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PHYSICO-CHEMICAL PROPERTIES AND ICHTHYOFAUNA DIVERSITY IN KARALA RIVER, A TRIBUTARY OF TEESTA RIVER AT JALPAIGURI DISTRICT OF WEST BENGAL, INDIA.

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ABSTRACT : The present investigation was carried out on the Karalla River, a tributary of the river Teesta from February, 2009 to July, 2010 at three stations to study the seasonal change of physico-chemical factors and ichthyofaunal diversity. The constituents monitored included air and water temperature, turbidity, pH, total dissolved solid, total suspended solid, total solid, depth, conductivity, dissolved oxygen, biological oxygen demand, free carbon dioxide, chloride, salinity, total alkalinity, hardness, nitrate, phosphate and silicate. Through out the study period the water was hard and a significant variation of the rest parameters was observed. In respect of Ichthyofauna diversity, a total of fifty five species belonging to eight orders and twenty families were identified. Among the 55 species, thirty one species were found under the order Cypriniformes, ten species were found under the order Perciformes, seven species were found under the order Siluriformes, three species were found under the order Synbranchiformes and a single species was found under the order Osteoglossiformes, Anguilliformes, Beloniformes and Tetraodontiformes each. This observation indicates that Cypriniformes order is the most dominating of all other seven important orders. There are thirty three species which were common to all the three sampling stations and hence can be considered as migratory ichthyofauna. In this lotic system the diversity and distribution of fishes were uneven. The un-even distribution and diversity may be due to physico-chemical factors of water, substratum soil quality, and unscientific fish capture technology. The increase in species richness at down streams (SII and SIII) also may be due to the occurrence of submerged weeds.
Keywords - Karala River, physico-chemical factors, ichthyofauna diversity.

INTRODUCTION

The planet earth is an ecosphere which is made up of four components. The hydrosphere is one of them. Within the biosphere water is an essential component which is represented in gaseous, liquid and solid states. On the entire earth the total quantity of water is estimated as 1350 km^2, of which 97.4% by volume is found in oceans. The remaining 2.6% is fresh water and is also locked up in ice caps or glaciers or in ground water too deep or salty to be used. According to G.Tyler Miller (Jr.), 2004 this fresh water is divided as ice caps and glaciers (1.984%), ground water (0.592%), lakes (0.007%), soil moisture (0.005%), atmospheric water vapor (0.001%), biota (0.0001%) and river (0.0001%).The study of riverine ecosystem-limnology involves, principally, the causal interaction of biotic communities to their surroundings.

Northern part of West Bengal, popularly mentioned as North Bengal is endowed with numerous fresh water rivers. River "Teesta" is one of them. The main stream of this river is connected by different tributaries. One of them is Karala which originates from the Baikunthapur forest and flows down to the river Teesta near Daspara (Mandal Ghat) in Jalpaiguri Town. This River bisects the Jalpaiguri district town in two halves. The total catchments area of the river is 141 km^2 most of which is covered by arable land. The basin of this river sustains life and livelihoods of tea gardeners, fishermen and slum-dwellers. Tea gardeners consume the water resource for tea plantation and drain off the utilized excess water which carries variety of pesticides and fertilizers to that river (Karala) .The fisherman utilize the downstream of this river for fish capture. Slum-dwellers exploit the water resource for bathing, washing of cloths etc. Sewage from municipality, garbage from market and ash of cremation directly mix up with this river. As a result the physical, chemical and biological characteristics of the river water are gradually changing and producing the harmful effect on aquatic biota and thereby human beings. A quantity of physico-chemical variables were undertaken to get an adequate knowledge of their oscillating rhythmic phenomena, and to throw a greater insight into the nature of the system.

This was corroborated by the analysis of ichthyofauna to judge resiliency and capacity for change in response to the physico-chemical factors seasonally. A considerable quantity of research has been carried out on the physicochemical parameters of riverine water and their impact on aquatic biota in India (Adebisi, 1980; Pande *et al*., 1988; Ray *et al*., 1996; Samanta and Chakrabarti, 1997; Chakraborty, 1998; Dhanapakiam *et al*., 1999; Shastri, 2000; Barat & Jha, 2002; Shahnawaz *et al*., 2009 and Sarkar *et al*., 2010). So far as ichthyofauna diversity in North Bengal is concerned, the earliest report seems to be of Shaw & Shebbeare (1937) who reported 131 species from the river, streams and ponds in the hills and plains of the Darjeeling District and the adjoining Duars. This is followed by Hora and Gupta (1940) who reported 58 species of fishes from Kalimpong, Duars and Siliguri Terai, North Bengal. During 1977, Jayaram & Singh, reported 96 species of fishes from the confluence of river Tengan with Mahananda, Atrai river, Purnabhasa river, river Dharla at Changrabandha, river Kalindri, river Mahananda at Malda Town, Jamuna at Hilli village of Balurghat, Teesta, Karotayar, Panga, Balasan, Jaldhaka etc. of North Bengal. However, this type of investigation has not been carried out in respect in Karala River, a tributary of the river Teesta of West Bengal. The objectives of this investigation were to explore physical and chemical properties of this river water in different seasons of the year, to study the diversity of fin-fish resources in this riverine wetland and correlate the fish population with hydrological parameters.

MATERIALS AND METHODS

Three different stations (Fig-1) were selected in that river for sampling of water and fish capture. The station-I (Aquiduct) is near the origin of the river. Its latitude, longitude, and elevation (from Mean Sea Level) are 26°47'13" N, 88°32'17" E, and 402 ft. correspondingly. The station-II (Hakim Para) is located in the district town and behind the hospital & market. Its latitude, longitude, and elevation (from Mean Sea Level) are 26°31'51" N, 88°43'23" E, and 283 ft. respectively. The station-III is located at the junction of Teesta and Karala near Daspara. Its latitude, longitude, and elevation (from Mean Sea Level) are 26°28'42" N, 88°44'27"E, and 268 ft. respectively. Nineteen physico-chemical parameters were under taken for the detailed investigation. Fortnightly the water samples were collected at the depth of 1 ft. The time of collection was 6.30 am to 8.30 am. All fifteen days samples were brought together as monthly average. All water sample were collected in duplicate form by two glass DO (Dissolved Oxygen) bottles with the capacity of 150 ml each and one large PVC (1 litter capacity) bottle. Immediately the water samples were transferred to the departmental laboratory for all physico- chemical studies except the air, water temperature, pH, conductivity and total dissolved solid (TDS). The air temperature was measured with the help of ordinary mercury thermometer at 1 ft. above surface water and the water temperature was measured with the same thermometer by placing it inside the water at the depth of 1 ft. on the three sampling stations. The depth of water body was measured by a marked (in ft.) wooden stick at the time of sampling. Other physico- chemical parameters were analyzed in the departmental laboratory in the same day as early as possible (within 2-3 hours) except BOD. The turbidity was measured by Turbidity meter and results are reported in units called Nephelometric Turbidity Units (NTUs). The pH, total dissolved solid (TDS), and conductivity were measured during sampling by Deluxe water and soil analysis kit (Model-171 of Electronics India). The total suspended solid (TSS) was measured by evaporation method and the total solid (TS) was calculated by the sum of TDS and TSS values. The dissolved oxygen, free carbon dioxide, BOD, chloride, salinity, hardness and total alkalinity, nitrate, phosphate and silicate were measured at the departmental laboratory in accordance with APHA (1995). The fishes were captured at three stations by different nets. At station-I the fishes were captured by cast net (mesh size 6mm. X 6 mm.) and naphi jal (local contrivance, mesh size 5mm.X 5mm). In station II and III the fishes were captured by vessel net or khara jal (local contrivance, mesh size 6 mm. X 6 mm.), gill net (variable mesh sizes), and cast net (5mm X 5 mm. mesh size). After capture the color, color patterns, spots etc. were noted immediately and their picture was taken by a powerful camera. The fishes were killed by formalin solution containing one part commercial formalin (37-40% HCHO) + nine part glass distilled water and 7 gm Borax/liter (Jayaram, 1981). All the fishes were kept in this buffer formalin solution for 4-5 hours for proper fixation. The fishes were identified by the literature of Talwar & Jhingran, 1991 and Jayaram, 1999 & 2006 and were confirmed from Freshwater Fish Section of Zoological Survey of India. The threat status and endemism of fishes were assigned following Barman (2007).The diversity and evenness indices were calculated by the references of Shannon & Wiener (1949) and Pielou (1975). The correlation coefficient between physico-chemical factors and with fish population was done by SPSS-16. The study was carried out from February, 2009 to July, 2010.

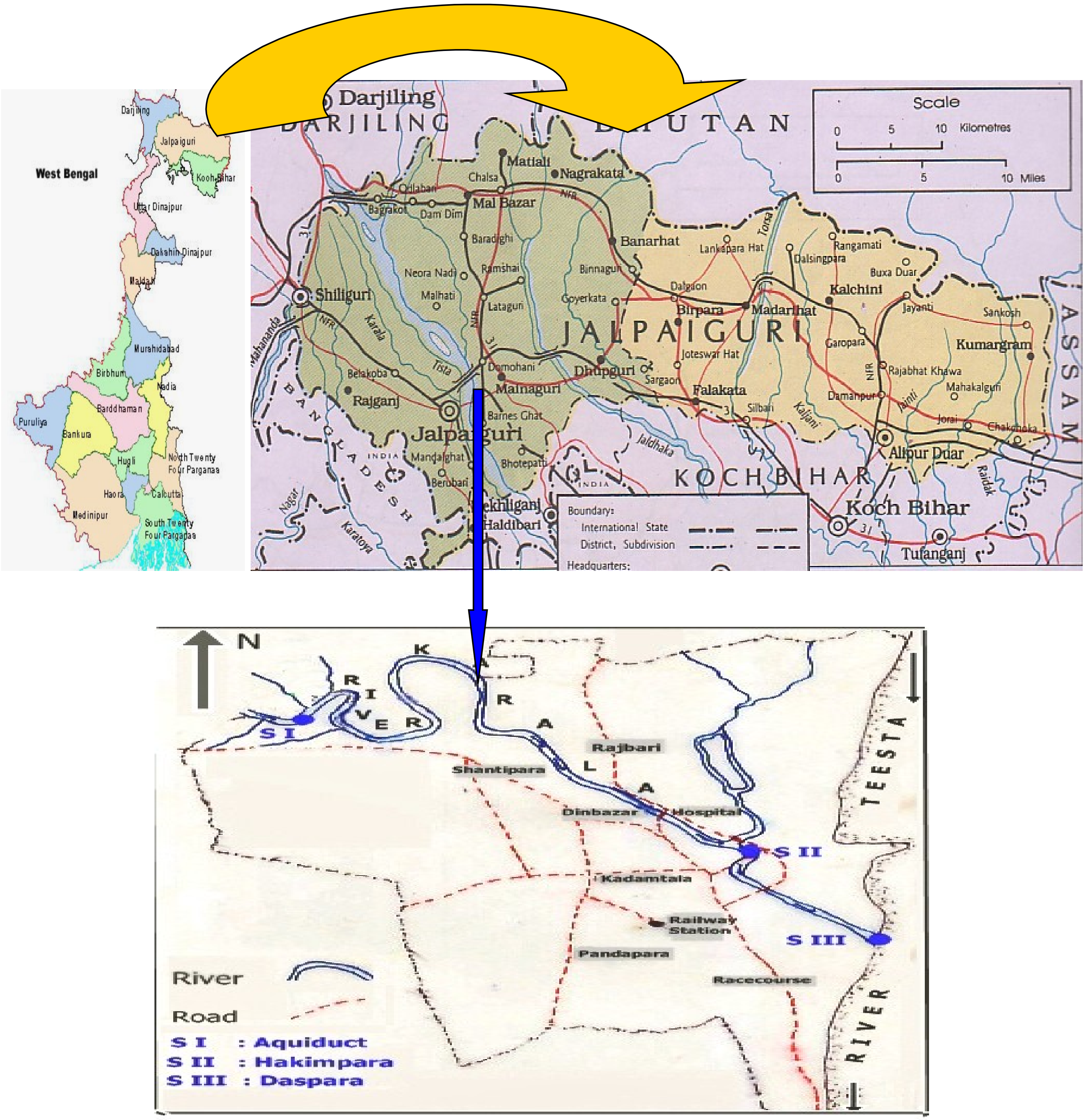

Fig. : 1
Map showing Origin and Distribution of Karala River with three different study sites

RESULTS AND DISCUSSION

The results of hydrological factors, correlation coefficient values and list of collected fishes are presented in Table-1, 2, 3, 4, 5, 6 and 7.

Maintenance of a healthy aquatic ecosystem depends on the physico-chemical properties as well as biological characteristics. Physico-chemical factors of water not only affect the distribution patterns and abundances of species; they also play an important part in species richness (the number of species in any given location). Temperature is one of the most important physical parameters, which controls the physiological activities and distribution of biota. Water bodies naturally show changes in temperature seasonally and daily; however, man-made changes to stream water temperature will affect fish's ability to reproduce. Many lakes and rivers exhibit vertical temperature gradients. The main source of temperature in water body is solar system. In the entire study the air temperature ranged between 9-29°C at SI, 12-28°C at SII and SIII. On any sampling day, the temperature of SII and SIII did not differ greatly but between SI & SII and SI & SIII it varied greatly.

This may be due to the distance between the stations and interval between the samplings. During pre-monsoon the water temperature at SI and SII lied in the range 29-30°C which was greater than the air temperature but at SIII it was 24-28°C and was lower than the air temperature. This is due to the thermal properties, depth and mixing of cold water from the hills. Throughout the monsoon at SI the water temperature was 24 - 30°C, at SII 28 - 30°C and at SIII 27 - 30.3°C. For the period of post-monsoon it was 12-19 °C at SI, 15 - 21°C at SII and 15 - 20.5°C at SIII. It also showed positive significant correlation with air temperature at both the stations (Table-4, 5 and 6).

Turbidity is the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. Light's ability to pass through water depends on the amount of suspended material present. Turbidity may be caused when light is blocked by large amounts of silt, microorganisms, plant fibers, sawdust, wood ashes, chemicals and coal dust. Any substance that makes water cloudy will cause turbidity. The most frequent causes of turbidity in lakes and rivers are plankton and soil erosion from logging, mining, and dredging operations. Turbidity affects fish and aquatic life by interference with sunlight penetration and reduces photosynthesis in plant resulting in lower oxygen concentrations and large carbon dioxide concentrations. For the period of study, monsoon showed the maximum turbidity range but the pre and post monsoon showed the least range. At the confluence of Teesta and Karala the water was more turbid than other two sampling sites. As the turbidity depends upon the TSS, so it shows significant positive correlation with it. It may be due to the soil erosion.

One of the important factors that serve as an indicator of pollution of water body is pH. The pH of natural water can provide important information about many chemical and biological processes and provides indirect correlations to a number of different impairments. At the period of study, the average pH on SI and SIII during pre and post monsoon was acidic. During early monsoon it was neutral to alkaline. The SII which is located at the heart of the town (Jalpaiguri) showed acidic pH during both the seasons. The acidic pH may be due to the high organic load and decomposition. The rain water is responsible for neutralization and finally to alkaline. The fluctuation of pH in this lotic system may be due to the buffering capacity.

Total solid (TS) of water is represented by the sum total of TDS and TSS. The solid substances present in the water stay either in dissolved or suspended forms. The dissolved forms are smaller and lighter than suspended ones. The TDS values of water ranged from 0.02 to 0.05 ppt at SI, 0.04 to 0.1 ppt at SII and 0.04 to 0.07 ppt at SIII. Comparatively SII station showed maximum TDS concentration. The TSS values of water ranged from 0.02-0.1 ppt at SI, 0.02-0.3 ppt at SII and 0.07-1.00ppt at SIII. Comparatively SIII station showed maximum TDS. The TDS and TSS were irreversibly related. This may be due to the addition of solids from runoff water.

Depth of water body is another important physical factor of lotic systems that controls the productivity and diversity of living things. At the period of study, the depth was maximum in SIII and minimum in SI. At both the stations the depth showed least at post and pre monsoon. This river has been silted day by day due to soil erosion and that finally caused irregular depth.

Electrical conductivity (EC) in natural waters is the normalized measure of the water's ability to conduct electric current. This is mostly influenced by dissolved salts present in water body. The EC values of water samples ranged from 30 to 40(µs/cm) at SI, 64 to 89 (µs/cm) at SII and 43 to 53(µs/cm) at SIII. Comparatively SII showed maximum EC. The EC depends upon the concentrate of ions and nutrients and variation of dissolved solids. Dilution water during rain depletes the EC value of water. It showed positive correlation with TDS. The variation of conductivity indicates the uneven occurrence of un-ionized chemical substances and due to poor irrigation management, minerals from rain water run off, or other discharges.

Oxygen is an important eco-chemical parameter which is essential for the metabolism of all aquatic aerobically respired biota. Dissolved oxygen in water indicates water quality and diversity of living things. The concentrations ranged from 4.05 to 8.1ppm at SI, 2.43-6.5 ppm at SII and 3.24-6.61 ppm at SIII. The highest values of DO were recorded from the end of pre monsoon to mid monsoon at all the stations. In the present study it showed a positive significant correlation with pH and temperature. This may be due to turbulence and oxygenation resulting from rain falls and mixing up of gleaming aerated water. Addition of varieties of biodegradable pollutants from domestic sewage, municipality's wastes, garbage from market and hospital etc. stimulate the growth of micro organisms which consume the dissolved oxygen for decomposition. So the concentration gradually depletes. The present observation is in agreement with similar ones reported by Chakraborty, 1998 and Barat & Jha, 2002.

Table1. Physico-chemical Parameters of water and fish population at SI of Karala River

Water quality (Physico-chemical)	Seasons					
	Pre-monsoon		Monsoon		Post-monsoon	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Air temperature (°C)	26-27	26.5±0.5	26-29	27.25±1.1	9-16	13.5±2.7
Water temperature (°C)	29-30	29.55±0.46	24-30	27.68±2.27	12-19	17±2.9
Turbidity (NTU)	8-32	19.75±9.3	20-42	33±8.8	5-15	8.75±4.1
pH	6.7-7.3	6.9±0.23	6.9-7.3	7.15±0.17	6.8-6.9	6.83±0.04
Total dissolved solid (ppt)	0.03-0.05	0.04±0.01	0.02-0.03	0.025±0.001	0.02-0.04	0.0325±0.001
Total suspended solid (ppt)	0.04-0.08	0.0625±0.015	0.07-0.1	0.0875±0.013	0.02-0.06	0.0375±0.018
Total solid (ppt)	0.07-0.12	0.1025±0.02	0.10-0.12	0.1125±0.001	0.04-0.1	0.07±0.03
Depth (ft)	1.5-2	1.8±0.21	14-18	16±2	1.5-1.2	1.75±0.25
Conductivity (µs/cm)	38-40	39.25±0.83	30-32	31.25±0.83	32-38	35±2.12
Dissolved oxygen (ppm)	5.28-6.5	5.7±0.48	5.68-8.1	6.69±1.05	4.05-4.86	4.4±0.3
Free CO_2 (ppm)	5.84-7.04	6.66±0.5	5.84-6.14	5.98±0.14	6.26-6.82	6.68±0.24
Salinity (ppt)	0.037-0.045	0.041±0.0002	0.035-0.044	0.038±0.0003	0.034-0.039	0.036±0.0002
BOD (ppm)	0.80-1.82	1.38±0.37	0.00-0.67	0.47±0.27	0.82-1.15	0.95±0.14
Nitrate (ppm)	0.25-0.65	0.46±0.18	0.1-0.22	0.15±0.05	0.15-0.20	0.19±0.02
Phosphate (ppm)	0.11-0.23	0.1925±0.05	0.05-0.12	0.073±0.03	0.06-0.09	0.075±0.011
Silicate (ppm)	0.52-0.61	0.543±0.04	0.12-0.22	0.16±0.04	0.17-0.38	0.238±0.08
Chloride (ppm)	2.2-5	3.2±1.15	3-7.5	4.45±1.81	4-8.1	6.025±1.45
Total alkalinity (ppm)	28-33	30.25±1.79	28-29.6	28.68±0.66	29.5-30.1	29.93±0.23
Fish population	126-194	161±27	123-228	155±43	73-160	102±35

Table2. Physico-chemical Parameters of water and fish population at SII of Karala River

Water quality (Physico-chemical)	Seasons					
	Pre-monsoon		Monsoon		Post-monsoon	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Air temperature (°C)	26-27	26.5±0.5	25-28	26.18±1.14	12-18	15.25±2.38
Water temperature (°C)	29-30	29.5±0.5	28-30	28.75±0.83	15-21	18.5±2.29
Turbidity (NTU)	10-35	19.25±9.4	35-62	48±10.9	5-15	8.75±4.1
pH	6.1-7.1	6.43±0.41	6.8-7.1	6.9±0.12	6.3-6.7	6.53±0.18
Total dissolved solid (ppt)	0.06-0.1	0.0875±0.016	0.04-0.05	0.045±0.001	0.06-0.08	0.0725±0.001
Total suspended solid (ppt)	0.05-0.1	0.08±0.02	0.1-0.3	0.2125±0.089	0.02-0.08	0.0425±0.025
Total solid (ppt)	0.14-0.19	0.1675±0.02	0.15-0.34	0.2575±0.08	0.1-0.14	0.115±0.02
Depth (ft)	12-17	13.25±2.17	22-25	22.75±1.3	12-17	14±1.87
Conductivity (µs/cm)	70-89	79.75±7.95	64-67	65.5±1.5	67-71	68.5±1.66
Dissolved oxygen (ppm)	4.4-6.5	4.98±0.88	4.46-6.49	5.02±0.85	2.43-4.05	3.38±0.7
Free CO_2 (ppm)	4.9-9.2	7.59±1.78	4.9-5.3	5.15±0.17	5.4-6.84	6.15±0.61
Salinity (ppt)	0.048-0.063	0.054±0.00056	0.042-0.045	0.043±0.00009	0.043-0.049	0.047±0.00025
BOD (ppm)	0.96-3.62	2.77±1.1	0.81-1.17	0.95±0.14	1.21-2.59	1.76±0.52
Nitrate (ppm)	0.31-0.84	0.583±0.239	0.10-0.25	0.20±0.0612	0.25-0.30	0.275±0.025
Phosphate (ppm)	0.27-0.31	0.285±0.015	0.06-0.11	0.078±0.019	0.07-0.17	0.1075±0.039
Silicate (ppm)	0.49-0.61	0.535±0.045	0.12-0.22	0.16±0.039	0.17-0.38	0.2375±0.083
Chloride (ppm)	10-18.08	13.095±3.08	6.9-8.2	7.275±0.54	7-10.5	9.375±1.386
Total alkalinity (ppm)	30-35	33.25±2.05	30-32	31.38±0.82	32.3-33.5	32.8±0.52
Fish population	302-555	411±109	232-586	423±152	157-400	285±96

The biological oxygen demand (BOD) gives an idea of the quantity of biodegradable organic matter present in an aquatic system which is subjected to aerobic decomposition by microbes. Accordingly it provides a direct measurement of the state of pollution. The concentration of BOD ranged from 0.00 to 1.82 ppm at SI, 0.81 to 3.62 at SII and 0.81-2.52 at SIII. At both the stations, the BOD values were highest for the period of premonsoon and minimum for the period of monsoon. This hydro chemical parameter was irreversibly correlated with DO at all three stations and supports the observations of Ray & David, 1966 and Barat & Jha, 2002.The BOD level indicates that SII is more polluted than other two stations.

Table3. Physico-chemical Parameters of water and fish population at SIII of Karala River

Water quality (Physico-chemical)	Seasons					
	Pre-monsoon		Monsoon		Post-monsoon	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Air temperature (°C)	27-28	27.25±0.43	25-28	26.175±1.14	12-18	15±2.12
Water temperature (°C)	24-28	25.075±1.69	27-30.3	28.325±1.21	15-20.5	17.875±1.95
Turbidity (NTU)	15-45	24.25±12.1	30-75	55±18.4	5-17	10.5±4.5
pH	6.4-7.1	6.63±0.29	6.8-7.2	7.03±0.18	6.4-6.6	6.53±0.08
Total dissolved solid (ppt)	0.04-0.07	0.059±0.011	0.04-0.042	0.041±0.0001	0.04-0.06	0.05±0.001
Total suspended solid (ppt)	0.15-1.00	0.38±0.36	0.25-1.00	0.65±0.31	0.07-0.17	0.1225±0.04
Total solid (ppt)	0.21-1.04	0.439±0.35	0.292-1.04	0.691±0.31	0.13-0.21	0.1725±0.03
Depth (ft)	12-15	12.75±1.3	20-23	20.75±1.3	12-15	14.25±1.3
Conductivity (µs/cm)	50-53	51.75±1.3	43-45	44±1	45-49	46.5±1.66
Dissolved oxygen (ppm)	4.05-5.83	4.9±0.63	4.86-6.61	5.6±0.65	3.24-3.79	3.6±0.21
Free CO_2 (ppm)	8.64-9.5	9.21±0.35	5.1-5.84	5.44±0.34	6.64-7.04	6.83±0.19
Salinity (ppt)	0.048-0.054	0.051±0.0002	0.039-0.042	0.041±0.0001	0.041-0.048	0.046±0.0003
BOD (ppm)	0.92-2.52	1.8±0.58	0.81-0.92	0.85±0.05	0.97-1.72	1.36±0.32
Nitrate (ppm)	0.26-0.52	0.335±0.108	0.20-0.40	0.2875±0.089	0.25-0.30	0.275±0.025
Phosphate (ppm)	0.11-0.21	0.158±0.043	0.05-0.11	0.068±0.025	0.07-0.09	0.078±0.0008
Silicate (ppm)	0.52-0.61	0.5575±0.04	0.12-0.22	0.16±0.04	0.17-0.38	0.2375±0.08
Chloride (ppm)	10-13.1	11.4±1.12	5.1-6.7	5.975±0.57	6.1-10	9.025±1.69
Total alkalinity (ppm)	27.5-30.5	29.5±1.22	26-29	27.53±1.48	28.7-29.6	29±0.37
Fish population	273-407	330±59	181-439	305±109	117-311	214±82

Table4-Correlation coefficient values among certain physico-chemical parameters and fish population at SI of Karala River

	AT	WT	Turb	pH	TDS	TSS	TS	Depth	Cond	DO	Free CO2	Salinity	BOD	Nitrate	Phosphate	Silicate	Chlo	TA	Fish Pop
AT	-																		
WT	.950**	-																	
Turb.	.696*	.654*	-																
pH	.475	.434	.852**	-															
TDS	.009	.104	-.298	-.596*	-														
TSS	.767**	.709**	.957**	.768**	-.121	-													
TS	.749**	.728**	.815**	.516	.267	.924**	-												
Depth	.526	.365	.756**	.690*	-.571	.736**	.495	-											
Cond.	-.021	.156	-.398	-.465	.452	-.427	-.241	-.749**	-										
DO	.746**	.702*	.939**	.824**	-.359	.908**	.744**	.745**	-.296	-									
Free CO2	-.433	-.332	-.792**	-.931**	.577*	-.757**	-.513	-.742**	.682*	-.743**	-								
Salinity	-.519	-.669*	-.355	-.170	-.335	-.428	-.544	-.090	-.206	-.424	.032	-							
BOD	-.068	.028	-.520	-.728**	.715**	-.474	-.186	-.742**	.817**	-.527	.801**	-.116	-						
Nitrate	.270	.359	.125	-.066	.447	.087	.257	-.462	.688*	.083	.198	-.142	.615*	-					
Phosphate	.390	.481	.092	-.108	.547	.101	.308	-.423	.771**	.096	.286	-.332	.731**	.888**	-				
Silicate	.260	.386	-.192	-.331	.448	-.200	-.022	-.601*	.926**	-.098	.492	-.270	.809**	.820**	.880**	-			
Chlo	-.520	-.669*	-.355	-.170	-.335	-.428	-.544	-.090	-.206	-.425	.032	1.000**	-.115	-.142	-.332	-.269	-		
TA	-.221	-.157	-.501	-.857**	.669*	-.461	-.190	-.565	.528	-.537	.839**	.016	.791**	.394	.354	.487	.016	-	
Fish Pop	.573	.677*	.321	.111	-.061	.257	.226	.208	.180	.272	-.047	-.364	.155	.227	.227	.327	-.365	.160	-

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

AT = Air temperature, **WT** = Water temperature, **Turb** = Turbidity, **TDS** = Total dissolved solid, **TSS** = Total suspended solid, **TS** = Total solid, **Cond** = Conductivity,
DO = Dissolved oxygen, **Free CO2** = Free carbon dioxide, **BOD** = Biological oxygen demand, **Chlo.** = Chloride, **TA** = Total alkalinity and **Fish pop.** = Fish population.

Table5-Correlation coefficient values among certain physico-chemical parameters and fish population at SII of Karala River

	AT	WT	Turb	pH	TDS	TSS	TS	Depth	Cond	DO	FreeCO2	Salinity	BOD	Nitrate	Phosphate	Silicate	Chlo	TA	Fish Pop.
AT	-																		
WT	.989**	-																	
Turb.	.639*	.573	-																
pH	.275	.180	.763**	-															
TDS	-.189	-.122	-.803**	-.880**	-														
TSS	.579*	.503	.942**	.647*	-.708**	-													
TS	.627*	.556	.889**	.523	-.563	.982**	-												
Depth	.394	.383	.792**	.501	-.795**	.760**	.678*	-											
Cond	.235	.264	-.374	-.624*	.830**	-.256	-.079	-.585*	-										
DO	.806**	.734**	.672*	.630*	-.430	.617*	.608*	.295	-.051	-									
FreeCO2	.008	.087	-.611*	-.932**	.860**	-.495	-.351	-.471	.697*	-.341	-								
Salinity	.088	.114	-.475	-.574	.848**	-.372	-.209	-.692*	.930**	-.103	.606*	-							
BOD	-.006	.068	-.642*	-.888**	.944**	-.522	-.359	-.588*	.881**	-.342	.884**	.858**	-						
Nitrate	.243	.240	-.221	-.061	.483	-.309	-.232	-.634*	.617*	.265	.134	.721**	.410	-					
Phosphate	.343	.375	-.357	-.509	.756**	-.336	-.192	-.619*	.831**	.202	.668*	.824**	.772**	.762**	-				
Silicate	.284	.314	-.389	-.493	.754**	-.369	-.231	-.643*	.819**	.180	.621*	.839**	.773**	.790**	.990**	-			
Chlo	.088	.114	-.475	-.574	.848**	-.372	-.209	-.692*	.930**	-.103	.606*	1.000**	.858**	.721**	.823**	.839**	-		
TA	-.220	-.115	-.705*	-.979**	.806**	-.606*	-.495	-.387	.546	-.621*	.919**	.461	.826**	-.054	.417	.389	.460	-	
Fish Pop.	.448	.524	.056	-.064	.039	-.067	-.068	.267	.118	.140	.041	.111	.195	.230	.160	.174	.111	.110	-

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

AT = Air temperature, **WT** = Water temperature, **Turb** = Turbidity, **TDS** = Total dissolved solid, **TSS** = Total suspended solid, **TS** = Total solid, **Cond** = Conductivity,
DO = Dissolved oxygen, **Free CO2** = Free carbon dioxide, **BOD** = Biological oxygen demand, **Chlo.** = Chloride, **TA** = Total alkalinity and **Fish pop.** = Fish population.

Table6-Correlation coefficient values among certain physico-chemical parameters and fish population at SIII of Karala River

	AT	WT	Turb	pH	TDS	TSS	TS	Depth	Cond	DO	Free CO2	Salinity	BOD	Nitrate	Phosphate	Silicate	Chlo	TA	Fish Pop
AT	-																		
WT	.903**	-																	
Turb	.585*	.791**	-																
pH	.457	.726**	.947**	-															
TDS	.003	-.385	-.613*	-.737**	-														
TSS	.518	.707*	.925**	.940**	-.593*	-													
TS	.526	.707*	.922**	.935**	-.573	1.000**	-												
Depth	.237	.512	.639*	.589*	-.682*	.374	.360	-											
Cond	.238	-.146	-.389	-.479	.836**	-.218	-.198	-.820**	-										
DO	.803**	.923**	.894**	.847**	-.397	.860**	.862**	.426	-.111	-									
FreeCO2	.201	-.186	-.548	-.582*	.774**	-.366	-.350	-.807**	.928**	-.244	-								
Salinity	-.044	-.405	-.583*	-.595*	.872**	-.402	-.382	-.851**	.896**	-.344	.874**	-							
BOD	-.006	-.394	-.609*	-.709**	.969**	-.583*	-.564	-.693*	.842**	-.390	.784**	.869**	-						
Nitrate	.222	.274	.457	.549	-.196	.734**	.742**	-.282	.267	.515	.104	.165	-.150	-					
Phosphate	.412	.160	-.084	-.030	.493	.131	.148	-.650*	.778**	.247	.740**	.713**	.563	.566	-				
Silicate	.377	.020	-.337	-.396	.767**	-.157	-.137	-.769**	.967**	.007	.935**	.853**	.764**	.293	.846**	-			
Chlo	-.045	-.405	-.583*	-.595*	.872**	-.401	-.382	-.851**	.896**	-.344	.874**	1.000**	.868**	.165	.713**	.853**	-		
TA	-.438	-.671*	-.955**	-.969**	.643*	-.941**	-.939**	-.519	.393	-.837**	.561	.513	.616*	-.601*	.002	.348	.513	-	
Fish Pop.	.510	.419	-.082	-.199	.160	-.184	-.183	.116	.154	.126	.269	-.095	.100	-.415	-.015	.274	-.096	.326	-

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

AT = Air temperature, **WT** = Water temperature, **Turb** = Turbidity, **TDS** = Total dissolved solid, **TSS** = Total suspended solid, **TS** = Total solid, **Cond** = Conductivity,
DO = Dissolved oxygen, **Free CO2** = Free carbon dioxide, **BOD** = Biological oxygen demand, **Chlo.** = Chloride, **TA** = Total alkalinity and **Fish pop.** = Fish population.

Table-7. List of fishes collected fishes from Karala River-their threat and status (according to catch frequency) at three sampling stations.

Scientific Name	SI (Aquiduct)	SII (Hakim para)	SIII (Das para)	Threat	Status
Danio devario (Hamilton)	+	+	+	NT	Common
Danio regina Fowler	-	+	+	OD	Occasional
Danio rerio (Hamilton)	+	+	+	OD	Frequent
Rasbora rasbora (Hamilton)	+	+	+	OD	Occasional
Barilius vagra (Hamilton)	+	+	+	VUL	Common
Barilius barna (Hamilton	+	+	+	NT	Occasional
Barilius barila (Hamilton)	+	+	+	VUL	Sporadic
Barilius bendelisis (Hamilton)	+	+	+	NT	Frequent
Esomus danricus (Hamilton)	+	+	+	OD	Occasional
Amblypharyngodon mola (Hamilton)	+	+	+	OD	Sporadic
Aspidoparia morar (Hamilton)	+	+	+	NT	Sporadic
Salmostoma phulo (Hamilton)	+	+	+	OD	Abundant
Puntius conchonius (Hamilton)	+	+	+	VUL	Common
Puntius chola (Hamilton)	+	+	+	VUL	Abundant
Puntius ticto (Hamilton)	+	+	+	NT	Common
Puntius shalynius Yazdani & Talukdar	+	+	+	NT	Rare
Puntius sarana sarana (Hamilton)	-	+	+	VUL	Rare
Puntius sophore (Hamilton)	+	+	+	NT	Frequent
Puntius vittatus Day	-	+	+	EN	Ext. rare
Puntius puntio (Hamilton)	+	+	+	OD	Occasional
Osteobrama cotio cotio (Hamilton)	-	+	+	NT	Rare
Cirrhinus reba (Hamilton)	-	+	+	VUL	Occasional
Cirrhinus mrigala (Hamilton)	-	+	+	NT	Sporadic
Crossocheilus latius latius (Hamilton)	-	+	+	OD	Rare
Chagunius chagunio (Hamilton)	+	+	+	VUL	Abundant
Labeo dyocheilus dyocheilus (McClelland)	+	+	+	OD	Occasional
Acanthocobitis botia (Hamilton)	+	+	+	NT	Rare
Schistura savona (Hamilton)	+	+	+	OD	Sporadic
Lepidocephalus guntea (Hamilton)	+	+	+	OD	Common
Somileptes gongota (Hamilton)	+	+	+	NT	Common
Psilorhynchus sucatio (Hamilton)	+	+	+	OD	Occasional
Mystus bleekeri (Dey)	-	+	+	VUL	Rare
Mystus tengara (Hamilton)	-	+	+	OD	Common
Amblyceps mangois (Hamilton)	+	+	-	NT	Common
Chaca chaca (Hamilton)	-	+	+	OD	Common
Olyra longicaudata McClelland	+	-	-	OD	Abundant
Wallago attu (Schneider)	-	+	+	NT	Occasional
Erethistoides montana montana (Hora)	+	+	-	OD	Common
Glossogobius giuris (Hamilton)	+	+	+	NT	Sporadic
Chanda nama Hamilton	+	+	+	OD	Sporadic
Pseudambassis ranga (Hamilton)	-	+	+	OD	Sporadic
Colisa fasciatus (Schneider)	+	+	+	OD	Sporadic
Badis badis (Hamilton)	+	+	+	OD	Sporadic
Channa gachua Bloch and Schneider	+	+	+	VUL	Sporadic
Channa stewartii (Playfair)	+	+	+	OD	Rare
Channa marulius (Hamilton)	-	+	+	NT	Sporadic
Channa striatus (Bloch)	+	+	+	OD	Rare
Channa punctatus (Bloch)	+	+	+	NT	Occasional
Notopterus notopterus (Pallas)	-	+	+	OD	Frequent
Anguilla bengalensis bengalensis (Gray)	+	+	+	EN	Rare
Xenentodon cancila (Hamilton)	-	+	+	NT	Common
Macrognathus aral (Bloch and Schneider)	-	+	+	NT	Abundant
Macrognathus pancalus Hamilton.	-	+	+	NT	Abundant
Mastacembelus armatus (Lacepede)	-	+	+	OD	Abundant
Ttetraodon cutcutia Hamilton	-	+	+	NT	Frequent

+ = Present - = Absent NT = Near Threatened VUL = Vulnerable END= Endangered OD= Out of Danger.

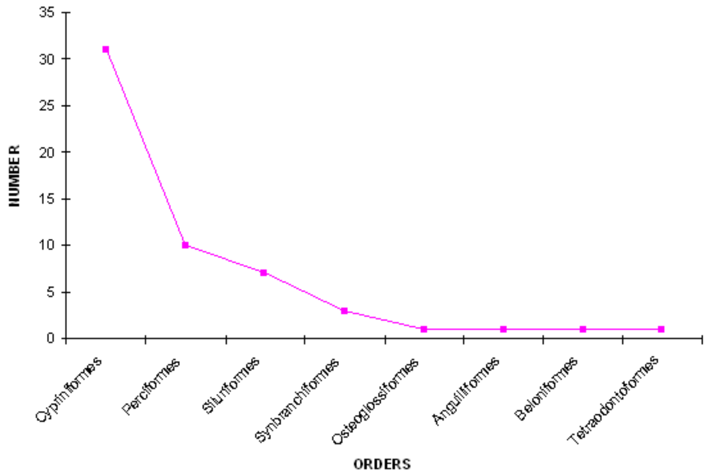

Fig.2:- Population of Ichthyofauna under different orders.

Free carbon dioxide is an odorless as well as colorless gas produced during the respiration cycle of animals, plants and bacteria. All animals and many bacteria use oxygen and release carbon dioxide. Green plants, in turn, absorb the carbon dioxide and, by the process of photosynthesis, produce oxygen and carbon-rich foods. Carbon dioxide quickly combines in water to form carbonic acid, a weak acid. The presence of carbonic acid in waterways may be good or bad depending on the water's pH and alkalinity. If the water is alkaline (high pH), then carbonic acid will act to neutralize it. But if the water is already quite acidic (low pH), the carbonic acid will remain un-dissociated. In the present study, the free carbon dioxide concentration ranged from 5.84-7.04 ppm at SI, 4.9-9.2 ppm at SII and 5.1-9.5 ppm at SIII respectively. It is inversely related with pH at both the stations. The result of carbon dioxide indicates high organic load in two down stream stations i.e., SII and SIII.

Alkalinity is not a pollutant. It is a total measure of the substances in water that have "acid-neutralizing" ability. pH measures the strength of an acid or base. Alkalinity indicates a solution's power to react with acid and "buffer" its pH. Alkalinity is important for fish and aquatic life because it protects or buffers against pH changes. In the present study, total alkalinity (TA) represents to bicarbonate alkalinity only. Average TA values were observed maximum during the pre monsoon and minimum during monsoon at both the stations. The pH, CO_2 and TA were interrelated to each other. TA with pH showed negative correlation but with CO_2 showed positive correlation. This may be due to the rate of decomposition of discharged organic matters from different sources.

Chloride concentration is one of the indicators of water pollution (Munawar, 1970). It is also related with the concentration of salinity. In the present study, the average chloride concentration showed an increase from SI (8.1 ppm) to SII (18.08 ppm) and thereafter decreased at SIII (13.1 ppm). Minimum concentrations were recorded during monsoon and maximum were recorded during pre-monsoon at both the stations. This may be due to he the organic waste load particularly sewage contamination.

Salts are naturally occurring compounds of a metal and non-metal cause salinity of water on dissolution. The importance of salinity of aquatic life is reflected in the difference between fresh water and marine water species. If salinity concentration is more than 1 ppt, it is called saline water. In the present study, the salinity of water was very poor and always less than 1 ppt. It ranged from 0.034-0.045 ppt at SI, 0.042-0.063 ppt at SII and 0.039-0.054 ppt at SIII. Chloride is one of the major inorganic anions in water, which is related with salinity and significantly correlated. It suggests that, organic wastes directly mixed with water body increasing the chloride concentration which finally increases the salinity during pre-monsoon. During monsoon rain fall dilutes the concentration of chloride causing the decrease of salinity.

To study water quality of Karala River, three nutrient factors were selected. Nitrate (NO_3^-) is one of the important nutrients in water body and is the common form of nitrogen in natural water. Nitrite (NO_2^-) is oxidized to nitrate after entering an aerobic regime. Similarly, plants and microorganisms reduce nitrate into nitrite but nitrite ion is quickly oxidized back to nitrate once it re-enters the water. Natural sources of nitrate are igneous rock, plant decay and animal debris (including fish, wild animals and birds), and discharges from car exhausts. Nitrate stimulates the growth of plankton and water weeds that provide food for fish.

This may increase the fish population. However, if algae grow too wildly, oxygen levels will be reduced and fish will die. In the present study, the nitrate concentration ranged from 0.1 to 0.65 ppm at SI, 0.1 to 0.84 ppm at SII and 0.2 to 0.52 ppm at SIII. Maximum concentration was estimated during pre-monsoon at all the stations. The average values were low at SI in comparison to other two study sites. This may be due to the contamination of nitrogenous fertilizer from tea gardens, sewage, rottenning of jute by farmers etc.
Phosphate (orthophosphate or total reactive phosphorus [TRP]) is the ionized form of orthophosphoric acid. In solution and in natural water, phosphate ion will have many forms and will be at a pH dependent equilibrium. The higher the pH, the more PO_4^{3-} will form from the deprotonation of HPO_4^{2}. Unlike total ammonia, phosphates are less soluble and less volatile, therefore, phosphates form salts with calcium and magnesium and fall out of solution to accumulate in the sediment. Phosphates ions in natural water exist in solution in its ionized form, as salts, in organic form or as a particulate species. Higher concentration rarely occurs, because after it enters a water system, it will be rapidly up taken by plants and bacteria. In general, phosphorous is an essential nutrient to living organisms. Inorganic phosphate, another ingredient of cultural eutrophication in water body, ranged from 0.05-0.23 ppm at SI, 0.06-0.31 ppm at SII and 0.05-0.21 ppm at SIII. At both the stations its concentration was maximum during pre-monsoon and the least when rainy season appears. This nutrient showed positive correlation with nitrate. This may be due to the domestic discharge and agricultural runoff where phosphate containing fertilizers are used, and changes in land use in areas where phosphorous is naturally abundant in the soil.
Silicate (soluble) is another nutrient of fresh water body. Silicon is usually present as a form of hydrated amorphous silicon or polymerized silicic acid, but once it is solidified and deposited, the amorphous silicon does not act as a source of supply during deficiency (Lewin, 1961). In the present study the silicate concentration ranged from 0.12 to 0.61 ppm in the river and more or less uniformly distributed. Like other two nutrients its concentration was greater at pre-monsoon in comparison to other two seasons. This may due to release soluble silicate from bottom mud, rocks, mineralization and disruption of silicic acid containing living things frustules by zooplanktons. Beklemishev, 1961 and Teasenow, 1966 reported that, the dissolved silicate was greatly accelerated by the disruption of diatom frustules by zooplanktons.
In respect of Ichthyofauna diversity, a total of fifty five species belonging to eight orders and twenty families were identified. Among the 55 species, thirty one species were found under the order Cypriniformes, ten species were found under the order Perciformes, seven species were found under the order Siluriformes, three species were found under the order Synbranchiformes and a single species was found under the order Osteoglossiformes, Anguilliformes, Beloniformes and Tetraodontiformes each. This observation indicates that Cypriniformes order is the most dominating of all other seven important orders (Fig-2).
In Cypriniformes, the total 31 species belong to 18 genera, 5 sub-families and 4 families were identified. An analysis of the taxonomic composition of Cypriniformes suggests cyprinidae to be the most dominant family with 26 (85%) representative species occurring in that river. Balitoridae and Cobitidae are the next two dominant families each having two species (Total-12%). Whereas the family Psilorhynchidae has single representative (3%) and is less dominated species.
In Perciformes, the total 10 species belong to 6 genera, 2 sub-families and five families were identified. An analysis of the taxonomic composition of Perciformes suggests Channidae to be the most dominant family with 5 (50%) representatives. Ambassidae, the next dominant family, has two representatives (20%).Whereas, the family Gobiidae, Belontiidae and Badidae are the three families each having single species representation (Total-30%) and are less dominated species.
In Siluriformes, the total 7 species belong to 6 genera and 6 families were identified. An analysis of the taxonomic composition of Siluriformes suggests Bagridae to be the most dominant family with 2 (30%) representative species occurring in that river. Whereas, the family Siluridae, Amblycepitidae, Sisoridae, Chacidae and Olyridae are the other five families each having single species representation (Total-70%) and are less dominated species. In Synbranchiformes, the total three species belong to 2 genera and one family were identified.
The diversity in terms of number of species recorded in the present study was 55 and was lesser than the report of Shaw & Shebbeare (1937) and Jayaram & Singh (1977) from the rivers of North Bengal.On the basis of catch frequency (The frequency of occurrence of each species was calculated based on the number of occasions the species was collected during the samplings by Tamang *et al*., 2007) 20% were common, 13% were abundant, 11% were frequent, 16% were occasional, 22% were sporadic, 14% were rare and 4% were extremely rare. According to IUCN 4% was endangered, 16% was vulnerable, 36% was near threatened and rest (44%) were indeterminate or out of danger. There are thirty three species which were common to all the three sampling stations and hence can be considered as migratory ichthyofauna.

The species richness in three sampling sites of this river showed considerable variation and higher richness was recorded in the mid to down stream. Maximum species richness was recorded from SII (Hakim Para, total number=54) and SIII (Daspara, total species=52) while lower species richness was recorded from SI (Aquiduct, total number=36).This may be due to organic load from sewage and market that cause the primary production in the water body.
The species diversity index of different sampling sites was ranged from 3.18 to 3.75. In this study maximum fish diversity index was recorded higher in SIII (H′ = 3.75) as compared with SII (H′ =3.63) and SI (H′ =3.18). This indicates good correlation with over all species richness across the sites. The evenness index of three sampling stations (SI=0.887, SII=0.91and SIII =0.949) indicates uneven distribution of fishes in this tributary. The correlation coefficient analysis of fish populations at three sampling stations showed the positive significant results. The un-even distribution and diversity may be due to physico-chemical factors of water, substratum soil quality, and unscientific fish capture technology. The correlation of fish populations with physico-chemical factors are presented in table-4, 5 and 6. The increase in species richness at down streams (SII and SIII) also may be due to the occurrence of submerged weeds. The present observation is in agreement with similar ones reported by Growns *et al*., 2003. The submerged weeds might have importance in fish assemblage and aggregation.

CONCLUSION

Aquatic ecosystems contain three sub-systems. The first involves the physico-chemical sub-system, the second sub-system includes all the biota and the third depending upon the productivity is a social sub-system and determines what the problems are, what has caused them and what their solutions ultimately will be. In the present investigation, the SII (Hakim Para) appears to be more disturbed by external influences compared to the Aquiduct and Daspara. The SI seems to be the least polluted. The domestic sewage, garbage from market, drainage materials from hospital, leaching of fertilizers & pesticides from tea gardens, use of ichthyotoxic substances for fish capture and ashes of cremation directly mix up with that river and are clearly manifested in these results. The deterioration of water quality is related with above causes. The results obtained from the present investigation shall be helpful in future management of the river Karalla of Jalpaiguri District.
India belongs to one of the top twelve mega diversity countries. Like Bangladesh, Myanmar, Nepal, and Pakistan, it is a developing country. The fish constitute one of the main food items of substance for many people of India. They provide a staple diet and supplement of proteins. Fish constitute almost half of the total number of vertebrates of world. Out of 39,900 identified vertebrates, fish contains 54.44% of which 38.72% is fresh water species (Jayaram, 1999). The knowledge of the diversity of fishes is one of the prerequisite for adopting the proper conservation strategies of fish fauna. Till date it is unfortunate that the Karala River of Jalpaiguri District has not received any attention from the ichthyological aspects. This report gains importance as the Karala River has been described as one of the most important tributaries of Teesta.

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