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RESEARCH ARTICLE

Chemical Hydrological Features and Water Quality Evaluation of Phewa Lake of Pokhara Valley Gandaki Province of Nepal

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Abstract

This study was conducted to investigate the hydrochemical characteristics and water quality of Phewa lake Pokhara. Water samples were collected and major hydrochemical features were analyzed viz.,Transparency, pH, electrical conductivity (EC), total dissolved solids (TDS),totalalkalinity(TA),total hardness(TH), dissolved oxygen(DO), microbial analysis (MA), nitrate (NO_3^-), phosphate (PO_4^{3-}), ammonia(NH_3), sulphate(SO_4^{2-}), chloride(Cl^-), iron(Fe^{2+}/Fe^{3+}), phosphorus(P) anddissolved solids(DS) . The obtained values of the hydrochemical characteristic of lake water have been compared with the world health organization(WHO). The presence of phosphate concentration andthe hardnessinPhewalake is higher than the WHO value indicating the problem of rapid eutrophication. This indicates that Phewa lake water has more magnesium and calcium soluble salt. Thus, the rapid eutrophication and higher concentration of organic matter could be a serious problem for lake sustainability. Various types of natural and anthropogenic activities like agricultural runoff, urbanization, discharge of domestic sewage, solid waste dump, and industrial effluent are the major problem for lake sustainability.

Keywords: *Hydrochemical parameters, pollution, eutrophication, water quality, sustainability.*

Introduction

The city of Pokhara is one of the largest cities in Nepal and is also known as a lake city because of its nine lakes viz.,Phewa, Begnas, Rupa, Khaste, Dipang, Gude, Neuroni, Maidi, Kamal Pokhari. Among them, Phewa Lake is one of the major tourist destinations. It is the source of fresh water and its wetland is assumed a single ecology.Phewalake is the largest lake inthe Gandaki zone and the second largest lake in Nepal. It is situated at the height of 742 m and it expands an area of about 5.23 km^2 with the largest depth of 24m[1]. It receives the water from tributaries and most of its volume expands during the monsoon season[2]. The chemistry of fresh water is influenced by both natural and artificial factors. The natural factor comprises precipitation, rock weathering, and evo-crystallization likewise artificial factor are agricultural run-off, and domestic and municipal emissions [3].The increase in inhabitants and rate of urbanizationin the lakes has many difficulties like water quality decline, sedimentation, siltation, and eutrophication are the result of germination of various macrophytes[4].The wetland ecosystem playsa vital role in the conservation and sustainable management of natural resources because it has attractive biodiversity[5].Emission of domestic garbage,fertilizer, and pesticides used in the farming fieldand other solid decay dumps can be the main issue for lake sustainability [6].This research was conducted to investigate the present status of hydrochemical parameters of Phewa Lake

and supposed to be a reference to future researchers for the sustainable management of water quality.

Material and Methods

Study Area: The Phewa Lake is one of the most important lentic ecological features, situated in the mid-hills (28°12'N, 82°56'E) at an altitude of 782m in the Gandaki Province, Nepal. It has a surface area of 4.35 km^2 and a maximum depth of 24m. Phewa lake is the biggest lake among the nine lakes inPokhara valleywith acatchment area of 110Km^2[7].

Sample Collection: The samples were collected in aclean sample bottlesfrom different places of Phewalake based on depth and situation of surrounding sites. pH, transparency, dissolved oxygen(DO), and the temperature were measured on-site of the lake andanotherparameters were examined in the chemistry laboratory within four hours of sample collection.

Hydrochemical Analysis: The hydrochemical characteristics were evaluated by standard operation procedure (SOP) to know the water quality of the lake.The temperature,P^H, EC, and transparency were measured with their respective quality monitoring instruments. TDS and DS were measured by filtration and evaporation methods. The chloride amount was measured by the Argenometric titration method, dissolved oxygen (DO) by the Winkler method, and total alkalinity (TA) by the double indicator method. The phosphate, nitrate, sulphate, ammonia, and iron were measured by using a spectrophotometer with their respective stock solution and chemicals. Potassium amount was measured by flame photometer and microbial analysis was done with the help of most probable number(MPN) method.

Table 1: *Methods Used for the Determination of Hydrochemical Parameters*

Parameters	Method employed
Transparency	Secchi Disc Method
Temperature	Standard Mercury Thermometer
Dissolved oxygen	Winkler's iodometric titration method
pH	Microprocessor pH meter
Total Alkalinity	Titration method
Total Hardness	EDTA Titration method
Total solid	Evaporation method
Total dissolved solids	Evaporation and filtration
Calcium	Titration method
Magnesium	Titration method
Chloride	Argenometric titration method
Conductivity	Conductivity meter
Phosphate	Ammonium moly bade method
Nitrate	Phenol Di-sulphonic Acid Method
Sulphate	Barium Chloride Method
Iron	Potassium Thiocyanate method
Ammonia	Sodium Nitroprusside
Potassium	Flame photometer
Microbial Analysis	MPN Method

Figure 1: *Geographical view of Phewa Lake*

Result and Discussion

The summary of measured hydrochemical parameters of the water in the Phewa lake of Pokhara is presented in Table 2. The results are then compared with WHO guideline values.

Table 2: *The result obtained from the analysis of water samples of Phewa Lake.*

Parameters	min	max	Mean	WHO standards (2020)
Transparency(cm)	130	200	152	100.0
Temperature(^{0}c)	21	23	22.1	12-25
ECµs/cm	32	48	38.6	400.0
Total alkalinity (mg/L)	40	150	63	100.0
TDS (mg/L)	30	80	55	500-1000
TS	100	220	146	150.0
DO (mg\L)	4.0	7.0	5.42	5.0
pH	5.05	6.43	7.091	6.5-8.5
Chloride (mg\L)	7.1	21.3	14.2	250.0
Total hardness (mg\L)	120	174	152.6	50.0
Calcium (mg\L)	17.635	52.104	32.305	10.0
Magnesium (mg\L)	9.746	29.238	17.543	5.0
phosphate(mg\L)	0.0025	0.0042	0.0036	0.02
Nitrate (mg\L)	21.407	33.688	27.156	50.0
Ammonia (mg\L)	0.0025	0.0350	0.0174	1.5
Iron (mg\L)	0.269	0.754	0.473	0.3
Sulphate (mg\L)	0.123	7.639	2.243	2.5
Potassium (mg\L)	0.86	2.1	1.121	2.0

The result showed that the water temperature was recorded in the range of 21 °C to 23 °C. The temperature playsa vital role inthe regulation of hydrochemical and biological activities in the aquatic surrounding[8].The increase in temperature causes high interaction of different components as a result quality of water declines [9]. P^H is another important characteristic of water thatreflect the suitability of water for drinking and other purposes. P^H of Phewalakeis in the range of 5.05 to 6.43whichis found within the guideline as recommended by WHO. The value of the transparency range was from 130cm - 200cm. The transparency of lake water showed that it was not very dirty that supports the aquatic lives.

The dissolved oxygen (DO) observed during the study period was slightly less or above or the same at different sites as the minimum permitted level of 5.0 mg/L (WHO, 2008). The DO range was from 4.0 mg/L to 7.0 mg/L. The DO value is very important for aquatic life so this value is suitable for aquatic organisms.The alkalinity of the water sample was due to the presence of carbonates, bicarbonates, and hydroxide ions in it. The present study showed that the total alkalinity of PhewaLake was found in the range of40 to 150 mg/L indicatingthe presence of carbonateand bicarbonates in the lake water. Total hardness of the water is in the range of 120-174mg/L.which is dependent upon the alkaline earth metals mainly calcium and magnesium salt dissolved in water[10].The value of hardness is within a WHO guideline but a little bit high is a sign of the water sample contains more amount of calcium and magnesium water-soluble contents. Electrical conductivity is the measure of the capacity of the aqueous solution to carry an electrical current and is based on total strength, mobility, and temperature. The range of EC in the present study of Phewalakeis 32-48 with the average of 38.6. TDS of the lake was found to be in the range of 30-80 mg/L. The variety of natural and human-induced pollutants causes an increase in TDS levels.

If the TDS value is higher it is dangerous to both humans and aquatic organisms.The water sample containsa maximum level of TDSsuch as water consumption humans are the victims of kidney and heart disease[11]. The chloride concentration of this lake was in the range of 7.1-21.3 mg/L which is within a WHO guideline.It is assumed that if chloride strength is more than 200 mg\L it is dangerous for human utilization as a result unpleasant taste of water[12]. The microbial analysis of the lake water sample was done by the most probable number(MPN) method. The microbial analysis of the water sample showed that this lake water containsa coliform group of bacteria.The sample was contaminated by coliform but no fecal coliform was detected. The presence of coliform indicates that there might be a presence of other enteric pathogen which may cause the enteric disease and such water are not suitable for consumption.

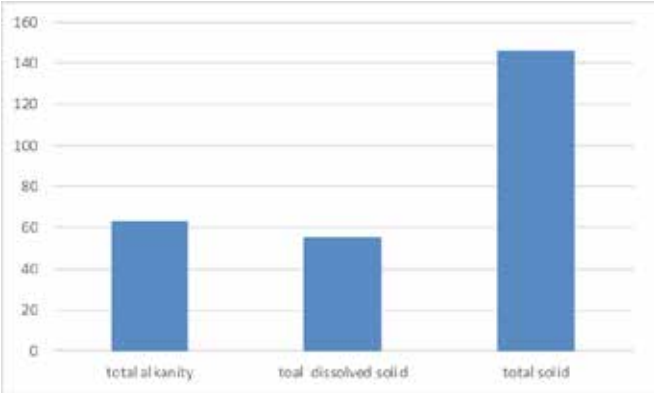

Figure 2: *Concentration of TA, TDS, TS in Phewa Lake*

The total ammonia content in the water sample was 0.0025-0.035 mg\L which is within a WHO guideline value. Higher concentration of ammonia will be a risk to human health like vomiting and gastric problem and also for aquatic organisms [13]. The high content of ammonia is due to the natural degradation of organic matter and sewage contamination. The concentration of phosphate was found to be 0.0025-0.0042 mg\L which is higher than WHO guidelines for drinking water which may be due to rapid acidification. The strength of nitrate concentration in lake water was found to be in the range of 21.40-33.68 mg/L. The present study showed that the nitrate concentration is high because of discharge of domestic run-off, and run-off from agriculture. The potassium concentration of the lake water sample was 0.86-2.1 mg\L.The adverse effect can also occur when the strength of potassium plasma is lower (hypokalemia)than the normal range (3.5-5.0 mmol/L).The sulphate concentration was in the range of 0.123 to 7.639 mg\L. The rise in strength of dissolved phosphate, nitrate, and sulphate over the period indicates the presence of these nutrients from artificial resources [14]. The level of iron was found in the range of 0.269-0.754 mg\L. Iron is present in water in two forms ferrous iron which is soluble in water and ferric iron which is insoluble in water.The presence of 0.3 ppm iron or more in lake water may be rusty red or brown color causingadverse effects on health. In the present study it is found that iron concentration was slightly higher than the WHO standard value. This is a sign that water containsiron-bearing soil and rock and iron dissolved into water consequent poor water quality. Thermodynamically, in natural water bodies and reservoirs,iron(II) is normally oxidized to iron(III) pH>6.5.However, soluble iron contains high molecular weight and occurs in complex forms[15].

Conclusion

The study of the hydrochemical parameters is carried out in Phewalake of Pokhara, Nepal. Considering the importance of water quality in the aquatic environment, the study focuses on the assessment of hydrochemical characteristics of the waters in Pokhara.The result indicated that the water quality of Phewa lake is more polluted both in the winter and summer seasons.Some of the parameters like phosphate and hardness areless or slightly higher than WHO guidelines value of drinking water. The pH values are frequently changed by the presence of organic and inorganic solid garbage together with the reaction of carbon dioxide. The phosphate and nitrate concentration of the Phewalake in the present study shows that these elements are slightly higher causing rapid eutrophication because of human activities toward the lake. The hardness of the lake water was found slightly higher, indicating the excessive presence of alkaline earth metals like calcium and magnesium water-soluble salts. Large strength of organic pollution and the rapid acidification process could be the issue threats that should be considered by the concerned organizations for the sustainability of the lakes. However, based onhydrochemical features ofthe lake that were found in an ecologically acceptable situation, water is fairly suitable for aquaculture and irrigation. This lake water is mildlypolluted and there is the possibility of aquatic life. Moreover, the rapid urbanization and discharge of domestic waste, and industrial sewage into the lake would be the other main threats to the sustainability of the lake. It is, therefore, regular monitoring of watershed and aquatic environment becomes essential to maintain their quality.

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