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ORIGINAL RESEARCH ARTICLE

An Assessment of Water Quality in Ramsar Convention Listed Neureni Lake in Pokhara, Nepal

Raju Kumar Poudel
Department of Chemistry, Prithvi Narayan Campus, Pokhara, Nepal

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Corresponding Author: *Raju Kumar Poudel,* ***Email****: poudelraju100@gmail.com*
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ABSTRACT

Water is one of the essential substances for the survival of the flora and fauna on the earth. Different physical activities such as photosynthesis, nutrient absorption, respiration and other metabolism processes depend on the quantity of water. This investigation has been carried out to assess the quality of water of Neureni Lake. This lake is listed in Ramsar Convention 2016 (i.e. conservation and sustainable use of wetlands of Nepal). Different physical (transparency, temperature and depth) and chemical parameters such as hydrogen ion concentration (pH), free carbon dioxide (F-CO_2), dissolved oxygen (DO), total hardness (TH), total dissolved solids (TDS), total solids (TS), chloride ions (Cl^-), magnesium (Mg) and calcium (Ca) were analyzed following the systematic methods recommended by American Public Health Association (APHA, 1999). The results obtained from this analysis have been compared with the standard values of the World Health Organization (WHO) and various lakes. The study shows that all the physico-chemical parameters of Neureni Lake meet the criteria of the WHO of water quality so that the quality of water of Neureni Lake is not so much contaminated with harmful or poisonous substances. In connection to maintaining the water quality of the lake, the physical and chemical components of water should be checked from time to time by controlling domestic sewage, not using pesticides and fertilizers in the field around the lake and controlling the rocky soil coming in the rainy season by making siltation dam.

KEYWORDS: Physico-chemical, transparency, dissolved oxygen, total hardness, Neureni Lake

INTRODUCTION

Water occurs in many varieties and is one of the most plentiful compounds. It is one of the most significant single worldwide natural component scattered in the sea, land and atmospheric surrounding and unified by the water cycle. All animation including human being depends on water. It is possible to survive without food and shelter for

some days, but it is almost impossible to survive without water. Aquatic environment is categorized into two classes: (a) Fresh water environment containing 0.001% - 0.5% salt and (b) Marine water environment containing 3.5% salt (Pennak, 1953). Lakes belong to the lentic environment of fresh water where the water quality is ruled by many environmental as well as seasonal features. The quality of lake water needs to be maintained to sustain entertainment business and fisheries and to provide drinkable water to the people (Pant RR et al., 2018). Lakes can be divided into three main classes based on the process of origin such as (a) Himalayan or Glacier Lakes: Rara, Tilicho, SheyPhoksundo and Gosaikunda (b) Sub-Himalayan Lake or Tectonic Lake: Fewa, Begnas, Rupa, Khaste and Neureni Lake (c) Oxbow Lake: Ghodaghodi Lake, Rani Lake, Devi Lake and Satrahazar Lake (Sharma, 1977).

Nepal is enriched with several types of wetlands in which water covers 5.06% of the total land area (FDD, 1992). The total area of the wetland has been estimated to be 7435.63 sq. km in the form of rivers (3950 sq. km), lakes (50 sq. km), paddy fields (3250 sq. km), marshy land (120 sq. km), reservoirs (13.8 sq. km) and village ponds (51.83 sq. km) comprising of around (5.5%) of the entire land region of Nepal (Rajbanshi & Gurung, 1994). In Nepal, lentic environment occupies around 3500 sq. km and the lotic environment occupies around 3950 sq. km (FDD, 1992). Altogether 5358 lakes are found in Nepal, out of which 2227 lakes are above 3000 meters altitude (Bhuju et al., 2010). They are commonly called *Pokhari*, *Tal*, *Rah*, *Dah* and *Kunda* [small water reservoirs], which constitute 50 sq. km of the total estimated area of wetland (Pradhan, 1982). Most of the lakes found in the Kaski district of Nepal are within Pokhara Metropolitan City. The lakes found in Pokhara are Fewa, Rupa, Begnas, Maidi, Khaste, Deepang, Kamalpokhari, Neureni and Gunde. Abiotic components of water affect the quality of the water ecosystem (Kunwar & Devkota, 2012). Watching the physico-chemical parameters of water is highly essential for determining the actual limnological condition of wetland (Pradhan, 1998). The lake cluster of Pokhara Valley Ramsar site includes nine lakes; out of which Neureni Lake is one of them (DNPWC, 2016). This study was performed to assess the condition of the physical and chemical parameters such as transparency, depth, temperature, hydrogen ion concentration, total solids, dissolved oxygen, total dissolved solids, free carbon dioxide, calcium, total hardness, magnesium, total alkalinity and chloride of Neureni Lake of Pokhara valley, Nepal. The Neureni Lake is one of the small lakes in Pokhara. Most of the part of this lake is covered with water vegetation, which affects its beauty. To enhance the beauty of Neureni Lake, it is necessary to remove weeds from the lake. Since not much research has been done on Neureni Lake, it is considered necessary to study the abiotic components of this lake and make it known to the world.

METHODOLOGY

Study Area

Neureni Lake (Figure 1) lies in Pokhara Metropolitan City, Ward No. 26, Kharane Phant, which is nearly 2.4 km away from the Prithvi Highway. It is located in between 84.0465°–84.0533° longitudes and 28.1889°-28.195° latitudes (http://nationalgeoportal.gov.np/cadastral/). Most of the part of this lake is covered with aquatic macrophytes. Water from Kaduche Mul and various seasonal rivulets are the primary inflow of Neureni Lake. Its water flows directly into Khaste Lake as an outlet.

Figure 1
Neureni Lake

Sampling

The water sample of Neureni Lake was collected on the first day of each month (May to August 2021) in the morning time (10.00 to 11.00 am) in a prewashed plastic container of one liter then kept at 4°C in the refrigerator in the science laboratory. After that, different abiotic components were tested in the chemistry laboratory by employing the standard operating procedure to detect the water quality of the entire lake for aquatic lives.

Analytical Procedure

The lake's depth was determined by fixing a certain weight on a measured rope and touching the bottom of the lake. A standard Secchi disc instrument was used to measure the transparency of lake water (Bastola, 2012). The water transparency can be measured by calculating the average values of the distance of just fading and just showing up of disc under the lake. The surface water temperature of the lake was recorded with the help of a standard mercury thermometer by submersing the mercury-containing thermometer bulb into the water surface of the lake.

Winkler's iodometric titration method was used to determine the amount of dissolved oxygen (DO) in the lake water using chemicals such as sodium thiosulfate solution, manganese sulfate, concentrated sulfuric acid and alkaline potassium iodide. Free carbon dioxide (F-CO_2) concentration in the lake water was detected by volumetric analysis with the help of phenolphthalein (indicator) and sodium hydroxide solution (0.05N). To determine the hydrogen ion concentration (pH) of the lake water, the electric pH meter was used. To determine the amount of total alkalinity of sample, the volumetric analysis process was used with the help of phenolphthalein, methyl orange indicators and hydrochloric acid HCl (0.1N). The reagents like ethylene diamine tetra acetic acid (EDTA), buffer solution and eriochrome black indicator were used to determine the total hardness present in the water samples using the EDTA titration method. The weighing and evaporation methods were used to determine the total solid (TS) materials present in the water sample. Similarly, the total dissolved solids present in the water were determined by filtering the water sample using "what man-40 filter paper" and then evaporating and weighing method. Magnesium and Calcium concentration in the samples was estimated by the volumetric analysis using an EDTA

and murexide indicator. The chloride ion content in the water sample was detected by the Argentometric titration method using the reagent-like solution of potassium chromate as an indicator and silver nitrate. All laboratory processes were performed by finding out the concurrent reading during the volumetric analysis.

Table 1

Methods Employed in Determining Physico-Chemical Parameters

Physico-chemical Components	Methods Used
1. Transparency (cm)	Secchi disc method
2. Depth (m)	Measuring tape
3. Temperature (°C)	Standard mercury thermometer
4. Hydrogen ion concentration	Microprocessor pH meter
5. Total Solid (mg/L)	Evaporation Method
6. Dissolved oxygen (mg/L)	Winkler's iodometric titration
7. Total Dissolved Solid (mg/L)	Filtration and Evaporation
8. Free Carbon dioxide (mg/L)	Titration Method (NaOH method)
9. Calcium (mg/L)	Titration Method
10. Total Hardness (mg/L)	EDTA Titration Method
11. Magnesium (mg/L)	Titration Method
12. Total alkalinity (mg/L)	Titration Method
13. Chloride (mg/L)	Argentometric Titration Method

Source: APHA, 1999

The physical parameters like transparency, temperature and depth were noted in situ whereas other chemical parameters like free carbon dioxide, total alkalinity, calcium, total hardness, dissolved oxygen, chloride ions, magnesium and total dissolved solids were analyzed in the chemistry laboratory of Prithvi Narayan Campus, Pokhara, following health and safety protocols (American Public Health Association, 1999). The standard reagents and chemicals were used during the laboratory analysis manufactured by SD fine, Nice Chemicals, Thermo-fisher scientific, LOBA Chemia, Himedia laboratory companies. The required reagents were prepared in the laboratory by dissolving calculated amount of chemicals in distilled water in a required amount. The obtained values were evaluated as per the guidelines of WHO for drinkable water (Table 4).

RESULTS AND DISCUSSION

The obtained values of abiotic components of water of Neureni Lake have been presented in Table 2 and then compared with other lakes (Table 3) as well as the standard values of WHO (Table 4).

Table: 2

The Obtained Values of Physico-Chemical Parameters of Neureni Lake

S.N.	Parameters	Months				Average Values
		May	June	July	August	
1	Depthness (m)	1.0	1.2	1.3	1.2	1.175
2	Transparency(cm)	40	38	40	45	40.75
3	Temperature(°C)	26	28	30	31	28.75
4	Dissolved Oxygen (mg/L)	6.3	6.1	5.8	5.2	5.85

5	Free Carbon dioxide (mg/L)	4.0	4.2	4.2	4.4	4.20
6	Hydrogen ion concentration(pH)	6.8	6.7	6.5	7.0	6.75
7	Total Alkalinity (mg/L)	108	105	104	110	106.75
8	Total Hardness (mg/L)	126	127	128	120	125.25
9	Total Solid (mg/L)	96	100	100	95	97.75
10	Total Dissolved Solid (mg/L)	54	54	65	60	58.25
11	Calcium (mg/L)	19	20	22	22	20.75
12	Magnesium(mg/L)	8.5	8.5	10.0	11.0	9.5
13	Chloride (mg/L)	10.0	12.7	15.6	14.2	13.125

Table: 3

Comparing the Physico-Chemicals Parameters of Neureni Lake with Other Lakes

Lakes	DO (mg/L)	F-CO_2 (mg/L)	pH	TA (mg/L)	TDS (mg/L)	Cl^- (mg/L)	Reference
Neureni	5.85	4.2	6.75	106.75	58.25	13.125	Present Study
Begnas	6.46	13.32	9.04	-	25.42	20.04	Pant, et al., 2019
Rupa	5.09	14.83	7.87	-	36.70	16.52	Pant, et al., 2019
Deepang	6.8	3.9	7.3	111.0	-	-	Bastola et al., 2010
Maidi	6.2	3.4	7.3	91.1	-	-	Bastola et al., 2010
Nagdaha	7.09	31.7	7.8	-	106	27.07	Pant, 2013
Kamalpokhari	3.4	7.625	8.125	278.75	-	-	Bastola, 2012

Table: 4

Values of Physico-Chemical Parameters Prescribed by WHO for Drinkable Water

Parameters	Guideline Value
Hydrogen ion concentration (pH)	6.5-8.5
Dissolved Oxygen (DO) (mg/L)	5
Total Dissolved Solid (TDS) (mg/L)	500
Total Hardness (TH) (mg/L)	500
Free Carbon-dioxide (F-CO_2) (mg/L)	4-25
Total Alkalinity (TA) (mg/L)	600
Magnesium (Mg) (mg/L)	150
Chloride (Cl^-) (mg/L)	250
Calcium (Ca) (mg/L)	100

Source: WHO (2008)

The depth of Neureni Lake was found to be maximum (1.3m) due to high rainfall in July 2021 and found to be minimum (1.0m) in May 2021. The average depth

of the lake was 1.1m during the investigation period. The measurement of water transparency is based on the penetration of light in the lake water column. During the rainy seasons, the transparency of lake water becomes lower as a result of washing of allochthonous sediment particles from the catchment area (Mustapha & Omotosho, 2005; Adeniji, 1982). The transparency of lake water was ranged from 38cm to 45cm, which indicates that water of the lake was lightly turbid, so it did not affect the aquatic environment. Air climate directly affects the surface water temperature of the lake. The temperature of surface water of Neureni Lake was found variable in each month. The maximum temperature (31°C) was noted in Neureni Lake in August 2021 and minimum (25°C) in May 2021. The main cause for increasing temperature was due to the summery climate during the period of data collection.

Dissolved Oxygen is one of the significant components of life. At normal pressure, atmospheric air contains 21% dissolved oxygen and approximately 35% dissolved oxygen in water as dissolved gas (El Morhit & Mouhir, 2014). The average value of the concentration of dissolved oxygen of Neureni Lake was recorded 5.8 mg/L, which is permitted value prescribed by WHO to support the aquatic environment. The value of DO ranged from 5.2 mg/L to 6.3 mg/L in the course of investigation duration. Low value of DO may be due to increased activities of microorganisms in water which consumes a lot of oxygen due to the metabolic process and the decomposition of organic materials and DO also decreases with an increase in temperature (Verma & Agrawal, 1988). The DO value of Neureni Lake appeared to be close as compared with the values of lakes presented in Table 3, but higher than that of Kamalpokhari. The concentration of DO below 5mg/L is considered to be deficient for different organisms to remain alive (WHO, 2008). So the amount of dissolved oxygen obtained from the analysis is suitable for aquatic lives in Neureni Lake. Carbon dioxide is an important factor for the aquatic ecosystem. The amount of F-CO_2 in the lake water depends on the photosynthesis process and respiration of plants (Chaudhary et al., 2014). As a result of organic materials decomposition with the help of microbes and breathing processes of aquatic plants as well as animals, the CO_2 concentration in the lake water increases (Bastola, 2012). An average amount of free CO_2 was recorded at 4.2 mg/L during the study period. The concentration of the free CO_2 of Neureni Lake was greater than Maidi and Deepang Lake but lesser than Kamalpokhari, Rupa, Begnas and Nagdaha (Table 3), so the average concentration of F-CO_2 resembles the criteria of WHO (4-25 mg/L). The observed values of hydrogen ion concentration of Neureni Lake were recorded to be 6.5 to 7.0 which indicated that the water of this lake was found slightly acidic as compared with other lakes (Table 3). The mean pH value of Neureni Lake was in the permitted level of 6.5-8.5 (WHO, 2008) (Table 4). Hence, aquatic organisms can live on the pH value of Neureni Lake obtained from research. As compared with other lakes, the total alkalinity of Neureni Lake was found to be higher than Maidi Lake but lower than Kamalpokhari and Deepang Lake (Table 3). The total alkalinity of this lake was within the permitted level of WHO (Table 4). The water hardness is usually due to the presence of solvable chlorides, sulfate and bicarbonates of magnesium and calcium. The total hardness values were found within the range from 120 mg/L to 128 mg/ L (Fig 3). 500 mg/ L is the value of total hardness of water prescribed by WHO for drinking water. The obtained value reveals that the Neureni Lake water lies within the limit. For the growth of the aquatic lives, water containing 15 mg/L or above hardness value may be preferable (Swingle, 1967).

Figure 2

Dissolved Oxygen and Free Carbon dioxide of Lake Water at Different Months (mg/L)

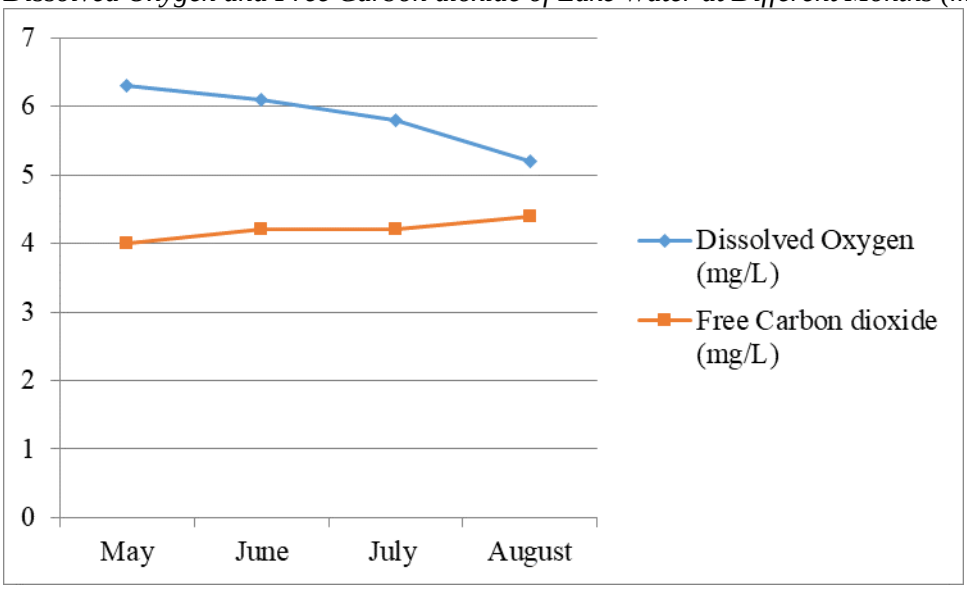
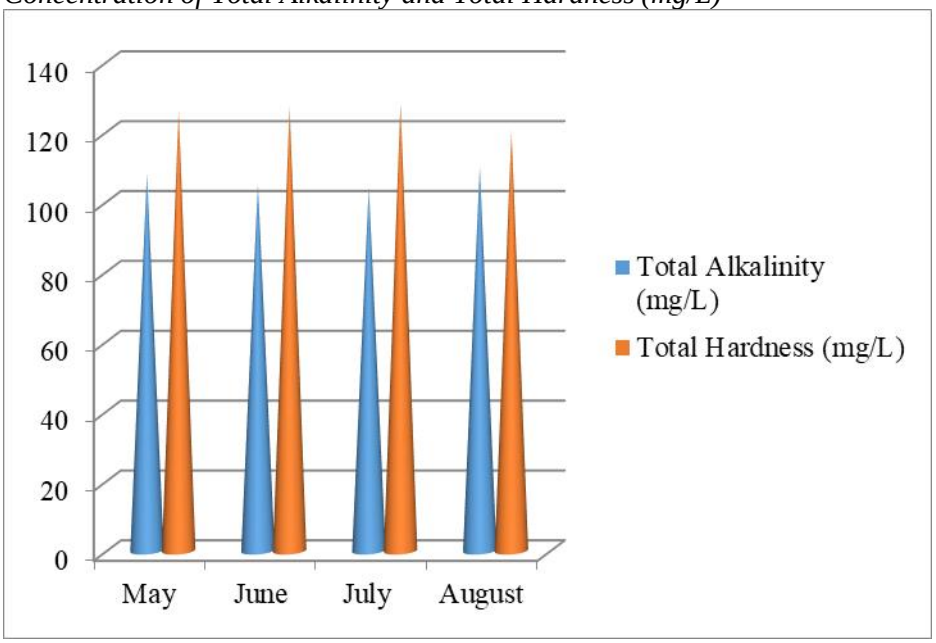


Figure: 3

Concentration of Total Alkalinity and Total Hardness (mg/L)



The water containing inorganic and organic substances in undissolved and dissolved form represents the amount of total solid substances present in the lake water. The total amounts of solids present in the water samples of Neureni Lake seemed to be 95-100 mg/L during the study period. Similarly, various kinds of materials such as organic or inorganic substances which are soluble in the water tell us about the amount of total dissolved solids (TDS) in the lake water (Khanal et al., 2021). A concentration of TDS ranges from 54-65 mg/ L (Fig 4). For an aquatic environment, the concentration of TDS less than 500 mg/L is suitable (WHO, 2008). So, this amount of TDS in Neureni Lake did not affect the aquatic plants and animals. The TDS of Neureni Lake was lower

than Nagdaha while it was higher than Begnas and Rupa. The concentration of calcium ions was noted lower in May (19 mg/L) but higher in July and August (22 mg/L). Calcium and magnesium ions containing minerals and rocks of rivulets and streams collected in Neureni Lake water due to soil erosion and high rainfall in August and July 2021. The calcium contained in water is inversely related to hydrogen ion concentration (Pearsall, 1930). During the investigation period, the lower concentration of magnesium was noted in May (8.5mg/L) and the greatest value of magnesium was found to be 11.0 mg/L in August. Thus, the obtained values of calcium and magnesium were within the criteria of WHO (Table 4). Some anthropogenic impacts may be due to the presence of chloride ions, which may be caused by the supply of polluted water directly into the lake (Rosha et al., 2012). The chloride ions concentration was recorded to be in the range between 10 mg/ L and 15.6 mg/ L in the course of the study period of Neureni Lake. The average value of chloride ions concentration was 13.12 mg/ L which was lesser than different lakes mentioned above (Table 3) as a result of a low amount of household sewage, fecal deposition, apatite and mica. The chloride ions concentration was within the permitted level of WHO guideline (250 mg/ L) for drinking water.

Figure 4

Concentration of Total Solids and Total Dissolved Solids (mg/L)

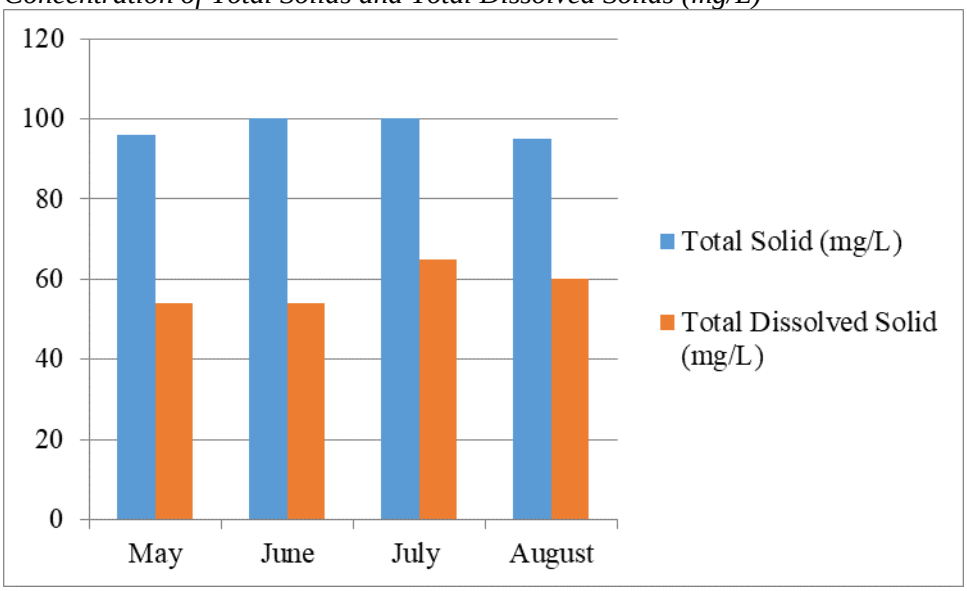
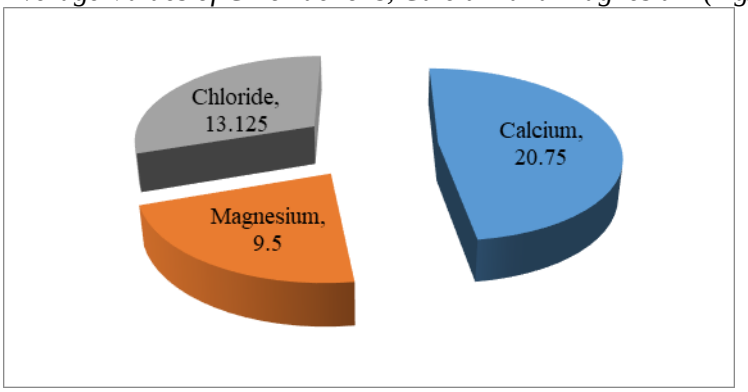


Figure 5

Average Values of Chloride ions, Calcium and Magnesium (mg/L)



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CONCLUSION AND RECOMMENDATIONS

The study carried out during the month of May-August 2021 shows that all these physico-chemical parameters are within the prescribed limit of the WHO guidelines of quality of water for fresh water environment. Neureni Lake is not much polluted and is found to be acceptable for fresh water environment and irrigation. But for drinking purposes, the water quality must be further tested because it contains different pathogenic organisms. An increase in population density around the lake creates a negative impact on this ecosystem. The local government must implement different policies and programs concerned with the natural resource management and the community should be well informed about the negative impact of pesticides, insecticides and other chemicals in the catchment sectors of Neureni Lake. The afforestation program and cleaning program need to be conducted to protect and preserve the lake. Hence, this study will be a foundation for further research and useful for the future management of Neureni Lake.

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