1. INTRODUCTION

1.1 Background

Gardenswartz and Rowe (1994) described diversity as being like an onion, possessing layers that once peeled away reveals the core. It has been estimated that the total number of all fishes is 32,500 species with more than 15,000 freshwater fish species (Nelson, 2006).Marine communities contain more species in total; fresh waters are far richer per unit volume of habitat that reflects the productivity, physiographic diversity and geographical isolation of freshwater habitats (Ormerod, 2003). Extremely contrast climatic and altitudinal variation is found in Nepal. The condition of climate of Nepal is greatly influenced by altitudinal variation. Due to the different altitudinal nature, the temperature distribution in Nepal is found variable: warmer low lands like Terai, moderate mid hill and cooler at the Himalayan region. In general, temperature increases from March to July and decrease from October to January (Pandey, 1987). The three distinct geographical regions in Nepal viz. the Himalayan Region which contributes about 15%, the sub Himalayan or Mountainous region is about 68% and the Terai region about 17% of the total area of Nepal (Amatya and Shrestha, 1967).

1.2 Water Resources of Nepal

Nepal is among the richest in term of water resources availability and it is one of the most important natural resource of the country. Water resources are abundant throughout the country in the form of snow covers, rivers, springs, lakes and ground water. The total renewable water resource of the country is estimated to be 237 km^3/year where 225 km^3/year for surface sources and 12km^3/year for ground water sources (DFD, 2007). Freshwater resource distribution is very small on the earth comprising 2.27% of total global water resources. The inlands freshwater resources of Nepal is very high totaling 8, 17,100 hector or about 5% of Nepal's land area (Table 1) (DOFD, 2007).

Table 1. Estimated water surface area in Nepal.

S.N	Resource details	Estimated area(ha)	Coverage (%)	Potential area (ha)
1	Natural Water	4,01,500	49	
	Rivers	3,95,000	48.34	78,000
	Lakes	5,000	0.61	
	Reservoirs	1,500	0.18	
2	Village Ponds	6,500	0.80	14,000
3	Marginal swamps	11,100	1.36	
4	Irrigated paddy field	3,98,000	48.71	
	Total	8,17,100	100	92,000

Source: Directorate of Fishery Development, (2013/2014).

River system of Nepal constitutes about 49% total water area of Nepal which drains into the Ganges system in India. All these large and small rivers give account to about 6,000 rivers which flows about 45,000 km in length. Approximately, 1000 of rivers are more than 10 km long and about 100 of them are longer than 160 km (Sharma, 1977).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 (Abbas, 1982; cited in Shrestha, 1992).

Major river systems of Nepal are Koshi, Gandaki, Karnali and Mahakali originated from the Himalayas and flows towards south. Nepal's location at the intersection of Paleartic and Oriental bio geographical realms, plus varied topography that generates a wide variety of aquatic habitat suitable for rich diversity of fishes (Rajbanshi, 2005). All these rivers cover 0.1 percent of total world water system and fish diversity accounts 0.21 percent of the total global fish diversity (Shrestha, 1995).

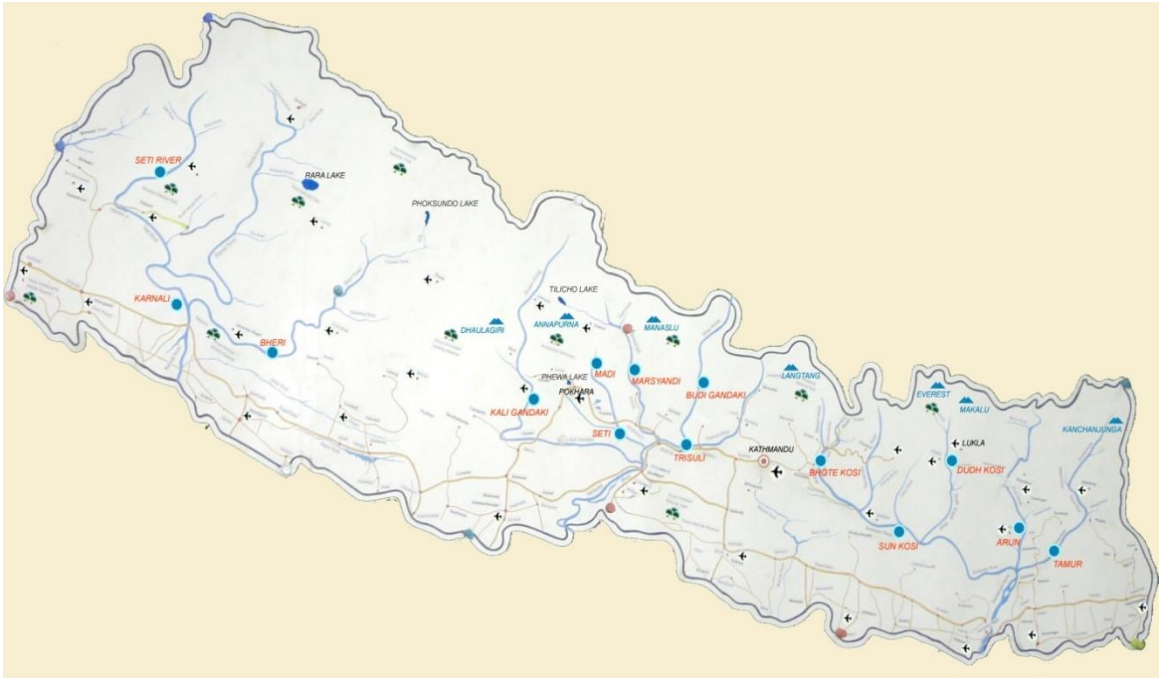

Fig. 1. Map showing Rivers and lakes of Nepal**.**

(Source: http://www.lahistoriaconmapas.com/atlas/maps/nepal-map-rivers)

1.3 Status of fish in Nepal

Nepal had wide distribution of the fishes and these fish species were accounted from different water bodies from an altitude of few meters in Terai to 3323m in Langtang Khola located in Langtang National Park (Shrestha, 1995).Gonch (*Bagarius bagarius*) is the largest fish found in Nepal whereas Zebra fish (*Branchydanio rerio*) is the smallest fish recorded in Nepal (Shrestha, 2001, Shrestha and chaudhary, 2003). Rajbanshi (2005)

and Saud and Shrestha (2007) had reported 187 fish species and 199 fish species respectively in Nepal. Shrestha (2008) reported 232 species of fishes belonging to 98 genera, 35 families, 11 orders including 14 endemic species and 15 exotic species in Nepal.

On the basis of the taxonomic status (Shrestha, 2008), there are 71 species under common category (30.60%), 53 species (22.84%) under least concerned, 27 species (11.63%) under conservation dependent and rare, 32 species (13.8%) under data deficient, pristine, rare and ornamental, 2 species (0.86%) under critically endangered, 9 species (3.88%) under vulnerable, 23 species (9.91%) under rare or near threatened and 15 species (7.32%) under exotic category.

Table 2. Status Accounts for fish species of Nepal.

S.N	Categories	Designated as	Number of fish 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	VU	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.

1.4 Status of fisheries in Agriculture of Nepal

Fisheries is a small but important sub-sector of agriculture which contributes around 3% of total agricultural gross domestic product (AGDP) or more than 1.0 percent of the gross domestic product (NAPP, 1994 cited in NARC, 1994). Fishing is traditional in Nepal. The net fish production is 64,900 Mt. of which fish production from aquaculture is 43,400 and the fish production from capture Fisheries is 21,500 Mt (DOFD 2013/14).

Table 3. Fish production in Nepal 2013/14

S.N	Particular	Pond	Total area (ha)	Fish production (Mt.)	Yields kg/Ha
1	Fish production From Aquatic practices			43,400	
A	Pond fish culture	34,400	8,600	37,427	4,352
.	Mountain	105	7	16.63	2,376
.	Hill	215	274	711.64	2,597
.	Terai	31,710	8,391	36,698.73	4,411
B	Paddy cum fish Culture (ha)		100	45	456
C	Cage fish culture(m3)		70,000	350	
D	Enclose fish culture		100	140	1400
E	Trout fish culture in Raceway (m2)		12,000	192	
F	Fish production in public sectors (Mt ton)			26	
2	Fish production in public capture fisheries			21,500	
A	River		395,000	7,110	18
B	Lakes		5,000	850	170
C	Reservoir		1,500	385	257
D	Marginal/swamps/ Ghols etc.		11,100	5,990	540
E	Low land irrigated Paddy field		3,98,000	7,165	18
	Total fish production (Mt.)			64,900.00	

Source: DOFD 2013/14

1.5 Threats to fishery resources of Nepal

Today most of the rivers are subject to physical alternation, degradation and pollution. River receives tones of domestic and agriculture waste, urban sewage and industrial effluent. Industrial effluent contains heavy metals, toxic chemicals which may kill fish, aquatic vegetation and affects many aquatic/natural purification processes of the rivers (Manivasakam, 1999). The river basins in Nepal have undergone an accelerated rate of change following tremendous demographic growth, which has created adverse effects upon biodiversity and native fish fauna (Swar and Shrestha, 1996). Development works like hydroelectricity dam project, urbanization, irrigation, chemical and channelization has been creating adverse impact on fish fauna (Shrestha, 1996). Beside, over and

irrational fishing , use of small mesh sized nets, use of explosions, electro fishing and free access to poison (herbal and chemical), introduction of exotic species are main conservation threats to fish diversity in general (Dhital and Jha, 2002). All these problems have posed danger to many of the indigenous species inhabiting water bodies (Shrestha, 1990/1998). In spite of religious value, natural habitat of Kali Gandaki River is deteriorating day by day due to aforementioned anthropogenic activities.

1.6 Objectives of the study

1.6.1 General objective

- To explore the fish diversity of Kali Gandaki River.

1.6.2 Specific objectives

- To analyze the physicochemical parameters of water.
- To study the fishing implements and fishing techniques used by the local fishermen in the Kali Gandaki River.

1.7 Justification of the study

The Kali Gandaki River is one of the sacred river of Nepal that descends from Muktinath. It flows north to south and the river is rich in large number of aquatic organisms that contribute to livelihood of fishermen. Although the water level varies considerably during winter and summer; but still, water mass is sufficient in this river to support abundant aquatic life. However, Kali Gandaki River is degenerating and fish density/diversity is also experienced to decline due to number of factors such as increasing fishing pressure (legal and illegal), heavy flooding, erosion, construction of road along the river side, hydroelectricity dam project, channelization and construction of bridge across the river(Shrestha,1996).

Although, most of the part of the Gandaki River System has been studied including Narayani River System of southern part of Nepal (Dhital and Jha 2002). But there is no documentation of recent basic aquatic bio-data in the present study sites. The main purpose of study is to explore baseline information of the aquatic bio-data of the Kali Gandaki River in present study sites.

1.8 Limitations of the study

Although, the present study has attempted to cover most of the subject matters related to the main objectives, it has its own limitations. Due to paucity of time, limited financial and technical supports, the study is restricted to given level only.

2. LITERATURE REVIEW

2.1 Historical fish study by foreign experts in Nepal

Small work has been done to explore the fish fauna of Nepal in spite of it's of huge water resources and great zoo-geographical significance. The first historical account had been given by Colonel Kirkpatrick (1793 AD). However, the credit of first scientific report on fish fauna of Nepal goes to Francis Buchanan (later Hamilton) for the work of 1822 "An Account of fish found in the River Ganga and its branches". Gunther (1861) reported some cold- blooded vertebrates including fishes collected by Hodgson in Nepal. Day (1878) mentioned the distribution of some fresh water fishes of Nepal in historical work "Fish of India Burma and Ceylon". Hora (1920-1952) obtained a collection of fishes from Nepal through Colonel Bailey in 1923 and collection included 159 specimens of 22 species. Menon (1949) reported 11 families comprising 26 genera and 52 species from the Koshi river of Himalayan region. Taft (1955) prepared a check list-list of 94 species from Kathmandu and adjoining areas. Other important Ichthyologists who had done taxonomic study freshwater fishes of Nepal were Shaw and Shebbeare (1937) and Misra (1959).

Menon and Datta (1961) described a new *Psilorhynhus pseudecheneis* as endemic fish of Nepal. Menon (1962) contributed a distributional list of fishes of the Himalaya in which he had reported 218 species of fishes. Dibbs (1965) studies the various aspects of development of fisheries of Nepal. His report was based on the work of Zwelling (1963), who undertook the assignment of studying fisheries in Nepal under the Food and Agriculture Organization (FAO) of United Nation. Shrivastava (1968) published a book entitled "Fishes of Eastern Uttar Pradesh" in which he mentioned a number of Nepalese fishes. Mesuda and Karki (1980) had published a check list of fish fauna of Trishuli River 6 families, 16 genera and 28 species. McGladdery *et al.* (1980) and Even *et. al.* (1985) noted 58 and 69 fish species respectively from the rivers of Royal Chitwan National Park (RCNP).Terashima (1984) had reported three new endemic species of cyprinid of the genus, *Schizothorax* from Lake Rara. Edds (1985) had reported a list of 111 and 113 native fish species from the River Kaligandaki/Narayani River and the waters of Royal Chitwan National Park, Chitwan respectively.

2.2 Fish studies in Nepal by local fishery scientists

Thapa and Rajbanshi (1968) had studied the ecology of hill stream fishes of Nepal. Majupuria and Shrestha (1968) published a paper on fresh water fish and fisheries in Nepal and Majupuria (1969) studied on socio-economic condition of fisherman of Kathmandu Valley. Bhatta and Shrestha (1975) listed 27 species of fish fauna of Suklaphanta. Tamang (1993) has included the four new species of fish in the fishery science viz. *Glyptothorax basnetti, G. bhutiai, G. deyi* and *Clupisoma bhandari* along with 2 new sub-species viz. *G. sinense sikkimensis* and *Laguviar ibieroi jorethangensis* from the drainages of Sikkim. Shrestha (1979) studied the resource 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 fishes. Shrestha (1981) listed 120 species of fish in the book "Wildlife of Nepal". Shrestha (1981) had written a short account on fishing from bamboo-bridge with lift Net. A milestone work in the field of taxonomic study of fish fauna in Nepal had been done by Shrestha (1970-1986) and published a book entitled "Fishes of Nepal" in 1981. Pokharel (1982) gave an account of the fishery species of Koshi River. Jha and Shrestha (1986) had collected 57 species of fishes from Karnali River. Bhutia and Acharya (1987) however studied the fish fauna, certain physicochemical condition and listed 25 species of fish from RangitRiver.EIA and socio-economic impact study was done in Arun Hydroelectric Project (New Era 1989). Later, detail study on spawning, ecology, behavior and migration of the fishes was done in upper Arun (New Era, 1999). Shrestha (1991) reported 59 cold water fish species from the natural water bodies of Mountains and Himalayan region. Sapkota (1992) studied fishery ecology of swamplands of Koshi River. Shrestha (1992) studied on the fishes in the flood plain of the Koshi River. Shah (1995) studied on the fishery ecology of the Trishuli River. IUCN (1998) identified 27 species of fish fauna from Ghoda ghodi Lake Complex. Karki (2000) studied on biodiversity and fishery resources of lower Karnali, Nepal and recorded 50 species of fish belonging to 29 genera under 15 families and 8 orders. Very recently; Shrestha (2001) did a taxonomic revision of 186 fish species with their nomenclature and systemic position according to new classification after Jayram (1999). Bajaracharya (2001) studied fish and fishery resources of the Bhotekoshi and Sunkoshi were recorded 16 species of fish under 3 families and 2 orders. Gurung *et al*., (2003) had recently reported 186 fish species - 176 indigenous and 10 exotic fish species. Gautam(2003) studied on the fish diversity of aquatic life resource of lake Rupa and recorded 23 species of fish belonging to 5 orders, 6 families and 18 genera. Malla (2004) studied fish diversity and distributional pattern in Daram Khola Baglung and recorded 21 species. Shah (2005) studies on the fish diversity of Budhiganga River and recorded 18 species of fish belonging to 2 orders, 4 families and 13 genera. Prajoo (2007) studied on fish diversity of Harpan khola and recorded 22 species of fishes belonging to 5 orders, 6 families and 16 genera.

Rajbanshi (2005) reviewed on current taxonomic status and diversity of fishes in Nepal" based on the current work of Menon (1999) and recorded a total number of 187 fish species representing 94 genera, 30 families and 10 orders. Kafle (2007) identified 25 species from Ghodaghodi Lake Complex. Rijal (2009) studied "Role of fisheries and aquaculture in livelihoods of Koshi Tappu Buffer zone community" and listed 60 fish species belonging to 7 order, 20 family and 40 Genera. Shrestha (2008) studied different water bodies of Nepal and reported 75 species of fish from Karnali river, 108 species from Koshi river, 34 species from Trishuli river, 102 species from Narayani river, 69 species from river Mahakali river, 82 species from Bagmati river, 69 species From Kaligandaki river and 29 species from Kulekhani reservoir in his book entitled "Ichthyology of Nepal". Mandal and Jha (2013) conducted a study on impacts of Damming on Icthyo-faunal Diversity of Marshyangdi River and reported 26 fish species.

3. MATERIALS AND METHODS

3.1 Study Period

The field study was carried out for 6 months from Nov. 2015 to Apr.2016 covering two different seasons i.e. December (winter) and March (spring). Each sampling station was visited two times during the study period for sample collection.

3.2 Study Area

The Kali Gandaki or Gandaki River (also known as Narayani in southern Nepal) is one of the major rivers of Nepal and a left bank tributary of the Ganges in India. It is also called Krishna Gandaki in Nepal (Negi, 2010). It is the river from Tibet at an elevation of 6,268m at the Nhubine Himal glacier in the Mustang region of Nepal (Garzione, Carmalan *et al.*, 2000).The river flows southward through a steep George, between the mountain Dhaulagiri, elevation 8,167m to the west, Annapurna I, elevation 8,091m to the east, south of the George is joined by Rahughat Khola at Galeshwor, Myagdi Khola at Beni, Modi Khola near Kusma, Badigaad at Rudrabeni with the turn east to run along the northern edge of Mahabharat Range and turning south again is joined by the Trisuli, east Rapti river at Devighat. The river is notable for its deep george through Himalayas, its enormous hydroelectric potential and abundant diversity of fresh water fishes. It has a total catchment area of 46,300 square kilometers (17,900 sq mi) (Negi, 2010).

The present study on fish diversity was carried out in one region of the Kali Gandaki River which is the transitional zone between Nawalparasi and Tanahun district, flowing from west to east. It was located at the latitude 27^0 84'N and longitude $84^0$14'E. The survey stations were spreading at 6 km from west (Ghumaurighat) to east (Gargadighat). Altogether three stations were established at approximate distance of 3.5 km and 2.5 km from Station I and II respectively, along with taking into account the nature of river. The study was done in about 1.5 km in each station. These major sampling stations established were as mentioned below:

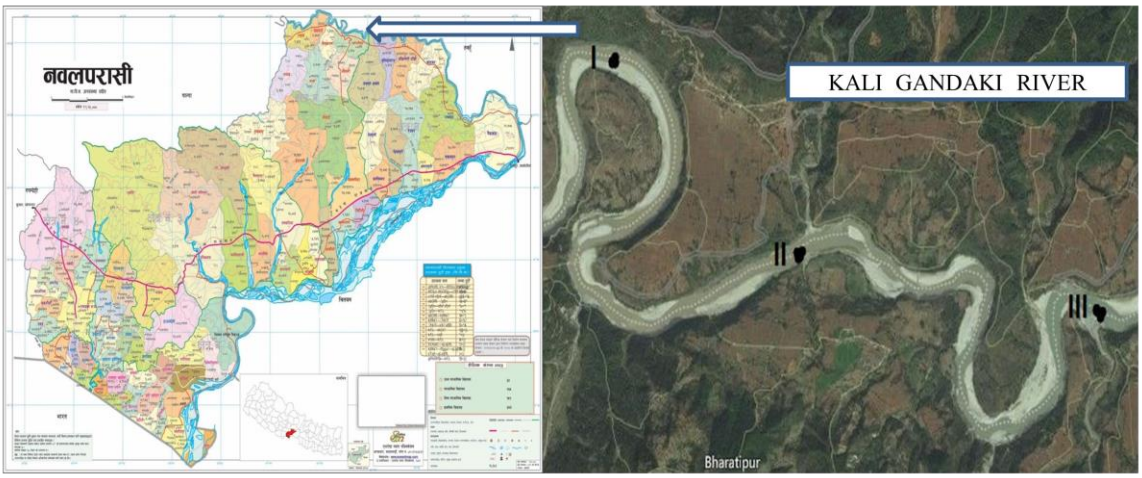

Figure 2: Map of the study area representing three stations. (Source: Google map**)**

Station I (Ghumaurighat)

The sampling station I was selected close to the religious temple (Kamadhenu Mandir). The area was with pool water making circular flow. The depth of the station was comparatively higher than other stations selected. It was between Ghumaurigath, Nawalparasi and Ramjhakot, Tanahun.

Station II (Attrauli)

The sampling station II was situated about 3.5 km east away from station I. The nature of water in river was run. The water was good and transparent. The depth of the station II was comparatively a little bit lesser than station I. Site was located between Attrauli village, Nawalparasi and Peepaltar, Tanahun.

Station III (Gargadighat)

The sampling station III was located at a distance of 2.5 km east away from station II. The area was with riffle water. Rocky bottom found inside the water. It was near to Suspension bridge and Grab area. Bank of the station III was the place for Mela at Ekadesi. It was located between Gargadighat, Nawalparasi and Madhuban, Tanahun.

3.3 Materials

Following materials were used during present dissertation.

3.3.1 Glassware

Conical flask, pipettes, burette, beaker, volumetric flask, BOD bottles, droppers, glass rod, measuring cylinders, standard mercury thermometer, separator funnels, secchi disc, syringe etc.

3.3.2 Chemicals

Hydrochloric acid (0.1 N), sodium hydroxide (0.1 N), conc. sulphuric acid, methyl orange indicator (0.65%), phenolphthalein indicator, 10% formalin etc.

3.3.3 Laboratory instruments

Camera, DO meter (Lutron DO-5519), Stand, Dissection box, Measuring tape, Fish preservation kid, Cotton, pH meter (Adawa pH-100), Field guide.

3.4 Methods

3.4.1 Data Collection

The primary data and basic data were collected by the direct field observations, interviews, photography and questionnaires. Field observations were made to study fish diversity and water quality analyze in Kali Gandaki River. To meet the objectives of the current study a set of questionnaires were prepared to collect the information on history of fishing habitats of fishes, techniques of fishing and the changes in fish abundance which have taken in a year. The secondary data were obtained from publication of government, technical and scientific journals, books, magazine, report and publication, dissertations.

3.5 Water Quality Analysis

The various physico-chemical parameters like temperature, transparency, bottom substratum, water velocity, water depth, pH, Free CO_2 and DO were observed and analysed after Adoni(1985), Trivedy and Goel (1986) and APHA(1998).

3.5.1 Physical Parameters

The main physical parameters studied during the study period are as follows:

3.5.1.1 Water Color

The color of water was determined by simple method. The direct observation was done from the bank at the distance of 4m.

3.5.1.2 Water Temperature

Water temperature was done by dipping mercury thermometer bulb directly into water for about two minutes at each station. The thermometer was randomly dipped at ten different places for three times (morning, day and evening) per day and the mean temperature was recorded.

3.5.1.3 Transparency

A Secchi disc was first lowered in water until it become invisible and the reading was noted down. Then the disc was gradually pulled up until it was first visible and reading was noted. The sum of the first invisible and first visible was divided by 2 and the final reading was recorded as (APHA, 1979).

Transparency (D) = (X+Y/2) cm

Where, D = Transparency in cm
X= depth at which Secchi disc disappears
Y= depth at which Secchi disc reappears

3.5.1.4 Depth

Bamboo stick deep method was used to measure the depth of river. The depth was measured at six different locations including opposite banks and middle of the water body. The average depth of each sampling station was calculated in cm.

3.5.1.5 Bottom Substratum

The nature of bottom substratum in each sampling station was examined carefully in the percentage of each substratum such as boulder, gravels, sand and mud which was recorded by self judgment method**.**

3.5.1.6 Water Velocity

The velocity of water was calculated by simple method of timing a float with a stop watch (Adoni *et al.*1985) in several regions of river. It was measured in the unit of m/s.

3.5.2 Chemical Parameters

pH and DO of water was measured at the sampling station during each field visit. The water samples were collected, fixed to analyze free CO_2 in the laboratory of Central Department of Zoology (CDZ), Kirtipur.

3.5.2.1 Hydrogen Ion concentration (pH)

A battery operated electrical pH meter was used to record the pH of water during the study period.

3.5.2.2 Free Carbon-dioxide (CO_2)

To analyze the free $C0_2$ in water, sample water of 100ml was taken in a conical flask and 3-4 drops of phenolphthalein indicator was added to it and titrated against the standard alkali solution (NaOH solution)of 0.05N strength. The calculation was done with the following formula.

Free CO_2 (mg/l) = (ml* N) of NaOH * 1000* 44/ Volume of sample used (ml)

3.5.2.3 Dissolved Oxygen (DO)

Dissolved oxygen was noted directly by using DO meter. The DO meter was dipped at both banks and middle and the average was taken.

3.6 Collection and Identification of fishes

The fishes were collected from each sampling site separately by employing local fishermen and from the local market near each sampling station. Cast net, paso, hook and line, ghorlong, dhadiya and other locally available devices were used for the collection of fish sample. The colouration and morphometric characteristics of the collected fishes were noted down as soon as the fishes were netted out. The measurement and photography were taken respectively. Total number of fish species collected from each sampling site was recorded. The different species with different sizes of the collected fish were kept for preservation in container containing 10% formaldehyde solution with the tail pointed upwards so as to avoid any damage to the caudal fin.

These preserved specimens were brought to the laboratory of Central Department of Zoology (CDZ) for identification. The collected fish samples were identified by using standard method of taxonomy keys after (Shrestha, 1981), (Shrestha, 1994), (Jayaram, 1999), (Shrestha, 2001) and (Shrestha, 2008).

3.7 Statistical Analysis

The Statistical analysis (Coefficient of co-relation) was done between some important physiochemical parameters like temperature, pH, DO etc. and fish diversity using Karl Pearson's method (Gupta, 1988).

$$\text{Coefficient of correlation (r)} = \frac{N.\Sigma XY - \Sigma X.\Sigma Y}{\sqrt{(N.\Sigma X^2) - (\Sigma X^2)(N.\Sigma Y^2) - (\Sigma Y^2)}}$$

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

3.7.1 Diversity Status:

3.7.1.1 Species 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,

$$H' = -\sum(Pi) \times \ln(Pi)$$

Where,

Pi= n/N

ni =No. of all individual species

N= Total no. of all individuals in the sample

ln= Logarithm of base e

3.7.1.2 Eveness Index:

To calculate where species are distributed evenly across landscapes elements, evenness index was determined by the following equation (Pieleu, 1966).

$$E = H'/\ln S$$

H'= Shannon Weiner's diversity index

S= Total no. of species in the sample

3.8 Fishing implements and fishing techniques

Fishing implements and fishing techniques were listed through direct observation and interviews. Three fishermen were interviewed about fishing implements and techniques.

4. RESULTS

4.1 Physical parameters of water

4.1.1 Water Color

The river was clear, transparent and light blue throughout the year except in monsoon; during which water color become grayish muddy due to heavy flooding and erosion.

4.1.2 Water Temperature

The surface water temperature ranged from 16^0- 21.5^0C with an average temperature of 18.58^0C during the studya period. The highest temperature was recorded 21.5^0C in March at Stations II and III and the lowest temperature 16^0C at Station I and III in November (Fig. 3).

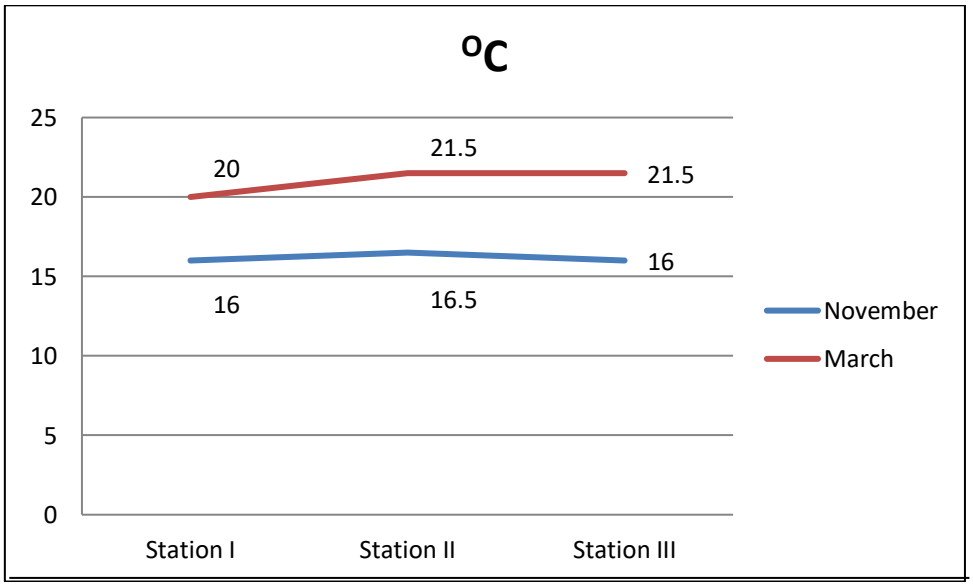

Fig. 3. Variation of temperature at different stations.

4.1.3 Transparency

The transparency ranged from 85.34 to 106.68 cm with an average transparency of 93.93 cm. The highest transparency was 106.68 cm recorded in November at Station I and the lowest transparency was 85.34 cm recorded in March at Station II (Fig. 4).

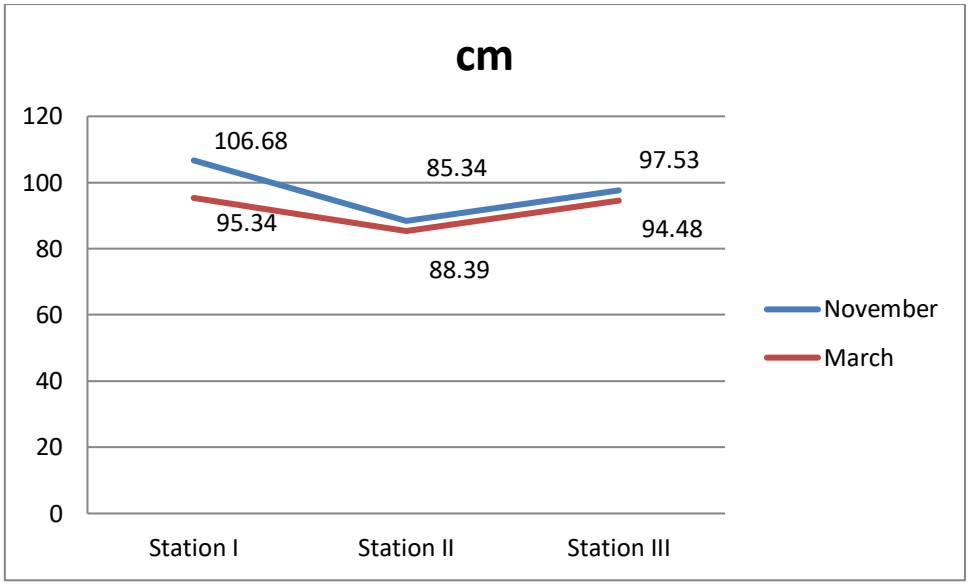

Fig. 4. Variation of transparency in different stations.

4.1.4 Depth

The depth of river varied from 290 to 314.98 cm. The highest depth was 314.98 cm in November at Station I and the lowest was recorded 290 cm in March at Station III. The average depth was 302.63 cm (Fig. 5).

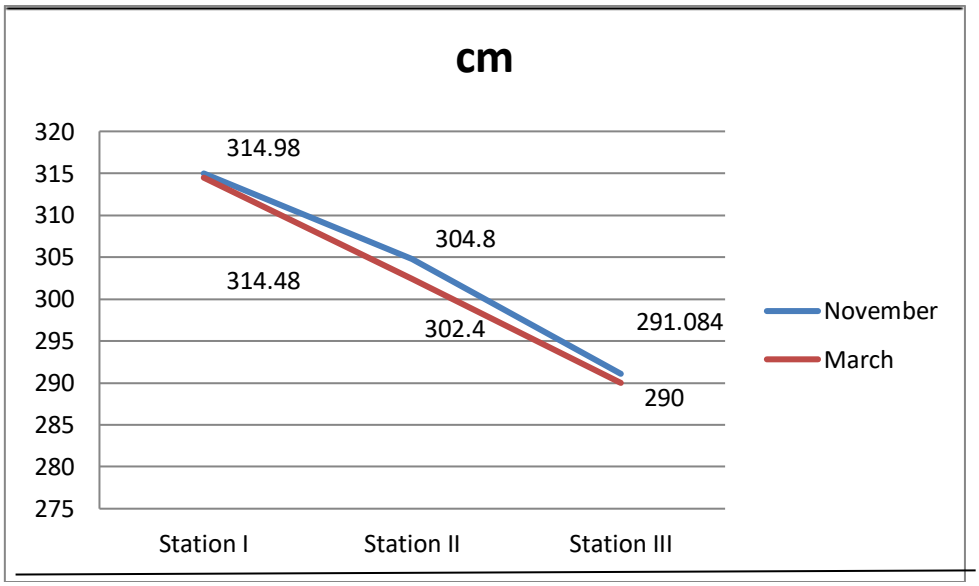

Fig. 5. Variation of depth at different stations.

4.1.5 Bottom Substratum

The substratum consisted boulders, rocks, pebbles, gravels, sand and mud (Fig. 6, 7 and 8 and Table 4).

Table 4. Description of bottom substratum in different sampling stations

S. No	Station	Altitude	Substratum	Percentage	Dominant substratum
1	I	405m	Boulder Gravel Sand Mud	30 15 50 5	Sand
2	II	415 m	Boulder Gravel Sand Mud	30 17 50 3	Sand
3	III	410m	Gravel Sand Mud Boulder	17 40 1 42	Boulder

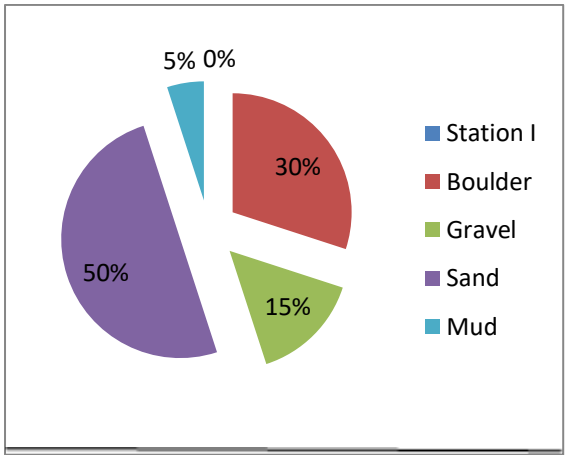

Figure 6. Substratum at Station I

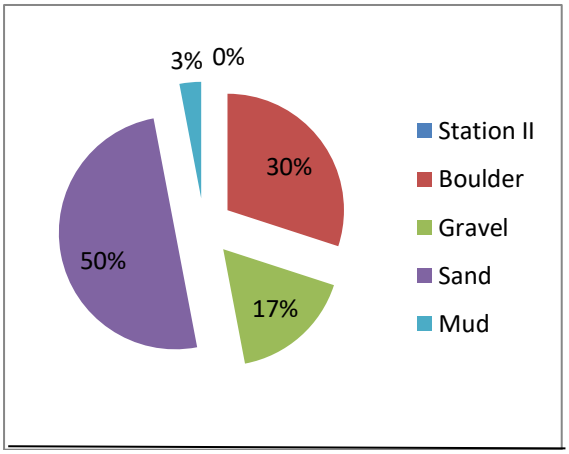

Figure 7. Substratum at Station II

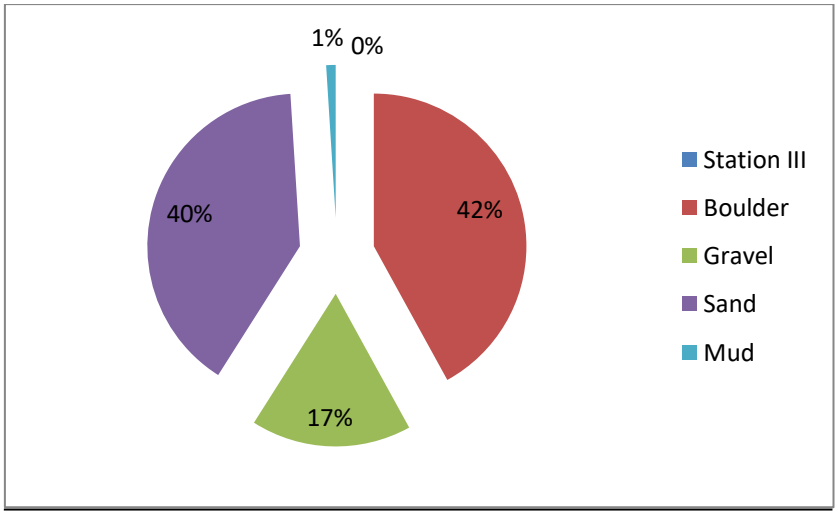

Fig. 8. Substratum at station III

4.1.6 Water Velocity

The water velocity ranged from 0.75 to 0.98 m/s. The highest water velocity was 0.98m/s recorded in March at Station III and the lowest 0.75m/s recorded in November at Station I. The average water velocity was 0.885 m/s during study period (Fig. 9).

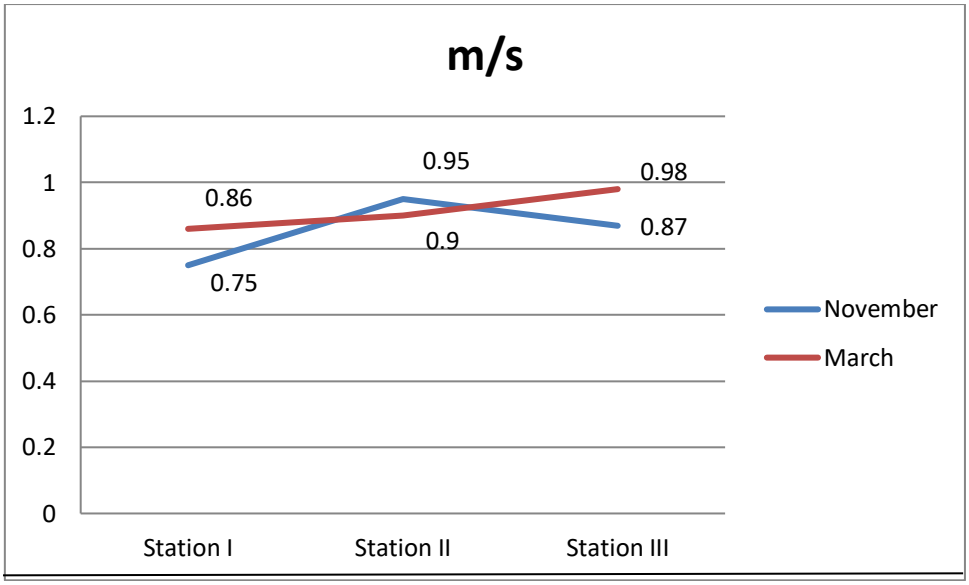

Fig. 9. Variation of water velocity at different stations.

4.2 Chemical parameters of water

4.2.1 Hydrogen Ion concentration (pH)

The pH ranged from 7.5 to 8.1with an average pH value of 7.85 during study period. The lowest pH was 7.5 at Station III in March. The pH was recorded highest of 8.1 at Station II in November (Fig. 10).

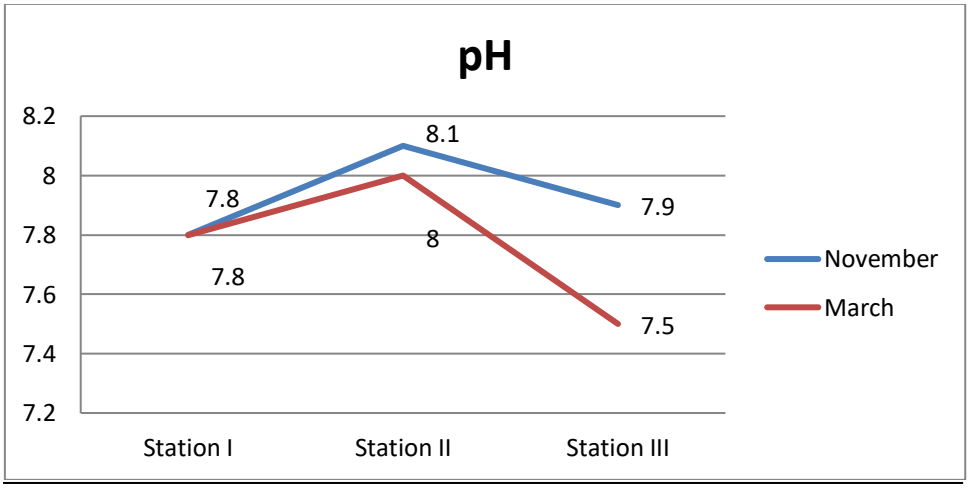

Fig. 10. Variation of pH at different stations.

4.2.2 Free Carbon-dioxide (CO_2)

The free carbon dioxide of ranged from 3.05 – 5.75 mg/l with an average value of 4.57 mg/l. The highest CO_2 was 5.75mg/l recorded in March at Station I. Free CO_2 was decreased to lowest value of 3.05 mg/l at Station III in November (Fig. 11).

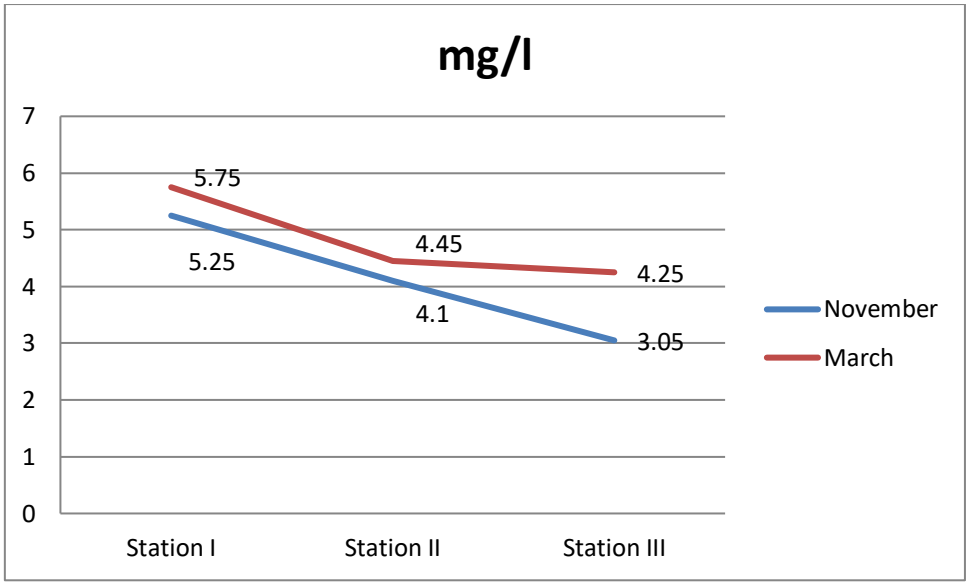

Fig. 11. Variation of free CO_2 at different stations.

4.2.3 Dissolved Oxygen (DO)

The dissolved oxygen of Kali Gandaki River ranged from 8.45 – 9.78 mg/l with average dissolved oxygen of 8.98 mg/l. The highest dissolved oxygen was 9.78mg/l recorded in March at Station II then it gradually decreased to lowest 8.45mg/l at Station III in November (Fig. 12).

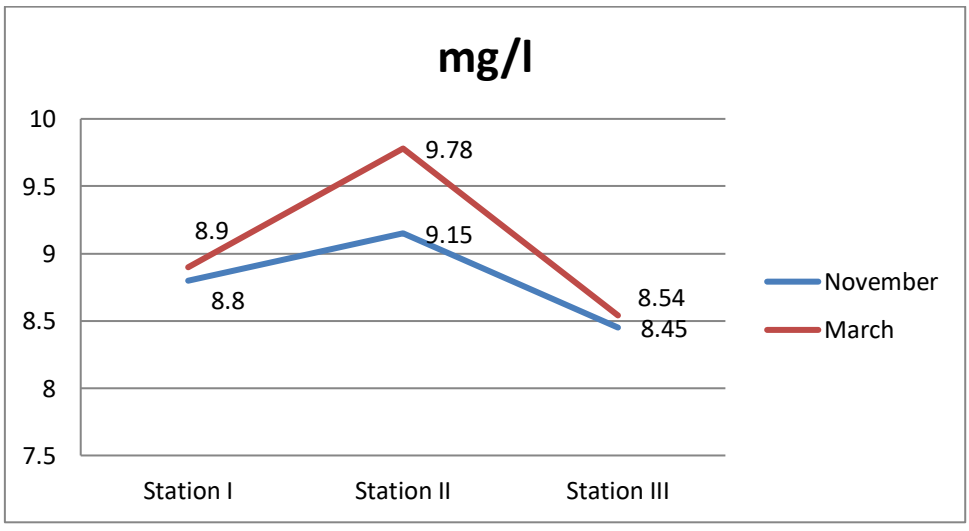

Fig. 12. Variation of DO at three stations.

4.3 Fish diversity

17 different fish species were recorded during the present study belonging 4 orders, 7 families and 12 Genera. According to the present study, highest diversity was found in Station I and lowest in Station III. The dominant fish species of Kali Gandaki River were *Barilius barila, Barilius bendelisis,* and *Pseudecheneis eddsi*. Other species are commonly found in the river are *Garra annandalei, Puntius terio* and *Barilius vagra* (Table 5).

4.3.1 Systematic positions of the fish

1. Order: Cypriniformes
Division: Cyprini
Suborder: Cyprinoidei
Family: Cyprinidae
Subfamily: Cyprinae
Genus: *Puntius*
Species: *terio* (Hamilton Buchanan, 1822)

Genus: *Tor (*Gray)
Species: *putitora* (Hamilton Buchanan,1822)

Subfamily: Garrinae
Genus: *Garra (*Hamilton)
Species: *annandalei* (Hora, 1921), *gotyla* (Gray,1832)

Subfamily: Rasborinae (Danioninae)
Genus: Barilius *(*Hamilton)
Species: *barila, barna, vagra, bendelisis* (Hamilton Buchanan, 1878)

Subfamily: Botiinae
Genus: *Botia* (Hamilton)
Species: *almorhae* (Gray,1831)

Subfamily: Noemacheilinae
Genus: *Nemacheilus*
Species: *beavani* (Gunther,1868), *botia* (Hamilton Buchanan,1822)

Family: Cobitidae
Subfamily: Cobitinae
Genus*: Lepidocephalus*
Species: *guntea* (Hamilton Buchanan,1822)

2. Order: Siluriformes
Division: Siluri
Suborder: Siluridae
Family: Bagridae
Genus: *Mystus* (Scopoli)
Species: *cavasius* (Jayaram,1977)

Family: Sisoridae
Genus: *Pseudecheneis*
Species*: eddsi* (Ng,2006)

3. Order: Synbranchiformes
Suborder: Mastecembeloidei
Family: Mastacembelidae
Genus: *Matacembelus*
Species: *armatus* (Lacepede, 1800)

Genus: *Macrognathus*
Species: *aral* (Bloch and Schneider, 1801)

4. Order: Perciformes
Suborder: Channoidei
Family: Channidae
Genus: *Channa*
Species: *orientalis* (Bloch and Schneider, 1801)

Table 5. Distribution, abundance and frequency occurrence of fishes.

S.N	Order	Species	Local name	NO. of individuals			Total	Frequency
				I	II	III		
1	Cypriniformes	*Barilius barila*	Fageta	15	13	10	38	14.2857
		Barilius barna	Fageta	10	6	-	16	6.015
		Barilius vagra	Fageta	9	8	2	19	7.142
		Barilius bendelisis	Fageta	16	12	10	38	14.2857
		Garra annandalei	Budhuna	6	8	10	24	9.022
		Garra gotyla	Budhuna	5	9	3	17	6.3909
		Puntius terio	Pothi	10	12	-	22	8.2706
		Botia almorhae	Bhagi	-	6	-	6	2.2556
		Tor puitora	Mahaseer	-	3	2	5	1.8796
		Nemacheilus beavani	Gadero	3	-	2	5	1.8796
		Nemacheilus botia	Pate gadela	1	3	2	6	2.2556
		Lepidocephalus guntea	Gainche	4	-	6	10	3.7593
2	Siluriformes	*Pseudecheneis eddsi*	Kabre	15	10	8	33	12.406
		Mystus cavasius	Tengra	5	3	2	10	3.7593
3	Synbranchiformes	*Matacembelus armatus*	Chuche bam	4	3	-	7	2.6315
		Macrognathus aral	Bami	5	3	-	8	3.0075
4	Perciformes	*Channa orientalis*	Bhoti	-	2	-	2	0.751
	Total						266	

Frequency = No. of specific species/ Total no. of catch * 100%

4.3.2 Order wise fish composition

Out of total 266 fish catch, 206 belonged to order Cypriniformes and 43 fishes belonged to order Siluriformes followed by 15 fishes of Synbranchiformes. The lowest number of fish catch was 2 of Perciformes. About 77% of fish species was found belonged to order Cypriniformes which was dominant in the study area and rest all composed 23% only (Table 6 and Fig 13).

Table 6. Order wise fish composition in Kali Gandaki River.

S.N	Order	No. of fish species	Frequency	No. of fish catch	Frequency
1	Cypriniformes	12	70	206	77.443
2	Siluriformes	2	12	43	16.165
3	Synbranchiformes	2	12	15	5.639
4	Perciformes	1	6	2	0.75
	Total	17	100	266	

Frequency = No. of fish catch/ Total no. of fish catch * 100%

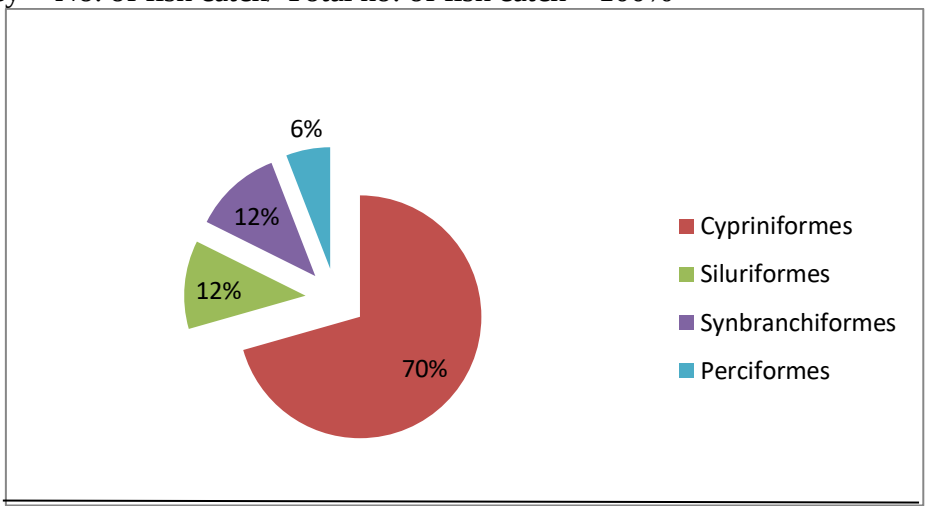

Fig. 13. Order wise fish distribution in Kali Gandaki River.

4.3.3 Family wise fish composition

Out of 266 fish catch, 185fishes belonged to family Cyprinidae and the lowest number 2 belonged to family Channidae. About 69.548% of fish species belonged to family Cyprinidae followed by Sisoridae constituting 12.406%, Mastacembelidae 5.639%, Balitoridae 4.135%, Bagridae 3.759%, Cobitidae 3.759% and Channidae 0.75% respectively (Table 7 and Fig 14).

Table 7. Family wise fish composition in Kali Gandaki River.

S.N	Family	No. of fish species	Frequency	No. of fish catch	Frequency
1	Cyprinidae	9	53	185	69.548
2	Balitoridae	2	12	11	4.135
3	Cobitidae	1	6	10	3.759
4	Bagridae	1	6	10	3.759
5	Sisoridae	1	6	33	12.406
6	Mastacembelidae	2	11	15	5.639
7	Channidae	1	6	2	0.7518
	Total	17	100	266	

Frequency = No. of fish catch/ Total no. of fish catch * 100%

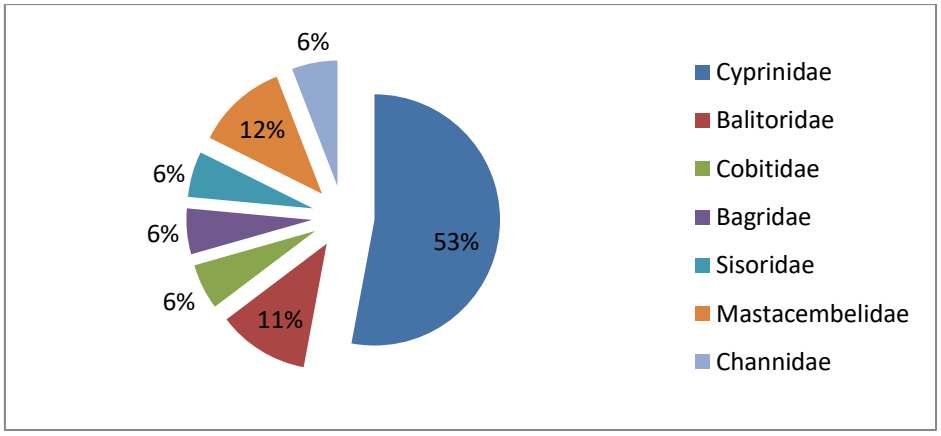

Fig. 14. Family wise fish distribution.

4.3.4 Frequency of fish species in different stations

During the study period all together 266 number of fishes were caught. 38 were *Barilius barila*, 16 were *B. barnaa*, 19 *B. vagra*, 38 *B. bendelisis*, 24 were *Garra annandalei*, 17 were *G. gotyla*, 22 were *Puntius terio*, 6 were *Botia almorhae*, 5 were *Tor putitora*, 5 were *Nemacheilus beavani*, 6 were *Nemacheilus botia*, 10 were *Lepidocephalus guntea*, 33 were *Pseudecheneis eddsi*, 10 were *Mystus cavasius*, 7 were *Matacembelus armatus*, 8 were *Macrognathus aral*, 2 were *Channa orientalis* (Fig. 15).

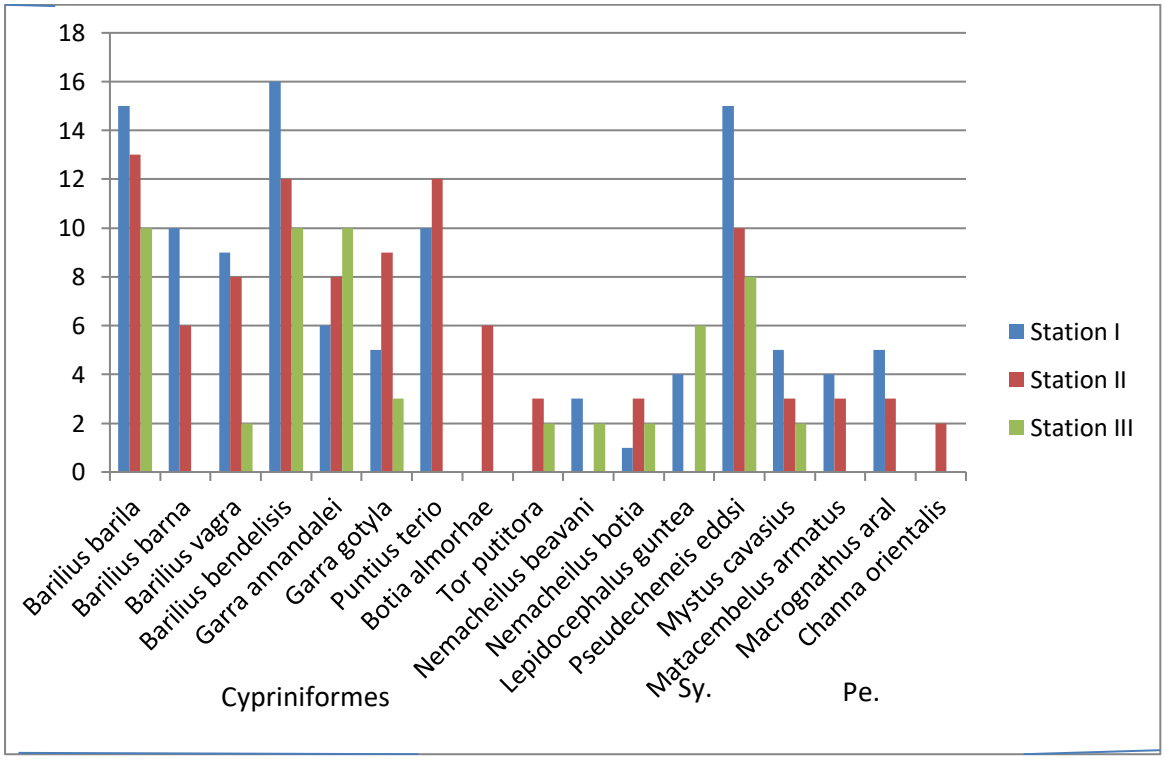

Fig. 15. Frequencies of fish species in different stations.

4.3.5 Correlation between the physical parameter and fish

The correlation coefficient between physical parameters such as water transparency, water depth, pH, CO_2 and DO were positive in all stations in March. Where, the coefficient of correlation between water temperature and water velocity were negative which is given in (Table 8).

Table 8. Correlation between physical parameter of water and fish number.

S.N	Variables	November (Winter)		March (Spring)	
		Coefficient of correlation(r)	Probable error (PEr)	Coefficient of correlation(r)	Probable error (PEr)
1	Water Temperature and F.D	0.981981	0.0027	-0.91165	0.0083
2	Water Transparency and F.D	-0.75572	0.0327	0.176807	0.04766
3	Water Depth and F.D	0.271964	0.0707	0.994215	0.00057
4	Water Velocity and F.D	0.733273	0.0353	-0.95819	0.004
5	pH and F.D	0.866025	0.0191	0.512837	0.03625
6	DO and F.D	0.944911	0.00818	0.184912	0.04752
7	Free CO_2 and F.D	0.163156	0.07435	0.955208	0.0043

F.D= Fish density

4.3.6 Diversity Status of fish of Kali Gandaki River

The value of Shannon Wiener diversity index (H'), and Evenness Index (I) were calculated based on stations (Fig. 16). Highest Shannon Wiener diversity index (2.55) was found in station II and the lowest (2.164) was found in station III. Evenness index was found to be highest (0.944) at station II and lowest value (0.902) in station III.

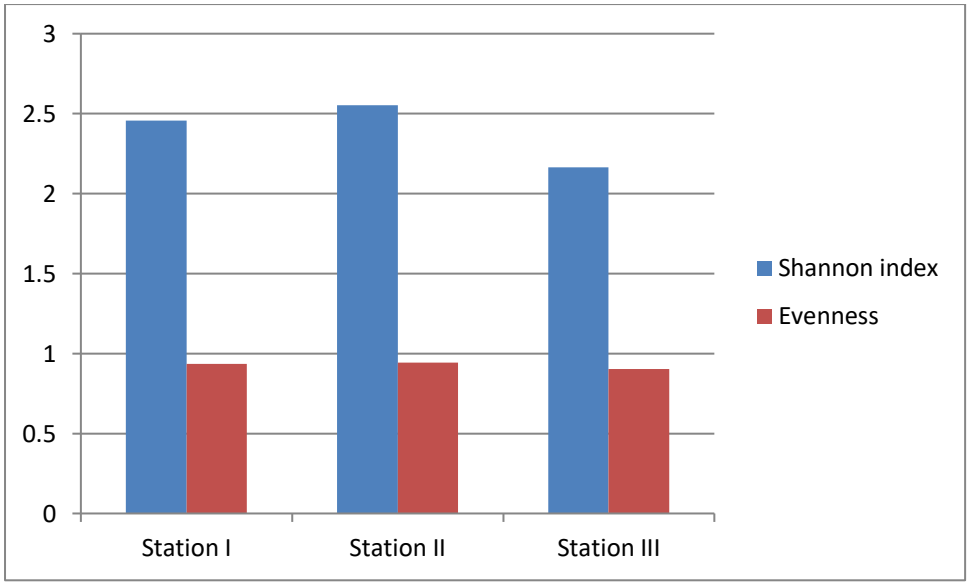

Fig. 16. Station wise fish diversity index and evenness index.

4.4 Fishing implements and fishing techniques

From the general survey, it was found that there are different kinds of fishing implements and techniques being used by the local fishermen in fish catching. Most of them are made from locally available goods while some materials are bought from market. All these fishing practice used in the Kali Gandaki River were mainly grouped in two categories.

A. Conventional fishing methods
B. Non- conventional fishing methods

Conventional fishing method included traditional fishing gears like hook, rod line, trapping devices, fishing with hand etc. Where, Non- conventional fish included Modern fishing implements.

A. Conventional fishing methods

I. Nets

A net is basically a piece of webbing of fine nylon or cotton threads in which the twines are intersected into regular meshes. Three types of nets have been observed in operation.

a. Cast net

Cast net is a circular net made from nylon thread and locally named as ‘ Jal ’ having mesh size about 15-25 mm. Along the end of circumference, pieces of iron or lead are attached

so as to make the net sinkable in water. Pouch and pockets like structure are made at the end of circumference of cast net where fishes are trapped. The centre of the net is tied with a long rope extending from the apex and throws it with a jerk into the water. After a moment, the net is dragged with the help of central rope and the catch is collected in the bamboo basket or bag. Cast net is effective throughout the year.

b. Gill net

It is rectangular shape net and commonly known as 'Kandejal'. Gill net has different mesh sizes varying with in length. In the lower border of the net small sinker are tied as to make the net sinkable. The net flows along with the current of water.

c. Bhurelijal

It is similar to the cast net in shape and texture but it has smaller mesh size from 5-15mm. The practice of the jal is effective and harmful for the fishes as it wipes out fish juvenile also destruct fishery resources.

II. Basket Implements

A number of basket implements were used for fishing in the Kali Gandaki River. They were with different shapes and sizes and were made up of bamboo or reed (nigala). The basket implements observed in fishing in the Kali Gandaki were as follows.

a. Dhadiya

Dhadiya is local name of a fishing implements made of bamboo stick with wide mouth and tapering end. It has conical shaped body designed with small opening mouth inside. Once the fish enter inside it cannot escape mainly used in Terai region. It is fixed in the small diverting water canal.

III. Hook and line

Fishing with Hook and line was locally known as 'Balchhi Khelne' which consists of hook tied in the tip of a long nylon threads lying on the long rod of bamboo. The hook was baited with different types of (living and nonliving) baits generally small sized fish, piece of earthworm, aquatic insects and commonly wet wheat flour in this area.

IV. Fishing with bare hand

This was the common practice of fishing without gears. The method was locally named as 'Hatte Khelne'. This method was very simple and wide used all over the river area. To grasp fish by hands young fishermen dipped their arms quietly in water and searched for

fish in cervices. When they succeeded to touch fish then they grasped the fish with thumb and middle finger to the gill opening and took it out to the bank. Moderate size fishes were captured with hand.

V. Fishing with towels and mosquito net

In this fishing method, small boys and girls used towel and mosquito net to catch the fishes. It was handled by two individual by dipping the towels under water moving from here and there up to the corner and lifting it out. This method was used in shallow water, when water levels are low in the river.

VI. Kure thunne (Blocking stone with bushes and grasses)

This was a simple method in which a flat stone, under which a large number of fishes sheltered, was blocked from all sides with the help of bushes and grasses. Then an opening was created from one side and fishes were collected one by one from this opening

VII. Use of poisons

Use of fish poison was a non-conventional fishing practice used in small channels of Kali Gandaki River and it feeder streams. Fish poison was extracted from plant derivatives like roots, leaves and barks of plants by crushing, mixing with sand and thrown in stagnant water. Dose was calculated according to their area of water body. The fishes which were paralyzed by poisoning were collected by hand or with the help of scoop net. Following are the plants used mainly to kills the fishes in the Kali Gandaki river area.

a) Khirro (*Sapium insignes*)
b) Chureepina (*Bassica butyracea*
c) Sihudi (*Euphorbis royleana*)
d) Ketuke (*Agave Americana*)
e) Maduwa (*Madhuca indica*)
f) Lahare bish

VIII. Diverting water mass

This was occasionally used method in the small channels of the Kali Gandaki river and its tributaries and locally known as ‘Duwali Thunne’. In this practice the whole water mass was diverted by construction a rough stone dam with wet mud and plants so that a semi dry fishing channels was produced at the end of which a fish trap was set to collect the fishes that escaped from capturing operation. At the middle of the channel, fish were caught by hands but in the pool region and stone, cervices, some poison were also used.

5. DISCUSSION

The density and diversity of the fishes mainly depends upon the biotic and abiotic factors, physico-chemical parameters, nature of ecosystem, age of the water mass, mean depth, water level fluctuations, conditions of bottom etc. The interactions of all these factors create favorable or unfavorable circumstances for the growth and development of any particular biotic elements (Dutta and Malhotra, 1986).

5.1 Physico-chemical parameters of water

5.1.1 Physical parameters of water

The water remained clear throughout the year except in rainy season i.e. from June to August. Due to heavy flooding and erosion water became muddy and the color of the water was found to be grayish. The current velocity of water in Kali Gandaki River was not found uniform; this might be due to slope gradient of river bed. In the present study water velocity was found to be highest (0.98m/s) in the month of March at station III and lowest (0.75m/s) was recorded in the month of November at station I (Fig 9). Stream velocity is merely the function of slope gradient of the river bed (Jhingran, 1975). In the present investigation, low velocities in the stations I may be due to the maximum flatness as well as minimum slope gradient of the riverbed. The water velocity has a great significance in distribution of fish species and regulates the level of DO (Whilton, 1975). Similarly, fishes like *Garra* sp., *Pseudecheneis* sp. were found in station II and III whereas *Barilius* sp., *Puntius* sp. etc were found in water with slow current as in station I. Fish diversity and water velocity shows positive correlation during November (r = 0.733273) but it was negative in March (r = -0.95819) (Table 6).

Water temperature ranged from 16^{o}C to 21.5^{o}C throughout the study period. Highest temperature (21.5^{o}C) was recorded in the month of March at station II and III whereas least (16^{o}C) was recorded in the month of November at station I and III (Fig 3). The correlation value of water temperature with the fish numbers were found (r = 0.981981) and (r = -0.91165) in November and March (Table 6). This showed decreased fish species composition with the rise in water temperature in Kali Gandaki River. Saud (2011) also found the decrease in fish catch with increase in water temperature in the Koshi River.

Water depth ranged from 290 to 314.98 cm throughout the study period. The highest water depth (314.98cm) was recorded in the month of November at station I whereas lowest depth (290cm) was recorded in the month March at station III (Fig 5). The correlation between water depth and fish diversity was found positive (r = 0.994215) in the month of March and (r = 0.271964) in the month of November (Table 6).

Transparency was recorded as highest value (106.68cm) during November at station I, whereas minimum value (85.34cm) was recorded at station II during March that might be due to rainfall (Fig 4). Fish diversity and water transparency was found to be positively

correlated during March (r = 0.176807), but it was negative in the month of November (r = -0.75572) (Table 6).Sharma (1996) also recorded the temporary decrease in transparency value in monsoon was caused by the rainfall and flood. Pokhrel (2011) also Listed, that the West Rapti river remained highly transparent throughout the year except in late summer and rainy season. Similarly, bottom substratum was found to be mostly of sand in large amount in station I and II whereas station III was dominated by boulders. In station I and II growth of vegetation and green algae in two bank of River during winter, spring and summer was found (Table 4, Figs 6-8).

5.1.2 Chemical parameters of water

Among the chemical factor, the concentration of dissolved oxygen of water is most important factor and dissolved oxygen above 5 mg/l is suitable to support diverse biota (APHA, 1998). The dissolved oxygen of Kali Gandaki River was also found to be ranged from 8.45 to 9.78mg/l with an average of 8.98mg/l (Fig. 12). Minimum in March might be due to high metabolic rate of organisms and high temperature. Ellis (1973) stated that the increase in water temperature resulted decrease DO. The dissolved oxygen showed positive correlation (r=0.944911) and (r=0.184912) in the month of November and March respectively (Table 6). Monitoring DO is one of the best ways of feeling the pulse of the aquatic ecosystem; as higher DO correlates with better quality of river at range of 7-11 mg/l (Beaven, 1877).

The highest value of pH (8.1mg/l) was recorded at station II during month of November and least value (7.5mg/l) was found at station III during March with an average value of 7.85mg/l (Fig. 10). The correlation between fish diversity and hydrogen ion concentration was found positive in the both month of November and March which was (r = 0.866025) and (r = 0.512837) respectively (Table 6).Generally low pH value is harmful to fishes. Water having pH value below 5.0 or above 9.5 are not suitable for fish life (APHA, 1967). The pH ranging from 7.0 to 8.5 is considered to support rich biota and fish (Bell, 1971).

In the present study, the value of free carbon dioxide was found to be highest (5.75mg/l) in the month of March at Station I and lowest (3.05mg/l) in November at Station III with an average value of 4.57mg/l (Fig 11). Sharma (2011) also found low CO_2 during the winter season and high in the summer season in Rani khola, Sikkim. The coefficient correlation between free carbon dioxide and fish diversity was found to be positive (r=0.955208) in the month of March and (r=0.163156) in the month November (Table 6). Most of the carbon dioxide in the water is formed by the decomposition of organic matter and from metabolism of organism. Carbon dioxide in surface water varies seasonally. The chemical parameters of the water also display great effect on the distribution of fish species in the river. The variation of physico-chemical environment had direct impact of the biotic response in the wet land including the diversity of fishes (Gooselike and Tumer, 1978).

5.2 Diversity of fish species

A total of 17 species of fish fauna were recorded belonging to 4 orders,7 families and 12 genera from all three sampling Stations of Kali Gandaki River.

Majority of the fish species collected from the river fell under the order Cypriniformes. About 77.443% of fish species belonged to order Cypriniformes, 16.165% to Siluriformes, 5.639% to Synbranchiformes and the lowest was 0.75% of order Perciformes. This is the largest order of fresh water fishes, which included 2,422 species (Nelson, 1984). Edd (1986) also reported the order Cypriniformes was common in Kali Gandaki and Narayani River. Sharma and Shrestha (2001) and Shrestha (2005) also reported order cypriniformes constituting highest catch in the Tinau River and Dano River respectively.

The fish species of family Cyprinidae was dominant in the assemblage composition with 69.548% followed by Sisoridae and Mastacembalidae with 12.406% and 5.639% respectively. The assemblage compositions of rests were 4.135%,3.759%, 3.759%, and 0.7518% of Balitoridae, Bagridae, Cobitidae and Channidae respectively (Table7). Sharma (1996), Karki (2000) and Bajracharya (2001) had found that Cyprinidae as the most common family in Tinau, Karnali and Sunkoshi and Bhotekoshi Rivers respectively.

Family Cyprinidae was found dominant consisting 9 species followed by Mastacembalidae and Balitoridae each with 2 species and remaining Bagridae, Cobitidae, Sisoridae and Channidae included one fish species only each (Table 5). Among fish species, *Barilius barila* and *Barilius bendelensis* were the dominant species recorded in all the stations throughout the study period. The frequency occurrence of *Barilius barila* and *Barilius bendelisis* were 14.2857% followed by *Pseudecheneis eddsi* (12.4060%) and lowest (0.751%) was *Channa orientalis* (Table 5).

The biodiversity index values (H_0) 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. Highest Shannon diversity index (2.55) was found in station II and the lowest (2.164) was found in station III (Fig. 16). A biodiversity index seeks to characterize the diversity of a sample or community by a single number (Magurran, 1988). 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. The main causes of the differences occurring in the biodiversity indexes are seasonal variations, atmospheric air currents and environmental conditions (Keskin and U¨nsal, 1998), and seasonal fish migrations (Ryer and Orth, 1987).

Evenness index value was highest (0.944) at station II and lowest value (0.902) observed in station III (Fig. 16). If we compare the temporal variation of dominance status among the all sampling stations, it did not fluctuate for a greater magnitude. The study findings

showed that fish diversity of the study area is reducing with the decrease of water quality. The reduced fish diversity eventually decreases the fish production of native species and creates extinction of several species. These consequences eventually create instability in the socio-economic sector of the study area in terms of increased poverty of local fishermen.The pollution, development works such as construction of roads, bathing, illegal fishing, and sand and stone mining etc. might be responsible for the decline species and density of fishes. The rapid proliferation of aquatic weed result in reduction of dissolved oxygen and change in water chemistry, increase rate of water loss due to evaporation were considered a serious threat to affect flora and faunal diversity (IFPRI 2009). Obiero and Munyirwa (1998) also reported to lower the temperature of water, pH, bicarbonate, alkalinity and increase in the free Carbon dioxide contents affecting the Biological Oxygen Demand (BOD) and nutrient level through luxuriant growth of aquatic weed

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Present study reveals the existing fish fauna, abundance and their distribution pattern in the Kali Gandaki River. The study also attempts to unveil the water quality and existing fishing practices.

A total of 17 fish species from different 3 sampling stations were recorded belonging to 4 orders and 7 families. Order Cypriniformes comprised of 3families: Cyprinidae, Cobitidae and Balitoridae with 12 species. Order Siluriformes comprised of 2 families: Sisoridae and Bagridae with 2 species. Order Synbranchiformes comprised of 1 family: Mastacembelidae with 2 species while Order Perciformes comprised of 1 family: Chhanidae with 1 species. Cyprinidae, Cobitidae and Balitoridae comprised 69.5%, 3.75% and 4.13% fish species respectively. Sisoridae and Bagridae comprised of 12.40% and 3.75% while Matacembelidae and Channidae consists of 5.639% and 0.75%. Most commonly observed species are *Barilius barila, Barilius bendelisis, Garra annandalei* and *Pseudecheneis eddsi* while the rare caught fishes were *Tor putitora* and *Channa orientalis.* The water quality parameters i.e. water temperature (16.0-21.5^{o}C), water transparency (85.34-106.68cm), depth (290-314.98cm), velocity (0.75-0.98m/s), pH (7.5-8.1),CO_2 (3-5.75mg/l) and DO (8.45-9.78mg/l) was recorded in present study. Shannon-weaver biodiversity index and evenness index (2.55), (0.944) and (2.164), (0.902) was noted at station II and Station III respectively. Local fishermen were known to use the various types of conventional as well as non-conventional gears and methods on fishing. The riverine environment of the Kali Gandaki River is degrading rapidly due to both natural and manmade causes leading to sharp declination in diversity and fish population.

6.2 Recommendations

To maintain fish density and diversity in Kali Gandaki River, some improvement measures should be undertaken instantly. Following are some recommendations:

- Use of fine meshed net like gillnet, mosquito net and any other illegal fishing practices should be strictly banned. This type of nets not only destroys the target fish population but also non target fish juveniles.
- Strict regulations should be implemented against fishing in breeding seasons.
- Regular training and awareness programs should be conducted in the local level for the conservation of river and biodiversity.
- The deep water pools of the Kali Gandaki River should be declared as fish sanctuaries for the protection of spawn.

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APPENDIX 3: A questionnaires used in interview with local fishermen

Zone: VDC: District:

Ward No: Village:

1. Name of the fisherman

Cast	Age	Sex	Religion

2. Number of member of the family

Total	Male	Female

3. Are you literate?

   Yes: No:

4. Are you giving school education to your children?

   Yes: No:

5. If no, then why?

6. Do you know about family planning?

7. How many members of your family are included in fishing?

8. How many fishermen come to fishing in this site?

9. Is fishing your main profession?

   Yes: No:

10. If yes in which category do you fall?

    Full time: Part time: Occassional:

11. Which fish species is abundant/ common/ uncommon in the river?

Name of fish	Abundant	Common	Uncommon	Remark

12. How much fish do you capture per month?

13. What type of fishing gears do you use for fishing?

14. Do you observed or heard about fish spawning/ breeding?

15. In which months or season do you observe more fry and fingerlings in the river in your catch?

16. Where do you catch the most number of species?

    Station I: Station II: Station III:

17. What do you think fish population has increased or decreased in the recent years?

    Increased: Decreased: Unknown:

18. If decreased pleased give the reason?

    Over fishing/ Use of dynamite/ Pesticide, Herbicides/ Electro fishing/ Pollution/ Others

19. Which is the most effective gears in the river?

20. Which fish species are mostly captured by you?

21. What are the aquatic predators of the river?

22. Do you receive any facilities/ conservation program etc from government and non-government agency?

23. Any suggestion would you like to give for the improvement of fishery of the Kali Gandaki River?