1972; Topani 1989). The species composition of benthic life was done group wise, genera-wise and wherever possible, species wise.

v) Analysis of Fish fauna:

Fishes were collected regularly by indigenous methods viz., by bait and hook, and by cast net. Fish catch in the stretch of river Beas from Manali to Bhunter were recorded by visting the local fish markets at Manali, Patlikulah, Raison, Dhobhi, Kullu and Bhunter. Besides this information regarding annual fish catch was also collected from the fish personnels of state fisheries department. Collected specimens were preserved in 5% formalin with a small abdominal incision. Fishes were identified using keys given by Day (1875), Jayaram (1999), Tilak and Husain (1977), and Talwar and Jhingran (1991). All the data of collections of four sites were pooled and average value was taken.

Chapter- 4.0 OBSERVATION

CHAPTER- 4.1 PHYSIOGRAPHY OF STUDY AREA

Himachal Pradesh has an over all total geographical area of 55,673.00 sq.mts. Himachal Pradesh is situated between 32^0 22' 40" to 33^0 12' 20" north latitude and 75^0 47' 55" to 79^0 04' 20" east longitude. The Himachal Pradesh is surrounded on the north by Jammu-Kashmir, on the northeast by Tibet, on the east and southeast by Uttaranchal on the south by Haryana and on southwest and west by Punjab as shown in fig. 1.

Topographically, the state represents mountainous to sub-mountainous terrain, the altitude of which range from 350 meters to 6975 meters above mean sea level. This terrain is endowed with iced cap peaks, winding hillocks, glacier-laden lakes, and natural water resources in the form of snow fed rivers, basin and spring fed streams. It is drained by a number of rivers; the most important among them are Beas, Satluj, Ravi, Chenab and Yamuna. These rivers originate from the Himalayas and have perennial source of water being fed by snow during summer.

The river Beas and Satluj are the two principal rivers of the district Kullu and these two rivers receive the entire drainage of the district. District Kullu is situated between 31^0 58' 00" north latitude and 77^0 06' 04" east longitudes. The Kullu district forms a transitional zone between the lesser and the greater Himalayas and present a typical rugged mountainous terrain with moderate to high relief. The altitude varies from 1300 meters to over 6000 meters from the mean sea level. The high reaches are bestowed with magnificent snow peaks and glaciers. The important glaciers of the district are Kalihen, Tirchu, Savaomga, Parbati, Beas Kund, Dibbi and Mantalai. Forest constitutes a major proportion of the total land. Deodar attains considerable dimensions in the upper Beas and Parbati valley.

All the higher ranges have dense forest valleys while as one descends lower, the growth of forest is less. Deodar, Kail, Cheel, Walnut, Rae, Tosh and Deodar are also available in plenty. A number of rivers, streams, ponds, tanks, cold-water lakes found in Kullu valley are shown in table-1.

Table-1. Perennial Rivers and Streams of Kullu Valley-

Name of River/Stream	Origin	Length (Kms.)
Phojal Nala	Kathi Kukri	20
Kothi Nala	Chander Tal	25
Thugri Nala -	-	40
Aleo Nala	Tahegan	25
Beas River	Pir Panjal	120
Anni Khad	Jolodejot	20

Shamsher Khad	Kanda Jot	20
Salwad Khad	Ranokot Jot	25
Kuppon Khad	Bajhar Jot	20
Shalwad Khad	Kanon	4
Dhaugi Nala	Dhaugi	5
Jeeva Nala	Majhan	10
Nahada Nala	Upereenahi	5
Suchahen Nala	Suchain	3
Shadhand Nala	Shadhand	5
Wah Nala	Shakti	6
Sainj Khad	Supakuni	45
Plachan Khad	Plach	45
Bashlehu Nala	Bashlehu	14
Tirthan River	Tirth	55
Ghidhar Nala	Basheer	5
Dehri Khad	-	5
Jimmi Khad	Sujad	12
Manglor	Garagushani	20
Seera Nala	Palchip (Panihar)	12
Hurla Nala	Chukran	5
Satluj River	Mansovar Lake	40
Mohal Khad	Gugli	21
Parvati River	Mantalai, Kheer Ganga	90
Sarvari Khad	Gordoth	40
Rauli Khad	Sheela Gadh	35

Jagat Sukh Nala	Cheeka Seri	25
Haripur Nala	Rtalab Seri	30
Chaki Nala	Chandrakhni	25

Pond / Tanks and Cold water lakes of Kullu Valley-

Particulars	Name	Area
Area more than 10 ha.	Chander Tal	11.25 ha.
Area more than 10 ha.	Kotlu Thach	12.50 ha.
Area more than 5 ha.	Parbathi Thach	6.00 ha.
Area more than 5 ha.	Umand nal	6.75 ha.
Area more than 5ha.	Umanga Pass	6.00 ha.
Area more than 5 ha.	Sarathach	5.00 ha.
Area less than 5 ha.	Small lakes (43)	70.80 ha.
	Total	118.30 ha.

The River Beas, selected for the study, originates from the Pir Panjal range near Rohtang Pass (Beas Kund) at a height of 4062 meters above the mean sea level and flows southwards for about 120 Kms. It receives river Parbati- a large main tributary and the other tributaries on the east at Bhunter which spread out in the shape of a fan based on the length of the river between Bhuin and Larjee, while a number of tributaries like- Solang, Manalsu, Sujain, Fozal, nalah and Sarwari confluent on the right of its west bank. The Sainj is fairly large river flowing to west from Supa Kuni a high peak (on the Spiti boundary. It joins the Beas at Larjee. River Tirthan a tributary joins the Sainj a little above the junction of the latter with the Beas. The disposition of the river Beas and its tributaries are shown in fig. 2.

CHAPTER- 4.1 (A) STATUS OF SELECTED SITES OF THE RIVERBED

Four sampling sites along the course of 50 km of river Beas in Kullu district were selected viz., Bhunter, Kullu, Patlikulah and Manali. The sites were selected on the basis of ecological parameters, interventing distance, water flow, benthos complexities, density of riffles, pools, cascades, approach ability, fishing potential etc. The sampling sites were approachable in all months/seasons of the year.

The disposition of the experimental sites of river Beas in Kullu valley is shown in Fig.-3.

Site-1) BHUNTER

The altitude of Bhunter is 1102 (msl), longitude 31^0 52’ 877” and its latitude is 77^0 09’ 106” and was located near to Bhunter airport. This site was 10 km away downward from Kullu town. At this site the riverbed was formed of 85% small boulders and stones and 15% is sand. Boulder size ranged from ½ feet to 3½ feet. Stones in the pool of the river covered with algae. Site was slightly polluted due to the sewage effluents. The riverbed was visible during winter season. (Fig. - 4)

Site-2) KULLU

The altitude of Kullu is 1146 (msl), longitude 31^0 55’ 713” and its latitude is 77^0 06’ 975”. This was 6 Km upwards to Kullu town and river water in the form of cascade. At this site water current was very fast. The riverbed was comprised of big boulders and stones. Boulder size ranged from ½ feet to 5 feet. During winter water level reduced exposing big boulders. Stones on the bank of the river were covered with algae. The river has Pine and Tosh trees on its both the banks (Fig. - 5).

Site-3) PATLIKULAH

The altitude of Patlikulah is 1701 (msl), longitude 32^0 08' 435" and its latitude is 77^0 10' 341". This site was located below the Patlikulah-Naggar Bridge, it was 23 km upwards to Kullu town. This site existed in the form of pools. Water current was medium to fast. The riverbed was comprised of big boulders and stones. Boulder size ranged from ½ feet to 4½ feet. Fishes were also visible during winter season over the bridge (Fig. - 6 & 7).

Site-4) MANALI

The altitude of Manali is 1924 (msl), longitude 32^0 13' 478" and its latitude is 77^0 12' 349". The site was 51 Km away from the origin place, Rohtangpass (Beas Kund) of the river. This site was in the form of riffles. Water current was fast. The water was splashed over the boulders and Stones. The riverbed was formad of big boulders and stones. Boulder size ranged from ½ feet to 6 feet. Due to heavy current and splashed water condition, bottom was not visible throughout the year (Fig. - 8).

CHAPTER- 4.1 (B) HYDROLOGY OF THE RIVER

Flow of current

The flow of water current in river Beas was not the same throughout the year. In rainy season, the rate of flow was recorded 432 cubic feet /sec. and 378 cubic feet/sec. was recorded during winter season.

Concentration of pools, cascade and riffles

The selected site of river Beas comprised of a number of pools, cascade and riffles etc.

Deptht

The average depth of the river Beas was 1 – 1.5 metre in winter season and 3 – 4 metre in summer and monsoon season (Fig. - 9).

Width

The average width of the river Beas was 50 metres (Fig. - 10).

Site-1 Bhunter

At this site water current was slow. Here the river water was in the form of pool.

Site-2 Kullu

At this site current of water was fast, water was deep and river was in the form of cascade.

Site-3 Patlikulah

The water current at this site was medium to fast. Here the river was in the form of riffle.

Site-4 Manali

At this site water current was fast. Here the river was in the form of cascade.

CHAPTER- 4.1(C) METEOROLOGICAL CONDITIONS

In any ecosystem abiotic and biotic factors are inseparable, inter-related and inter-act upon each other. Ecological study will be meaningless if the meteorology of the area is not studied. The meteorological data of two years of study presented here were obtained from Agriculture research station Bajaura (Jhiri).

Atmospheric temperature

The minimum atmospheric temperature was recorded during February (7.5 °C) and maximum during June (32.2 °C) in first year, while it was minimum (11.5°C) in January and maximum (28.0°C) in the month of June during second year of study. The coldest months of the study period were January/February whereas the hottest month was June during both the years. The mean air temperature of both the years was observed to be 20.5 °C (Table 2 a & b; Fig. - 11).

Rain fall

Except for October 2003 and March 2004, every month had showers. The minimum and maximum rain fall was recorded in the month of December (6.4mm) and March (140.3mm) respectively during first year of the study. During second year the minimum and maximum rain fall was recorded in November (5.0mm) and October (155.0mm). Fluctuation in water level was directly related to the rain fall. Range of variation in average monthly rainfall was from 5.0mm – 155.0mm during the period of investigation (Table- 2 a & b; Fig. - 12).

Relative Humidity

In both the years, slight fluctuations in relative humidity were recorded in morning hours and high fluctuations recorded in evening hours. The minimum and maximum relative humidity was recorded in October (26.0%, in evening) and November (94.0%) in morning) respectively during first year. In second year, of the study the range of variation was 82.0% - 93.0% (in morning) and 25.0% - 62.0% (in evening) (Table 2 a & b; Fig.- 13 &14).

Table-2 a. Fluctuation in Air temperature, rainfall and relative humidity of the valley from December 02 – November 03.

Month	Air temperature (°C)	Rainfall (mm)	Relative Humidity (%age)	
			Morning	Evening
Dec., 2002	13.2	6.4	91.0	35.0
Jan., 2003	12.2	25.0	92.0	37.0
Feb	7.5	226.9	92.0	46.0
Mar	16.7	140.3	87.0	42.0
Apr	25.0	70.9	87.0	44.0
May	22.6	17.7	80.0	38.0
Jun	32.2	57.0	80.0	36.0
Jul	28.8	59.4	88.0	55.0
Aug	27.2	115.7	92.0	61.0
Sep	27.8	69.1	91.0	58.0
Oct	24.8	0	89.0	26.0
Nov	12.8	24.4	94.0	39.0
Mean	**20.9**	**59.4**	**88.5**	**43.0**

Max.	**32.2**	**140.3**	**94.0**	**61.0**
Min.	**7.5**	**6.4**	**80.0**	**26.0**

Table-2 b. Fluctuation in Air temperature, rainfall and relative humidity of the valley from December 03 – November 04.

Month	Air Temperature(°C)	Rainfall (mm)	Relative Humidity (%age)	
			Morning	Evening
Dec., 2003	13.6	37.7	93.0	44.0
Jan., 2004	11.7	121.7	92.0	49.0
Feb	13.8	31.1	91.0	39.0
Mar	19.0	0	86.0	25.0
Apr	23.3	66.5	83.0	31.0
May	24.5	101.9	84.0	28.0
Jun	28.0	30.3	82.0	45.0
Jul	26.8	108.7	84.0	49.0
Aug	27.8	152.1	92.0	62.0
Sep	26.1	13.2	87.0	49.0
Oct	14.2	155.0	91.0	50.0
Nov	14.5	5.0	93.0	41.0
Mean	**20.2**	**68.1**	**88.1**	**42.6**
Max.	**28.0**	**155.0**	**93.0**	**62.0**
Min.	**11.7**	**5.0**	**82.0**	**25.0**

CHAPTER- 4.2 PHYSICO-CHEMICAL FACTORS OF WATER

Each organism that lives in water extracts some energy and material from it. Life is possible only within a narrow range of conditions which water maintains in an aquatic environment. The biology of fish can not be understood in isolation from the surrounding water. The Physico–chemical factors of the water, in one way or another influence the aquatic life. Fish assemblage depends upon the physico - chemical environment, hence changes in composition of a fish community often indicate a variation in temperature regime, dissolved oxygen, pH, salinity, and water flow. Therefore, abiotic factors play an important role in determining fish communities. The physico-chemical factors of river water were studied from December 2002 to November 2004 and its seasonal variations have been depicted in table 3 a & b.

i) Water Temperature-

Temperature is one of the most important factor, which affects the biota as well as other factors. Low temperature reduces metabolic activity. Feeding, breeding, respiration and all other physiological activities of fish are influenced by temperature. Results of the present study showed that the fluctuations of water temperature ranging from 5.2 ^{0}C-17.7^{0}C in the first year while between 6.8 ^{0}C-17.2^{0}C during the second year. The mean water temperature of both the years was observed to be 11.7^{0}C. It was high during monsoon and low during winter. The value of water temperature showed regular decrease from September to January and then showed increasing trend during both years of the investigation (Table 3 a, b & c; and Fig.15)

ii) Transparency -

The penetration of light into water is critically important to fishes because of its role in i) producing heat ii) driving photosynthesis, which directly or indirectly provides feeding opportunities iii) providing behavioral or reproductive clues iv) allowing sufficient illumination for permit visual activities like foraging or finding mates (Matthews, 1998). Thus, it is important to measure the transparency of a water body. Results of the present study showed that the transparency of the river water ranged between 6.1 cm. - 53.2 cm. during first year. The highest value was recorded during November and the lowest in month July. In second year, transparency varied from 4.5 cm. - 62.3 cm. being maximum in December where as minimum was recorded in August. Mean of two years observation was commuted 30.1 cm. (Table 3 a, b & c; Fig.16)

iii) Hydrogen ion concentration (pH) -

pH of water is an important factor that influences metabolism of organisms inhabiting it. Measurement of pH is most important and frequently used to test water chemistry. Fishes are relatively poor regulators of internal pH, thus changes in the pH of their environment can alter enzyme activities of electrolyte composition of body fluid, causing severe stress. Low pH interferes with oxygen uptake and pH outside a range of 4.0 -10.00 can kill fish (Matthews, 1998). Therefore, study of this factor is highly important. During the first year the range of pH was recorded between 7.0 - 7.7 with a mean of 7.3 while during the Second year it ranged from 7.0 - 7.6 with a mean of 7.2. The mean pH of both years was observed to be 7.2. The minima and maxima pH were observed in the month of September, October and August respectively, during first year. During second year, minimuma and maximums pH was observed in the month of October and January respectively. The mean pH of both periods was absorbed to be 7.2. The mean of pH for all months indicated alkaline water, which was quite suitable for fish. (Table3 a, b & c; Fig.17)

iv) Dissolved Oxygen-

Dissolved oxygen is essential for the metabolism of all aerobic aquatic organisms and oxygen distribution is important for the direct need of many organisms. It affects the solubility and availability of many nutrients and therefore the productivity of aquatic ecosystem. Hence, determination of this factor is essential. During the first year of the study the range of dissolved oxygen was recorded 9.2 ppm - 12.6 ppm with a mean of 10.7 ppm, while during second year it ranged from 9.7 ppm - 12.8 ppm with a mean 10.7 ppm. The minima and maxima were recorded in August and December respectively during first year. During second year, minima and maxima were observed in July and December respectively. The mean dissolved oxygen of both the years was observed to be 10.7ppm. (Table3 a, b & c; Fig.18)

v) Total Alkalinity-

The alkalinity is a term that refers to the buffering capacity of the carbonate system in water. Alkalinity or acid combining capacity, which is generally caused by the carbonates and bicarbonates of calcium and magnesium, is an important parameter for assessing the productivity of fresh water. In the first year total alkalinity ranged from 53.7 ppm - 85.0 ppm with an average of 68.7 ppm, while it varied from 60.0 -85.6 ppm with an average of 72.0 ppm during second year of the study. Maximum alkalinity was observed in February in both the years where as the minimum alkalinity was observed in August in first year and May, June in second year. The mean alkalinity of two years was 70.3 ppm. (Table 3 a, b & c; Fig.19)

Table.3 (a) Monthly fluctuations in Physico-Chemical factors in River Beas during Dec.02-Nov. 03.

Months	Water Temperature(^{0}C)	Transparency (cm)	pH	Dissolved Oxygen (ppm)	Alkalinity (ppm)
Dec., 02	6.2	51.5	7.5	12.6	75.6
Jan.,03	5.2	47.8	7.6	12.0	70.6
Feb.	7.1	43.3	7.4	11.2	85.0
Mar.	9.2	46.1	7.4	11.2	83.1
Apr.	11.3	51.5	7.3	10.0	80.1
May.	10.0	29.3	7.1	10.8	61.2
Jun.	12.8	10.2	7.3	10.2	57.5
Jul.	16.0	6.1	7.5	9.7	59.3
Aug.	17.7	7.7	7.7	9.2	53.7
Sep.	17.1	9.9	7.0	9.9	56.2
Oct.	12.9	29.5	7.0	10.9	67.5
Nov.	8.1	53.2	7.4	11.4	75.6
Mean	**11.1**	**31.4**	**7.3**	**10.7**	**68.7**
Max.	**17.7**	**53.2**	**7.7**	**12.6**	**85.0**
Min.	**5.2**	**6.1**	**7.0**	**9.2**	**53.7**

Table. 3(b) Monthly fluctuations in Physico-Chemical factors in River Beas during Dec. 03-Nov. 04.

Months	Water Temperature(^{0}C)	Transparency (cm)	pH	Dissolved Oxygen (ppm)	Alkalinity (ppm)
Dec., 03	8.2	62.3	7.5	12.8	75.6
Jan.,04	6.8	51.1	7.6	12.5	84.3
Feb.	8.5	38.1	7.4	10.8	85.6
Mar.	9.9	33.0	7.3	10.6	82.5
Apr.	12.5	31.5	7.1	10.3	80.6

May.	13.8	28.2	7.3	9.9	60.0
Jun.	15.8	15.2	7.1	10.1	60.0
Jul.	17.0	5.5	7.4	9.7	61.2
Aug.	17.2	4.5	7.3	9.8	60.0
Sep.	15.5	9.5	7.1	10.8	63.7
Oct.	14.0	25.3	7.0	11.0	68.7
Nov.	8.7	43.7	7.4	11.2	82.5
Mean	**12.3**	**28.9**	**7.2**	**10.7**	**72.0**
Max.	**17.2**	**62.3**	**7.6**	**12.8**	**85.6**
Min.	**6.8**	**4.5**	**7.0**	**9.7**	**60.0**

Table.3(C) Commuted mean of physico-chemical factors of River Beas from Dec. 02-Nov. 04

2002-03	**11.1**	**31.4**	**7.3**	**10.7**	**68.7**
2003-04	**17.2**	**28.9**	**7.2**	**10.7**	**72.0**
Mean	**11.7**	**30.1**	**7.2**	**10.7**	**70.3**

CHAPTER- 4.3 a) STUDIES OF PLANKTON FAUNA

The plankton concentration in general was poor in the river Beas. The average number of total plankton (Phytoplankton and Zooplankton) encountered during the period of study was 169.8 units/litre. During first year, total planktons encountered ranged between 31.0 units/litre to 380 .0 units/litre with annual mean of 132.0 units/litre. However, during second year the planktonic fauna having commuted mean 207.5 units/litre varying between 49.0 units/litre to 577.0 units/litre depicted increased treand.

Phytoplankton contributed 91% where as zooplankton contributed 9% during the two year of investigations. The cycle of standing crop of plankton indicated that February was the peak period in both the years. The range of qualitative abundance of plankton in river Beas is shown in table 4 and Monthly fluctuations of phyto and zooplankton has been given in Table 5 a, b & c and Fig 20, 21 & 22.

Phytoplankton-

In present study, Phytoplankton formed the major component of the total and thus found mainly responsible in determining the fluctuations of total plankton. During first year the annual mean of phytoplankton 88.4% (116.8 units/litre) of total composition ranging between (21.0 units/litre) minimum in August and maximum was in February i.e. 374.0 units/litre, while in second year annual mean was recorded 92.6% (192.4 units/litre) of total composition ranging between 43.0 units/litre minimum in August and maximum was in February (568.0 units/litre.)

Phytoplanktons were comprised of members of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Rodophyceae. Qualitatively the algal flora of the river was largely composed of Chlorophyceae, as the dominant group followed by Bacillariophyceae and Cyanophyceae and Rodophyceae was placed fourth in order of abundance but quantitatively Bacillariophyceae took the lead during most of period of investigation. Monthly fluctuation of various groups of phytoplankton is shown in table 6 a, b & c and Fig. 23, 24, 25 & 26.

Bacillariophyceae:

In view of crystal clear, pollution free, cold water of Beas, *Bacillariophyceae* constituted the major portion (50.3%) of phytoplankton. Two year commuted mean was recorded (77.9) ranging between minimum 14.0 units/litre to 166 units/litre maximum. In all six species of diatoms were recorded. The species in order of abundance were Gomphonema, Cymbella, Cyclotella, Navicula, Synedra and Amphora. During the first year of investigation annual average value (units/litre) of Bacillariophyceae was 59.8 (51.2%) ranging from minimum 14.0 units/litre (August) to 112.0 units/litre (January) maximum. The second year annual average recorded was 96.0 (49.8%) with a minimum range in August i.e., 33.0 and maximum 166 units/litre in November. (Table 6a, b & c: Fig. 23).

Chlorophyceae:

Quantitatively *chlorophyceae* constituted the sub-dominant component of phytoplanktan contributing (46.5%) of the phytoplanktonic fauna. This group was mainly represented by *Schroederia spp., Closteridium spp., Ulothrix spp., Clostoriopis and Selenastrum spp.,* etc. in order of abundance. Two year commuted mean was recorded (71.8) ranging between 2.0 units/litre to 391 units/litre maximum. During the first year of study period annual average recorded was 54.1 (46.3%) ranging from 2.0 units/litre (September) to 286 units/litre maximum (February). The second year annual average value (units/litre was 89.6 (46.6%) with a minimum range in August (10.0) and maximum 391.0 in February. (Table-6a, b & c; Fig 24).

Rodophyceae:

Rodophyceae constituted (2.7%) of the total phytoplankton population. This group was represented by two genera viz., *Lemanea spp., and Batrachospermum*. Mean of the two year observation was commuted 4.2 whereas lowest and highest number 1.0 units/litre to 34.0 units/litre of *Rodophyceae* were recorded during study period. The annual average value 2.3 units/litre ranging between 2.0 units/litre to 9.0 units/litre was observed during first year, whereas annual average value 6.1 units/litre of Rodophyceae ranging between 1.0 units/litre to 34.-0 units/litre was observed during second year of the study. Maximum value of *Rodophyceae* for two years of study period was noticed in February (Table 6a, b& c: Fig. 25).

Cyanophyceae:

Cyanophyceae constituted 0.4% of the total phytoplankton population. This group was represented by a single genus *Microcystis spp.* Two year commuted mean was recorded (0,5) ranging between nil to 2.0 units/litre maximum. During first year of the study annual average recorded 0.6 (0.5%) with a minimum range 1.0 units/litre to 2.0 units/litre maximum. During second year monthly average value (units/litre) of Cyanophyceae was 0.5 (0.3%) ranging from nil to 2.0 units/litre maximum (Table 6a, b & c: Fig. 26).

Zooplankton-

The average contribution of zooplankton in total planktonic fauna was 9%. The two year commuted mean 14.8 units/litre, while minimum value was 2.1% and maximum was 19.6% of zooplankton was recorded in total plankton production. During first year, annual mean for zooplankton was recorded 15.2% (183.0 units/litre) of total composition ranging between 2.1% (4.0 units/litre) minimum in October and maxima reached in 19.6% (37.0 units/Litre), while in second year annual mean was recorded 15.1% (182.0 Units/Litre) of total composition ranging between 3.2% (6.0 units/litre) minimum in August & November and maxima was in September 14.2% (26.0 units/litre). Maximum of zooplankton was recorded i.e. in May and June of first year, while it was the highest in June and September in second year. Mean of two years observation was commuted which showed dominance of copepods contributing 36.4% where as rotiferan hold second position 30.4% , where as protozoa shared 18.2% and cladocerans composing 15.5% of total catch. Monthly fluctuation of different groups of total zooplankton have been given in table 7 a, b & c and Fig.27 & 28.

Copepods:

The adult specimens as well as different developmental stages of copepod formed bulk of zooplankton. The common form among them was *cyclop spp.* The average number of copepod encountered during the two years study period was 5.4 contributing 36.1% of total zooplankton forming the dominant group. During first year and second year annual mean was commuted 5.6 units/litre (37.1%) and 5.3 (35.1%) respectively. The maximum number encountered during the month of June (16.0 units/litre) in the first year and the same was observed during the month of September in second year (Table 7a, b & c; Fig. 27 & 28).

Rotifera:

Rotiferea comprised the dominant component along with the copepods in the zooplankton community. The common species encountered during the study period are *Keratella spp.* and *Brachionus spp.* The average number of rotifers encountered during the years was 4.5 units/litre. The maximum number was encountered during the month of June (12.0 units/litre) and minimum during February, April and July (2.0 units/litre) in first year. In second year maxima and minima was observed during the month of December (10.0 units/litre) October (2.0 units/litre) respectively. Mean of two year observation was commuted 4.5 units/litre contributing 29.5% where as lowest and highest number 2.0 units/litre and 12.0 units/litre of rotifers were recorded respectively during the whole study period (Table 7a, b & c; Fig. 27 & 28).

Protozoa:

Protozoa as represented by *Arecella spp., Difflugia spp.* and *centropyxis spp.* formed an important group among zooplankton. Their average availability during the two years was 2.7 units/litre (18.3%) ranging between 1.0 units/litre to 9.0 units/litre. They were found maximum (8.0 – 9.0 units/litre) during the month of January and June during the years of the study. First year annual mean was 2.9 (19.1%) varying between (2.0-9.0 units/litre) whereas in second year, values varied between 1.0 -9.0 units/litre with an annual average 2.6 units/litre (17.5%). Protozoans were dominated in the month of June during study period (Table 7a, b &c; Fig. 27 & 28).

Cladocera:

Cladocera represented by *Daphnia spp.* and *Bosmina spp.* Their average availability during the two years was 2.3 units/litre (15.8%) ranging between 2.0 - 8.0 units/litre. They were found maximum during month of April (6.0 units/litre) in first year and March (8.0 units/litre) in second year. First year annual mean was 2.1 (14.2%) varying between 2.0 - 6.0 units/litre, whereas in second year values varied between 2.0 - 8.0 units/litre with an annual average 2.6 units/litre (17.5%) (Table 7a, b & c; Fig. 27 & 28).

Table.4 Range of qualitative abundance of planktons in river Beas.

Chlorophyceae	
Schroederia spp.	* * * *
Clostoriopis spp.	* *
Closteridium spp.	* * * *
Ulothrix spp.	* * *
Actidesmium spp.	* *
Pleurococcus spp.	*
Selenastrum spp.	* *
Entromorpho spp.	* *
Ankistrodesmum spp.	*
Horidium spp.	* *
Cosmarium spp.	* *
Tetraspora spp.	* *
Microspora spp.	*
Monostroma spp.	*
Prasiola spp.	*
Bacillariophyceae	

Gomphonema spp.	* * * *
Navicula spp.	* *
Synedra spp.	*
Cymbella spp.	* *
Cyclotella spp.	* *
Amphora spp.	*
Rodophyceae	
Batrachospermum spp.	* *
Lemanea spp.	*
Cyanophyceae	
Microcystis spp.	*
Protozoa	
Arcella spp.	*
Difflugia spp.	*
Centropyxis spp.	* *
Rotifer	
Keratella spp.	*
Brachionus spp.	*
Copepods	
Cyclop spp.	* *
Cladocerans	
Daphnia spp.	*
Bosmina spp.	*

* * * * = *most abundant (present throughout the year)*

* * * = *abundant*

* * = *common*

* = *rare*

Table.5 (a) - Monthwise fluctuation (number (u)*10/litre) of plankton from Dec, 02-Nov, 03.

Months	Phytoplankton	Zooplankton	Total
Dec	150.0	18.0	168.0
Jan	163.0	18.0	181.0
Feb	374.0	6.0	380.0
Mar	85.0	16.0	101.0
Apr	148.0	14.0	162.0
May	67.0	24.0	91.0
Jun	38.0	37.0	75.0
Jul	104.0	6.0	110.0
Aug	21.0	10.0	31.0
Sep	26.0	20.0	46.0
Oct	62.0	4.0	66.0
Nov	164.0	10.0	174.0
Total	1402.0 (88.4%)	183.0 (11.5%)	1585.0
Mean	116.8	15.2	1320.0
Min	21.0	4.0	31.0
Max	374.0	37.0	380.0

Table.5 (b) - Monthwise fluctuation of plankton (number (u)*10/litre) from Dec, 02-Nov, 04.

Months	Phytoplankton	Zooplankton	Total
Dec	295.0	18.0	313.0
Jan	203.0	14.0	217.0
Feb	568.0	9.0	577.0
Mar	216.0	16.0	232.0
Apr	96.0	14.0	110.0
May	112.0	16.0	128.0
Jun	174.0	31.0	205.0

Jul	85.0	18.0	103.0
Aug	43.0	6.0	49.0
Sep	96.0	26.0	122.0
Oct	106.0	8.0	114.0
Nov	315.0	6.0	321.0
Total	2309.0 (92.6%)	182.0 (7.3%)	2491.0
Mean	192.4	15.1	2075.0
Min	43.0	6.0	49.0
Max	568.0	31.0	577.0

Table.5 (c) Commuted mean of plankton during Dec., 02-Nov., 04.

2002-2003	116.8	15.2	132.0
2003-2004	192.4	15.1	207.5
Mean	154.6	15.1	169.7

Table.6 (a) Monthly fluctuation (number (u)*10/litre) of phytoplankton from Dec., 2002 – Nov., 2003.

Months	Bacillariophyceae	Chlorophyceae	Rodophyceae	Cyanophyceae	Total
Dec	81.0	60.0	9.0	-	150.0
Jan	112.0	44.0	6.0	1.0	163.0
Feb	86.0	286.0	-	2.0	374.0
Mar	60.0	25.0	-	-	85.0
Apr	58.0	84.0	4.0	2.0	148.0
May	36.0	31.0	2.0	-	67.0
Jun	30.0	8.0.0	-	-	38.0
Jul	81.0	21.0	-	2.0	104.0
Aug	14.0	5.0.0	2.0	-	21.0
Sep	24.0	2.0.0	-	-	26.0
Oct	44.0	18.0	-	-	62.0
Nov	92.0	66.0	5.0	1.0	164.0
Total	718.0 (51.2%)	650.0 (46.3%)	28.0 (1.9%)	8.0 (0.5%)	1402 .0
Mean	59.8	54.1	2.3.0	0.6	116.8.0
Min	14.0	2.0	2.0	1.0	21.0
Max	112.0	286.0	9.0	2.0	374.0

Table.6 (b) Monthly fluctuation (number (u)*10/litre) of phytoplankton from Dec., 2003 – Nov., 2004.

Months	Bacillariophyceae	Chlorophyceae	Rodophyceae	Cyanophyceae	Total
Dec	148.0	132.0	13.0	2.0	295.0
Jan	49.0	149.0	5.0	-	203.0
Feb	142.0	391.0	34.0	1.0	568.0
Mar	140.0	66.0	10.0	-	216.0
Apr	68.0	28.0	-	-	96.0
May	72.0	40.0	-	-	112.0
Jun	130.0	38.0	4.0	2.0	174.0
Jul	68.0	15.0	1.0	1.0	85.0
Aug	33.0	10.0	-	-	43.0

Sep	82.0	14.0	-	-	96.0
Oct	54.0	52.0	-	-	106.0
Nov	166.0	141.0	7.0	1.0	315.0
Total	1152.0 (49.8%)	1076.0 (46.6%)	74.0 (1.8%)	7.0 (3.2%)	2309.0
Mean	96.0	89.6	6.1	0.5	192.4
Min	33.0	10.0	1.0	1.0	43.0
Max	166.0	391.0	34.0	2.0	568.0

Table.6 (c) Commuted mean of phytoplankton during Dec., 03 - Nov., 04.

2002-2003	59.8	54.1	2.3	0.6	116.8
2003-2004	96.0	89.6	6.1	0.5	192.4
Mean	77.9	71.8	4.2	0.5	154.6

Table.7 (a) Monthly fluctuation (number (u)*10/litre) of zooplankton from Dec., 2002 – Nov., 2003.

Months	Protozoa	Rotifera	Cladocera	Copepoda	Total
Dec	2.0	10.0	4.0	2.0	18.0
Jan	8.0	8.0	2.0	-	18.0
Feb	-	2.0	4.0	-	6.0
Mar	4.0	-	2.0	10.0	16.0
Apr	-	2.0	6.0	6.0	14.0
May	4.0	4.0	4.0	12.0	24.0
Jun	9.0	12.0	-	16.0	37.0
Jul	4.0	2.0	-	-	6.0
Aug	4.0	-	2.0	4.0	10.0
Sep	-	6.0	-	14.0	20.0
Oct	-	4.0	-	-	4.0
Nov	-	4.0	2.0	4.0	10.0
Total	35.0 (19.1%)	54.0 (29.5%)	26.0 (14.2%)	68.0 (37.1%)	183.0
Mean	2.9	4.5	2.1	5.6	18.2
Min	2.0	2.0	2.0	2.0	4.0
Max	9.0	12.0	6.0	16.0	37.0

Table.7 (b) Monthly fluctuation (number (u)*10/litre) of zooplankton from Dec., 2003 – Nov., 2004.

Months	Protozoa	Rotifera	Cladocera	Copepoda	Total
Dec	4.0	10.0	-	4.0	18.0
Jan	8.0	-	4.0	2.0	14.0
Feb	1.0	8.0	-	-	9.0
Mar	-	8.0	8.0	-	16.0
Apr	-	4.0	2.0	8.0	14.0
May	-	4.0	6.0	6.0	16.0
Jun	9.0	6.0	4.0	12.0	31.0

Jul	6.0	-	-	12.0	18.0
Aug	2.0	-	-	4.0	6.0
Sep	-	8.0	2.0	16.0	26.0
Oct	-	2.0	6.0	-	8.0
Nov	2.0	4.0	-	-	6.0
Total	32.0 (17.5%)	54.0 (29.6%)	32.0 (17.5%)	64.0 (35.1%)	182.0
Mean	2.6	4.5	2.6	5.3	15.1
Min	1.0	2.0	2.0	2.0	6.0
Max	9.0	10.0	8.0	16.0	31.0

Table.7 (c) Commuted mean of zooplankton during Dec., 03 - Nov., 04.

2002-2003	2.9	4.5	2.1	5.6	15.2
2003-2004	2.6	4.5	2.6	5.3	15.1
Mean	2.7	4.5	2.3	5.4	15.1

CHAPTER- 4.3 b) VEGITATION

Plant communities along streams or rivers are central elements in the natural landscape interacting with both terrestrial and aquatic ecosystem (Naiman and Decamps, 1990 Hunter, 1990, Monsoon 1993). It is possible that these communities can be used as the indicators of the condition in the upland and aquatic communities (Holland et. al., 1991) plants, the producer or autotrophs have got an important position not only in the food chain but in the complete ecosystem. Larger aquatic plants provide shelter to other organism from excess lights and refuge from predatory enemies. Plant communities along river are dynamic, species rich and can be correlated with the productivity and biomass. They provide habitat for many animals species as wall as corridors for movement of both animals and plant species (Johal, 2001). These plant communities also constitute the major organizer of biotic association in aquatic habitat both supplying food (Cummins et. al., 1987). The vegetation of the hill river Beas of western Himalayas comprises Bryophytes, Pteridophytes, Gymnoperms and Angiosperms.

A) Bryophytes: Riccia spp., Sphagnnem spp. and Funnaria spp.

B) Pteridophytes: Asplenium spp., Pteridium spp., Pteris spp., Adiantum spp. and Dryopteris spp.

C) Gymnosperm: Pinus excelsa, Pinus longifolia, cedrus Deodara, Abies spp. and Picea spp.

D) Angiosperm:

I) Herbs: Solanum nigrum, Solanum plantifolium, Mentha arvensis, Verbascum thaspus, Sonchus asper, Echinops spp., Aster spp., Xanthium stumarium, Bidens pilosa, Oxalis carniculata, Panthium stromenium, Amaranthus spinos, Gravillea robusta, Siegesbecllia orientalis, Dicliptera roxburghiana, Dodonaea viscose, Sida cardifolia, Sida acuta, Fragaria vesca, Syzygium jambolanum, Coronopus didymus, Euphorbia prostate, Solanum tuberosum, Strobilanthes Dalhousie, Erigeron bonariensis, Echinops nivens, Impatiens recemosa, Impatiens thomsonii, Impatiens macranthomum, Solanum surattense, Amaranthus gracilis and Azchnis nutuns.

II) Shrubs: Ipomoea carnea, Butea monosperma, Euphorbia prostata, Euphorbia roylena, Euphorbia hirta, Ricinus cummunis, Canabis sativa, Opuntia spp., Chenopodium spp., Achyranthes spp., Zizypus spp., and Murraya Koenigii.

III) Monocots*:* Cyperus rotundus, Cymbopogon martini, Setaria glauca, Elesine compress, Sorghum antidoltale, Saccharum bengalense, Saccharum bengalense, Arundo donax, Bambusa spp., Cyperus spp., Zea mays, Triticum Vulgare and Oryza sativa.

VI) Trees: Euclyptus spp., Populus spp., Salmalia spp., Cedrela toona, Pyrus malus, Prunus communis, Prunus domestica, Prunus amygdalus, Morus alba, Acacia Arabica, Ficus roxburghii and Alnus nepalensis.

CHAPTER- 4.4 STUDIES OF BENTHIC FAUNA

The macrobenthic concentration was high in the river, the commuted annual mean of benthos encountered during two years study period 246.2 units/m^2 ranging between 38.0 units/m^2 to 421.0 units/m^2. Insecta contributed 243.1 units/m^2 and molluscans contributed 1.6 units/$m^{2\ and}$ annelids contributing 1.2 units/m^2 within the two years study period. The cycle of benthic fauna indicated peaks in April and November in both the years. During the two years investigations, macrobenthic invertebrates were comprised of insecta, molluscs and annelids in order of abundance with respective percentage of 98.7%, 0.6% and 0.4% respectively. Monthly fluctuation of total macrobenthos and different groups of benthos has been given in table- 8 a b & c; fig. 29, 30 & 31.

1. Insecta

In the present study, class Insecta represented by the following order; Ephemeroptera, Trichoptera, Diptera, Coleoptera, plecoptera, Odonata. Insecta formed the major component (243 units/m^2) 98.7% of the total benthos, and thus found mainly responsible in determining the fluctuation of total benthic fauna. The monthly fluctuation of different groups of insecta has been given in table 8 a, b & c; Fig. 29 & 30.

i) Ephemeroptera (May fly)

The order Ephemeroptera was represented by 6 genera viz., *Baetis sp., Hexagenia sp., Heptagenia sp., Caenis sp., Iron* sp., and *Ephemerella* sp. The Mayflies were most abundant and present throughout the study period. During First year, the annual mean of Ephemeroptera was recorded 177.3 units/m^2 (79.3%) with a minimum range 26.0 units/m^2 (December) and maximum 334.0 units/m^2 (November). During second year the annual mean was recorded 190 .1 units/m^2 with minimum range 53.0 units/m^2 (July) and maximum 362.0 units/m^2 (February). The two year commuted mean was recorded 183.7 units/m^2.

ii) Trichoptera (Caddis fly)

Caddisfly was represented by *Triaenode sp., Hydroptila sp., Hydrosychidae sp., and Brachycentrus sp.* The two year commuted mean was recorded 17.2 units/m^2 ranging between 1.0 units/m^2 - 59.0 units/m^2. Caddisfly were present throughout the study period. In first year, the annual mean of Trichoptera was recorded 9.2 units/m² (4.1%) with a minimum range 1.0 units/m² (December) and maximum 34.0 units/m² (March), while in second year the annual mean was recorded 25.8 units/m² with minimum 9.0 units/m² (August) and maximum 59.0 units/m² (May). (Table 8 a, b & c).

iii) Diptera

The order Diptera was represented by *Simulium sp. Tabanus sp. Antocha sp., Maruina sp., Psychoda sp., Tendipes* sp., and *Atherix* sp. The average density of organisms was recorded 27.3 units/m² during the period of investigation. During first year, the annual mean of Diptera was observed 16.9 units/m² (7.5%) with a range 1.0 units/m² (March) and 109.0 units/m² (April). During second year the annual mean was observed 37.8 units/m² (14%) with a range 2.0 units/m² (December) and 159.0 units/m² (April). (Table 8 a, b & c).

iv) Coleoptera

The order Coleoptera was represented by *Dytiscus* sp., *Elmis* sp., *Hydrophorus* sp., and *Hydrophilus* sp. The average density of organisms was recorded 9.2 units/m² during the two years study period. During first year, the annual mean of Coleoptera was observed 13.0 units/m² (5.8%) with minima 1.0 units/m² (January &

May) and maxima 71.0 units/m² (March) respectively, while in second year, annual mean was recorded 5.4 units/m² (2.0%) with minima and maxima 1.0 units/m² (April) and 21.0 units/m² (June) respectively. (Table 8 a, b & c).

v) Plecoptera (Stone fly)

The stonefly was represented by 3 genera of stone fly viz., *Perla* sp., *Peltoperla* sp. and *Nemoura* sp. The two year commuted mean was recorded 4.9 units/m² ranging between 1.0 units/m² - 49.0 units/m². In first year, the annual mean of Plecoptera was recorded 6.0 units/m² (2.6%) with a minimum range 2.0 units/m² (April) and maximum 49.0 units/m² (November), while in second year the annual mean was recorded 3.9 units/m² with minimum 1.0 units/m² (February) and maximum 37.0 units/m² (November). (Table 8 a, b & c).

2) Annelida

In the present study class Annelida represented by one order namely, Gnathobdellida. Annelida contributed 0.1% of the total benthos during the two years study period.

Gnathobdellida

The order Gnathobdellida was represented by single genus, *Hirudinaria* (Leeches) during the period of study. The two years commuted mean was recorded 1.2 units/m² ranging between 1.0 units/m² - 10.0 units/m². In first year, the annual mean of Gnathobdellida was recorded 0.3 units/m² (0.1%) with a minimum range 1.0 units/m² and maximum 4.0 units/m², while in second year the annual mean was recorded 2.2 units/m² with minimum 2.0 units/m² (July) and maximum 10.0 units/m² (November). (Table 8 a, b & c).

3) Mollusca

In the present study class Mollusca represented by one order namely, Basommatophora. Mollusca contributed 0.1% of the total benthos during the two years study period.

Basommatophora

This order was represented by *Lymnaea sp. and Limax sp.* (Polyrhytis) in the collections during the period of investigation. The two years commuted mean was recorded 1.6 units/m² ranging between 1.0 units/m² - 19.0.0 units/m². During first year, the annual mean of Basommatophora was recorded 0.2 units/m² (0.1%) with minima 1.0 units/m² and maxima 3.0 units/m² (November) respectively, while in second year, annual mean was recorded 3.0

units/m² (1.1%) with minima 1.0 units/m² (March) and maxima 19.0 units/m² (April) (Table 8 a, b & c).

Table.8 (a) - Monthly fluctuation of different orders of benthos during Dec., 02- Nov., 03.

Months	Ephemer optera	Tricho ptera	Pleco ptera	Coleo ptera	Diptera	Odona ta	Annelids	Mollusca	Total
Dec,02	26.0	1.0	-	9.0	2.0	-		-	38.0
Jan,03	38.0	3.0	-	1.0	6.0	2.0	-	-	50.0
Feb	105.0	1.0	-	-	2.0	-	-	-	108.0
Mar	174.0	34.0	-	71.0	1.0	-	-	-	280.0
Apr	226.0	9.0	2.0	8.0	109.0	-	-	-	354.0
May	178.0	5.0	4.0	1.0	24.0	-	-	2.0	214.0
Jun	150.0	5.0	-	2.0	7.0	1.0	-	-	165.0
Jul	403.0	1.0	6.0	5.0	3.0	-	-	-	418.0
Aug	80.0	13.0	7.0	16.0	15.0	-	-	-	131.0
Sep	269.0	20.0	-	12.0	24.0	-	1.0	-	326.0
Oct	147.0	6.0	4.0	23.0	3.0	-	3.0	-	184.0
Nov	334.0	13.0	49.0	8.0	7.0	1.0	-	1.0	413.0
Total	2130 (79.3%)	111 (4.1%)	72 (2.6%)	156 (5.8%)	203 (7.5%)	4 (0.1%)	4 (0.1%)	3 (0.1%)	2683
Mean	177.3	9.2	6.0	13.0	16.9	0.3	0.3	0.2	223.5
Min	26.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	38.0
Max	334.0	34.0	49.0	71.0	109.0	4.0	4.0	3.0	418.0

Table.8 (b) - Monthly fluctuation of different orders of benthos during Dec., 03- Nov., 04.

Months	Ephemeroptera	Trichoptera	Plecoptera	Coleoptera	Diptera	Odonata	Annelids	Mollusca	Total
Dec,03	234.0	-	-	-	2.0	-	-	-	236.0
Jan,04	128.0	22.0	3.0	-	4.0	1.0	9.0	4.0	171.0
Feb	362.0	10.0	1.0	6.0	15.0	1.0	-	6.0	401.0
Mar	189.0	37.0	-	6.0	6.0	1.0	-	1.0	240.0
Apr	136.0	43.0	2.0	1.0	159.0	1.0	-	2.0	344.0
May	158.0	59.0	-	2.0	99.0	-	-	19.0	337.0
Jun	150.0	23.0	-	21.0	29.0	-	-	-	223.0
Jul	53.0	11.0	-	-	12.0	-	2.0	-	78.0
Aug	135.0	9.0	-	7.0	13.0	-	-	-	164.0
Sep	244.0	32.0	-	-	61.0	-	-	-	337.0
Oct	181.0	22.0	4.0	17.0	44.0	-	6.0	-	274.0
Nov	312.0	42.0	37.0	5.0	10.0	1.0	10.0	4.0	421.0
Total	2282 (70.7%)	310 (9.6%)	47 (1.4%)	65 (2.0%)	454 (14.0%)	5 (0.1%)	27 (0.8%)	36 (1.1%)	3226
Mean	190.1	25.8	3.9	5.4	37.8	0.4	2.2	3.0	268.8
Min	53.0	9.0	1.0	1.0	2.0	1.0	2.0	1.0	78.0
Max	362.0	59.0	37.0	21.0	159.0	1.0	10.0	19.0	421.0

Table8(c) - Commuted mean of benthos from Dec, 02 - Nov, 04.

2002-03	177.3	9.2	6.0	13.0	16.9	0.3	0.3	0.2	223.5
2003-04	190.1	25.8	3.9	5.4	37.8	0.4	2.2	3.0	268.8
Mean	183.7	17.2	4.9	9.2	27.3	0.3	1.2	1.6	246.1

CHAPTER- 4.5 FISH FAUNA

Besides serving as an important item of food, fish provides other byproducts too. Thus, its study becomes significant from commercial point of view. Changes in the composition of a fish assemblage often indicate a variation in pH, turbidity regime, temperature regime, dissolved solids, water flow, transparency, dissolved oxygen, substrate composition and pollution level etc. The gain or loss of certain species is a common consequence of environmental change. As fish are conspicuous they often are the primary indicators of the water quality of streams/rivers and lakes. Further, fish are ecological important, they offer intense commercial and recreational interests surrounding their study. These diverse interests translate into a need for the scientist, often supported by public funds, to be aware of the sensitivity of such investigations.

CHAPTER- 4.5 (a) FISH CATCH

In the present study, the maximum fish catch (36.0 t) was observed in the month of January, while minimum (2.6 t) was in the month of July during first year of the study. During second year, the maxima (33.8 t) were observed in January while minima (0.7 t) were observed in June. Total fish landing in first year was 195.8 t while it was 191.7 t in second year. The fish landing was found to be low from March to August, while it increased from September to February in both the year (Table 10 a & b; Fig. 32).

b) Fish fauna

A survey of the fish fauna at different study sites of the river Beas revealed the presence of two exotic fishes namely *Salmo trutta fario* and *Onchorhynchus myskiss* and have four native fishes namely *schizothorax richardsonii*, *Glyptothorax horii*, *Garra gotyla gotyla*, and *Nemacheilus spp.* (Loaches) (Fig. 33,34,35,36 & 37).

Thus, a total of 6 species belonging to 6 genera, 3 families and 3 orders have been recorded from the study area. The maximum number of fishes belongs to the order Cypriniformes- 3 (50.0%), followed by Salmoniformes, 2 (33.3%) and Siluriformes, 1 (16.6%). The systematic arrangement of the fishes collected from the selected stretches of river Beas is given below (Jayaram, 1999).

Superclass - Gnathostomata

Class - Actinopterygii

Subclaas - Neopterygi

Division - Teleostei

Subdivision - Euteleostei

Superorder - Ostariophysi

Order - Cypriniformes

Family - Cyprinidae

Subfamily - Oreininae (Schizothoracinae)

Genus - Schizothorax (Heckel)

1. Schizothorax *richardsonii* (Gray)

Genus - Garra (Hamilton-Buchnan)

2. Garra *gotyla gotyla* (Gray)

Genus- Schistura (McClelland)

3. Nemacheilus *rupecola*_ (McClelland)

Order - Siluriformes

Family - Sisoridae

Genus - Glyptothorax

4. Glyptothorax *indicus* (Talwar)/syn. G. *Horai* (Shaw & Shebbeare)

Superorder - Protacanthopterygii

Order - Salmoniformes

Family - Salmonidae

Genus - Salmo (Linnaeus)

5. S. *trutta fario* Linn. (Brown Trout)

Genus - Onchorhynchus Suckley

6. *Onchorhynchus myskiss* (Smith & Stearby, 1989)/Salmo *gairdnerii gairdnerii* (Jayaram, 1999).

Amongst different species Schizothorax *richardsonii* represented the most dominant species, followed by *Onchorhynchus myskiss, Salmo trutta fario*, *Nemacheilus rupecola* and *Garra gotyla gotyla, Glyptothorax indicus* in order of abundance (Table 9).

The trout and Salmons are the most important as "sport fishes" as well as "food fishes" of the world. The cold water fisheries an amateur fishery is usually employed to the members of Salmonidae and particularly to trout which prefers thermal regime between the snowmelt water of Himalayas and slopes of Western Ghats. Amongst them brown trout (*Salmo trutta fario*) and rainbow trout (*Onchorhynchus myskiss*) are significant.

Brown trout was first introduced in the year 1911-1912, while the rainbow trout in 1919-1922 in Himachal Pradesh. Both trout are carnivore, sight feeder and voracious eaters. In nature, they mostly sustain on aquatic entomofauna.

Schizothorax richardsonii commonly known as "snow trout" generally distributed in the torrential streams, rivers and lakes of high altitudes all along the Himalayas in India, beside Sikkim, Napal, Myanmar, Afganistan, Tibet, Pakistan, China and Rusia. Snowtrout commonly known “googly” in Himachal Pradesh is represented by 17 species belonging to 8 genera from Indian sub-continent. Of these *Schizothorax richardsonii* is the most abundant and widly distributed in upper stretches of river Beas. It prefered a habitat of fast flowing deep water, rapids, stony river bed, and low water temperature and shady area.

Onchorhynchus myskiss commonly known as “rainbow trout” has wider thermal tolerance, shorter incubationperiod, more resistant to disease and grows faster in comparision to brown trout. Onchorhynchus myskiss prefered to live in rapids and also found in deep pools, runs and riffles. It is most suitable for culture and today; it is very well reared in Himachal Pradesh as well as north-eastern states of the country.

Salmo trutta fario commonly known as “brown trout” is strictly carnivorous fish. It prefered rapids, riffles and deep pools, rocky bed and low water temperature.

Nemacheilus rupicola (Loaches) It prefered shallow pools, runs and abundant in riffles.

Garra gotyla gotyla was recorded abundantly in deep pools, runs and riffles and also present in shallow pools.

Glyptothorax horaii prefered rapids and also recorded in deep pools, runs and riffles.

Table. 9 - Status or the availability of different species.

Fish Species	Dominant	Common	Present	Trace
Schizothorax richardsonii	+ + + +			
Onchorhynchus myskiss		+ + +		
S. trutta fario			+ +	
Nemacheilius rupecola			+ +	
Gara gotyla gotyla			+ +	
Glyptothorax horaii				+

Trace +
Present ++
Common +++
Dominant ++++

Table.10 a. Fish catch during December, 02 – November, 03.

Months	**Catch (t) #**
December, 02	24.6
January, 03	36.0
February	31.9
March	4.3
April	3.6
May	5.3
June	2.7
July	2.6
August	5.4
September	31.1
October	24.2
November	24.1
Total fish catch	**195.8**
Mean	**16.3**
Min.	**2.6**
Max.	**36.0**

 # Data of fish catch were taken from the Department of fisheries, Kullu.

Table. 10 b. Fish catch during December, 03 – November, 04.

Months	**Catch (t) #**
December, 03	23.8
January, 04	33.8
February	33.4
March	3.9
April	7.2
May	3.4
June	0.7
July	1.5
August	2.1
September	24.7
October	33.0
November	24.2
Total fish catch	**191.7**
Mean	**15.9**
Min.	**0.7**
Max.	**33.8**

Table. 10(C) Commuted mean of fish catch from Dec, 02 - Nov, 04.

200-03	**16.3**
2003-4	**15.9**
Mean	**16.1**

Data of fish catch were taken from the Department of fisheries, Kullu.

CHAPTER-4.6 HABITAT RESTORATION OF SELECTED STRETCHES OF RIVER BEAS

Once teeming with plenty of trout and forage fishes the catches of river Beas have sharply declined in recent years attributed largely to habitat loss, pollution, increased sedimentation caused by deforestation, indiscriminate mining activities, rapid road construction, destructive fishing methods and release of silt/muck into river Beas etc.

Environmental changes as a result of natural and human agencies, which affect watershed, are continuously taking place. The sharp–edged barren mountain hops above the original bush line, landslides blocking valleys, lose shingle riverbeds are telltale evidences of protected denudational processes which have caused adverse environmental changes in the ecology of river Beas. The fury caused by the landslides and blockade in river Beas and massive fish mortalities during the ninetees are well known. Similarly, the high rate of increase of human population and completion of slew of river projects has compounded problems to the pristine ecology of river Beas. To the polluting agencies, in recent years, there have been added arrays of agriculture pesticides which seriously aggravated the problem and making the riverine environment least hospitable to fishes. Deeply concerned over the situation the Western countries are undertaking habitat restoration programme of the streams.

As per study it was found that the physical environment selected by fishes of river Beas depends mainly on geological morphological and hydrological processes that influence riparian vegetation and form a mosaic of stream channels and flood plain habitat. Processes with in the riparian corridor of river thus influence the river and its riverine habitat. The study indicated that in the river Beas, the sediments are usually finer, ranging from sand to fine silt and all deposited to form point bars and natural levees. The trout seldom spends its entire life in the same habitat and migrate upstream and downstream for feeding and breeding purpose. During its life history, trout require different habitats with suitable microhabitat conditions for each specific life-stage. The micro–habitat is directly influence by structural complexity of the region, hydraulic variables, streams substrates and biotic variables such as predation.

As per study trout in river Beas depends our pathways along four dimension viz., longitudinal, lateral, vertical and temporal. To complete their life cycle trout need suitable spawning sites in the river close to the area where they live as adult fish. A large number of fishes however migrate and scale of migration range to tens of meters in case of resident stock to several meter in non-resident ones. Survival and life history of trout are directly related to interacting longitudinal pathways.

Further the capacity of hill rivers to support a rich fish community depends on habitat complexity. Habitat does not affect the species composition of fish but also has a bearing on age structure and fish population. Distinct relation was found between the status of habitat and fish abundance. Under the study, at the micro-habitat level, three type of riffle habitat- low grade riffle, rapid and cascades and six type of pools viz., secondary pools, channel pools, trench pools, plunch pools backward pools lateral scoured pools and downed pools were identified in the river Beas. The trout specimens collected from swift flowing riffles were largest in size and weight, fish abundance was also directly proportional with cover ability in the sheltered zone.

Ad finem, river Beas offered a picture of deteriorated habitat erosion. Not to speak of large pool riffle, cascade, they often represent silt–filled choked water. Deforestation has taken away the shaded area depriving the fish stock of resting and hiding pockets. Similarly the large scale mining and removal of bottom stones have wiped away the nestling and spawning grounds. The decreasing need is to address the situation and initial remedial measures.

CHAPTER-4.7 REVIVAL OF FISHERIES IN RIVER BEAS

As stated earlier the fisheries of River Beas has considerably depleted over the past few years. The situation calls for series of steps - ecological, conservational and developmental for rectification and revival of fisheries of yesteryears. Paraphrased below is the strategy suggested to be adopted for habitat restoration, seed transplantation and development of angling pockets in the river.

A) Ecology Improvement- the following steps are required in the programme of ecology improvement
Silt removal, bank improvement, flow maintenance,
creation of pools, riffles, cascades, etc.

B) Vegetal improvement-
Plantation of suitable plants on the banks of streams

C) Seed ranching-
Stocking of farm reared seed in ecologically suitable pockets

D) Assessment of stocking-
Marking / tagging of 5% of seed stocked in the streams

E) Study on growth & survival of transplanted seed

F) Estimation of carrying capacity of River Beas

Removal of perturbation

A study indicates that there is clear relationship between the status of riverbed and fish. The silt shrinks the volume and space of fish dwelling and often results in the migration of fish stock to upstream or making them vulnerable to fishing mortalities.

Taking all this into consideration it is important to remove the accumulated silt so as to ensue a steady environmental flow to the river.

Establishment of spawning and feeding zones

Trout, Mahseer and Schizothorax prefer shady and safe resting and feeding pockets in the river. While the mahseer usually prefers pools and feels at home in riffles and cascades. These eco-pockets not only provide much-vaunted hiding sites but also plenty of oxygen available due to splashing and churning of flowing water. The design and extent of these eco-pockets ensure stimulation of natural conditions. Thus for revival of stock it is essential to carve out artificial riffles, cascades, eco-pockets reds.

Plantation of slopes in the stream banks

- Vegetation ranging from trees and shrubs to emergent reeds is highly effective in stabilizing banks prone to erosion. Plantation of suitable trees on the river bank in patches devoid of trees is imperative.

- As the vegetation provides a diverse habitat assemblage of fishing acts as a filter and traps allochthonous autochthonous material, which in turn serves as nutrients for the plant communities themselves or for the associated periphyton and fish communities.
- The nutrient pump affects of the emergent vegetation increases the concentration of elements
- Vegetation contributes the autotrophic production that decays and form rich detritus which is utilized as food by the organisms.

Stock enhancement

In stock depleted streams, planting of legal size fry/fingerlings is a major management tool, which helps in the speedy fish rehabilitation of the stream. Releasing large quantities of troutling in the Beas river is necessary in order to offset the losses occurred due to natural and fishing mortalities as the recruitment has fallen short of the harvested fishes.

Evalutation of seed ranching programme

Evalutation of survival and growth of the stocked material is crucial to the entire 'habitat restoration programme' this needs to be achieved varios testing techniques viz., feed back of the anglers, information generated through tagging and sampling studies.