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Assessment of the Water Quality of Ghodaghodi Lake Using Selected Physico-chemical Parameters

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ABSTRACT

The physicochemical parameters of Ghodaghodi lake were investigated during pre-monsoon (May, 2018) and Post-monsoon season (November, 2018). Water samples for physicochemical parameters were collected and analyzed using standard methods. Four different sampling sites (I, II, III, and IV) were studied. Triplicate of water samples were collected from each site of Lake and physico-chemical characteristics, i.e., pH, temperature, depth, dissolved oxygen, total alkalinity, total hardness, conductivity, total dissolved matter, free CO_2, nitrate and inorganic phosphorous were analyzed. Random sampling method was used. Altogether, 8 quadrats (four paired quadrats) were plotted in each site of the study area per season. Altogether 32 quadrats were laid down per season. Water samples were collected from the depth of 0.5 m within the 1 ×1 m quadrats. CO_2, hardness, temperature and depth was also found to be high during pre-monsoon and these parameters have low values during post-monsoon. pH, conductivity, alkalinity, DO and TDS, value (±SD) was found to be high during post-monsoon with value and low during pre-monsoon. The average value of physicochemical parameters studied were water temperature (22.92°C), pH (7.69), DO (3.2 mg/L), electrical conductivity (180.71 ìS/cm), TDS (91.43 ppm), Free CO_2 (128.29 mg/L),Total hardness (191.16 mg/L), Total alkalinity (177.41 mg/L), phosphate (0.33 mg/L) and nitrate (0.0.095 mg/L). Very low DO concentrations in lake indicated very stressful conditions for aquatic life forms. This is of great concern especially regarding the conservation of critically endangered gharial, vulnerable marsh crocodile, and many other fish species. The limnological status of the lake estimated in this study is of critical importance to implement management actions for the conservation and better management of Ghodaghodi lake, a wetland of western terai, Nepal.

Key words: Hydrochemical, Limnological status, Premonsoon , Postmonsoon, Ramsar site

INTRODUCTION

Water resources are of critical importance to both natural ecosystem and human development (Ibrahim 2009). It is crucial for agriculture, industry and human survival. The physicochemical and biological characteristics of water determine the health of aquatic ecosystem (Verma et al. 2012). Impairment of water quality in reservoirs arises largely from anthropogenic contamination and natural mineralization (APHA 2005, Adamu et al. 2014).

The major threats to aquatic bodies like lakes and reservoirs, worldwide seems to be chemical pollution, eutrophication, alien plants and animal species, acidification, heavy metal contamination (Mustapha 2008) and overharvesting of aquatic resources. Due to increased population and use of fertilizers in agriculture and man-made activities, the natural aquatic environment is increasingly polluted leading to depletion of aquatic biota and water quality (Adakol et al. 2008, Kawo et al. 2008). The diversity and distribution of wetland flora and fauna are affected by the changes in the water chemistry (Deshkar et al. 2010). Study of different water quality parameters help in understanding the metabolic events of the aquatic system. The physical and chemical parameters serve as pollution indicators in water quality monitoring which is a fundamental tool in the management of fresh water resources (Balarabe 2001). Different anthropogenic threats in lakes and water reservoir are causing the changes in physico-chemical properties of reservoir. The monitoring the parameters of underlying sediments is very essential to determine the actual limnological status of wetlands (Niraula 2012).

Nepal's wetlands are facing degradation primarily due to eutrophication and land reclamation. These are critically threatened by the effects of anthropogenic activities such as deforestation, unregulated hunting, dam construction, and increased pollution due to discharges of untreated effluents and runoff from agricultural fields (Niraula 2012, Joshi et al. 2001). The wide spread growth of alien invasive species of floating vegetation has almost covered the open water sector causing habitat modifications that might have affected water quality and altered ecological processes and functions that support rare and endangered autochthonous species of plants and animals.

Information regarding status, physiochemical characteristics of wetland in Nepal is very limited. Few scientific contributions regarding environmental status of the eastern and central Nepal are available in recent period (Niraula 2012, Joshi et al. 2001, Kunwar and Devkota 2012, Pandey and Devkota 2016, Pant et al. 2020) ; while information regarding wetland of western Nepal is scant.

Ghodaghodi lake is one of the most concerned wetland; as it is one of the largest interconnected natural lakes in the plain land of Western Nepal. As it is listed in Ramsar site; yet there is less information regarding water quality. This study is an attempt to fill this gap by assessing some of the physicochemical parameters of the water to evaluate the limnological status of the lake and to assess the suitability of lake water for irrigation and aquaculture. This study will be beneficial while making plan for conservation and sustainable management of lake.

MATERIALS AND METHODS

Study area

Ghodaghodi Lake complex lies in Ghodaghodi municipality (28° 41' 03" N latitude and 80° 56' 43'' E longitude, altitude 205 m above sea level), Kailali district of provision no. 7 in Western Terai (Fig. 1). The lake complex consists of a system of around 14 large and shallow oxbow lakes and ponds with marshes and meadows, streams and swamps. It is surrounded by tropical deciduous mixed *Shorea robusta* forest in the lower slopes of Siwalik Hills. One of the major lakes of the complex is Ghodaghodi Lake which covers an area of 138 ha (Lamsal et al. 2014). It has an area of 138 ha. and average depth 4m. It is palm-shaped. The area is remarkable for its rich biodiversity and connectivity between the Terai plains and the Siwalik of Nepal. The important and direct benefit from this lake to local people is fishing and collection of medicinally important plants. Ghodaghodi Lake is an important religious shrine dedicated to the Ghodaghodi deity. Watershed includes barren land, mixed sal (*S. robusta*) forest, scrubland, and agricultural land (Sah and Heinen 2001). The indigenous Tharu community celebrates a traditional festival, 'Agan Panchami', in December with a cleansing dip in this holy lake.

Water Sampling Method

Water samples were collected in clean plastic bottles from four sites (Table 1) at the depth of 0.5 m of lake during pre-monsoon (May 2018) and post-monsoon (November 2018) seasons. All the sampling bottles were rinsed with the respective water before taking the water samples. Thirty two samples of water, eight from each site of lake were collected during pre-monsoon and post-monsoon season year 2018. The parameters like temperature, pH, depth, dissolved oxygen (DO), conductivity, total solid matter were measured on the spot were measured on-site by using a multi-parameter instrument HANNA Combo and DO-meter. Free CO_2, alkalinity, hardness, nitrate and phosphate were done in the laboratory of Central Department of Botany, Kirtipur, Nepal. Sampling, preservation and analysis of water quality parameters were carried out following standard methods for examination (Table 2).

Statistical Analysis

The normality and homogeneity of variance for physico-chemical parameter were tested by SPSS Statistics 20. Shapiro-Wilk significant value was used to test the normality of the data, if $p>0.05$, data considered a normal. Both parametric (one-way ANOVA) and non-parametric (Kruskal Wallis test) statistical tests were performed to analyze differences in the mean value of variables. One way ANOVA was performed to analyze differences in the mean value of temperature, depth, DO, alkalinity and hardness among sites because data for these variables meet the criteria for normality and homogniety of variance. Kruskal Wallis test were performed to analyze differences in the mean value of pH, free CO_2, conductivity, total dissolved solid, phosphate and nitrate among sites. Independent sample T-test was performed to analyze differences in the mean value of water parameters between seasons.

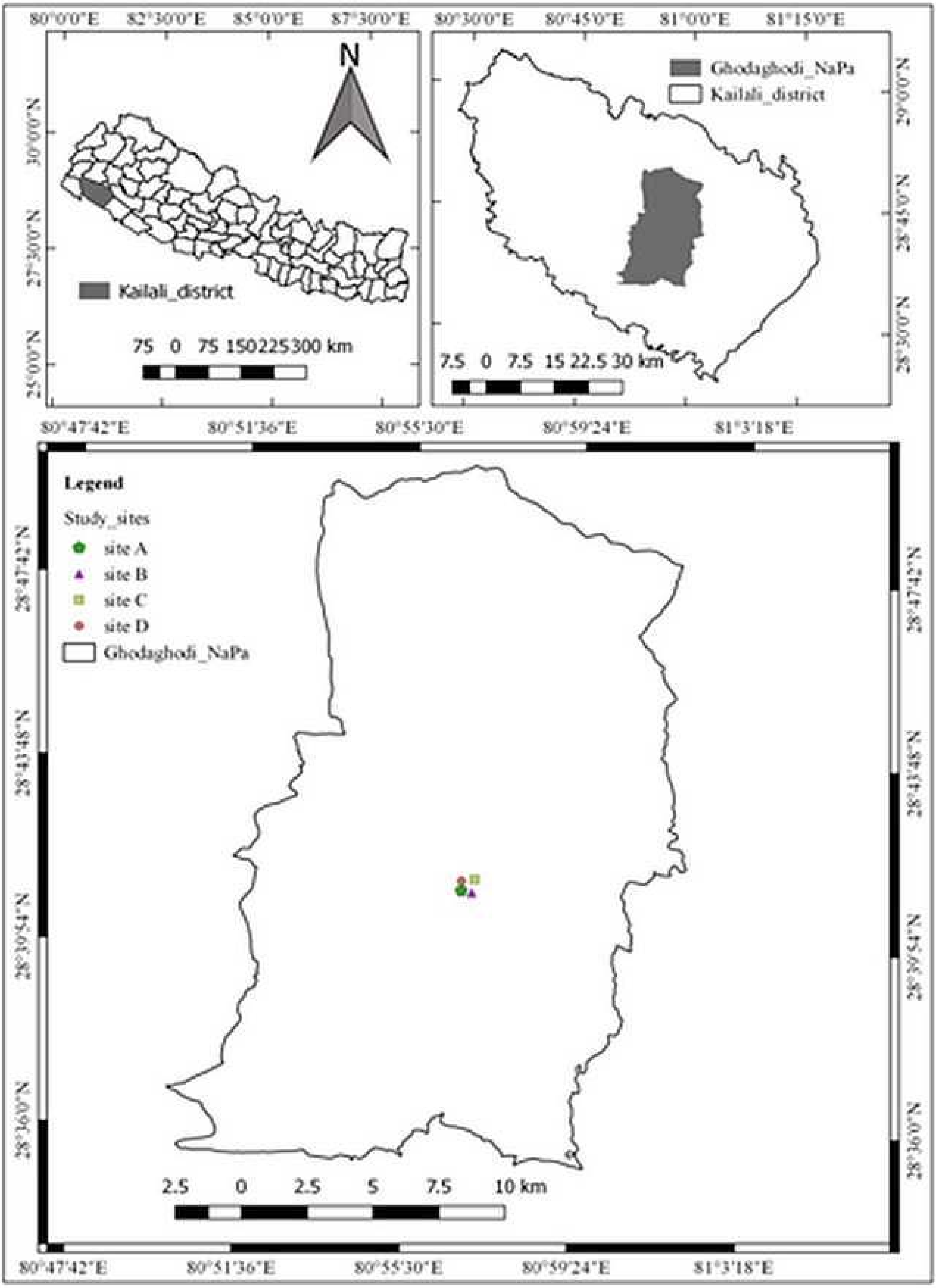

Figure 1. Map of a) Nepal showing Kailali district, b) Kailali district showing Ghodaghodi municipalities, c) Ghodaghodi municipalities showing sampling location

Table 1. Description of sampling sites

Site I	Eastern site near the green tower which is surrounded by tall trees and also by small herbs near the edges. It is less disturbed area.
Site II	Western which is far from temple. It is disturbed area as people do illegal fishing
Site III	Northern which was also surrounded by tall trees and also by small herbs near the edge. It is the station for breeding of crocodile and is not so disturbed like other station
Site IV	Southern site near the temple which was also disturbed. View tower is also present there so there is disturbance by human activities

Table 2. Methods (Rice et al. 2012), used for determination of physico-chemical parameters of lakes' water

Parameters	**Methods**
Temperature	Mercury thermometer
DO (mg/L)	Standard Wrinkle's method
Phosphate (mg/L)	Ammonium Molybdate Solution method
Total hardness (mg/L)	EDTA Method
Free CO_2 (mg/L)	Phenolphthalein-Titration method
Total alkalinity (mg/L)	Acid-Base Titration method
Nitrate (mg/L)	Phenol Disulphonic acid method
TDS (ppm)	Complete Evaporation method
Conductivity (µs/cm)	Conductivity meter

RESULTS AND DISCUSSION

Water Quality

In the present result temperature was 28.85±0.49°C during pre-monsoon while 16.98±1.72°C in post-monsoon season with average value 22.92±0.74 (Table 3). High temperature of surface water was observed during the pre-monsoon season, which could be due to the influence of atmospheric temperature. Higher temperature of lake could be due to increase in rate of chemical reaction and nature of biological activities, since temperature is one of the factors that govern the assimilative capacity of the aquatic system (EPA 1976, Forstner and Wittlmann 1979). The temperature variations in the lake were normal for metabolic activities of organisms such as fish as reported by Boyd and Lichtkoppler (1979) and will not affect the water quality for drinking or fish production.

Figure 2. Google earth map of sampling sites

Dissolved oxygen is considered as one of the most important parameter for water quality assessment; whose presence is vital to aquatic fauna and flora. It plays crucial role in life processes of animals in water. In present study, it was found to be highest in site I (3.30 mg/L) and lowest was at site II (2.77 mg/L) during pre-monsoon (Table 4), while during post-monsoon highest dissolved oxygen was found in site I (4.71 mg/L) and lowest was at site II (1.95 mg/L) (Table 5). It was observed significant difference ($p<0.05$) for the mean value of DO between sites during pre-monsoon and was observed no significant difference ($p>0.05$) between sites during post-monsoon. In average 3.2 mg/l was the dissolved oxygen in the present result at different sites during different seasons. It was observed that there was significant difference ($p<0.05$) for the mean value of DO between seasons (Table 3).The decrease in DO during pre-monsoon might also be due to increase in temperature (Adedeji et al. 2019). High value of DO at site I may be due to less disturbed area (Rahman and Huda 2017). The lower value of dissolved oxygen may be due to higher rate of decomposition of organic matter. DO level below 5 mg/L is considered to be insufficient for the survivability of many organisms and even for drinking purpose (WHO 2006) So water of lake is unsuitable for fishery and drinking purpose.

Table 3. Physico-chemical characteristics (mean±SD) of Lake water in two seasons

Parameters	**Pre-monsoon**	**Post-monsoon**	**Average**	**F**	**Significance (p)**
Temperature (°C)	28.85±0.49	16.99±0.98	22.92±0.74	13.824	**0.000**
DO (mg/L)	3.04±0.48	3.36±1.10	3.2±0.79	23.908	**0.000**
Free CO_2 (mg/L)	162.77±51.85	93.81±46.76	128.29±49.31	0.928	0.326
pH	7.20±0.24	8.19±0.30	7.69±0.27	0.110	0.741
Total hardness (mg/L)	233.56±64.80	148.75±53.41	191.16±59.37	2.878	0.095
PO_4 (mg/L)	0.51±0.21	0.16±0.02	0.33±0.11	52.205	**0.000**
Nitrate (mg/L)	0.10±0.03	0.09±0.02	0.095±0.02	0.160	0.690
Total alkalinity (mg/L)	192.81±34.92	162±51.12	177.41±43.02	1.858	0.178
TDS (ppm)	90.34±18.35	92.53±5.20	91.43±23.55	2.322	0.133
Conductivity (µs/cm)	188.25±28.75	183.16±17.32	180.71±23.03	1.008	0.319
Depth (m)	1.02±0.15	0.83±0.32	0.93±0.23	0.628	**0.012**

F- value and significance value (p) were determined by Independent Sample T-test. (DO=Dissolved Oxygen, PO_4=Phosphate, Totl_Hrdn=Total Hardness, Free_CO_2 =Free Carbondioxide, Totl_alka=Total Alkalinity, TDS=Total Dissolved Solid, Cond=Conductivity, Temp=Temperature).

Table 4. Relationship of physico-chemical parameters between and among sites of pre-monsoon season

Parameters	**Site I**	**Site II**	**Site III**	**Site IV**	**(χ^2)**	**d.f.**	**Mean**	**Sig (p)**
Temp	28.40±0.34	29.51±0.27	27.94±0.56	29.54±0.79	20.336	3	28.85±0.49	**0.000**
DO	3.04±0.54	2.77±0.39	3.08±0.60	3.30±0.39	15.7622	3	3.04±0.48	**0.001**
Free_CO_2	188.52±56.64	121.70±56.34	173.79±43.43	167.05±50.99	4.414	3	162.77±51.85	0.220
pH	6.94±0.36	7.28±0.17	7.27±0.25	7.30±0.16	9.961	3	7.20±0.24	**0.019**
Totl_Hrdn	307.50±89.58	223.75±48.21	216.50±50.38	186.50±71.01	9.112	3	233.56±64.80	**0.028**
PO_4	0.51±0.23	0.45±0.20	0.49±0.20	0.56±0.20	1.307	3	0.51±0.21	0.729
Totl_alka	166.50±40.65	164.50±28.70	188±42.96	132.25±27.35	9.153	3	162.81±34.92	**0.027**
Nitrate	0.10±0.03	0.06±0.03	0.09±0.02	0.13±0.02	23.849	3	0.10±0.03	**0.003**
TDS	108.50±20.84	74.38±2.39	109.50±40.92	69±9.26	23.849	3	90.34±18.35	**0.000**
Cond	218.75±43.06	149.25±3.26	206.38±50.29	138.63±18.61	23.757	3	178.25±28.75	**0.000**
Depth	1.06±0.17	1.04±0.17	1.08±0.10	0.88±0.15	7.094	3	1.02±0.15	0.069

Chi-square value (χ^2) and significance value (p) were determined by one-way ANOVA and Kruskal-Wallis test. (Temp = Temperature, DO = Dissolved Oxygen, Free_CO_2 = Free Carbondioxide, Totl_Hrdn = Total Hardness, PO_4 = phosphate, Totl_alka = Total Alkalinity, TDS = Total Dissolved Solid,).

Table 5. Relationship of physico-chemical parameters between and among sites of post-monsoon season

Parameters	**Site I**	**Site II**	**Site III**	**Site IV**	**(χ^2)**	**d.f.**	**Mean±SD**	**Sig(p)**
Temp	15.16±1.11	16.55±0.33	17.83±2.01	18.40±0.47	17.358	3	16.99±0.98	
DO	4.71±1.55	1.95±0.61	3.67±1.17	3.12±1.07	4.556	3	3.36±1.10	0.207
Free_CO_2	102.87±58.22	92.33±48.55	86.40±36.84	93.64±43.43	0.338	3	93.81±46.76	**0.015**
pH	8.28±0.20	8.16±0.06	8.05±0.24	8.26±0.68	8.106	3	8.19±0.30	0.728
Totl_Hrdn	150.75±61.91	141.50±45.82	168.25±68.49	134.50±37.40	1.081	3	148.75±53.41	0.953
PO_4	0.16±0.02	0.15±0.02	0.14±0.01	0.17±0.01	10.434	3	0.16±0.02	0.075
Nitrate	0.09+-0.02	0.05+-0.02	0.08+-0.03	0.12+-0.02	19.899	3	0.09+-0.02	**0.000**
Totl_alka	200.25±31.56	186.25±79.32	215±52.93	166.50±40.65	6.917	3	192±51.12	**0.000**
TDS	107.75±15.98	79.25±1.28	101.88±1.25	81.25±1.58	24.997	3	92.53±5.02	**0.000**
Condutivity	216.50±35.89	148.50±27.72	204.63±3.20	163±2.045	25.963	3	183.16±17.32	0.44
Depth	0.88±0.30	0.71±0.16	0.96±0.57	0.76±0.24	2.768	3	0.83±0.32	0.429

Legend same as Table 4.

The free CO_2 depends on the respiration of plants, photosynthesis rate as well as microbial decomposition (Choudhary et al. 2014). In this study free CO_2 varied from 93.81±46.76 mg/L to 162.77±51.85 mg/L with a higher value in the pre-monsoon season. This may be attributed to the combined effect of higher temperatures and microbial decomposition. The aquatic organisms are greatly affected when free CO_2 concentration exceeds 25 mg/L (Thomas et al. 2015). Similar high value during pre-monsoon and low value in post-monsoon was observed by Rajan and Samuel (2016). In the present study, the free CO_2 crosses the limit which could be the issue of sustainability of aquatic organisms. The more value of CO_2 in pre-monsoon may be due to decrease in productivity leading to decomposition forming more CO_2 in water (Rajan and Samuel 2016).

Alkalinity is the measure of water's ability to neutralize acidity. The alkalinity of lake in present study ranged from 162±51.12 mg/L to 192.81 ± 34.92 mg/L with average value 177.41±43.02 mg/L. It was observed low in post-monsoon as compared with pre-monsoon. High alkalinity during post-monsoon was also found by Mruthyunjaya et al. (2016). Such kind of seasonal variation could be due to the flushing and dilution by late monsoon rainfall along with surface runoff. Since, the water bodies are divided into three categories according to total alkalinity value i.e. poor nutrient (1 mg/L to 15 mg/L), moderately rich nutrient (16 mg/L to 60 mg/L), and rich nutrient (>60 mg/L) (Pant 2013). Thus, the lake was found to have a rich nutrient in terms of alkalinity concentration.

pH is the measure of the intensity of acidity or alkalinity. A slight change in pH can change the acidity or basicity of the water (Rajan and Samuel 2016). The mean value for pH was found as low (7.20±0.37) during pre-monsoon and high during post-monsoon season (8.19±0.37). The average pH range ((7.69±0.27) of the water samples were found within the range defined by WHO guidelines of 6.5-8.5) (W HO, 2006). It indicates good, favorable and suitable conditions for the optimal survival conditions for aquatic life. The value of pH is higher during the pre-monsoon season might be due to higher temperatures and other geochemical processes (Rehman Qaisar et al. 2018).

Nitrogen and phosphorous has been considered as major nutrients and are the limiting factors for all kind of freshwater bodies. It's abundance in aquatic system causes the eutrophication which has very serious consequences for the lake water. Nitrogen in the form of nitrate was found more during pre-monsoon (0.10 mg/L) while, low during post-monsoon (0.09 mg/L) (Table 3). The higher value of total nitrogen during pre-monsoon might be due to high microbial activity and excretory products of aquatic animal. Low value during post-monsoon period might be due to inactiveness of microbes when decomposition rate becomes low or may also due to dilution of water bodies after monsoon (Kunwar and Devkota 2012). Similar view was also expressed by Simkanda (2003) in Gaindahawa Lake. There was high value of nitrate at site IV that could be due to disturbed area, as there is temple nearby site and people usually throw sewage produced in temple, High value of nitrate at disturbed site also reported by Raman and Huda (2017).

Phosphate has been considered as the main nutrients for the productivity of aquatic ecosystem. But if the quantity of phosphate gets much higher in the water body it speeds up eutrophication of the river and lake (Isratpia et al. 2018). During the present study, higher phosphate value was recorded during pre-monsoon (0.51±0.20 mg/L) while lowest in post-monsoon (0.16±0.02 mg/L) with average value 0.33±0.11mg/L. The lower value during post-monsoon might be due to rapid biological uptake and the formation of water insoluble calcium carbonate (Zutshi and Vaas 1973; Zutshi and Khan1977). The lake can be categorized as hyper-eutrophic on the basis of trophic level proposed by Forsberg and Ryding (1980). Nepal Water Quality Guideline reported that 0.6 mg/L of phosphate is suitable for aquaculture point of view (NDWQS 2005). As per the guideline, the phosphorus contents in the Ghodaghodi lake (0.33mg/L) was less than this limit.

In present study average value of nitrate concentration was 0.095±0.02 mg/L. The result of nitrate was well below the permissible limit of WHO standard guidelines i.e. less than 10 mg/L. Generally nitrate comes directly from fertilizer application or from biological oxidation of ammonia (Acharya and Rajbhandari 2014). The low value of nitrate indicates that there is no risk for eutrophication of the lake. Low value of nitrate also supports less plankton growth. Low value may be due to the inactiveness of microbes or when decomposition rate becomes low or may also be due to the dilution of water bodies during monsoon season.

Hardness in water is caused by metallic ions dissolved in water which includes calcium and magnesium ions. It is expressed as calcium carbonate (mg/l). According to the WHO (2003) limits, the range between 0-40 considered as soft, 40-100 mg/L as moderately hard, 100-300 mg/L considered as extremely hard. The average value of hardness was found higher (233.56±78.31) during pre-monsoon and low (148.75±53.66) during post-monsoon season (Table 5). It might be due to high flow rate and less amount of Ca^{++} and Mg^{++} (Bhattarai et al. 2008). High value of hardness was also observed during pre-monsoon by Bhattarai et al. (2008). High value of hardness was found during pre-monsoon season by Choudhary et al. (2014), also. Freshwater can be classified into the following groups based on hardness: soft: 0-60 mg/L, moderate hard: 61-120 mg/L, hard: 121-160 mg/L, and very hard: >180 mg/L. As average value of hardness of water of Ghodaghodi lake (above 180mg/L)' using these criteria, the water quality of the lake was found to be in very hard category. Relatively, higher values of total hardness in the both season might be due to the addition of calcium and magnesium content from surrounding lands.

Conductivity is determined by decomposition of organic matter, input of ions from inlet, temperature of the water and total solids. It was found highest during post-monsoon (183.16±17.32 µs/cm) and lowest during pre-monsoon (178.25±28.75 µs/cm, Table 3). Higher value of conductivity during post-monsoon might be due to the presence of inorganic solids such as chloride, sulphate, sodium, magnesium, calcium and iron cations (Saxena et al. 2014).

Total dissolved solids are simply the sum of cation and anion concentration expressed in mg/l. A high content of dissolved solid influence osmoregulation of fresh water organisms reduces solubility of gases like oxygen and result into eutrophication of the aquatic ecosystem (Bhattarai and Dahal 2017). Pollution is the main cause of total dissolved solid. There may be other causes of TDS in the river water, e.g. sewage discharge, runoff, irrigation water leaching and landslide. The water becomes potable when the concentration of TDS is less than 1000 mg/l (WHO 2006). TDS in this lake fluctuated between 120 to 225 mg/l with average value of about 190 mg/l which suggest that the lake is not eutrophic The higher values might be due to lower water level and perhaps various kinds of ions present in water body (Mruthyunjaya et al. 2016) . Similar observation was done by Raut et al. (2015) in Panchpokhari. High TDS value during post-monsoon might have been due to the addition of solids from the catchment. The mean value for depth was more during pre-monsoon while low during post-monsoon. Temperature plays a vital role in physical, chemical and biological properties of water and has direct influence on aquatic biota (Rajan and Samuel 2016). Effects of changes in temperature would adversely affect the water quality.

Spatial Variation in Water Quality

Both parametric (one-way ANOVA) and non-parametric (Kruskal Wallis test) statistical tests were performed to analyze differences in the mean value of variables. One way ANOVA was performed to analyze differences in the mean value of temperature, depth, DO, alkalinity and hardness among sites because data for these variables meet the criteria for normality and homogniety of variance. Kruskal Wallis test were performed to analyze differences in the mean value of pH, free CO_2, conductivity, total dissolved solid, phosphate and nitrate among sites. There was significance difference in DO, Total hardness, total alkalinity, nitrate, TDS, Conductivity, pH, and water temperature among sites during premonsoon season. Likewise, there was significance difference in dissolved oxygen (DO), phosphate (PO4), Nitrate, TDS, Conductivity and Temperature during post monsoon season.

Correlation Analysis

In the present study, inorganic phosphorous shows a significant positive correlation with hardness (r= 0.507), free CO_2 (r=0.584), depth (r=0.352) and temp (r=0.627). Similarly total alkalinity shows positive correlation with TDS (r=0.461), conductivity (r=0.460) and pH (r=0.313). Strong negative

Table 6. Spearman Correlation coefficient values between physico-chemical characteristics during research period

Parameters	Do	PO_4	Totl_Hrdn	Free_CO_2	Totl_alka	Nitrate	TDS	Cond	pH	Depth	Temp
Do	1.000										
PO_4	.005	1.000									
Totl_Hrdn	.109	.507**	1.000								
Free_CO_2	.079	.584**	.269*	1.000							
Totl_alka	.093	-.247*	.130	-.189	1.000						
Nitrate	.243	.045	-.165	-.053	-.242	1.000					
TDS	.405**	-.117	.134	-.039	.461**	.022	1.000				
Cond	.399**	-.120	.116	-.019	.460**	.043	.979**	1.000			
pH	-.039	-.692**	-.468**	-.570**	.313**	-.005	.115	.145	1.000		
Depth	-.007	.352**	.167	.232	-.121	-.042	.032	.048	.464**	1.000	
Temp	-.170	.627**	.369**	.489**	-.403**	.001	-.484**	-.463**	-.810**	.365**	1.000

** Correlation is significant at the level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). (DO=Dissolved Oxygen, PO_4=Phosphate, Totl_Hrdn=Total Hardness, Free_CO_2 =Free Carbondioxide, Totl_alka=Total Alkalinity, TDS=Total Dissolved Solid, Cond=Conductivity, Temp=Temperature). Here positive value indicates highly positively correlated to other variable while negative value indicate highly negatively correlated to other variable.

correlation was shown by phosphorous (r=-0.692), hardness (r=-0.468) and CO_2 (r=-0.570) with pH (Table: 6). No other strong correlation was found in this study.

CONCLUSION

Result of present study revealed that, the water quality in Ghodaghodi Lake was found unfavorable to aquatic organisms. Very low DO concentrations in lake indicated very stressful conditions for aquatic life forms. This is of great concern especially regarding the conservation of critically endangered gharial, vulnerable marsh crocodile, and many other fish species. During study period, high value of phosphate was found during pre-monsoon. The lake can be categorized as hyper-eutrophic on the basis of trophic level proposed by Forsberg and Ryding (1980). CO_2, hardness, temperature and depth was also found to be high during pre-monsoon and these parameters have low values during post-monsoon. pH, conductivity, alkalinity, DO and TDS, value (±SD) was found to be high during post-monsoon with value and low during pre-monsoon. The limnological status of the lake estimated in this study is of critical importance to implement management actions for the conservation and better management of Ghodaghodi lake, a wetland of international importance. Future studies should be focused on the determination of nutrient mass balance in the lake to identify the main sources of nutrients and implement adequate management practices for reducing pollution and improving the limnological status of the lake.

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Authors' contribution: AD conceptualized and designed the study; BKS collected and analyzed data, and prepare first draft of the manuscript; AD revised and finalized the manuscript.

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