Research Article

Water Quality Parameters of Rupa Lake in Pokhara, Nepal

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ABSTRACT

In this study, physical and biochemical water quality parameters are analyzed from five selected stations in Rupa Lake Pokhara, Nepal using standard procedures. Analyzed parameters are: temperature, turbidity, total solids (TS), electrical conductivity (EC), pH, total alkalinity (TA), total hardness (TH), chloride content, sulphate and dissolved oxygen (DO). Based on the observed water quality parameters, the quality of Rupa Lake water is discussed and compared with WHO standard values for drinking water. Recorded laboratory results shows that water of Rupa Lake is useful for agricultural, industrial, aquatic life, and fishery purposes.

Keywords: *Dissolved oxygen, Nephelometer, Rupa Lake, total hardness, water quality Parameters*

INTRODUCTION

Water is the very important natural resource required for sustaining human and all living organism. It covers approximately 70% mass of human body. A state of deviation of water from the pure condition is known as water pollution (De, 2018). Polluted water contains unwanted physical, chemical, biological or radio chemical substances (Omer, 2019). The sources of fresh water are polluting day by day due to increasing population growth, rapid urbanization in developing countries and increasing world environmental pollution. As a result risk is growing to public health, food security, biodiversity, ecosystem services etc. (WHO, 2019). Water quality parameters: physical, chemical and biological mainly determine the quality of water. Physical parameters are turbidity, temperature, colour, taste and order, solids, and electrical conductivity (EC). Chemical parameters comprise pH, acidity, alkalinity, hardness, chloride, ammonia, chlorine residual, sulphate, fluoride, nitrogen, iron, manganese, copper, zinc, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), toxic inorganic and organic substances, radioactive substances etc. Biological parameters are pathogens (bacteria, helminths viruses, protozoa etc), total E -Coli, Plankton,

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algae, rutifers etc. (Omer, 2019; Khopkar, 2011). Regular monitoring of lake water quality parameters becomes important to find out its pollution condition and to specify its application for aquatic life, animal farming, fisheries, irrigation and recreation.

Lekhnath area of Pokhara (Old Lekhnath municipality) is known as city of seven lakes: Begnas, Rupa, Khaste, Dipang, Maidi, Gunde, and Nyureni. Rupa Lakes is the third largest lake among the eight lakes in Pokhara metropolitan, Kaski, Nepal. Rupa is fresh water lake with relatively low population density around it. The main occupation of local residential people is agriculture and animal farming, fisheries, fishing, boating, business including hotel and restaurant. Rupa Lake is also polluting day by day due to urbanization, agriculture and animal farming, natural erosion and sedimentation, construction of road and fisheries inside lake area. The main objective of the study was to study the water quality parameters of Rupa Lake, Pokhara Nepal. These parameters were temperature, turbidity (clearity), electrical conductivity (EC), total solid (TS), pH, total hardness (TH), dissolved oxygen (DO), chloride, and total alkalinity. Water samples were collected from five sites of Rupa Lake in March first, 2023 and were analyzed in chemistry research laboratory of Prithvi Narayan Campus (T.U.), Pokhara for water quality parameters. Analyzed result showed that most of the parameters remain within the recommended limit of World Health Organization (WHO).

Thousands of studies have been conducted to study the physicochemical parameters of ground water and surface water including lakes, ponds, streams, rivers etc. by many researchers but only less number of studies related to water quality parameters of Rupa Lake were observed from the literature. Thus the study of water quality parameters of Rupa Lake becomes essential. Shukla et al. (2013) have carried out the physicochemical analysis of water from four lakes: Kankariya, Vastrapur, Malav and Chandola located in Ahmadabad city in which turbidity, TDS, DO, dissolved CO_2, alkalinity, chloride, calcium, magnesium, total hardness, copper and sulphate ranges from 4 to 11 NTU, 668 - 942 ppm, 4.4 - 5.9 ppm, 6.1 - 7.0 ppm, 150 - 170 ppm, 60 - 84 ppm, 67 - 73 ppm, 7.8 - 32 ppm, 279 - 343 ppm, 15.27 - 19.76 ppm, and 61 - 74 ppm respectively. Pant et al. (2019) carried out the study on the water quality assessment of Begnas and Rupa Lake in Pokhara, Nepal and presented the recorded values for pH, NH_3 – N, DO, BOD, total hardness, EC, TDS, chloride nitrate and phosphate (Table 1). Keremah et al. (2014) had conducted the physicochemical research of fish ponds water in fresh water of 5 local government area of Bayelsa state, Nigeria and presented the results (Table 1). In 2013, Jadhav et al. conducted the study for physicochemical parameters of drinking water from natural resources: Shelar Lake, Kawal Lake and explored the analyzed values (Table 1).

Similarly, Shawnigan Lake water quality assessment had been carried out by Rieberger et al. (2004) and compared with WHO standard values (Table 1). Shrivastava and Kanungo (2013) reported the physicochemical parameters of 10 ponds water of Surguja district (from 2009 to 2010) by comparing with each other and standard values (Table 1)

Table 1

WHO Standard Water Quality Parameters and Recorded Parameters from Different

Parameters	WHO Standard Values (Desirable Range)	Values from Different sources						
		Ponds Water (Surguja District)	Begnas Lake	Rupa Lakes	Shelar Lake	Kawad Lake	Snwnigan Lake	Fish Pond Water
Temperature (oC) PH	< 35 (20 –30) 6.5– 8.5 (6.5 – 9)	17.57-31.2 6.93 - 7.55	26.73 9.04	25.45 7.87	31.4 7.5	31.9 7.2	- 7.4	24.9 - 25.3 6.24-6.68
Dissolved NH3(mg/l)	0.2 (0.0125 – 0.2)	0.34 - 0.55	0.1	0.17	-	-	0.015	
DO (mg/l)	8 – 10 (5.0 – Saturation)	2.43 - 4.45	6.46	6.7	6.12	6.41	-	2.8 - 6.6
BDO (mg/l)	10 (0.29)	4.22 - 7.23	26.28	53.83	-	-	-	2.9- 4.52
Total alkalinity (mg/l)	1.0 (50 – 400)	134.7-205.00	-	-	-	-	4.5	43.1-93.7
COD (mg/l)	-	9.15 - 18.00	-	-	18.2	24.14	-	-
Turbidity (NTU or ppm)	£ 0.2 (£ 0.5)	-	-	-	18	4	0.49	20.6 - 45.1
Total hardness (mg/l)	200 (50 – 400)	138.12 - 219.37	13.75	16.53	10.48	10.45	20.5	19.7-44.3
EC (µS cm–1)	400 (20 – 1500)	115.11-212.13	35.76	52.33	8.13	8.03	6.1	117.3 - 378.4
TDS (mg/l)	- (500 mg/l)	152.12 - 265.97	25.42	36.7	-	-	-	27.9-145.4
Chlorine (mg/l)	5	-	-	-	-	-	-	-
Chloride (mg/l)	250 (600)	21.46 - 49.97	20.4	16.52	482.3	506.2	-	-
SO4– –(mg/l)	250	-	-	-	6.17	4.22	-	-
NO3– – (mg/l)	50	-	1.77	2.46	13	18	-	-
Total N (mg/l)	12.21	-	-	-	-	-	0.187	-

Sources: Literature Review

DATA AND METHODS

Study Area and Sampling Sites

Rupa Lake (Rupa Tal), a fresh water lake, is located between Pokhara metropolitan-31, 32 and Rupa rural municipality, Kaski district, Nepal. It is a medium size lake, but third biggest lake in Pokhara valley, situated at an elevation of almost 624 meter above the mean Sea level with an average water depth from 3 m to 6 m. The study area is located between 84^0 06' 18'' and 84^0 07'21'' east longitude, and 28^0 08'38'' and 28^0 09'57'' north latitude. The maximum east-west breadth is about 854 meter and that of north to south 2766 meter. Five stations are selected for collecting the water samples to study water quality parameter as listed in table 2 and figure 1.

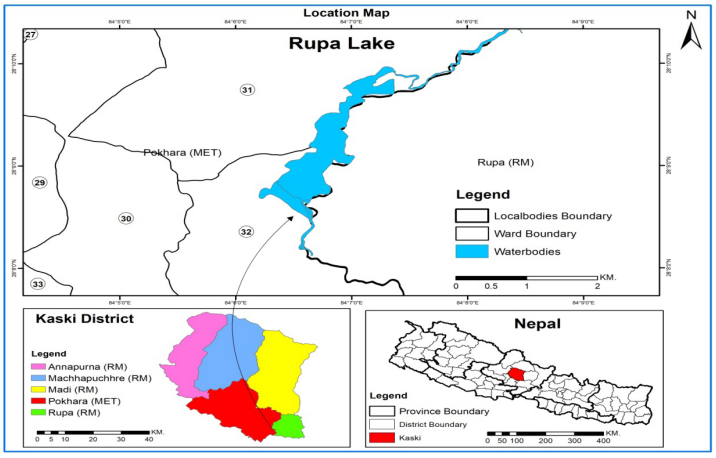
Table 2

Water Sample Stations in Rupa Lake

Station No.	Location of Station	Station Description
1	East perimeter	East end of the lake between phapretar and Jamunkuna of Rupa Rural Municipality
2.	West perimeter	West end of the lake near north north-east end of Pokhara Zoological park
3.	Inflow site	North-east inflow of the lake near Paddy field
4.	Outflow site	South flow end of the lake near Bhimsendanda
5	Centre of the lake	Approximately centre and deepest site of the lake water Between Jamunkuna and Pokhara Zoological park.

Figure 1

Location Map of Rupa Lake in Pokhara, Nepal



Simple Collection

Water samples from five selected stations in Rupa Lake were collected by using glass bottles of one-liter capacity at the depth 10 cm from the surface of water early in the morning of first March, 2023. Maximum photosynthetic activity of primary fish food were observed in this layer and in the early morning hour dissolved DO and CO_2 values remain in critical concentrations. Before sample collection, glass bottle and lead was sterilized by boiling first and then rinsed with water of sampling stations. Collected samples were stored in chemistry research laboratory of Prithvi Narayan Campus at required temperature (4^oC) in dark. Estimation of DO, and pH were carried out within a few hours of sample collection and other experiments were carried out within 2 days of sample collection.

Analysis of Water Quality Parameters

Determination of Temperature: Temperature of different water samples was determined by using digital thermometer directly in the sample stations and expressed in degree Celsius.

Determination of Relative Turbidity: Turbidity (Cloudiness) of water is measured by nephelometric turbidimeter and expressed in nephelometric turbidity unit (NTU) (Omer, 2019; Khopkar, 2012). One NTU is equivalent to 1 mg/l of silica in suspension (APHA, 2005).

Determination of Total Solid (TS): Total solid (Total suspended solid + total dissolved solid) was determined by gravimetric method of analysis. Known volume of water was heated in a porcelain dish to dryness and then in muffle furnace at 105^oC for an hour to get constant weight and expressed in mg/l.

Determination of Electrical Conductivity (EC): EC of lake water samples was determined by using calibrated digital conductivity meter with cell (glass electrode) and expressed in $\mu S\ cm^{-1}$ unit (APHA, 2005).

Determination of pH: The negative common logarithm of hydrogen ion concentration is known as pH and used to indicate the strength of acidic or basic solution. (Spellman, 2017; Omer 2019). pH varies with temperature of water. pH of Lake water samples was measured by using calibrated digital pH meter.

Determination of Total Alkalinity: Total alkalinity of Lake water samples was determined by double indicator (phenolphthalein and methyl orange) titration method with standard sulphuric acid in which OH^-, HCO_3^- and CO_3^{--} are completely neutralized. It is expressed in mg/l as $CaCO_3$.

Estimation of Total Hardness: Total hardness of lake water was estimated by

complexometric titration with ethylene diamminetetraacetic acid (EDTA) at required pH in presence of indicator Eriochrome Black-T and expressed in terms of mg/l as $CaCO_3$ (Vogel, 1994). At the end point, the color of indicator changes from wine red to blue. It gives total Ca^{++} and Mg^{++} ions.

1 ml of 0.01 M EDTA ≡ 1.0 mg $CaCO_3$

Determination of Chloride: Chloride content of lake water was determined by titration with standard silver nitrate solution using K_2CrO_4 as an indicator. At the end point, permanent reddish tinge (Ag_2CrO_4) was observed (Mohr's method).

1 ml of 0.282N $AgNO_3$ = 1 mg Cl^-.

For estimation of smaller quantity of chloride (< 0.15 mg/l), potentiometric titration with $AgNO_3$ solution is used in glass and silver-silver chloride electrode system (De, 2018).

Determination of Sulphate: The amount of sulphate ions present in the water samples was determined by gravimetric method or an indirect titration method with EDTA solution, known volume of $BaCl_2$ (25ml, 0.01M) was added to the fixed volume (e.g. 10 ml) lake water sample to get ppt of $BaSO_4$. The excess of Ba^{++}ions in solution was determined by titrating with standard (0.05 M) EDTA solution. Near the end point, 5.0 ml of 0.01M $MgCl_2$ was added to detect the clear end point (Stirling, 1985; Ganeshalingam, 2012).

1 mole of EDTA = 1 mole of Ba^{++} = 1 mole SO_4^{--}

1 ml of 0.05 M EDTA = 4.8035 mg SO_4^{--}

Estimation of DO: DO concentration in water was determined by Winkler titration mention. In this method, DO is allowed to react with KI to liberate I_2 which intern treated with standard $Na_2S_2O_3$ solution. The amount of iodine consumed represents the DO used in Oxidation. The reaction rate can be increased by the addition of Mn(II) salt in strong alkaline medium (De, 2010).

$$Mn^{2+} + \frac{11}{22} O_2 + 2OH^- \rightarrow MnO_2 \downarrow + H_2O$$

$$MnO_2 + 2I^- + 4H^+ \rightarrow Mn^{2+} + I_2 + 2H_2O$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

1 ml of 0.025 M $Na_2S_2O_3$ = 1 mg/l DO

RESULTS AND DISCUSSION

The analyzed water quality parameters of water from Rupa Lake and WHO recommended standard values for drinking water are listed in the following table.

Table 3

Laboratory Result of Determined Water Quality Parameters of Rupa Lake

Parameters	East Perimeter	West Perimeter	Inflow Site	Outflow Site	Centre of the Lake	Mean Value	SD	WHO Standard Values
Temperature	18.5	19.0	18.5	19.2	19.0	18.88	2.25	<35 (20-30oC)
Turbidity	1.0	0.9	0.5	0.8	0.8	0.8	0.01	£ 0.2
Total solids (TS)	149.87	129.00	128.50	142.33	126.15	135.17	8.23	500
Electrical Conductivity (EC)	190.46	190.00	221.30	165.50	192.00	191.85	25.68	400 (20-1500)
PH	7.35	7.10	7.2	7.2	7.2	7.21	1.97	6.5-8.5
Total Alkalinity (TA)	65.0	78.0	451.0	53	51	44.6	6.35	1.0 (50-400)
Total Hardness (TH)	54.0	51.0	62.0	60.0	60.0	57.4	3.39	200
Chloride content	105.0	89.0	97.0	87.0	92.0	94.0	7.64	250
Sulphate	57.642	48.035	67.249	52.838	57.624	56.277	6.98	250
Dissolved Oxygen (DO)	7.0	6.0	8.0	7.0	8.0	7.2	1.05	8-10

Note: All the parameters are expressed in mg/l except pH, EC (µS/cm), turbidity (NTU) and Temperature (^oC). Acceptable values of WHO are given within bracket.

Table 3 clearly represents the results of ten water quality parameters: temperature, turbidity, total solids, EC, pH, TA, TH, chloride content, sulphate and DO as determined by using standard methods for water of Rupa Lake as well as WHO standard values for drinking water.

Figure 2

Comparison of Observed Water Quality Parameters: TS, EC, TA, TH, Chloride and Sulphate of Rupa Lake with WHO Standard Values Graphically

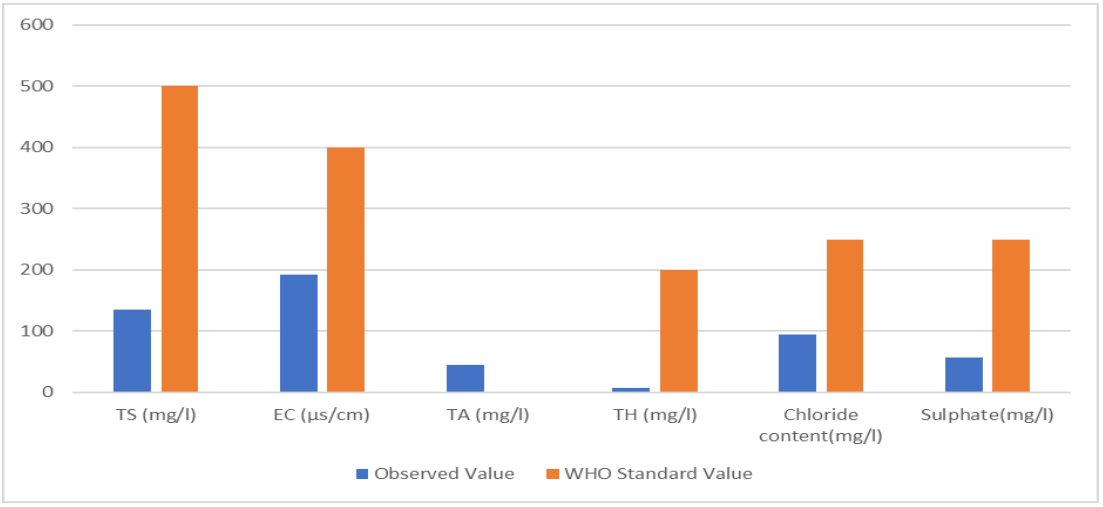
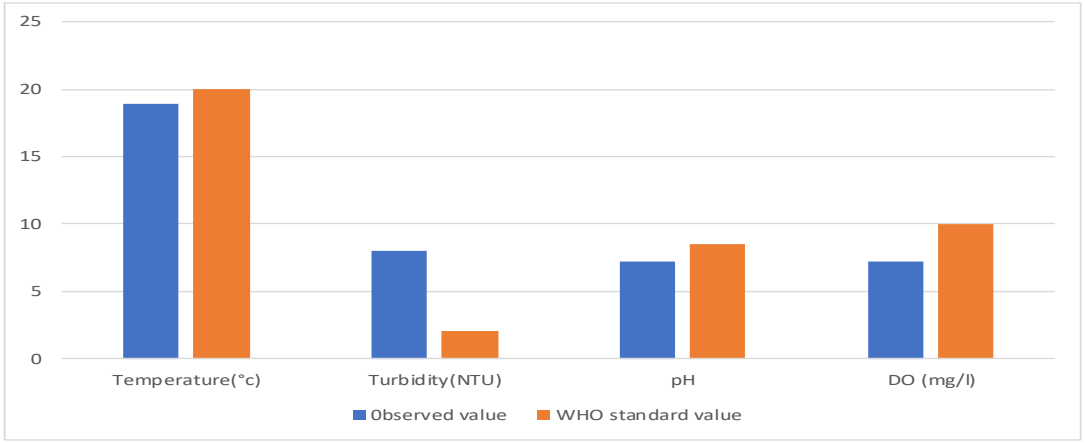


Figure 2 shows the mean values of experimentally analyzed mean water quality parameters: TS, EC, TA, TH, chloride, sulphate, and their respective WHO standard values for drinking water. Observed value of TS, TH, chloride content and sulphate is less than WHO values but EC, and TA is within the permissible limits.

Figure 3

Comparison of Observed Water Quality Parameters: Temperature, Turbidity, pH, and DO of Rupa Lake with WHO Standard Values Graphically



Note: In figure scale of turbidity is 10 times of observed value

Figure 3 expresses the mean values of experimentally analyzed mean water quality parameters: Temperature, Turbidity, pH, and DO and their respective WHO standard values for drinking water. Recorder temperature is less than permissible minimum value, turbidity is much more, pH is in between permissible value of WHO, dissolved oxygen is less than recommended minimum value of WHO.

The experimental results of water quality parameters of five different stations in Rupa Lake water have been summarized in table 3 and interpretation of data has been made by comparing with WHO standard values for drinking water. The temperature of different stations in Rupa Lake ranged from 18.5^0C (for east perimeter and inflow station) to 19.2^0C (for outflow station) with mean value of 18.88 indicating relatively low temperature than that prescribed by WHO values for drinking water. Temperature of lake water depends on the factors: air temperature and humidity, surface area of lake water, amount of solar radiation, turbulence of water and air above water surface, geological and geographical situation of lake etc. The odour, solubility, viscosity, palatability, chemical reactions, sedimentation and chlorination process, DO, BOD, biosorption of heavy metal in lake water are influence by temperature (Omer, 2019). Growth of micro-organism in water increases with increasing the temperature of lake water. Turbidity (cloudiness) of water measures the ability of light to pass through the water. It is due to presence of suspended materials like mud, clay, slit, chemical precipitates, organic material, plankton and other particulate materials in lake water. Turbidity of water sample from east perimeter is maximum (1.0 NTU) followed by west perimeter (0.9 NTU), centre of the lake (0.8 NTU) = Outflow site (0.8 NTU), and inflow site (0.5 NTU) with mean value of 0.8 NTU. All these observed values are greater than that of WHO standard value (0.2 for drinking water. Total Solids (TS) in water is the sum of total suspended solid (TSS) and total dissolved solid (TDS). TS in lake water originate from natural sources, sewages, urban runoff, industrial waste and organic matters. In the present study, experimentally observed mean TS value was 135.17 mg/l ranging from 126.15 (for centre station) to 149.87 mg/l (for east perimeter station). All these values are below WHO referred TS values for drinking water (500 ppm) (Ganeshalingam, 2013). The notable observed solid in Rupa Lake waste may be due to slow rate of flow of water from inflow to outflow sites. TS have no direct health effect and no health based guideline value for it. Observed data of turbidity and TS showed that these values were accumulated around the dense residential and fishery area.

Electrical conductivity (EC) of solution is its capacity to conduct electrical current. EC of water increases with increasing concentration of conducting ions: Ca^{++}, Mg^{++}, Na^{+}, K^{+},

HCO_3^-, Cl^-, H^+, NH_4^+, NO_3^-, I^- etc in water. Analyzed EC increases from minimum165.5 µS/cm (for outflow station) to maximum value 221.3 µS/cm (for inflow station) and mean value 191.85 µS/cm. These values fall within the permissible limit of WHO values for drinking water as presented in table 1 and 3. EC values of water vary with nature of ions, concentration of ions, ionic strength and temperature of water. The result showed that overall less electrical conductivity of Rupa Lake is due to less polluted water and relatively more EC at inflow station among the five stations is due to source of ground water. Acidic, basic or neutral nature of lake water is indicated by its PH values. pH 7 indicates neutral water, pH > 7 shows alkaline water and pH < 7 expresses that acidic water. Analyzed PH value of water sample (Table 3) was ranged from 7.10 (for west perimeter station) to 7.35 (for east perimeter station) indicating slightly alkaline nature of water but these analyzed values are within the WHO recommended range for drinking water (6.5–8.5) and favorable for domestic use and living organism need (WHO, 2011). pH has no direct impact on consumers but it is one of the most important operational water quality parameter. Aquatic plants and animals require specific pH and highly affected by slight change of pH; low pH decreases the fishes and aquatic insects; very low and high pH is fatal and only few animals can exist at pH < 3 and > 11(Omer, 2010). Total alkalinity is the capacity of solution to neutralized acid at designated pH and it is due to presence of OH^-, HCO_3^- and CO_3^{--} or mixture of two of these two ions (Khopkar, 2011). Total alkalinity of water sample for Rupa Lake was observed from 41.0 mg/l (for inflow station) to 78.0 mg/l (for west perimeter station with mean value of 44.6 mg/l. These values are within the acceptable range of WHO (50 - 400 mg/l) and pH is favorable for growth of phytoplankton like green algae, cyanobactera etc. Alkalinity or acidity of aquatic water remains almost constant due to buffer action.

Total hardness of water is due to presence of carbonate, bicarbonate, sulphate and chlorides of polyvalent, metallic ions mainly calcium and magnesium. Thus, total hardness represents the sum of calcium ion and magnesium ion in mg/l as $CaCO_3$. Experimentally, recorded hardness varied from 51.0 (for west perimeter station) to 62.0 mg/l (for inflow station) having mean value 57.40 mg/l in Rupa Lake water which falls within the WHO acceptable values (50 - 400 mg/l). Based on the analyzed data, water of Rupa lake is moderately hard (hardness; 50 - 150 mg/l as $CaCO_3$). The range for soft water is < 50, hard water = 150 - 300 and for very hard water is > 300 mg /l as $CaCO_3$. Hard water provides nutrient elements for plants but creates scale in boilers, water heaters and pipes. Naturally occurring chloride enters in streams, lakes and ground water from chloride containing rocks, agricultural runoff, and waste water. Analyzed chloride content in Rupa Lake was observed from 87.0 (for outflow

station) to 105.0 mg/l (for east perimeter station) and mean value of 94.0 mg/l. These data are accepted by WHO recommended chloride content for drinking water (250 mg/l). Chloride is not harmful to public health, but high concentration causes an unpleasant salty taste and sodium part of table salt is connected to kidney and heart disease (WHO, 1996; Omer 2019). Sulphate ions in nature are originated from the oxidation of sulphide ores, weathering of gypsum and Epsom salts, leaching of sodium sulphate (Glauber's salt), industrial waste etc (Kudesia, 1998). Mean value of sulphate ions in the samples of Rupa Lake water was 56.277 mg/l and varied from 48.035 mg/l (for west perimeter station) to 67.249 mg/l (for inflow station) indicating low amount of sulphate than that recommended by WHO for drinking water (250 mg/l). WHO provides no health base guideline for sulphate and SO_4^{--} has no significant danger to public health but high concentration in drinking water produces objectionable taste and unwanted laxative effects (Ambasht, 2005). Dissolved Oxygen (DO) is the most important water quality parameter in lakes, streams, rivers and ponds. Higher the concentration of DO, better will the water quality and vice versa. In the present study, highest amount of DO was 8.0 mg/l for centre station followed by inflow station (8.0 mg/l), east perimeter station (7.0 mg/l) = outflow station (7.0 mg/l), and west perimeter station (6.0 mg/l) as recorded in the laboratory. Solubility of DO influences by temperature (At 0, 20 and 30^0 C, amount of DO is 14.6, 9, and 7 mg/l), pressure and salinity. Amount of DO in water depends on physical, chemical and biological activities of water body. Recorded values of DO are within the recommended values by WHO (5 mg/l to saturation). Oxygen depletion rate is increasing per year due to decreasing chlorophyll and increasing polluting agent in the surface water reservoirs including lakes.

Pollution of surface water is due to chemicals from agricultural activities, industrial and natural sources, water treatment materials, pesticides used in water for public health purposes, cyanobacterial toxins, soil erosion, dispersal of human and animal waste, and radiations from radioactive substances (UNICEF, 2008).

CONCLUSIONS

Water quality parameters of Rupa Lake water were determined by using standard methods. Most of the analyzed parameters are within the permissible limit of WHO for drinking water. From the laboratory results, Rupa Lake water can be described as slightly alkaline, turbid with notable amount of total solid and dissolved oxygen. Lake water appears to be suitable for aquatic life along with fishery and agricultural uses but not suitable for drinking purpose without treatment.

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