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Limno-plankton diversity and water quality in shallow Lake Ecosystem in central Nepal

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Abstract

We investigated the diversity of limnoplankton along with habitat parameters in a shallow Rupa Lake, one of the major fishery resources in Pokhara valley of Central Nepal. We conducted field visit from June to December 2002 and collected water samples from three sampling sites. We analyzed temperature, depth, transparency and pH of water in the field and further we collected samples from all sites separately to identify rest of the water quality parameters. Water samples for zooplanktons were collected by using Wisconsin's Plankton Net and for phytoplanktons, water samples were stored in plastic bottles and fixed with Lugol's solution (1%). All of the physico-chemical parameters were fluctuating in similar pattern in all sites throughout the study period. Sites II and III were possessing comparatively less dissolved oxygen than site I except during July and August. Nitrates and phosphates were recorded in higher concentrations from site II and III than site I during most of the study period. we found the zooplanktons from three different groups as Rotifera (38%), Cladocera (35%) and Coopepoda (27%). Also, we observed highest density of zooplanktons (1123/L) in December from site II whereas the lowest density (357/L) in August from site I. We detected 20 species of phytoplankton from seven families, where Bacillariophyceae (41%) was most dominant family followed by Chlorophyceae (24%) and Cyanophyceae (15%). Maximum density of phytoplankton (5730/L) was recorded in November (site II) and minimum (666/L) was observed in July (site I).

Keywords: aquatic, limnology, sampling, water quality.

Introduction

The earth is occupied less than 0.3% of inland lakes and reservoirs by volume that provide important resources and ecosystem services to humans. Life within an aquatic body is mainly run by balance physico-chemical parameters and correlation among them that can be used as a basis to study trophic status and fisheries resources prospective (Jhingran et al, 1969).Variations in physico-chemical parameters have a significant role in the distribution, periodicity, qualitative as well as quantitative composition of fresh water biota. The understanding of aquatic ecosystems including physical, chemical and biotic environmental

variables within it further helps to manage them (Wetzel, 2001). Moreover, the diversity, distribution, abundance of plankton and the variation according to the abiotic factors afford information of energy turnover in the aquatic ecosystem (Forsberg, 1982).In any form of size, depth and origin, a lake acts as an ecosystem with complex interactions among all biotic and abiotic components within it (Likens, 2009).In this study we will attempt to understand the interrelation between major physico-chemical parameters and limno-plankton diversity pattern in a stagnant but shallow lake of central Nepal.

In Nepal, limnological studies of lotic and lentic water bodies were conducted after 1960. Löffler, 1969) explored physico-chemical and biological aspects of 24 high altitude lakes (4500-5600m asl) of Nepal. Since then over 150 publications on limnology of lakes were conducted until 2010 (Bhuju et al. 2012). In Lake Rupa, some study presented a bathymetric map (Ferrow and Swar 1978),comparative study on limnology of three major lakes of Pokhara valley with major focus on physico-chemical parameters and nutrient loads (Rai, 2000). Also, other researchers Gurung (2007), Kunwar (2012), Gurunget al., (2009), Swar and Fernando (1980) and Oli (1996) did different aspects of limological studies of the Lake Rupa. Most of them were focused on studying seasonal variations on physico-chemical parameters and or biological parameters like planktons, macrophytes, aquatic weeds and fish species as separate factors.

Materials and Methods

Study area and Sampling locations

Rupa Lake is a shallow, sub-tropical and tectonic water body situated in mid-hill region of central Nepal (Gautam et al., 2016). It lies between 28^0 08'- $28^0$10' N and 84^0 06'-84^0 07' E at an elevation of 600m from sea level. The watershed is elongated in irregular shape from north to south and is bounded by hills from either side on east and west (Gautam et al., 2016). A perennial inlet stream enters from the northern side through the agricultural lands and the outlet stream exits from the southern part irrigating the rice fields.

We selected three sampling stations across the lake from north to south. First sampling location (site I) was sited near the inlet area of the lake, locally known as *TalbesiMuhan* that was close to agricultural lands and was fed by inlet stream *Tal-BeshiKhola*. Site II was fixed at the middle part of Lake Rupa locally called as *Sangure*. It was a narrow part of the lake that elongates north to south and far from frequent human encroachment. Third sampling location (Site III) *BarahThaan* was at south most part of the lake covering wide area with significant human encroachment.

Water quality analysis

We analyzed the physico-chemical characteristics like temperature, depth, visibility and pH of water in the field itself by using standard mercury thermometer, graduated string, white Sechi disc (20 cm. diameter) and digital pH meter, respectively in all three sites. We also collected rest of parameters like dissolved oxygen(DO, hereafter Do only**),** free Carbon dioxide(CO_2,), total alkalinity, total hardness, nitrates and phosphates, the water samples from all three sites and analyzed at Fisheries Research Center (FRC), Pokhara following the standardized methods outlined in (APHA, 1995) and (Trivedi and Goel,1986).

Study of planktons

We collected water samples from all three sampling sites in the lake once in a month from June an 2002 to July to December 2002. For the study of zooplanktons, we used Wisconsin's Plankton Net of mesh size 75µm and 20 cm diameter. Then, we stored the water samples in plastic tubes (50ml) and preserved in Procaine solution (1%). After four hours, we added formaldehyde solution (5%). For phytoplankton, we collected water samples in plastic jars (500ml) and fixed with Lugol's solution at a final concentration of 1% allowing it for natural sedimentation. We brought both the water samples in laboratory of Fisheries Research Center (FRC), Pokhara for analysis and identified both zooplanktons as well as phytoplankton species separately following Edmondson (1959), Needham and Needham (1962), Masuda and Pradhan (1998), Whitford and Schumacher(1973) using Nikon binocular microscope. Further, we used *Sedgewick Rafter cell* counter to count Phytoplanktons whereas haemocytometer for the zooplanktons and were estimated in per liter of water by volume.

Results

Variations in physico-chemical parameters at three sampling sites of Lake Rupa during the study period are shown in Table 1. Surface water temperature of the lake varied between 17^0c to 28^0c. It was recorded lowest in December (Site I) and highest in July (Site I

and III). We observed the Secchi disc transparency fluctuating between 0.75 m to 2.1m. Same value of lowest transparency (0.75m) was observed in two different months August and November (Table 1, Figure 1). DO concentrations ranged between 4.0 mg/L to 9.8 mg/L showing highest fluctuation in its level within continuous months June and July. Free CO_2 concentration was fluctuated between 4.0mg/L to 9.8mg/L throughout this study period recording highest in June from site II and lowest in November from site III. Also, the pH was almost alkaline and ranged between 7.0 (June, Site II) to 9.31 (December, Site III) (Table 1, Figure 2). We recorded the highest and lowest concentrations of both Nitrates and Phosphates in same study periods during June and September respectively. Concentration of Nitrates ranged between 0.17 mg/L – 0.55 mg/L whereas the Phosphates concentration varied between 0.006 mg/L to 0.025 mg/L (Table 1, Figure 4). Total alkalinity (140 mg/L) was recorded maximum in June (site II) and the lowest value (73 mg/L) was observed in September (site III). Also, total hardness fluctuated between 33mg/L (December) to 75 mg/L (October) (Table 1, Figure 3).

Table1. Physico-chemical parameters of Lake Rupa, June –December 2002.

Months	Sites	Depth (m)	Transparency (m)	Temp. (°c)	DO (mg/l)	Free CO_2 (mg/l)	pH	Alkalinity (mg/L)	Hardness (mg/L)	Nitrates (NO_3-N) mg/L	Phosphates (PO_4-P) mg/L
June	I	2.0	0.9	25	5.5	17	7.14	129	55	0.51	0.021
	II	3.8	2.0	26	5.1	20	7	140	59	0.55	0.025
	III	3.5	2.1	27	5.2	18	7.03	130	76	0.59	0.023
July	I	2.2	0.9	27	4.5	14	7.7	130	64	0.49	0.021
	II	3.9	1.8	28	4	17	7.8	127	67	0.54	0.021
	III	3.6	1.5	28	4	15	8	133	68	0.54	0.02
Aug	I	1.5	0.75	25	9.8	12	8.35	88	65	0.18	0.013
	II	4.5	0.9	26	8.9	13	8.46	95	68	0.25	0.016
	III	4.25	1.0	26	9.3	12	8.57	93	61	0.19	0.016
Sept	I	1.5	1.0	21	8	8	7.2	69	61	0.22	0.009
	II	4.35	1.5	22	7.67	9	7.1	73	62	0.3	0.013
	III	4.25	1.2	23	7.6	9	7.3	73	62	0.3	0.013
Oct	I	1.5	1.0	19	7	12	8.9	110	75	0.34	0.015
	II	4	1.6	20	6.7	15	8.13	110	74.3	0.39	0.017
	III	3.8	1.15	20	7	15	9.2	100	71	0.42	0.016
Nov	I	1.45	0.8	18	8.5	3.8	7.8	93	69	0.17	0.006
	II	3.8	0.75	19	8.3	3.9	7.7	93	76	0.2	0.006
	III	3.7	0.8	19	8.5	3.8	7.7	89	67	0.24	0.007
Dec	I	1.4	1.0	17	5.7	8	9.1	85	40	0.29	0.009
	II	3.3	1.1	18	7.7	10	9.23	88	42	0.31	0.011
	III	3.45	1.0	18	7	10	9.31	85	33	0.36	0.011

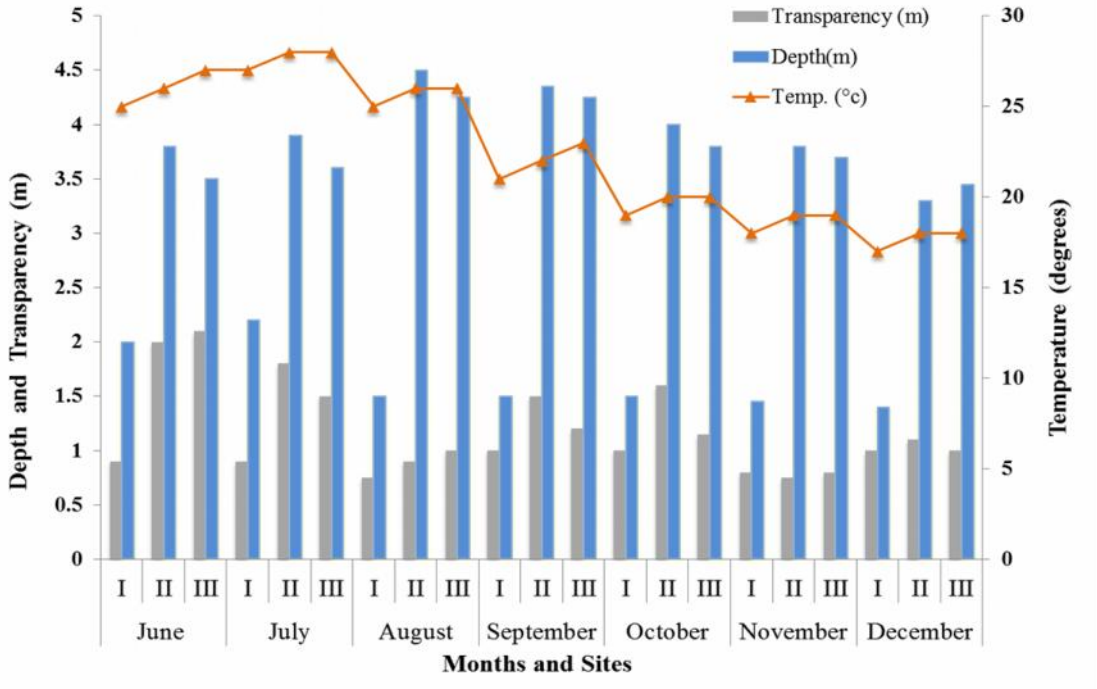

Figure 1: Monthly variations of three physical parameters: Depth and Transparency (meter), and Temperature (degree Celsius)

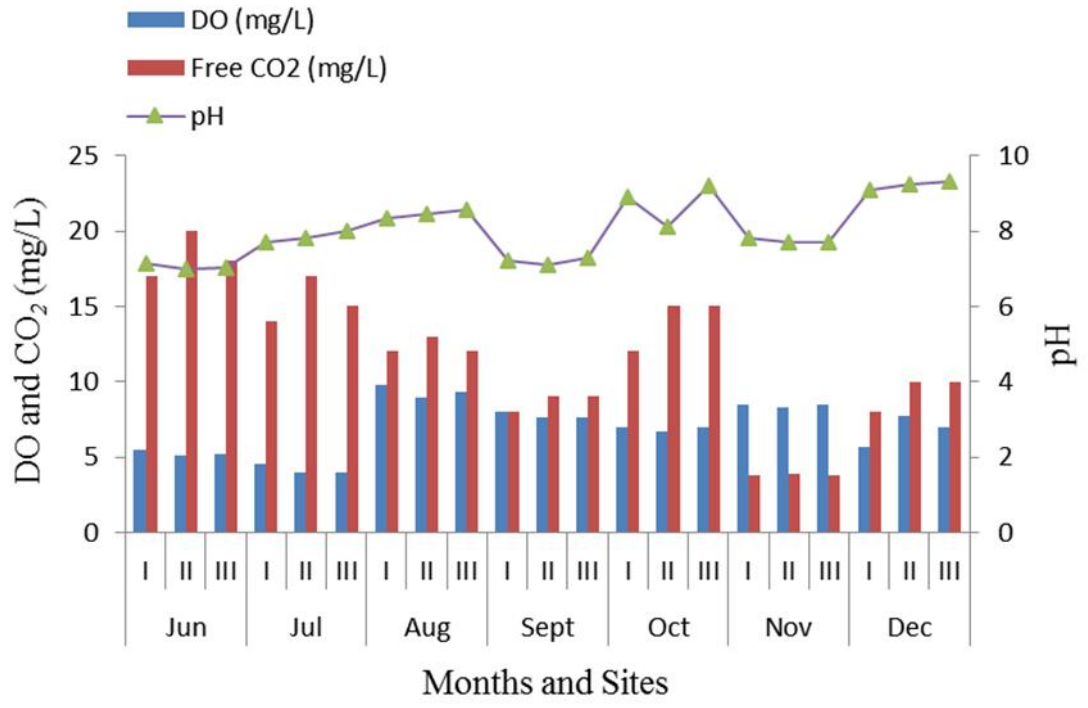

Figure 2: Monthly variations of Dissolved Oxygen (mg/L), Carbon-dioxide (mg/L) and pH values

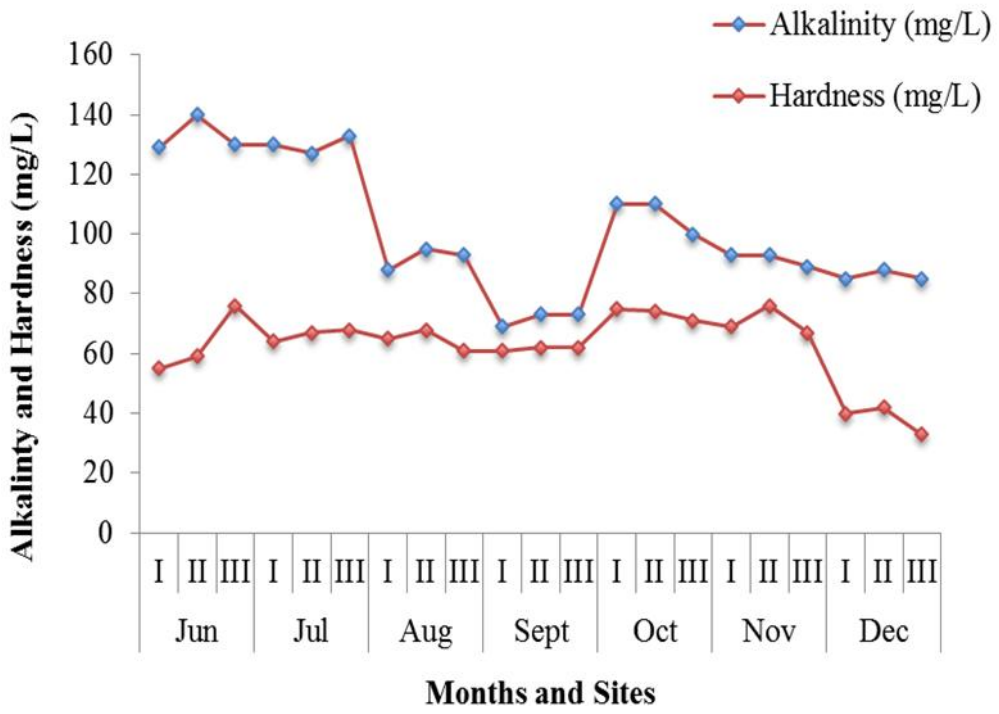

Figure 3: Monthly variation on Alkalinity and Hardness (mg/L)

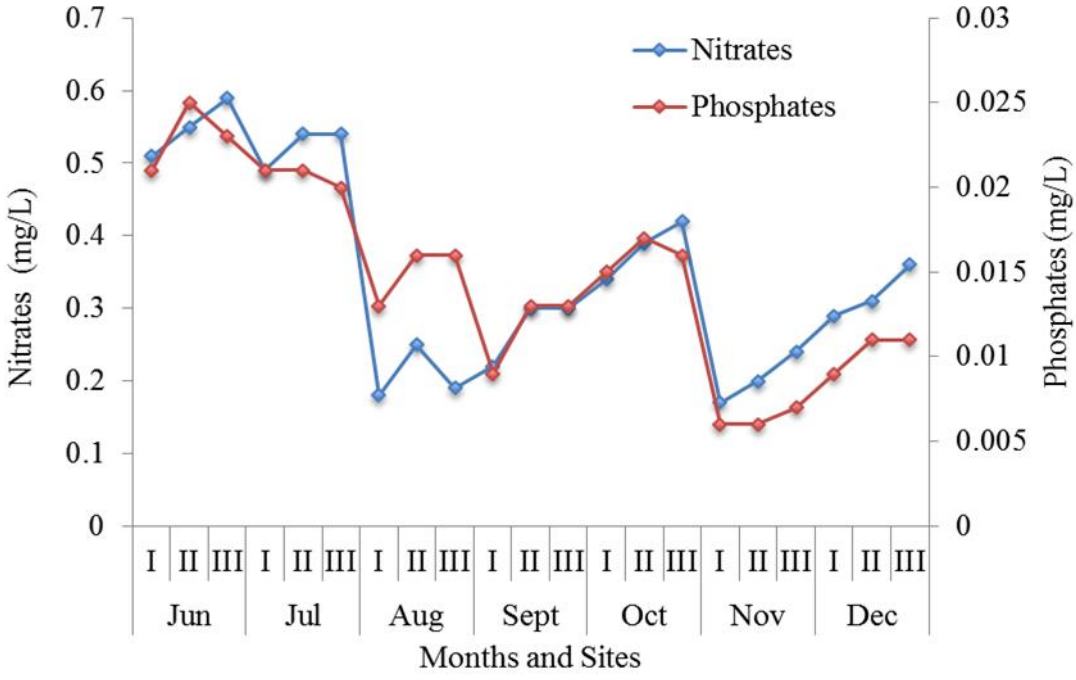

Figure 4: Monthly variation of Nitrates and Phosphates (mg/L)

There were 17 species of zooplanktons from three classes namely Rotifera, Cladocera and Copepoda (Table2). Rotifers (38%) were dominant over Cladocera (35%) and Copepoda (27%) (Figure 5B).We observed highest density of zooplanktons (1123/L) in December from site II whereas the lowest density (357/L) was recorded in August from site I. (Table 2).

Table 2. Distribution pattern for each species of zooplankton in Rupa Lake: (+) Low, (++) Moderate, (+++) High. Symbol in graphs: + =1-10 /L; ++ = 11-20/L; +++ = 21 and above, and individuals, -= absence.

Zooplanktons	Site I	Site II	Site III
Rotifera			
Synchaeta sp.	++	+	+++
Keratella sp	++	+++	+
Trichocera sp.	+	+++	++
Brachinus sp.	++	+	+++
Polyarthra sp.	+	++	++
Kellicotia sp.	+	++	+
Asplanchna sp.	-	+	++
Cladocera			
Bosmina sp.	+	+	++
Chydorus sp.	+	++	++
Daphnia sp.	++	+++	++
Holopedium sp.	+	++	++
Polyphemus sp.	+	++	+
Diaphanosoma sp.	+	+	+++
Ceriodaphnia sp.	+	++	+
Copepoda			
Mesocyclopes sp.	++	+++	+
Diacyclopes sp.	+	+	++
Diaptomus sp.	+	++	+++
Nauplii	+	++	++
Eggs	+	++	-

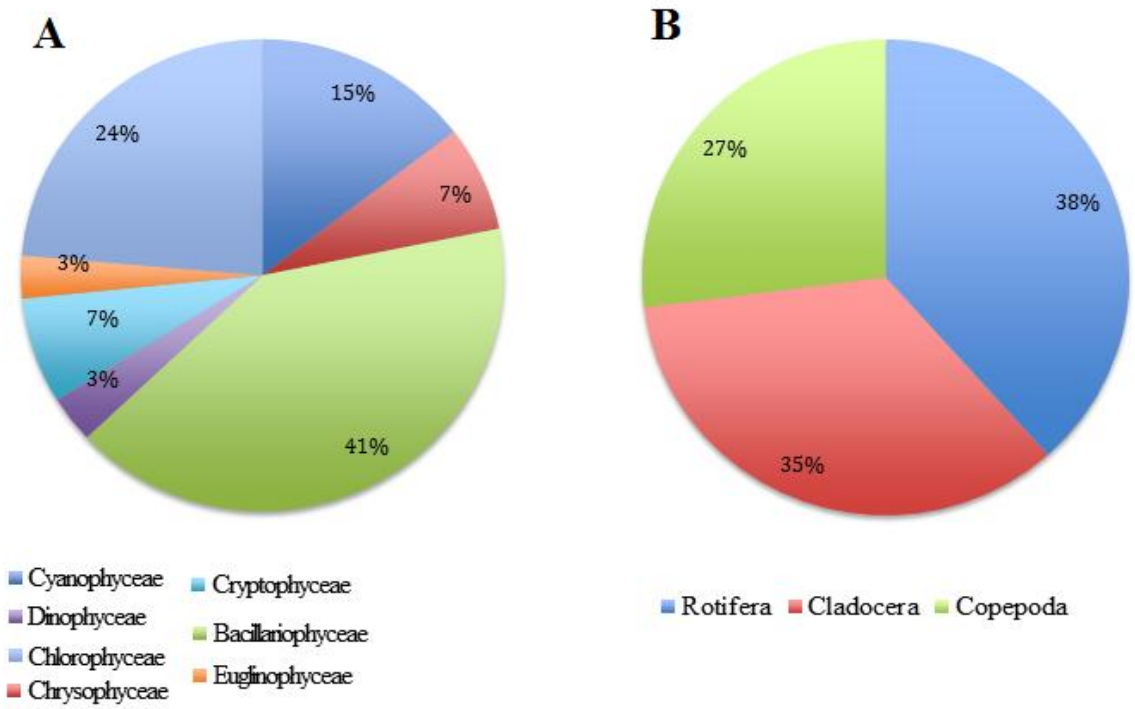

Figure 5: Average Population density of phytoplanktons (A) and zooplanktons (B) in Lake Rupa

We recorded 20 species of phytoplankton that represented by seven families (Table 3). Bacillariophyceae (41%) was most dominant family followed by Chlorophyceae (24%) and Cyanophyceae (15%) during whole study period (Figure 5A). Maximum density of phytoplankton (5730/L) was recorded in November (site II) and minimum (666/L) was observed in July (site I).

Table 3: Distribution pattern for each species of phytoplankton in Rupa Lake: (+) Low, (++) Moderate, (+++) High. Symbol in graphs: + =1-100 /L; ++ = 101-200/L; +++ = 201 and above, and individuals, -= absence.

Phytoplanktons	Site I	Site II	Site III
Cyanophyceae			
Anabaena sp.	++	+++	+++
Microcystis sp.	+	+++	+
Chrysophyceae			
Dinobryon sp.	+++	++	+
Bacillariophyceae			
Cyclotella sp.	+	++	+++
Melosira sp.	+	++	+++
Synedra sp.	+++	++	+
Nevicula sp.	++	+++	+
Tabillaria sp.	++	+	+++
Amphora sp	+	++	++
Dinophyceae			
Ceratium sp.	+	++	+++
Peridinium sp.	++	+++	+
Cryptophyceae			
Cryptomonas sp.	+++	+	+
Euglinophyceae			
Euglena sp	+++	+	++
Chlorophyceae			
*Volvax*sp.	+	++	++
*Staurastrum*sp.	+	+	++
Ankistrodesmus sp.	++	++	+
Scenedesmus sp.	+	++	+++
Pediastrum sp.	+	+	++
Oocystis sp.	+	+++	++
Crucigenia sp.	+++	++	+

Discussion

We recorded highest depth of 4.5 m at site II during August as the water level rises up along with input of rainwater from surrounding slopes of the lake. Lowest values of Secchi disc transparency (0.75m) during August and November were related with rain-fed turbidity and highest production of phytoplankton respectively. June marked highest transparency of 2.1m at site III probably due to more settlement of suspended particles and less production of phytoplanktons.

We found that more than 5.0 mg/L of DO which is a good indication of a highly productive nature of water body (Das, 2000). We recorded least concentration of DO 4mg/L from sites II and III in July which directly relates with highest temperature in both sites during same period (Table 1). In summer season, DO decreased due to increased temperature of water (Naz and Turkmen, 2005). Immediately after the onset of rainy season in August, we observed highest concentration of DO 9.8 mg/L from site I. It might be related with force flow of inlet stream that diffuses atmospheric air into the water. Our findings are also supported by the study of Welcomme (1979). Whilist, higher values of DO were observed during November from all three sites (≥8.3 mg/L) when there was highest record of phytoplankton density. Rajagopal et al., (2010) has reported the abundance of

phytoplankton linked with high dissolved oxygen during photosynthesis. The pH value 7.0-9.31of this study attributes with Jones et al., (1989) who stated that most lakes in Nepal are neutral to alkaline. But, Rai (2000) had reported the pH range of 5.4 -8.7 with extraordinary low value of 2.5 in May (1994) causing the mass killing of fishes from this lake. Higher concentrations of nitrates during June/July and lower in November were related with the findings of Kunwar et al., (2012)from Lake Rupa. The higher values of nitrates may be contributed to biological oxidation of ammonia whereas the lower coincides with de-nitrification(Seike et al., 1990; Abdo,2005). The lake is eutrophic based in phosphate concentration suggested by Forsberg and Ryding (1980). Phosphate value was higher during pre-monsoon months and lower during post-monsoon periods in Lake Rupaas suggested by Heron (1961).

Population density of phytoplankton was highest in November that directly relates with the reduction in concentrations of both nitrates and phosphates from all three sites. Similarly, phytoplankton density was very low during pre-monsoon months (June and July) and related to higher values of nitrates and phosphates. Among the various forms of nitrogenous nutrients, nitrate is the most important as it is the final form being absorbed by the plankton for their growth (Begum et al., 2003).Our result showed that seasonal variation on zooplankton abundance relates with the records of Swar and Fernando (1979),Rai (2000), and Husen and Dhakal(2010).

Overall, physico-chemical parameters and limno-plankton diversity of the Lake ecosystem were observed more variable with time duration rather than with sampling sites. These resources were favourable to sustain the fish diversity but certain factors such as human encroachment, agricultural eutrophication, natural siltation should be considered effectively so as to mitigate the potential threats in lake ecosystem.

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