FISH DIVERSITY OF BAGMATI RIVER, SARLAHI, NEPAL

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A thesis submitted
In partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology with special paper Fish and Fisheries

Submitted to
Central Department of Zoology
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu
Nepal

April, 2017

DECLEARATION

I hareby declare that the work presented in this thesis entitled **" FISH DIVERSITY OF BAGMATI RIVER, SARLAHI, NEPAL"** has been done by myself and has not been submitted elsewhere for the award any degree. All source of information have been specifically acknowledgement to the author (s) and institution (s).

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RECOMMENDATION

This is to recommend that the thesis entitled **"FISH DIVERSITY OF BAGMATI RIVER, SARLAHI, NEPAL"** has been carried out by **Mr. Niraj Sharan Yadav** for the partial fulfillment of **Master's Degree of Science in Zoology** with special paper '**Fish and Fisheries'.** This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

Date: 19th April, 2017

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On the recommendation of supervisor "**Assoc**. **Prof. Dr. Archana Prasad"** this thesis submitted by **Mr. Niraj Sharan Yadav** entitled **"FISH DIVERSITY OF BAGMATI RIVER, SARLAHI, NEPAL"** is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for **Master's Degree of Science in Zoology** with special paper **Fish and Fisheries.**

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by **Mr. Niraj Sharan Yadav** entitled **"FISH DIVERSITY OF BAGMATI RIVER, SARLAHI, NEPAL"** has been accept as a partial fulfillment for the requirements of **Master's Degree of Science in Zoology** with special paper **Fish and Fisheries.**

EVALUATION COMMITTEE

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2074-01-24 (B.S.)

ACKNOWLEDGEMENTS

First of all, I would like to express my heart gratitude to my respected supervisor Assoc. Prof. Dr. Archana Prasad Central Department of Zoology, T.U. Kirtipur for her enthusiastic supervision, guidance and continuous suggestion for the completion of my research work. I would like to express my sincere gratitude to prof. Dr. Ranjana Gupta the Head of Department of Central Department of Zoology, Tribhuvan University for her academic support.

I would also like to express my thanks to some fishermen of the study area who supported me for the fish catching and fishing technique. I would also like to express my thanks to all the staffs of Central Department of Zoology, Tribhuvan University for their supports during the completion of master`s degree.

Finally, my special acknowledgement goes to my friends Praveen Singh, Rajesh Sah, Barun Pandit and my brother Sanjiv Yadav, Anirudh Yadav for their help to complete my research work. I am gratefully indebted to all family members for who have contributed directly or indirectly their valuable suggestion, guidance, and coordination for the completion of my research work

Niraj Sharan Yadav

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LIST OF ABBREVIATIONS

Abbreviated form	Details of Abbreviations
^0C	Degree Celsius
%	Percentage
∑	Summation
APHA	American Public Health Association
C	Common
CDR	Conservation dependent and rare species
Cm	Centimeter
CN	Critically Endangered
CO_2	Carbon-dioxide
S	Species richness
DO	Dissolved Oxygen
J	Species evenness
DoFD	Directorate of Fisheries Development
EN	Endangered species
Ex	Extinct
Fig	Figure
H’	Shannon Weiner diversity index
ha	Hector
HCL	Hydrochloric Acid
Km	Kilometer
Km^2	Square Kilometer
ln	Natural Logarithm
m	Meter
ml	Millimeter
m/s	Meter per second
N	Normality
n	Total number of species in a sample
NaOH	Sodium Hydroxide
Ni	Total number of individual species
NO	Number
PA	Phenolphthalein Alkalinity
PE	Probable Error
P^H	Hydrogen Ion Concentration
PRO	Pristine rare ornamental species
r	Coefficient of correlation
R	Rare Near Threatened
SN	Serial Number
UN	Uncommon
V	Vulnerable
Max	Maximum
Min	Minimum
Sps.	Species
mt	Metric ton

v	velocity
mg/L	Milligram per liter
Kg/year	Kilogram per year
CBS	Central Bureau Statistics
$MnSo_4$	Magnesium Sulphate
KI	Potassium Iodide
UNDP	United Nation Development Committee
ADB	Asian Development Bank
VDC	Village Development Committee

ABSTRACT

The present work deals with" Fish diversity of Bagmati River, Sarlahi, Nepal". The Bagmati river flows in the Central Terai region of Sarlahi and Rautahat districts of Nepal. The study was focused on the fish diversity and physico-chemical parameter. The data was collected through selecting the sampling site and the field was visited on winter, spring and summer seasons. The physico-chemical parameters of the water was analyzed by using different tools and technique. The fish sampling was performed by local fishermen used for the design of Cast net and local nets. The socio-economic conditions of the fishermen were observed by interviewing local fishermen. The work recorded a total of 16 fish species belonging to 7 orders, 9 families and 12 genera. The fish were collected from 12 species in Rajghat, 13 species from Manpur and 12 species Khairwa. The *Cyprinidae* (55.85%) family showed commonly found in Bagmati river but *Belonidae* (2.25%) family was a lowest number of fish. The water quality parameters, i.e., water temperature (12.6-22.1^{0}C), DO (5.67-6.89 mg/l) and pH (7.1-8.0) were found within the suitable range supporting diverse fish species physico-chemical parameters. The correlation coefficient in water temperature 0.941, 0.475 & 0.612, water depth 0.374, 0.343 & -0.881, transparency -0.965, 0.914& 0.622, and water velocity is 0.714, 0.831 & 0.583 and Chemical parameters were pH is 0.720. -0.992 & 0.913, DO is -0.592, 0.223 & 0.410 and Free CO_2 0.584, 0.494 & -0.842. The highest Shannon Wiener diversity index was found in station II (2.49) and lowest value was found in station II (2.38). The maximum richness value was observed at (12.77) station II where minimum value was observed at (11.76) station I. Evenness index was found to be highest at station II (0.97) and lowest at station I (0.95). It has been observed that the fish population is deteriorating day by day due to various factors such as electric fishing, the killing of brood fishing during spawning season and also by heavy flooding, damming and unsuitable environment of the fish composition. The present study has been perform to offer a baseline report for the fish diversity in Bagmati river.

1. INTRODUCTION

1.1 Geographical Background

Nepal's location at the intersection of the Palearctic and Oriental biogeographical realms, plus varied topography that generates a wide variety of aquatic habitats (Shrestha and Edds, 2012). Nepal occupies 0.3 and 0.03 % of land area of Asia and the world respectively. The country has a great variety of topography which is reflected in the diversity of weather and climate simultaneously. Specially, the country experiences tropical, mesothermal, micro-thermal, taiga and tundra types of climate (CBS, 2014). Nepal is one of the water richest country in the world in freshwater resources occupying at least 5.5% of its area with different types of wetlands (Shrestha, 1981). It has large numbers of rivers and fresh water lake. The major water sources of fresh water bodies are melting snows of the Himalayas. There are a lot of water resources in Nepal with about 6,000 rivers flowing from North to South (Gautam, 2015).

There are three major river systems in Nepal. Koshi in the East, Narayani in the Centre, and Karnali in the West. The Koshi River in the eastern part of Nepal has 33 fish species, the Kali Gandaki River, which drains in the central part of Nepal has 35 species, and from the Bagmati River 22 species have been reported (Shrestha, 1999). She has also given zone based on the presence of the dominant fish species for the Bagmati and Gandaki rivers (Petr and Swar, 2002).

Some fish species of Nepal may tolerate a wide range of water temperature (10^{o}-20^{o} ^{0}C), high dissolved oxygen level, low carbon dioxide level, high transparency and sparse vegetation. Government of Nepal has given priority assisted by international agencies including the UNDP, ADB and JICA. The fish production has been increased from 9,225 kg/ year in 1991/92 to 41,481 kg /year in 2014/15 (Shrestha, 1999).

1.1.1 Water Resources

Nepal is endowed with abundant water resources from an availability point of view. The bodies of water here are regarded as the key strategic natural resources with the potential to act as the catalyst for the all-round development and economic growth of the country. There are about 6000 rivers in Nepal with a total drainage area of 194,471 sq. km. Out of this, 74 % lies within the country. 33 of these rivers has a drainage area that exceeds 1,000 km/sq. The drainage density expressing the closeness of the spacing of channels is about 0.3 km/sq. The development of Nepal's water resources could generate hydroelectric Power, furnish water for irrigation and supply water for domestic and industrial uses (Aryal and Karnikar, 2011). The potential sources of inland fisheries include rivers, lakes, reservoirs, ponds, wetlands and irrigated rice fields (Table 1). Approximately 48.8% of the total water area of Nepal, with 49% being paddy fields, 1.4% swamps around irrigated fields and 0.8% village ponds. Collectively, these water bodies cover nearly 3% of the total surface area of Nepal and it is estimated that some 500,000 ha of water surface may be available for fish production (Pradhan and Pant, 1995).

Table 1. Available water resources

Resources Details	Estimated Area (ha.)	Coverage percent (%)	Potential of fisheries (ha.)
Natural waters	401500	48.9	-
(a) Rivers	395000	48.1	-
(b) Lakes	5000	0.6	3500
(c) Reservoirs	1500	0.2	78000
Ponds	8600	1.1	14000
Marginal/Swamps/goals etc.	12500	1.5	12500
Irrigated paddy Fields	398000	48.4	100000
Total	820600	100	

(Source: DoFD, 2014)

1.1.2 River systems of Nepal

Nepal's rivers are originated from the Himalayas, Mahabharata Hills and Siwalik and Churia Hills. Nepal has fresh water resources from the sea. Each river has several tributes forming a network that carries- across all parts of the country (Figure 1).

Himalayas: These Rivers are incised in the hills and mountains and are comparatively less vulnerable until they debouch into the Terai plain. These are the Koshi, the Gandaki, the Karnali and the Mahakali.

Mahabharata hills: These Rivers transport significant amounts of sediment while flowing through the Churia range and exhibit lateral shifting. These rivers are wide as they enter into the Terai plain and start meandering after the Bhabar zone. These rivers are the Kankai, Kamala, Bagmati, Tinau, West Rapti and Babai.

Siwalika hills: The smaller rivers originating from the southern slope of the Churia hills are named as Churia Rivers. The length of these rivers up to the Nepal-India border ranges between 25 km to 85 km. These rivers have special morphological characteristics that aggravate the flooding and inundation in the Terai of Nepal. The most vulnerable Churia Rivers are the Ratuwa, Bakraha, Lohendra, Khando, Rato, Jhim, Lakhandehi, Lal Bakaiya, Pashaha, and Rohini, (Adhikari, 2013). The rivers in Nepal are characterized by wide, seasonal fluctuation of flow. The monthly flow generally reaches their maximum in July-August and decline to their minimum in February-March. About 80% of the total flow occur during five months (June - October) and the rest during the remaining months. It can be generalized that the smaller the size of the river catchment area, the wider is the range of flow fluctuation (Aryal & Karnikar, 2011). The river bed and adjacent terraces are composed of sediments carried during river flow and deposited where the water meets the Gangetic plains Sediment size tends to decrease the increasing distance from the foothills (Smith *et al*., 1996).

1.1.3 Freshwater fish fauna of Nepal

The fishes of Nepal are very similar to those of Southeast Asia, consisting mainly of carps, catfishes, seal fishes, feather backs, eels, and hill stream fishes. The total water available area is 8, 20,600 ha with potential of fisheries 92,000 ha to be added in future. There are 217 species of fish reported so far from these water bodies and few of them are endemic to

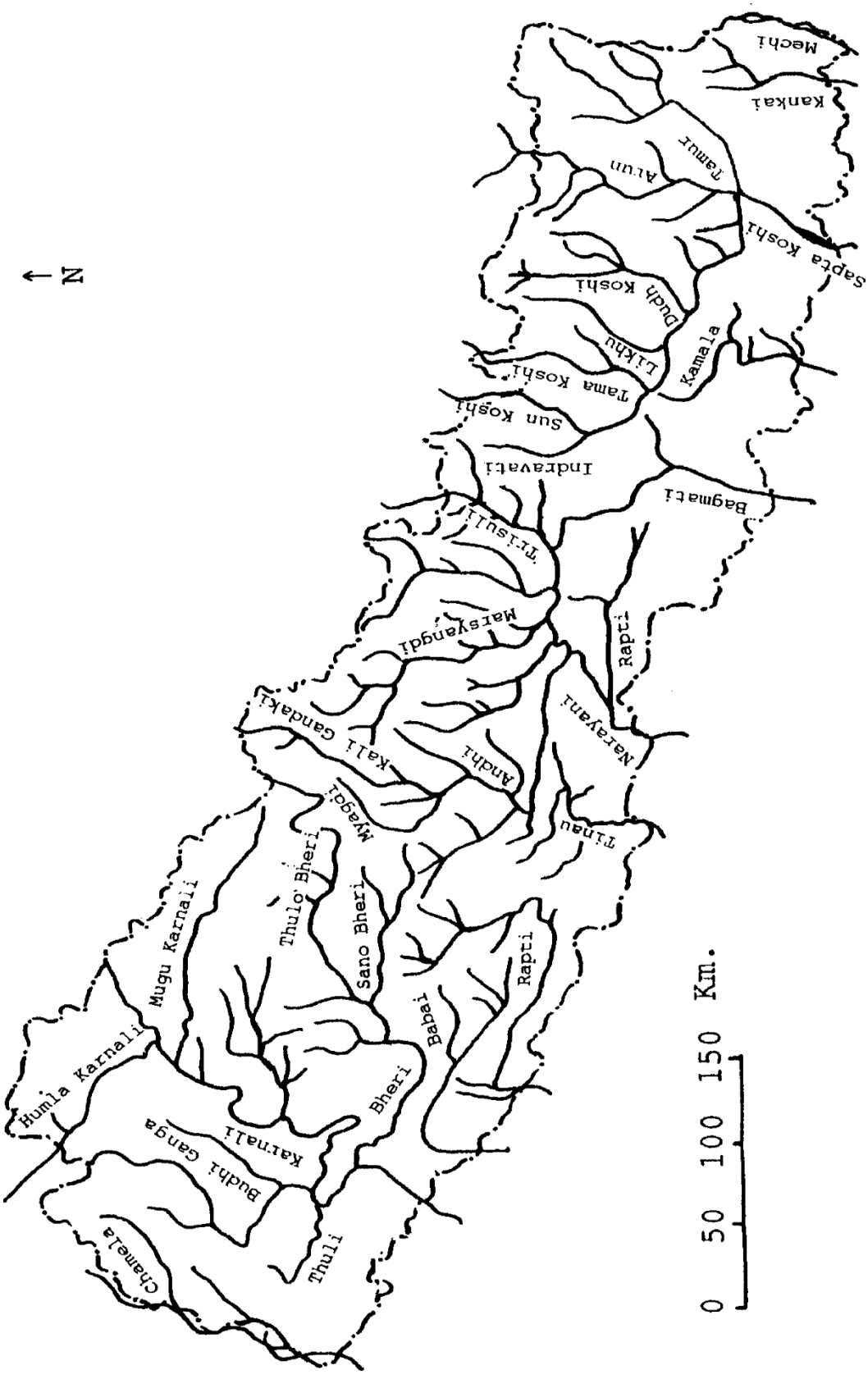

Figure: 1 Major rivers of Nepal (Shrestha, 1999)

Nepal .Similarly, 15 exotic fish species is available in the country of which 8 are popularly cultured (Mishra and Kanwar, 2014). The size, diversity of the fishes is great, with the largest fish, Sahar (*Tor putitora*), recorded at 45 kg with a length of 1.8 m and the smallest fish, Zebra (*Danio rerio*), being just 26 mm in length (Shrestha, 1994). Some authors have also mentioned that the largest fish recorded was Gounch (*Bagarius bagarius*) that weighed 80 kg (Shrestha, 2002). Several authors have also shown new record of fishes, however, most of them are combined. The most recent work is a compilation of 227 fishes in Nepal (Gurung, 2012). Fishes are cultivated in ponds, cages, pens, rice fields, and raceways. Fish cultivation contributes to the major fish production of the country mostly in the lowland warm areas. The major fish species in these areas are Bighead Carp (*Aristichthys nobilis*), Silver carp (*Hypophthalmichthys molitrix*), Grass carp *(Ctenopharyngodon idella*), Common carp (*Cyprinus carpio*), and Rohu (*Labeo rohita*), Mrigala (*Cirrhinus cirrhosus*) and Bhakur (*Catla catla*) are also used in aquaculture, but to a lesser extent. Commercial fishery has been practiced in some of the places like Pokhara, Hetauda, Janakpur, Biratnagar, Rajbiraj and Bhairahawa (Shrestha, 2002; Gurung, 2003) but they have limited supplies and cannot support increasing demand in the country. Some of the remote places like upper Karnali Valley, Kaligandaki, Sunkoshi, Khimti, Chatra and Chisapani are famous commercial fishery centers, but are run on a small scale due to lack of physical infrastructures for the preserving facilities (Shrestha, 2002). These are some the fish conservation status list of the Nepal. Showing the Table 2.

Table 2. List of conservation status of fishes of Nepal.

S.N.	Categories	Designated as	No. of species
1.	Common	C	71
2.	Uncommon or lower risk/ least common	UN	53
3.	Conservation Dependent and Rare	CDR	27
4.	Data deficient pristine rare Ornamental	PRO	32
5.	Critically endangered	CN	0
6.	Endangered	EN	2
7.	Extinct	EX	0
8.	Vulnerable	V	9
9.	Rare Near threatened	R	23
10.	Exotic	E	15
	Total		232

(Sources: Shrestha, 2008)

1.1.4 Fisheries production of Nepal

The decline in professional fishing in European inland water can be attributed partly to competition with other human activities in the inland fisheries (Jadhav, 2009). Freshwater fish are the only records of production reported. Total fish production in Nepal reached to 57,520 mt in the year of 2012/13 (Mishra and Kanwar, 2014). Aquaculture and capture fisheries are the two sources of fish production. Contribution of aquaculture was 36,020 mt whereas capture fisheries was 21500 mt during 2012/13 (Mishra and Kanwar, 2014). Traditional fishing methods are used by most of the subsistence farmers e.g. nets (cast nets, gill nets and scoop nets), fishing rods (hook-line), loops, diversion of river channel and fish

spearing. Recently the use of destructive fishing methods has increased, including electric fishing, explosives, and poisons (Gurung, 2003).

1.1.6 Bagmati River of Nepal

The Bagmati River originates where three headwater streams converge at Baghdwar just below the springs and monsoon rainfall and a number of tributaries as it flows lies above the southern edge of the Shivpuri Hills about 15 kilometers northeast of Kathmandu valley floor and passes through the Valley and enters Chobhar Gorge near the Dakshinkali temple complex. The gorge cuts through the Mahabharata Range or Lesser Himalaya. The Bagmati also crosses the lower Siwalik Hills before reaching the Terai, at Karmaiya. Then it cross through India at Dheng. The length of the river within Nepal is 204km and the area of the basin is around 3,828 km² from about 2,700m altitude to 53m (Manjan and Aggarwal, 2014). This includes areas in eight districts of Nepal: Kathmandu, Lalitpur, Bhaktapur, Makwanpur, Kabhre, Sindhuli, Rautahat, and Sarlahi. They are three physiographic regions: Middle Mountain, Siwalik, and Terai (Milner *et al.,* 2015). Then through Sarlahi and Rautahat border, it reaches to India at Dheng, Bagmati River is a flat up to 100m. But rises gradually up to 125m. Then becomes steep after 125 m from Indo- Nepal border (Sharma, 1997). The 21 fish species were found from Bagmati River (Shrestha, 2001). Nowadays, only 3 species are found in Bagmati River of which *Schizothorax richardsonii* was the only species found in all the seasons (Jha, 2006).

1.1.6 The Rivers of Sarlahi district

Sarlahi is one of the small district of Nepal having 1259 km^2 in area. The average temperature ranges from 20°C to 31°C, while average rainfall is about 1,700mm. Sarlahi lies between $26^0$40' to $27^0$10' latitude and $85^0$20' to $85^0$50' longitude. The altitude of the district ranges from 60 to 808 meters above sea level. The Bagmati River, Lakhandei River and Jhim River cross the district and flow towards Bihar in India, in addition to dozens of smaller seasonal rivers. The Bagmati, Narayan Khola, Madar, Bamanti, Daine, Atrauli, Chapini, Koti, and Ghurmi together have a catchment area of 2,720km^2. These rivers and seasonal streams often cause floods that affect human settlements. It borders Mahottari, Rautahat and Sindhuli districts on the East, West and North respectively and India on the South. Most of the people of this district are poor, illiterate and involved mainly in agricultural activities (UNFCO, 2013).

1.2. JUSTIFICATION OF STUDY

Bagmati River is second class River of the Nepal. The water level is polluted in Kathmandu district but these divides into many tributaries and moves towards Terai region. Winter and autumn season is the favorable condition of fish but during summer season the faunal diversity is low because temperature is high. Bagmati River in Sarlahi have high degenerating level of the fish which is due to many factors such as increasing the fishing pressure (legal or illegal), flooding, construction road across the river side, construction of many small and large bridge. Some fish species like *Puntius, Channa orientalis, C. punctatus, Mystus, Lepidocephalus and Microganthus etc.* were reported from the rivers in Sarlahi (Karn, 2003). The present study had been under taken to gather the basic

information of indigenous fish species and about fish communities depending on fishing for their livelihood in this river.

1.3 LIMITATION OF THE STUDY

A regular sampling of fishes was carried out alternative month for a period of six months i.e February, April and June in 2016. As feasibility study was performed in the Bagmati River in Sarlahi regarding their environmental impact assessment before and difficult to the measuring of the physical parameter. Although other methods as described in materials and methods were inserted for the study.

1.4. OBJECTIVES

1.4.1. General objective

To study the fish diversity of Bagmati River, Sarlahi, Nepal.

1.4.2. Specific objectives

1. To analyze the physico-chemical parameter.
2. To compile diversity of fish in different sampling stations.
3. To practices the fishing by the fisherman.

2. LITERATURE REVIEW

2.1 Historical Review

The history of Ichthyology coincided with that of Zoology which dates back from the time of Aristotle (384-322). He had a perfect knowledge of the general structure of fishes and his information regarding the various group of aquatic amphibians, mammals and various group of aquatic invertebrates. His nomenclature of Ichthyology was limited to 115 species of fishes, all of which were native of Aegina Sea adjacent to Greece. After Aristotle, proper work on fishes was available for nearly 1800 years. This was considered a period of regression in the science of Ichthyology.

During 16th Century, after ichthyology came in limiting with the some of the important works of the Salvani (1514-1572), studied 92 fishes from Rome in Italy and Rondelet (1507-1557) found 57 freshwater fishes from Mediterranean place. Belon (1517-1575 AD) was based on his original observation of 110 fishes from Mediterranean Sea in Europe.

In 17th Century, Piso and Margrov (1611-1678 AD) a described about 100 fishes in Brazil. In 18th and early 19th Century, Ray and Willughby (1635-1672) have described 420 fish species from Great Britain and Germany and also arranged the general of body and fins. Artidt (1705-1734) the father of Ichthyology has also described order of fishes. Linnaeus (1707- 1778 AD) made great foundation of the science of Ichthyology.

Early in 19th Century, Russal (1803) described 200 fishes in Vizagapatnam on the coast Coromandel in India and Hamilton (1822), Donovan (1802) studied "An account of fishes from the river Ganga and its branches".

By late 19th and 20th century, Guenther (1830-1914) published catalogue of the fishes which is kept in British museum, London in eight volumes. The work contained an account of 6,847 species together with the description of another 1,682 doubtful species. Jorden and Jordan (1923) has classified "A classification of fishes including family and genera" (Gupta and Gupta, 2008).

2.2 Fish studies in Nepal by foreign expert

Little work has been done to explore the fish fauna of Nepal in spite of huge water resources and great zoo-geographical significance. The earliest record of the fish and fishery of Nepal was done by Hamilton (1822) who collected number of fish from Nepal and is kept in the British museum, London. Banareseu (1972) studied some Cyprinidae fishes from Khumbu Himalaya in Nepal. Taft (1955) and Swan (1954) gave the check list of 102 species of fishes which belongs to 21 families. Day (1886) mentioned the distribution of some fresh water fishes of Nepal in his historical work "Fishes of India, Burma and Ceylon". Menon (1954), Mishra (1959), Dewit (1960) and Das (1967) also described the fishes of Nepal. Most of the above mentioned studies were mainly based on taxonomy point of view and do not consider the ecology and behavior of fishes.

2.3 Fish studies in Nepal by local expert

Thapa and Rajbanshi (1968) studied the ecology of hill stream fishes from Nepal. Majpuria and Shrestha (1968) published a paper on fresh water fish and fisheries in Nepal. Bhatta (1970) had listed 57 species of fishes in his book 'Natural history and economic botany of

Nepal. Bhatta and Shrestha (1973) have listed 27 species of fishes from Suklaphanta Western Nepal. Shrestha (1978) studied the resources biology and aquatic ecology of fresh water of Kathmandu valley. Shrestha (1980) studied fishing gear and methods used in Narayani River and reported 103 species of fish. Mesuda and Karki (1980) had published a check list of fish fauna of Trishuli River with 6 families, 16 genera and 28 species.
Sharma and Shrestha (2001) recorded a total of 35 species belonging to 25 genera, 12 families and 5 orders from Tinau River, Western Nepal. Singh (2001) recorded fishes belonging to 6 orders 13 families and 26 genera from in fish diversity and fishery resources of Babai River in Nepal. Rajbanshi (2005) reviewed on "Current taxonomic status and diversity of fishes of Nepal". Based on work of Menon (1999) a total number of 187 fish was recorded representing 94 genera, 30 families and 10 orders. Jha (2006) studied the captured fish representing 5 orders, 12 families, 33 genera and 47 species from nine rivers of central and western region rivers of Nepal. Sarkar and Pal (2008) studied the diversity of fish in different reservoir and rivers of Terai region and altogether 83 species of fish belonging to 24 families and 51 genera were reported. Gautam, Saund and Shrestha, (2010) studied a total 2,273 fishes and classified them as 42 fish species belonging to 6 orders, 18 families and 34 genera from Jagadispur reservoir in the Ramsar sites of Nepal. Pokharel (2011) recorded the total of 30 species of fishes belonging to 5 orders, 9 families and 22 genera from Seti Gandaki river and its two major tributaries, Mardi Khola and Vijaypur Khola, in Pokhara Valley, Western Nepal. Saund, Thapa and Bhatt (2012) recoded only 24 fish species belonging to 3 orders, 4 families and 13 genera during the investigation period at Pancheshwar Multipurpose Project area in Mahakali river of Nepal. Mandal and Jha (2013**)** recorded only 26 species of fish belonging to 5 orders, 6 families and 18 genera from the different localities of Marshyangdi River in Lamjung district. Gautam, Jain, Poudel and Shrestha (2016) studied 23 different species of fish from 5 orders, 6 families, and 18 genera occuping this aquatic ecosystem wherein 19 species are indigenous and 4 of them are exotic from the Rupa Lake located in the mid-hill region of Central Nepal. Shrestha (2016) has recorded 48 fish species under 35 genera belonging to 17 families and 6 orders from Triyuga River, Nepal. Edds, (1986). More than 65% of the 182 fish species known in Nepal occur in the Gandaki River which exhibits extremes of altitude and environmental conditions. The Ichthyofauna consisted mainly of Cypriniformes and Siluriformes and also included Cyprinodontiformes and Perciforms. The fish fauna showed longitudinal replacement and addition of species, as the number of species increased from one in the headwaters to a maximum of 33 in lowland sites. Shrestha (1981) had recorded the 120 species comprising 10 order, 26 families and 63 genera. Shrestha (1990) has reported 31 species including *Rita rita* (Hamilton-Buchanan) as the threatened species of Himalayan waters of Nepal. Shrestha (1999) studied the river Bagmati and Gandaki and listed 22 species of fish. She has also proposed river zonation based on the presence of the dominant fish species for the two rivers of Nepal. Shrestha (2001) has reported for Nepal a total of 182 fish species belonging to 92 genera under 31 families and 11 orders, as compared to 186 species of 75 genera, 31 families and 11 orders reported earlier. Shrestha (2002), reported a total of 81 cold water species under 37 genera belonging to 2 orders, 7 families and 10 subfamilies with their updated nomenclature and systematic. Shrestha (2008) studied different water bodies of Nepal and reported 75 species of fish from Karnali

river, 108 species from Koshi river, 34 species Trishuli river, 102 species from Narayani river, 69 species from Mahakali river, 82 species from Bagmati River and 69 species from Kaliagandki, river in this book entitled “Ichthyology of Nepal”. Bagra and Das (2010) identified total of 44 species 9 families in Fish Diversity of Siyom River in Arunachal Pradesh India. Patra and Datta (2010) recorded only 31 species of the fish belongs to 18 genera 4 families of Cypriniformes in Karla river, a tributes of Teesta river at Jalpaiguri district of West Bengal. Patra (2011) also reported only 55 species of fish belonging to eight orders, 20 families in Karla River. Patra and shah (2013) reported only 46 species belonging to 7 order 18 families, 26 genera are reported Damodar River, Burdwan district. Valentina1, Singh, Tamuli and Teron (2015) recorded 62 species of fish represented by 7 orders, 15 families and 32 genera from Karbi Anglong district, Assam, India.

3. MATERIALS AND METHODS

3.1. Study period

The present field study was conducted in the month of February, April and June (3 months) in 2016 during which the frequent field visit was made. Each sampling station was visited in three months during the collection of the study period.

3.2. Study area

The present study is done in the Bagmati River in Sarlahi district. The main tributaries of Bagmati River at Sarlahi are Manusmara, Ekarasi and Bhaumi River etc. A preliminary survey was done prior to the selection of sampling station the present study confined only from Karmaiya to Chhattaul and the area covered 27 km. They connect with each other. The criteria of sampling station based on the season, but representative are like human settlement additional variations, confluences of tributaries etc. The first station lies on the narrow river but second and third stations lied on the wide river. For the collection of fish species from different sampling areas of Bagmati River at Sarlahi district, three study sites were undertaken, viz. Site I – Rajghat, Site II –Manpur and Site III- Khairba (Fig. 3 & 4).

Figure 2: Showing the map of districts in Nepal.

Figure 3: Showing the location of station area.

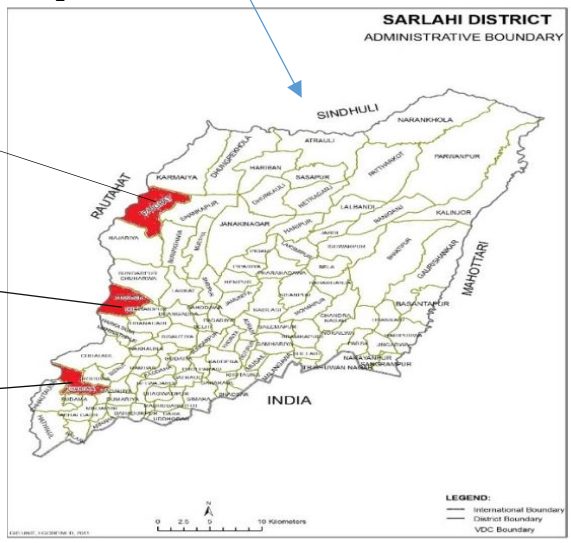

Figure 4: Showing the station area of Sarlahi district

(Source: map google.com)

(A) Station I (Rajghat)

The sampling station I was selected at Rajghat which near the approximately, 7 Km north from the Mahindra Highway at Karmaiya. At this station were found in the boulders large amount of pebble gravels and sand. Their present status of the river bed due to the water was clear and cold with the medium velocity of water than other stations. There was not a human settlement on the side of the river. It is denoted range of the $27^0$02`49" N to $85^0$25`57" E. Location area. This area was jungle side and little mans were settlement. Locals used to plunder the construction materials like sand, boulders and pebbles. So, there were found in few fishes in this study area.

Photograph 1: Sampling station –I (Rajghat)

(B) Station II (Manpur)

The sampling station II was selected at Manpur situated at 7.16 Km downstream from the1st stations at Rajghat. At this station river becomes flat with low water velocity in the river bottom consists of large amount of sand and gravel etc. with agricultural land in the side. It is denoted range of the $26^0$55`48" N to $85^0$24`27" E. location area. There has a population settlement of the area. The population were washing cloths and doing every work of season.

Photograph 2: Sampling station – II (Manpur)

(C) Station III (Khairba)

The sampling station III was selected at Khairaba which is situated at 8.6 km downstream from the 2nd stations at Manpur station. At this station river becomes flat with low water velocity the river bottom consists large amount of sand gravels etc. There also in the agricultural land side. It is denoted range of the $26^0$49`56" N to $85^0$21`31" E. location area. There is no human settlement near the station.

Photograph 3: Sampling station – III (Khairba)

3.3 Sources of data collection

The primary sources of data are based on the direct field observation, sampling, photography and other information were gathered from fisherman of the study area. Fields were made to study the fish diversity and water quality analysis. Socio-economic condition of fisherman was also taken by interview.

3.4 Physico-chemical Parameters

The physico-chemical parameter of an aquatic ecosystem regulated by many factors: depth of water, fluctuation weather, varied climate condition and other chemical properties like measures of the DO, pH and free carbon dioxide etc.

Physico-chemical parameters of water were determined following APHA (1979), Trivedi and Goel (1984).

3.4.1 Physical parameters

(a) Water colour - The colour of water was determined by taking water in a beaker from the river and placed on a white paper and thus the colour was observed.

(b) Water Temperature - Water temperature was recorded by using a standard mercury thermometer by dipping directly into water for two to three minutes to record the water temperature while the air temperature was recorded the sunlight. The result was expressed in degree Celsius (^{0}C).

(c) Water Depth - The depth was measured in the using of rope with hanging the stone and measuring tape was used to recorded depth in centimeters (Cm).

(d) Transparency - Transparency of the water was recorded with the help of Secchi disc (APHA, 1979). The Secchi disc was lowered in the water and measuring tape was used

recorded the depth in the centimeter (Cm). Then the disc was gradually pulled up and the reading was noted at which it reappeared.

The transparency was calculated by applying the following formula

Transparency (D) = $\frac{X+Y}{2} cm$

Where,

X= depth of Secchi disc disappear.

Y= depth of Secchi disc reappear.

(e) Water velocity - Water velocity was measured by the distance travelled by flowing water upon the time taken. Distance was measured in100 m long by using the rope or measuring tape and was calculated the water velocity.

Water velocity (v) = $\frac{\text{distance travelled}}{\text{time taken}}$

3.4.2. Chemical parameter

Among the various chemical parameters of water, pH, DO, and CO_2 etc. of water was measured at the sampling station during each fields. The chemical parameter of the water was analyzed with the help of portable water analysis kit. Precaution and instruction were thoroughly followed during sample collection as giving in instruction from book Chemical biological method for water pollution studies (Trivedi and Goel, 1984).

(a) Potential of hydrogen ion concentration (pH)

pH is the measure of intensity of acidity and alkalinity and measure the concentration of hydrogen ions in water. pH is generally measured the log scale and equals to the negative logarithm of hydrogen ions.

$pH = -\log_{10}[H+]$

$= -\log_{10}\frac{1}{[H+]}$

The hydrogen ion concentration was measure by comparing treated water colour comparator scale colour and reading was noted in the dip in the water and measured in the pH value.

(b) Dissolved Oxygen

Dissolved Oxygen was recorded by taking the sample water in a DO bottle avoiding the air bubbles. Then dissolved oxygen chemical 1(reagent1) and 2 were added to the bottle and the stopper was closed with quick thrust. After 4-5 minutes, the DO reagents 3 was added to the stopped bottle. Take a Measuring cylinder which is put in Sodium Thiosulphate (0.025N) then put the dropped in DO concentrated bottle then colour was changed in yellowish to colourless. Dissolved oxygen is one of the important parameter in water quality in physical and biological process prevailing in the water. Dissolved Oxygen concentration of 5mg/L or more are acceptable for most aquatic organism (Stickney, 2000). When oxygen concentration drop below 2-3 mg/L, hypoxic condition are present (Kalff, 2000). It exists in the bubble in the water and it was measured by using Winkler`s Iodometric method (1888).

Dissolved oxygen (mg/l) = $\frac{(\text{ml}\times\text{N})\text{of Na2S2O3} \times 1000\dot{x}8}{\text{V2}\frac{(\text{V1}-\text{V})}{\text{V1}}}$

Where,

V= Volume of $MnSo_4$ and KI added

V_1 = Volume of sample bottle after placing the stopper i.e. BOD bottle.

V_2 = Volume of content titrated.

(c) Free Carbon dioxide

The amount of the carbon dioxide in water is necessary to retain calcium in the form of calcium carbonate. The large amount of CO_2 is available to the water through respiration by plants and animals. The sample (100ml) water was taken in a conical flask and drop (2-3) of phenolphthalein indicator were added to it. The colorless solution indicated the presence of free carbon dioxide. This solution was treated against standard alkali titrant (NaOH soln.) of (0.05N). The end point (sight pink) was noted. The calculation was done by using the formula.

Free CO_2 (mg/l) = $\frac{(\text{ml} \times \text{N})\text{of NaOH} \times 1000 \times 4}{\text{volume of sample used ml}}$

3.5 Analysis of Biological Parameter

The components of aquatic system. They are the free swimming microbial organism having neutral buoyancy capacity. These are collect in the formalin (5% to 10%) bottle and identification in the Central Department of Zoology, Kirtipur.

3.6 Fish Sampling and Identification

The fish were collected at each sampling stations with the help of employing the local fishermen. The fish were collected by the cast net, drag net and hooks etc. made by the local fishermen and collection of specimens at each stations preserved in 5- 10% formalin solution in the plastic bag or container. The larger fishes were giving longitudinally incision along the abdomen then put the formalin. Fish specimens collected from the sampling areas were brought to the laboratory of Central Department of Zoology for identification using standard method of taxonomy Shrestha (1994), Jayram (1999) and Jhingaram (1991).

For direct observation on fishing method and habitat condition each site was visited. The socio-economic status of the local fisherman was also taken by prepared questioners and interviews (Annexes-V).

3.7 Statistical Analysis

Statistical analysis of fish number in relation with the temperature, pH, carbon dioxide and dissolved oxygen by using correlation coefficient method by the Karl Pearson method (Gupta, 1988).

Correlation coefficient (r) = $\frac{N.\sum xy - \sum x \sum y}{\sqrt{N}.\sum x2 - (\sum x)2\sqrt{N}.\sum y2 - (\sum y)2}$

Probability Error (P) = $\frac{1-r2}{\sqrt{N}} \times 0.6745$

The better analysis of fish species was carried out. This statistical methods are using by the Shannon-Weiner index, Evenness index and species richness. **(**Gautam *et al.*, 2016)

Shannon-Weiner index

Shannon-Weiner diversity index: H '= -Σ Pi log Pi

Where:

H = the Shannon diversity index

P_i = fraction of the entire population made up of species i

S = numbers of species encountered

∑ = sum from species 1 to species S

Evenness index

Evenness index was determined by the following equation (Pieleu, 1966).

Evenness (J) =H'/ln S

Where,

J = Evenness index,

H' is the *Shannon – Weiner index,*

Hmax=log S, 'S' is the number of species.

Species richness index

The species richness is calculated the species richness (Margalef, 1968)

Species richness (S) = s-1/ln N

Where,

S= index of species richness

N= total number of species

s= Individual number of species

3.8 Socio-Economic Condition of Fishermen

Socio-economic condition was found in the questioners and survey, basic information of the different species and demographic status of fishermen (Annex V and Plate V).

3.9 Major Hazard of fishery resources of Bagmati River

Fishing methods were obtained from fishery resources by direct observation during field visit and traditional methods. The human activities were monitored as one of the major hazard.

4. RESULTS

4.1. Physical parameter

4.1.1 Water colour:-The water colour of Bagmati River in Sarlahi was clear and transparent. During monsoon season due to heavy flooding the colour of river was greyish and muddy in other season it was clear. Water colour was measure by putting a drop of it on what tile.

4.1.2 Water depth: - The depth of river during study period and ranged from 96.3cm to 84.2 cm. highest depth was recorded in winter season 96.3 cm in February at station III, lowest was recorded 84.2 cm in April at station I. The average depth was recorded as 90.25cm.

Table 3. Station and month wise water depth

Months	Stations			Max	Min
	I	II	III		
February	86.7	89.4	96.3	96.3	86.4
April	84.2	86.2	92.2	92.6	84.2
June	87.6	88.4	87.1	88.4	87.1
Average	86.17	88	91.86	92.43	85.23

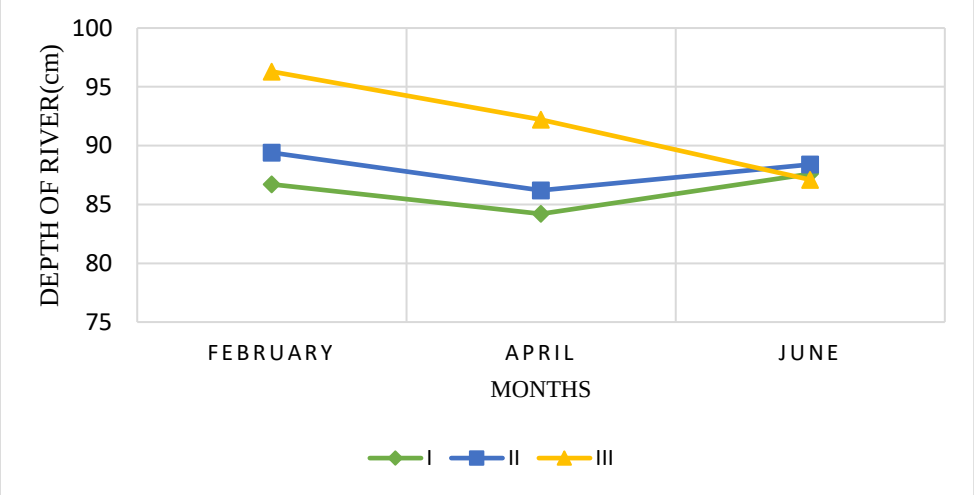

Figure 5: Showing water depth

4.1.3 Water temperature: - The surface water temperature ranged from 12.6-22.1 ^{0}C. During the study period of lowest temperature was recorded at station I (12.6^{0}C) and highest at station III (22.1^{0}C). The average value of water temperature was 16.93 ^{0}C.

Table 4. Station and month wise water temperature

Months	Stations			Max	Min
	I	II	III		
February	12.6	14.2	13.1	14.2	12.6
April	16.3	17.2	18.7	18.7	16.3
June	18.5	20.4	22.1	22.1	18.5
Average	15.8	17.3	17.7	18.33	15.8

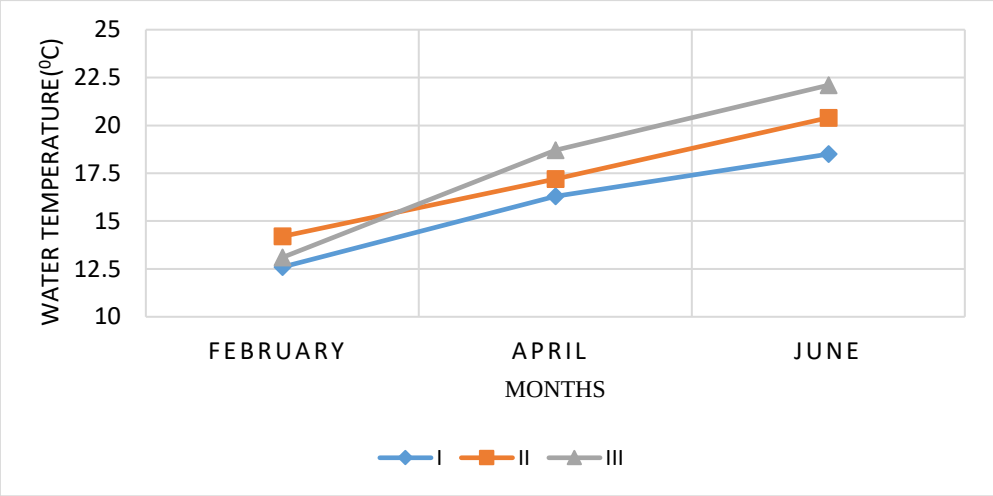

Figure 6: Showing water temperature

4.1.4 Transparency

The water was almost clear and transparent throughout the year except in rainy seasons. The transparency ranged from 14.8 to 46.2cm. The highest transparency was 46.2 cm recorded in February at station III and lowest transparency was 14.8 cm recorded in April at station I. The average transparency was recorded in 29.87cm

Table 5: Station and month wise Transparency

Months	Stations			Max	Min
	I	II	III		
February	45.2	42.6	46.2	46.2	42.6
April	26.3	28.4	27.6	28.4	26.3
June	14.8	17.6	20.2	20.2	14.8
Average	28.76	29.53	31.33	31.6	27.9

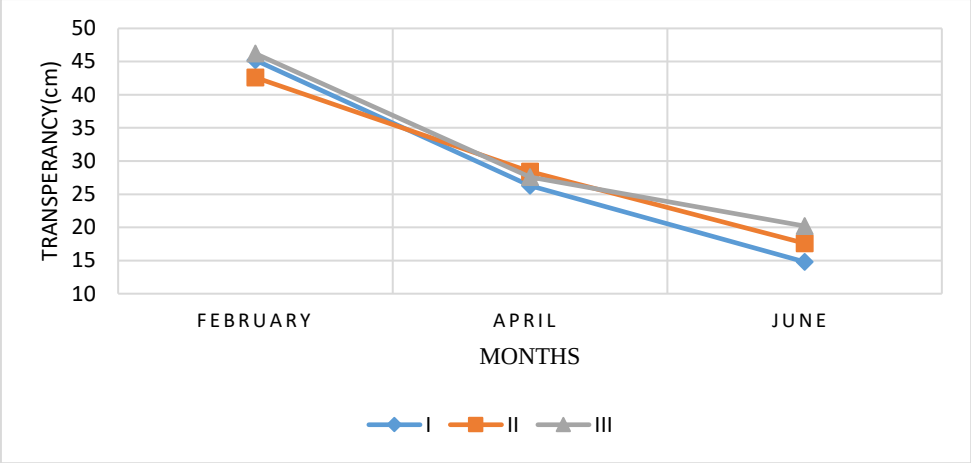

Figure 7: Showing Transparency

4.1.5 Water velocity: - The water velocity plays important for the distribution of fish. The water velocity ranged from 1.098 to 1.190 m/s recorded in the sampling stations. The average water velocity was 1.122 m/s during study period.

Table 6: Station and month wise water velocity

Months	Stations			Max	Min
	I	II	III		
February	1.103	1.098	1.123	1.103	1.123
April	1.111	1.146	1.149	1.111	1.146
June	1.124	1.162	1.190	1.124	1.190
Average	1.113	1.335	1.154	1.113	1.153

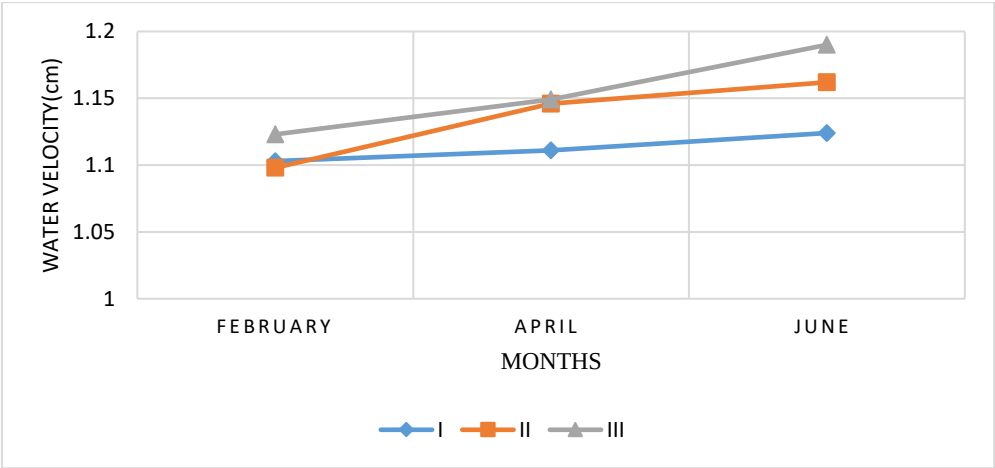

Figure 8: Showing Water velocity

4.2 Chemical parameter

4.2.1 Hydrogen ion concentration (pH): The pH ranged from 7.1 to 8.0. The lowest pH was 7.1 at station I. The pH was recorded highest 8.0 at station III in February. The average pH value was recorded in 7.76.

Table 7: Station and month wise pH value

Months	Stations			Max	Min
	I	II	III		
February	7.2	7.5	7.6	7.6	7.2
April	7.1	7.4	7.5	7.5	7.1
June	7.3	7.6	8.0	8.0	7.3
Average	7.2	7.5	7.7	7.7	7.2

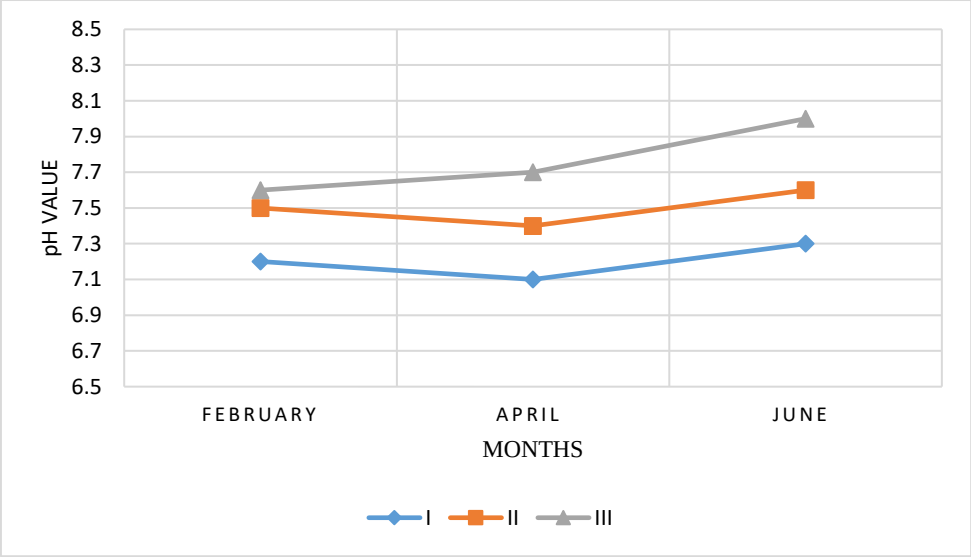

Figure 9: Showing pH Value.

4.2.2 Dissolved Oxygen (DO)

The oxygen is the important for the fish distribution of the rivers. The dissolved oxygen of Bagmati River at Sarlahi the ranged from 5.67-6.89 mg/l with an average dissolved oxygen of 6.36 mg/l at station III in February.

Table 8: Station and month wise Dissolved Oxygen

Months	Stations			Max	Min
	I	II	III		
February	6.89	6.48	6.08	6.89	6.08
April	6.48	6.89	5.67	6.89	5.67
June	6.08	5.67	6.48	6.48	6.08
Average	6.48	6.35	6.07	6.75	5.94

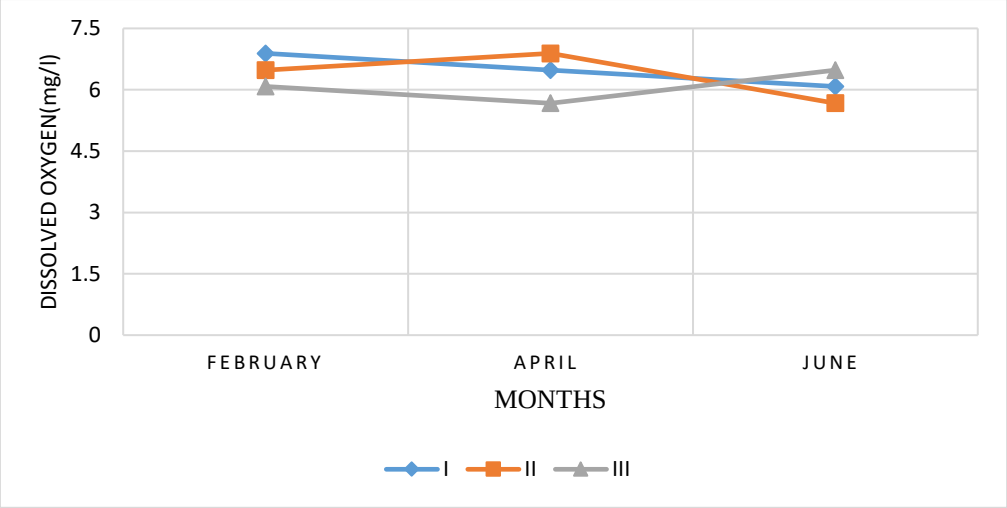

Figure 10: Showing DO

4.2.3 Free carbon dioxide (CO_2)

The free carbon dioxide of the Bagmati River ranged from 2.19- 3.07 mg/l. The highest Free CO_2 was 3.07 mg/l recorded in May at station II. Free CO_2 was decreased to lower value of 2.19 mg/l at station I in February with an average value of 2.47mg/l.

Table 9. Station and month wise Free Carbon dioxide.

Months	Stations			Max	Min
	I	II	III		
February	2.19	2.26	2.94	2.94	2.19
April	2.56	3.01	2.24	3.01	2.24
June	3.07	2.65	2.57	3.07	2.59
Average	2.60	2.64	2.58	3.0	2.34

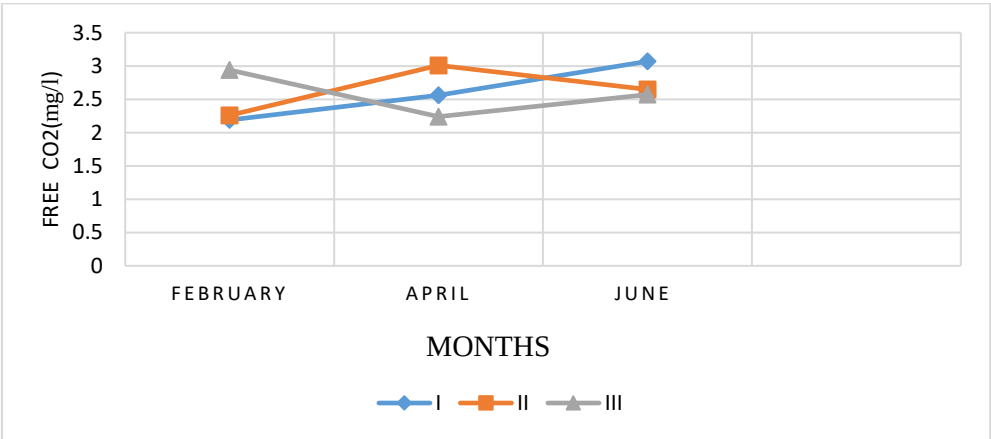

Figure 11: Showing Free CO_2.

4.3 Fishery resources of Bagmati River

4.3.1. Species Diversity

Bagmati River was found to be enriched by various types of fishes. A total number of 16 fish species were found during the study period. The fishes belongs to the 7 orders, 9 families and 12 genera.

4.3.2 Systematic position of fishes

The collected fish were identified and classified based on classification after Shrestha (2001) and Jayaram (1999). Show the Plates – I, II, III & IV (Annex-I).

Table 10. Systematic position of fishes.

S.N.	Order	Family	Genus	Species
I.	Cypriniformes	Cyprinidae	Labeo	*L. rohita*
				L. gonius
				L. dero
			Changuis	*C.chagunio*
			Puntius	*P. sophore*
			Puntius	*P. sarana*
		Cobitidae	Lapidocephalus	*L. guntea*
II.	Osteoglossiformes	Notopteridae	Notopterus	*N. chitala*
III.	Beloniformes	Belonidae	Xenentodon	*X. concilla*
IV.	Channiformes	Channidae	Channa	*C. gachua*
			Channa	*C.puncatatus*
V.	Perciformes	Nandidae	Nundus	*N. nundus*
VI.	Synbranchiformes	Mastacembelidae	Macrognathum	*M. aculeatus*
			Macroganthus	*M. puncalus*
VII.	Siluriformes	Claridae	Clarias	*C.batrachus*
		Bagridae	Mystus	*M. tengra*

4.4 Fish distribution and frequency occurrence in the Bagmati River.

There are 16 species of fish was recorded during the study period. *Puntius sophore* was more dominant fish during the study period. All the fishes of frequency distribution and recorded in the all sampling stations. These were as follows: *Labeo gonius, Labeo dysochelius, Lepidocephalus guntea, and Puntius sarana*. Shown in Table 11.

Table 11. Shown in the frequency distribution of Bagmati River.

S. N.	Scientific name	Local name	Total no. of fish	Frequency %	Sampling stations		
					I	II	III
1.	*Chagunius chagunio*	Rewa	22	9.90	9	7	6
2.	*Labeo gonius*	Kursha	19	8.55	6	6	7
3.	*Channa punctatus*	Garai	14	6.30	-	11	3
4.	*Puntius sophore*	Pothi	31	13.96	9	12	10
5.	*Puntius sarana*	Darahi	19	9.91	7	-	12
6.	*Labeo dyochelius*	Garadi	21	9.45	5	9	7
7.	*Channa gachua*	Chenga	9	4.05	5	4	-
8.	*Labeo rohita*	Rohu	12	5.40	-	6	6
9.	*Mystus tengra*	Tengri	13	5.85	2	5	6
10.	*Clarius batrachus*	Mangur	7	3.15	-	5	2
11	*Lepidocephalus guntea*	Lata	17	7.65	6	7	4
12.	*Nundus nundus*	Dhalo	6	2.70	-	4	2
13.	*Notopterus chitala*	Moi	9	4.05	2	-	7
14.	*Macrogyanthus aculeatus*	Gainchi	8	3.60	3	5	-
15.	*Macrogyanathu pancalus*	Kath gainchi	10	4.50	6	4	-
16.	*Xenentodon concilla*	Kawa macha	5	2.25	3	-	2
	Total		222	100%	63	85	74

4.4.1 Genus wise fish distribution and frequency occurrence

In total fish belonging to 12 Genus was recorded during the study period. The distribution and frequency of the fishes were recorded of the many large and small fishes from all sampling stations. Shown in Table 12.

Table 12. Shown the result of fish frequency distribution by genus wise.

S.N.	Genus	No. of fish caught	Average no (%)
1.	*Chagunius*	22	9.90
2.	*Labeo*	52	23.42
3.	*Channa*	23	10.36
4.	*Puntius*	50	22.52
5.	*Mystus*	13	5.85
6.	*Lepidocephalus*	17	7.65
7.	*Nundus*	6	2.70
8.	*Notopterus*	9	4.05
9.	*Macrogyanthus*	8	3.60
10.	*Mastacembelus*	10	4.50
11.	*Clarius*	7	3.15
12.	*Xenentodon*	5	2.25
	Total	222	100 %

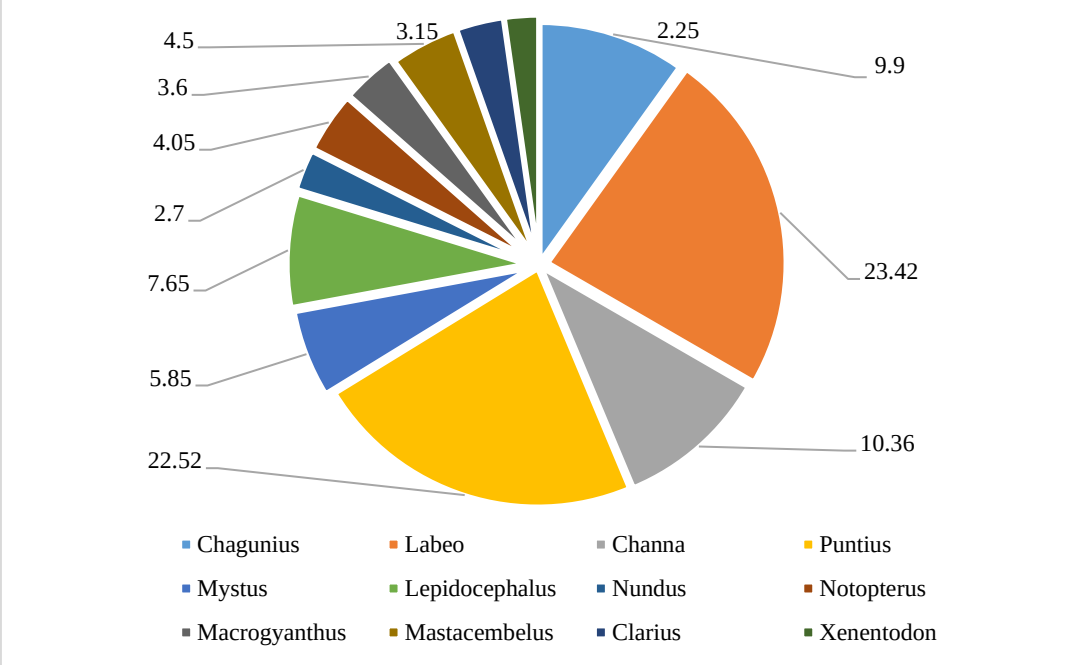

Figure 12: Showing the fish genus distribution.

4.3.2. Family wise fish distribution pattern of Bagmati River in Sarlahi.

There were 9 family recorded of the sampling station period. Cyprinidae family (55.85%) was dominant and Belonidae family (2.25%) was small in Table 13.

Table 13. Family wise fish distribution and pattern

S.N.	Family	No. of fish	Average no. (%)
1.	*Cyprinidae*	124	55.85
2.	*Cobitidae*	17	7.65
3.	*Notopteridae*	16	7.20
4.	*Channidae*	23	10.36
5.	*Belonidae*	5	2.25
6.	*Nanidae*	6	2.70
7.	*Bagridae*	13	5.85
8.	*Mastecembalidae*	18	8.14
9.	*Claridae*	7	3.15
	Total	222	

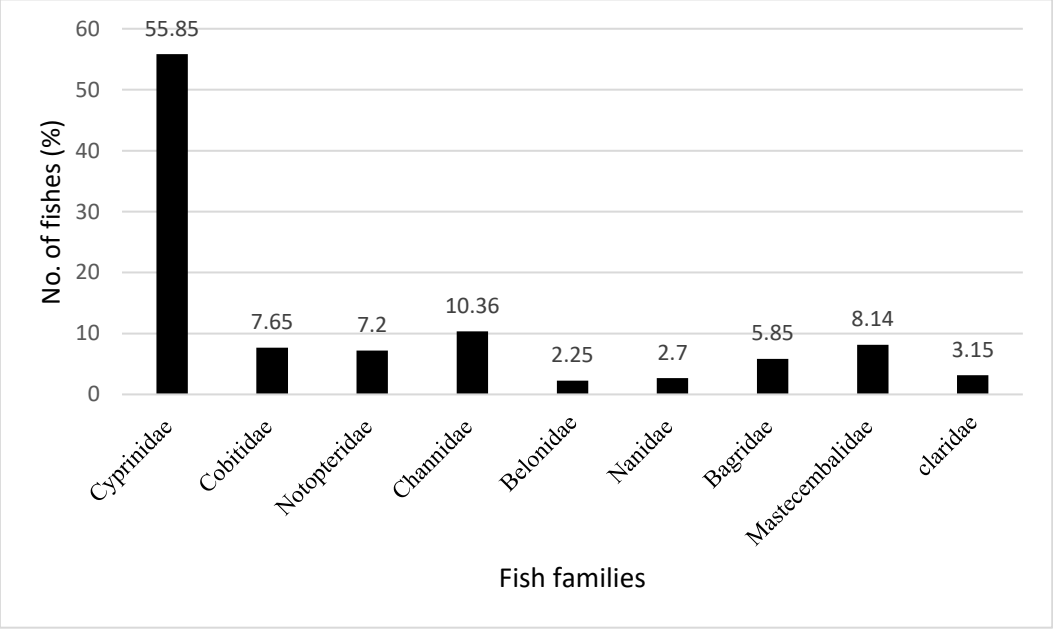

Figure 13. Showing the fish family distribution

4.5 Statistical Analysis

4.5.1 Correlation Coefficient and Parabola error in different variables

The statistical analysis to determine the coefficient of correlation and probable error between the different physico-chemical parameter and number of fish for all the stations have been calculated by Karl Pearson method. As shown in Table 14.

Table 14. Show the correlation value of the physico-chemical and fish density.

S.N.	Variants	Station I		Station II		Station III	
		Coefficient of correlation	Probable error (P.Er.)	Coefficient of correlation	Probable error (P.Er.)	Coefficient of correlation	Probable error (P.Er.)
1.	Correlation between water temperature and fish number	0.941	0.045	0.475	0.038	0.612	0.024
2.	Correlation between water depth and fish number	0.374	0.33	0.343	0.34	-0.881	0.087
3.	Correlation between transparency and fish number	-0.965	0.03	0.914	0.06	0.622	0.23
4.	Correlation between water velocity and fish number	0.714	0.19	0.831	0.12	0.583	0.26
5.	Correlation between pH and fish number	0.720	0.38	-0.991	0.007	0.427	0.06
6.	Correlation between DO and fish number	-0.590	0.25	0.223	0.37	-0.410	0.32
7.	Correlation between CO_2 and fish number	0.584	0.25	0.494	0.29	-0.842	0.11

4.5.2 Diversity abundance of species in communities

High values of H would be representative of more diverse communities. A community with only one species would have an H value of 0 because P_i would equal 1 and be multiplied by ln P_i which would equal zero. If the species are evenly distributed then the H value would be high. So the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community.

Table.15 showing the diversity abundance of different communities.

Stations	Number of Individuals (N)	Shannon-Wiener Index of Diversity (H')	Species Evenness(J)	Species Richness (S)
Station I	63	2.383	0.966	11.758
Station II	85	2.495	0.979	12.774
Station III	74	2.426	0.952	12.765

The value of Shannon Wiener diversity index, Species richness and Evenness were calculated individually at each station. The highest Shannon Wiener diversity index was found in station II (2.495) and lowest value was found in station I (2.383). The maximum Species richness value was observed in lowest (11.76) at station I whereas highest value was observed (12.77) at station III. Evenness index was found to be highest at station II (0.98) and lowest at station III (0.95). The value of Shannon-Wiener diversity, Species richness and the Evenness in different stations data are present in the Annex- II, III & IV.

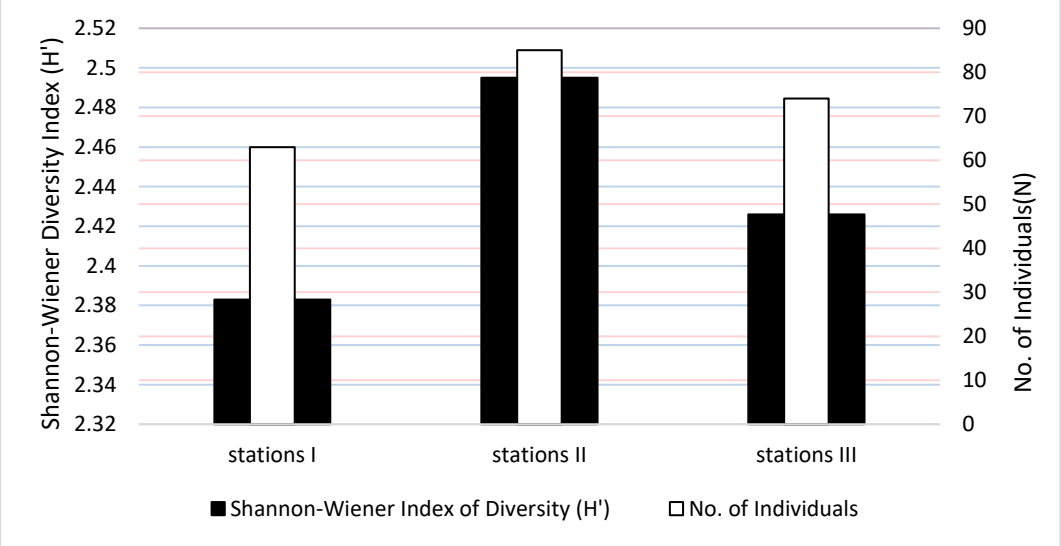

Figure 14. Showing the abundance of Shannon- winner diversity index.

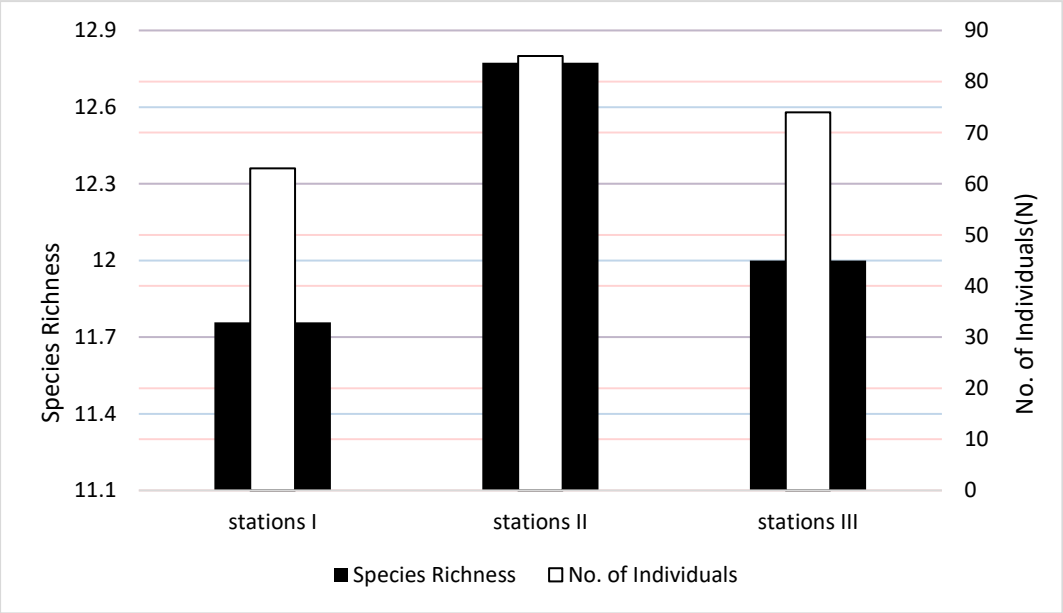

Figure 15: Showing the abundance of species richness.

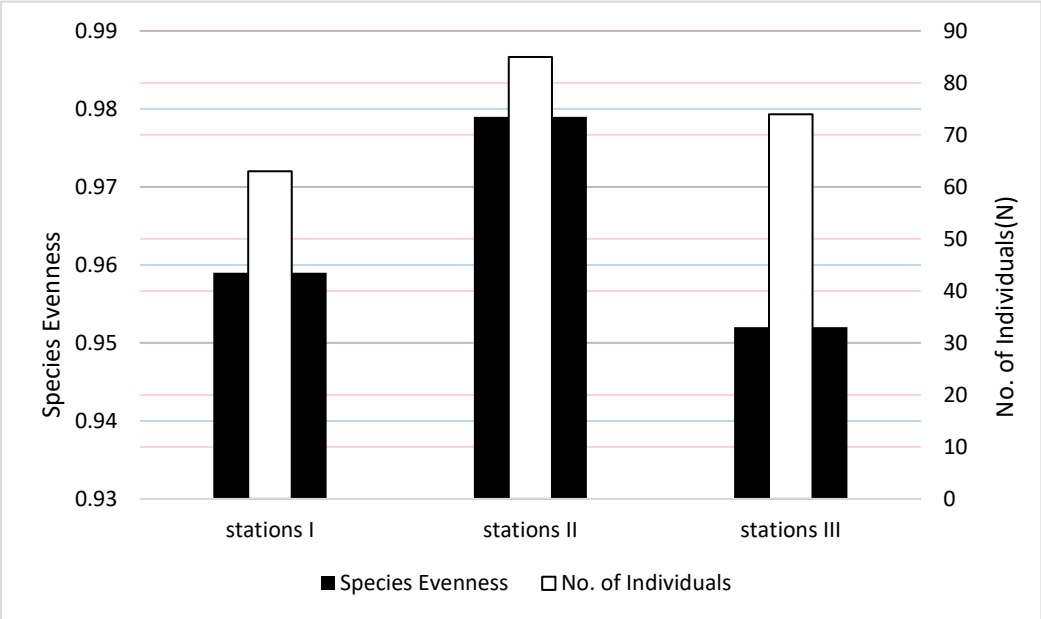

Figure 16: Showing the abundance of species evenness.

4.6 Short description of some important fishes.

Among, single species were recorded 3 orders. During the study period 16 fish species reported from Bagmati River. Some important fish species are described concerning their morphology, habitat, behavior, and fin formula.

The fish species were recorded from the three sampling stations of the study area of the Bagmati River in Sarlahi. Different and same fish species were found in all stations. Viz. Labeo spp., Puntius spp., Channa spp. and other species.

Labeo spp. (Cuvier, 1817) - Labeo spp. is mouth sometime anterior but mostly inferior. Lips is continuous round, barbules two to four. Anal short, scale large, moderate and small sized. Lateral line is complete. The all Labeo spp. fishes are very testy for food and fishing games. They are herbivores and detrivores feeding on algae, vegetable and mud. Average size of the fish was recorded in 8cm to 25cm.

Labeo rohita (Ham. 1822) - They are also called as "Rohu". Their body was bluish black along dorsal side becoming silvery with radish ting on side. Fins was grey in colour and orange margin and lateral line was present. Average size of fish was recorded in 10 to 22 cm. they are found in fresh water bodies rarely in blackish water. These are bottom feeder fish and breeding season in July to August.

Labeo gonius (Cuvier, 1816) - It is also called as `Kursha`. Their Body colour was greenish grey becoming lighting in abdomen. Lips was fringed. Small scale with long lateral dark bands was present in it. It is fresh water fish usually found in river and spawning in monsoon season (July- August). Average size of fish was recorded in 8 to 22 cm.

Channa punctatus (Bloch, 1785) - Most frequently in all kinds of water. They are highly carnivorous bottom feeder fishes and breeding seasons in February to March. Dark greenish black along the dorsum becoming pale green on the sides and paler on the abdomen. They are also known as ` Garai`. Average size of fish was recorded in 13 cm.

Channa gachua (Hamilton, 1822) - It is commonly known as "Chenga". Body is elongated and sub-cylindrical with depressed with head which is dorsally covered with plate like scales. Body colour is dark on dorsal and the sides and belly is dirty white. A blue black is present on the base of pectoral fin while the tip is black. Ventral fin has orange tinge while other fins are dark. Dorsal and anal fins are long. It can attain a maximum size of 13.6 cm. It is carnivorous in nature. Breeding season of this species ranges from June to August.

Puntitus sophore (Ham- Buch, 1822) - Dark spots presents in tip at tail and another at base of dorsal fin rays. Body is modestly compressed. Mouth is small and upper jaw slightly longer and burble absent. Body colour was silvery and greyish colour and underside white. Breeding in monsoon season.

Xenentodon concilla (Ham- Buch, 1822) - Body is elongated, head and strongly compressed laterally, dorsal profile highly convex. Dorsal portion was present coppery green colour and silvery at side colour. These are carnivorous and predators' fish. They are found in fresh water and breeding season was from June and July.

Notopterus chitala (Lacepede, 1800) - Dorsal and anal fin is similar and arranged symmetrically to the tail. Generally, eye is comparatively large, ventrally white and strike. It is also found in fast- flowing water. It feeds on algae and small animal.

4.7 Fishing implements in Bagmati River

In Bagmati River various kinds of fishing implements and methods are being used. Most of the methods used in the Bagmati River are seasonal which are described below.

4.7.1 Nets (Jaal)

Various kinds of nets are used in Bagmati River for fishing, viz., Cast net, Scoop nets and Hook.

a) Cast net

It is a large casting type of net which is used to catch large and medium sized fishes. It is made up of cotton or nylon thread and its body is bell shaped. The rim is folded inside by 5-10 inches, the margin of which is tied with the body of the net at a regular distance of 3-4 inches to give bag like structure, each knot consisting of a pair of iron or lead beads. The mesh size of the net ranges from 1.5 cm- 2.5 cm and catches Rohu *(Labeo rohita) and Chagunius chagunio* (Rewa).

b) Scoop net

It consists of a rectangular wooden or steel-frame which is supported by a short handle of wood. The rectangular frame carries an oval net which is made of jute or mosquito net. It is generally used in muddy water or in diverted channel of river to catch fishes like snake headed fish *Channa sps*, and *Punctatus sps* etc. but very few fishermen use this type of net in the Bagmati River.

4.7.2 Electric fishing

Electric fishing is done at some places in the Bagmati River with the help of 12 volt battery. For this, two rods of opposite poles are dipped in river water so as to kill the fishes lying between these rods. Generally, Asala (*Schizothorax sps*), Fageta (*Barilius sps*) and juvenile fishes becomes victim of this method. Thus this is one of the harmful fishing practices which cause a great loss of young fish.

4.8 Socio-economic status of fishermen

A set of questionnaire was developed and administered to local inhabitants of villages located near Bagmati River such as Rajghat, Manpur and Khairaba to know the socio-economic status of local fishermen. The information obtained were analyzed critically and the conclusions were made which are described below.

Fishermen of Bagmati River are locally known as Majhi or Mallah who generally inhabit the places near the bank of the river. Fishermen are always dominated by the people of higher caste and they get a lot of social harassment from the other communities.

Fishing activities continue throughout the year except the monsoon during which they are engaged in the work of agriculture. About 72% of the fishermen are living in small houses made up of bamboo (*Dandrocalmus strictus*) and Khar (*Imperata cylindrical*) and the bmboo wall is lapped with alluvial soil, seventeen percent have their houses made up of brick wall and have roofs of the Tali. Local fishermen themselves make different types of fishing implements especially during leisure periods with the help of locally available plant (bamboo) and nylon strings. According to the local fishermen, the best fishing season in Bagmati River is from March to June for fishing good-sized fishes. They sell about 90 percent of the total catch composition of fishes at local markets at the rate of Rs. 100/- to

350/- per kg depending upon the species of fishes. The rest catch will be consumed by the family.

4.9. Conservation and management considerations of Bagmati River

The Bagmati River supports 16 fish species of biologically diverse ichthyofaunal with dominance of family Cyprinidae. There are serious problems in Bagmati River regarding fish conservation and management.

4.9.1 Management problems

There are no management activities under way in the riverine fishery in Bagmati River. Some of the important management problems associated with the Bagmati River are as follows:

4.8.1 Destruction of Natural Habitat by Land Slides

Improper land use system and heavy deforestation in the jungle area or open land cause landslides which destroy the natural fish habitat in the Bagmati River.

4.8.1.2 Use of Destructive Fishing Methods

In the Bagmati River fishes are being killed by destructive methods like poisoning and electric fishing in the diverted river channel and pool regions respectively. Such fishing methods not only kill the fries, fingerlings and brood fishes but also destroy the breeding habitats of the fish themselves. The human activities were remarkably disturbing the environment. Soap and detergent used in washing clothes in the river might have affected the aquatic life.

4.8.1.4 Lack of Awareness

Lack of awareness about the importance of riverine fishery in the local inhabitants is the problem for the destruction of riverine fishes. Uneducated local fishermen do not understand the destructive nature of the use of poison, dynamite and the importance of natural habitat of fish. They do not know what size of fishes should be catched. Released of immature captured fishes was back into river not seen.

5. DISCUSSION

The present study approaches were to analyze fish distribution and water quality of Bagmati River in Sarlahi. The studied were analyzed to the February, April and June in 2016. Running water system provides a diverse range of habitats for different types of indigenous fishes.

The physico-chemical parameter of an aquatic environment exhibit influencing factor for the quantity of aquatic life. In the present study, the water temperature was recorded to decrease in February station I (12.6^0C) and increase in June at station III (22.1^0C). Saund *et al* (2012) was found more than this study because the temperature season and water depth was different. The highest of the transparency in month of February (46.2cm) and lowest was June (14.8cm). Gautam *et al* (2010) was found lowest than this study. The correlation between transparency and fish density was found negative at station I and positive at II and III with the value of correlation – 0.96, 0.91 & 0.62 respectively. The transparency was changed in the water depth and human activities.

During the study it was observed that small species like *Chenguis chigunio* were found to be a distribution in shallow habitat while large sized species like *Labeo spp.* was recorded in deeper pool. The depth of river was found ranging from 84.2-96.3 cm. The correlation between water depth and fish density found to be positive during study period at station I, II and III with the value of correlation 0.33, 0.34 and 0.087 respectively. Water velocity decreased downstream and maximum velocity observed in monsoon months and minimum in winter months. The velocity of water in Bagmati River ranged from 1.098-1.190 m/s. The correlation between water velocity and fish density was found positive at stations with values of 0.706, 0.828, and 0.579 respectively.

The concentration of Dissolved oxygen is the most important factors in water which required above 5 mg/l to support diverse biota (Stickney, 2000). The DO was found to be highest value of 6.89mg/l in the month of February and April. The lowest value was 5.67mg/l in the month of April and June respectively. Paudel (2012) and Gauam (2012) slightly more than this study. DO was reported that it was maximum in winter and minimum in summer, the decreased water temperature during winter season has a greater capacity to hold DO than warm water and led to a lower rate of respiration thereby allowing maximum DO in winter.

In the present study period pH range from 7.1 – 8.0 mg/l with an average value of 7.76 mg/l. The pH. Showed the positive correlation with fish density at station III and I, of 0.91 & 0.427 and negative correlation at station II of -0.994 respectively. Similarly report given by Shrestha *et al*., (2009) and Paudel (2012). The pH value was increased in the month of August and June because of fluctuation of habitat, water velocity and change in season. According to Ohle (1938) the limit above or below which pH has a harmful effect is given as 4.8 and 10.8.

Most of the carbon dioxide in the water is formed by the decomposition of organic matter and from respiration of organism. In the present study carbon dioxide varied from the 2.19-3.07 mg/l with an average value of 2.60 mg/l. The coefficient of correlation between free carbon dioxide and fish number showed positive at stations I and II but negative at station III with 0.58, 0.49, -0.842 respectively.

All together 16 species were recorded in three stations where the highest fish catch was from the *Labeo* and *Puntius* which covers at 55.85% of total collected fish and the lowest species were recorded as *Concilla, Chitala and Nandus* etc. Which constitutes the 2.25%, 2.70% and 3.72%. Similarly report was found the Narayani river and Marsyangadi river (Jha and Bhujel, 2013) and (Mandal and Jha, 2013).
Total 9 different Families were recorded during study from different sampling stations of Bagmati River at Sarlahi. Cyprinidae comprised highest number of fish species 55.58% followed by Channidae 10.36% Cobitidae7.65%, Notopteridae 7.20% and rare in Belonidae 2.70% each in total number. Saund *et al.,* (2012) and Gautam *et al.,* (2016) had also found that Cyprinidae as common family in Mahakali, and Rupa Lake. Number of fish species was recorded higher in stations II and III and lower in station I. The diversity of all aquatic organisms including fish was determined by several factors. The richness of fish species in stations II and III could be correlation with increase transparency. The reason for that, the lower number fish species at station I might be related with poor water qualities due to deforestation human activities. According to the locals and fishermen the fishes are now in decreasing in the Bagmati River.

The value of Shannon Wiener diversity index, Species richness and Evenness were calculate and observed to the data of individually at each station. The highest Shannon Wiener diversity index was found in station II (2.495) and lowest value was found in station I (2.383). (Aggrey and Mensah, 2012), was also recorded the ranged from 2.54 to 2.83 in Shannon winner diversity index. The maximum Species richness value was observed in lowest (11.76) at station I whereas highest value was observed (12.77) at station II. Evenness index was found to be highest at station II (0.97) and lowest at station III (0.95). (Negi and Mamgain, 2013) was also found the species richness, showed variation and ranged from 0.036- 0.173. The value of Shannon-Wiener diversity, Species richness and the Evenness in different station are the different value which is depends upon the fish density, water quality and construction of the river.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The "Fish diversity of Bagmati River, Sarlahi, Nepal" were studied for the period of three months from February to June 2016 covering the different three stations. Information was collected on species composition local names, location of catch and fishing methods used to catch different species from all stations. Along with the physico-chemical parameters and managements consideration of Bagmati River was studied. A total number of 16 species fish fauna was collected from the different stations of Bagmati River belonging to 7 order, 9 families and 12 genera. Fish were not uniformly distributed but influenced by the Velocity of water, Water temperature, Depth of water, Dissolved Oxygen, Free CO_2, pH. Upper reaches of the Bagmati River was the habitat of *Labeo, Puntius Lepidocephalus* and dominant fish species in the river. Present fish record included common fish species, economically important fishes like *Chitala, Concilla* and *Nundus.* The fishes of the Bagmati River were biologically diverse. Different stations were found with different fish species as because of the species were dependent of temperature, water velocity, pH, CO_2, and DO. The study which is also describe the statistical data in correlation coefficient, Shannon-winner diversity index, species evenness and species richness.

The study showed riverine environment undergone degradation due to various natural landslide, soil erosion and manmade activities like road construction alongside of the river bridge, construction, over fishing, illegal fishing, use of soap and detergent, stone extraction. Nepal government immediately has to look into the local resources, to harvest and conserve the resources for effective and sustainable management. As biodiversity including fish diversity is a part concern this work should supplement the knowledge at international level.

6.2 Recommendations

Improvements of fisheries of natural waters offer a great opportunity for self-employment and income generation among poor people living along the rivers. But no work had been done so far for the conservation of fish fauna in Bagmati River, as a result, there is a decline in density and diversity of riverine fish species. Therefore, for successful conservation and management of indigenous fish species in the Bagmati River were following recommendation are suggested.

- The local fisherman should provide with technical, financial and other allied support service to make them able to utilize the existing sources and also to conserve them.
- Many non-convention method of fishing like poisoning, dynamiting, electro fishing, diverting water masses etc. are being used in this river. Such activities should be controlled immediately.
- Rehabilitation of important fishes should be done by the introduction of hatchery reared fry and fingerlings.
- At present the rivers of Nepal are utilized either for hydroelectricity power or for irrigation purpose where as these can be utilized for fish production too. For this purpose, there is need for the conservation for the fresh water fishery resources through the involvement of researcher, local communities from the planning stage up to the implementation.

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ANNEX- I

Classification of fish species

I. Order - Cypriniformes

Family - Cyprinidae

Genus - Labeo (Cuvier, 1816)

Species - *L. rohita* (Hamilton- Buchannan, 1822)

Local name - Rohu

Genus - Labeo (Cuvier, 1816)

Species - *L. gonius* (Hamilton - Buchannan, 822)

Local name - Kursha

Genus - Labeo (Cuvier, 1816)

Species - *L. dychalous* (Ham. – Buch., 1822)

Local name - Garadi

Genus - Chagunius (Smith, 1945)

Species - *C. chagunio* (Ham. - Buch) 1822

Local name - Rewa

Genus - Puntius (Hamilton- Buchanan, 1822)

Species - *P. sophore* (Ham. -Buch., 1822)

Local name - Pothi

Genus - Puntius

Species - *P. sarana* (Ham. – Buch., 1822)

Local name - Darahi

Family - Cobitidae

Genus - Lapidocephalus (Bleeker, 1859)

Species - *L. guntea* (Hamilton- Buchanan, 1822)

Local name - Lata (Letaba)

II. Order - Osteoglossiformes

Family - Notopteridae

Genus - Notopterus (Lacepede, 1800)

Species - *N. chitala*

Local name - Moi

III. Order - Beloniformes

Family - Belonidae

Genus - Xenentodon (Regan, 1912)

Species - X. *concilla* (Hamilton- Buchanan, 1822)
Local name - Kauwa machha

IV. Order - Channiformes
Family - Channidae
Genus - Channa
Species - C. *gachua* (Hamilton- Buchanan, 1822)
Local name - Chenga

Genus - Channa (Scopoli, 1777)
Species - *C. puncatatus* (Bloch, 1785)
Local name - Garai

V. Order - Perciformes
Family - Nandidae
Genus - Nundus
Species - *N. nundus* (Hamilton- Buchanan, 1822)
Local name - Dhallo

VI. Order- - Synbranchiformes
Family - Mastacembelidae
Genus - Macrognathum (Lacupede, 1800)
Species - *M. aculeatus*
Local name - Gainchi

Family - Mastacembelidae
Genus - Macrognathum (Lacupede, 1800)
Species - *M. puncalus*
Local name - kath Gainchi

VII. Order- - Siluriformes
Family- - Claridae
Genus- - Clarias
Species - - C.*batracus*
Local name- - Magur

Family - Bagridae
Genus - Mystus (Scopoli, 1777)
Species - *M. tengra* (Mishra, 1976)
Local name - Tengri

ANNEX- II

Diversity abundance of the Shannon index, Species richness and Species evenness of fish.

Station –I (Rajghat)

S.N	Species	Local name	No. of fishes	Relative Abundance (Pi)	ln(Pi)	Pi*ln(Pi)
1	*Chagunius chagunio*	Rewa	9	0.142	-1.945	-0.27799
2	*Labeo gonius*	Kursha	6	0.095	-2.351	-0.22394
3	*Channa punctatus*	Garai	0	0		0
4	*Puntius sophore*	Pothi	9	0.142	-1.945	-0.27799
5	*Puntius sarana*	Darahi	7	0.211	-2.197	-0.24414
6	*Labeo dyochelius*	Garadi	5	0.0793	-2.533	-0.20109
7	*Channa gachua*	Chenga	5	0.0793	-2.533	-0.20109
8	*Labeo rohita*	Rohu	0	0		0
9	*Mystus tengra*	Tengri	2	0.0317	-3.449	-0.10952
10	*Clarius batrachus*	Mangur	0	0	0	0
11	*Lepidocephalus guntea*	Lata	6	0.095	-2.351	-0.22394
12	*Nundus nundus*	Dhalo	0	0	0	0
13	*Notopterus chitala*	Moi	2	0.031	-3.449	-0.10952
14	*Macrogyanthus aculeatus*	Gainchi	3	0.047	-3.044	-0.14498
15	*Macrogyanathu pancalus*	Kath gainchi	6	0.095	-2.351	-0.22394
16	*Xenentodon concilla*	Kawa macha	3	0.047	-3.044	-0.14498
		Total	63			-2.38311
	Species Richness (S):	11.758				
	Number of Individuals (N):	63				
	Shannon-Wiener Index of Diversity (H'):	2.383				
	Species Evenness (H'/ln(S)):	0.966				

ANNEX-III

Diversity abundance of the Shannon index, Species richness and Species evenness of fish.

Station –II (Manpur)

S.N	Species	Local name	No. of fishes	Relative abundance (Pi)	ln(Pi)	Pi*ln(Pi)
1	*Chagunius chagunio*	Rewa	7	0.0823	-2.49674	-0.20561
2	*Labeo gonius*	Kursha	6	0.0705	-2.65089	-0.18712
3	*Channa punctatus*	Garai	11	0.1294	-2.04476	-0.26462
4	*Puntius sophore*	Pothi	12	0.1411	-1.95774	-0.27639
5	*Puntius sarana*	Darahi	0	0		0
6	*Labeo dyochelius*	Garadi	9	0.1058	-2.24543	-0.23775
7	*Channa gachua*	Chenga	4	0.0470	-3.05636	-0.14383
8	*Labeo rohita*	Rohu	6	0.0705	-2.65089	-0.18712
9	*Mystus tengra*	Tengri	5	0.0588	-2.83321	-0.16666
s10	*Clarius batrachus*	Mangur	5	0.0588	-2.83321	-0.16666
11	*Lepidocephalus guntea*	Lata	7	0.0823	-2.49674	-0.20561
12	*Nundus nundus*	Dhalo	4	0.0470	-3.05636	-0.14383
13	*Notopterus chitala*	Moi	0	0		0
14	*Macrogyanthus aculeatus*	Gainchi	5	0.0588	-2.83321	-0.16666
15	*Macrogyanathu pancalus*	Kath gainchi	4	0.0470	-3.05636	-0.14383
16	*Xenentodon concilla*	Kawa macha	0	0		0
			85	1		-2.49569
	Species Richness (S):	12.774				
	Number of Individuals (N):	85				
	Shannon-Wiener Index of Diversity (H'):	2.4956				
	Species Evenness (H'/ln(S)):	0.979				

ANNEX- IV

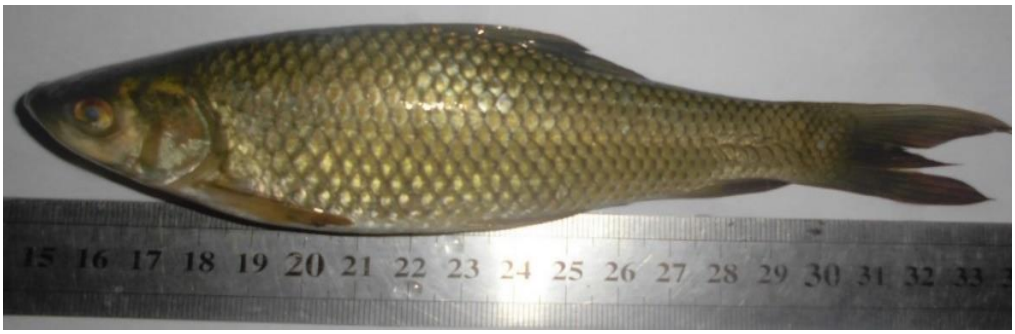
Diversity abundance of the Shannon index, Species richness and Species evenness of fish.

Station – III (khairaba)

S.N	Species	Local name	No. of fishes	Relative abundance (Pi)	ln(Pi)	Pi*ln(Pi)
1	*Chagunius chagunio*	Rewa	6	0.0810	-2.512306	-0.2037
2	*Labeo gonius*	Kursha	7	0.0945	-2.358155	-0.22307
3	*Channa punctatus*	Garai	3	0.0405	-3.205453	-0.12995
4	*Puntius sophore*	Pothi	10	0.1351	-2.00148	-0.27047
5	*Puntius sarana*	Darahi	12	0.1621	-1.819158	-0.295
6	*Labeo dyochelius*	Garadi	7	0.0945	-2.358155	-0.22307
7	*Channa gachua*	Chenga	0	0		0
8	*Labeo rohita*	Rohu	6	0.0810	-2.512306	-0.2037
9	*Mystus tengra*	Tengri	6	0.0810	-2.512306	-0.2037
10	*Clarius batrachus*	Mangur	2	0.0270	-3.610918	-0.09759
11	*Lepidocephalus guntea*	Lata	4	0.0540	-2.917771	-0.15772
12	*Nundus nundus*	Dhalo	2	0.0270	-3.610918	-0.09759
13	*Notopterus chitala*	Moi	7	0.0945	-2.358155	-0.22307
14	*Macrogyanthus aculeatus*	Gainchi	0	0	0	0
15	*Macrogyanathu pancalus*	Kath gainchi	0	0	0	0
16	*Xenentodon concilla*	Kawa macha	2	0.0270	-3.610918	-0.09759
			74	1		-2.42622
	Species Richness (S):	12.767				
	Number of Individuals (N):	74				
	Shannon-Wiener Index of Diversity (H'):	2.4262				
	Species Evenness (H'/ln(S)):	0.952				

PLATE-I

Fish diversity of Bagmati River, Sarlahi, Nepal



1. Rohu (*Labeo rohita*)

2. Kursha (*Labeo gonius*)

3. Garadi (*Labeo dyochelius*)

4. Rewa (*Chagunius chigunio*)

PLATE-II

Fish diversity of Bagmati River, Sarlahi, Nepal

5. Pothi (*Puntius sophore*)

6. Pothiya (*Puntius sarana*)

7. Lata (*Lepidocephalichthys guntea*)

8. Pabadha (*Notopterus chitala*)

PLATE-III

Fish diversity of Bagmati River, Sarlahi, Nepal

9. Kaiwa machha (*Xenontodon cancilla*)

10. Chenga (*Channa gachuwa*)

11. Garai (*Chana punctatus*)

12. Dhalo (*Nandus nandus*)

PLATE-IV

Fish diversity of Bagmati River, Sarlahi, Nepal

13. Gainchi (*Macrognathus aculeatus*)

14. Kath gainchi (*Mastacembalis pancalus*)

15. Mangur (*Clarius batrachus*)

16. Tengri (*Mystus tengra*)

PLATE-V

Fishermen used in fishing gears and collection of fish at Bagmati River.

1. Cast nets

2. Phaso

3. Collection of fish in Study area

4. Fishermen houses of Khairba

ANNEX- V

Questionnaire for the fishermen of study area

A list questionnaires used in interview with Fishermen of the Bagmati River to study socio-economic condition and their demography.

1. Interview of fisherman

   Name: Age: Sex:

   Religion: Cast: VDC:

2. Number of the member of the family.

   Total: Male: Female:

3. Are you giving school education to your children?
4. How many members of your family are included in fishing?
5. Is fishing main profession?
6. If yes in which categories do you fall?

   Full time fishermen Part time fishermen Occasional

6. Which fish species are found common/uncommon in this river?
7. What type of fishing gear are used in different time of the year?
8. Where do you catch the most number of species?

River Zonation			
Running water	Shallow	Sand bed	Boulders

9. In which season or months do observed more fries and fingerling in the river in your catch?
10. How much fish capture per month / year?
10. What do you think fish population has increased or decreased in the recent year?

    Increased Decreased don't know

11. If you sell fish where do you sell it?

In place	Market/ village	Distance from home

11. If increased or decreased please give the reason?

    Overfishing Use of Dynamite Pesticides/Herbicides

    Electro- fishing Construction of project others

12. Any suggestion would you like to give for the improvement of fishery of the Bagmati River?