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Nutrient richness in the sediment of seven major lakes of Pokhara Valley, Kaski, Nepal

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ABSTRACT

Sediment is an active zone for accumulation and cycling of nutrients that supplies vital nutrients and minerals to promote lake productivity, ensuring the overall health and balance of lake ecosystem. The aim of this study was to assess the richness of nutrients in the sediment of Phewa, Begnas, Rupa, Khaste, Neureni, Dipang, and Gunde lakes of Pokhara valley. The results showed that pH level of all lakes sediment was found to vary from acidic condition to nearly alkaline. These lakes were found to organically rich sediments, ranging from 2.5-6.4%. The mean nitrogen content in the sediment of Begnas was within normal range 0.1-0.2%, however, rest of lakes were beyond the normal range. Phosphorus concentrations were found surplus, while potassium concentrations were found low in the sediments of these lakes. Anthropogenic and agricultural activities, landslides and siltation, urbanization and development activities in the catchments area of Pokhara valley lakes are major source of external nutrient loading into bottom of lakes. Therefore, it is necessity to initiate action towards conservation of these beautiful natural resources by controlling further external nutrient loading, which will improve the lake ecosystem for both fishery and tourism.

Key words: Sediment; Organic matter; Phosphorus; Nitrogen; Potassium; Eutrophication

I.INTRODUCTION

Lake sediment is an active zone for accumulation and cycling of nutrients, acting as both sink and source of nutrients and pollutants [1]. The composition of bottom sediment and their distribution influence concentration and availability of nutrients present in lake [2]. Hydrology and vegetation cause differences in the distribution of nutrients in the sediments [3].

Bottom sediment acts as primary source of nutrients for overlying water. The nutrients primarily phosphorus and nitrogen, are usually bound up in lake sediments [4] and are highly responsible for lake productivity [5]. In freshwater lakes, phosphorus is limiting nutrient, hence influences overall production of lake [6]. However, excessive nutrients input can result algal bloom and organic matter deposition that results water quality issues such as eutrophication and anoxic lake environment [7].

Despite of providing ecosystem services and sustaining local livelihood, lakes of Pokhara Valley have been experiencing pollution and dynamic changes in lake environment [8]. Urban and rural watershed areas of Phewa Lake are under a lot of human pressure due to improper sewage system of Pokhara city while the proximity of Begnas and Rupa Lake near one another also does not exempt them from potential pollution risks [9].

Nutrient concentration in the sediment of Phewa, Begnas and Rupa has been reported by earlier study of [5]. However, nutrient concentration in the sediment of other lakes has not been explored yet. The objective of this study is to analyze the nutrients present in the sediment of seven lakes of Pokhara Valley. Thus, present study will help to further management of lakes to sustainable use for fisheries as well as to keep the beauty of lake intact for tourism.

II. MATERIALS AND METHODS

This study was conducted in seven major lakes of Pokhara Valley: Phewa, Begnas, Rupa, Khaste, Neureni, Dipang and Gunde Lake located in Kaski district. Major physiographical features of seven lakes are presented in Table 1 and study area in Figure 1.

Table 1- Physiographical features of seven lakes of Pokhara valley [10]

Lake	Latitude	Longitude	Catchment Area (km^2)	Water body(km^2)	Altitude(m)
Phewa	28.1943-28.2902	83.8004-83.9898	119.39	4.33	763-2482
Begnas	28.1621-28.2167	84.0814-84.1332	18.6	3.13	647-1447
Rupa	28.1390–28.2061	84.1004-84.1699	26.02	1.11	580-1420
Khaste	28.1908-28.2115	84.0449-84.0603	2.69	0.13	739-1186
Neureni	28.1889-28.1950	84.0465-84.0533	0.18	0.027	742-866
Dipang	28.1777-28.2025	84.0645-84.0821	2.39	0.14	687-1269
Gunde	28.1889-28.2001	84.0392.84.0476	0.61	0.08	741-948

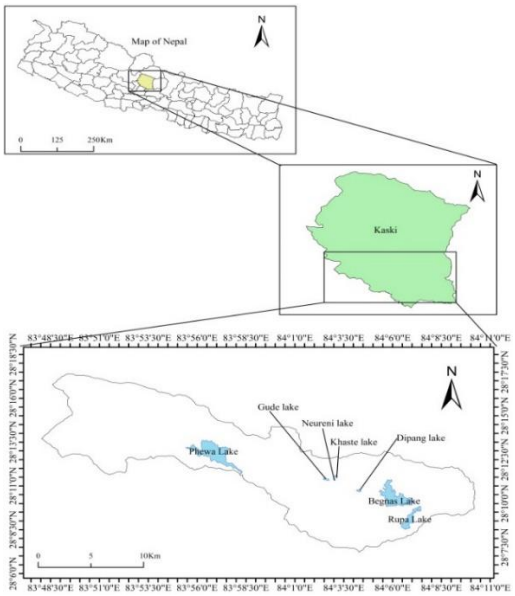

Figure 1: Map of Nepal showing seven lakes of Pokhara Valley

This study was conducted in the November 2023. After monsoon was over, sediment samples were collected from three representative sampling sites: the inlet, middle and outlet areas of each lake using an Ekman dredge. Total nine samples (3 from each site) of each lake were collected (Figure 2).

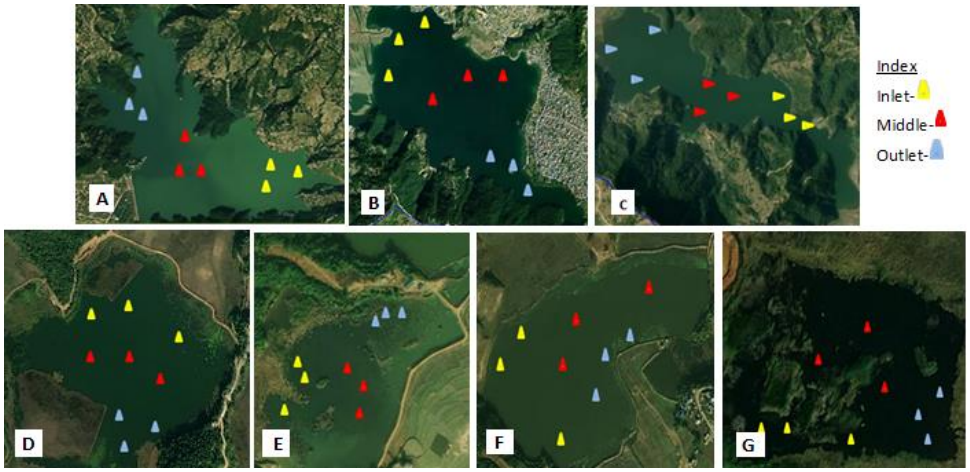

Figure 2: Sampling sites of individual lakes; (A) Begnas, (B) Phewa, (C) Rupa, (D) Dipang, (E) Neureni, (F) Khaste and (G) Gunde.

Each sample were spread over separate plastic in shaded areas of laboratory to avoid direct sunlight and left for air-drying at room temperature for about 5 to 7 days. Dried samples were ground to make fine particles and sieved through a 0.2 mm screen. Each sample (weighing 200 grams) was packed and sent for further analysis at Soil and Fertilizer Testing Laboratory, Pokhara. Prepared soil samples were analyzed for pH, nitrogen, phosphorus, potassium, and organic matter using standard soil analysis methods described by [11].

The collected data were summarized in Microsoft Excel Version 2010 and were subjected to statistical analysis in SPSS Version 29.0. Comparison between means were done using one-way ANOVA (Analysis of Variance) at P = 0.05.

III. RESULT AND DISCUSSION

Lake sediment is rich in micro and macronutrients, particularly phosphorus and nitrogen, as well as organic and inorganic compounds and trace elements derived from internal and external environments [12]. Nutrients in the sediments of seven major lakes of Pokhara Valley are presented in Table 2.

Table -2. Mean ± SD value of nutrients in the sediments of seven major lakes of Pokhara Valley

Lakes	pH	Organic matter (%)	Nitrogen (%)	Phosphorus (kg/ha)	Potassium (kg/ha)
Phewa	6.1^{a}	6.4 ± 0.03^{b}	0.32 ± 0.001^{b}	78.51 ± 50.76^{abc}	151.6 ± 37.1^{b}
Begnas	6.7^{a}	2.5 ± 1.32^{a}	0.13 ± 0.06^{a}	34.61 ± 21.96^{a}	61.2 ± 7.06^{a}
Rupa	5.3^{a}	6.4 ± 0.03^{b}	0.32 ± 0.001^{b}	117.57 ± 10.47^{bc}	141.2 ± 19.4^{ab}
Khaste	5.9^{a}	6.4 ± 0.02^{b}	0.32 ± 0.001^{b}	137.39 ± 18.53^{c}	161.2 ± 46.3^{b}
Neureni	6.4^{a}	6.1 ± 0.47^{b}	0.31 ± 0.02^{b}	67.9 ± 11.29^{abc}	144.9 ± 27.5^{ab}
Dipang	6.6^{a}	6.4 ± 0.05^{b}	0.32 ± 0.005^{b}	126.92 ± 40.9^{bc}	152.9 ± 41.6^{b}
Gunde	5.7^{a}	6.4 ± 0.01^{b}	0.32 ± 0.001^{b}	44.58 ± 28.31^{ab}	108.1 ± 16.01^{ab}

pH level in the lake sediment

pH level in the sediments of seven lakes are presented in Table 2. It was found varying from slightly acidic to nearly neutral. Begnas and Dipang lakes were nearly alkaline as compared to other lakes. However, there were no significant differences (P >0.05) between pH of each lakes. The recommended pH value of lake sediment for sustaining aquatic life is 6.5 - 8.5 [13]. On the basis of this range, present study showed favorable pH level in the sediment of Begnas and Dipang while other lakes pH was found beyond that range. The mean value of pH level in the sediments of present study was found higher in the Phewa and Begnas lakes and lower in the Rupa Lake as compared to the findings of [5] where they reported mean values of pH sediment was 5.2, 5.1 and 5.9 of Phewa, Begnas and Rupa lakes respectfully. The acidic sediment in the lakes of Pokhara may be due to anthropogenic activities and land erosion from catchment area of these lakes. Lake sediment becomes acidic due to anthropogenic activities and erosion process [13].

Organic matter (%)

The mean values of organic matter in sediment of seven lakes are presented in Table 2 and varied from 2.5 to 6.4 % with lowest in the Begnas Lake as compared to other lakes (P <0.05) (Table 2). Likewise, total organic carbon was found lowest in Begnas (1.5%) and highest in Dipang (3.7%) and Phewa (3.72%) (Figure:4).

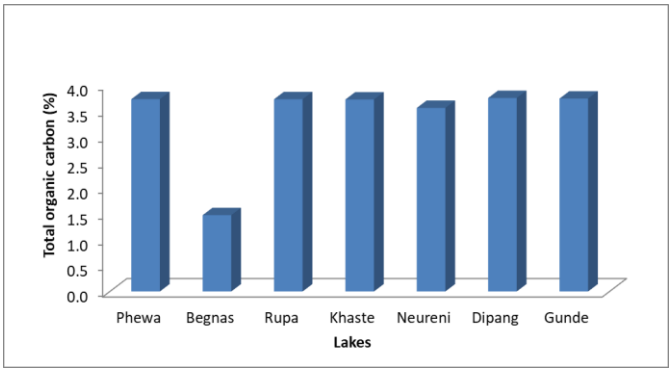

Figure 4: Total organic carbon (%) in sediment of seven lakes of Pokhara Valley

The present study findings showed high organic matter in the Phewa and Begnas lakes and less in Rupa Lake as compared to [5] where they reported OM contents of Rupa Lake was 7.1%, Phewa Lake was 5.2% and Begnas Lake was 1.6%. High organic matters present in lakebed are due to anthropogenic activities, and accumulation of heavy macrophytes into lakebed [14, 15]. Furthermore, except Begnas Lake, remaining lakes have organic carbon level >3% in the sediment. High organic carbon level >3% in the sediment may lead to frequent algal bloom [14].

Nitrogen concentration

The nitrogen concentrations (%) of seven lakes are presented in Table 2. The present study showed that mean nitrogen concentrations in these lakes varied from 0.13 to 0.32 %. Nitrogen level was significantly lowest in the Begnas Lake in comparison to other lakes ($P < 0.05$). Nitrogen concentrations was relatively higher in Rupa, Begnas and Phewa lakes as compared to the findings [5] where it was reported to varies 0.1to 0.2%. High nitrogen level in the lakes may be due to excessive use of chemical fertilizers, agricultural runoff, domestic and urban discharge into lakes as well as less microbial activity in bottom sediment [16, 17].

Phosphorus concentration

Phosphorus contents (kg/ha) in the sediment of seven lakes are presented in Table 2. Mean phosphorus levels in the sediments of seven lakes fluctuated between 34.61 to 137.39 kg/ha. The result showed that phosphorus level was significantly highest in the Khaste and lowest in Begnas Lake ($P < 0.05$).
The present findings of Phosphorus concentrations were higher in the sediment of Phewa, Begnas and Rupa lakes as compared to past study [5]. Along with anthropogenic and agricultural activities, phosphorus level can increase in the sediment due to deposition of dead macrophytes in the bottom sediment that release lots of phosphate and ammonium during their decay [18, 19].

Potassium (K) concentration

The mean potassium (kg/ha) of seven lakes are illustrated in Table 2. Potassium in the sediment of seven lakes varied from 55 to 170 kg/ha. Potassium concentration was found to significantly lowest ($P < 0.05$) in the Begnas Lake and highest in the Khaste Lake (Table 2). Anthropogenic activities, potassium rich fertilizer and municipal waste discharge into lake are responsible for fluctuation of potassium level in lakes (Skowron et al. 2018)[20].

Correlation analysis

pH showed negative moderate correlation with nitrogen and organic matters whereas negative weak relation of pH with phosphorus and potassium established (Table 3). Similarly, organic matter showed an excellent correlation ($r = 1$; $P < 0.01$) with nitrogen that suggest concentration of nitrogen might be regulated by organic source (Table 3). Organic matter was moderately correlated with phosphorus but strongly correlated with potassium ($P < 0.01$). The correlation analysis showed that organic matter contents were closely related to macronutrients and could influence on their concentration.

Table -3. Correlation matrices between pH, organic matter and macronutrients present in bottom sediment of lakes

	pH	Organic matter	Nitrogen	Phosphorus	Potassium
pH	1				
Organic matter	-0.321	1			
Nitrogen	-0.318	1.00**	1		
Phosphorus	-0.152	0.427	0.426	1	
Potassium	-0.278	0.668**	0.679**	0.533*	1

** Correlation is significant at 0.01 level (2-tailed) ; * Correlation is significant at 0.05 level (2 tailed)

Impact of nutrient release on the lake environment

The major limiting nutrients for freshwater lakes are nitrogen and phosphorus, and variations in these nutrients alter the trophic status of the lake [21]. The present study indicated that most of the lake's sediments were enriched with Nitrogen and Phosphorus. Some previous studies have pointed out that anthropogenic activities like agricultural runoff, urbanization, sewage, domestic effluents, and landslides in the catchments area are the major external sources of nutrients which may affect sustainability of Pokhara valley lakes [22, 23, 5, 24, 10, 25, 26]. However, the release mechanisms of sediment Nitrogen and Phosphorus are closely interrelated to both biotic and abiotic processes, and it can be influenced by various environmental factors such as oxygen, pH,

temperature, redox conditions, microbial activity, hydrodynamics, etc. [27]. The present study indicated that most of the lakes are acidic to nearly alkaline. However, Phosphorus found to release under alkaline condition than acidic condition and least amount of P released under neutral [28]. Present study showed that each lake has high level of organic matter which comes from external sources and concentration of nitrogen might be regulated by organic sources. Therefore, immediate action should be taken towards developments of vegetation and improved agricultural practices in the catchment areas of lakes, reduction of sediment load in the lake water, eco-zoning of lake shoreline, and totally reduction of pollution in these lakes [24] to control further degradation of lake environment.

IV. CONCLUSION

The sediment of Rupa, Phewa, Khaste, Neureni, Dipang, and Gunde lakes were found to have higher nutrient level while Begnas Lake has medium nutrient level. These findings will be applicable for implementation of lake management plan. For the sustainable use of these lake resources in the future for fisheries as well as tourism, lake environment management policy should be implemented with innovative and short duration rapid action plan.

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