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Seasonal variation in water quality and fish diversity of Rampur Ghol, a wetland in Chitwan, Central Nepal

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Abstract

The present study was carried out on Rampur Ghol in three seasons *viz.*, monsoon, post-monsoon and pre-monsoon from September, 2012 to April, 2013 to assess the seasonal variation in physico-chemical parameters of water and fish diversity. The analysis of various physico-chemical parameters showed significant seasonal fluctuation in the water quality. However, the Ghol water was found to be suitable for fish fauna. Similarly, fish diversity analysis showed that Rampur Ghol is rich in fish fauna with 22 species belonging to 13 families and five orders. The study showed significant decline of fish species as well as their abundance from past studies.

***Key words*:** Seasonal variation, water quality, fish diversity, Rampur Ghol

Introduction

Wetlands are among the most productive ecosystems in the Earth. They play a great role in providing wildlife habitat, shelter for migratory birds, regulating water quality, flood control, reducing sediment load, production of organic material, dependence of agriculture prone areas, and conservation of rare and endangered species (Garg, 1989). Freshwater habitats or the freshwater wetlands occupy approximately 0.8% of the earth's surface but support more than 100,000 species out of approximately 1.8 million, i.e., almost 6% of all described species and 12% of all animal species (McAllister *et al*., 1997). About one third of the global vertebrates (Dudgeon *et al*., 2006) and about 40% of the global fish species are confined to freshwater (Nelson, 2006). However, freshwater ecosystems are the most endangered ecosystems in the world and the decline in freshwater biodiversity is far greater than in most affected terrestrial ecosystems (MEA, 2005). The major threats to global freshwater biodiversity including fishes can be grouped under five interacting categories: overexploitation, water pollution, flow modification, destruction or degradation of habitat, and invasion by exotic species (Dudgeon *et al*., 2006).

Nepal, being a landlocked country consists of freshwater resources covering about 5% of the total area of the country (Kafle & Savillo, 2009) which constitute about 2.27% of world's fresh water resources. These water bodies are in the form of rivers and streams, lakes, reservoirs, ponds, swamps/wetlands and paddy fields rich in freshwater diversity including fish diversity. Of the total 11,952 freshwater fish species of the world, 232 species (117 indigenous and 15 exotic) have been reported from Nepal (Shrestha, 2008). The fish diversity of Nepal has been studied in

rivers and tributaries, lakes, ponds, pools, irrigation canals by a number of scientists (Swar & Gurung, 1988; Jha *et al.*, 1989; Shrestha *et al.*, 2009, Gautam *et al.*, 2010; Kumar *et al.*, 2011). There are limited studies made on fishes of marshy lands, called Ghol in Nepali (Jha & Shrestha, 2000) which are also the habitats of various flora and fauna. This study aims to assess the water quality and fish diversity of Rampur Ghol of Chitwan, Nepal.

Study Area

The Rampur Ghol lies in ward no. 2 of Mangalpur VDC, Chitwan district, Central Nepal at latitude 27^0 39' 24.52"N, longitude 84^0 20' 58.77" E and altitude of 167 m above mean sea level. It is a freshwater marshy land surrounded by agricultural lands on the northern edge of Agriculture and Forestry University (AFU). It is about 9 km south west from the Narayanghat Bazar and covers an area of 23 ha (Jha & Shrestha, 2000). It is fed by several intermittent small streams from the adjacent sides in downstream near Aquaculture and Fisheries Department, AFU and Nepal Agriculture Research Council and drains through a permanent outlet. The water level increases during the rainy season, and recedes during the winter. It is the main source of water to Haraiya, Bangai and Baruwa villages of Sharadanagar Village Development Committee for irrigation. The Rampur Ghol falls in the subtropical climatic region dominated by summer monsoon climate. The monsoon begins from late June and continues until early October. It has winter in between December and February and a relatively dry pre-monsoon or summer between March and May.

Sampling

The study was conducted from August, 2012 to April, 2013. Samplings from selected sites were taken for three seasons i.e. monsoon (August, 2012), post-monsoon (December, 2013) and pre-monsoon (April, 2013). For conducting the research 11 sampling sites (Site A_1, A_2, 1, 2, 3 4, 5, 6, 7, 8 & 9) were selected (Fig. 1). Water samples were collected from all sampling sites but fishes were not collected from siteA_1 and site A_2 as the flow of water was very low in these sites and no fishes were seen by visual observation. Sampling was not carried out in sites A_1, A_2, 1 and 2 in pre-monsoon season as these sites were dry during the sampling period.

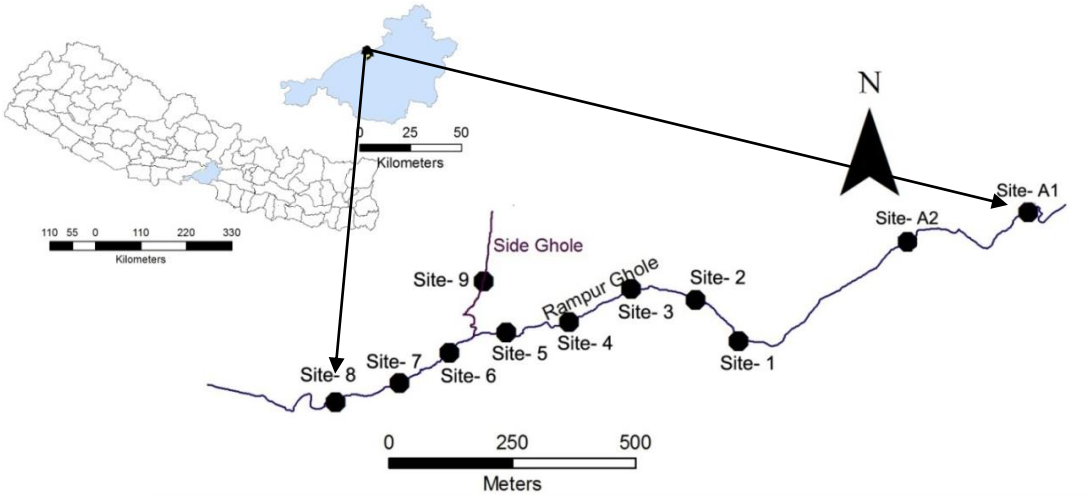

Figure 1. Map showing the Sampling area and sampling sites

Water samples from sampling sites of the Ghol area were collected from the surface in clean and rinsed plastic bottles between 8:30 a. m. to 10:30 a.m. Physico-chemical parameters *viz*., temperature, pH, dissolved oxygen (DO), free CO_2 and electrical conductivity (EC) were measured at the sampling sites whereas chloride, total alkalinity and total hardness, nitrate-N phosphate-P and total ammonia-N were analyzed in the laboratory following standard methods (APHA, 2005).

Fishes were sampled from nine sites i.e. from site-1 to site-9. Fishes were collected with the help of locally prepared fish trap called "Ghamka" in local language. It consisted of net having mesh size 5mm x 5mm hanged on the U-shaped wooden frame of area 1600 cm^2. The fishes were captured by dragging the trap inside the water up to the distance of about 0.5m. Twenty samples were taken randomly within the distance of about 100m. A local fisherman was hired for this purpose. The species were identified according to a system developed by Shrestha (2008). The specimens were preserved in 10% Formalin.

Analysis of Variance (ANOVA) was used to compare the parameters between seasons. During the model building, linearity of models was checked through diagnostic plots and Fligner-Killeen test for homogeneity of variance. Whenever the linear model criteria were satisfied, ANOVA was used, otherwise non-parametric methods were used. Variation in fish abundance was tested by using Simultaneous Tests for General Linear Hypotheses using 'multcomp' package. The estimates of species richness (chao, Jacknife 1, Jacknife 2 & boot) were calculated by using sample based rarefaction methods. All these analyses were done by using R 3.0.1 (R Development Core Team, 2013).

Results

Water Quality

The results of physico-chemical parameters of water of Rampur Ghol are shown in table 1. The mean water temperature was highest in pre-monsoon (30.53 ± 0.20^0C) and lowest in post-monsoon (17.35 ± 0.94^0C) and the variation was significant ($p < 0.001$) (Fig. 2(a)). The pH was maximum {7.10(6.80-7.50)} in pre-monsoon and minimum {6.80 (6.50-7.50)} in post monsoon showing significant ($p = 0.034$) variation (Fig. 2(b)).

Table1. Physicochemical parameters of water of Rampur Ghol in different seasons

Seasons / Parameters	Monsoon		Post monsoon		Pre Monsoon	
	Mean	**SD(range)**	**Mean**	**SD(range)**	**Mean**	**SD(range)**
Temperature (^{0}C)	27.34	0.20	17.35	0.94	30.53	0.75
pH (range value)	6.98	(6.6-7.3)	6.80	(6.5-7.5)	7.10	(6.8-7.5)
EC (µS/cm)	226.45	8.89	218.09	15.58	296.57	36.36
DO (mg/l)	6.05	0.81	8.57	1.06	5.97	1.45
Chloride (mg/l)	6.10	1.27	6.17	2.23	12.58	3.00
Free CO2 (mg/l)	10.58	1.4	10.41	1.17	11.94	1.71
Total Alkalinity (mg/l)	153.73	7.27	120.00	14.49	164.29	12.72
Total Hardness (mg/l)	121.36	6.74	133.27	7.23	160.29	28.44
Nitrate-N (mg/l)	0.307	0.188	0.460	0.061	0.334	0.084
Phosphate-P (mg/l)	0.261	0.109	0.147	0.039	0.207	0.080
Ammonia-N (mg/l)	0.351	0.099	0.161	0.011	0.323	0.073

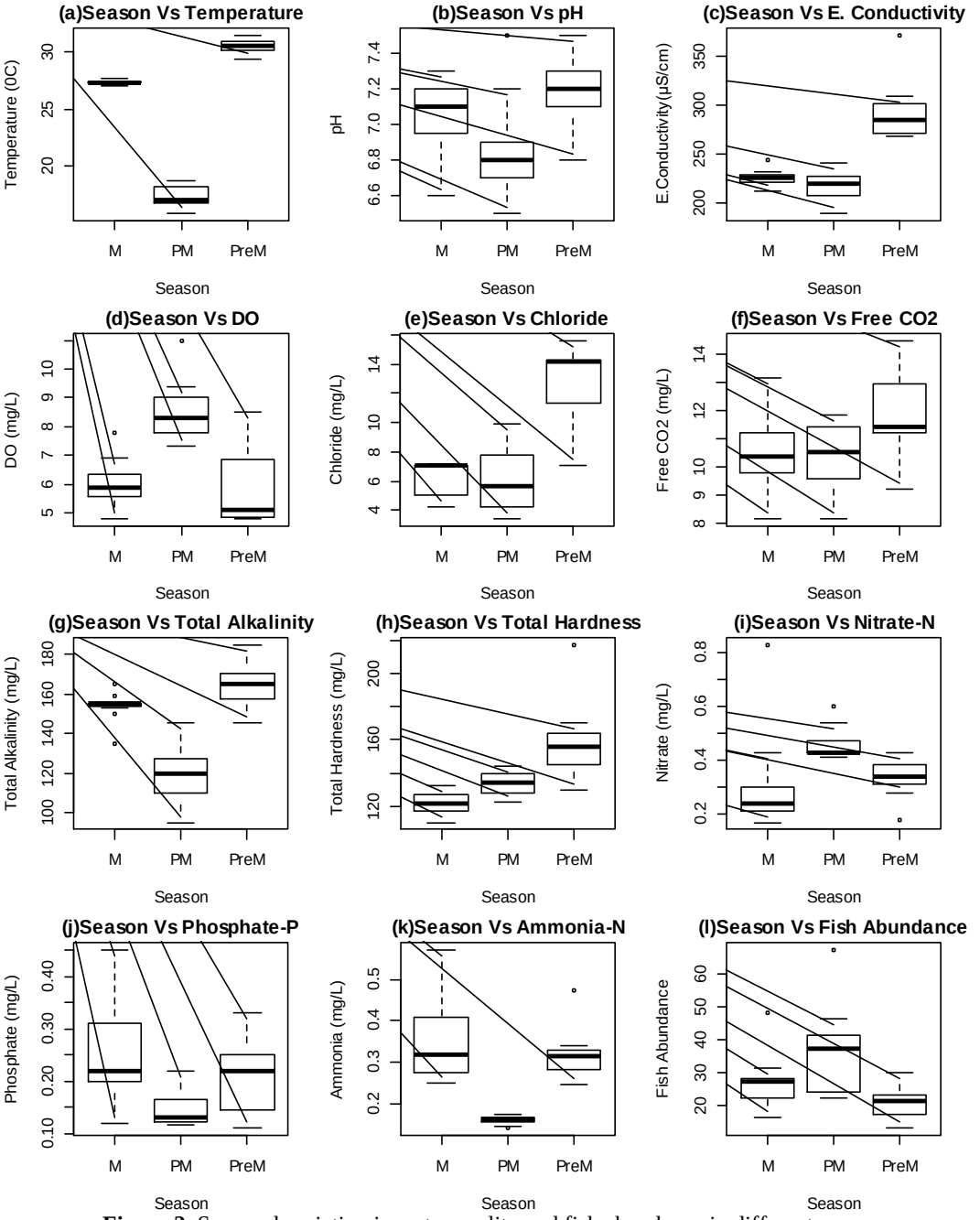

Figure 2. Seasonal variation in water quality and fish abundance in different seasons.

The mean values of EC were found maximum (296.57±36.36 µS/cm) in pre-monsoon and minimum (218.08±15.58 µS/cm) in post-monsoon with significant ($p < 0.001$) variation (Fig.

2(c)). The mean value of DO was found to be highest (8.57±1.06 mg/L) in post-monsoon season, and lowest (5.97±1.45 mg/L) in pre-monsoon season. The seasonal variation in DO was found to be significant (p= 0.0002) (Fig. 2(d)).

Mean chloride was recorded maximum in pre-monsoon (12.58 ±3.00 mg/l) and the minimum in monsoon (6.10±1.27 mg/l with significant (($p < 0.001$) variation (Fig. 2(e)). The mean value of free CO_2 was obtained to be highest (11.94±1.71 mg/l) in pre-monsoon and lowest (10.41±1.17 mg/l) in post-monsoon season (Fig. 2(f)).

The average value of total alkalinity ranged from 164.29±12.72 mg/l in pre-monsoon to120.00±14.49 mg/l in post-monsoon and the variation was found to be significant ($p<0.001$) (Fig. 2(g)).The Total hardness was found to be between 121.36±6.74 mg/l in monsoon and 160.29±28.44 mg/l in pre-monsoon seasons and varied significantly ($p<0.001$) in different seasons (Fig. 2(h)).

The range of mean nitrate-N ranged from 0.307±0.188 mg/l in monsoon to 0.460±0.061 mg/l in post-monsoon with significant (p= 0.0256) seasonal variation (Fig. 2(i)).The highest value of phosphate-P was obtained in monsoon (0.261±0.147 mg/l) lowest value in post-monsoon (0.147±0.039 mg/l) and the variation was significant (p= 0.0112) (Fig. 2(j)). The mean value of ammonia-N was recorded to be highest (0.351±0.099 mg/L) in monsoon season and lowest (0.161±0.011 mg/l) in post-monsoon with significant (p= 0.0122) (Fig. 2(k)) seasonal variation.

Fish Diversity

A total of 22 species of fishes belonging to 5 orders, 13 families and 22 genera were recorded in the study (Table 2). Among five orders, Cypriniformes was the most dominating order having 9 species with 77.49% catch composition, followed by Perciformes with 4 species and 17.54 % catch composition, Siluriformes with 5 species and 2.21% catch composition, Synbrachiformes with 3 species and 2.08 catch composition and Beloniformes was with one species (*Xenentodon cancila*) and 0.69% catch composition (Table 2). Based on total individuals and catch composition, the top three species were *Puntius sophore*, *Brachydanio rerio* and *Leptocephalus guntea* with catch composition 19.48% (141), 19.06% (138) and 12.57% (91), respectively. *Amblyceps mangois*, *Clarias batrachus Macrognathus aral*, and *Monopterus cuchia* were the least abundant species with catch composition 0.14% and 1 individual each.

A total of 724 individuals (245 in monsoon season, 332 in post-monsoon and 147 pre-monsoon) belonging to 5 orders, 13 families and 22 species of fishes were recorded in the study. Compared to monsoon and post-monsoon seasons (19 species each), only 16 fish species were recorded in pre-monsoon.

Some species were season specific, for example *Clarias batrachus* and *Macrognathus aral* were recorded only in monsoon season, *Amblyceps mangois* in post-monsoon season and *Monopterus cuchia* in pre-monsoon. Of the total species, 14 species were found all the seasons. Two species (*Mystus bleekeri* and *Mystus tengara*) were the species common to monsoon and post-monsoon seasons and one species (*Channa orientalis*) was the common species to post-monsoon and pre-monsoon seasons. However, there were no common species between monsoon and pre-monsoon seasons.

It was found that the variation in fish abundance was significant between pre-monsoon and post-monsoon (p=0.0166) but not in monsoon. Thus, it can be said that the fish number declined significantly in pre-monsoon (Fig. 2(l)).

Table 2. Abundance and catch composition (CC) of fish fauna of Rampur Ghol in Monsoon (Mo), post monsoon (Po-Mo) and pre-monsoon (Pr-Mo).

SN	Species	Family	Order	Abundance				CC
				Mo	PoMo	PrMo	Total	(%)
1	*Acanthocobitis botia*	Balitoridae	Cypriniformes	8	9	4	21	2.90
2	*Amblyceps mangois*	Amblycipitidae	Siluriformes	0	1	0	1	0.14
3	*Badis badis*	Nandidae	Perciformes	23	27	7	57	7.87
4	*Brachydanio rerio*	Cyprinidae	Cypriniformes	36	65	37	138	19.06
5	*Channa orientalis*	Channidae	Perciformes	0	1	1	2	0.28
6	*Channa punctatus*	Channidae	Perciformes	13	15	10	38	5.25
7	*Clarias batrachus*	Clariidae	Siluriformes	1	0	0	1	0.14
8	*Colisa faciatus*	Belontiidae	Perciformes	7	20	3	30	4.14
9	*Danio devario*	Cyprinidae	Cypriniformes	8	13	7	28	3.87
10	*Esomus danricus*	Cyprinidae	Cypriniformes	10	24	6	40	5.52
11	*Heteropneustes fossilis*	Heteropneustidae	Siluriformes	4	3	0	7	0.97
12	*Lepdocephalus guntea*	Cobitidae	Cypriniformes	29	40	22	91	12.57
13	*Macrognathus aral*	Mastacembelidae	Synbranchiformes	1	0	0	1	0.14
14	*Macrognathus pancalus*	Mastacembelidae	Synbranchiformes	6	3	4	13	1.80
15	*Monopterus cuchia*	Synbranchidae	Synbranchiformes	0	0	1	1	0.14
16	*Mystus bleekeri*	Bagridae	Siluriformes	2	1	0	3	0.41
17	*Mystus tengara*	Bagridae	Siluriformes	3	1	0	4	0.55
18	*Puntius chola*	Cyprinidae	Cypriniformes	6	5	6	17	2.35
19	*Puntius conchonius*	Cyprinidae	Cypriniformes	18	15	8	41	5.66
20	*Puntius sophore*	Cyprinidae	Cypriniformes	53	66	22	141	19.48
21	*Puntius ticto*	Cyprinidae	Cypriniformes	16	20	8	44	6.08
22	*Xenentodon cancila*	Belonidae	Beloniformes	1	3	1	5	0.69
Total		**13**	**5**	**245**	**332**	**147**	**724**	**100**

The various estimates of richness showed that the ranges of species richness in monsoon, post-monsoon and pre-monsoon were 16-20, 20-22 and 20-36, respectively (Table 3). Shannon Diversity index (H) was obtained highest (2.48) in monsoon and lowest (2.30) in pre-monsoon. Similarly the species evenness was found highest in pre-monsoon (0.81) and lowest in post-monsoon (0.84) (Table 3).

Table 3. Estimates of species richness and diversity in different seasons

Seasons	Estimated Species Richness					Observed Sp. Richness	Shannon Index (H)	Evenness Index (E)
	Jack1	Jack2	Chao	Boot	Range			
Monsoon	21.66	21.96	20.5	20.41	20-22	19	2.48	0.84
Post-mon	23.33	27.32	36.0	20.19	20-36	19	2.39	0.81
Pre-mon	17.57	19.12	19.5	16.16	16-20	16	2.30	0.83

Discussion

Water Quality

Higher water temperature in pre-monsoon might be due to higher air temperature as water temperature is influenced by air temperature and intensity of solar radiation. The pH value remained slightly acidic to alkaline i.e., between 6.5 to 7.5 throughout the study periods and it was found slightly higher in the pre-monsoon. This might be due to higher water temperature.

Higher temperature causes increased pH level due to conversion of CO_2 to organic carbon by the process of photosynthesis (King, 1970). The seasonal variation in temperature and pH values observed in the study agrees with the results of Niroula *et al*. (2010), Thapa Chhetry and Pal (2012) and Hazarika (2013).

The lower EC values in pre-monsoon might be due to rainfall in the catchment area and the successive dilution of water. Chaurasia and Tiwari (2011) also found similar results in Rapti River, India. Minimum DO in pre-monsoon may be due to high metabolic rate of organisms Decomposition of organic matter may be an important factor in consumption of DO, which is vigorous during warm weather (Badge & Verma, 1985). Maximum DO in the post monsoon may be due to low temperature. Similar trends were found by previous studies (Niroula *et al.*, 2010; Chaurasia & Tiwari 2011; Thapa Chhetry & Pal (2012)) in different wetlands. All the sites have DO values higher than 5 in all seasons suggesting good oxygen conditions for fishes.

Higher Chloride concentration in water also indicates the presence of organic waste of animal origin (Munawar, 1970). The higher values of chloride content in pre-monsoon season may be due to the excreta of cattle during grazing as it is reported that the grazing activities are more intense during pre-monsoon season. The higher concentrations of free CO_2 during pre-monsoon might be due to increase in temperature, decomposition rate and respiration rate of living organisms (Verma & Agrawal, 1996). Thapa Chhetry and Pal (2012) also found maximum value in summer however they found minimum value in winter.

Higher values of alkalinity in pre-monsoon might be due to increased rate of photosynthesis in higher temperature which reduces the carbonic acid in water (Mitsch *et al.,* 2000). The findings of the study related to alkalinity are in agreement with the results of Chaurasia and Tiwari (2011) and Hazarika (2013) but are in disagreement with results of Thapa Chhetry and Pal (2012). The maximum values of total hardness in pre-monsoon might be due low volume of water and minimum value in monsoon might be due to dilution. Thapa Chhetry and Pal (2012) also obtained similar results.

Nitrate is usually derived from anthropogenic sources like agricultural field, domestic sewage and other waste effluents containing nitrogenous compounds (Das & Acharya, 2003). The higher nitrates in post-monsoon season might be due to influx of nitrogen rich compounds from surrounding area. The higher values of phosphate in monsoon season might be due to the surface runoff from the surrounding fish ponds and crop fields fertilized with phosphate. The lower values of ammonia in post-monsoon might be due to lower temperature which lowers the microbial activity. Niroula *et al*. (2010) also found similar results in their study. All the parameters except total hardness and total alkalinity were found within the target range of Nepal Water Quality Guidelines for Aquaculture (CBS, 2008).

Fish Diversity

The number of fish species reported in this paper is lower compared to the species reported by Jha and Shrestha (2000). The less number of the species in present study may be due to absence of *Notopterus notopterus, Cirrhinis mrigala, Labeo rohita, Wallagu attu, Mystus cavasius, Channa marulius, Nandus nandus* and *Glossogobius giuris* which were reported by Jha and Shrestha (2000) even in the first phase of their research. However, we recorded *Amblyceps*

mangois and *Acanthocobitis botia* as two additional species not reported by them. Though *Glossogobius giuris* is reported as very common by the local fisherman, we couldn't find them on our samplings. Most of the fish species of Rampur Ghol were also reported from Narayani/Rapti River systems in Chitwan (Jha, *et al*., 1989).

The higher number and diversity of fish species occurred in monsoon and post-monsoon seasons (19 species each) might be due to presence of sufficient water, ample food resources and less anthropogenic activities. In contrary to it, less water flow and high anthropogenic activities could be cause of the less number of fish species (16 species) as well as their abundance and diversity in pre monsoon. The spawning migration of fishes might be one of the reasons behind higher species in monsoon and post monsoon.

As the evenness index was found to be higher than 0.8 in all seasons, species are evenly distributed in the study area. The various estimates of richness showed that the number of fish species in Rampur Ghol could be higher than those obtained in the study.

Conclusion

From the analysis of aforementioned physico-chemical parameters, Ghol water was found to be suitable for aquaculture as most of the parameters were within the target range of Nepal water quality guidelines of aquaculture (CBS, 2008). However, there is significant seasonal fluctuation in the water quality. Similarly, fish diversity analysis showed that Rampur Ghol is rich in fish diversity. Altogether 22 species belonging to 13 families and five orders were recorded in the area. The study showed the significant decline of fish species as well as their abundance in pre-monsoon season in different seasons with a reduced species number.

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