is depicted in Fig. 3, which shows that water availability within Beas is directly related to irrigation needs rather than availability upstream i.e. during December to March when availability of water upstream is less than monsoon, water released down the barrage is more because the need for wheat production during the season is less compared to rice production during summer-monsoon season . **The water release as per irrigation demands causes stress especially breeding strain to resident as well as local migrant fishery i.e. IMC** because of their breeding time during this period.

2.2 Evaluation of Pollutional Load : The main effluent discharge in Beas is at village Chakwal (Mukerian) through Chakwal Nalla and around end point through Kali or West Bein.

Chakwal Nalla (Table 2 a & b) : Chakwal Nalla, carrier of paper - pulp/sugar distillery and municipal discharge indicate water within it is anaerobic (D.O., 2.77 mg^{-1}) throughout the year, saturated with Carbon dioxide barring rainy season, has high content of dissolved solids (370.08 mg^{-1}) rendering water very hard, Total hardness, 317.07 mg^{-1}, having high conductivity (740.4 µmhos/cm), B.O.D. (30.6 mg^{-1}) and C.O.D. (288.4 mg^{-1}) levels. The Nalla becomes highly polluted during post-monsoon when sugar distilleries operate to full capacity. During that period the salt content of Nalla water like Ca (124.3 mg^{-1}), Mg (35.0 mg^{-1}) and Chloride (42.7 mg^{-1}) was high increasing the content of total dissolved solids thereby specific conductivity (1044 µmhos/cm) also. The Nalla totally becomes anerobic having lowest D.O. (1.9 mg^{-1}), high levels of B.O.D (43.3 mg^{-1}) and C.O.D (469.0 mg^{-1}).

In spite of presence of all these characteristics water reaction within Nalla is alkaline, pH, 7.1 and has conducive alkalinity (62.0 mg^{-1}) which may be due to Nalla being deep having good water flow which does not allow salts/solids to settle on soil as is depicted by soil characteristics

Table 1 : Average water release (cusecs) in upper stretch of Beas between 2002-05

Months	Inflow	Shah Canal/Mukerian -Hydel	Outflow	% of water below Barrage
April	4680	4358	322	6,88
May	8466	7693	377	4.45
June	9058	8611	320	3.53
July	5780	5480	300	5.19
August	6309	6086	300	4.75
September	6364	6079	300	4.71
October	8427	7000	1354	16.06
November	8583	7520	1054	12.28
December	7170	5538	1591	22.18
January	6247	5000	1065	17.04
February	5421	4283	1086	20.03
March	6847	4170	2677	39.09

Table : 2 Characteristics of Effluent Load getting into Beas river between the year 2002-05

A) Water

Site	pH	D.O (mg^{-1})	CO_2 (mg^{-1})	B.O.D. (mg^{-1})	C.O.D. (mg^{-1})	TDS (mg^{-1})	Sp. cond. (µmhos/cm)	T. alkalinity (mg^{-1})	T. hardness (mg^{-1})	DOM (mg^{-1})	Chloride (mg^{-1})
Chakwal Nalla (av.)	7.1	2.77	sat	30.6	288.4	370.08	740.47	62.0	317.07	3.670	36.67
Range	6.8-7.3	1.9-4.3	sat	21.0 -43.3.	55.3-469.0	191.3-522	383.7-1044.7	26.0-113.3	225.8-456.7	1.77-5.82	14.7-48.0
Kali Bein (av.)	7.2	5.9	1.38	19.4	58.67	143.5	288	97.17	150.7	2.75	20.92
Range	7.0-7.7	2.7-8.3	0.8-5.3	15.0-24.20	44.7-75.3	125.30-166.7	251.3-334.7	81.3-106.0	129.2-173.3	2.15-3.67	15.0-25.0

B) SOIL

Site	Sand (%)	Silt (%)	Clay (%)	pH	Sp. cond. (µmhos/cm)	Organic carbon (%)	Free calcium (%)	Avl. Nitrogen (mg/100g)	Avl. Phosphorus (mg/100g)
Chakwal Nalla (av.)	61.49	26.73	11.78	7.57	343.75	0.281	7.49	13.42	2.24
Range	53.9-72.4	18.2-33.6	9.4-14.1	7.16-7.9	196-455.7	0.174-0.39	4.13-9.08	8.59-19.32	1.5-3.0
Kali Bein (av.)	68.53	21.44	10.03	7.56	322.0	0.363	9.07	13.70	3.78
Range	54.8-74.4	18.7-29.6	6.9-15.6	7.3-7.6	184.7-598.0	O.285- .653	5.0-17.2	11.64-15.31	2.13-4.44

(Table 2 b). Nalla has alkaline soil reaction, with pH varying between 7.16-7.9, corroborating with free $Caco_3$, 4.13-9.08%. Organic carbon percentage was also moderate 0.174-0.39 in different seasons and specificconductivity comparatively low, 343.75 µmhos/cm than water (Table 2 a and b).

2.2 b. Kali/West Bein (Table 2a & b) : Kali Bein basically seasonal tributary (85 km) passing mainly through agricultural fields bring in municipal load of Hoshiarpur and Kapurthala districts. Bein waters are alkaline, pH 7.2 and conducive for productivity having average dissolved oxygen content, 5.9 mg^{-1} and total alkalinity of 97.7 mg^{-1}. Other characteristics like B.O.D. (19.4 mg^{-1}), C.O.D. (58.67 mg^{-1}), TDS 143.5 mg^{-1} and specific conductance (288 µmhos/cm) depict Bein comparatively less polluted than Chakwal Nalla.

Bein waters become almost anerobic (D.O., 2.7 mg^{-1}) during monsoons, when it posses high free CO_2(5.3 mg^{-1}) which may be due to halt in release of both wanted and unwanted elements via macrophytes because of washing off/settling of macrophytes,mainly water hyacinth during the season and putrifaction of this organic debris.

Comparative low B.O.D. (15.0 mg^{-1}) and C.O.D (44.7 mg^{-1}) was observed during post-monsoons and high oxygen content (8.3 mg^{-1}) during winter when Bein was heavily infested with macrophytes.

Fluctuations in water characteristics show macrophytes play crucial role in maintenance of Bein. These oxygenate its water and help in release of nutrients, but comparative high specific conductivity (322 µmhos/cm), percentage of organic carbon (0.215-0.653) and calcium carbonate (5.0-17.2) indicate settling of organic load on Bein bed, thereby showing that Bein waters too can have untoward effect on river Beas and its fishery especially during monsoons when free flow pushes water hyacinth into river at Harike, where from these do not have free escape due to presence of Harike barrage, thus causing loss of open surface area, siltation and organic infestation at Harike, thereby affecting fishery. The Bein has intermittent access to river depending upon infestation of macrophytes and availability of water at tail end as well as water level at Harike.

3. EVALUATION OF RIVER ECOLOGY

3.1 Texture of river bed (Table 3a & b) : The texture of river Beas was sandy along the foot hills of Shivaliks. It contains 77.1% s and; 16.6% silt and 6.3% clay at Talwara. The bed changes after river re-enters plains of Punjab and more so after the change in flow due to re-induction of its resources from Mukerian onwards. It becomes sandy loam having 60.3-64% sand, 26.0-29.4% silt and 8.9-12.0% clay (Table 3a).

The texture of bed soil fluctuates seasonally especially from Mukerian onwards. It is loamy during monsoons having 54.4-69.4% sand, 20.8-34.7% silt and 8.7-13.4% clay and sandy during winter having 67.6-73.8% sand. But content of clay do not vary much (10.9-12.4%) at tail end/culmination point at Harike (Table 3b) making it more productive zone.

The predominant sand bed along upper zone between Talwara to Mukerian contribute very little to aquatic productivity thereby to fishery as depicted by fish catch estimate.

3.2 Soil characteristics (Table 3a & b) : The Beas bed has alkaline reaction throughout with pH ranging between 7.0-7.6; however at Talwara reaction becomes slightly acidic during winter to pre-monsoon (pH, 6.38-6.9). The large scale pebble mining at the site during these seasons may be the probable cause for same. Comparatively low pH, 7.0 at OF Mukerian during post-monsoon only show the impact of high pollutional load of Chakwal Nalla during the period (Table 3b). Difference in reaction from BOF Mukerian onwards (pH 7.39-7.93) depict impact of externous

effects, but similar seasonal reaction at the particular site, envisaged impact of similar soil texture all along the notified stretch.

Free $Caco_3$: Beas bed is moderate in calcium carbonate content The overall reaction ranges between 5.19 to 6.81% (Table 3a). Presence of Free $Caco_3$ content corroborates with pH values. It being generally high from Mukerian onwards. The concentration shows seasonal fluctuation, being high during pre-monsoon (8.9-11.5%) and low during winter (3.83-5.50%) as is the case with Ph.

Organic Carbon : Average organic carbon in soil was low (0.28-0.35%) barring Harike (0.43%), where it fluctuated between 0.27-0.69%, depicting more water retention capacity Seasonal observations depicted that the values were very low in post-monsoon (0.15-0.29%) and high during winter (0.39-0.69%) as depicted in Table 3 b. The reason being that high temperature and good water flow during post-monsoon in Beas helps in rapid mineralization, while in winter low temperature and decay of vegetation especially water hyacinth within river cause high decomposed matter and low mineralization thus high organic carbon. Exception to above was observed at Talwara during monsoons (0.63% organic carbon) the reason may be low mineralization of river bed due to absence of flow at Talwara during the season.

Mineral content : Available nitrogen (7.6-9.98 mg) and phosphate (1.6-2.45 mg/100 gm) depict system having low production value especially upper stretch with 1.3-1.9mg phosphate level in different seasons. The concentration increases as river flows downwards, 1.81-2.45 of available phosphate and 7.6-9.98 mg/100 g of available nitrogen mainly under the impact of Chakwal Nalla.

Seasonal fluctuation in available phosphate and nitrogen content corroborates with organic carbon values i.e. when mineralization is low in winter in Beas especially in stretch from Mukerian onwards available phosphorus (1.33-1.80 mg/100 g) and Nitrogen (5.46-11.0 mg/100 g) are also low compared to post-monsoon when mineralization is rapid, available phosphorus (2.21-2.73 mg/100 g) and nitrogen (10.13-11.29 mg/100 g) are also high (Table 3b).

Specific conductivity : Specific conductivity of bed soil in general range between 142.5-254.8 µmhos/cm. The conductivity was generally high at Talwara (224-315 µmhos/cm) and Harike (191-287 µmhos/cm) mainly due to mining activity at former and impact of Kali Bein effluents at latter. The conductivity showed co-relation with availability of water. It being high (201.7 to 315 mhos/cm) during minimum flow including monsoon especially at sites subjected to water abstraction and low (122.5-232.3 µmhos/cm) during winter when water release from barrage was more (Table 1). Near similar values of conductivity (233.7 to 238.0 mhos/cm) at OF Mukerian show that Chakwal Nalla effluents are low in organic load and do not exhibit untoward impact on river.

3.3 Water Quality (Table 4a & b) : Physical water characteristics along with dissolved oxygen content and pollutional impact differentiate Beas into upper segment between Talwara and rest of stretch as was evident by soil texture also. Other limno-characteristics being almost similar barring point pollution discharge area (Table 4a).

Talwara zone has clear transparent waters up to bottom barring monsoon when transparency is low 20 cm. The temperature within the segment fluctuates between 18 to 28°C, water has alkaline reaction, pH 7.5-7.6 with low amplitude of variation even in different seasons (Table 4b). Average dissolved oxygen content was high, 8.22 mg^{-1} and B.O.D. (7.79 mg^{-1}) and C.O.D. values (29.3 mg^{-1}) comparatively less. There is not much seasonal fluctuation in oxygen content, 7.3-9.0 mg^{-1} but B.O.D. (3.83-12.0 mg^{-1}) and C.O.D (20.0-32.7 mg^{-1}) exhibit seasonal fluctuation being lowest

Table 3a : Physico-chemical characteristics of soil of River Beas between 2002-2005

Sites	Sand (%)	Silt (%)	Clay (%)	pH	Sp. conductivity (mmhos/cm)	Organic carbon (%)	Free calcium carbonate (%)	Av. Phosphorus (mg/100g)	Av. Nitrogen (mg/100g)
Talwara	77.1	16.6	6.3	7.0	254.8	0.341	5.42	1.6	8.05
AOF	72.1	19.9	8.0	7.48	194.3	0.317	5.67	1.81	8.48
Mukerian OF	60.3	29.4	10.3	7.48	228.42	0.353	6.52	1.92	9.98
BOF	64.0	27.1	8.9	7.61	203.5	0.339	6.81	1.99	9.74
Beas Bridge	63.1	26.0	10.9	7.67	142.5	0.289	5.19	2.45	7.6
Harike R. Beas	61.2	26.8	12.0	7.58	244.4	0.432	6.15	1.91	8.07

Table : 4a Physico-chemical features of water of R. Beas between 2002-2005

Stations Parameters	Talwara	Mukerian			Beas Bridge	Harike
		(AOF)	(OF)	(BOF)		River Beas
Water temp. ℃	23.3	23.8	24.18	24.3	22.83	23.5
Transparency (cm)	37.4	39.87	31.3	35.0	35.08	30.5
pH	7.52	7.47	7.19	7.42	7.34	7.40
Sp. conductivity (mmhos/cm)	193.75	218.87	235.08	204.75	187.75	188.75
TDS (mg^{-1})	96.08	109.18	166.67	101.67	93.27	93.75
DO (mg^{-1})	8.22	7.61	6.87	7.43	7.53	7.7
CO_2 (mg^{-1})	0.5	-	0.33	-	0.15	0.12
T. alkalinity (mg^{-1})	68.5	78.6	84.33	71.75	63.25	64.0
DOM (mg^{-1})	1.410	1.606	2.475	1.917	1.698	1.71
T. hardness (mg^{-1})	128.958	143.05	168.51	149.79	125.76	123.33
Chloride (mg^{-1})	19.42	13.93	17.08	18.58	16.33	17.42
Silicate (mg^{-1})	1.405	1.955	2.925	2.472	1.72	1.77
Dissolved Inorganic phosphate (mg^{-1})	0.185	0.240	0.293	0.268	0.235	0.246

Table : 3 (b) Seasonal changes in Soil texture of River Beas (2002-05)

Parameters	Sand (%)				Silt (%)				Clay (%)			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	73.4	72.1	79.4	79.3	18.8	19.0	15.7	15.2	7.8	8.9	4.9	5.5
Mukerian												
AOF	76.97	71.16	69.5	75.0	16.13	21.2	22.1	16.2	6.9	7.2	8.4	8.8
OF	58.4	63.7	57.9	73.8	31.3	27.6	29.7	18.2	10.3	8.7	12.4	8.0
BOF	62.2	69.4	65.1	72.4	28.5	20.8	28.5	20.4	9.3	9.8	9.1	7.2
Beas bridge	68.1	55.9	60.8	67.6	25.1	30.7	25.4	22.8	6.8	13.4	13.8	9.6
Beas Harike	58.4	54.4	62.2	70.2	29.3	34.7	25.5	17.4	12.3	10.9	12.3	12.4
Parameters	pH				Free calcium carbonate (%)				Organic carbon (%)			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	6.9	7.27	7.55	6.38	9.0	7.88	2.50	2.50	0.170	0.635	0.150	0.505
Mukerian												
AOF	7.35	7.63	7.32	7.86	7.5	5.67	3.58	5.50	0.185	0.280	0.150	0.390
OF	7.8	7.72	7.03	7.40	10.5	6.75	5.75	3.88	0.360	0.315	0.275	0.610
BOF	7.9	7.78	7.47	7.39	11.5	7.58	5.67	4.33	0.223	0.260	0.295	0.560
Beas bridge	7.93	7.60	7.53	7.59	8.99	4.50	3.75	4.58	0.205	0.165	0.183	0.572
Beas Harike	7.79	7.60	7.47	7.41	11.42	5.25	4.08	3.83	0.415	0.350	0.273	0.690
Parameters	Specific conductivity (µmhos/cm)				Available Phosphate (mg/100g)				Available Nitrogen (mg/100g)			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	249.3	315.0	224.0	232.3	1.950	1.85	1.90	1.32	7.19	12.60	10.80	6.44
Mukerian												
AOF	202.7	201.7	214.0	122.5	1.900	1.67	2.14	1.36	6.91	9.24	11.29	5.46
OF	233.7	238.0	236.7	191.3	2.210	1.23	2.21	1.70	9.05	8.87	11.29	14.0
BOF	196.7	181.3	220.0	187.3	2.27	1.40	2.28	1.80	9.61	10.08	10.31	10.83
Beas brdige	278.7	218.0	239.3	185.3	1.98	2.24	2.73	1.70	5.32	7.37	10.13	7.56
Beas Harike	287.3	236.7	262.7	191.0	1.84	1.80	2.73	1.33	6.50	6.53	10.72	8.49

during monsoons (Table 4b)which may be under the impact of dilution in river water within Himalayan zone.

Water quality from Mukerian onwards was almost similar with slight variation at point pollution discharge- OF Mukerian.

The temperature of lower stretch exhibit maximum fluctuation(Table 4b) between 15.5-31°C, high during monsoon (27.7-31°C) and low during winter (15.5-18°C). The decline in temperature during winter may slow down the growth of aquatic animals particularly fish.

Transparency of the stretch on an average was more than 30 cms barring at Harike site which is heavily infested with weeds. Transparency like temperature exhibit seasonal fluctuation. It being high during pre and post-monsoon >50 cm ,low during monsoon 11.3-14.0 cm and moderate during winter, 30-37.7 cm.

Water has alkaline reaction, pH varies between 7.19-7.4 throughout. Dissolved oxygen within stretch was almost similar (7.43-7.7 mg^{-1}) barring stressed point (6.87 mg^{-1}). Dissolved oxygen exhibit indirect co-relation with temperature. It being high (7.9-8.9 mg^{-1}) during winter and low during monsoon (6.0-6.5 mg^{-1}) lowest at OF Mukerian 5.9 mg^{-1} under the impact of Nalla effluents (Table 4b).

Specific conductivity : Mineralisation status of aquatic system is expressed through conductivity. The conductivity of lower Beas barring stressed point ranged between 187.55 to 204.75 µmhos/cm, showing that river water contains medium concentration of dissolved salts/minerals as is evident by moderate content of calcium, 27.0-27.42 mg^{-1} and magnesium, 13.25-14.1 mg^{-1} except around Mukerian stretch where these may be additionally derived by ingress of Chakwal Nalla inducing high mineralization thereby comparatively high values of specific conductivity 235.08 µmhos/cm; calcium 29.0-36.04 mg^{-1}; magnesium 19.9- 26.6 mg^{-1} and total hardness, 134.2-200.8 mg^{-1}.

The seasonal fluctuation in conductivity show that river Beas except stressed stretch of Mukerian have high conductivity values during pre-monsoon when water level in river was low than monsoon whereas within Mukerian stretch high conductivity (247- 285 µmhos/cm) was observed during monsoon when maximum effluents from Nalla get flushed into river due to more water and fast current. The overall conductivity was low during winter (156.3-197.7 µmhos/cm) may be under the impact of low temperature inducing low mineralization.(Table 4b).

Total alkalinity : The total alkalinity range of 64.0-78.6 mg^{-1} indicate the system moderately productive (Table 4a). It being comparatively high, 84.33mg^{-1} in the range of 57.0-96.0 mg^{-1} around stressed zone (OF-BOF Mukerian) than rest of the stretch (64.0-78.6 mg^{-1}) indicating that Chakwal Nalla effluents fertilize the river and enhance its productivity.

The seasonal fluctuation within the stretch followed same trend as conductivity. It being high during monsoon (96.0 mg^{-1}) at Mukerian and during pre-monsoon (65.3-82.7 mg^{-1}) along rest of Beas (Table 4b).

Nutrient Status (Table 4a & b) : The average inorganic phosphate values ranged between 0.185-0.293 mg^{-1} in entire river course (Table 4 a). Higher values were noted in stressed zone (0.217-0.380 mg^{-1}) followed by Beas Harke (0.159-0.300 mg^{-1}) both these centres receive municipal effluents either solely or along with industrial effluent. Lowest values were noted in fresh zone at Talwara (0.125-0.230 mg^{-1}) indicating low productivity.

Table 4 (b) : Seasonal fluctuation in water characteristics of River Beas (2002-05)

Parameters	Water Temperature (°C)				Transparency (cms)				pH			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	25.0	28.0	22.0	18.0	33.3	20.0	51.7	56.0	7.53	7.50	7.50	7.6
Mukerian												
AOF	26.3	29.2	19.3	17.5	50.7	14.7	42.7	55.0	7.63	7.47	7.30	7.6
OF	27.7	31.0	20.3	17.8	40.3	11.3	43.7	30.0	7.53	7.47	7.39	7.07
BOF	27.8	30.7	20.0	18.0	46.3	11.3	45.7	36.7	7.35	7.47	7.30	7.27
Beas bridge	27.3	27.3	20.2	15.5	50.7	12.0	47.0	33.7	7.39	7.39	7.16	7.32
Beas Harike	27.7	29.3	20.3	16.7	29.0	14.0	41.3	37.7	7.53	7.37	7.32	7.4
Parameters	Dissolved oxygen (mg^{-1})				B.O.D. (mg^{-1})				C.O.D. (mg^{-1})			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	8.7	7.9	7.3	9.0	9.0	3.83	6.4	12.0	32.7	20.0	32.3	32.4
Mukerian												
AOF	8.1	6.0	8.5	8.6	12.7	7.70	8.2	16.8	45.7	28.7	28.7	51.0
OF	7.07	5.9	7.2	7.3	19.0	13.80	18.0	20.7	130.0	38.0	67.2	115.1
BOF	7.6	6.0	8.3	7.9	14.7	10.10	12.1	15.3	94.0	36.0	40.2	67.9
Beas bridge	8.0	6.5	6.9	8.1	12.7	8.30	9.8	12.6	42.0	26.2	30.5	41.5
Beas Harike	7.7	6.3	8.1	8.9	13.7	9.53	10.7	13.2	43.0	26.9	44.9	40.5
Parameters	Total alkalinity (mg^{-1})				Total dissolved solids (mg^{-1})				Specific conductivity (micro mhos/cm)			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	80.0	71.3	58.0	64.7	129.7	103.3	73.7	77.7	260.7	208.7	149.3	156.3
Mukerian												
AOF	82.7	96.0	58.0	66.0	114.0	125.7	107.0	76.5	228.7	254.3	211.3	153.5
OF	90.7	96.0	61.3	83.3	132.3	141.7	98.7	94.0	266.7	285.0	199.3	189.3
BOF	87.3	75.3	57.0	67.3	117.3	122.7	59.0	77.7	237.3	247.0	178.7	156.0
Beas brdige	78.0	74.0	49.7	66.7	117.0	102.7	77.3	98.0	236.0	207.7	155.3	196.7
Beas Harike	65.3	72.0	54.0	64.7	65.3	72.0	54.0	64.7	236.7	202.3	154.7	161.3

Parameters	Total Hardness (mg^{-1})				Calcium (mg^{-1})				Magnesium (mg^{-1})			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	131.7	118.3	133.3	132.50	27.3	20.3	23.7	27.7	15.2	16.2	17.8	15.2
Mukerian												
AOF	135.0	159.2	139.0	133.75	31.0	28.0	31.7	29.0	13.8	21.4	14.5	14.7
OF	134.2	190.0	200.8	152.5	34.0	32.3	36.0	31.7	11.8	26.2	26.6	17.6
BOF	128.3	163.3	168 3	139.2	31.0	30.7	31.3	29.0	12.2	20.4	21.6	16.0
Beas bridge	105.0	125.8	134.2	130.8	26.7	23.0	24.0	32.0	9.2	16.4	17.8	12.2
Beas Harike	75.8	119.2	128.3	136.7	26.0	24.0	27.0	32.7	10.6	14.2	14.6	13.6
Parameters	Chloride (mg^{-1})				Silicate (mg^{-1})				Inorganic phosphate (mg^{-1})			
Station	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Talwara	32.3	13.0	17.3	15.0	1.6	0.52	1.9	1.60	0.230	0.207	0.180	0.125
Mukerian												
AOF	14.0	11.1	18.7	10.0	2.1	0.79	2.6	2.30	0.250	0.227	0.230	0.117
OF	15.2	10.3	23.7	16.7	3.2	5.57	3.6	2.40	0.310	0.263	0.380	0.217
BOF	16.0	10.0	16.7	11.7	3.1	4.27	3.1	2.70	0.310	0.275	0.310	0.191
Beas bridge	24.7	9.0	15.3	15.7	1.7	0.46	2.4	2.30	0.260	0.241	0.250	0.171
Beas Harike	26.7	10.3	16.7	16.0	1.5	0.57	2.7	2.27	0.270	0.247	0.300	0.159

Silicates along the course ranged between 1.40-2.92 mg^{-1}. It being high (2.4-5.57) at stressed point and minimum (0.52-1.9 mg^{-1}) at Talwara . The concentration of silicates exhibit impact of effluents. The values were high (4.27-5.57 mg^{-1}) at stressed zone and low along rest of Beas (0.46-0.79 mg^{-1}) during monsoons.

Chloride content varied between 13.93-19.42 mg^{-1} along the river, minimum along flowing waters and maximum at shallow zone at Talwara. It exhibited almost similar trend throughout the system being low during monsoon (9.0-13.0 mg^{-1}) and high(14.0-32.3 mg^{-1}) during pre-monsoon may be due to more evaporation especially in shallow zone of Talwara.

3.4 Pollutional Load (Table 4b) : Pollutional load as assessed by B.O.D. and C.O.D. values forms one of the basis of delineation of river into 3 zones, Talwara zone, having comparatively low values of B.O.D. (3.83-12.0 mg^{-1}) and C.O.D. (20.0-32.7 mg^{-1}), stressed zone (Mukerian) with high values of B.O.D. (10.10-20.7 mg^{-1}) and C.O.D. (36.0-130.0 mg^{-1}), diluted zone, major portion of river below Mukerian to its culmination where B.O.D. ranged between 8.3-13.7 and C.O.D., 26.2-44.9 mg^{-1}.

River Beas exhibit seasonal fluctuation both in quantum and nature of pollution. During monsoon when total dissolved solids, alkalinity and other mineral contents are high especially in stressed stretch both B.O.D. (3.83-13.8) and C.O.D. (20-38.0 mg^{-1}) values were comparatively low depicting low organic as well as inorganic influence, which may be due to dilution of organic effluents because of localized rain fall in upper stretch and more water flow in lower stretch as well as near absence of industrial effluents mainly sugar distillery which remain non-operational during the season.

High C.O.D. values (115-130 mg^{-1}) were observed at stressed zone during winter to summer (Sugar mill operational period) compared to near similar values (32.4-32.7mg^{1}) at Talwara and diluted zone (40.5-43.0 mg^{-1}), indicating Chakwal Nalla carry industrial effluents mainly, compared to other nallas around Goindwal (Beas bridge) and Kali Bein.Great variation in C.O.D. values, 36.0 to 130.0 mg^{-1} in stressed zone is due to the seasonal effluent discharge brought in by Chakwal Nalla mainly from sugar industry which operate mostly from November onwards till onset of monsoon depending on availability of raw material. During winter, Beas all along exhibited comparatively high values of B.O.D (12-20.7 mg^{-1}) which may be due to settling of organic effluents and due to death and decay of macrophytes mainly water hyacinth because of low temperature.

3.5 Gross Primary Production : Gross primary production of river Beas varied between 177.09-207.03 $mgC/m^3/hr$ with minimum at Talwara and maximum at BOF Mukerian (Table 5) reflecting higher level of nutrients at latter site as observed in limno-chemical characteristics (Table 4).

Gross production in Beas was comparatively high and similar (194.37-207.03 $mgC/m^3/hr$) at influenced sites i.e. Mukerian and Harike. The net production (117.18-135.36 $mgC/m^3/hr$) and community respiration (71.87-89.4 $mgC/m^3/hr$) rates also exhibited same trend as that of G.P., being minimum at Talwara and rest of stretch behaving uniformly with slight high values at BOF Mukerian.

Table : 5 Gross Primary Production (mgC/m³/hr) in Beas river (2002-05)

Season / Stations	Pre-monsoon	Monsoon	Post-monsoon	Winter	Average
Talwara	166.667	218.75	166.70	156.25	177.09
Mukerian OF	218.75	218.75	168.125	171.870	194.370
BOF	218.75	234.37	187.50	187.50	207.03
Beas Bridge	177.08	210.93	171.87	192.70	188.14
Beas Harike	187.50	234.37	166.70	203.12	197.92

Low amplitude of variation in gross productivity in different seasons within Beas reflect that river conditions especially flow and turbidity do not change much in different seasons as is evident by controlled water flow. GP was maximum in monsoons unlike riverine conditions due to minimum water availability. The ratio between Gross and Net productivity varied between 1.46 (Beas Harike) to 1.55 (BOF Mukerian), indicating that Net productivity within Beas is almost similar with slight increase at Mukerian zone as evident by nutrient value.

The P/R ratio an indicator of organic pollution was slightly on higher side (2.17-3.13) indicating river having mild organic pollution especially at AOF Mukaerin (Fig. 4) may be due to direct inflow of municipal effluents of Pathankot town brought in by Chaki tributary. Low amplitude of variation between the stations as shown in Fig. 4 indicate almost uniform level of pollution with slight decrease at BOF Mukerian which may be under repercussion of flushing by induction of Shah Canal.

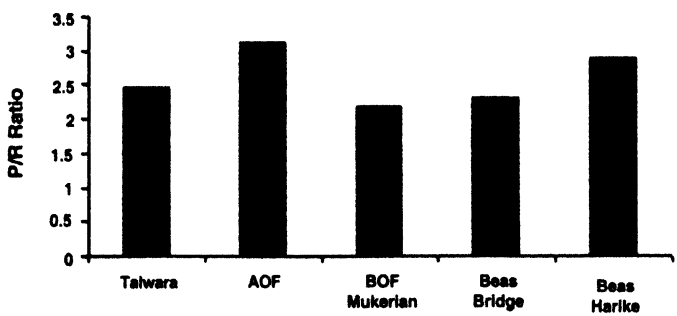


Fig. : 4

3.6 Plankton (Table 6 a,b,c) : Average standing crop of plankton within Beas varied between 80-270 u/l. The density increased as river flows from Talwara downwards except at stressed zone (OF-Mukerian) where it was minimum (60 u/l) under the adverse impact of industrial effluents (Fig. 6).

Low density of plankton at Talwara (80 u/l) may be due to shallow nature of river, less depth, low water column, fast current, comparatively less available nutrients and sandy soil texture. High density at tail end at Beas-Harike (270 u/l) may be due to wetland characteristics of river at Harike due to presence of Harike barrage and high nutrient load as observed.

Seasonal observations (Table 6b) along Beas indicate that density was high during pre-monsoon/ summers (106-308 u/l) and winter (100-328 u/l) even at stressed point (73-78 u/l) and low during monsoon (45-177 u/l) and post-monsoon (67-199 u/l) even at stressed point (44-67 u/l) as is riverine characteristics exhibiting bimodal growth.

Population on the whole was mainly formed by phytoplankton (57-225 u/l) representing 80.5 to 95% of population than zooplankton (3-45 u/l) representing 5-19.46% of total population The representative groups within 3 zones are shown in Fig. 6.

Phytoplankton showed overwhelming presence at all centers (80.53-95%) being abundant in stretch above Mukerian (90-95%) than lower stretch below Mukerian (80.53-83.3%). The group was represented by bacillariophyceae, myxophyceae and chlorophyceae (Table 6a).

Bacillariophyceae occurred at all centres (38.3-90.7%) dominant at Talwara (90.7%) indicating it more fresh than rest as observed by soil, water characteristics. The group was present at all centres in all seasons (T able 6b) represented by 15 genera (Table 6c), out of which *Eunotia, Cyclotella* and *Staurnies* were present in clean zone(Talwara). The most common diatoms all along Beas were *Naviucla, Diatoma.* and *Frustulia.* Myxophyceae (10.3-57.71%) was next common group observed.Present from Mukerian onwards having highest incidence at pollution discharge site indicating eutrophication of river along this site. The group was present in all seasons at all sites being dominant at OF Mukerian during winter to pre-monsoon (56-70%). The group was represented by 6 genera (Table 6c), common being *Microcystis* and *spirulina.* Chlorophyceae was present all along river from Mukerian onwards (9.3-26.3%) barring OF-Mukerian indicating high inorganic load at the site detrimental to green algae.Large scale seasonal variation was exhibited by the group except at Harike (Table 6b). The group was represented by 11 genera, common in the system were *Spirogyra & Ulothrix.*

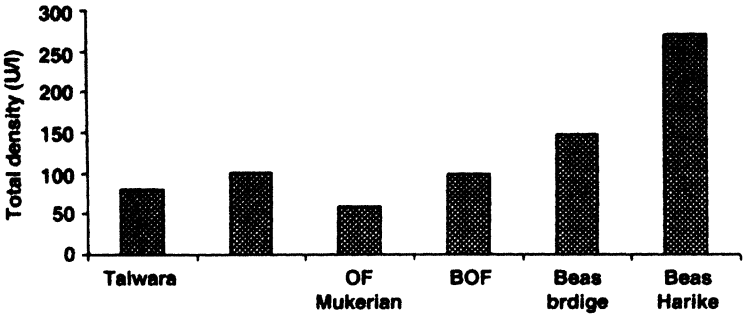
Zooplankton abundance (3-45 u/l) improved from upper to lower stretch indicating organic enrichment as indicated by soil and water characteristics (Table 3 & 4). It formed 5 to 19.4% of total population, being less 5-10% above effluent influx and more 16.16-19.46% below influx sites. Rotifers, Copepods and Protozoa represented the group.

Rotifers was the only group present throughout except at effluent discharge site (OF-Mukerian) indicating high content of pollution at the site as rotifers are sensitive to low oxygen deficient eutrophicated waters. The group was represented by 2 genera-*Brachionus* and *Filina* (Table 6c). Rotifers were present during winter to pre-monsoon only (Table 6b).

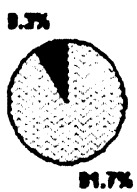
Copepods were mainly present in lower stretch between Beas bridge to Harike indicating that nutrient levels comparatively more than upper stretch but less than affected stretch are suitable for its growth. These were present during Monsoon to post-monsoon at free flowing stations and in all seasons at Harike (Table 6b) The group was represented by two genera-*Cyclopsis, Diaptomus* and their *Nauplii.*

Protozoa were present only in stressed zone (Table 6a & b) and generally during pre-monsoon/ summer represented by 3 genera (Table 6b & c)

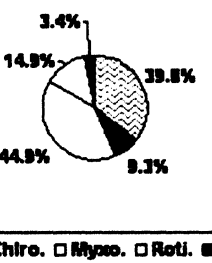
Fig. 6 : Plankton density and composition of River Beas (2002-05).



Upper Stretch (Talwara)



Stressed Stretch (OF+BOF)



Lower Stretch (Bridge + Harike)

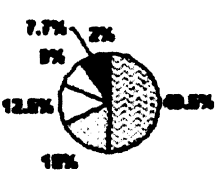


Table 6a : Plankton density (u/l) and composition percentage (%) along River Beas between 2002-2005

Stations	Total	Percentage (%)					
	(u/l)	Bacillariophyceae	Chlorophyceae	Myxophyceae	Rotifers	Copepods	Protozoan
Talwara	80		90.7	-	-	9.3	-
AOF	101	72.7	9.3	11.0	7.0	-	-
Mukerian OF	60	38.3	-	57.7	-	-	4.0
BOF	99	41.3	9.3	32.0	14.7	-	2.7
Beas Bridge		149	56.0	9.7	14.7	12.3	4.0 2.0
Harike Beas		270	43.0	26.3	10.3	5.7	11.3 -

Table 7a : Periphyton concentration (ucm^{-2}) and population composition (%) along River Beas between 2002-2005

Stations	Total	Percentage (%)		
	(ucm^{-2})	Bacillariophyceae	Chlorophyceae	Myxophyceae
Talwara	634	84.7	10.0	5.3
AOF	249	70.7	12.7	16.7
Mukerian OF	128	44.0	1.7	54.3
BOF	205	55.2	4.0	40.7
Beas Bridge	245	64.0	14.3	21.7
Harike Beas	364	60.3	17.0	22.7

Table 6b : Seasonal changes in plankton density and distribution in river Beas (2002-05)

Station	Talwara				Mukerian (AOF)			
	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Total plankton density (u/l)	106	45	67	100	155	66	99	165
Phyto	95	45	67	78	133	66	88	132
Zoo	11	-	-	22	22	-	11	33
Percentage composition (%)								
Bacillariophycaeae	90	100	100	78	65	83	78	50
Chlorophyceae	-	-	-	-	7	16	-	10
Myxophyceae	-	-	-	-	14	-	11	20
Rotifera	10	-	-	22	14	-	11	20
Station	**Mukerian (OF)**				**Mukerian (BOF)**			
	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Total plankton density (u/l)	73	44	67	78	149	66	89	111
Phyto	62	44	67	78	111	66	89	67
Zoo	11	-	-	-	38	-	-	44
Percentage composition (%)								
Bacillariophycaeae	15	75	67	44	25	50	63	40
Chlorophyceae	-	-	-	-	15	17	-	-
Myxophyceae	70	25	33	56	28	33	37	27
Rotifera		-	-	-	25	-	-	33
Protozoa	15-	-	-	-	7	-	-	-

Station	Beas Bridge				Beas Harike			
	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Total plankton density (u/l)	189	77	144	188	308	177	199	328
Phyto	128	55	133	155	247	144	166	273
Zoo	61	22	11	33	61	33	33	55
Percentage composition (%)								
Bacillariophycaeae	56	43	69	53	42	44	56	38
Chlorophyceae	-	-	15	11	31	19	22	32
Myxophyceae	12	29	8	18	7	19	6	13
Rotifera	20	-	8	18	13	6	-	7
Copepod	12	14	-	-	7	12	16	10
Protozoa	-	14	-	-	-	-	-	-

Table 6c : Microphytic vegetation and micro organisms present in river Beas as Plankton and Periphyton forms (2002-05)

Bacillariophyceae	Talwara	Mukerian			Beas	Harike		
		AOF	OF	BOF	bridge	Beas	Sutlej	Conf.
Melosira	-	+	-	-	-	-	-	-
Navicula	+	+	+	+	+	+	+	+
Diatoma	+	+	+	+	+	+	+	+
Synedra	-	+	-	-	+	-	+	-
Amphora	+	+	+	-	-	-	+	+
Cyclotella	+	-	-	-	-	-	-	-
Cymbella	+	+	-	+	-	-	+	-
Staurnies	+	-	-	-	-	-	-	-
Nitzschia	+	-	-	+	-	+	+	+
Meridion	-	-	-	+	-	-	-	-
Frustulia	+	+	-	+	+	+	-	-
Eunotia	+	-	-	-	-	-	-	-
Gomphonema	+	-	-	-	-	+	-	+
Fragillaria	+	+	-	-	-	-	-	-
Tabllaria	+	-	-	-	-	+	-	-
Chlorophyceae								
Spirogyra	+	+	-	+	+	+	+	+
Cladophora	+	-	-	+	-	+	+	+
Crucigenia	-	-	-	-	-	-	-	-
Characium	+	-	-	-	+	+	+	+
Microspora	+	+	-	-	-	+	-	-
Coclastrum	-	-	-	-	-	-	+	-
Ulothrix	+	+	-	-	-	+	+	+
Ankistrodesmus	+	-	-	-	-	+	+	+
Sclenastrum	-	-	-	-	-	-	+	-
Tribonema	-	-	-	-	-	+	+	-
Protococcus	-	-	-	-	-	+	+	-
Myxophyceae								
Microcystis	+	+	+	+	+	+	+	+
Spirulina	+	-	+	+	+	+	+	+
Phormidium	+	-	+	+	-	+	+	+
Nostoc	-	-	-	-	-	-	+	-

Polycystis	-	-	+	-	+	-	+	-
Coelospherium	-	-	-	-	+	-	-	-
Rotifers								
Brachionus	+	+	+	+	+	+	+	+
Filinia	+	-	-	-	+	+	-	+
Copepods								
Cyclops	-	-	-	-	+	+	+	+
Diaptomus	-	-	-	-	-	+	-	+
Cladocera								
Daphnia	-	-	-	-	-	-	+	-
Diaphanosoma	-	-	-	-	-	+	-	-
Protozoans								
Monas	-	-	-	+	+	-	+	+
Phacus	-	-	+	-	+	-	+	+
Euglena	-		+	+	-	-	-	+

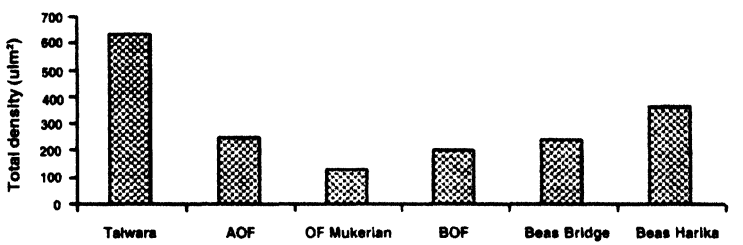
Table 7 b : Seasonal changes in periphyton density and composition along river Beas (2002-05)

Station	Talwara				Mukerian (AOF)			
	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Total periphyton density (ucm^{-2})	624	445	565	981	433	166	255	399
Phyto	624	445	565	981	433	166	255	399
Zoo	-	-	-		-	-	-	-
Percentage composition (%)								
Bacillariophycaeae	88	82	80	78	73	66	70	79
Chlorophyceae	10	5	16	16	8	7	22	8
Myxophyceae	2	13	4	6	19	27	8	13
Station	**Mukerian (OF)**				**Mukerian (BOF)**			
	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Total periphyton density (ucm^{-2})	177	89	132	111	250	67	166	255
Phyto	177	89	132	111	250	67	166	255
Zoo	-	-	-	-	-	-	-	-
Percentage composition (%)								
Bacillariophycaeae	53	37	50	30	41	16	60	56
Chlorophyceae	6	-	-	-	13	-	-	-
Myxophyceae	41	63	50	70	46	84	40	44
Station	**Beas Bridge**				**Harike (River Beas)**			
	Pre-mon	Monsoon	Post-mon	Winter	Pre-mon	Monsoon	Post-mon	Winter
Total periphyton density (ucm^{-2})	312	150	189	330	422	211	374	433
Phyto	312	150	189	330	422	211	374	433
Zoo	-	-		-	-	-	-	-
Percentage composition (%)								
Bacillariophycaeae	63	71	71	63	57	58	70	56
Chlorophyceae	16	-	17	17	21	16	12	21
Myxophyceae	21	29	12	20	22	26	18	23

3.7 Periphyton (Table 7 a & b) : Periphyton concentration along Beas was high at Talwara (634 ucm^{-2}) low at stressed zone (128 ucm^{-2}) and moderate (245-364 ucm^{-2}) in lower stretch (Fig. 7). The concentration showed direct co-relation with substratum, transparency and river flow. Gravel/stony substratum, low depth, high transparency and clean environment at Talwara and heavy macrophyte presence coupled with low water current at Harike were conducive for high concentration at these two sites.

Seasonal variation of periphyton population (Table 7b) indicate that concentration was high during winter (981 ucm^{-2}) followed by summer (624 ucm^{-2}) at Talwara, while rest of the stretch had high concentration during pre-monsoon (177-433 ucm^{-2}), followed by winter (111-433 ucm^{-2}). The concentration was low all along during monsoon (67-211 ucm^{-2}) and post-monsoon (133-374 ucm^{-2}), thereby behaving like phytoplankton flora having bi-modal population growth. Large scale fluctuation in density was observed in the stretch from Mukerian onwards due to fluctuation in water level and current.

Fig. 7 : Periphyton density and composition percentage of River Beas (2002-05).

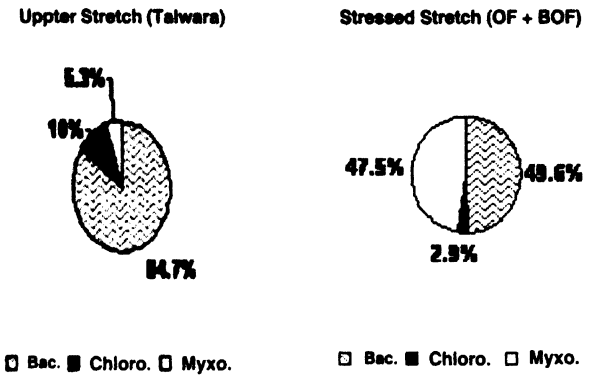


Periphyton population was exclusively formed by phytoplankters. The population was mainly formed by diatoms (84.7-70.7%) before induction of Chakwal Nalla, by blue green algae (54.3-40.7%) at stressed zone while lower diluted stretch had presence of diatoms (64-60%), blue green algae (21.7-22.7%) and green algae (14.3-17%) as depicted in Table 7b & Fig. 7. Dominance of diatoms in upper stretch indicate zone clean, that of blue green algae along OF-BOF Mukerian, stretch polluted and presence of all groups in lower stretch, the zone rich in nutrients.Comparative high presence of blue green algae (21.7-22.7%) than green algae (14.3-17%) along lower stretch between Beas bridge to Harike show the subtle effect of various insignificant Nallas as well as Kali Bein effluents on Beas as observed in soil characteristics.

Periphyton flora had poor diversity having 28 genera only, out of which 14 genera belonged to diatoms, 9 to green algae and 5 to blue green algae. Forms were same like phytoplankters and did not observe much seasonal variation except that *Gomphonema* among diatoms and *Microspora* among green algae were present only in winter (Table 6b).

3.8 Macrozoobenthos (Table 8 a b c) : Bottom macro-fauna along Beas was moderate in upper stretch, 605 organisms/m^2 at Talwara, low in stressed zone 236-350 um^{-2} at Mukerian and fluctuated between high of 1580 um^{-2} at Beas bridge to low of 316 um^{-2} at Beas Harike (Table 8a & Fig. 8).

Bottom population in Beas both in density and diversity was influenced not only by river bed characteristics as is the norm but also by condition of water especially its thermal status and water flow in a given stretch.



Talwara region with stone gravel bed, low depth, clean environment and conducive water temperature especially during summers (not exceeding 25°C) facilitates breeding of variety of insects, thus the region had enough of insects population (27.84%) along with gastropods (37.18%), bivalves (14.90%), chironomids (13.77%) and Hirudinea (4.0%) among oligochaetes (Fig. 8).

Stressed zone (OF-BOF) of Mukerian although having low density due to river being deep having fast flow caused by flushing of Shah Canal and also due to untoward effect of Chakwal Nalla effluents nonetheless support maximum diverse population in the form of insects (32.8%); tubificids (21.9%); gastropods(16.5%); bivalves (2.8%); chinonomids (3.5%) shrimps (11.8) and others (5.1%) which include water nematodes during winter and fish spawn at BOF region during

monsoon. High incidence of tubificids and presence of water nematode show that the site contains the organisms capable of living in polluted and oxygen deficient waters as such depict the river stretch polluted as envisaged by high B.O.D and C.O.D. values (Table 4), but at the same time level of pollution is not that much as to create anaerobic conditions so as to allow only specific community to grow (Fig. 8).

Beas bridge stretch having actual river characteristics had high density but low diversity. Population mainly formed by gastropods, (54.57%); tubificids (27.97%), insects (12.87%) and decapods (3.9%) with occasional bloom of hemipteran nymphs in winter (Table 8a).

Low macrobenthos density (316 um^{-2}) at Harike may be due to low transparency caused by infestation of weeds mainly water hyacinth, but rich nutrient load and soil characteristics support diverse zoobenthic population in the form of prawns (29.09%), tubificids (27.88%), molluscans (15.03%), insects (16.51%), chironomids (4.22%) and cladocerans (6.56%). High percentage of tubificids and cladocerans depict water having organic load under the influence of Kali Bein.

Seasonal variation in Density and composition

Benthic density exhibited seasonal fluctuation (Table 8b) akin to specific habitat and nature of population. It fluctuated between 234-1320 um^{-2} at Talwara and 33-716 um^{-2} at AOF Mukerian, low in winter and high in monsoon depending upon the life cycle pattern of some resident insect population and water flow regime being minimum during monsoon. Population did not fluctuate much in stressed zone 282-433 um^{-2} (OF) 121-131 um^{-2} (BOF Mukerian) may be having similar flow conditions throughout.

Large scale fluctuation in density (33-3454 um^{-2}) at Beas bridge may be due to similar community structure getting influenced uniformly. Low fluctuation (200 to 387 um^{-2}) at Beas Harike may be due to area having almost similar characteristics throughout especially pertaining to water column and flow rate because of Harike barrage.

Seasonal fluctuation in population diversity (Table 8b) was mainly observed among Insects. Stone fly nymphs represented by 2 genera (3%) during pre-monsoon and caddis fly larvae (6.6%) represented by 4 genera during monsoon were present at Talwara only. May fly nymphs represented by six genera were present throughout the river (8.4-33.3%) but abundant (33.3%) during monsoons in upper stretch and during post-monsoon (18.51%) in lower stretch. The population differed at generic level,upper segment having *Ephemerella* and lower stretch having mostly *Baetis* nymphs. Hemipteran larvae represented by 15 genera although present all along in all seasons were abundant during post-monsoon forming 30% of population at Talwara and in full bloom at Harike.

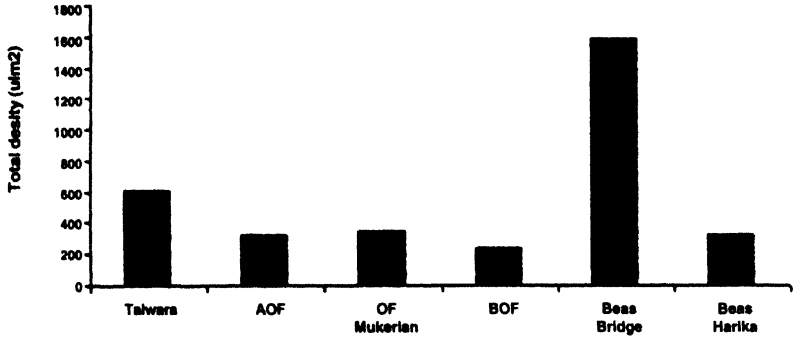
Coleopteran larvae represented by 13 genera were abundant in all seasons particularly at point pollution discharge (16.66-57.58%); present only during pre-monsoon at Talwara (6.11%) and absent in lower stretch.

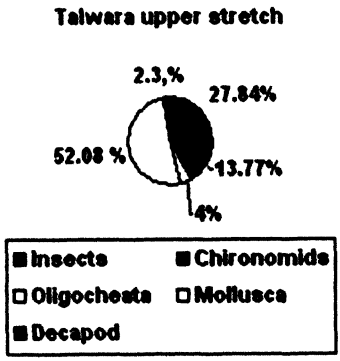
Amongst Odonata, Damsel fly nymphs were abundant in upper stretch (6.62-7.15%) during post-monsoon only and dragon fly nymphs (36.35%) at Harike during winter. The former was represented by 4 genera and latter by two. The other group exhibiting seasonal fluctuation was Decapods (Prawns), present throughout between pre-monsoon to post-monsoon, being abundant in latter season (8.3-50.37%) and absent in winter may be due to low water temperature especially in lower stretch (15.5-16.7°C).

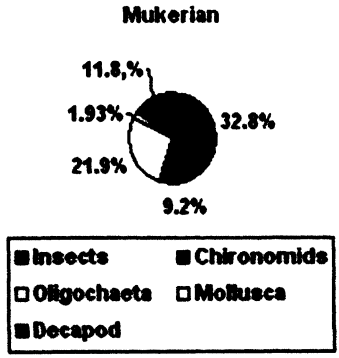
Diversity of macrozoobenthos (Table 8c) at various sites along Beas show that species confined to clean environment-Talwara were *Nemoura* larvae among stone fly nymphs. *Caenis*, among may fly nymphs, *Limnephilus, Lepidostoma*, among caddies flies and *Goniobasis* and *Promenetus* among gastropods. *Placobdella & Glossiphonia* among leech, *Hyponeura* among damsel fly nymphs as such these classify as saprophobic (non tolerant) forms.

Certain forms were present both in clean and diluted zone like *Nymphula, Leptocella Hydropsyche* (caddis worm). Some in addition to above environment in stressed zone too like *Heptogenia, Ephemerella, Baetis* nymphs among may flies *chironomous among* dipterans. *Notonecta, Anisops, Limnometra, Plea* among Hemipterans. *Eretes stictus, Hydrophilus, Psephenus, Haliplus* among coleopteran. *Faunus ater, Corbiculla regularis* among molluscans. *Machrobrachium sp., Syncaris* among decapods as such these classify as Saproxenic sp. having wide range of tolerance.

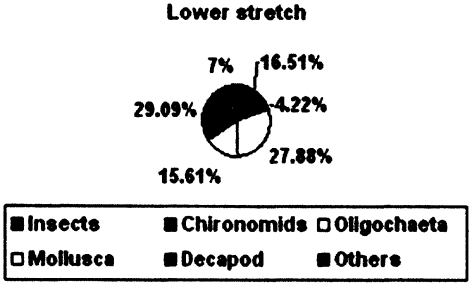
Fig. 8 : Macrobenthic density (um-2) and composition.







Certain forms were present only in stressed zone (OF-BOF) Mukerian *like Diplonychus, Ranatra elongate, Corixa hieroglyphica, Belostoma* among bugs. *Cybister sp., Rhantaticus, Helichus, Diplopnychus, Regimbartia* among Beetles. *Physa Planispora* among molluscans. *psychoda, Hiridinaria* among leech. *Branchiura* among oligochaetes hence classify as saprophilic species-tolerant species.



3.9 **Macrophytes :** Submerged weeds along Beas were present only at Talwara and Harike, rest of Beas had emergent weeds confined to banks.Average macrophyte biomass (wet) along 2 sites was as follows.

Site	Talwara	Harike
Biomass kgm^{-2}	0.041	5.64
Population composition (%)	*Vallisneria* (60.83%) *P. richardsonii* (4-8%), *Hydrilla*, (5-7%) *Chara* (nil-2%) *Azolla* (nil-2%)	*Eichhornia cressipes*-70% *Nelumbo lutea* (nil-20%) *Lemna minor* (nil-10%) *Alternanthera* (nil-10%) *Ipomia* (Nil-4%)

Macrophytes were present throughout the year at these places being more during post-monsoon to winter at Talwara. At Harike macrovegetation was minimum during monsoon (0.5 kgm^{-2}), low during winter (4 kgm^{-2}) and high during pre and post-monsoon (12 kgm^{-2}). The high biomass at Harike is due to wetland characteristics caused by Harike barrage and nature of weed-water hyacinth.

Macrophyte showed population diversity both at Talwara and Harike. The dominant species present at former site was *Vallisenaria* (60.83%) and at latter site, *Eichhornia* cressipes (70%) in all seasons. *Hydrilla* and *Chara* sp. at Talwara were season specific being present during pre-monsoon and winter respectively. At Harike *Nelumbo lutea* (nil-20%) was present during winter. *Alternanthers* and *Ipomia* sp. present during pre-monsoon only. Presence of *Vallisenaria* and *Chara* at Talwara only denote these non tolerant weeds, while dominance of *E. cressipes* at Harike, a pollution tolerant weed.

Macrophyte density did not show much change during the observed tenure except at Talwara were biomass decreased from 0.008 to 0.005 kgm^{-2} between 2002 to 05 may be due to mining activities in river bed causing disturbances in river bed. Macrophyte composition did not show any change at Talwara but at Harike percentage composition of *N. lutea* and *Alternanthera* sp. decreased from 2002 to 2005.

Table 8a : Macrobenthic density (um^{-2}) and composition of River Beas between 2002-2005

Stations		Total (um^{-2})	Percentage (%)														
			Ephe :	Hemi :	Coleop :	Odon :	Dipt :	Chiro :	Hirud :	Tubi :	Gastr :	Biva :	Deca:	W. nema	Clad :	Fish spawn	Misc
Talwara		605	8.45	10.87	1.53	1.8	2.03	19.53	2.34	-	30.79	19.56	2.30	-	-	-	0.08 stone fly
	AOF	323	11.68	5.65	4.80	2.34	-	2.09	-	12.82	19.43	5.31	11.02	2.5	-	-	-
Mukerian	OF	350	3.24	5.70	39.44	4.69	-	5.7	1.86	22.81	9.27	-	4.89	4.1	-	-	-
	BOF	236	3.1	11.37	11.84	2.1	0.8	13.72	2.1	22.89	10.45	1.57	12.68	4.12	-	1.8	-
Beas Bridge		1580	8.77	4.2	-	-	-	-	0.77	27.17	54.57	-	3.9	-	-		
Harike Beas		316	4.60	3.58	-	9.90	0.08	6.48	-	27.88	11.00	4.66	29.00		6.57		

Table 9a : Macrophyte associated fauna density (um^{-2}) and composition of River Beas between 2002-2005

Stations		Total (um^{-2})	Percentage (%)														
			Ephe :	Hemi :	Coleop :	Odon :	Dipt:	Chiro :	Hirud :	Tubi :	Gastr :	Biva :	Deca :	Acri	Clad : spawn	Fish	Misc
Talwara		78	12.48	6.17	0.4	3.46	5.62	6.97	2.21	-	26.45	14.36	12.36	-	-	0.85	9.71
	AOF	11	14.22	15.72	24.53	5.4	0.92	12.0	-	-	-	8.33	10.89	-	-	1.39	-
Mukerian	OF	18	6.48	5.53	30.79	21.80	-	7.27	1.98	8.17	9.70	0.30	4.16	-	-	1.52	-
	BOF	17	-	23.1	8.3	12.24	-	4.15	-	10.13	11.03	9.75	4.4	2.8	0.41	2.0	1.2
Beas Bridge		28	0.50	1.7	7.9	5.96	-	8.32	1.66	21.04	23.89	3.2	27.18	-	-	0.50	-
Harike Beas		20	9.2	-	5.4	5.82	-	3.74	1.52	7.0	38.15	7.6	25.36	-	-	-	0.29

Table 8b : Seasonal changes in bottom macrofauna in River Beas (2002-05)

Season	Pre-mon	Monsoon	Post-mon	Winter	Season	Pre-mon	Monsoon	Post-mon	Winter
Talwara					**Mukerian (AOF)**				
Total density (um^{-2})	532	1320	334	234	Total density (um^{-2})	377	716	166	33
Groups composition (%)					**Group composition (%)**				
Insecta					**Insecta**				
Pelecoptera	3.0	-	-	-	Ephemeroptera	-	33.3	13.45	-
Ephemeroptera	-	25.5	-	8.3	Hemiptera	22.22	-	-	-
Trichoptera	-	6.6	-	-	Coleoptera	8.3	0.6	10.32	-
Hemiptera	7.0	6.5	30.0	-	Diptera (chironomous)	8.3	-	-	-
Coleoptera	6.11	-	-	-	**Odonata**	2.76	-	6.62	-
Diptera (*chironomous*)	35.25	2.77	-	40.12	**Annelids**				
Odonata	-	-	7.15		Oligochaeta	-	32.8	18.51	-
Anneldia				-	**Mollusca**				
Hirudinea	7.0	-	2.36	-	Gastropoda	33.3	-	44.44	-
Mollusca					Pelecypoda	20.84	-	-	-
Gastropoda	19.15	29.0	30.19	44.82	**Crustacea**				
Pelecypoda	21.0	28.83	22.22	6.2	Decapoda	4.17	33.3	6.62	-
Crustacea					Misc.	-	-	-	100
Decapoda	0.92	8.3	-						
Mukerian (OF)					Mukerian (BOF)				
Total density (um^{-2})	332	354	282	433	Total density (um^{-2})	299	121	311	214
Groups composition (%)					**Groups composition (%)**				
Insecta					**Insecta**				
Ephemeroptera	4.56	8.4	-	-	Ephemeroptera	-	12.5	-	-
Hemiptera	1.50	7.68	-	14.44	Hemiptera	-	7.14	22.72	15.62
Coleoptera	57.59	33.54	50.0	16.66	Coleoptera	2.75	44.64	-	-
Diptera (*chironomous*)	-	-	22.72	-	Diptera (*Chironomous*)	54.17	-	-	3.12
Odonata	-	9.61	4.54	4.3	**Odonata**	-	-	-	8.3
Anneldia					**Anneldis**		-	-	
Hrudinea	4.66	-	-	-	Hrudinea		-		8.3
Oligochaeta	23.7	-	22.72	42.85	Oligochaeta	8.35	-	36.35	46.87
Mollusca					**Mollusca**				
Gastropoda	4.66	10.47	-	21.73	Gastropoda	33.3	-		8.5
Pelecypoda	-	-	-	-	Pelecypoda	1.4	-	4.64	-
Crustacea					**Crustacea**				
Decapoda	3.0	13.46	-	-	Decapoda	-	21.42	33.3	-
W. Nematodes	16.5	-	-		**W. Nematodes**	-	7.14	-	9.37
					Misc. (Fish spawn)	-	7.14	-	-

Season	Pre-mon	Monsoon	Post-mon	Winter	Season	Pre-mon	Monsoon	Post-mon	Winter
Beas Bridge					**Beas Harike**	387	300	377	200
Total density (um^{-2})	578	3454	2253	33	Total density (um^{-2})				
Groups composition (%)					**Group composition (%)**				
Insecta					**Insecta**				
Ephemeroptera	-	-	18.51	16.6	Ephemeroptera	-	-	18.51	-
Hemiptera	-	-	-	16.6	Hemiptera	4.76	-	bloom	-
Diptera (*chironomous*)	-	-	-	-	Diptera (*Chironomids*)	16.88	-	9.04	3.01
Anneldia					**Odonata**	2.38	1.04	-	36.35
Hirudinea	3.06	-	-	-	**Annelids**				
Oligochaeta	34.0	-	11.3	66.6	Oligochaeta	11.90	46.0	2.22	51.41
Mollusca					**Mollusca**				
Gastropoda	62.9	100	55.40	-	Gastropoda	6.6	19.77	17.77	-
Pelecypoda	-	-	-	-	Pelecypoda	9.52	-	-	9.13
Crustacea (Decapods)	-	-	15.6	-	**Crustacea**				
					Decapoda	33.3	33.0	50.37	-
					Cladocera	15.15	-	11.11	-

Table 8c : Macro-organisms present in River Beas and Harike as benthic and epiphylic forms

Site	Talwara	Mukerian			Beas bridge	Harike		
Organisms		AOF	OF	BOF		Beas	Sutlej	Confluence
Plecopetra								
Nemoura sp.	+	-	-	-	-	-	-	-
Nymphula	+	+	-	-	-	-	-	-
Trichoptera								
Limnephilus	+	-	-	-	-	-	-	-
Lepidostoma	+	-	-	-	-	-	-	-
Leptocella	+	-	-	+	-	-	-	-
Hydropsyche	+	+	-	-	-	-	-	-
Ephemeroptera								
Caenis	+	-	-	-	-	-	-	-
Heptogenia	+	-	+	-	-	-	-	-
Ephemerella	+	+	-	-	-	-	-	-
Isonychia	-	+	-	-	-	-	-	-
Brachycercus	-	+	-	-	-	-	-	-
Baetis nymphs	-	+	+	+	+	+	+	+
Crane fly larvae								
Phalacrocera	+	+	-	-	-	-	-	-
Helius	+	-	+	-	-	-	-	-
Hemiptera								
Notonecta	+	+	+	+	+	+	+	+
Anisops	+	-	+	-	-	-	-	-
Erithares	+	-	-	-	-	Bloom	-	-
Diplonychus	-	+	-	-	-	-	-	-
Laccotrephes	-	+	+	-	-	+	+	-
Ranatra elongata	-	+	-	-	-	-	-	-
Corixa hieroglyphica	-	+	-	-	-	-	-	-
Lethocerus indicum	-	+	+	+	-	-	-	-
Belostoma	-	+	+	+	-	-	+	-
Galastocaris bufo	-	+	+	+	-	+	-	+
Aphelocherius variegates	+	-	+	-	-	+	-	-
			+	-	-	-	-	-

Salda littoralis	-	-						
Limnometra	+	-	-	-	-	-	+	-
Hebrus	-	-	+	-	-	-	-	-
Microvelia	+	-	+	+	-	-	+	+
Plea	+	+	+	-	-	-	-	-
Coleoptera								
Dytiscus	-	+	+	+	+	+	-	-
Hydaticus	-	+	+	+	+	-	+	-
Cybister	-	-	+	+	-	-	-	+
Eretes sticticus	+	+	-	-	-	-	-	-
Rhantaticus	-	-	+	-	-	-	-	-
Helichus	-	+	+	-	-	-	-	-
Diplonychus	-	-	+	-	-	-	-	-
Regimbartia	-	-	+	+	-	-	-	-
Hydrophilus larvae	+	+	+	-	-	+	-	-
Psephenus larvae	+	-	+	-	-	-	-	-
Psephenus adult	+	-	+	-	-	-	-	-
Octhebius	-	+	-	-	-	+	-	-
Hydrocanthus	-	-	-	-	-	-	+	-
Hydrophorus	-	-	-	-	-	-	+	-
Haliplus	+	-	-	+	-	-	-	-
Berosus larvae	-	+	+	+	-	+	-	-
Odonata (Zygoptera)								
Enallagma nymph	-	+	+	+	+	+	-	-
Hyponeura nymph	+	+	-	-	-	-	-	-
Argia nymph	-	-	-	+	+	+	-	-
Coenagrion nymph	-	-	-	-	-	+	+	+
Miss. damsel fly nymphs	+	+	+	+	+	+	+	+
Gomphus	+	+	+	+	+	+	+	+
Ophiogomphus	-	+	-	-	+	+	-	+
Miss dragon fly	-	-	-	-	-	+	+	+
Crustacea								
Mysis	+	+	-	-	-	-	-	-
Syncaris	+	+	-	+	+	-	-	-
Gammarus	+	+	-	-	-	-	-	-
Macrobrachium sp.	+	+	+	+	+	+	-	+

Diptera								
Chironomous pupae	+	+	+	+	+	+	+	+
Chironomous larvae	+	+	+	+	+	+	+	+
Psycoda	-	-	-	+	-	-	-	-
Dixa	+	+	-	-	-	-	+	-
Elliptera	+	+	-	-	-	-	+	+
Eristalis	-	-	-	-	-	+	-	-
Hirudinea								
Placobdella	+	-	-	-	-	-	-	-
Herpobdella	+	-	-	-	+	+	-	-
Glossiphonia	+	-	-	-	-	-	-	-
Haemopsis	-	+	+	+	-	+	-	-
Hirudinaria	-	-	+	-	-	-	-	-
Oligochaeta								
Nais	-	-	+	-	+	-	+	-
Limnodrillus	-	-	+	+	+	+	+	+
Tubifex	-	+	+	+	+	+	+	+
Branchiura	-	-	-	+	-	+	+	-
Aquatic earth worm	-	+	-	-	-	+	-	+
Mollusca (Gastropoda)								
Faunus ater	+	-	-	-	-	+	-	-
Melania straitella	+	+	-	-	-	+	-	-
M. scabra	-	+	+	+	+	+	-	-
Lymnaea columella	+	-	-	-	-	+	+	+
L. singula	+	-	-	-	-	-	+	+
L. acuminate	+	-	-	-	-	-	-	+
L. pinguis	+	+	-	-	-	-	-	-
L. auricularia	+	-	-	-	-	-	-	-
L. stgnalis	+	-	-	-	-	-	-	-
Gyraulus convexiusulus	+	+	+	+	+	+	+	+
Pleurocerca	+	-	-	-	-	-	-	-
Cyclotopsis	+	+	-	+	-	+	-	-
Cyclophyorus	-	+	-	-	-	+	+	+
Glessula	-	-	-	+	+	+	-	+

Aplexa	-	-	-	-	+	+	-	-
Valvata	+	-	+	-	-	-	-	+
Physa	-	+	+	+	-	-	-	+
Zootecus	-	+	-	-	-	-	-	-
Planorbis	-	-	+	+	-	+	-	+
Planispora	-	-	-	+	-	-	-	-
Goniobasis	+	-	-	-	-	-	-	-
Promentus	+	-	-	-	-	-	-	-
Viviparous dissimilis	-	-	-	-	+	+	+	+
Pelecypoda								
Corbicula regularis	+	+	+	+	+	+	-	+
C. straitella	+	+	-	+	+	+	-	+
Sphaerium	+	-	-	-	+	-	+	-
Lamellidens sp.	+	-	-	-	+	+	-	-
Water nematodes	-	+	+	+	-	+	+	+
Cladocera								
Daphnia	-	-	+	+	-	+	+	+
Acari	-	-	+	+	-	+	+	-
Fish spawn	+	-	+	+	+	-	-	+

Table 9b : Seasonal changes in macrophyte associated fauna in River Beas (2002-05)

Season	Pre-mon	Monsoon	Post-mon	Winter	Season	Pre-mon	Monsoon	Post-mon	Winter
Talwara					**Mukerian (AOF)**				
Total density (um^{-2})	103	130	62	17	Total density (um^{-2})	19	9	17	3
Groups composition (%)					**Group composition (%)**				
Insecta					**Insecta**				
Pelecoptera	8.64	0.95	2.65	-	Ephemeroptera	4.16	-	38.51	-
Trichoptera	8.9	9.20	8.66	-	Hemiptera	22.88	5.55	19.43	100
Ephemeroptera	17.75	5.26	5.26	11.11	Coleoptera	12.5	61.11	-	-
Hemiptera	4.49	0.63	19.40	-	Odonata	4.16	11.11	0.92	-
Coleoptera	1.50	-	-	-	*Chironomous sp.*	16.66	-	22.2	-
Odonata	7.26	-	6.6	-	Gastropoda	-	-	0.92	-
Diptera	0.30	-	-	22.22	Pelecypodea	25.0	-	-	-
Chironomous sp.	13.39	3.94	7.57	2.99	Crustacea	10.46	22.2	18.00	-
Hirudinea	-	-	-	8.82	Misc.	4.16[a]	-	-	-
Gastropoda	23.96	21.04	25.81	32.02					
Pelecypoda	9.5	25.12	14.00	8.82					
Crustacea	1.38	33.16	-	14.5					
Misc.	2.77	0.63	-	-					
Total density (um^{-2})	332[a]	354[a]	282	433					
Mukerian (OF)					**Mukerian (BOF)**				
Total density (um^{-2})	16	29	24	3	Total density (um^{-2})	22	11	10	23
Groups composition (%)					**Group composition (%)**				
Ephemeroptera	-	-	-	-	Ephemeroptera	-	-	-	-
Trichoptera	-	-	25.92	-	Trichoptera	-	-	-	-
Hemiptera	7.63	4.76	9.7	-	Hemiptera	-	8.3	54.1	50.0
Coleoptera	63.78	28.46	30.95	-	Coleoptera	-	33.3	-	-
Diptera (*chironomous*)	-	-	22.72	-	Diptera (*Chironomous*)	54.17	-	-	3.12
Odonata	11.57	-	25.64	50.0	Odonata	18.15	10.0	8.33	12.5
Chironomous sp.	-	-	1.70	25.0	*Chironomous sp.*	-	-	16.6	-
Oligochaeta	-	34.9	-	-	Oligochaeta	41.72	-	-	-
Gastropoda	16.5	11.36	-	25.0	Gastropoda	1.65	5.0	-	37.5
Pelecypoda	-	2.27	-	-	Pelecypoda	36.30	-	-	-
Crustacea	-	16.66	2.38	-	Crustacea	-	5.0	12.5	-
Misc.	-	2.38[a]	3.7[a]	-	Misc.	-	8.3[a]	4.33[a]	-
							2.49	4.0[a]	
							5.0[d]		

Season	Pre-mon	Monsoon	Post-mon	Winter	Season	Pre-mon	Monsoon	Post-mon	Winter
Beas Bridge					**Beas Harike**				
Total density (um^{-2})	13	5	90	4	Total density (um^{-2})	31	4	41	8
Groups composition (%)					**Group composition (%)**				
Ephemeroptera	1.96	-	-	-	Ephemeroptera	9.52	-	-	27.78
Hemiptera	6.6	-	-	-	Coleoptera	1.15	-	19.0	-
Coleoptera	6.6	25.0	-	-	Odonata	-	-	12.88	-
Odonata	1.96	20.0	1.89	-	*Chironomous sp.*	14.96	-	2.8	-
Chironomous sp.	13.3	-	-	20.0	Hirudinea	-	-	2.8	-
Oligochaeta	35.29	-	18.87	30.0	Oligochaeta	16.9	-	8.3	-
Pelecypoda	-	10.0	2.8	-	Pelecypoda	6.89	-	12.5	11.0
Crustacea	16.47	20.0	22.25	50.0	Crustacea	23.80	-	18.77	38.88
Misc.	1.96(a)	-	-	-	Cladocera	-	-	3.7	-
					Misc.	-	-	-	-

Significance of superscript

a) Fish Fry b) Acari c) Misc. insects d) water nematode

3.10 Macrophyte associated fauna (Table 9a & 9b) : The Meiofauna or macrophyte associated fauna was present throughout the potomoan zone of river although macrophytes were present only at two sites, at rest of places, population was attached with emergent grass along river banks. The average density of epiphytic forms was high at Talwara (78um^2) moderate in lower zone (28-20 um^2) and less (11-18um^2) in stressed zone.

Epiphytic population mostly comprised of insects, molluscans and decapods. At Talwara region it was mostly formed by insect nymphs (37.44%) and gastropods (36.78%). At stressed zone by insects (61.4%) belonging to coleoptera, hemiptera and odonata and at lower stretch all the groups were almost equally present gastropods (29.35%), decapods (26.16%), oligochaeta (18.2%) and insecta (17.64%)as shown in Fig 9.

Seasonal variation in density and composition

Epiphytic population like bottom macrofauna exhibited seasonal fluctuation both in density and diversity (Table 9b), but fluctuation was site specific depending upon flow of water and amount of nutrient load.

At Talwara the density was more between pre-monsoon to monsoon (103-130 um^{-2}) and least in winter (17 um^{-2}) like bottom macrofauna. The reason being high temperature and less water flow in former and low temperature and more water flow in latter season.

At stressed zone density varied between 3-29 um^{-2} minimum in winter and maximum in monsoon-post-monsoon, when river at the zone had high nutrient load due to high flushing by Chakwal Nalla.In lower stretch density was high during pre (13-31) and post-monsoon (41-90um^2) low in monsoon (1-5 um^{-2}) and winter (4-8um^2) unlike bottom macrofauna, thereby exhibiting that monsoon flushing within Beas on the whole especially in lower stretch affect only surface waters and is not so great as to have its impact on river bed etc.

Population diversity exhibited that stone fly nymphs, were present only at Talwara. May fly nymphs although present both at upper and lower stretch were dominant at former site (5.26-17.75%) and mostly present during pre-monsoon/summers. Coleopteran (nil-63.78%), Hemiptera (nil-54.1%), Odonata (nil-50%) were dominant at stressed zone, former being absent during winter all along. Decapods (prawns) as epiphytic forms were present in all seasons but abundant in winter (38.88-50%) especially wherever macrophytes were present, exhibiting importance of shelter for the group (Table 9b).

Meiofauna contained fish spawn also mainly between Talwara to Beas bridge. Fish spawn of minor carps (2.77%) at Talwara and that of miscellaneous fishery at AOF Mukerian (4.16%) and Beas bridge (1.96%) was observed in the month of May; while at stressed zone, presence of fish fry of assorted fishery in the range of 2.38-3.7% was observed between monsoon to post-monsoon depicting that Chakwal Nalla may be facilitating breeding to some extent (Table 9b).

Main change in meiofauna during the course of study was observed in prawn population which showed increasing trend from 2002 to 2005.

The Insect and other population present in Beas as bottom macro organism and ephphytic forms (Table 8c) was comprised of almost 100 genera, out of which 2 belonged to Plecoptera, 1 to Lepidoptera, 4 to Trichoptera, 6 to Ephemeroptera, 16 to Hemiptera, 15 to Coleoptera, 7 to Odonata, 4 to Decapoda, 5 to Diptera, 2 to Cranefly larvae, 5 to Hirudinea, 5 to Oligochaeta, 23 to Gastropods, 3 to Bivalves, 1 to Cladocera., 1 to Acari.

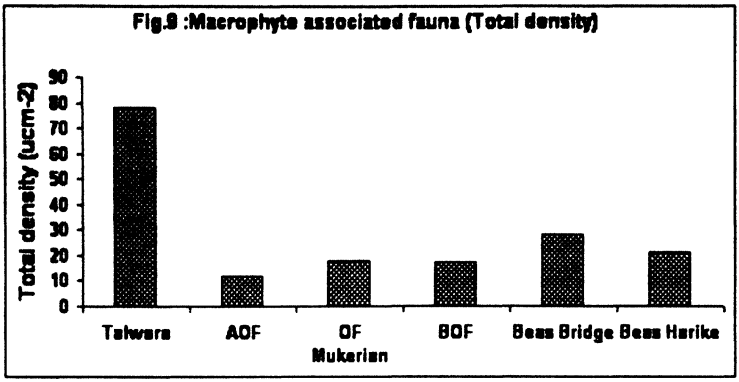
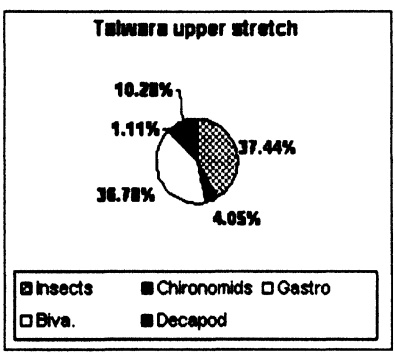
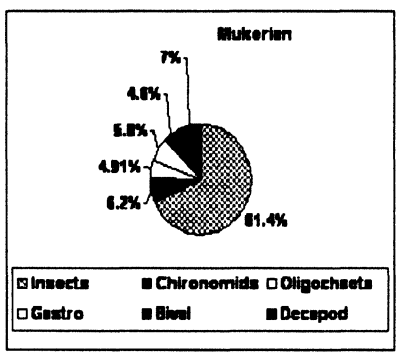
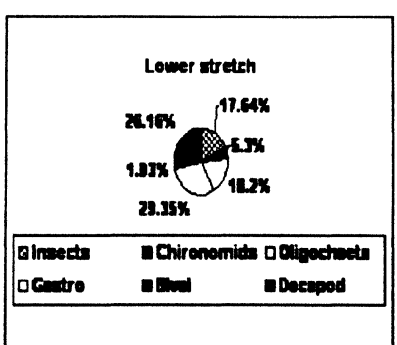


Fig.8 :Macrophyte associated fauna (Total density)
Total density (ucm-2)
90
80
70
60
50
40
30
20
10
0
Talwara
AOF
OF
BOF
Beas Bridge
Beas Harike
Mukerian


Talwara upper stretch
10.28%
1.11%
37.44%
36.78%
4.05%
Insects
Chironomids
Gastro
Biva.
Decapod


Mukerian
7%
4.6%
5.8%
4.91%
6.2%
61.4%
Insects
Chironomids
Oligochaets
Gastro
Bival
Decapod


Lower stretch
17.64%
26.16%
5.7%
1.93%
18.2%
29.35%
Insects
Chironomids
Oligochaets
Gastro
Bival
Decapod

4. Fish and Fishery : River Beas is known to contain fish from its rhithron zone within Shiwalik Himalayas. The reservoir on the river-Pong Dam is a good source of fishery currently has average yield of 40 kg/ha (Per com.). The commercial exploitation of riverine stretch exists from Talwara onwards. The fishing rights vest with Punjab Fisheries except that of Talwara dam which vest with Himachal Fisheries.

4.11 FISHERY SPECTRUM

a) **Fishing activity :** River Beas is auctioned along with other natural water resources annually on district basis, generally in the month of September for commercial fishing.

Fishing is done on contract basis all along river except at Talwara dam where Co-operative mode of fishing activity exists.

Fishing is done round the year except during monsoons (June and July) at Talwara and July-August in rest of stretch, when it is banned officially.

Fishing at main points is done by 120-150 full time fishermen belonging to Bihar and Eastern U.P., who are hired by the contractor. Each contractor per district has a party of these outsider fishermen numbering 15-20, whom they make to operate within their jurisdiction . In addition local fishermen belonging to Masiha community too operate. Local fishermen are mainly from Talwara, Sultanpur and Harike areas, where 50-100 operate full time and almost same number partially.

b) **Fishing equipment :**

Crafts : Small country boat. Each boat carries minimum 2 persons. Boats operate on individual basis.

Gears : The main gears operative in Beas are :

1. *Line and Hook :* Line and hook is used mostly between winter to pre-monsoon, when water is clear.
2. *Rope – Loop system :* This type of fishing is done mostly where current is swift, depth low generally after Talwara barrage to Mirthal (Distt. Gurdspur) along foot hills.
3. *Fry drag net (Chatti jal) :* The net is like any other drag net but made of mosquito cloth having fine mesh size generally used between Nurpur-Mirthal where depth is low.
4. Gill net
5. Caste net

c) **Fish marketing :** Fish disposal was of 111rd channel at all landing centres but Being of different mode at Talwara than rest.

Centre	Channel
Talwara	Fisher-Co-operative-Wholesale cum Society Commissioning agent-Retailer-consumer
Pathankot	Fisher-Contractor-Wholesale cum
Mukerian	Commissioning agent-Retailer-consumer
Amritsar	-do-
Harike	-do-
Sultanpur	-do-

d) **Fish Price spread :** Fishermen get 50% of wholesale price.

The retail price was maximum for miscellaneous fishery like, *Eel, Murrels, E. vacha,* Rs. 80-100/- kg having wt. above 1 kg, followed by catfishes, *Mystus seenghala/aor* and *W. attu* Rs. 60-100/- kg depending on size. IMC gets Rs.30-60/- kg depending on size. Common carp Rs. 25-40/- kg depending on size and Minor carps Rs.30-35/- kg.

4.12 Fishery Resources : Fish resource estimation of Beas has been evaluated from the total arrivals of fish catch at 6 landing centres for 3 years. The stations were, Talwara, Pathankot, Mukerian, Amritsar, Sultanpur and Harike.

a) **Estimated Fish catch (Table10) :** The average annual estimated fish catch from 165 km of river Beas between Talwara to Harike was approximately 260 tons /year; ranged between 147.6 t/ (02-03) to 381.2 t/y (04-05). The biomass showed approximately 160% increase. The increase was mostly due to following (i) Auctioning policy of the State i.e. the catchment area of Harike and Sultanpur landing centres fall within district Amritsar and Kapurthala where in both rivers of Beas and Sutlej co-exist. Since the auctioning is done district-wise and if contractor happens to be same for both the districts fish produce from the area finds assess to any of 3 landing centres i.e. Amritsar, Harike and Sultanpur, preferably to such centres having high market return Amritsar in this case. For the year September 2004-05 contractor for above mentioned district was same, hence the fish catch from Harike and Sultanpur included some Sutlej fishery also, hence the increase. (ii) More fishing effort at tail end of Beas due to low water level during 2004-05.

The fish catch during 3 year's of observation (Table 11) showed nominal changes (11.20 to 24.5 t/y) at Talwara and Pathankot (27.5 to 38.6 t/y) and least at Mukerian (21.9 to 28.9 t/y), because no man made interference was noticed in this particular stretch in the form of fishing activity. Contrary to this, fish biomass varied greatly at Amritsar (26 to 112.7 t/y) and Harike (26.0 - to 117.9 t/y) and to some extent at Sultanpur (21.6 to 63.0 t/y) mainly due to above mentioned reason and (ii) Restoration of better aquatic habitat in and around Harike wetland by the Army in collaboration with Punjab Govt. and WWF India during 2000-01 through Project "SAHYOG" which may have resulted in better fish recruitment during that year resulting in enhancement of biomass in subsequent years. Observations revealed that river contains more fish (26.0-117.9 t/y) in lower stretch than upper stretch (12.0-38.6 t/y) between Talwara to Mukerian, hence the catch per km is less, 1.160 t/y being 0.116 t/m for first 65 km and it is more 1.850 t/km/yr being 0.185 t/m/km for lower (100km) stretch.

b) **Average monthly fish catch (Table 12) :** The average fish catch per month computed from 3 years data show that fish catch at Talwara was 1.97 tons ranging between 1.01-2 tons round the year barring the month of March (4.0 t) and September (3.0 t) when enhancement in catch is due to presence of common carp mainly. The reason being that this fishery falls easy prey to fishing activity because of its breeding nature around this time.

The average catch/month at Pathankot (3.2t) show seasonal variation. It being low during post-monsoon (1.50-2 t) and winter (0.99-2.40 t) and high during pre-monsoon to monsoon (5.20 to 6 t). The high catch was mainly due to high catch of minor carps forming 88.89-91.40% population during the season. The fishery being susceptible to fishing because of paucity of shelter in the area during these seasons having minimum water level in the catchment area as observed in Table 1.

The average fish catch/month at Mukerian (2.43t) show least fluctuations. It ranged between 1.23 to 3.95 t being low in February and high in September to October. High catch during latter

period was due to high catch of IMC (38.22-52.02%) compared to its low catch in other season, thereby depicting that IMC from Harike migrate upto Mukerian where these may be caught either during breeding time or while having backward run-post-monsoon.

Average monthly catch at Amritsar (6.48t) ranged between 4.3 (June) to 9.39 t (November). The catch in addition to environment and biological factors is also influenced by market valuation. The less catch in summer/pre-monsoon may be due to more water level in river along the stretch as well low demand. The high catch during post-monsoon (7.26-9.39 t) may be due to low water level and high demand, as main big size commercial fishes are disposed off from this landing centre because of high market value. The individual fishery show persistence of major carps in the area, being highest (50%) during monsoon and that of large size cat fishes (9.29-16.17%).

Average monthly catch at Harike was highest (7.88t); ranging between 4.07 to 13.08 t, being low during post-monsoon (4.0-5.95 t) and high during summers (9.60-13.8 t). The catch depicts large IMC (32.69-51.48%) and common carp (18.41-33.54%) population in the area. Persistence of high IMC contribution (39-52.55%) towards total biomass in all seasons show that this fishery is resident of the area.

Sultanpur stretch of Beas had monthly average catch of 4.91tons ranging between 3 to 8.70 t, low during winter to summer (3.0-5.0 t) and high during monsoon (6.20 t) to post-monsoon (4.80-8.70 t). High catch in monsoon was due to IMC and during post-monsoon due to miscellaneous fishes. Maximum major carp fishes were caught during pre-monsoon to monsoon (59.48-41.37%) when this fishery may be having upward local run from Harike towards Kali Bein.

c) Fish catch composition (Table 10) : The 3 year observations denoted that fishery of Beas was mainly formed of IMC (28.28%) followed by minor carps (22.44%), common carp (22.02%) and miscellaneous (17.75%). Large size cat fishes were least represented (8.54%).

IMC were mainly represented by *C. mrigala* (12.65%), followed by *L. rohita* (8.22%) and *L. calbasu* (5.06%). *C. catla* was of very low order (2.35%) confined to Harike only. Large size cat fishes were almost equally represented by *W. attu* (4.28%) and *M. seenghala* (3.8%). *M. aor* (0.46%) being very scarce and present in Harike only.

Minor carps dominant in upper stretch were represented by *L. dyocheilus* and *L. dero* and by *L. gonius, L. bata , C. reba* in lower stretch.

Miscellaneous group was formed of Murrels, *B. bagarius, R. rita, N. notopterus, N. chitala* wherein *B. bagarius* was mainly confined to upper and *N. chitala* to lower stretch.

Persistent presence of *C. carpio* all along Beas in all age groups and sizes and forming almost the second important group of fishery within river envisage its establishment within the system.

Comparative account of fish composition within Beas during observed period (Table 10) show that fishery within river has not changed much except in (i) contributory percentage of IMC and catfishes (ii) Induction of *C. gariepinus* from 2003-04 onwards, although on a small scale (0.05%) around Harike.

The IMC biomass has increased 28.7 t/y to 140.10 t/y resulting 100% increase in contributory population from 19.45 to 36.76%, mainly contributed by *C. mrigla* (from 8.54 to 19.02% and *L. rohita* (4.02 to 10.76%) between 2002 to 2005. The increase may be attributed to good recruitment during 2000-01 due to cleaner habitat at Harike because of operation "SAHYOG".

Large size catfish population has decreased from 11.38 to 7.32%. The decline has been witnessed from 2003 onwards (Table 10) especially around Harike (Table 11) from 10.38 to 4.32% and at Sultanpur, from16.20 to 7.69% which may be due to invasion of *C. gariepinus* competing for the food.

4.13 Fish diversity (Table 11) : Fishery present within Beas was observed to be formed by 54 species out of which 31 are economically important (Annexure-1). Its upper stretch running along foot hills of Shiwalik Himalayas hold cold water (*S.richardsonii*) to eurythermal carps. Lower stretch has *N. chitala* and *M. aor.*

Talwara centre having biomass of 12.0-24.5 t/y has dominance of *C. carpio* (66.67-84.50%) which may be due to (i) Induction of common carp seed regularly by H.P. fisheries in Talwara Dam and (ii) Conducive environs, lentic nature of river formed by existence of barrage at this site. The stretch contains eurythermal minor carps (12.24-25.0%) and *T. putitora* (0.03-1.30%) also mainly below barrage.

Pathankot centre having biomass range of 27.5-38.6 t/y ,whose catchment area too is along foot hills of Shiwalik and seasonal mountainous tributary-Chaki, has dominance of cold water eurythermal minor carps - *L. dero, L. dyocheilus* (84.97-90.03%). Presence of *T. putitora* (2.18-5.44%), mainly during winter and *S. richardsonii* (nil-2.35%) between winter to premonsoon.

Mukerian centre, pure plain stretch having lotic environment, where Beas regains maximum water resources, has dominance of IMC (23.68-50.23%), although minor carps (18.72-40.14%) are also substantial . Regular presence of *T. putitora* (1.31-2.42%) during winter depict that Mahseer ascends upto Mukerian within Beas for its feeding.

Lower stretch between Amritsar to Harike where in river has good water resource, flow and depth contain mostly IMC (23.97-51.48%), large size catfishes (4.32-19.62%) and common carp (12.96-39.06%) – all important commercial fishery mainly because fish gets protected area within Harike wetland.

The changes observed in lower stretch were (i) Decline in catfish fishery (Table 10 & 11). (ii) Invasion of *C. gariepinus* at Harike.

4.14 Length-frequency distribution (Table 13) : Length frequency distribution of commercial fishery show that maximum fishes like *C. mrigala* (48.5%), *L. rohita* (42.0%), *C. carpio* (59.9%), *T. putitora* (67.9%) were dominant in IInd group in the length range of 306-500 mm.

Catfishes, *M. seenghala* (44%), *W. attu* (44.1%) and *L. calbasu* amongst IMC were dominant (62.7%) in IIIrd group in the length of 458-635 mm for former and 407-535 mm for later.

C. catla, the least represented species among IMC was present equally (26.5-28.6%) between IInd to IVth group in the catch. The species showed growth even upto Vth group (763-864 mm) present as 8.6% of catla catch within Beas.

Presence of 7.6% of *C. catla* and 11.07% of *T. putitora* in 1st group in Beas catch show their over exploitation within the system.

Comparative account of length frequency data show that there was gradual decline in 1st group (0-300 mm) catch of *C. catla* from 11.1% to nil and of *T. putitora* from 11.1 to 6% between 2002 to 2005, showing fall in recruitment indirectly.

Decline in VIth group (865 mm and above) of *M. seenghala* from 5 to 2% and that of *W. attu* from 13% to nil depict the fishery is not getting conducive environs for its growth which affects the biomass as well as recruitment.

Table : 10 Comparative fishery resources of River Beas between 2002-2005

Years	2002-03		2003-04		2004-05		Average (%)
Species	**(t)**	**(%)**	**(t)**	**(%)**	**(t)**	**(%)**	
C. mrigala	12.6	8.54	14.60	10.41	72.50	19.02	12.65
C. catla	3.0	2.03	10.60	4.49	2.0	0.53	2.35
L. rohita	6.0	4.02	23.40	9.90	41.0	10.76	8.22
L. calbasu	7.1	4.80	9.30	3.93	24.60	6.45	5.06
Sub-total (IMC)	**28.7**	**19.45**	**67.90**	**28.73**	**140.10**	**36.76**	**28.88**
Minor carps	42.10	28.52	43.10	18.24	78.40	20.57	**22.44**
Tor sp.	1.40	0.95	1.10	0.47	3.00	0.79	**0.73**
C. carpio	32.6	22.09	57.4	24.29	75.10	19.70	**22.02**
C. gariepinus	-	-			0.20	0.05	**0.21**
S. richardsonii	-	-	0.90	0.38	0.90	0.24	**0.08**
M. aor	0.70	0.47	1.80	0.76	0.60	0.16	0.46
M. seenghala	9.90	6.71	4.90	2.07	10.0	2.62	3.8
W. attu	6.20	4.20	9.70	4.11	17.30	4.54	4.28
Sub-total (Cat fishes)	16.80	11.38	16.40	6.94	27.9	7.32	8.54
Misc. group	26.00	17.61	49.50	20.95	55.7	145.7	17.71
G. Total/Year	**147.6**		**236.3**		**381.2**		
Productivity T/km/month	0.0894		0.1432		0.2310		

Table 11 : Fish diversity within River Beas (2002-2005)

Years	Station	T. landing (t/y)	Percentage (%)							
			IMC	Minor carp	Catfish	*C. carpio*	*Tor* sp.	*C. gariepinus*	*S. richardsonii*	Misc.
2002-03		23.10	0.43	21.21	1.30	73.59	1.30	-	-	2.16
2003-04	Talwara	12.00	0.83	25.01	1.67	66.67	0.03	-	-	5.83
2004-05		24.50	-	2.24	1.22	84.50	0.81	-	-	1.22
2002-03		28.10	1.07	90.03	2.13	1.78	2.49	-	-	2.49
2003-04	Pathankot	27.50	-	86.91	1.09	0.72	2.18	-	3.64	5.45
2004-05		38.60	-	84.97	-	5.96	5.44	-	2.33	1.30
2002-03		22.80	23.68	30.70	20.18	4.82	1.31	-	-	19.30
2003-04	Mukerian	21.90	50.23	18.72	10.96	5.02	1.36	-	-	13.70
2004-05		28.90	25.26	40.14	9.34	5.54	2.42	-	-	17.25
2002-03		26.00	18.46	13.85	19.62	23.07	-	-	-	25.0
2003-04	Amritsar	53.10	30.57	2.45	11.13	39.0	-	-	-	16.79
2004-05		112.70	38.59	8.96	13.58	617.12	-	-	-	21.14
2002-03		26.00	32.69	2.30	10.38	20.0	-	-	-	34.24
2003-04	Harike	46.40	43.66	7.10	6.02	33.54	-	0.38	-	9.67
2004-05		117.90	51.48	9.33	4.32	18.41	-	0.18	-	16.28
2002-03		21.60	44.44	3.24	16.20	12.96	-	-	-	23.15
2003-04	Sultanpur	63.00	23.97	4.92	7.46	20.95	-	-	-	42.70
2004-05	(R.S.+R.B)	58.50	48.89	16.92	7.69	16.24	-	-	-	10.24

Table 12 : Average fish landing (t/month) between 2002-2005

Months	Talwara	Pathankot	Mukerian	Amritsar	Harike	Sultanpur
January	1.01	0.99	1.37	5.26	5.67	3.00
February	1.75	1.15	1.23	6.43	9.73	4.00
March	4.00	2.40	2.91	5.62	13.08	4.90
April	1.40	5.20	1.75	4.69	4.93	4.40
May	2.00	6.00	2.39	7.36	13.05	5.00
June	2.04	6.00	2.52	4.35	9.60	3.60
July				Closed season		
August						
September	3.00	5.00	3.95	5.60	4.60	6.00
October	1.76	2.00	3.90	8.84	5.95	8.70
Nov.	1.15	1.80	2.01	9.39	5.12	4.80
Dec	1.65	1.50	2.27	7.26	4.07	4.70
Average	**1.97**	**3.2**	**2.43**	**6.48**	**7.88**	**4.91**

Table 13 : Percentage of different groups of commercial fishes within R. Beas between 2002-2005

	Length range (mm)			Group-wise percentage (%)								
Groups	*Catla, Rohu, Mrigala, Carpio & Tor* sp.	*L. Calbasu*	Cat fishes	*C. mrigala*	*C. catla*	*L. rohita*	*L. calbasu*	*C. carpio*	Mahseer	*M. aor*	*M. seenghala*	*W. atu*
I	0-305	0.254	0.279	4.9	7.6	6.4	2.9	11.2	11.0	-	1.2	-
II	306-500	255-406	280-457	48.5	26.5	42.0	33.3	59.9	67.9	13.2	28.1	15.0
III	501-660	407-535	458-635	38.6	28.5	26.9	62.7	22.5	19.7	34.6	44.1	44.1
IV	661-762	536-660	636-762	7.9	28.6	20.5	1.0	4.7	1.3	37.8	22.6	28.6
V	763-864	661-above	763-864	-	8.6	-	-	1.6	-	8.3	1.3	6.3
VI	865-above		865-above	-	-	-	-	-	-	6.0	2.3	4.3

5. Impact of river Beas on Harike Wetland

Harike wetland is a man made wetland which came into existence in 1952 as a result of construction of barrage at confluence of river Beas and Sutlej at Harike-pattan with the objective of providing irrigation and drinking water facility to southern Punjab and Rajasthan.

Harike is one of the six wetlands of International importance in India designated under Ramsar Convention and is known as "Ramsar Site" since 1990. The site was declared as "Bird Sanctuary" by Govt. of India under "Wild Life Act" in 1992. The wetland was observed to harbour more than 50% of fishery resources of Sutlej and Beas (Moza and Mishra, 2002) and has sufficient water except during summer/pre-monsoon (April-May) as such paucity of water is not a problem

As the wetland is the main source of fishery especially IMC (Moza and Mishra, 2002), observation on its ecology especially pertaining to its two main resources i.e. Beas and Sutlej was undertaken along with that of river Beas so as to know the impact of ingress from these resources, so that any management measure if needed to keep the wetland in healthy condition can be taken up by the concerned agency, although wetland no longer contribute to fish produce directly now, as fishing is banned since 2000, yet healthy maintenance of stock is very important, therefore assessment of the environment of the resource is essential.

Ecological evaluation of Harike was done at 3 points (i) Mouth of river Beas before the confluence -Beas (ii) Mouth of river Sutlej before the confluence i.e. inlet of Sutlej (iii) Confluence-after the mixing of two resources in the main wetland.

ECOLOGICAL EVALUATION :

Soil quality (Table 14) : Harike has sandy loam soil (57.2-66.5% sand, 23.7 -30.8 % silt and 9.1- 16.6% clay, contribution of sand more through Beas having 54.4 – 70.2% sand compared to Sutlej 52.6-63.25% sand. Soil is alkaline at all sites, pH ranging between 7.4 to 7.9 at confluence just like its two resources -Beas and Sutlej.

Availability of low values of organic carbon, 0.273-0.690%; nitrogen, 6.50-10.7 mg/100g and phosphorus 1.33-2.73 mg/100g in Beas compared to Sutlej 0.315-0.832 % of Organic carbon; 8.59-14.0 mg/100g of Nitrogen, 2.0-3.20 mg/100g of av. Phosphorus indicate that input of nutrient load by Beas into Harike is less than Sutlej.

Specific conductance range of 287.3-191.0 µmhos/cm along Beas bank site was considerably less especially in winter season compared to 294.7-388.3µmhos/cm values along Sutlej, highest during winter. The conductance values of 262.7-212.0µmhos/cm at confluence site, envisage that pollution impact in wetland especially during winter due to Sutlej inflow is lessened by the inflow of Beas.

Water quality (Table 15) : Physical characteristics of wetland like temperature and transparency (14-41.3 cm) envisage more influence by clean waters of Beas having transparency range of 14-41.3 cm compared to Sutlej with 15-36 cm trans values.

The water of main wetland range from being neutral (pH, 6.97) to alkaline (pH, 7.44) having dissolved oxygen range of 5.5-7.2 mg^{-1}; CO_2,nil to 0.38 mg^{-1}; specific conductance range of 267.3-193.7 µmhos/cm. Observations on above said parameters from two sources of wetland Beas and Sutlej indicate that Beas with more oxygenated waters D.O, 6.3-8.9 mg^{-1} and low total dissolved solids (117.7-77.0 mg^{-1}), having Specific Conductivity range of 236.7 -154.7 mmhos/cm diminishes the untoward impact of Sutlej having low oxygenated waters (DO, 4-4.9 mg^{-1}) with high specific conductance of 411.3-256.0 µmhos/cm especially during pre-monsoon.

Table 14 : Impact of River Beas on ecology of Harike wet land-Soil quality

Parameters / Sites	Seasons	Sand (%)	Silt (%)	Clay (%)	pH	Organic carbon (%)	Free-calcium carbonate (%) (µmhos/cm)	Avl. Phosphorus (mg/100g)	Avl. Nitrogen (mg/100g)	Sp. conductivity
Beas inlet		58.4	29.3	12.3	7.79	0.415	11.42	1.84	6.50	287.3
Sutlej inlet	Pre-monsoon	52.6	31.8	10.6	**8.03**	0.315	17.7	2.56	8.59	306.3
Confluence		66.5	23.7	9.8	7.94	0.250	11.7	2.47	7.65	222.0
Beas inlet		54.4	34.7	10.9	7.60	0.350	5.25	1.80	6.53	236.7
Sutlej inlet	Monsoon	63.2	34.7	11.8	7.63	0.460	7.80	2.00	9.80	344.7
Confluence		60.1	30.8	9.1	7.59	0.335	6.5	1.77	8.87	262.7
Beas inlet		62.2	25.5	12.3	7.47	0.273	4.08	2.73	10.77	262.7
Sutlej inlet	Post-monsoon	60.9	26.4	12.7	7.47	0.480	6.75	3.20	13.04	294.7
Confluence		57.2	26.2	16.6	7.48	0.300	4.88	3.00	11.97	252.7
Beas inlet		70.2	17.4	12.4	7.41	0.690	3.83	1.33	8.49	191.0
Sutlej inlet	Winter	61.8	22.4	13.5	7.41	0.832	6.33	2.33	14.09	**388.3**
Confluence		28.0	10.2	7.41	7.48	0.398	7.00	1.46	7.98	212.0

Table 15 : Impact of River Beas on ecology of Harike wet land-Water quality

Parameters / Sites	Seasons	Water temp. (°C)	Trans. (cm)	pH	DO (mg^{-1})	Alkalinity (mg^{-1})	TDS (mg^{-1})	Sp. cond. µmhos/cm	Ca (mg^{-1})	Mg (mg^{-1})	Cl. (mg^{-1})	Si. (mg^{-1})	Inorgan. Phosphate (mg^{-1})
Beas inlet		27.2	29.0	7.53	7.7	65.3	117.7	236.7	26.0	10.6	26.7	1.5	0.220
Sutlej inlet	Pre-monsoon	29.7	34.7	7.21	**4.4**	**100.0**	204.7	**411.3**	**40.0**	13.0	**34.7**	3.1	0.360
Confluence		29.3	30.0	7.27	7.07	74.0	133.0	267.3	26.3	12.0	24.7	2.4	0.330
Beas inlet		29.3	14.0	7.37	6.3	72.2	100.3	202.3	24.0	14.2	10.3	0.57	0.247
Sutlej inlet	Monsoon	29.3	15.0	7.16	**4.4**	73.3	143.7	285.3	32.7	20.2	12.3	0.49	0.301
Confluence		29.3	14.0	7.44	5.5	68.0	118.0	237.7	27.7	17.4	11.7	0.67	0.273
Beas inlet		20.3	41.3	7.32	8.1	54.0	77.0	154.7	27.0	14.6	16.7	2.7	0.300
Sutlej inlet	Post-monsoon	19.3	36.0	**6.90**	**4.0**	61.3	127.3	256.0	33.0	22.4	25.0	**4.7**	0.440
Confluence		20.0	41.3	6.97	6.0	54.3	54.3	236.0	35.7	19.2	21.0	**4.1**	0.362
Beas inlet		16.7	37.7	7.4	8.9	64.7	80.0	161.3	32.7	13.6	16.0	2.27	0.159
Sutlej inlet	Winter	17.8	28.0	7.2	**4.9**	86.0	144.7	**289.3**	35.3	19.4	26.7	3.40	0.330
Confluence		16.8	36.7	7.3	7.2	70.7	96.0	193.7	37.7	12.6	18.7	2.77	0.221

The pollutional load brought in by Sutlej as depicted by its B.O.D. (21.9 mg^{-1}) and C.O.D. (78.60 mg^{-1}) values too gets diminished at confluence site as was observed by their respective values, 15.18 and 55.18 mg^{-1} at the site some ½ km below. The change is brought in by flushing of Beas due to its waters having low B.O.D. (11.78 mg^{-1}) and C.O.D. (38.83 mg^{-1}) load especially during winter as depicted below

Nutrient load of wetland with calcium 26.3-37.7, magnesium, 12.0-19.2, chloride 11.7-24.7 and silicate 0.67-4.1 mg^{-1} also diminished due to dilution by Beas water as observed in Table 15. Productivity of wetland as depicted by dissolved inorganic phosphate content, 0.221-0.362 mg^{-1} also gets lowered under the impact of Beas having comparatively low inorganic phosphate content (0.159-0.300 mg^{-1}) than Sutlej (0.301-0.440 mg^{-1}).

In nutshell above observations on soil and water quality indicate that river Beas helps in keeping environment of wetland in good condition especially during winter when water ingress from Sutlej is less and pollutant load more.

The impact of River Beas on the pollution load of wetland

B.O.D. (mgl^{-1})					
Site/Season	Pre-monsoon	Monsoon	Post-monsoon	Winter	Av.
Beas	13.7	9.53	10.7	13.2	11.78
Sutlej	19.3	18.70	24.3	25.3	21.9
Confluence	15.0	13.50	12.5	19.7	15.18
C.O.D. (mgl^{-1})					
Beas	43.0	26.9	44.9	40.5	38.83
Sutlej	100	45.1	80.7	88.7	78.60
Confluence	70.7	39.2	46.5	64.3	55.18

Primary Productivity : Gross primary production of wetland varied between 145.83-208.33 $mgC/m^3/hr$ with minimum during post-monsoon and maximum during summer-pre-monsoon unlike its two resources. The average gross production at 3 sites as depiced below showed values higher along Sutlej bank (205.72 $mgC/m^3/hr$) followed by Beas bank (197.92 $mgC/m^3/hr$). The net production (98.95-156.25 $mgC/m^3/hr$) and community respiration (56.25-103.125 $mgC/m^3/hr$) rates too reflect similar seasonal trend.

Gross Production ($mgC/m^3/hr$) at Harike Wetland (2002-05)

Season	Pre-monsoon	Monsoon	Post-monsoon	Winter	Average
SITE					
Beas inlet	187.50	234.37	166.70	203.12	197.92
Sutlej inlet	208.33	265.62	192.70	156.25	205.72
Confluence	208.33	195.313	145.83	177.08	181.63

The ratio between gross and net production at Harike was, 1.46 at Beas inlet, 1.51 at Sutlej inlet and 1.48 at confluence indicating net productivity along wetland is almost similar as evident by nutrient values, thereby indicating that net production of wetland is influenced almost as much by river Sutlej as by Beas.

The ratio between Primary production and Respiration at 3 sites within Harike was 2.5 at Beas and 2.7 at Sutlej and Confluence indicating organic pollution load of main wetland is more due to latter than former river.

Biotic Evaluation

Plankton (Table 16) : Standing crop of plankton within wetland at confluence site was low 219 u/l (294-121 u/l range) compared to that of Beas inlet, 253 u/l (177-328 u/l range) and Sutlej inlet, 235 u/l (132-288 u/l range).

Periphyton (Table 17) : Periphyton concentration too was low at confluence, 348 ucm^{-2} (177-444 ucm^{-2} range) than Beas inlet, 362 ucm^{-2} (211-433 ucm^{-2} range) and Sutlej inlet, 399 ucm^{-2} (223-489 ucm^{-2} range).

Population composition of microphytic vegetation was almost similar all along wetland so far its composition is concerned but variation exists in percentage of each contributing group.

At confluence site, the population was formed by diatoms 34.5%, green algae 20.5%, blue green algae 26.75%, rotifers 9.25% and copepods 9% compared to 45% diatoms, 26% green algae, 11.25% blue green algae, 6.5% rotifers and 11.25% copepods at Beas and 35.5% diatoms 14.75% green algae, 32.5% blue green algae, 13.25% copepods, 3% rotifers and 1% protozoans at Sutlej.

Contributing percentage of bluegreen algae, copepods and rotifers at confluence indicate that Harike population is more influenced by Sutlej than Beas.

The microphytic vegetation of wetland was mainly formed by *Diatoma, Navucula, Frustulia, Amphora, Nitzschia* among diatoms. *Ulothrix, Cladophora Ankistrodesmus* among green algae. *Microcystis,, Spirulina, Phormedium* among blue green algae. *Brachionus, Filina* among rotifers. *Cyclops, Diaptomus* among copepods. All most all forms were present at all sites except that *Frustulia, Tabellaria, Crucigenia* were present only at Beas inlet site having comparatively low pollutional load than rest as such these 3 genera can be classified as non-resistant genera and also *Filina* and *Diaptomus* to some extent as these were present only at Beas bank and confluence site being absent at Sutlej site.

Macrozoobenthos (Table 18) : Average biotic population in the form of macrozoobenthos was 961 um^{-2} (75-2498) at confluence compared to low of 316 um^2 (200-387um^2) at Beas and high of 1390 um^{-2} (312-1599um^2) at Sutlej site.

The population composition like total density varied greatly at 3 sites (Table 18) and exhibited both site and seasonal variation At confluence, it was mainly formed by Gastropods (63.9%) during pre-monsoon, tubificds (bloom) during monsoon and beetle nymphs (50%) during winter. Prawns in the range of 10.35-6.5% were present between post-monsoon to winter. Compared to this contributing population at Beas bank site was formed mainly by Insect nymphs, Prawns being dominant (50.37%) during post- monsoon and absent all together during winter,tubificids although present throughout but abundant during winter (51.0%), Gastropods (nil-19.77%) and Cladocerans (nil-15.15%).

Present during pre-monsoon and Hemiptera nymphs formed bloom during post-monsoon.

At Sutlej bank site benthic density exhibited seasonal trend, being high during winter to pre-monsoon (1599-3112 um^{-2}) when water resources in the river are less. Population was mainly contributed by pollution tolerant communities like ,Oligochaetes, 45.87% (27.3-66.6%) followed by Chironomids, 18.44% (nil-37.39%), Gastropods, 15.90% (7.19-27.13%) and Coleoptera nymphs, 10.08% (3.7-19.23).

Table 16 : Impact of River Beas on Biotope of Harike wet land - Plankton

	Seasons	Total density (u/l)	Percentage Composition (%)							
			Phyto (u/l)	Zoo (u/l)	Bacill.	Chloro.	Myxo.	Rotifera	Copepods	Protozoa
Sites										
Beas inlet		308	247	61	42	31	7	13	7	-
Sutlej inlet	Pre-monsoon	288	249	39	36	17	32	-	14	-
Confluence		294	244	50	32	27	24	10	7	-
Beas inlet		177	144	33	44	19	19	6	12	-
Sutlej inlet	Monsoon	132	99	33	33	8	33	-	26	-
Confluence		121	88	33	28	9	36	18	9	4
Beas inlet		199	166	33	56	22	6	-	16	-
Sutlej inlet	Post-monsoon	255	211	44	44	13	26	4	9	-
Confluence		217	184	33	41	24	20	5	10	-
Beas inlet		328	273	55	38	32	13	7	10	-
Sutlej inlet	Winter	266	233	33	29	21	38	8	4	-
Confluence		-	-	-	-	-	-	-	-	-

Table 17 : Impact of River Beas on Biotope of Harike wet land - Periphyton

	Seasons	Total density (u/l)	Percentage Composition (%)		
			Bacillariophyceae	Chlorophyceae	Myxophyceae
Sites					
Beas inlet		422	57	21	22
Sutlej inlet	Pre-monsoon	440	52	14	34
Confluence		383	46	24	30
Beas inlet		211	58	16	26
Sutlej inlet	Monsoon	223	40	25	35
Confluence		177	56	6	38
Beas inlet		374	70	12	18
Sutlej inlet	Post-monsoon	445	60	10	30
Confluence		389	52	17	31
Beas inlet		433	56	21	23
Sutlej inlet	Winter	489	55	7	38
Confluence		444	50	7	43

Population composition envisage that wetland is equally influenced by both the resources but impact of effluent ingress during monsoon is high via Sutlej than Beas.

Meiofauna (Table 19) : Macrozoo-organisms associated with macrophytes too contribute substantially to food chain of wetland. The density of meiofauna was highest at Sutlej bank side, 57 um^{-2} (118-21 um^2) followed by confluence site, 29 um^{-2}(63-74um^2) and Beas site, 20 um^{-2} (41-4 um^2).

The population at Beas site was mainly formed by Gastropods 38.6 % (6.25-100% range) followed by Prawns, 25.36 % (nil-38.88%). Among Insect nymphs, may fly nymphs 9.2% (nil-27.28%) formed sizeable population followed by beetle nymphs 5.4% (nil-19%).

The population at Sutlej inlet site was contributed mainly by Gastropods, 24.0% (4.45-58.3% range) but to lesser extent than other two sites and by pollution tolerant communities like, Chironomids, 15.93% (nil-37.54% range), Cladoceran, 13.41% (nil-36.23% range), tubificids 8.25% (nil – 23.46%). Among Insect nymphs, Hemipteran were more 22.2% (5.0-27.5%) followed by Odonate nymphs 11.71% (nil-26.66%).

The population at confluence site was mainly formed by Prawns 40.95% (nil-88.2%). Molluscans both Gastropods 15.71% (nil-50% range) and Bivalves, 10.77 %(nil-22.22% range) formed sizeable population. Insects were represented almost equally by all groups (Table 19). The prawn population within wetland was observed to be sustained due to influx of Beas as these were totally absent along the zone influenced by Sutlej.

Fauna of wetland in the form of benthic organisms or associated epiphytic forms had many genera common at all sites like *Baetis* nymphs among may fly, *Notonecta* among Hemiptera, *Berosus larvaii, Dyticus, Hydaticus, Hypophorus* among Coleoptera, *Gomphus, Enallagoma* among Odonates, *Helius* among crane fly larvae, *Chironomous* larvae among diptera, *Lymnaea pinguis, Physa, Gyraullus, V. dissimilaris* and *Corbicula straitella* among molluscans. *Haemopsis, Herpobdella* among Hirudinea, *Tubifex, Limnodrillus* and *Branchiura* among oligochaetes denoting these genera having wide range of tolerance.

But certain forms like *Lithocercus, saidia littoralis, Laccotrepes* among Bugs, *Belostoma* among Beetles; *Psychoda* among diptera, *Glossohponia* among leech and *Hydrachina* (Acari) are present only at Sutlej site denoting these more pollution resistant able to live in depleted oxygen conditions.

Forms like *Enithares, Plea* and *Galastocoris bufo* (Hemiptera), *Argia* (Odonate, *Hydrophilus, Octhebius* (Coleoptera), *Fauna ater* (mollusca) were present only along Beas side hence can be designated comparatively sensitive.

Macrophytes : The vegetation density along wetland like other biotope was outcome of both resources. The density (wet biomass) was 4.84 kg/m^2 at confluence site compared to 7.04 kg/m^2 at Sutlej and 5.64 kg/m^2 at Beas bank site. But macrophyte population showed Sutlej resource having more impact than Beas as population was exclusively formed by *E. cressipes* at both confluence and Sutlej while along Beas bank site, it was formed by *E. cressipes* (70%), *Nelumbo lutea* (nil-20%), *Lemna minor* (nil-10%), *Alternanthres* (nil-10%) and *Ipomia* (nil-4%) although all except water hyacinth were present seasonally.

The abiotic and biotic factors along wetland-confluence site indicate that condition of wetland gets influenced by both resources equally, but impact of Sutlej was more along monsoon to post-monsoon when resources from that sources were more compared to winter. Observations also indicated that river Beas helps in keeping wetland in stabilized condition by diluting the more polluted waters of Sutlej especially its dissolved oxygen content mainly during winter.

Table 18 : Impact of River Beas on Biotope of Harike - Macrozoobenthos

	Seasons	Total density (um^{-2})	Percentage Composition (%)											
			Ephe.	Hemi.	Coleo.	Odo.	Dipter.	Chiro.	Oligo	Gast	Pelecy	Deca	Clad	Misc.
Sites														
Beas inlet		387	-	4.76	-	2.38	-	16.68	11.90	6.61	9.52	33.3	15.15	-
Sutlej inlet	Pre-monsoon	312	-	16.6	19.2	0.18	-	1.28	35.0	2.76	-	-	15.28	-
Confluence		310	-	-	31.90	-	-	1.90	-	3.84	25.0	-	-	-
Beas inlet		300	-	-		1.04	-	-	46.0	19.77	-	33.0	-	-
Sutlej inlet	Monsoon	533	-	-	0.81	-	-	37.39	54.88	7.19	-	-	-	-
Confluence		tubif.bloom	-	-	11.11	-	-	-	bloom	-	-	-	11.11	7.16 [a]
Beas inlet		317	18.57	Bloom	-	-	-	-	2.22	17.77	-	50.37	11.11	-
Sutlej inlet		315	-	3.7	3.7	-	3.7	35.11	27.3	27.13	-	-	-	-
Confluence	Post-monsoon	2498	-	-	-	0.30	-	3.64	71.98	12.75	0.30	10.35	-	-
Beas inlet		200	-	-	-	36.35	3.01	-	51.41	-	9.13	-	-	-
Sutlej inlet	Winter	159	-	-	16.6	-	-	-	66.6	16.6	-	-	-	-
Confluence		975	-	-	50.0	12.5	-	-	-	25.0	-	6.5	-	-

Superscript a = Water nematode

Table 19 : Impact of River Beas on Biotope of Harike wet land - Meiofauna

	Seasons	Total density (um^{-2})	Percentage Composition (%)											
			Ephe.	Hemi.	Coleo	Odon	Chiron	Hirud	Oligo	Gast	Plecy	Deca	Clad	Misc
Sites														
Beas inlet		31	9.52	-	1.15	-	14.96	-	16.09	26.38	6.89	23.80	-	1.15
Sutlej inlet	Pre-monsoon	118	1.40	13.51	21.62	1.75	37.54	-	9.36	4.46	-	-	9.86	-
Confluence		63	1.3	7.11	3.16	3.11	22.11	0.90	1.38	10.89	22.22	-	6.94	12.5 [a]
Beas inlet		4	-	-	-	-	-	-	-	100	-	-	-	-
Sutlej inlet	Monsoon	44	-	2.86	5.71	-	-	5.56	23.64	24.79	-	-	36.23	0.95 [d]
Confluence		7	-	-	3.0	-	-	-	-	50.0	15.0	30.0	-	-
Beas inlet		41	-	-	19.0	12.58	-	2.8	8.3	6.25	12.5	38.77	3.7	-
Sutlej inlet	Post-monsoon	46	-	27.5	6.58	18.43	26.18	3.03	-	8.46	-	-	7.57	2.6 [c]
Confluence		29	-	13.75	9.20	18.64	-	-	3.9	1.95	5.36	45.46	-	1.93 [b]
Beas inlet		8	27.78	-	-	-	-	-	-	22.0	11.0	38.88	-	-
Sutlej inlet	Winter	21	-	5.0	-	26.66	19.99	-	-	58.3	-	-	-	-
Confluence		17	11.77	-	-	-	-	-	-	-	-	88.23	-	-

Significance of Superscrip. t a = Fish spawn; b = Acari; d= Crab ; c= Crane fly larvae

6. CONCLUSION

Environmental status of Beas

The present study of river Beas within plains of Punjab has indicated that river from Talwara to Mirthal (dist. Gurdaspur) is subjected to heavy water abstraction due to diversion of its resource into Shah Canal and to some extent by soil erosion via Chakki bank stream, but still retains clean environment

River is polluted at Mukerian only that too on point pollution discharge site due to induction of industrial cum municipal effluents through various Nallas, main being Chakwal.

River after Mukerian especially Terrikein village regains clean environment due to induction of water resources from Shah Canal. River at Harike around its culmination with Sutlej is again subjected to effluent load mainly organic through Kali/West Bein.

Impact of water abstraction

Manipulation of water resources has decreased water volume in app. 50-60 km of Beas resulting in habitat loss for some biotic communities mainly plankton (80 u/l) resulting in low Gross primary production (177.0 mgC/m^3/hr) and low fish production, 12.0-38.6 t/year especially of quality fish like IMC (nil-1.07%) and large size catfish (nil-2.13%).

Sufficient presence of other biotic forms like periphyton concentration (634 ucm^{-2}), macrozoobenthos density (605 um^{-2}) in upper abstracted stretch envisage that the zone contains food resources for particular fishery-bottom dwelling with browsing feeding habits, yet the fish produce of 0.116 t/km/month is less than lower stretch, 0.185 t/km/month; mainly due to water constrain as observed by monthly catch estimate. The total catch at Talwara (2 to 4 t/month) and Pathankot (2.40-6 t/month) was high between March to September when water resources were minimum (300-377 cusecs) indicating fishes succumb more to outside pressure -fishing during the period.

Quality fishery like IMC and large size catfishes get restricted to lower Beas where these represent 18 to 51.48% and 4.32-20.78% of total population respectively. Near absence of this fishery may be due to insufficient water resources to sustain it above Mukerian with the result their overall production gets hampered.

Minimum outflow 300-320 cusecs during monsoon below Talwara barrage cause also severe breeding strain to IMC fishery as these are not able to take upward breeding run during breeding season.

Impact of various pollutional load in production potential

The two effluent carriers, *Chakwal Nalla* and *Kali Bein* tributary once facilitating breeding of Beas fishery have become sort of death traps for brooders as well as general fishery.

Chakwal Nalla due to its carcinogenic effluent causing anerobic conditions (D.O., 2.77; B.O.D., 30.6 and C.O.D., 288.4 mg^{-1}) Kali Bein for its high organic silt load, heavy macrophyte infestation and drying up nature.

However, as far as their impact on general productivity is concerned, these do not make Beas waters critical (D.O., 6-8 mg^{-1}) or unproductive (T. alkalinity, 54-96 mg^{-1}) rather productivity gets enhanced as is evident by high gross (194.37-207.03 mgC/m^3/hr) and net production (117.18-135.36 mgC/m^3/hr) along the influenced sites. Density of various food webs mainly plankton (99-220 u/l) get increased, concurrent with availability of food as well as water resources, fish

production gets enhanced. Total fish catch of Beas along the stretch having in flux of pollutants (Mukerian to Harike) ranged between 2.16 to 11.79 t/m/year, culminating in fish produce of 0.1850 t/km/month.

Availability of more water resources ensured availability of quality fish like IMC (18.51-51.48%) and large size catfishes (4.32-20.78%) indicating that pollutants of observed magnitude do not have negative impact as long as availability of water is sufficient

Status of Beas in terms of fishery

Perusal of 3 year data show that average fish produce from Beas was 260 tons / year being 26.0 t/ month contributed by 54 fish species out of which 31 species form main stay commercial fishery.

Upper abstracted stretch contains cold water eurythermal fishery, minor carps mainly *L. dero, L. dyocheilus* and *Puntius* sp.,contributing, 87.3% of total population. Mahseer, mainly *T. putitora* contribute 0.03-5.44% of population.

Presence of cold water carp, *S. richardsonii* at Pathankot landing centre (nil -3.64%)only during winter to pre-monsoon suggest that this fish species may be ascending into Beas via *Chakki tributary* for feeding purpose.

Lower Beas has abundance of commercial fishery like IMC, large size catfishes, Murrels etc. It also has sizeable amount of Common carp contributing 3rd highest group representing 22.02% of total population..

Introduction of this fish no doubt takes place in uplands (Pong and Talwara dam) but the fishery has established in Potomoan zone too, mainly around places having conducive lotic type of environment i.e. near Talwara and Harike barrages, than in stretches having lentic type of environment (Mukerian to outskirts of Harike).

Existence of thai magur, *Clarias gariepinus* although localized (Harike) and intermittent nonetheless was observed to have invaded the system.

In brief it was observed that diversion of water resources than pollutional influx affect ecology and fish productivity of Beas.

Fishing by Chatti Jal and Rope Loop type which takes away juvenile fishery brooders from the system affects the natural recruitment hence final produce.

RECOMMENDATIONS FOR CONSERVATION AND SUSTANANCE OF FISHERIES IN RIVER BEAS

Sustenance of resources 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 Beas sub basin of Indus system.

6.1 Eco-conservation :

Eco-conservation in river Beas-like any other river having trans state boundaries necessitates national approach beyond state boundaries, as the action in uplands greatly affects the lower basin, like sedimentation caused by deforestation in Himachal Pradesh. **Massive forestation programme along foot-hills of Shiwalik Himalaya needs to be undertaken to halt soil erosion.**

Commercial exploitation of Beas bed along Talwara to Mirthal segment for extraction of stones/ pebbles and its tributary-mainly Chakki should not be allowed in all seasons as it affects breeding ground and food web, especially of Mahseer fishery and of Schizothorax , both endangered speceies.

Problem of pollution within Beas although not serious currently still may be causing over all stress on the fishery especially during winter when B.O.D. (15.3-20.7 mg^{-1}) and C.O.D. levels (51-115 mg^{-1}) shoot up in affected stretch due to Chakwal Nalla effluent. Presence of large number of saprophilic forms in the food web and colonization of macrophytes at tail end under the impact of Kali Bein, is also cause of concern, because environmental changes causing change in food spectrum may affect growth of individual fishery causing change in fish spectrum as well as fish production. Therefore it is necessary to tackle the problem of pollution by concerned authority-Punjab Pollution Control Board.

For better environment and sustained fish production within this river, industrial treatment plants should come up along the course of Beas at Mukerian and Goindwal.

Sewage treatment plants at Beas town onwards need to be formed along both banks of Beas as these are heavily populated. **Sewage treatment plants are absolutely essential along Kali/West bein to diminish organic load of Bein and Beas**.

The Harike zone of river contains sufficient fishery resources, almost 50% more than rest, but growing siltation and water hyacinth infestation is cause of concern. Deweeding of the site should be taken up on annual basis and desilting on time frame period to maintain aqua-resources thereby fish productivity of this wetland

Removal of water hyacinth from Kali Bein (after barrage to confluence with Beas) is absolutely essential for breeding of Harike fishery and over all productivity not only of Beas but that of Sutlej as well.

Maintenance of 200 cusecs of water within Kali Bein should be made mandatory throughout the year to maintain flow. Water thrift from Kali Bein for irrigation purposes be banned and made punishable offence.

Use of Chatti jal and Rope-loop type of fishing be strictly banned . To make it successful exercise the yearly hike in auctioning amount by concerned deptt without any rationale should be abandoned so that contractor is not forced to raise the amount by illegal methods

6.2 Development Measures

The upper stretch of Beas between Talwara to Mirthal was observed to be condusive for eurythermal carps like *L. dero* and *L. dyocheilus*, production of same can be enhanced by ranching the stretch with seed of resident minor carps

For sufficient seed availability artificial propagation of these carps need to be standardized.

Talwara dam should be stocked with Mahseer - *T. putitora* seed as well in addition to common carp as ecology of the site is conducive for this fishery too.

Chakki tributary need to be exploited for brooders of *S. richardsonii*. The seed obtained from these can be utilized in upper region of same tributary where large scale mining is not taking place.

Gene pool of *C. catla.*, *M.aor* and *N,chitala* from river Beas need to be preserved for future. All these fishes have healthy growth and grow up to vth/stage. The former although forming 2.35% of T. population only forms 8.6% of its own population in Vth/group.

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ANNEXURE 1

FISH SPECIES RECORDED FROM RIVER BEAS (TALAWARA-HARIKE)

I. ORDER : CLUPEIFORMES

Sub order : Clupeoidei

Family : Clupeidae

1. *Gadusia chapra* (Ham)

Sub order : Notopteroidei

Family : Notopteridae

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

II. ORDER : CYPRINIFORMES

Family : Cyprinidae

4. *Chela bacaila / oxygaster*
5. *Tor putitora*
6. *Puntius sarana*
7. *Puntius sophore*
8. *P. straitus*
9. *P. conchonius*
10. *P. tetraarupagus*
11. *P. chrysopterus*
12. *P. puntius*
13. *P. punjabensis*
14. *Catla catla*
15. *Cirrhinus mrigala*
16. *C. reba*
17. *Labeo rohita*
18. *L. calbasu*
19. *L. dero*
20. *L. dyocheilus*
21. *L. gonius*
22. *L. bata*
23. *Osteobrama cotio*
24. *Cyprinus carpio communis*

25. *C. c. specularis*
26. *Schizothorax richardsonii*

    Family : Cobitidae
27. *Botia birdii*
28. *Lepidocephalichthys guntea*

III. ORDER : SILURIFORMES

    Family : Bagridae
29. *Mystus aor*
30. *M. seenghala*
31. *M. vittatus*
32. *M. tengra*
33. *M. bleekeri*
34. *Rita rita*

    Family : Sisoridae
35. *Bagarius bagarius*

    Family : Siluridae
36. *Ompak pabda*
37. *Wallago attu*

    Family : Schilbeidae
38. *Eutropiicthys vacha*

    Family : Heteropneustidae
39. *Heteropneustes fossilis*

    Family : Clariidae
40. *Clarias batrachus*
41. *C. gariepinus*

IV. ORDER : SYMBRANCHIFORMES

    Family : Amphinoidae
42. *Amphipnuos cuchia*

V. ORDER : BELONIFORMS

    Family : Bedlonidae
43. *Xenantodon cancilla*

VI. ORDER : CHANNIFORMES

    Family : Channidae
44. *Channa marulius*

45. *C. punctatus*

46. *C. straitus*

VII. ORDER : PERCIFORMES

Family : Nanidae

47. *Nandus nandus*

Family : Ambassidae

48. *Ambasis ranga*

49. *A. nama*

Family : Anabantidae

50. *Colisa fasciatus*

Family : Goboidae

51. *Gobius giurius*

52. *Glossogobius*

VIII. ORDER MASTACEMBELIFORMES

Family : Mastacembelidae

53. *Mastacembelus armatus*

54. *M. pancalus*

Fish-Diversity in Beas (Potomoan Zone)

Endangered species	:	*Ompak pabda*
Vulnerable species	:	T. *putitora, L. dero, L. dyocheilus.* (Carps) *B. bagarius* (catfishes)
Indeterminate species	:	*E. vacha, X. cancilla*
Rare species	:	*Botia birdi, Lepidocephalichthys guntea, Mystus vittatus, M. bleekeri, Amphipnous cuchia*

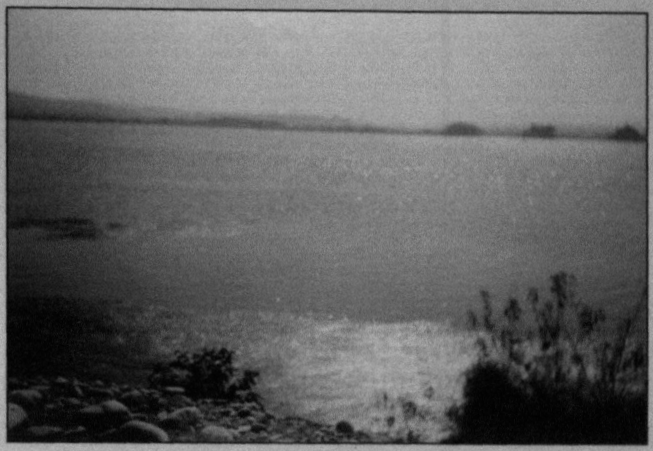

Fig. 1 River Beas at Talwara above barrage

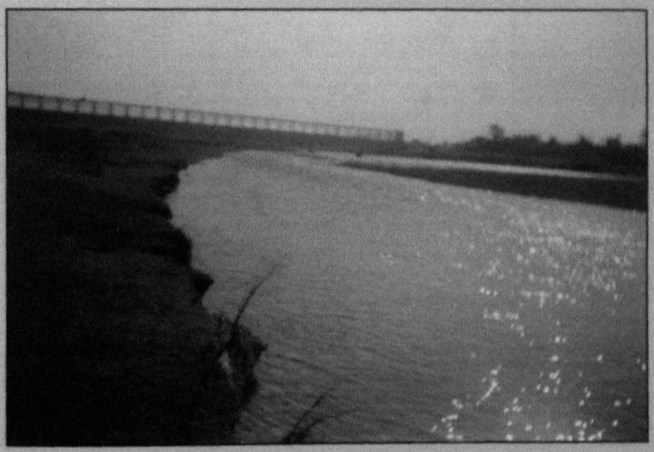

Fig. 2 River Beas at Talwara below Barrage (Post-monsoon)

Fig. 3 Beas at Talwara below Barrage (Monsoon)

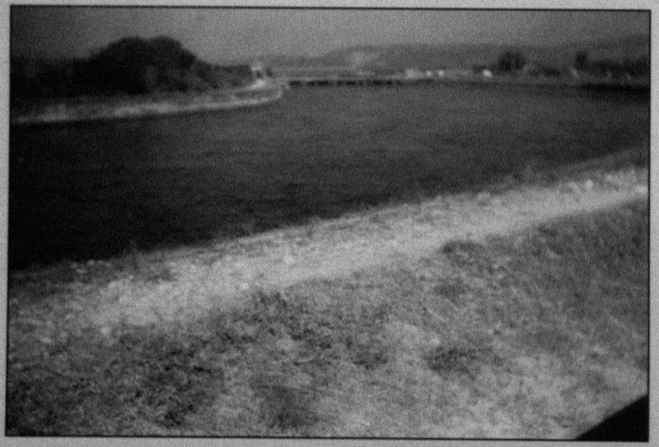

Fig. 4 Shah Nehar at Talwara

Fig. 5 Reinduction of Shah Nehar into River Beas at Terrikein

Fig. 6 River Beas at Mukerian at the induction of Chakwal Nalha

Fig. 7 Inlet of River Beas at Harike showing Siltation

Fig. 8 Inlet of River Beas at Harike

Fig. 9 Confluence site at Harike (Note the difference in colour of two rivers)

Fig. 10 Confluence site at Talwara showing dominance of *C. Carpio*

Fig. 11 Fish landing at Pathankot (winter) showing dominance of Mahseer

Fig. 12 Fish landing at Harike showing presence of large size cat fishes

Fig. 13 Fish landing at Mukerian showing presence of IMC and cat fishes

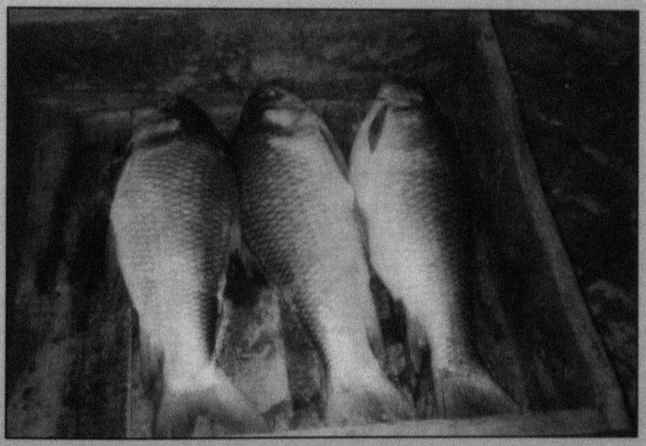

Fig. 14 Presence of *C. catla* at Harike

Fig. 15 Kali Bein before induction into Beas (Alluwal village) Infestation of water hyacinth

Fig. 16 Kali Bein at Source

Fig. 17 Presence of *Clarius Garieprinus* at Harike

Fig. 18 Fish Market at Amritsar