1. INTRODUCTION

1.1 Topography, Geography and Climate

Nepal, a fascinating landlocked country situated along the southern slopes of the Himalayans. It is bounded on the north by Tibet region of China and on the south, east and west by India. It is roughly rectangular and elongated in shape having about 885 km in length (east west) and 193 km in breadth (north-south). The altitude of Nepal ranges from 70 m above sea level in Terai region (south) to 8848 m, the highest peak of the world, Mount Everest in the North. The country is situated on the Northern hemisphere in between 26° 22' to 30° 27' north latitudes and 80° 4' to 88° 12' east longitude with the total area of 1,47,181 sq km.

Topographically, Nepal contains series of the most rugged and inaccessible hilly terrains in the world. Approximately 75 percent of its land is occupied by mountains. The terai, a belt of lowland along the southern border, is the only area of flat land. The country can be divided into four physical belts, each of which extends east to west across the country. These includes: (a) the Terai, the low, flat fertile land close to the border of the India. (b) the forested Churia foothills and the inner Terai, rising from the Terai plains to the rugged Mahabharat range. (c) the mid mountain region between the Mahabharat range and outer Himalayas, and (d) the great inner Himalayan range rising to more than 8,848 m.

Nepal has extremely contrast climatic and altitudinal variations. The climate of Nepal is greatly influenced by altitudinal variation. Due to the altitudinal effect, the temperature distribution in Nepal is not uniform - warmer low lands like Terai, inner-Terai and mid lands and cooler midhills and the Himalayan region. In general, temperature increases from March to July and decreases from October to January (Pandey 1987).

1.2 Water Resources

Water resources of Nepal is fresh water and broadly categorized into two divisions

(a) Lotic Water (Running water) viz. Rivers, streams, and springs.

(b) Lentic Water viz. lakes, ponds, swamps, bogs, reservoirs etc.

Nepal is very rich in bio-diversity and natural resources. In spite of its small area, it is endowed with a wide range of renewable water resources in the form of rivers, rivulets and streams, lakes, reservoirs, ponds etc. The inland water resources of Nepal totaling 817,100 hector which cover about 3% of land area and consists of natural water (river, lakes, reservoirs, etc), village ponds marginal swamps and irrigated paddy fields. Various types of inland water resources existing in the country provide great scope for the expansion of fisheries. Wetlands are essentially important for their economical, socio economic, cultural, scientific, aesthetic, and recreational values. They support to provide tremendous socio-economic benefits to humankind through agricultural production, aquaculture, wood and timber production.

Table 1: Estimated water surface area in Nepal

S.N.	Resource Details	Estimated Area (ha).	Coverage %	Potential areas
1.0	Natural water systems			
1.1	Rivers	395,000	48.34	-
1.2	Lakes	5000	0.61	-
1.3	Reservoirs	1,500	0.18	78,000
2.0	Village ponds	6,500	0.80	14,000
3.0	Marginal swamps around irrigated fields	11,100	1.36	-
4.0	Irrigated rice field	398,000	48.71	
		817,100	100.0	92,000

Source: DOFD, 2013/14

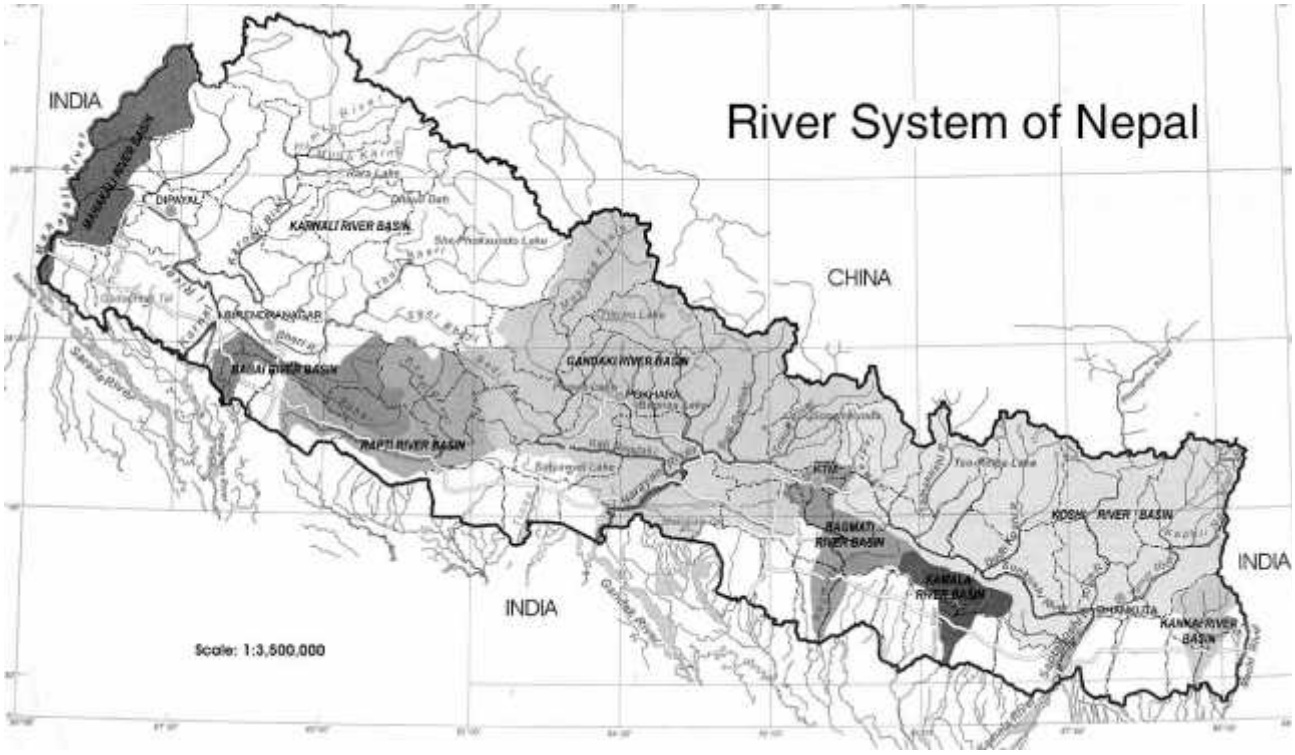

Figure 1: River system of Nepal

1.2.1 Natural Water Resources

The natural water resources of Nepal consist of river, lakes and reservoirs comprising of approximately 49.13% of the total existing water area of Nepal (table 1). The river is the importance in regard to coverage which is 48.34% of the total area. Lakes and reservoirs covering only 0.79% of the total area

Rivers

The rivers are the major constituents of water resources of Nepal (Table 1). There are more than 6,000 rivers in Nepal with a total length of 25,000 km. There are three major rivers systems originate from Himalayans region and each river system has seven main tributaries.

Karnali river system (western): It is the major river system of western Nepal. Karnali rises in the Tibetan region of china and travel about 507 km and reached to the India where it join to the Ganges river system. It has seven major tributaries and subsequently called Sapta-Karnali:

(1) Mugu Karnali
(2) Humla Karnali
(3) Sani Bheri
(4) Thuli Bheri
(5) Tila
(6) Budiganga
(7) Seti

Gandaki river sysyem (central): It is the major river system of central Nepal. The gandaki river rises from the Muktinath area and flows between Dhaulagiri and Gosainthan. It has also seven main tributaries called Sapta-Gandakai which are:

(1) Kali Gandaki
(2) Budi Gandaki
(3) Seti Gandaki
(4) Trisuli
(5) Modi

(6) Myagdi
(7) Marsyandi

Koshi river system (eastern): from the point of view of drainage area, Koshi is the greatest river system of Nepal. It flows particularly in the eastern Nepal in the east of gosaintha and west of Kanchanjangha area. It has following tributarirs:

(1) Sunkoshi
(2) Dudhkoshi
(3) Tamakoshi
(4) Indrawati
(5) Arun
(6) Tamor
(7) Likhu

Besides these, second grade Rivers (Kankai, Kamala, Mechi, Babai, Rapti, Tinau, Mahakali) are also equally important that are originated from Mahabharat range. They do not dry in winter season and carry sufficient flow for irrigation. Third grade rivers originated from siwalik range and dry in summer. They cannot be used for irrigation and power generation. All these river systems constitute the 48.34% of the total water area of Nepal, which drains into the Ganges system in India. The combined run off from all rivers of Nepal contributes 40% of the annual flow of the Ganges river and 71% of the dry season flow (Shreshta 1992).

Lakes

There are several lakes scattered all over the country. The estimated area of lake is about 5,000 ha that is 0.6% of the total existing water areas. The lakes can be categorized into 3 types on the basis of their origin viz. 1) glacial, ii) oxbow and iii) tectonic. There are 17 major glacial lakes in the northern Himalayan region, which are located above 4000 m altitude. Tectonic lakes occur in the hill region. The most of the lakes of Nepal are tectonic origin which when drained out were replaced by flat basins.

Among these three types of lakes ox-bow are mainly confined to the southern part of the country which indicates the shift of river course. More than two dozon of ox-bow lakes are present in Nepal are located in Chitwan National Park, Nawalparasi, Bardiya, and Kailali (Sharma 1997).

Reservoirs

There are few reservoirs with a total area of 1500 ha. comprising 0.18% of the total existing water area of Nepal. These reservoirs are mainly constructed for hydroelectric and irrigation purposes. Among the existing reservoirs, the Indrasarobar reservoir, Kulekhani is impounded reservoir for producing hydroelectric power by damming Kulekhani river in the mid hill region of Nepal. Other existing reservoirs are Trisuli (16 ha), Marsyangdi (62 ha), and Sunkoshi for irrigation & generating hydroelectric power. The estimated 78,000 ha reservoirs will be added for hydropower generation and irrigation from Gandaki basin (45, 000 ha), Bagmati river (9,000 ha) and Karnali river (24,000 ha) (FDD 1993). It is estimated that 50,00,000 ha of water surface will be available for fish production; out of which approximately 100,000 hectares would be from lakes, reservoirs and village ponds (Pant 1995).

1.3 Fish Resources

The various forms of water bodies of the country provided to be a good shelter to a large number of indigenous species having high economic and academic value. The review on the taxonomic status of the fish shows that there were 187 fish species found in Nepal (Rajbanshi 2005). Shrestha (2008) had reported 232 species belonging to 114 genera, 37 families, and 11 order. On the basis of this taxonomic status, 71 species of common(30.60%), 53 species of uncommon or lower risk (22.84%), 27 species of conservation dependent and rare (11.63%), 32 species of data deficient (13.79%), 2 species of endangered (0.86%), 9 species of vulnerable (3.87%), 23 species of rare or near threatened (9.94%), and 15 exotic species (6.46%).

Table 2: Tentative list of conservation status of fishes of Nepal

S.no.	Categories	Designated as	Number of Species
1.	Common	C	71
2.	Uncommon or lower risk / least concern	UN	53
3.	Conservation Dependent and rare	CDR	27
4.	Data deficient Pristine Rare Ornamental	PRO	32
5.	Critically Endangered	CE	0
6.	Endangered	EN	2
7.	Extinct	EX	0
8.	Vulnerable	V	9
9.	Rare or Near Threatened	R	23
		Total Native species	217
10.	Exotic		15
		Total Native and Exotic Fishes In Nepal	232

Source: Shrestha (2008)

In last few decades, inland water have been subjected to a range of stress caused by direct and indirect human activities such as irrigation, hydroelectric projects, urbanization, industrialization etc (Swar and Shrestha 1997). In particular, the river basin in Nepal has undergone extensive change thus created adverse effects to aquatic bio-diversity especially native fish fauna. Many problems associated with human activities lead to threatening many of the indigenous species inhabiting water bodies (Shrestha 1998).

Shrestha (2008) has recommended 10 species of fish in Nepal as the indicator species for their legal protection. These were *Neolissochilus hexagonolepis, Chagunius chagunio, Tor putitora, Tor tor, Schizothorax richardsonii, Anguilla bengalensis, Myersglnis blythi, Schizothorax progastus, Brachydanio rario,* and *Psilorhynchus pseudocheneis*.

1.4 Status of Fisheries in Nepal

Fisheries are a small but potentially important sector of agriculture in Nepal. At present, fisheries contribute about 1.7% of the agricultural gross domestic product (Pradhan and Shrestha 1997). Although the present relative economic importance of fisheries appears to be rather low, the potential for increasing its economic contribution in the future through aquaculture is very high. Fish culture has a short history in Nepal while capture fishery in rivers, lakes, reservoirs, wetlands and flood plains had been practiced since time immemorial. Significant increase in the amount of fish production can be achieved through the development and management of culture fisheries.

The aquaculture production programme commenced in 1981/1982 with the installation of the aquaculture development project, supported by the Asian Development Bank (ADB) and the United Nation Development Programme (UNDP). Aquaculture production reached 4939 metric tons in 1986/97 from 750 metric tons in 1981/82, which shows an increase of over six times within five years during the first phase of project period. The increase in aquaculture production has continued and production reached 11925 metric tons in 1996/1997 to 36,528 metric tons in 2002/03 and 56485 metric tons in 2013/2014(Table 3).

Table 3: Area coverage and production from aquaculture and fisheries in Nepal.

S. No.	Particulars	Area (ha)	Production(mt.)
1.	**Aquaculture**	**70921**	**34995**
1.1	Pond-fish culture	8020	30500
1.2	Paddy-cum fish culture	100	45
1.3	Pen/Enclosure fish culture	100	140
1.4	Cage- fish culture(m3)	60000	360
1.5	Raceway culture	1	200
1.6	Fish culture in Gholes	2700	3750
2.	**Capture Fisheries**	**810928**	**21490**
2.1	Rivers	395000	7110
2.2	Lakes	5000	850
2.3	Reservoirs	1500	385
2.4	Irrigated paddy field	398000	7165
2.5	Marginal Swamps, Gholes etc	11428	5990
Total			**56485**

Source: DOFD (2069/70)

1.5 Statement of the problem and Justification of Study

The wetlands of Madi valley are well known for biological diversity with many habitats. The Reu River is one of the important rivers of Madi valley. It is the main source of water for many wildlife fauna of Chitwan national park. Studies so far conducted in Narayani and Rapti Rivers of Chitwan show the existence of numerous fish species including the endemic fishes.

The degradation of freshwater ecosystems is severe in many parts of the world and fish species are among the most endangered species. Particularly, the wetlands of Madi valley are victims of human activities and human pressure by overfishing. There is a possibility of the

disappearance of fish species, even before they are discovered. Despite their importance, Reu river has not yet been largely investigated and its biodiversity is still unknown by the scientific world. In addition, several studies in Chitwan area focused on terrestrial biodiversity: plants, mammals and birds being the main groups. Little is known on fishes from Reu river. Therefore there is a need to investigate fish diversity in this river and eventual threats for their survival.

1.6 Objectives of the study

The main objective of the study was to explore the wetland biodiversity of the Reu river focusing on fish ecology.

The Specific objectives were ;

- To investigate seasonal fish diversity
- To investigate the seasonal physiochemical parameters..
- To study the socio-economic condition of local fisherman.
- To recommend measures for proper management of riverine wetlands as well as for the sustainable utilization and conservation of fisheries resources.

2. LITERATURE REVIEW

The commencement of the history of ichthyology coincides with that of Zoology, which dates back from the time of Aristotle (384-322B.C). Aristotle said to be the father of natural history. He had an accurate knowledge of the general structure of fishes and distinguished them previously from the aquatic amphibian, mammals and from the various groups of aquatic invertebrates. His information on the habit of fishes was surprisingly accurate, although he adopted the nomenclature of local fisherman to designate species of fishes. His knowledge of ichthyology was limited only to 115 species of fishes, all of which were native of Aegian Sea adjacent to Greece.

After Aristotle, no proper work on fishes was available for nearly 1800 years, which was a period of regression in the science of the ichthyology. The contribution of Pierra Belon (1517-1575 A.D) was based on his original observation of the fishes of Mediterranean sea in Europe and known about 110 fishes. Piso (1611-1678 A.D.) was a noteworthy, scholar of ichthyology. He and his colleagues catalogue about 420 species including those which were already recorded.

The other notable contributors are Linnaeus (1707-1778), Mcclelland (1839), Bleeker (1853) etc. published catalogue of fishes of the British museum, London in eight volumes. The work contains an account of 6847 species together with the description of another 1682 doubtful species.

The earliest record of fish and fishery of Nepal goes back to the eighteenth century. The first historical account starts from 1973 AD by colonel Kirkpatric followed by Francis Buchanan (Later Hamilton) at the beginning of 19^{th} century. Hamilton was the first author to provide valuable references of the fishes of Nepal (1822) in his work entitled "An account of the fishes found in the river Ganges and its branches" which provided the description of 269 species of fishes of the Ganges and its tributaries. Hence Hamilton furnished the first authentic information concerning the description of Nepalese fishes. His study was primarily concerned with the fishes inhabiting in the Terai region of Nepal. Besides Hamilton, Gunther (1861) reported

some cold blooded vertebrates including fishes, collected by *Hodgson* in Nepal. Beavan (1872) described two imperfectly known species of cyprinid fishes from Panjab and had mentioned some of the fishes of Nepal. Day (1878-1889) performed his classical work "Fishes of India, Burma and Ceylon" in which he referred a number of fresh water fishes of Nepal. Boulenger (1907) reported a small collection of Nepalese fishes. Regan (1907) also reported a small collection of Nepalese fishes and he classified teleostean fishes of the order ostariophysi, and 5 species of Nepalese fishes.

Hora (1920-1939) published many papers regarding his fish collection and the collection was included 158 specimens of which 22 species are from Nepal. He gave an excellent account of the Mahseer (*Tor putitora*, Hamilton) in the series of journal of Bombay Natural History Society and indicated the distribution of the species all along the Himalayas. Hora (1940) reported the Nepalese "Katle" Neolis*socheilus hexagonolepis* (Mc Cleland).

Menon (1949) collected fishes from the lower stretches of Koshi river and produced a check list of the fishes of Koshi. His collection was included 11 families comprising 26 genera and 52 species. Further in 1954 and 1956 he described the fish fauna from the Koshi drainage of ten eastern Himalayas and discussed zoo-geographical significant of their distribution. In 1962, he gave a distributional list of all known species of fishes from the defined drainage system in the Himalayas and recorded 69 species from Koshi drainage.

Menon and Dutta (1961) described a new fish *Psilorhynchus pseudocheneis* from Bhotekoshi during the Indian Choyu expedition to Nepal. Swan (1954) collected a number of fishes during California Himalayan expedition to Makalu. Taft (1955) conducted a fish survey of Nepal and prepared a check list of 94 species of fishes representing 13 families from Kathmandu, Trisuli, Simara and Biratnager. David (1959) gave some account of fish seed collection centers from Koshi and suggested as probable breeding ground of major carps of India. De Witt (1960) studied fishes of Nepal and gave a checklist of 102 species of fishes belonging to 21 families

without any description of their biology and ecology.

Majupuria and Shrestha (1968) published a paper on "Fresh water fishes and fisheries of Nepal". Shrestha (1981, 1992), Rajbanshi (1982) worked on the bibliography of fish and fisheries of Nepal and had listed 330 references. Ferro and Swar (1978) made study on biological and limnological condition of lakes and water in Pokhara Valley with reference to the existing fish population and their feeding habits. Majupuria (1969) introduced a paper on 'Socioeconomic condition of fisherman of Kathmandu Valley'. Shrestha (1970) studied 'Taxonomy of fishes of Nepal'. Bhatta and Shrestha (1973) gave an account of 27 species of fish from the Mahakali river. Masuda and Karki (1980) provided a checklist of fish fauna of the Trisuli river and they have reported 6 families, 16 genera and 28 species of fishes. Shrestha (1980) studied the fishing gears and methods used in Narayani river. He had reported 103 species of fishes from Narayani bridge fishing with lift net.

Shrestha (1990) reported 74 species from Karnali river, 108 species from Trisuli, 102 species form Narayani, and 69 species from Mahakali river in his book "Resource ecology of the Himalayan water". He also described about the swamp land ecology and fish management and conservation in this book.

Shrestha (1994) reported fishes, fishing implements and methods of Nepal. She had described 66 genera and 129 species of fish reported so far by the author. Biodiversity profiles project (1995) described the status of 185 fish species found in Nepal. Shrestha (2001) published a paper entitled “Taxonomic Revision of fishes of Nepal” in which the thorough taxonomic revision of 186 fish species reported earlier (Shrestha 1998) with their nomenclature and systematic position according to new classification after Jayram (1999).

Rajbansi (2005) published a paper entitled “Review of Current Taxonomic Status and Diversity of Fishes of Nepal” based on the current work of the Menon (1999). In this paper he reported a total number of 187 fish species representing 94 genera, 30 families and 10 orders. Shrestha (2008) reported 232 fish species in his book entitled “ichthyology of Nepal”.

Srivastava(2013) conducted studied Fish Diversity and Conservation perspectives of Gandak River, India within the stretch of 10 K.M. in Uttar Pradesh and reported 54 species of many commercially important fishes. Mandal and Jha (2013) conducted a study on impacts of Damming on Ichthyo-faunal Diversity of Marshyangdi River in Lamjung District, Nepal and reported 26 species of fishes belonging to 5 orders, 6 families and 18 genera. Paudel (2006) reported 59 species belonging to 38 genera, 19 families and 7 orders in Rapti river, Chitwan. Baro et al. (2014) also studied the status of ornamental fish diversity in Sunkosh River, Badoland Territorial council, Assam, India and recorded total 49 ornamental fish species belonging to 34 genera, 18 families and 6 orders.

A large number of contributions have cited about fishery and on the ecology and fish behaviors. In spite of large number of studies as mentioned above, still much more study have to be done, such as on the management and conservation, ecology and behavior of fishes existing in the hill streams and their relationship with the physical, chemical and biological parameters.

3. MATERIALS AND METHODS

3.1 Study Area

The study area is located in Madi valley of Chitwan (Fig. 2). Madi valley is a part of buffer zone of Chitwan National Park, a world-renowned National Park. It is surrounded by thick forest hills on the south, east and west. It is separated from mainland Chitwan by two rivers Reu and Rapti River, and thick forest of Chitwan National Park. On the south, it borders to Bihar, India. Madi is a beautiful valley of Chitwan district that lies at southern part.

The Reu River originates in the Deurali dada, near the Sanischare hill (boarder of Nepal and India). It flows in northern part of Madi valley which joins with different canal in different places like Ayodhyapuri, Kalyanpur, Gardi and Bagauda VDC of Madi.The Reu River has 11 Tributaries. They are Kusum khola, Bagai khola, Baikunthe khola, Ghagar khola, Paterekhola, Rimal khola, Badarmude khola, Ratani khola, Magai khola, Chitai khola and Mareth khola. The River is flat and slow running. In many places, it is shallow in depth. Most of the area is wide with flood plain. The bank of the river contains cobbles, gravels along with pebbles, sand and mud. It meets Rapti River at Adrauli, Meghauli and finally it reaches into Narayani River System at Golaghat Chitwan.

Figure 2 : Map of Study Area

3.1.1 River Ecology

The Reu river flows from inner Terai to Southward along the bank supported by different vegetation like (*Shorea robusta*), Sissoo (*Dalbargia sisso*), Simal (*Bombax seiba*), Khair (*Acacia catechu*), Chilaune (*Schhima wallichi*), Katush (*Castanopsis indica*), Palash tree known as the flame of the forest and silk cotton tree with spectacular crimson flowers visible from a distance. In the shore of river, different types of grasses including the elephant grass (*Saccharum* sps.) renowned for its immense height (8 m) and short grasses (*Imperata* sps.) which is used for roof thatching and making mats, rope and paper by local people. Northern bank of river covers dense forest of chitwan national park and south bank supports different grasses.

The study area provides a good habitat for wild life. One horned rhinoceros (*Rhinoceros unicornis*), Gaur (*Bos gaurus*), Royal Bengal tiger (*Panthera tigris*), wild elephant (*Elephas maximus*), Four horned antelope (*Tetraceros quadricornis*), pangolin, jungle cat (*felis chaus*), Deer (*Axis axis*) etc are recorded from study sites. These animals are protected by CNP; where they shelter and come to the river for drinking and bathing in summer. The birds like Bengal florican, lesser florican, giant hornbill, black stork, white stork etc. are also found around the river.

The study area is composed of plains with mild water current. River is flat and wide with heavy flood during rainy season. The bank of the river consists of boulder, gravels and pebbles, rubble, cobbles, sand, and mud with the growth of grasses. Some part of the bank consists of agricultural lands remained covered by water during the flood.

It has a range of climatic seasons offering a unique experience. From November to March, average temperatures 20^{o}C offering an enjoyable climate. From March to June, temperatures can reach as high as 39^{o}C. In July, August and September, river becomes heavily flooded. The clean surrounding offers a better view of wildlife to visitors. Between September-November and February-April, migratory birds join the residential birds and create spectacular bird watching opportunities.

This study was conducted in the 20 km reach of the river between the Gaurinagar to Bankatta. Three sites were established at somewhat regular distance along the study area. The fieldwork was conducted from March 2014 to march 2015.

3.1.2 Sampling sites

Stations for biological and chemical study were selected to represent the most obvious areas of the river. Unless, a very large number of sites is selected, all the habitat types cannot be investigated, but it is hoped that areas chosen covered the main range of condition found in the various zones. A reconnaissance survey was made prior to field study to select the sites for sampling. The selection of sampling site based on the confluences of the tributaries, river ecology and human settlement etc. Three main sampling sites were selected, indicated as I-III.

Station I- Gaurinagar

The first sampling station has been selected near Gaurinagar, which is situated at an elevation of 165 m. above the sea level in Kalyanpur V.D.C of Madi, Chitwan. Substrate was predominantly small boulders with stones, gravels and sand between mixed types of forest are present in the north bank and tall grasses covered the south bank of the river.

Station II- Dhobaha

The second station Dhobaha is selected between the first station Gaurinagar and third station Bankatta. This station is situated at an altitude of 153 m. Gravel, stone were not present in this station. Sand was dominant substrate of this station. Human settlements are existing on both side of river. Small sized grasses cover the bank of river.

Station III- Bankatta

The third station is selected in the Bankatta that lies near the army check post of Chitwan national park. This station is situated at an altitude of 145m. Reu bridge is located in this station. Few hotels are also located on the bank of river. The river bed comprises predominantly Sand and mud. North bank is covered by thick forest of Chitwan national Park and tall grasses are found in south bank. Small oxbow lakes are formed in this station.

To meet the objectives of the current study above three stations were fixed with different considerations such as the characteristics of the river, tributaries joining the mainstream, human activities and dam or bridge sites. Each station was visited monthly starting from March 2014 to March 2015 covering Pre monsoon, Monsoon & Post monsoon season.

3.2 Physicochemical parameters

Physicochemical parameters such as Water Temperature, velocity, depth, dissolved oxygen (D.O.) and pH were investigated regularly.

3.2.1 Physical parameters

Temperature

The water temperature was recorded by using a standard mercury thermometer. Thermometer was dipped directly into water for two minutes. The result was expressed in degree Celsius. The readings were noted down in the record sheet.

Water velocity

The velocity was measured monthly during the study period. Water velocity of running water was measured with the help of float method. First of all 1 km distance was measured with the help of measuring tape. The starting and end points were marked. Then a cork was released at the starting point and the time taken by it to reach the end point was recorded. The velocity was expressed in m/s.

Depth

The depth of water was measured by immersing graduated rod in river until it touches the bottom and the point which was just inside the water was noted. It was repeated at different place to take average depth.

3.2.2 Chemical Parameters

Water samples were collected monthly from different three stations of Reu river directly from the surface water in a glass bottles. Chemical analysis was done using the standard methods of APHA (1976) and Adoni (1984).

Hydrogen ion concentration

The pH of water is negative Logarithm of hydrogen ion concentration. A battery operated electrical pH meter was used to record the pH of water during the study period at every station in Reu River.

Dissolved Oxygen (DO)

Modified Wrinkler's method was used to determine the dissolved oxygen. Water sample was collected in a BOD bottle (300ml) without bubbles. Then 2ml of manganese sulphate and 2 ml of alkaline iodide azide solution were added and shaken well. Brown precipitate collected at the bottom, was dissolved by adding 2 ml. of concentrated sulphuric acid. Then the solution was titrated against standard sodium thiosulphate solution (0.025 N) and the calculation was done by using the following formula:

$$\text{D.O. (mg/l)} = \frac{ml \times normality of\ titrant \times 8 \times 1000}{V_2\{(V_1 - V)/V_1\}}$$

Where, V = Volume of $MnSO_4$ and KI added.

V_1= Volume of BOD bottle

V_2= Volume of the part of the content titrated**.**

3.3 Biotic Parameters

The samples were studied at the laboratory using methods described by Adoni (1984), Edmondson (1959), Needam and Needham (1962), Masuda and Pradhan (1988).

3.3.1 Planktons

Planktons are the free floating and drifting microscopic organisms having neutral buoyance capacity. The planktons of plant origin are named phytoplankton while of animal origin are called zooplankton. They are important components of water system and include aquatic bacteria, algae and microscopic forms of crustaceans. They are also indicator of water quality in aquatic ecosystem.

Phytoplankton and Zooplankton samples were collected from the surface water of river by plankton net (30 No. Bolting Silk cloth), once in a month from each station. Planktons (both phyto and zooplankton) were preserved in 5% formalin solution in separate bottles. The qualitative analysis was done by placing a drop of concentrated sample on a glass silk covered with a cover slip. The sample was analyzed under the compound microscope. Both types of planktons up to genus level were identified after Edmondsen (1959), Masuda and Pradhan (1988), and Adoni (1985).

3.3.2 Collection of Fishes and Identification

The fishes were collected monthly from all stations with the help of local fishermen using local implements like cast net, Paso, Rod, and line. Fishes were also collected from the local market at Basantapur, Baruwa and Kirtanpur etc. All the collected fishes were preserved in 10% formaldehyde. The preserved specimens were identified after Shrestha (2008), Shrestha (1994) and Jayaram (1981) in the Central Department of Zoology.

3.4 Fishing Appliances

Fishing appliances in Reu river were studied during field visit through direct observation, photography and interview with fisherman. The collected data was compiled with the help of Shrestha (1994) and Shrestha (1995).

For the direct observation on fishing methods and habitat, regular visit were conducted on the various section of the Reu river. In each visit, data were gathered on fish collection and made observation on the fishing practices and recorded

different gears and appliances used by the local fisherman.

3.5 Socio-economic status of fisherman

A set of questionnaire was developed and administered to local inhabitants of villages located near Reu river to know the socio-economic status of local fisherman. The information obtained were analysed critically.

3.6 Statistical Analysis

3.6.1 Coefficient of correlation

The statistical analysis (Coefficient of Correlation) between some important physicochemical parameters of water viz, temperature, pH, DO with fish density was calculated using Karl-Pearson's method (Gupta 1988).

$$\text{Correlation (r)} = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{N\Sigma X^2 - (\Sigma X)^2}\sqrt{N\Sigma Y^2 - (\Sigma Y)^2}}$$

$$\text{Probable error (P.E.)} = \frac{1-r^2}{\sqrt{N}}0.6745$$

3.6.2 Species Diversity Index (Shannon-Weiner diversity index)

The diversity of species was calculated by using Shannon-Weiner diversity index(Shannon and Weaver, 1949).

Shannon Weiner diversity index is designated as H, which is calculated as:

$H = -\Sigma (ni/N) \log (ni/N)$

Or, if $Pi = ni/N$

$H = -\Sigma Pi \log_e Pi$

Where,

ni = Importance values for each species is the number of individuals in each species, the abundance of each species.

N = Total Importance value, the total number of individual observed.

Pi= ni/ N = the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.

The value of Shannon Weiner Diversity Index usually falls between 1.5 and 3.5, only rarely it surpasses 4.5. A value near 4.6 would indicate that the numbers of individuals are evenly distributed between all the species.

3.6.3 Species Richness Index

The species richness is calculated by using Margalef Species richness (Margalef's 1968). Margalef richness index is designated as d, which is calculated as:

Margalef species richness (d) = s-1/logN

4. RESULTS

4.1 Physical Parameters

4.1.1 Temperature

The surface water temperature in Reu River ranges from 17°*C* to 32°*C* (Figure 3). The maximum water temperature was recorded 32°*C* in July at station II and the minimum temperature was recorded 15°*C* at station I and II during January. Temperature reached 31°*C*. at station I during June, July, September, and October and minimum temperature recorded 15°*C* during December and January. The air temperature of Reu river ranged from 19°*C* to 39°c. Lowest air temperature was recorded during January at station I and III while highest temperature was recorded during July at station II.

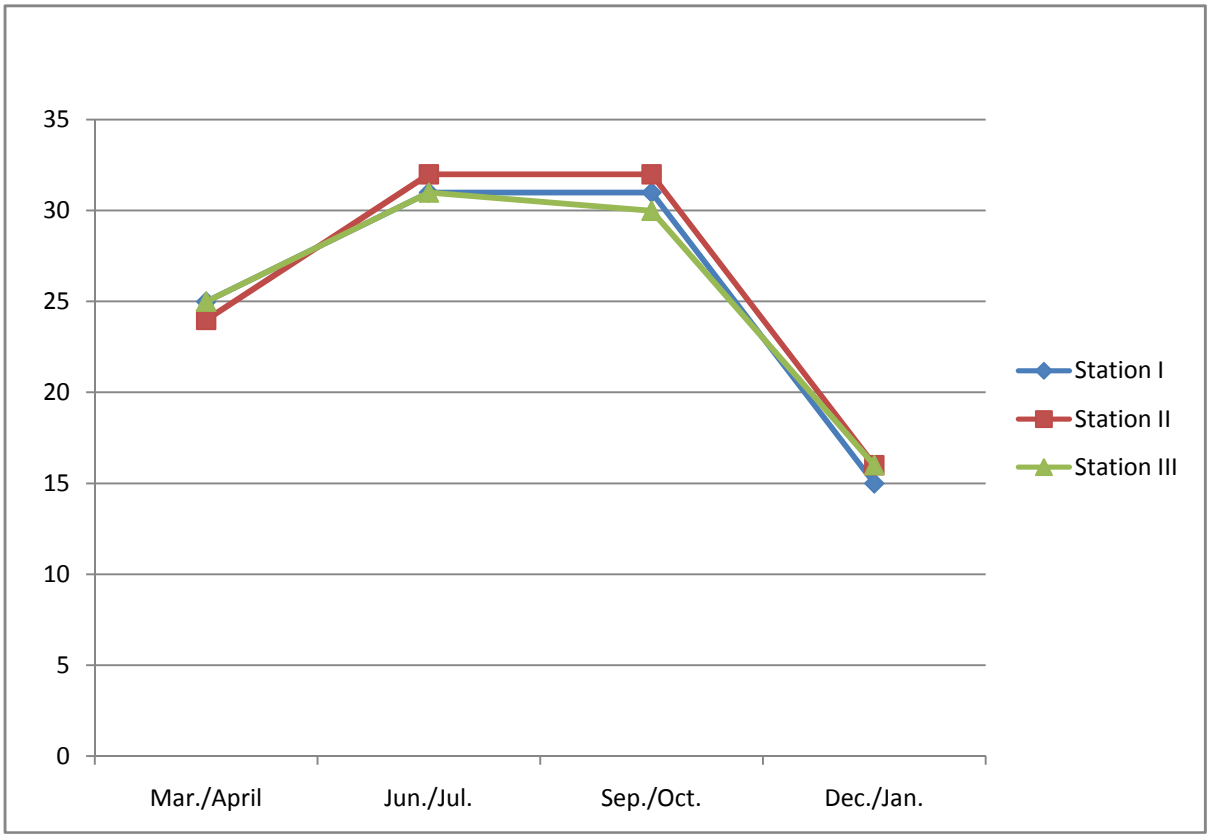

Figure 3: Variation of temperature at different seasons

4.1.2 Water Depth

The depth of the Reu River was comparatively same in all section. Depth was increased in monsoon as the water volume increases. Average depth was found 40 cm in all stations during winter and pre-monsoon but increased up to 200 cm during monsoon (Figure 4). In monsoon, the water depth was increased up to 150 cm in June. /July. and September/October. Water depth was observed 40 cm during March / April at Station I. Similar depth pattern was recorded at station II. Maximum water depth was observed 200 cm in September / October at station III.

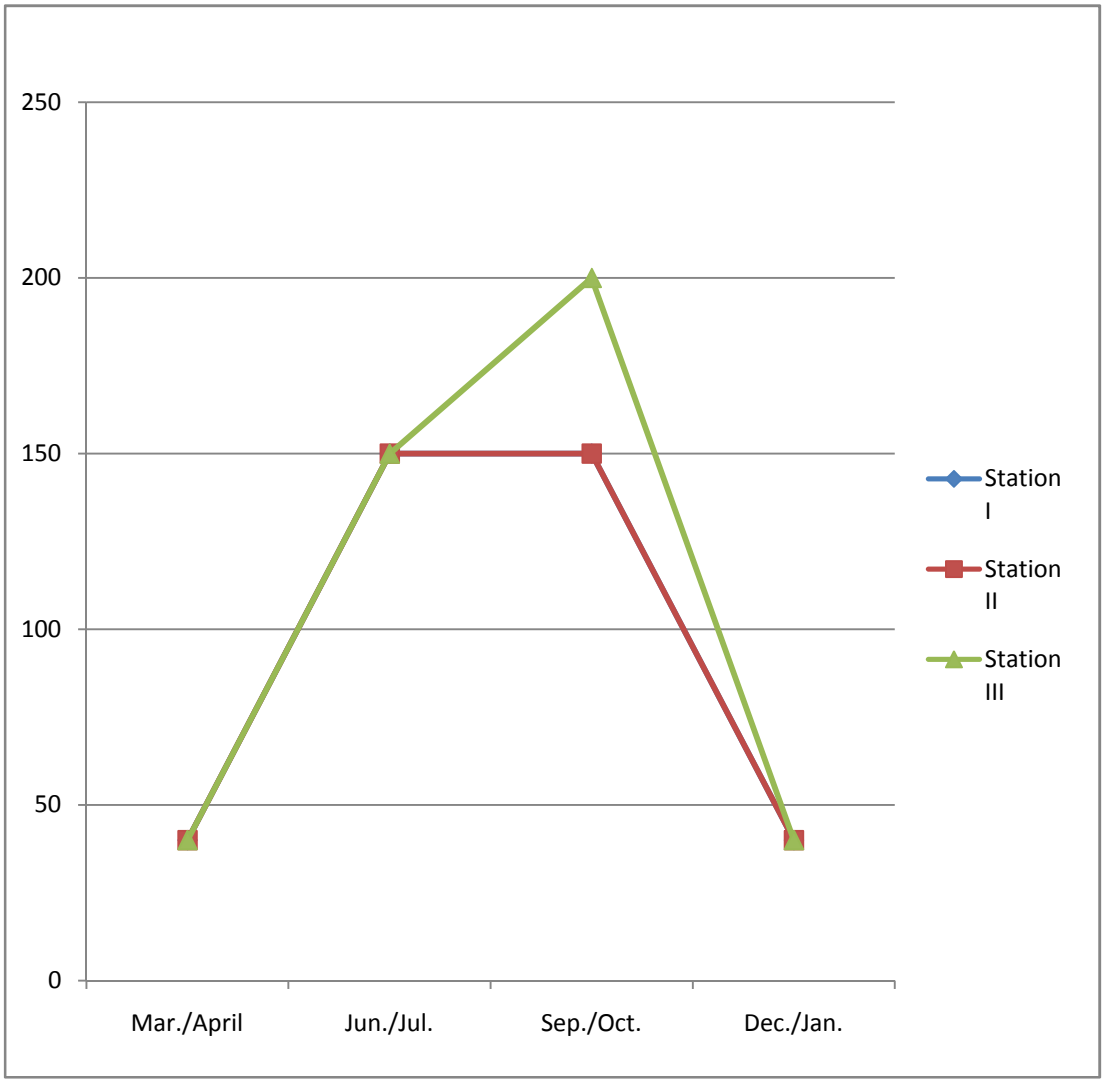

Figure 4: Variation of depth at different Seasons

4.1.3 Velocity

The highest velocity was recorded from station I in July i.e.1.7 m/s. Similarly, the lowest velocity was recorded 0.60 m/s from station III in January. At station I the minimum velocity was 0.65m/s during December / January. And maximum velocity was 1.7m/s during June. /July. During March/April, the velocity of Reu River reached up to 0.70m/s and in September. /October the velocity was recorded. 1.2m/s. (Figure 5).

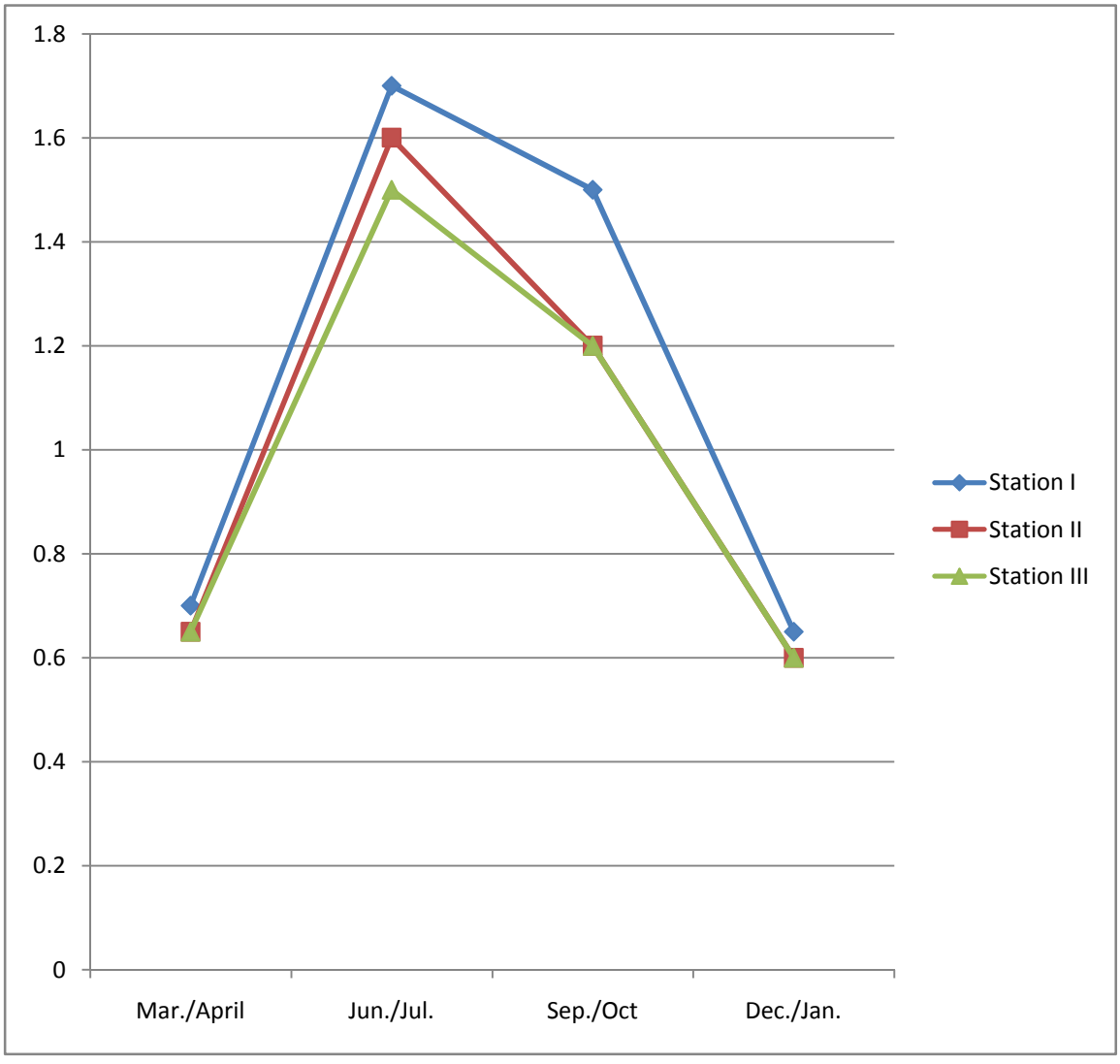

Figure 5: Variation of velocity at different seasons

4.2 Chemical Parameters

4.2.1 pH

The pH of Reu River was almost neutral to slightly alkaline. pH was almost same in all three stations as maximum pH was recorded as 8.1 and minimum pH was 7.6. No fluctuation in pH was observed in all three sections at same month. At station I, the pH ranged from 7.6 to 8.1. Highest pH was measured as 8.1 during June/July and lowest as 7.6 during September./October. pH 7.8 was observed in March/April and December. /January. at station II, pH 7.8 was recorded in all months except in September. / October. pH 8.1 was observed in September. / October. as the highest pH of this station. At station III, the pH was recorded 8.1 in June/ July, 7.8 in March / April and December. /January. And 7.6 in September. / October.

Figure 6: Variation of pH at different seasons

4.2.2 Dissolved Oxygen

The maximum and minimum value of dissolved oxygen was recorded 8.5 mg/l and 6.0 mg/l in December. /January. and March/ April respectively at station III (Figure 6). At station I, highest value of DO 8.2mg/l and lowest value of 6.2 mg/l was observed. DO values of 6.4mg/l and 7.9 mg/l were recorded in the month of June. /Juyl. and September. /October. respectively. At station II, 6.3 mg/l in March. /April, 6.8 mg/l in June. /July, 8.1 in September. /October and 8.0 in December. /January. were recorded.

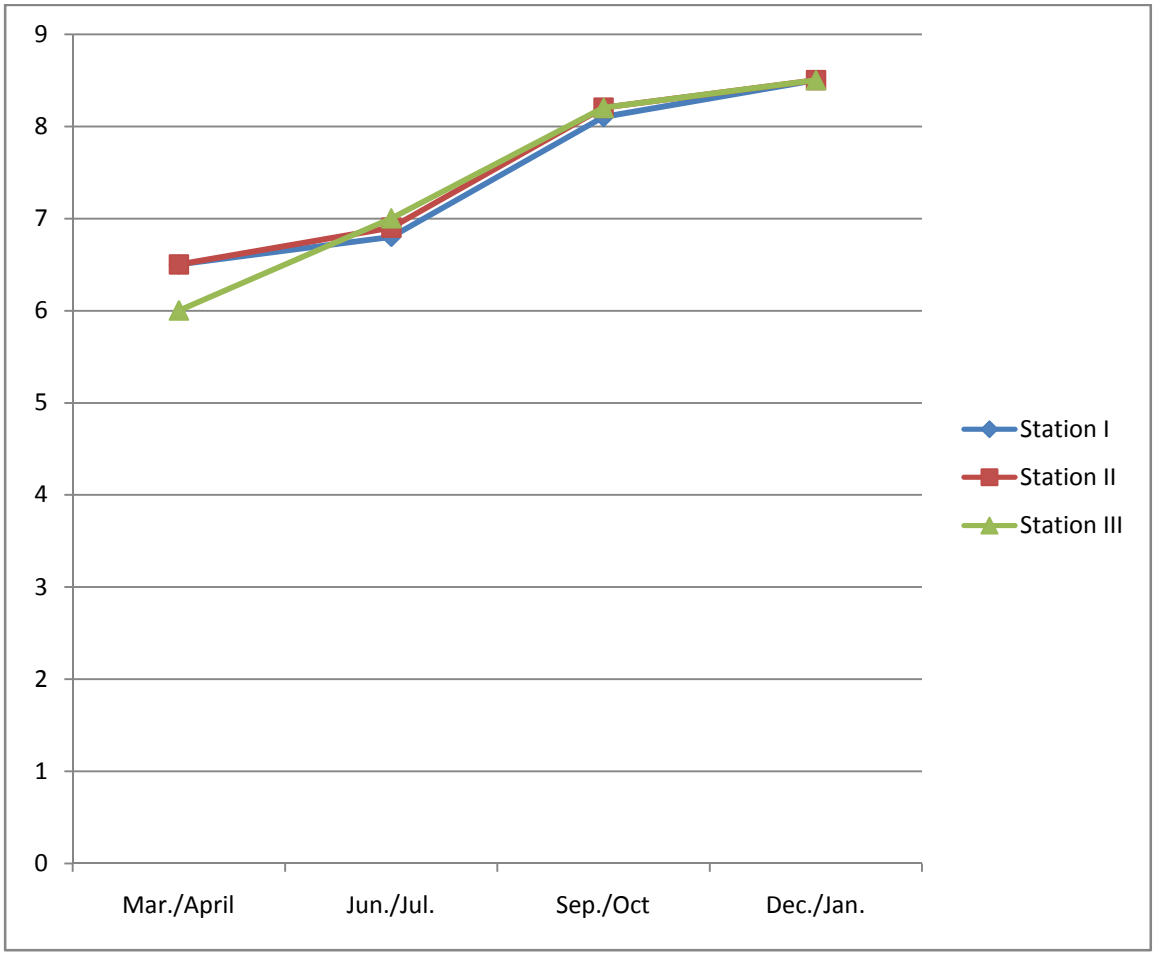

Figure 7: Variation of dissolved oxygen at different seasons

4.3 Biotic Parameters

4.3.1 Phytoplankton

Phytoplankton are the primary producers of the river ecosystem. They are chlorophyll bearing organisms, which are responsible for the photosynthesis. The phytoplankton found in Reu River during this study were-*Clostrodium, Oscillatoria, Spirogyra, Microspora* and *Navicula.*

4.3.2 Zooplankton

During present study, few Rotifers, Copepods and Cladocera such as *Cyclops*, *Daphnia* and *Monostyla,* were recorded.

4.4 Fishes

The Reu River provides a good habitat for the fresh water fishes of different species. Fish sampling during the study period at different station reported 26 different fish species (Table 4). These fishes are belonging to 12 families, 19 genera under 7 orders. The most common species distributed in Reu River was *Puntius* and *Barilius*. These species were found commonly in all station. *Tor tor* and *Garra* species were found only at station III.

Wallago attu and *salmostoma bacaila* was found only in July and August. *Notopterus notopterus* was occasionally found in Reu River. *Garra* species was also found in july to September.

Table 4: List of Fish Collected from Reu River

Order	**Family**	**Sub Family**	**Genus**	**Species**	**Local name**
Synbranchiformes	Mastacembalidae	Mastacembalinae	*Macrognathus*	*Aral*	Sano baam
			Macrognathus	*Puncalus*	Setani
Perciformes	Channidae		*Channa*	*Orientalis*	Chiple Bhoti
			Channa	*Punctatus*	Khasre Bhoti
Beloniformes	Belonidae		*Xenontodon*	*Concilla*	Donga
Anguiliformes	Anguilidae		*Anguila*	*Bengalensis*	Baam
Osteoglossiformes	Notopteridae		*Notopterus*	*Notopterus*	Nenari
Siluriformes	Bagaridae	Bagrinae	*Mystus*	*Vitatus*	Tengra
			Mystus	*Tengara*	Tengra
	Siluridae		*Ompok*	*Bimaculatus*	Pati
			Wallago	*Attu*	Barari
	Heteropneutidae		*Heteropneustus*	*Fossilis*	Singi
	Claridae		*Clarius*	*Batracus*	Magur
	Sisoridae		*Eristhistoides*	*Cavatura*	Kathpepa
			Glyptothorax	*Alaknandi*	Pathhar chatty
Cypriniformes	Cyprinidae	Rasborinae	*Barilius*	*Vagra*	Faketa
			Barilius	*Bendelisis*	Guira
		Cultrinae	*Salmostoma*	*Bacaila*	Chepuwa
			Securicola	*Gora*	Godari
		Cyprininae	*Puntius*	*Chola*	Tilke poti
			Puntius	*Sophore*	Sidre
			Puntius	*Conchonius*	Dhawahi
			Puntius	*Phutinio*	Gudrahari
			Tor	*Tor*	Asala
		Garrinae	*Garra*	*Gotyla*	Budhuna
	Balitoridae	Nemachelinae	*Schistura*	*Rupecola*	Guira

4.4.1 Distribution and frequency occurrence of Fishes in the Reu River

A total of 313 fish belonging to 26 species were collected from the Reu River (Table 5). All these fish species were not equally distributed in all stations of the river. Highest number of fish species were recorded from station III and lowest from station I. Among the total fish species, order cyperiniformes constitutes the largest group consist of 11 species. The order siluriformes constitutes 8 species. Order synbranchiformes and perciformes constitute 2 species while beloniformes, anguilliformes and osteoglossiformes were represented by single species. The most common fish species distributed in all the sampling stations were *Barilius sps, Puntius sps, Channa sps, Mystus sps*. Apart from this, *Macrognathus sps, clarius batracus, eristhistoides cavatura* were also quite common. *Puntius sophore* had the highest frequency occurrence of 10.92% and *glyptothorax alaknandi* had the lowest frequency occurrence of 0.33%. Other most common fish species were Puntius chola and *barilius vagra* with the frequency of 9.93% and 9.27 % respectively.

The family wise percentage analysis of fish species composition showed the 38.46% of reported species fall under the family *Cyprinidae*. Family Bagrida*e*, Siluridae, Sisoridae, Channidae, and Mastacembalidae were found 7.69% each while rest of the family Belonidae, Balitoridae, Anguillidae, Notopteridae, Heteropneustidae and Claridae constitute 3.84% each (Figure 10,11,12).

Table 5: Distribution and Frequency Occurrence of Fishes

S.N.	Species	Station			Total	Frequency (%)
		I	II	III		
1.	*Macrognathus aral*	0	0	18	18	5.750799
2.	*Macrognathus puncalus*	0	5	8	13	4.153355
3.	*Channa orientalis*	4	7	5	16	5.111821
4.	*Channa punctatus*	4	3	7	14	4.472843
5.	*Xenontodon concilla*	1	3	2	6	1.916933
6.	*Anguila bangalensis*	0	7	0	7	2.236422
7.	*Notopterus notopterus*	0	0	2	2	0.638978
8.	*Mystus vitatus*	2	6	2	10	3.194888
9.	*Mystus tengara*	2	1	4	7	2.236422
10.	*Ompok bimaculatus*	3	0	0	3	0.958466
11.	*Wallago attu*	1	1	1	3	0.958466
12.	*Heteropneutus fossilis*	5	3	1	9	2.875399
13.	*Clarius batracus*	2	4	5	11	3.514377
14.	*Eristhistoides cavatura*	6	3	4	13	4.153355
15.	*Glyptothorax alaknandi*	0	0	1	1	0.319489
16.	*Barilius vagra*	13	8	7	28	8.945687
17.	*Barilius bandelisis*	11	9	7	27	8.626198
18.	*Salmostoma bacaila*	0	0	8	8	2.555911
19.	*Securicola gora*	1	0	1	2	0.638978
20.	*Puntius chola*	7	15	8	30	9.584665
21.	*Puntius sophore*	13	12	8	33	10.54313
22.	*Puntius conchonius*	4	7	7	18	5.750799
23.	*Puntius putinio*	6	5	7	18	5.750799
24.	*Tor tor*	0	0	2	2	0.638978
25.	*Garra gotyla*	0	0	3	3	0.958466
26.	*Schistura rupecola*	3	6	2	11	3.514377
Total		88	105	120	313	100%

Table 6: Seasonal distribution of fishes in Reu River

S.N.	Species	Pre-monsoon	Monsoon	Post monsoon	Total
1	*Macrognathus aral*	7	4	7	18
2	*Macrognathus puncalus*	4	5	4	13
3	*Channa orientalis*	6	3	7	16
4	*Channa punctatus*		4	10	14
5	*Xenontodon concilla*	1	1	4	6
6	*Anguila bangalensis*		5	2	7
7	*Notopterus notopterus*		2		2
8	*Mystus vitatus*	3	2	5	10
9	*Mystus tengara*	4		3	7
10	*Ompok bimaculatus*	3			3
11	*Wallago attu*		3		3
12	*Heteropneutus fossilis*	2	2	5	9
13	*Clarius batracus*		6	5	11
14	*Eristhistoides cavatura*	3	4	6	13
15	*Glyptothorax alaknandi*	1			1
16	*Barilius vagra*	11	5	12	28
17	*Barilius bandelisis*	6	8	13	27
18	*Salmostoma bacaila*		6	2	8
19	*Securicola gora*	2			2
20	*Puntius chola*	9	11	10	30
21	*Puntius sophore*	7	5	21	33
22	*Puntius conchonius*	7	6	5	18
23	*Puntius putinio*	3	9	6	18
24	*Tor tor*		2		2
25	*Garra gotyla*		3		3
26	*Schistura rupecola*	3	1	7	11
Total		**82**	**97**	**134**	**313**

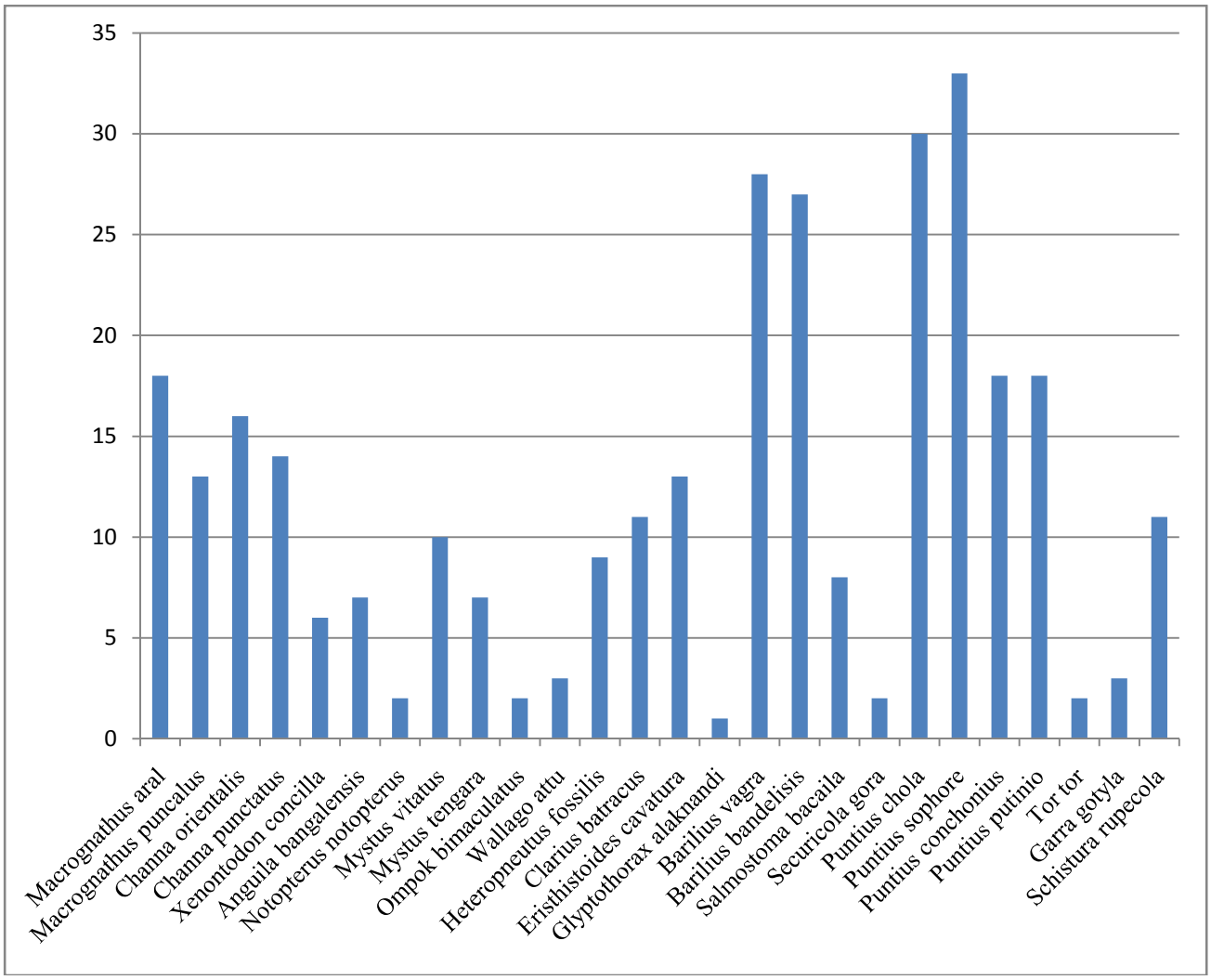

Figure 8: Number of individuals of each species collected from Reu River

4.4.2 Species diversity

The value of Shannon Wiener diversity index (H) and Margalef richness (d) were calculated according to stations and seasons (Figure 8, 9).

The highest Shannon diversity index, (H=1.41) were recorded at station I followed by (H= 1.26) at Station III and (H= 1.17) at Station II. Species richness index were recorded highest (d=11.062) at station III followed by (d=8.74) at station I and (d=8.41) at station II. Similarly the highest Shannon diversity index, (H=1.174) were recorded at monsoon followed by (H=1.1730) in premonsoon and (H=1.163) in post monsoon. Species richness index were recorded (d=10.57) in monsoon followed by (d=8.88) in premonsoon and (d=8.46) in post monsoon.

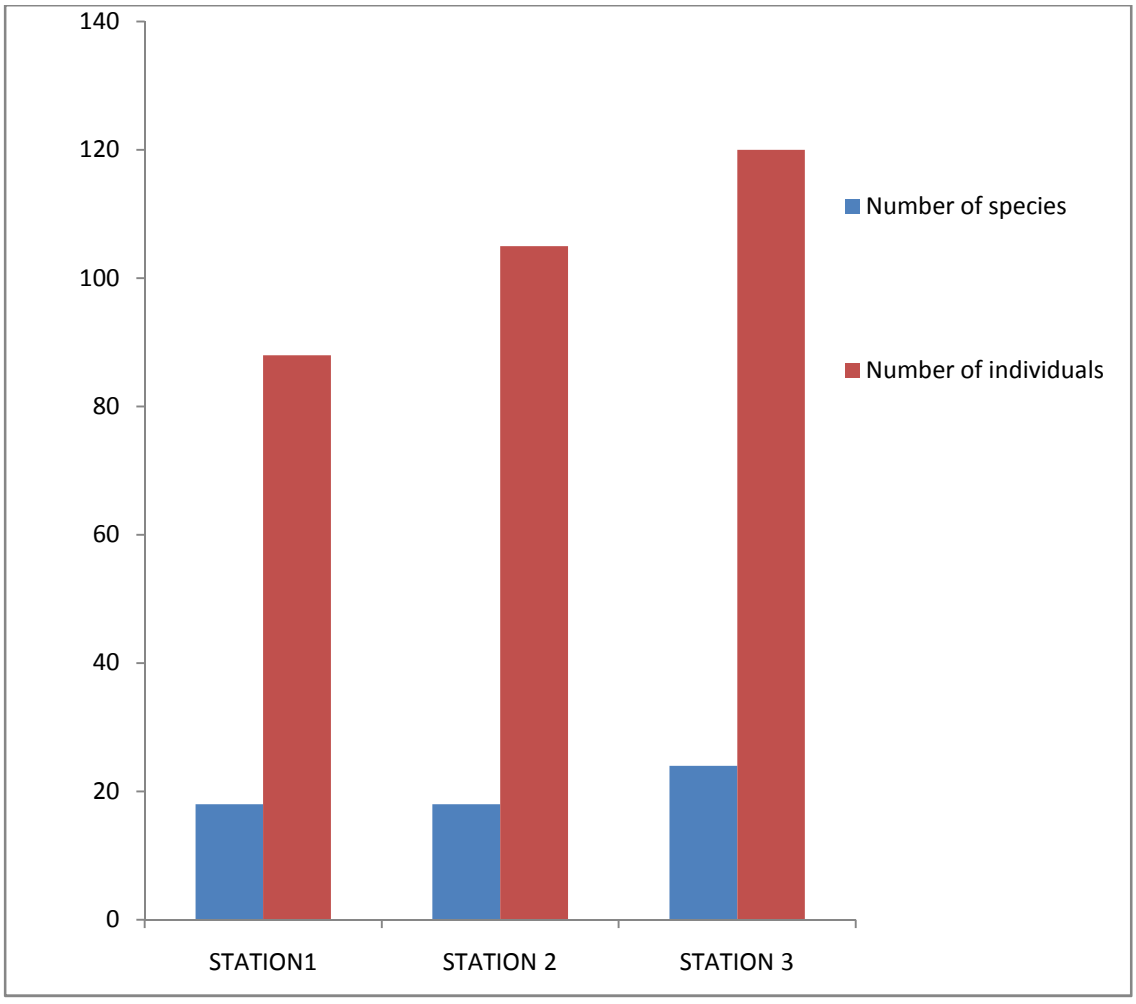

Figure 9: Station wise diversity of fishes in Reu Rive

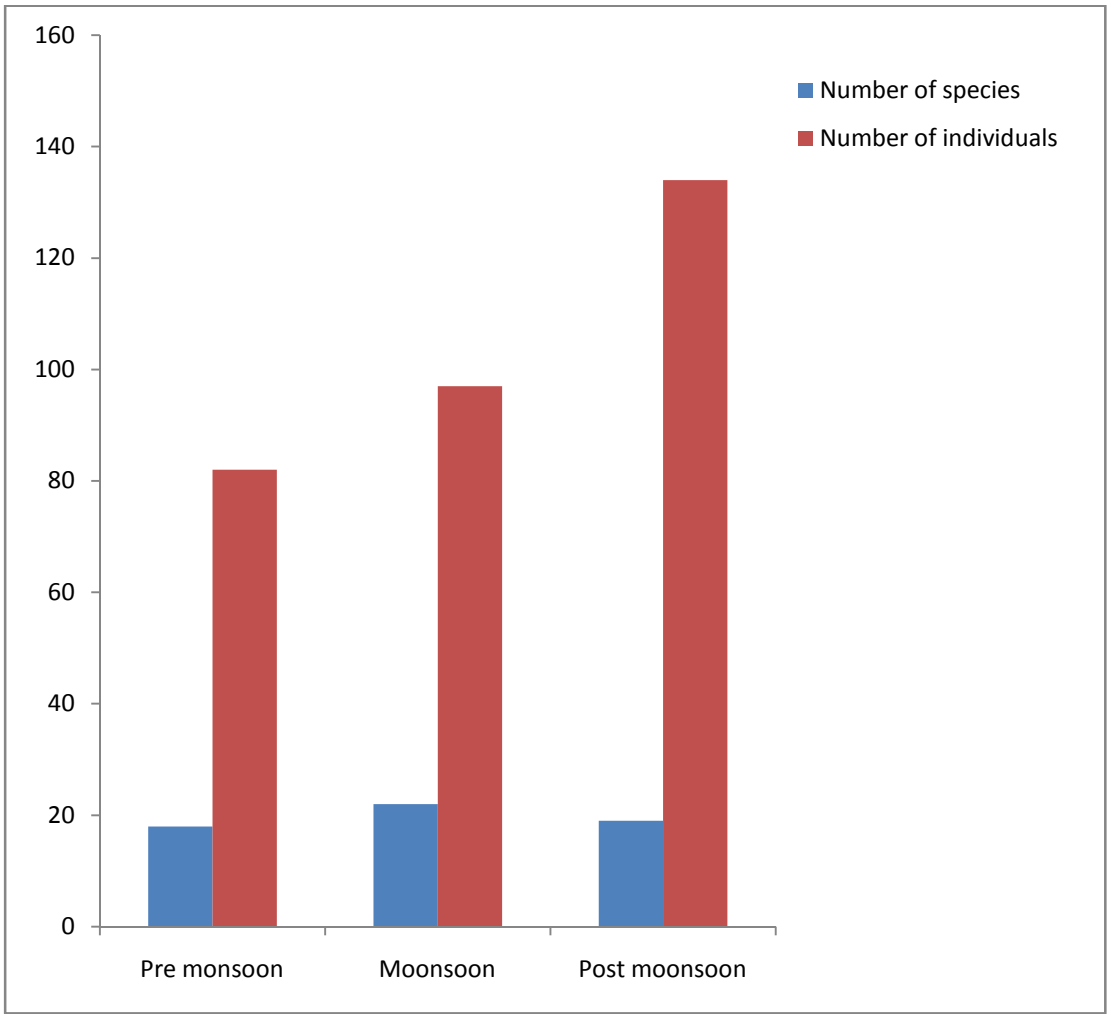

Figure 10: Seasonal variation of fishes in Reu River

4.4.3 Correlations between physiochemical parameter and fishes

Coefficient of correlation between the different physico-chemical parameters and number of fish for all the stations have been calculated by using the relation of Karl Pearson (Gupta 1988). Table 7 shows the correlation coefficient between some physio-chemical parameters and the fish number collected from each station. Correlation between Temperature and Water Depth vs. Number of fish composition are positively correlated while water velocity vs. number of fish composition showed negative correlation. Chemical parameters pH vs. Fishes are negatively correlated while DO vs. Fishes is positively correlated.

Table 7: Coefficient of correlation between physio-chemical parameters and fish species in Reu River

S.N.	Parameters	Correlation(r)	Probable Error (P.Er)
1	Temperature vs. No. of Fishes	0.13	0.38
2	Water Depth vs. No. of Fishes	0.99	0.007
3	Velocity vs. No. of Fishes	-0.17	0.37
4	pH vs. No. of Fishes	-0.11	0.38
5	DO vs. No. of Fishes	0.62	0.24

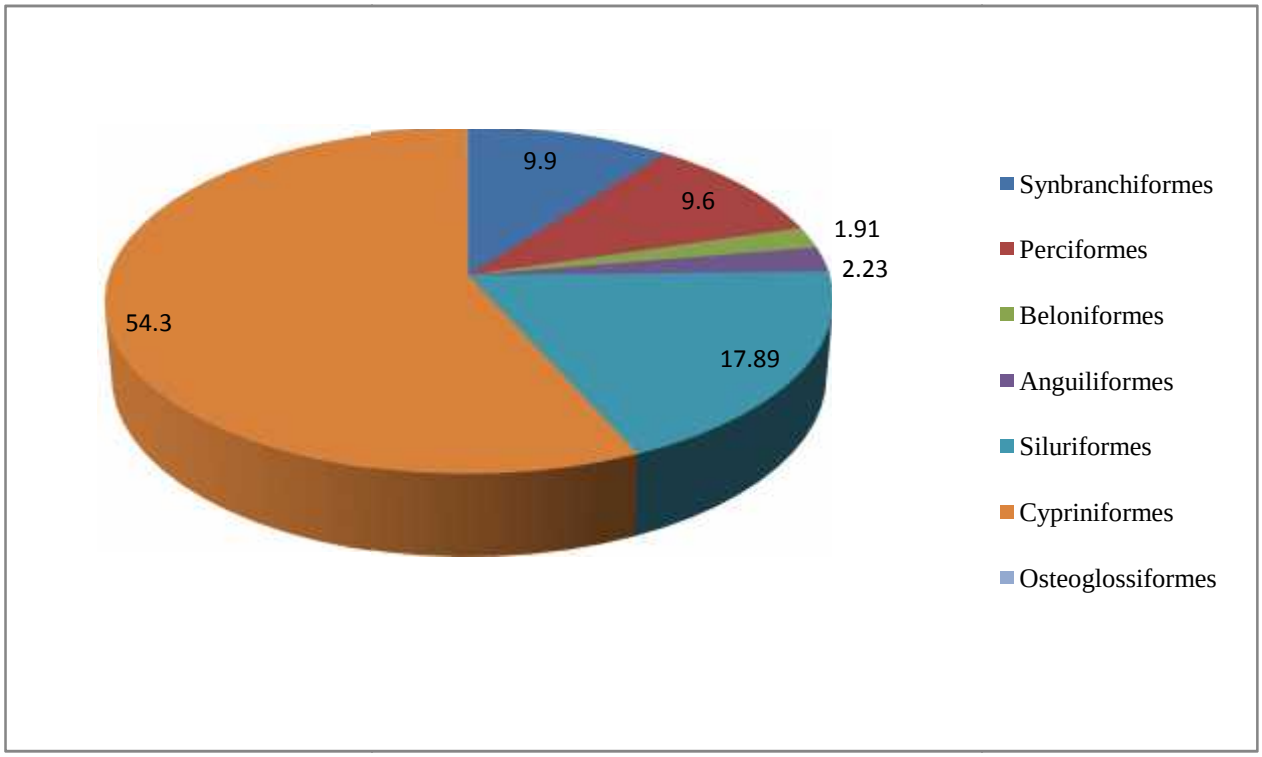

Figure 11: Order wise Fish composition in Reu River

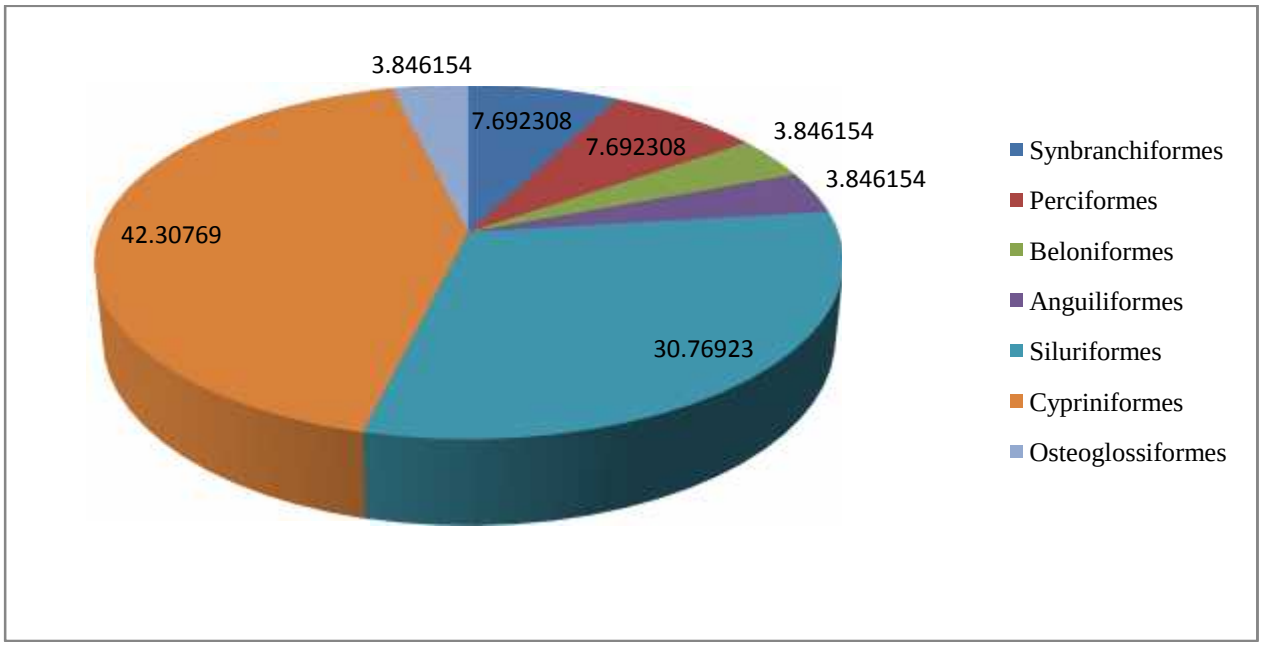

Figure 12: Order wise fish composition catch by number.

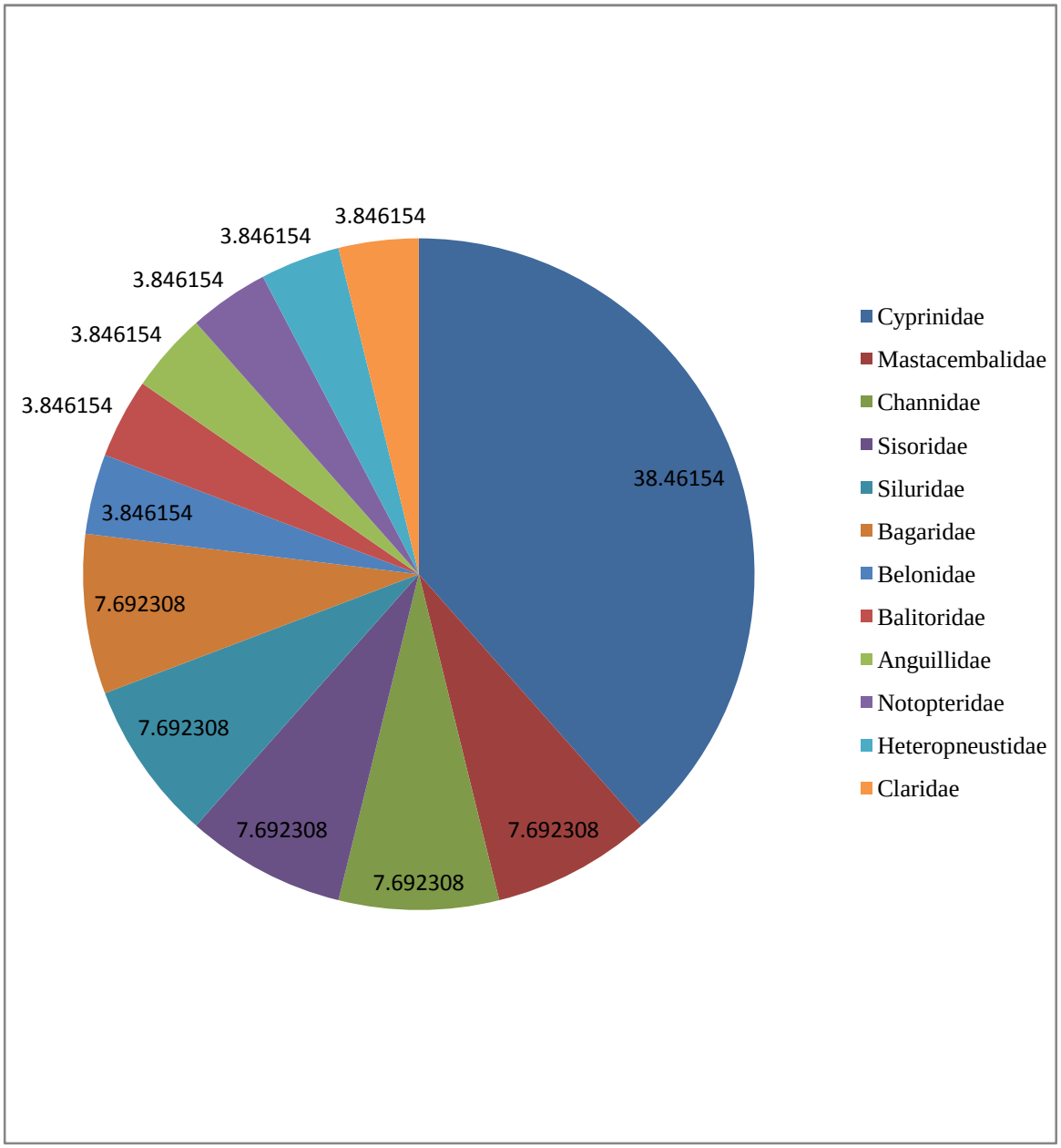

Figure 13: Family wise Fish Species Composition in Reu River.

4.5 Socio-Economic Condition of Fishermen

The socio-economic condition of fisherman was studied in the peripheral areas of Reu River. The numbers of houses engaged in fishing were varied in different stations. In Gaurinagar (I) station, few were engaged in fishing; whereas approximately 50 houses in dhobaha (II) station and 100 houses in Bankatta (III) station. In Bankatta fisherman will be come from another village also. Generally, Tharu communities were recorded involved in fishing; but all the communities involved in fishing were Bote, Majhi, Tharu, Darai, and muslim and sometime Pahadi Kshetri people involved in fishing as occasional fishermen. These fishermen used different implements or gears for fishing depending upon the seasons.

Depending upon the time spending in fishing, the Fishermen of Reu River could be classified into three categories. i) Occasional Fishermen ii) Part time Fishermen and iii) Fulltime Fishermen.

Occasional Fishermen: Occasional Fishermen were those who engaged in fishing activities when their agricultural or other types of basic work load became low. These people did fishing when they had leisure from other work. Generally occasional fishing is carried in summer and spring. Fishermen used different types of locally available implements like hook, rod and line, mosquito net and without gear. In Reu River most of the Fishermen were occasional fishermen.

Part-time Fishermen: Part-time Fishermen were those who had agricultural land or other source of income for their livelihood. They did fishing during the leisure period because their income source was not sufficient to fulfill their needs. They used all the types of fishing implements. The fishing activities were higher during spring and summer due to low water level and easier for fishing.

Full-time Fishermen: There are few full time Fishermen in Reu River. Mainly Tharu and Darai are involved in full time fishing. In Reu River one or two family member were involved in full time fishing while remaining members are involved in different occupation.

4.5.1 Economic Conditions

Economically the Fishermen inhabiting around the Reu River were not so poor. They have their own land for agriculture. The major occupational castes were Tharu, Majhi, Bote and Darai and Musalman. The houses of Fishermen were small huts with roof made up khar (*Imperata* sps.) and the wall is tapped with soil. Only few Fishermen had brick house with tiled roofs. Most of the Fishermen are having 7-11 family members.

Mostly Fishermen of 40-60 years of age were engaged in fishing. Fishermen kept themselves totally busy during the fishing season (Feb-Sept.). Fishing was done mostly during the morning and evening. They used various types of fishing gears like nets, basket implements, hook, rod and line. Fish caught was used mainly for consumption in home. Few Fishermen are brought directly in the market for selling. Preserving practices was not observed during field visit. In the Reu River, Fishermen were found harvesting about 1-2 kg fish per day during fishing season. According to the local Fishermen, the amount of fish in the river had significantly decreased over the years due to various reasons like over exploitation, flood and irrational fishing. Therefore, the income from fishing was negligible.

During the survey, it was noticed that male was found involved in fishing more than female. The young generations were not so interested in fishing. Below 40 years men were not seen in river for fishing during field visit.

4.5.2 Education

Most of the Fishermen near the Reu River were illiterate. Fishermen were not aware about the family planning, so only few fishermen took benefit of it. It was very hard to find the educated person. However, the children of Fisherman are going to school. The Fisherman of this area are very interested to give education to their child. The Fishermen near the riverbank were found aware about sanitation but unfortunately used shore of the river as toilet.

4.5.3 Fish Market

The fish market system in the study area was not well managed. The main fish marketing sites were Basantapur, Baruwa and Kalyanpur. Sometimes Fishermen carried fish door to door to sell in village. Sometimes the Fishermen exchanged fishes with rice, green vegetables, potatoes etc. of local villagers. Fish was popular in Tharu community. The Demand was high in their festival Maghi. Mainly exotic Carps are available in market. Reu River could not fulfill the market demand.

4.6 Fishing practices and fishing implements in Reu River

Different kinds of fishing practices have been found in Reu River. Two types of fishing practices i.e. fishing with gear and without gear were most common for capturing different fish species. Fishing was mostly done in the morning and evening. Fishes were collected in basket called Phurlung made up of bamboo. The most common fishing implements used in Reu River were:

4.6.1 Fishing gears

The fish catching practices using various implements was common practice. In Reu River, different types of implements were used for catching fish:

A. Nets

Gill Net

Gill net is locally known as Mahajal. This net is rectangular and tied across the river in a fixed stand horizontally overnight. The fishes were collected in the next morning. Sinkers were tied in the lower border of the net to make it sinkable. More than two Fishermen were found involved to operate the net. The Fishermen prepared this net themselves with transparent synthetic or cotton fibres. Such type of net was found operated in rainy season when there was sufficient water in river. Fishes such as *Labeo rohita*, *Wallago attu* etc were caught in this net.

Tiyari Net

It is similar to gill net. It is commonly known as Tiyari Jaal or Tehari Jaal. The Fishermen prepared this net with transparent synthetic or cotton fibre.

Cast Net

It is locally called 'Jaal' which is circular net made up of nylon thread. The circumference of the net is wide which tapers gradually towards the apex. Along the rim of the net cylindrical pieces of iron, called sinkers are attached to make the net sinkable in water. While throwing the net, the Fisherman throws it with a jerk into water; it spreads out in the water in a rounded way. After some time with the help of a central rope, the net is dragged and the fishes are collected in a basket made up of bamboo called dhadiya. Generally the cast net was about 15-25ft in dimension. The cast net is mostly applied in shallow water. Fishes such as *Barilus, Puntius, Neolissocheilus* were caught in large amount by this implements.

Bangla Net

It is also called dip net. This is one of the most popularly used net by the Fisherman. This net was made up of two long bamboo poles about 4-5 m long; between them the rectangular net of about 6×2 m. in size was found fixed. It was operated by two Fishermen by dipping the net under water and moving for sometimes here and there and lifting it out. Bangla net is used in shallow water during summer months.

Scoop Net

It is locally called Ghorlang. It consisted a long wooden or bamboo handle of varying sizes. The handle was joined to a circular frame made up of bamboo or niyalo. The dimension of circular frame was about 130 cm deep. It is also known as dip net.

Scoop net could be handled easily by a single man. Fisherman held the net with the help of handle and dips the net into water and lifted out suddenly with jerks. Fisherman repeated the operation till he collects a good catch. It was mostly used in rainy season when the current of water was rapid.

B. Basket Implements

Ganj

It is a typical basket implement with open wide and round mouth. Body tapers from mouth curving slightly ending into a blunt end which was used as handle and suddenly lifting it out of the water. The catches were poured in another basket called dhadiya. This was used when water is shallow and low current.

Dhadiya

It is another mostly used basket implement with a wide month and tapering body. Mouth was covered with bamboo sticks except in one side where there is a small opening. In the interior of the opening there is such an arrangement of bamboo sticks that once fish got inside could not come out. Only small fishes like *Barilius, Puntius*, and fingerlings of *Labeo* etc were caught.

C. Other Fishing Implements

Rod and Line

Rod and line is locally known as 'Balchhi'; which consisted a long rod slightly curving at the tip. Fine cotton or nylon thread is tied at the curved tip of rod. The end of the line is attached to the hook. Just above the hook there is a sinker made up of lead or stone attached. Bait like earthworms, small fishes. Insects were kept in hook and placed overnight under water to attract fishes around the bait and caught in hook.

Paso

Paso is another device used for catching fish. In Reu River, flattened match box, long rod, nylon cord and lead weight are used to make paso. At one end of the rod, loops are made to entangle the fish. In paso no bait is used, fishes are attracted to overhanging lead weight. This device was found used from September to May when the water was clear.

4.6.2 Other Fishing Practices

Fishing without gear is also another fishing practice done in Reu River. The fish collection was found to be done manually. This method is very simple and the most primitive method of fishing. It was practiced during daytime during summer in areas dried after flood or in shallow shore area. Fishes hiding under the stones or in mud were caught directly. To grasp fish by hand, Fisherman dipped his arms quite slowly into water and tried very cautiously to reach hiding fish in crevice. When he succeeded in catching fish, he moves his hand very carefully to hold struggling fishes. Sometimes when the shore area was dried-up during summer after flood, the Fisherman lift water in bucket and throw in the shore and the fishes are collected in basket.

4.6.3 Use of poison

Use of poison is non-conventional method of fishing. Nowadays use of poisoning is rarely done.

4.6.4 Diverting Water Mass

This method is used in the dry season when the water level in the river is minimum. In this practices the whole water mass is diverted by constructing the rough dam. So semidry condition is appeared. Then the fishes are collected by using hand and aluminium disc.

5. DISCUSSION

The fishes of Nepal have wide distribution according to the altitude variation and climatic condition. Two hundred and thirty two fish species belonging to 114 genera, 37 families and 11 orders are distributed in different river system and other water bodies of Nepal (Shrestha 2008). During present study, 26 species were sampled belonging to 19 genera, 12 families and 7 orders**.**

The physicochemical properties of water were recorded at Gaurinagar, Dhobaha and Bankatta stations. It was seen that the physical quality of water environment appear to be basically more important than the chemical ones in many respect in governing the distribution of fishes (Hynes 1970). Among the physical parameters, temperature was the most important factor which affects the distribution and growth of the fishes in all three stations. The water temperature of Reu River was 15-31^{o}C, 16^{o}C-32^{o}C and 16 to 31^{o}C in Gaurinagar, Dhabaha and Bankatta respectively. Coefficient of correlation value of water temperature with the fish number was found 0.13 with probable error 0.38. This showed that fish species composition increases with the rise of temperature in Reu River. The water temperature was recorded varied in different months with variation in fish catch also. The fish catch in the month of April and May was high at increase in water temperature before the onset of monsoon and in the month of September and October before the onset of winter.

Water velocity plays important role in determination of habitat and abundance of flora and fauna in a river by grading the Riverbed and material and maintainance of high level of dissolved oxygen (Whiton 1975). The water velocity of Reu River at different station was recorded. The maximum velocity was recorded 1.7m/s at station I (Gaurinagar) in June/July. The minimum velocity of Reu River was recorded 0.60m/s in December at station II and station III. Water velocity was higher during monsoon at each station due to high flood of water. Coefficient of correlation value of water velocity with the fish number was found -0.17 with probable error 0.37. This showed that fish species composition decreases with the increase in velocity in Reu River.

The chemical parameters also greatly affect the distribution of fish species in the river. Among all the chemical factors, the concentration of dissolved oxygen is the most important factor of all. Dissolved oxygen above 5 ppm is suitable for the support of diverse biota (APHA 1976). The dissolve oxygen of station I, II and III ranged between 6.0-8.5 ppm, 6.5-8.5 ppm and 6.0 – 8.5 ppm respectively.

The pH of natural water is an important environmental factor, the variation of which is linked with the species composition and life process of animal and plant community inhabiting there (jhingram 1991). The pH value of Reu River was almost same in all three stations. The pH of all three stations ranged from 7.6 to 8.1. The water of Reu River was slightly alkaline with average pH 7.84. Phytoplanktons are the primary producers of the river ecosystem. Phytoplanktons are chlorophyll bearing organisms, which are responsible for the photosynthesis. Some phytoplankton found in Reu River during this study were- *Clostrodium*, *Oscillatoria, Spirogyra, Microspora* and *Navicula.* Zooplanktons are also important factor for the river ecosystem. During present study, few Rotifers, Copepods and Cladocera such as *Cyclops*, *Daphnia* and *Monostyla,* were recorded.

The fishes of Nepal have wide distribution according to the climatic condition and altitudinal variation. A total of two hundred and thirty two fish species belonging to 114 genera, 37 families and 11 orders are distributed in different river systems and other water bodies of Nepal (Shrestha 2008). In present investigation, a total of 26 fish species were recorded from Reu River. Majority of the fish species collected from the river fall under the order cypriniformes. This is the largest order of fresh water fishes, which includes 2,422 species (Nelson 1984). Edds (1886) had reported the order cypriniformesas the most common order of Kaligandaki/Narayani River. Reu River is also the tributaries of the Narayani river system. Majority of the fish species collected from the river fall under the family Cyprinidae. *Barilius vagra, Barilius bendelisis, Puntius sophore, Puntius conchonius, Puntius chola, Tor tor* etc. were the example of species found in Reu River. Few species like *Barilius* and *Puntius* were widely distributed in all three stations. Cyprinidae was the most common family having highest frequency of 38.46% of total species. Family

Balitoridae consist of single species *schistura rupecola*. Order Siluriformes was the second common order of Reu River. Family Bagaridae, Siluridae, Sisoridae, Claridae and Heteropneustidae were recorded. *Mystus* Species from Bagaridae, *Ompok bimaculatus* and *Wallago attu* from Siluridae and *Eristhistoides cavatura* and *Glyptothorax alaknandi* from Sisoridae were collected from this river. *Eristhistoides cavatura* was the widely distributed species of Order Siluriformes comprises highest frequency of 4.30% of the total catch. *Ompok bimaculatus* and *Glyptothorax alaknandi* were only found at station III in July and August. 8 different species were recorded from order Siluriformes with the frequency of 30.76%. Order Osteoglossiformes represented by single species of *Notopterus notopterus* of family Notopteridae. It was found in station III only and was very uncommon fish of this river. Order Anguilliformes in Reu River represented by single family Anguillidae and single species *Anguilla bengalensis.* Anguilla was found in station II with least frequency. Only two species were found out of 313 total fish caught during study period.

Xenontodon concilla locally called Donga of family Belonidae belonging to order Beloniformes were found in all three stations. Beloniformes consists about 1.98% of total catch and bears single species. Order Perciformes represented by single family Channidae and two species *Channa orientalis* and *C. punctatus.* Both species commonly found in all three stations. 9.333% of total catch percentage cover by two species. Channa species were found throughout all the stations of the river in all season. Order Synbranchiformes were commonly found next than the order cypriniformes and Siluriformes. 10.26% of total catch fish were under order Synbranchiformes. Mastacembalidae is the single family of order synbranchiformes represented by two species of *Macrognathus aral* and *M. puncalus. Macrognathus aral* was found in III station only and *M. puncalus* was found in II and III station. Both species were not recorded from station I.

A biodiversity index seeks to characterize the diversity of a sample or community by a single number (Magurran 1988). The concept of the ‘‘species diversity’’ involves two components: the number of species or richness and the distribution of individuals among species. However, the formal treatment of the concept and its measurement is complex (Williamson

1973). Shannon–Wiener diversity index considers the richness and proportion of each species while Evenness indices represent the relative number of individuals in the sample and the fraction of common species respectively. The biodiversity index values obtained from present study is not so very high according to Shannon-Weaver biodiversity index values and they do not exactly show the differences occurring among the stations either. According to Keskin and U¨ nsal (1998), the reason for showing lower species biodiversity is that fishing gears used have high selectivity effect. The equipment effect of the fishing gear used in this study was ignored. Highest Shannon diversity index was found in station I (1.410) and it was found highest during monsoon (1.174) where lowest was observed at station II (1.17) and during Post-monsoon (1.163). The main causes of the differences occurring in the biodiversity indexes are atmospheric air currents and environmental conditions (Keskin and U¨ nsal, 1998), and seasonal fish migrations (Ryer and Orth, 1987). The maximum margalef richness value was observed at station III (11.062) where minimum value was observed at station II (8.41) and in case of seasons higher richness value was found during monsoon(10.57) where lower value observed during post-monsoon(8.46). In Shannon (H), and Mergalef (d) diversity there was no significant difference observed. Therefore, it may be concluded that the seasonal difference in species diversity is a common phenomenon in the studied area.

Economically the Fishermen inhabiting around the Reu River were not so poor. They have their own land for agriculture. Majority of Fisherman are part-time and occasional Fisherman. The major occupational castes were Tharu, Majhi, Bote and Darai and Musalman. Most of the Fishermen near the Reu River were illiterate. Fishermen were not aware about the family planning, so only few fishermen took benefit of it. It was very hard to find the educated person. Only a minority of children could go to the school.

Study of fishing appliances and practices used in Reu River revealed that still fisherman follow the traditional fishing technique. Both conventional and non-conventional methods were used in Reu River. Cast net and basket implements were commonly used. Use of poisoning was rarely observed in Reu River.

The woody debris deposited on river shoreline outside the Chitwan National Park was found quickly removed by villagers for fuel wood consumption. The removal of woody debris decreased stream productivity eliminating essential habitat for several fish species. Extraction of sand and stones from river for a construction purpose was another problem disturbing the area of development and shelter of small juveniles during monsoon.

The Reu River is an extremely important water resource providing shelter to about 26 species of biologically diverse ichthyofauna with predominance of Order Cypriniformes and family Cyprinidae. There are several factors which are not only hampering the productivity of the water bodies but responsible for the extinction of certain fish species. Developmental work and agricultural pesticides were the major threats to Icthyofauna. In Gaurinagar and Harinagar area fishes were cultivated near the river bank. In monsoon, there was probability of migration of fishes from pond to river. These cultured fishes might compete with wild fishes for food and shelter. This could be one of the threats to the native species of the river.

6. CONCLUSION AND RECOMMENDATIONS

The present study entitled "Species Diversity and Distribution of fish community of the Reu River" was conducted since March 2014 to February 2015 covering three different seasons - winter, summer and rainy. The present work included some physicochemical parameters and biological parameters like fish fauna, their distribution patterns, management of the Reu River. This study also documented the socio-economic status of Fishermen, fishing implements used in Reu River and fish marketing systems.

A total 26 species of fishes were collected from the different section of river belonging to 7 orders, 12 families and 19 genera. Fishes were collected from the different station of Reu River with the help of local Fisherman mostly by the use of cast net and basket implements called dhadiya. Fishes were not uniformly distributed in Reu River. Among 26 species almost all species were found in Bankatta station except *ompok bimaculatus* and *Anguilla begalensis*. *Tor tor, Garra gotyla, glyptothorax sps* and *Macrognathus aral* were only found in station I (Bankatta).

One endangered species *Tor tor* and two rare species namely *Eristhistoides cavatura* and *Glyptothorax alaknandi* were found in Reu River. *Schistura repecula* fall under the category data deficient and rest of the species are categorized as common and uncommon by Shrestha (2008) Some phytoplankton found in Reu River during this study were-*Clostrodium, Oscillatoria, Spirogyra, Microspora* and *Navicula*. Few Rotifers, Copepods and Cladocera such as *Cyclops, Daphnia* and *Monostyla,* were also recorded as zooplankton.

Economically the Fishermen inhabiting around the Reu River were not so poor. They have their own land for agriculture. Majority of Fisherman are part-time and occasional Fisherman. The major occupational castes were Tharu, Majhi, Bote and Darai and Musalman. Most of the Fishermen near the Reu River were illiterate. Fishermen were not aware about the family planning, so only few Fishermen took benefit of it. Due to lack of educational awareness, the literate fisherman were very difficult to find. However, the children are going to school.

Improvement of fisheries in natural water bodies offers a great opportunity for self-employment and income generation among poor people living along the rivers. The initiation towards conservation and management of indigenous biotic resources in Reu River was not taken seriously. The fisherman and local community must be aware of the importance of riverine fisheries. For successful management and conservation of existing fish species, the following recommendations are made:

- Inappropriate fishing practices like use of fine meshed net, gill net and mosquito net not only catch the targeted fish but also non targeted fish juveniles. These harmful hods must be banned for the conservation and management of fish diversity.

- The different species of fishes breed in different seasons. Usually, female fishes are caught during breeding seasons due to which loss of large quantity of egg resources leading to death of brood fishes. Thus, setting of closed season and stopping the fishing activities during such breeding season is very much required.

- Local people participation is an important aspect in the development process to be continued in self-sustaining basis. Therefore the local fisherman should be provided with technical, financial and other allied support services to make them able to utilize the existing resource for their self-enlistment and also to conserve them.

- More than two dozens of irrigation channels constructed across river cause downward drying of the river and depletion of fishes. Therefore government should provide appropriate irrigation facilities to ensure minimum release of water to support aquatic fauna.

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