

**FISH DIVERSITY OF SETI KHOLA, POKHARA, KASKI,  
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 Biology and Aquaculture

**Submitted to**

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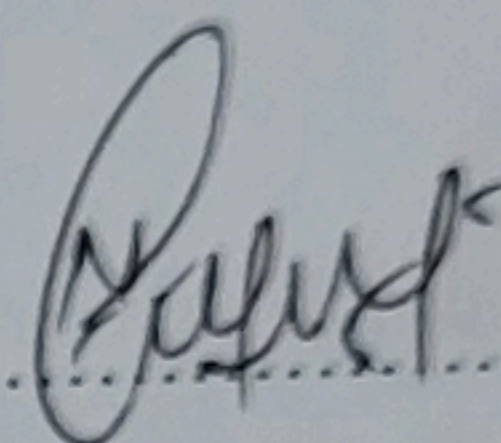
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Lainchaur, Kathmandu, Nepal

February, 2023

## DECLARATION

I hereby declare that the work presented in this thesis entitled "Fish Diversity of Seti Khola, Pokhara, Kaski, Nepal" has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).



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## ABSTRACT

The present study was conducted to investigate fish species diversity of the Seti Khola of Pokhara, Kaski. The duration of the study was from Kartik 2078 to Baishakh 2079 (October 2021 to April 2022). Five different sites were designated in the river to sample fishes and to measure physico-chemical parameters like, Temperature, DO, pH, alkalinity, Electrical conductivity, Turbidity and Hardness of Seti Khola. Fishes were collected with the help of local fishermen using locally available devices such as a cast net (8 mm) and a gill net (10 mm). A total of 14 species belonging to 4 orders, 5 families and 11 genera were recorded. Cypriniformes was recorded as the dominant order, which comprised 71.43% of total fishes collected, followed by Anabantiformes (14.29%), Siluriformes (7.14%), and Salmoniformes (7.14%). Of the recorded species, the conservation status of 3 were threatened, 3 were vulnerable, 5 were least concern, one was near threatened and one was critically endangered. One exotic species, Rainbow trout (*Oncorhynchus mykiss*) was also collected during the study. The range of Shannon diversity index was found to be from 1.52 at site V to 2.26 at site I. This showed that the diversity status of the Seti Khola was low to medium during the study period. Based on Pearson's correlation coefficient, the most important physico-chemical parameters affecting fishes were found to be alkalinity ( $r=0.80$ ) and Temperature (0.42). Except pH and Hardness, remaining physico-chemical parameters showed positive association with fish species.

# 1. INTRODUCTION

## 1.1 Background

The current status of fish shows 252 fish species in Nepal belonging to 15 orders and 41 families (Shrestha, 2019). Due to the great zoographical and geographical status of aquatic resource and the variation in them, Nepal provides a great opportunity to analyze the vertical distribution of fish from all altitude ranging from 1500 m to 2700m. On the basis of Ichthyology of Nepal (Shrestha, 2019), there are 2 endangered (EN), 11 vulnerable (VU), 23 rare or near threatened (R/NT), 42 are deficient pristine rare ornamental (PRO), 28 conservation dependent and rare species (CDR), 59 uncommon or lower risk/least concern (UN), 71 common species (C) and 16 exotic species (\*).

Geographically, Nepal is a small Himalayan country with a total area of 1,47,181 sq.km. Nepal is surrounded by China and India. Its geographical position lies between 26°22' to 30°27' north latitude and 80°4' to 88°12' east longitude. Nepal is located at 68m from the sea level and extended up to 8,848m up to the Mt. Everest.

Topographically Nepal is divided into 3 regions namely upper Himalayan, mid Hilly and the lower Terai region. The Himalayan region lies at the altitude between 4877m to 8848m from the sea level and occupies about 15% of total area of Nepal. Hilly region is located between Himalayan and Terai region which occupies 68% of the total area of Nepal and lies between the altitude of 610m to 4800m from sea level. The Terai and the inner Terai occupies 17% of the total area of Nepal.

Since the beginning of time, humans have used fish as food, fun, biological control agents, animal feed, waste, ornament, sport, and other things in the aquatic environment. Several fish species can be found in the valley's lotic water bodies (Pokharel, 2011). Literature on fish species diversity of Nepal include the works of Hamilton (1822) who was probably the first ichthyologist to give an authentic information of fishes of Nepal.

## 1.2 Water resources

Worldwide only 3% of a fresh water exists in streams, rivers, lakes, glaciers and remaining sea water forms 93% (Wetzel, 1983). The aquatic environment of Nepal is divided into lotic or flowing water and lentic or stagnant water.

Nepal has a total of 819,300 hectares of inland water resources (DoFD, 2014). Nepal is a small Himalayan country which covers 2.7% of the water resource and has a great potential for hydropower generation (Rai, 2008; Gubhaju, 2012).

**Table 1:** Estimated water resources of Nepal

S.N.	Resource detail	Estimated area (ha)	Coverage (%)
1	Natural resources	401,500	49
1.1	Rivers	395,000	48.21
1.2	Lakes	5,000	0.61
1.3	Reservoirs	1,500	0.012
2	Ponds	7,300	0.89
3	Swamps and wetlands	12,500	1.52
4	Irrigated paddy fields	398,000	48.57
	Total	819,300	100

Source: Directorate of Fisheries Development (DoFD, 2014)

## 1.3 Rivers in Nepal

In Nepal, there are more than 6000 rivers and streams of 21,000 km in length flowing north to south. The major rivers of Nepal are Koshi, Mahakali, Narayani and Karnali. Most of the rivers are originating from the mountains of Nepal. All the rivers of Nepal occupy about 48.21% of total water sources of Nepal.

Rivers of Nepal flows from north to south, and finally merge into the Ganges river system of India contributing 40% of annual flow and 71% of dry season flow (Abbas, 1982). The water current of the rivers is generally slower as they reach the plain areas of the southern part of the country. They are rich in aquatic biota. On the basis of origin, the rivers of Nepal are divided into

### 1.3.1 Rivers originating from high Himalayan region

The Sapta-Koshi, Sapta-Gandaki, Sapta-Karnali and Mahakali are the major rivers originating from the Himalayan region of Nepal. They are located in eastern, central, western and far-western regions of the country respectively.

### 1.3.2 Rivers originating from Mahabharat region

Mechi, Kankai, Kamala, Bagmati, Tinau, Babai, West Rapti are the rivers originating from the Mahabharat region of Nepal and characterized by great seasonal fluctuation.

### 1.3.3 Rivers originating from Siwalik and Churia region

Rivers mainly fed by rainwater are the rivers originating from Siwalik and Churia region. The catchment area of these rivers is 350km<sup>2</sup> in area. These are characterized by little or no flow of water during the dry season (Rajbanshi, 2012).

## 1.4 Fish diversity and their conservation status

**Table 2:** Current status of fishes of Nepal

S.N.	Categories	Designated as	No. of fish species
1	Common	C	71
2	Uncommon or lower risk/Least concern	UN	59
3	Conservation dependent and rare	CDR	28
4	Data deficient pristine rare ornamental	PRO	42
5	Critically endangered	CE	0
6	Endangered	EN	2
7	Extinct	EX	0
8	Vulnerable	VN	11
9	Rare or near threatened	R	23
	Total native species		236
10	Exotic	*	16
	Total native and exotic fishes of Nepal		252

(Source: Shrestha, 2019)

## **1.5 Seti Khola**

Seti River originates near the base of Mt. Machhapuchhre (6,997m) and Mt. Annapurna (7,525m) flowing downwards receives several tributaries and passes through the heart of Pokhara valley forming deep gorges (Pokharel *et al.*, 2011). It joins the Trishuli River at Gaighat (Sharma, 1977). The major tributaries are Mardi Khola and Vijaypur Khola, Sardikhola and Bhurjungkhola. The total length is about 202 km.

## **1.6 Objective**

### **1.6.1 General objective**

The general objective of this study was to study the fish diversity of Seti River of Pokhara, Kaski district.

### **1.6.2 Specific objectives**

The specific objectives of this study were:

- To determine the physico-chemical parameters of Seti River.
- To explore the fish diversity of Seti River.
- To analyze the relation between Physico-chemical parameters and the fish diversity of Seti River.

## **1.7 Significance of the study**

Seti River, originated from Mt. Machhapuchhre and Mt. Annapurna provides good habitats for aquatic plants and animals including different hill stream fishes. These days, fishes of the Seti River are suffering from several impacts such as soil erosion, illegal fishing practices, construction of dams and so on. So diversity study is becoming essential in order to update the fishes of this river. On the other hand, although previous studies were conducted in some downstream stretches of the Seti Khola, fish diversity above the Mardi Dovan (upstream stretches) is largely unknown. Therefore, the present study was carried out to explore fish diversity in upper reaches of this river. The results of this study will be helpful in the management and development of fisheries resource of the Seti River.



## 2. LITERATURE REVIEW

The previous fish diversity studies carried out by different authors are given below. Shrestha (2019) reported a total of 252 fish species of Nepal belonging to 120 genera, 40 families and 15 orders. John (1986) studied fish population density of different fish species and their structural adaptive modification and morphology of the fishes in stream of Seti, Mardi Khola and associated rivers and reported a total of 27 fish species. Jha (2006) studied Fish Ecological Studies and its application in assessing ecological integrity of rivers in Nepal and reported 18 fish species from Seti Gandaki River. EIA (2009) reported 19 fish species whereas EIA (2011) reported 32 fish species.

Pokharel (2011) studied fish ecology of Seti Gandaki River and recorded 30 fish species belonging to 5 orders, 9 families and 22 genera. Later Pokharel (2018) studied correlation between fish assemblage structure and environmental variables of the Seti Gandaki River Basin and recorded 30 fish species belonging to 5 orders, 9 families and 24 genera.

Ng and Edds (2005) reported new species like *Pseudecheneis serracula* and Ng (2006) further reported one new species *Pseudecheneis eddsi* from Seti Gandaki River. Vaidya *et al.* (2008) investigated the water quality in Bagmati river, Taudah lake, Nag Pokhari pond, Siddha Pokhari pond and Godavari fish pond of the Kathmandu valley. The water quality of the investigated water bodies was found to be deteriorated due to discharge of untreated effluents, solid wastes and poor conservation practice.

Shrestha and Edds (2012) studied the distribution of fishes by using voucher specimens collected during 1996 fish survey of Nepal and reported 10 orders, 30 families and 76 species. Limbu *et al.* (2018) investigated ichthyofaunal diversity of Dewmai Khola of Ilam district, Nepal and reported a total of 16 fish species belonging to 3 orders, 6 families and 11 genera were recorded. The dominant order was Cypriniformes followed by Cobitidae and Psilorhynchidae. Shrestha (2017) reported 48 fish species under 35 genera belonging to 17 families and 6 orders inhabiting in Triyuga River. *Barilius shacra*, *Garra annandalei*, *Badis badis*, *Olyra langicaudata* and *Anguilla bengalensis* were some of the species recorded.

Anond *et al.* (2007) reported two indigenous fish species in Kulekhani reservoir namely Katle (*Neolissochilus hexagonolepis*) and Kange (*Nazirator chelynoides*) with 2.4% and 1.36% abundance respectively. Other exotic fish species mainly carps were dominant group comprising 96.29% at sites. Sharma *et al.* (2001) investigated fish fauna and their distribution pattern in Tinau River, western Nepal and reported 35 species belonging to 5 orders, 12 families and 25 genera. Cyprinidae was reported as the dominant family followed by Cobitidae.

### **3. MATERIALS AND METHODS**

#### **3.1 Materials required**

The following materials were used during the study period

- Cast net/ gill net
- pH meter
- DO meter
- Conical flask
- Thermometer
- Burette
- Pipette
- Beaker
- Secchi disc
- Sampling bottle

#### **3.2 Chemicals required**

Following chemicals were used during the study period:

- HCl
- Phenolphthalein
- Methyl orange
- Formaldehyde

#### **3.3 Study area**

Seti River is one of the very famous and main rivers of western Region in Nepal having both historical and religious importance. The river is originated from the base of Mt. Machhapuchhre and Mt. Annapurna and meets Trishuli River at Ghaighat and covers a total length of about 202 km (Pokharel, 2011). The study area lies from Pulamukh which is below the confluence of Seti Khola and Mardi Khola upto the Tatopani (Kharpani) area.



**Figure 1:** Map of study area of Seti Khola

### **3.4 Study period**

The field visit was carried out for seven months from Kartik 2078 to Baishakh 2079 (October 2021 to November 2022). Each sampling site was visited in every second week of the months for fish sampling and measurement of water quality parameters.

### **3.5 Descriptions of sampling sites**

A total of five sampling sites were fixed on the basis of human settlement, grazing land, agricultural land and the presence of bridge.

#### **Site I**

The first site was Pulamukh which is below the confluence point of Seti and Mardikhola. It is a crematory site of Hindu people where dead bodies are cremated. The river bed has stone and boulders with small amount of gravels.

#### **Site II**

The second site was confluence point of Seti khola and Mardikhola called Mardi Dovan. It is characterized by shallow and rapid rivers. The riverbed consists of boulders, stone and pebbles and small amount of gravels and sand.

### **Site III**

The third site was the confluence point of Seti khola and Bhurjungkhola River called Dhaba. This site lies under the suspension bridge with some sort of disturbance. The riverbed consists of stone, gravels and sand with small amount of boulders.

### **Site IV**

The fourth site was the confluence point of Seti and Sardikhola river called Khottara. This site is also disturbed by the pipeline of hydropower. The river bed consists of sand, pebbles, gravels and boulders. Water current is comparatively higher at this site.

### **Site V**

The fifth site was the Kharpani area called Chipleti/ Tatopani. This area is characterized by dense human settlement, cattle grazers, farm lands and a bridge. Water current is comparatively higher at this site. People from different parts of the country visit this area to have hot water bath. The riverbed consists of gravel, pebbles, boulders and stones.

## **3.6 Water quality analysis**

Different atmospheric conditions regulate the physical and chemical properties of water (Pokharel, 2011). The measured physico-chemical parameters were pH, water temperature, dissolved oxygen, alkalinity, EC, turbidity and hardness. Some of the parameters were measured at the site where some were measured in the water quality testing laboratory, Pokhara. The measured physical and chemical parameters of Seti khola were discussed below:

### **3.6.1 Water temperature**

The water temperature of Seti khola was recorded by using digital thermometer. The temperature was measured simply by dipping the bulb of thermometer inside the water surface by avoiding the direct sunlight.

### **3.6.2 pH**

The pH is simply known as the negative logarithm of hydrogen ion concentration. A pH meter was used to record the pH of water during the study period in each sampling site.

### **3.6.3 Dissolved Oxygen (DO)**

The dissolved oxygen was measured by using DO meter. DO was measured by dipping the probe into the water.

### **3.6.4 Total alkalinity**

Alkalinity is the capacity of water to resist acidification. Phenolphthalein and the methyl orange were the indicators used to test alkalinity. Few drops of phenolphthalein indicator were added in the 100 ml of water sample, if the color doesn't change that indicated the absence of phenolphthalein alkalinity or carbonates and hydroxides in the given water. If the solution was turns in to the pink color, then it was titrated against 0.1N HCl solution until it becomes colorless again. The few drops of methyl orange were added in the same solution; the color of the solution was changed. The alkalinity is expressed as mg/l, which can be calculated by using formula;

$$\text{Total alkalinity (mg/l)} = \frac{(\text{ml} * \text{normality of HCl}) * 50 * 1000}{\text{ml of sampled used}}$$

### **3.6.5 Electrical conductivity**

The ability of water to conduct electricity is the electrical conductivity of water. All the dissolving substances including salts dissolved in water can be breakdown in to positively and negatively ions. These free ions conduct electricity in the water. Electrical conductivity of water was measured in the water quality testing laboratory, Pokhara.

### **3.6.6 Turbidity**

The quality of being cloudy with suspended matter in water is the turbidity. It was measured by using Nephelometers (Turbidity meter) in the water quality testing laboratory, Pokhara.

### **3.6.7 Hardness**

The deposition of calcium and magnesium within the water molecules is the hardness of water. The hardness of water was measured in the water quality testing laboratory, Pokhara.

### **3.7 Fish samplings, preservation techniques and identification of collected fish species.**

Fishes were collected from each sampling site by hired local fisherman. Locally prepared gears like cast net (8mm), gill net(10mm) were used to collect fish. Cast net was thrown 8-10 times in each sampling site and gill net was casted overnight and in the morning the stuck fishes were collected. Sampling was done for four days (morning) in each month. Before preservation the collected fish were photographed. The collected fishes were preserved in 10% formalin according to the body size in a transparent bottle. The preserved specimen was brought to the laboratory of Amrit Campus for identification. The collected fishes were identified by using identification keys (Jayram, 2010; Shrestha, 2008; Shrestha, 2019).

### **3.8 Diversity indices**

#### **3.8.1 Shannon Weiner index**

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

Shannon –Weiner diversity index is designed as  $H'$ , which is calculated as:

$$H' = -\sum(Pi) \times Ln(pi)$$

Where

$$pi = ni / N$$

$N_i$ = number of individual of species of  $i$ .

$N$ = Total number of individuals in the sample.

$Ln$  = Logarithm of base  $e$ .

#### **3.8.2 Evenness index**

To calculate whether species are distributed evenly across seasons and across landscapes elements, evenness index was determined by the following equation (Pielou, 1966).

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

Where,

$H'$  = Shannon-Weiner diversity index

$S$  = Total number of species in the sample

### 3.8.3 Species richness

Species richness is the total number of species present at a site. it can be calculated as:

Margalef species richness(d) =  $S - 1/\ln N$

Where,

$S$  = Total number of species

$N$  = Total number of individuals

### 3.8.4 Correlation coefficient (r)

The correlation coefficient (r) between species and Physico-chemical parameters was determined by using following formula:

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



## 4. RESULTS

### 4.1 Fish diversity in Seti Khola

A total of 14 fish species were recorded during present study which includes 4 orders, 5 families, and 11 genera. Cypriniformes was the dominant order which represents 71.43% of total fish species followed by Anabantiformes (14.29%), Siliuriformes (7.14%) and Salmoniformes (7.12%). Cyprinidae was the dominant family which represents 64.29% of total fish species followed by Channidae (14.29%), Sisoridae (7.14%), Nemachilidae (7.14%) and Salmonidae (7.14%).

**Table 3:** Fish species collected in Seti Khola showing Order, Family, Common name and IUCN category

S.N.	Scientific Name	Orders	Family	Common Name	IUCN category
1	<i>Channa orientalis</i> (Bloch and Schneider, 1801)	Anabantiformes	Channidae	Snakehead	VU
2	<i>Channa punctata</i> (Bloch, 1793)	Anabantiformes	Channidae	Spotted snakehead	LC
3	<i>Barilius bendelisis</i> (Hamilton, 1807)	Cypriniformes	Cyprinidae	Hamilton's baril	LC
4	<i>Garra nepalensis</i> (Hamilton, 1822)	Cypriniformes	Cyprinidae	Garra	CR
5	<i>Naziritor chelynoides</i> (McClelland, 1839)	Cypriniformes	Cyprinidae	Dark mahseer	VU
6	<i>Neolisochilus hexagonolepis</i>	Cypriniformes	Cyprinidae	Copper mahseer	NT

	(McClelland, 1839)				
7	<i>Puntius conchionius</i> (Hamilton, 1822)	Cypriniformes	Cyprinidae	Rosy barb	LC
8	<i>Puntius sophore</i> (Hamilton, 1822)	Cypriniformes	Cyprinidae	Pool barb	LC
9	<i>Rasbora daniconius</i> (Hamilton, 1822)	Cypriniformes	Cyprinidae	Slender Rasbora	LC
10	<i>Schistura fasciata</i> (Lokeshwor and vishwanath, 2011)	Cypriniformes	Nemachilidae	Ray-finned fish	TH
11	<i>Schizothorax plagiostomus</i> (Heckle, 1838)	Cypriniformes	Cyprinidae	Snow trout	TH
12	<i>Schizothorax richardsonii</i> (Gray, 1832)	Cypriniformes	Cyprinidae	Common snow trout	VU
13	<i>Oncorhynchus mykiss</i> (Walbaum, 1792)	Salmoniformes	Salmonidae	Rainbow trout	
14	<i>Pseudocheneis eddsi</i> (McClelland, 1842)	Siluriformes	Sisoridae	Planet catfish	TH

(LC=least concern, CR=critically endangered, TH=threatened,  
VU=Vulnerable, NT=near threatened)

## 4.2 Systematic position of fish

The collected fish species of Seti Khola were identified after Jayram (2010), Shrestha (2008) and Shrestha (2019). The systematic position (Order, Family and Sub-family) of collected species is given below:

1. *Puntius sophore* (Hamilton, 1822)  
Order: Cypriniformes  
Family: Cyprinidae  
Subfamily: Barbinae
2. *Puntius conchoni* (Hamilton, 1822)  
Order: Cypriniformes  
Family: Cyprinidae  
Subfamily: Barbinae
3. *Garra nepalensis* (Hamilton, 1822)  
Order: Cypriniformes  
Family: Cyprinidae  
Subfamily: Labeoninae
4. *Rasbora daniconius* (Hamilton, 1822)  
Order: Cypriniformes  
Family: Cyprinidae  
Subfamily: Danioninae
5. *Schizothorax plagiostomus* (Heckel, 1838)  
Order: Cypriniformes  
Family: Cyprinidae  
Subfamily: Barbinae
6. *Schizothorax richardsonii* (Gray, 1832)  
Order: Cypriniformes  
Family: Cyprinidae  
Subfamily: Barbinae
7. *Barilius bendelisis* (Hamilton, 1807)  
Order: Cypriniformes  
Family: Cyprinidae

8. *Naziritor chelynooides* (McClelland, 1839)  
Order: Cypriniformes  
Family: Cyprinidae
9. *Neolissochilus hexagonolepis* (McClelland, 1839)  
Order: Cypriniformes  
Family: Cyprinidae
10. *Channa punctata* (Blotch, 1793)  
Order: Cypriniformes  
Family: Cyprinidae
11. *Channa orientalis* (Blotch and Schneider, 1801)  
Order: Cypriniformes  
Family: Cyprinidae
12. *Pseudochenesis eddsi* (McClelland, 1842)  
Order: Siluriformes  
Family: Sisoridae
13. *Schistura fasciata* (Lokeshwor and Vishwanath, 2011)  
Order: Cypriniformes  
Family: Nemachilidae
14. *Oncorhynchus mykiss* (Walbaum, 1792)  
Order: Salmoniformes  
Family: Salmonidae

### **4.3 Fish diversity and abundance in Seti Khola**

The maximum number of individuals was recorded in Kartik with a total of 135 individuals followed by Chaitra (129), Baishakh (125), Falgun (114), Mangshir (113), Magh (103) and Poush (101). The number of individuals of each species collected at each sites in different months is shown in table 5. The maximum number of individuals was recorded for *S. plagiostomus* with 185 followed by *S. richardsonii* (175) and *G. nepalensis* (117). The minimum number of individual was recorded for *O. mykiss* with one individual.

**Table 4:** Distribution of fishes in Seti khola

S.N	Name of species	Months/Station																																												
		Kartik					Mangshir					Poush					Magh					Falgun					Chaitra					Baishakh														
		1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	All Total								
1	<i>Channa punctata</i>	-	-	-	5	3	1	-	-	4	2	2	-	-	4	1	-	-	-	1	2	-	-	-	2	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	16		
2	<i>Puntius saphore</i>	1	-	-	1	3	4	1	-	8	2	-	-	-	2	2	3	-	-	5	1	-	-	-	1	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	21	
3	<i>Puntius conconius</i>	2	3	-	5	2	-	-	-	2	4	2	-	-	6	3	-	-	-	3	5	2	-	-	7	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	25	
4	<i>Channa orientalis</i>	2	1	-	3	1	-	-	-	1	3	2	-	-	5	2	-	-	-	2	3	-	-	-	3	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	17	
5	<i>Pseudocheneis eddsi</i>	2	1	-	3	4	1	-	-	5	1	1	-	-	2	3	1	-	-	4	3	-	-	-	3	1	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	20		
6	<i>Garra nepalensis</i>	4	7	2	3	4	20	2	5	1	2	1	11	1	3	2	1	8	3	1	7	3	2	16	4	7	5	1	1	18	5	6	2	3	5	21	4	6	4	8	1	23	117			
7	<i>Rasbora dromicoides</i>	-	-	-	0	-	-	-	-	0	-	-	-	1	1	-	-	-	0	-	-	-	-	0	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2		
8	<i>Oncorhynchus mykiss</i>	-	-	-	0	-	-	-	-	0	-	-	-	-	0	-	-	-	0	-	-	-	-	1	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1		
9	<i>Schizothorax plagiostomus</i>	7	5	15	5	3	35	4	5	9	3	4	25	4	3	9	3	2	21	3	2	9	1	2	17	6	5	9	2	1	23	7	6	13	5	6	37	4	7	9	3	4	27	185		
10	<i>schizothorax richardsoni</i>	7	4	6	7	3	27	5	7	3	5	3	23	7	4	2	3	1	17	4	3	8	2	2	19	5	9	7	6	2	29	6	11	8	3	5	33	2	9	8	5	3	27	175		
11	<i>Schistura fasciata</i>	-	-	2	1	-	3	-	-	3	2	-	5	-	1	1	-	2	1	1	2	-	1	-	1	-	2	3	-	5	-	3	1	-	4	-	5	1	-	6	6	26				
12	<i>Barilius bendelisis</i>	4	1	-	-	-	5	2	1	-	-	3	5	2	-	-	-	7	2	2	-	-	-	4	1	2	-	-	3	1	1	-	-	2	4	2	-	-	-	-	-	-	-	6	30	
13	<i>Noziritar chelynoides</i>	3	6	4	4	-	17	6	3	-	-	9	5	7	6	1	-	19	11	3	6	-	3	23	2	3	2	-	-	7	3	7	1	-	11	6	3	-	4	2	15	101				
14	<i>Neolisochilus hexagonolepis</i>	3	6	2	-	-	11	8	5	4	-	17	5	2	-	-	7	3	2	2	-	-	7	6	3	4	-	-	13	7	3	-	-	4	14	8	3	4	-	-	15	84				
<b>Total</b>		37	37	31	20	10	135	40	32	21	12	8	113	37	26	24	9	5	101	37	17	33	7	9	103	34	35	29	12	4	114	31	37	28	12	21	129	33	30	31	21	10	125	820		

#### 4.4 Fish composition in Seti Khola

##### 4.4.1 Order wise fish composition of fishes collected in Seti River

The table 6 shows the order wise fish composition in Seti Khola. Cypriniformes was the dominant order with 10 species which represents 71.43% of total fish species followed by Anabantiformes (2 species; 14.29%), Siluriformes (1 species; 7.14%), and Salmoniformes (1 species; 7.14%).

**Table 5:** Order-wise fish composition

S.N.	Order	No. of species	Composition (%)
1	Cypriniformes	10	71.43
2	Anabantiformes	2	14.29
3	Siluriformes	1	7.14
4	Salmoniformes	1	7.14
	Total	14	100

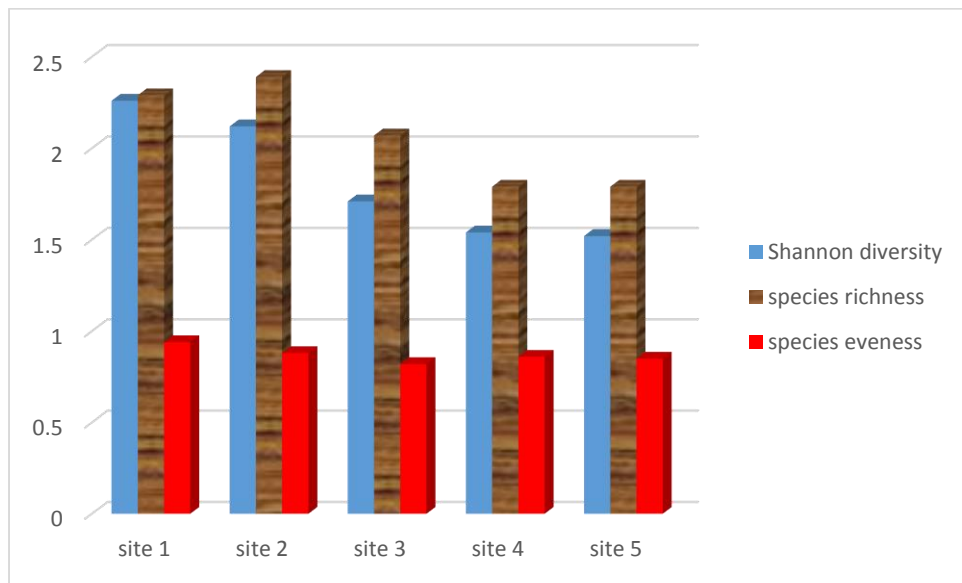
##### 4.4.2 Family wise fish composition of fishes collected in Seti River

The table 7 shows the Family wise fish composition in Seti Khola. Cyprinidae was the dominant family with 9 species which represents 64.29% of total followed by Channidae (2 species; 14.29%), Sisoridae (1 species; 7.14%), Nemachilidae (1 species; 7.14%) and Salmonidae (1 species; 7.14%).

**Table 6:** Family-wise fish composition

S.N.	Family	No. of species	Composition (%)
1	Cyprinidae	9	64.29
2	Channidae	2	14.29
3	Sisoridae	1	7.14
4	Nemachilidae	1	7.14
5	Salmonidae	1	7.14
	Total	14	100

#### 4.4.3 Shannon-Weiner diversity, Evenness and Species richness of Seti Khola

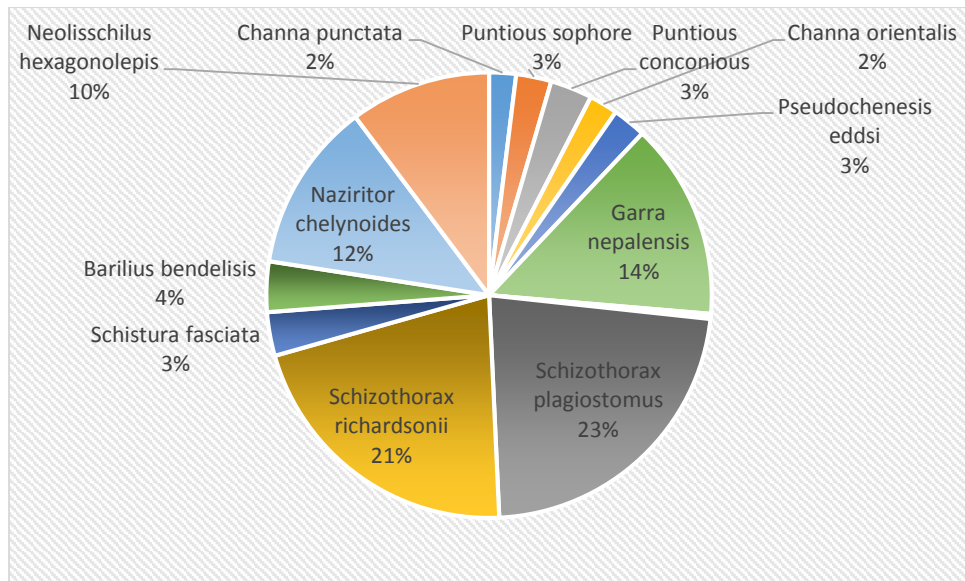


**Figure 2:** Shannon weiner diversity, evenness and richness of Seti Khola

Figure 2 shows the Shannon-Weiner diversity, species evenness and species richness of the Seti Khola. The site 1 is more diversified with value 2.26 followed by site 2 (2.12), site 3 (1.71), site 4 (1.54) and site 5 (1.52). Likewise, species richness is more in site 1 and site 2 which is 2.39 followed by site 3 (2.07) and site 4 (1.79) and site 5 (1.79). Similarly, the species evenness is more in site 1 which is 0.94 followed by site 2 (0.88), site 4 (0.86), site 5 (0.85) and site 3 which is 0.82.

#### 4.5 Number of individuals collected in different months in Seti Khola

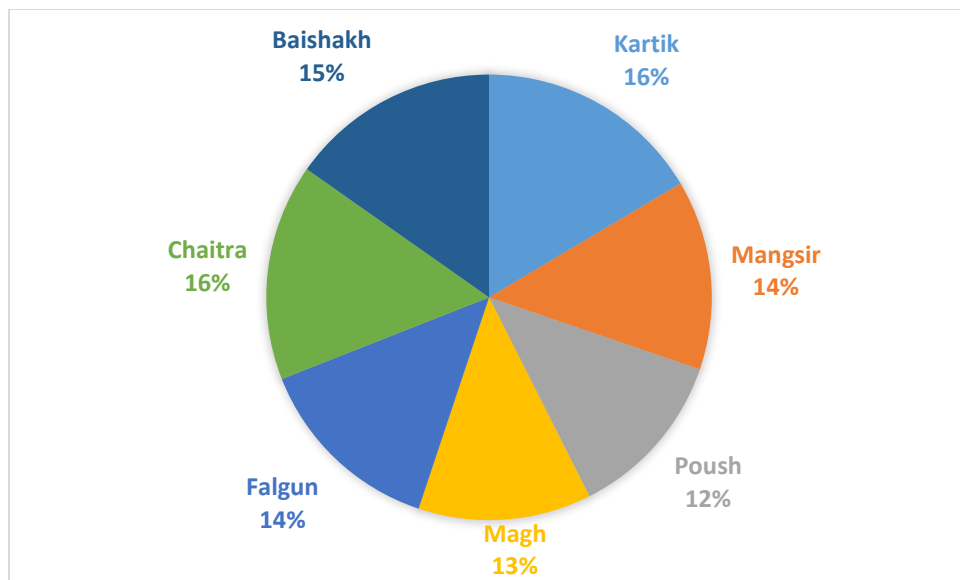
A total of 14 species were recorded. *Schizothorax plagiostomus* was collected with the highest number of individuals (23%), followed by *S. richardsonii* (21%), *G. nepalensis* (14%), *N. chelynoides* (12%), *N. hexagonolepis* (10%), and so on.



**Figure 3:** Number of species collected in (%) different sampling sites in Seti Khola

#### 4.6 Month wise collection of individual fish species

The highest number of individual was collected in Kartik (135) which represents 16% of total followed by Chaitra (129;16%), Baishakh (125;15%), Falgun (114;14%), Mangsir (113;14%), Magh (103;13%) and Poush (101;12%).



**Figure 4:** Number of individuals collected (%) in each month in Seti Khola

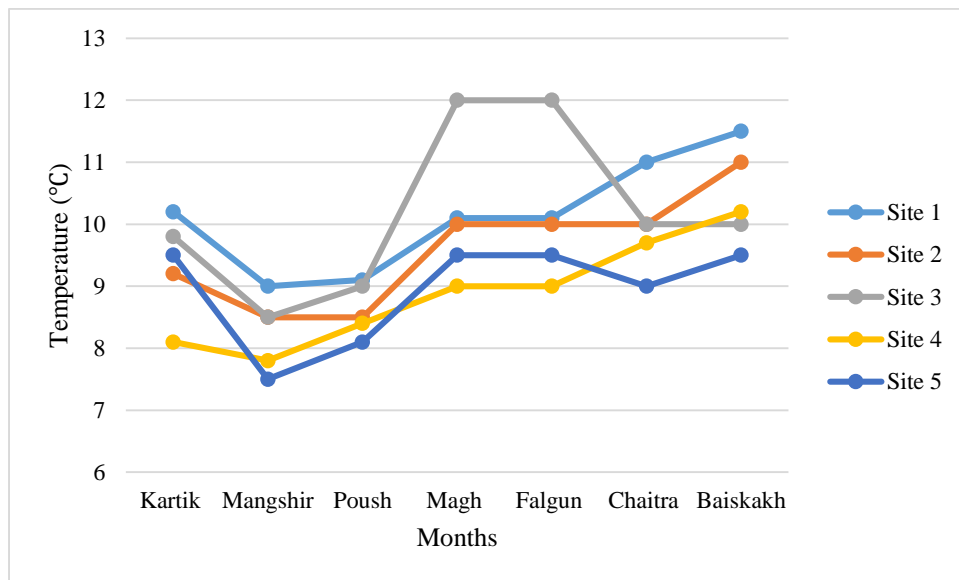
#### 4.7 Water quality parameters

The water quality parameters of the Seti Khola are given below:



#### 4.7.1 Water temperature

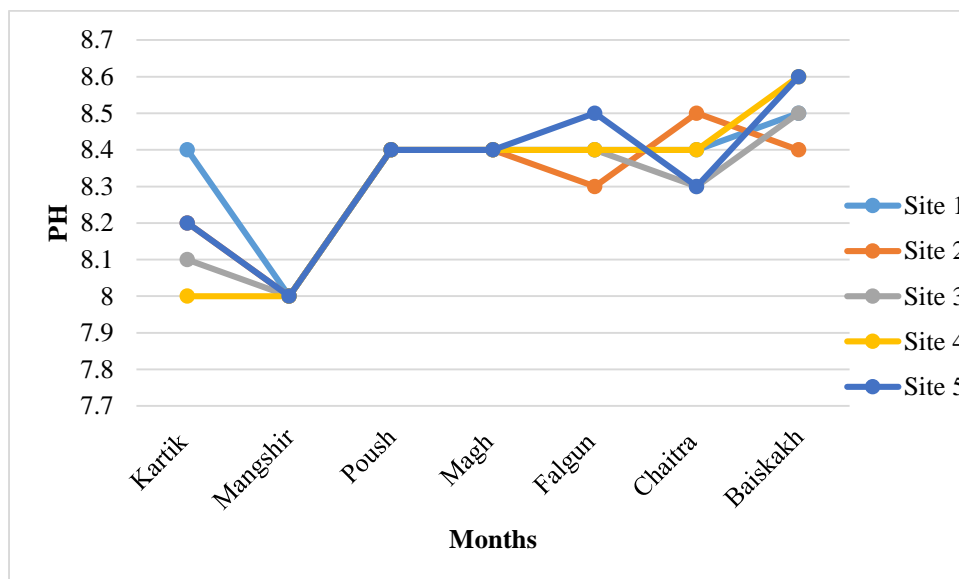
The temperature ranged from 7.5 to 12 °C in Seti Khola throughout the study period. The highest temperature was found in each of Magh and Falgun at site 3 whereas the lowest temperature was found to be 7.5 °C in Mangshir at site 5.



**Figure 5:** Temperature variation in each month in Seti khola

#### 4.7.2 pH

pH ranged from 8 to 8.6 showing the lowest 8 value in the all sites in Mangshir and highest PH was found to be 8.6 in the month Baishakh at site 4 and 5.



**Figure 6:** pH variation in each month in Seti Khola

### 4.7.3 DO

Dissolved oxygen plays a vital role in the fish diversity. The maximum dissolved oxygen in the Seti Khola was found to be 11.6 (mg/l) at site 3 in Mangshir while it was lowest in each of Kartik and Mangshir at site 4 which is 9 (mg/l).

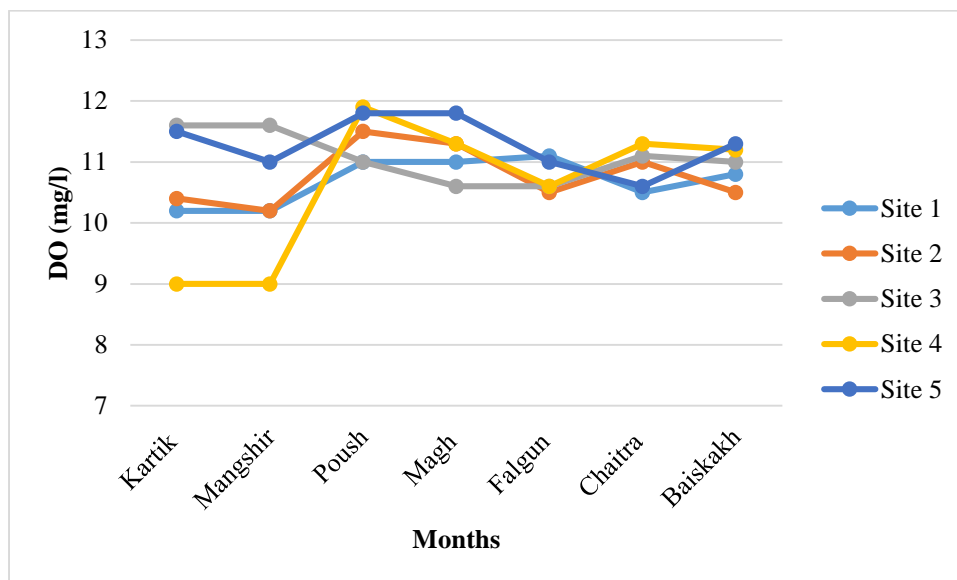


Figure 7: DO variation in each month in Seti Khola

### 4.7.4 Alkalinity

The total alkalinity of water was ranged from 24 (mg/l) to the 42 (mg/l). The lowest value obtained was 24 (mg/l) at site 5 in Poush and the highest value 42 (mg/l) at site 1 in each of Mangshir and Chaitra.

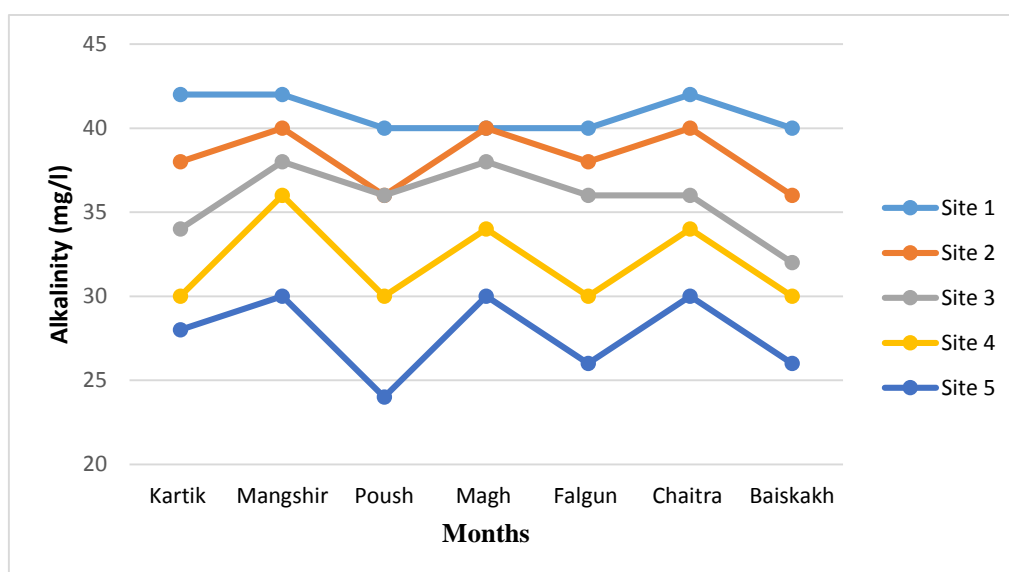
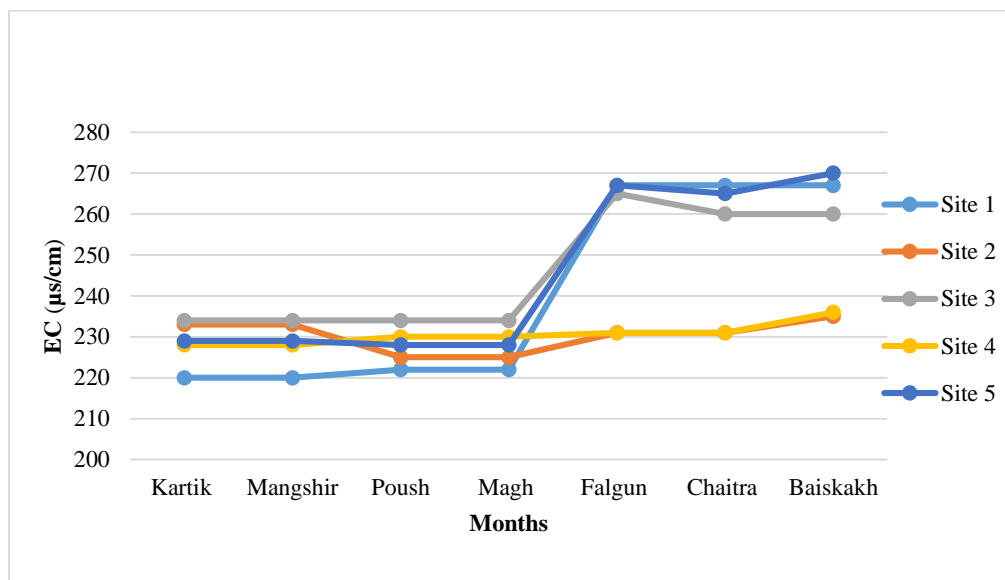


Figure 8: Alkalinity variation in each month in Seti Khola

#### 4.7.5 Electrical conductivity

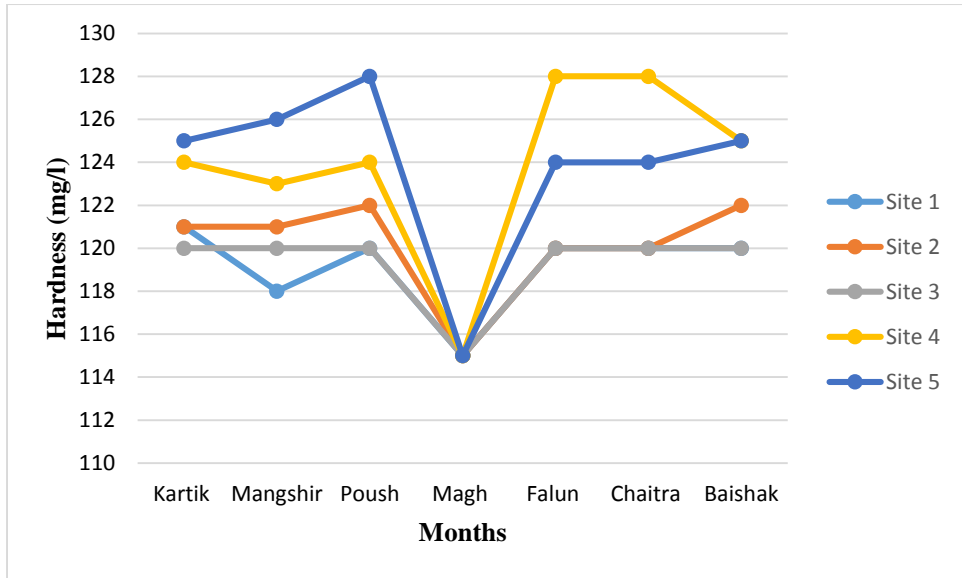
During the study period the EC ranges from 220 to 270  $\mu\text{s}/\text{cm}$ . the lowest value was observed to be 220  $\mu\text{s}/\text{cm}$  in Kartik and Mangshir whereas the highest value was observed at site 5 during the month of Falgun, Chaitra and Baishakh respectively.



**Figure 9:** Electrical Conductivity variation in each month in Seti Khola

#### 3.7.6 Hardness

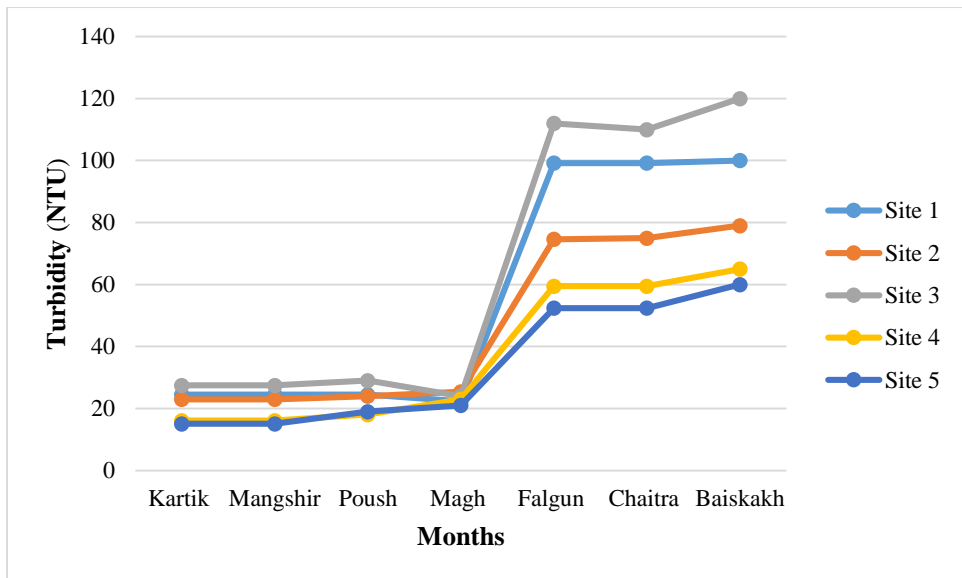
The hardness of water represents the high mineral content in the water. The value of hardness of Seti River throughout the study period was ranged from 115 to 128 mg/l the highest value was observed 128 in the site 4 for the month Falgun and Chaitra and the lowest value was observed 115 mg/l at site 1 in Magh.



**Figure 10:** Hardness variation in each month Seti Khola

### 3.7.7 Turbidity

Turbidity indicates the cloudiness in the water. The lowest Turbidity was observed to be 15.1 NTU (Nephelometric Turbidity Unit) in Mangshir at site 5 and the highest value was observed to be 120 at site 3 in Baishakh.



**Figure 11:** Turbidity variation in each month in Seti Khola

**Table 7:** Correlation between species and Physico-chemical parameters

<b>Water parameters</b>	<b>Correlation coefficient (r) with fish</b>
Temperature	0.42
DO	0.31
pH	-0.03
Alkalinity	0.80
EC	0.002
Turbidity	0.30
Hardness	-0.47

Seven physico-chemical parameters were measured during the study period. Temperature, DO, Alkalinity, EC, Turbidity show positive correlation with the fish species whereas pH and Hardness shows negative correlation with fish species. Alkalinity shows highly positive correlation (0.80) with fish species and temperature (0.42), DO (0.31) and Turbidity (0.30) shows medium correlation whereas EC shows low positive correlation (0.002) with the fish species. Hardness of water shows medium negative correlation (-0.47) with fish species and pH of water shows low negative correlation (-0.03).

Table 8: Physico-chemical parameters measured in Seti Khola

Physicochemical parameters	Months/Station																																		
	Kartik			Mangshir			Poush			Magh			Falgun			Chaitra			Baisakh																
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5										
S.N	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5					
1 Temperature	10.2	9.3	9.8	8.1	9.5	9	8.5	8.5	7.8	7.5	9.1	8.5	9	8.4	8.1	10.1	10	12	9	9.5	10.5	11	10	12	9	11	10	10	9.7	9	11.5	11	10	10.2	9.5
2 PH	8.4	8.2	8.1	8	8.2	8	8	8	8	8	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.4	8.4	8.4	8.4	8.5	8.3	8.4	8.3	8.5	8.4	8.5	8.6	8.6
3 Dissolved oxygen	10.2	10.4	11.6	9	11.50	10.2	10.2	11.6	9	11	11.5	11	11.9	11.8	11.3	10.6	11.3	11.8	11.8	11.1	10.5	10.6	10.6	11	10.5	11	10.5	11	11.1	11.3	10.6	10.8	10.5	11	11.2
4 Basicity	42	38	34	30	28	42	40	38	36	30	40	36	36	30	24	40	38	34	30	40	38	36	30	26	42	40	36	34	30	34	40	36	32	30	26
5 Electrical Conductivity	220	233	234	228	229	220	233	234	228	229	222	225	234	230	228	224	220	229	231	228	267	231	265	231	267	267	231	260	231	265	267	235	260	236	270
6 Turbidity	24.5	23	27.5	16.1	15.1	24.5	23	27.5	16.1	15.1	24.5	24	29	18.1	19	22.3	25.4	24	23	21	99.2	74.6	112	59.5	52.4	99.2	75	110	59.5	52.4	100	79	120	65	60
7 Hardness	121	121	120	124	125	118	121	120	123	126	120	122	120	124	128	115	119	124	124	127	120	120	120	128	124	120	120	120	128	124	120	122	120	125	125

## 5. DISCUSSION

A total of 14 fish species were collected from five sampling sites of Seti Khola belonging to 4 orders, 5 families and 11 genera. However, the result of EIA of Upper Seti Hydropower Project (2011) shows higher species richness than present study of Seti River and its two major tributaries, Mardikhola and Bijaypur Khola in Pokhara.

In Seti khola, the most common fish species was *Schizothorax richarsonii* and *Schizothorax plagiostomus*. The result shows the most dominant order was cypriniformes. In a total of 14 species, 10 species belong to the order cypriniformes which covers 71.43% of total fish species, 2 species belong to the order Anabantiformes covers 14.29% and 1-1 species of order siluriformes and salmoniformes comprises 7.14%. The study revealed that order cypriniformes was dominant order similar as of Kaligandaki and Narayani River reported by (Edds, 1986) and Marshyangdi River in Lamjung district of Nepal (Mandal and Jha 2013). Species richness and abundance was seen higher in Chaitra and Baishakh which is similar with the result of Edds *et al.* (2002) and Nislow *et al.* (2002).

Environment variations such as water temperature, pH, dissolved oxygen, alkalinity, electrical conductivity, turbidity and hardness play an important role in fish diversity. The water temperature of study area ranged from 7.5 to 12°C throughout the study period. The lowest temperature was 7.5°C during Mangshir and the highest was 12°C during Magh and falgun Pokharel *et al.* (2018) reported mean and standard deviation of water temperature  $18\pm 4$  from the Seti Gandaki river basin. Sharma *et al.* (2007) reported variation in temperature due to variation in altitude, which is the characteristics features of streams in the mid-hill with origin from the higher mountains. The Cyprinines have been mentioned to contribute to a major portion of the fish biota (Edds, 1993; Pokharel, 2006; Shrestha, 2001; Swar, 2005). Similar pattern of species composition, family and group dominance was observed in the present work and also the important species, *S. richardsonii*, *G. nepalensis*, *N. hexagonolepis* were found to be dominant forms at most of the study sites.

The value of pH ranged from 8 to 8.6 throughout the study period, which indicates that the water was alkaline in nature which is same as the reports presented by Mishra *et al.* (2016) in Melamchi River Sindupalchowk Nepal.

Dissolved oxygen plays a vital role in the fish diversity. The maximum dissolved oxygen in the Seti Khola was found to be 11.6 in the site 3 for month Mangshir while it was lowest in the month Kartik and Mangshir in the site 4 which is 9 and nearly same result was reported by Mishra *et al.* (2016).

Water velocity plays important role in determination of fish habitat and their abundance in a river by grading the riverbed and material and maintenance of high level dissolved oxygen Whiton (1975).

The total alkalinity of water was ranged from 24 mg/l to the 42 mg/l. the lowest value obtained was 24 mg/l in the site 5 for month Poush and the highest value was 42 in the site 1 for the month Mangshir and Chaitra. Hussain *et al.* (2013) and Pokharel *et al.* (2018) reported the same results in Seti Gandaki River basin.

Salts and the others chemical that dissolve in the water can break down into positively charged ions and negatively charged ions. These free ions in the water conduct electricity. During the study period the EC ranges from 220 to 270  $\mu\text{s}/\text{cm}$ . the lowest value was observed to be 220  $\mu\text{s}/\text{cm}$  in the month Kartik and Mangshir whereas the highest value was observed 270 in the site 5 during the month Falgun, Chaitra and Baishakh.

Turbidity indicates the cloudiness in the water. The lowest Turbidity was observed to be 15.1 NTU (Nephelometric Turbidity Unit) in the month Mangshir and the highest value was observed to be 120 in the month Baishakh.

The hardness of water represents the high mineral content in the water. The value of hardness of Seti River through the study period was ranges from 115 to 128 mg/lit. The highest value was observed 128 in the site 4 for the month Falgun and Chaitra and the lowest value was observed 115 in the sites 1 for Magh through the study period.

In the present study, the species richness value is higher in lower region as compared to the middle and upper reaches, which is similar to the results of Pokharel (2011). According to Hossain *et al.* (2016) abundance of fish is high in February to April. A biodiversity index seeks to characterize the diversity of a sample or a community by a single number (Magurran, 1998). The concept of species diversity involves two



components i.e. species richness and species evenness. However, the formal treatment of the concept and its measurement is complex Williamson (1973).

Shannon -Weiner diversity index consider the richness and proportion of each species and evenness represents the relative number of individuals in the sample and common species respectively. The biodiversity index values obtained from present study was normal according to Shannon-Weiner biodiversity index values and they do not exactly show the differences occurring among the sites either. Highest Shannon-Weiner diversity index was found in site 1 whereas the lowest value was observed at site 5. The main causes of difference occurring in the diversity indices are environmental conditions Keskin *et al.* (1998). The evenness index was found to be maximum at site 1 (2.39) and lowest was found in site 5 (1.79). There is no any significant difference observed in the Shannon-Weiner diversity index and the evenness index.

The environmental variations like Temperature, Alkalinity, Turbidity, electrical conductivity shows positive correlation with the fish species whereas pH, Dissolved oxygen and Hardness shows negative correlation with different species.

## 6. CONCLUSION AND RECOMMENDATION

### 6.1 Conclusion

A total of 14 species belonging to 4 order, 5 families and 11 genera were collected from the different sites of Seti Khola. Species like *Schizothorax richardsonii*, *Schizothorax plagiostomus* and *Garra nepalensis* were found to be common species of the Seti khola during the study period. The most dominant order was Cypriniformes. The highest Shannon-Weiner diversity index was found in site 1 (2.26) whereas lowest value was observed in site 5 (1.52). the species richness was found maximum at site 1 (2.39) whereas minimum was found in site 5 (1.79). the highest species evenness was found to be maximum at site 1 (0.94) and minimum was found in site 3 (0.82). The environmental variables including alkalinity, hardness, temperature, dissolved oxygen, turbidity were found to be important variables to shape the fish assemblage structure of present study area.

### 6.2 Recommendations

The study area is facing stress due to various development works like hydropower and construction of roads. These activities bring change in physico-chemical parameters, which affect the habitat of aquatic animals including fish fauna.

- So, awareness programs for local level regarding the conservation of fishes in the river are recommended. Regular survey on fishes of the Seti River is highly recommended in order to know their diversity status.
- The extensive implementation of Aquatic Animal Protection Act (2017) is recommended.

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## PHOTO PLATES



**Photo 1:** Testing alkalinity of water



**Photo 2:** Testing alkalinity of water





**Photo 3:** Measuring DO of water



**Photo 4:** *Pseudecheneis eddsi*



**Photo 5:** *Puntius sophore*



**Photo 6:** *Schizothorax richardsonii*



**Photo 7:** *Garra nepalensis*



**Photo 8:** *Channa punctata*



**Photo 9:** *Channa orientalis*



**Photo 10:** *Schizothorax plagiostomus*



**Photo 11:** *Barilius bendelisis*



**Photo 12:** *Schistura fasciata*



**Photo 13:** *Rasbora daniconius*



**Photo 14:** *Naziritor chelynoides*



**Photo 15:** *Neolisochilus hexagonolepis*



**Photo 16:** *Oncorhynchus mykiss*