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Research Article

Assessing Physico-Chemical Parameters of Drinking Water in Majkhola, Tansen, Palpa

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Abstract

Water is an important component of the ecosystem that sustains life on the planet since water provides vital components for human health. To gain a precise picture of water quality, studies of the components found in the water are critical. Three physical and six chemical criteria were examined to assess the quality assurance of drinking water of Majkhola. All tests were carried out according to the protocols outlined in the standard methodology. For this investigation, four water samples were collected in the morning from different areas of Majhkhola throughout three months, from December 2018 to February 2019. The purpose of this study was to evaluate the water quality parameters. pH (6.85 – 8.5), Conductivity (72.3 – 79.9 μm/s), Alkalinity (37.84 – 39.27 mg/L), Chloride (2.509 – 3.76 mg/L), Dissolves Oxygen (DO) (0.8 – 1.3 mg/L), Hardness (60 – 72 mg/L) and Total Dissolved Solids (100 – 150 mg/L) of water samples values lay within the permissible guideline values as prescribed by WHO and national standard but temperature (18 – 21°C) of water samples crossed the WHO permissible value and there is no prescribed limit of free CO_2 (2 – 4) mg/L) in WHO. These metrics' values in the research area suggest that water samples are within normal or acceptable limits. As a result, water is safe to drink and meets local and international physical and chemical criteria to preserve excellent health. Based on the findings, it was concluded that the current study's findings are highly encouraging and reflect the health status of Majkhola's water area.

Keywords: Majkhola; NDWQS; Physico-chemical parameters; Water Quality; WHO guideline values

Introduction

Water is one of the most necessities, and obtaining safe drinking water is a serious concern for human health. 7 percent of the global burden of health problems is due to unsafe and insufficient drinking water, as well as poor cleanliness (Cairncross *et al.*, 2010). Because the health and well-being of the human race are inextricably linked to the quality of water utilized, water has a profound impact on human health, and the quality of the drinking water supplied is critical in deciding the health of people and the entire communities (Sharma *et al*., 2015; Javana *et al*., 2009). The importance of clean, safe water in preserving excellent health has long been acknowledged in underdeveloped countries like Nepal, the quality of drinking water is sometimes overlooked (Tamrakar *et al*., 2017).

The physical, chemical, and biological aspects of water are commonly used to characterize its quality (Gorde *et al*., 2013). Chemical factors are used to determine the presence of inorganic matter, soluble salts of organic matter in water, and physical characteristics are utilized to form an image and influence visual quality (Chen *et al*., 2013). According to WHO norms and NDWQS values, physicochemical parameters such as pH, temperature, hardness, alkalinity, CO_2, dissolved oxygen, total dissolved solids, chloride, and others were analyzed to determine the quality of water and indicate optimal production at optimum levels (Uddin *et al*., 2014; Verma *et al*., 2015; Shakya *et al*., 2012; Yadav *et al*., 2015). NDWQS and WHO publish guidelines that describe realistic minimum standards of safe practice to protect consumers' health and/or derive numerical "guideline values" for water constituents and water quality indicators (Qureshimatva *et al*., 2015; Aryal *et al*., 2012; WHO, 1996). The criteria and heavy metals used in water testing are solely determined by the purpose for which the water will be used and the extent to which its quality and purity are required (Vaidya *et al*., 2017; Shrestha *et al*., 2017).

The purpose of this study is to determine the current state of Majkhola's water quality. The primary purpose of this study is to determine the quality of drinking water using physicochemical characteristics to ensure that the water is suitable for use in a drinking water monitoring system. The resulting result or value of parameters informs us about deteriorating water quality and the many types of threats posed by water contaminants. The study's goals are to assess the drinking water quality in the Majhkhola area and to raise public awareness about the water-borne problem.

Materials and Methods

Study Area

Palpa district, which is part of Province No. 5, is located in Nepal's Western Development Region's Lumbini zone. The district, which has Tansen as its headquarters, spans 1373 km^2 and is located in latitudes of 27°52'0" north and 83°29'0" east (Fig. 1). In the Lumbini Zone of Western Nepal, the Majkhola, a little river, flows inward no. 5, Dharampani of Tansen Municipality.

Fig. 1: Location of Majkhola, Tansen, Palpa. (Source: Google Map)

Selections of Sites

From December 2018 to February 2019, four samples represent two separate water source areas of the same river (mouth of a river), one from the collection reservoir and the other from the water supply pipe from which water is given through the pipeline to each and every individual residence.

Collection of Samples

One-liter plastic bottles were used to collect the water samples. They were thoroughly cleaned before being rinsed with sample water. The water samples were collected in one-liter bottles in the morning. The sample bottles were then labeled before moving on to the laboratory test procedure.

Physico-Chemical Parameters

Temperature, pH, Electrical Conductivity, Alkalinity, Total Hardness, Chloride, Dissolved Oxygen, Total Dissolved Solids, and CO_2 values of WHO recommendations and NDWQS were analyzed to evaluate the Physico-chemical characteristics of Majhkhola. pH, Temperature, and Electrical Conductivity were measured immediately in the study area, whereas other data were assessed in the Chemistry lab, Tribhuvan Multiple Campus, Tansen, Palpa (Table 1).

Determination of pH

An automatic digital pH meter was used to determine the pH. A standard buffer solution with pH 7.0 and 4.0 was used to calibrate the pH meter. After washing the gas electrode with distilled water, the sample water was added. After that, the glass electrode was dipped in the beaker containing the water sample until the reading steadied. The pH value was recorded in the notebook. All other samples' pH was tested in the same way. Before each measurement, the glass electrode was cleaned with distilled water and rinsed with sample water.

Determination of Temperature

Water was fetched from running water and placed in a beaker to determine the temperature. A mercury-filled Celsius thermometer was used to record the temperature at the site.

Determination of Electrical Conductivity

A conductivity meter was used to measure electrical conductivity. The sample water was added to another 100 mL of the beaker after rinsing the gas electrode and the 250 mL beaker with distilled water. The glass electrode was dipped in the beaker containing the water sample and held there until the reading stabilized at a predetermined point and readings were recorded.

Determination of Dissolved Oxygen

Preparation of N/80 of $Na_2S_2O_3.5H_2O$ solution:

In a 250 mL volumetric flask, 0.775 g of Na2S2O3.5H2O was weighed in a weighing machine, dissolved in distilled water with a few drops of 0.1N Na2CO3, and the volume was made up to the mark by adding distilled water.

Preparation of 50% $MnSO_4$ Solution:

The volume was made 100 mL in a 100 mL volumetric flask by weighing 50 g of $MnSO_4.5H_2O$ and dissolving it in distilled water.

Preparation of 20% Alkaline KI solution:

The volume was made 100 mL by adding distilled water after 49 g of NaOH, 20 g of KI, and 0.5 g of sodium azide were dissolved in distilled water.

Methodology

First and foremost, the sample was properly collected in a 250 mL BOD vial, avoiding any kind of bubbling and trapped it into the bottle. 5 mL of water was withdrawn from the bottle, 2 mL of manganese sulphate (50 percent $MnSO_4$) was poured from the bottle wall, and 2 mL of alkaline KI solution (20 percent KI) was added deep below the surface. A precipitate appeared. The stopper was then tightened, and the bottle was shaken frequently by inverting it to ensure thorough mixing of the contents. After allowing the precipitate to settle, the bottle was filled with 85 percent concentrated H_3PO_4 and shaken vigorously to dissolve all of the precipitates. Then, using starch as an indicator, 50 mL of sample was placed in a conical flask and titrated against a sodium thiosulphate ($Na_2S_2O_3$) solution of 0.0125 N strength. The original blue color had faded to a colorless state towards the end. DO is calculated adopting the following formula:

$$DO(mg/L) = \frac{(mL \times N) \text{ of Titrant} \times 8 \times 1000}{V_2 \times \frac{(V_1 - V)}{V_2}}$$

Where, V_1= volume of sample bottle after placing the stopper

V_2= volume of part of content titrated

V= volume of $MnSO_4$ and KI added

Determination of CO_2

Preparation of N/50 Oxalic Acid solution:

In a 250 mL volumetric flask, 0.315 g of $H_2C_2O_4.2H_2O$ was carefully weighed and dissolved, and the volume was made up to the mark by adding distilled water.

Preparation of N/40 NaOH solution:

0.25 g NaOH was weighed and dissolved in a 250 mL volumetric flask, then distilled water was added to make it up to the mark.

Standardization of N/40 NaOH solution with N/50 Oxalic acid:

10 mL of N/50 oxalic acid solution was pipetted out and poured in a 250 mL conical flask and one or two drops of phenolphthalein indicator were added. N/40 NaOH solution was taken in a burette and then titrated against this solution.

Preparation of N/50 NaOH solution:

N/50 NaOH solution was prepared by diluting the N/40 NaOH by adding distilled water to the desired mark in a 250 mL volumetric flask.

Methodology

Free CO_2 in water was determined by using the titration method. For this 50 mL of water sample was taken in a conical flask and two drops of phenolphthalein indicator were added. Then, using the burette, it was titrated against previously specified N/50 NaOH until the pink hue showed. The titration's end point was marked by a color shift. Free CO_2 calculated adopting the following formula:

$$\text{Free } CO_2 \text{ (mg/L)} = \frac{A \times \text{Normality of NaOH} \times 44 \times 1000}{\text{Volume of Sample in mL}}$$

Where, A= Volume of NaOH used in mL

Determination of Chloride

Preparation of Potassium Chromate Indicator solution:

In a small amount of distilled water, 5g potassium chromate was dissolved and silver nitrate solution was added till the formation of the red precipitate. After allowing the solution to stand for 12 hours, it was filtered and distilled water was used to get the volume up to 100 mL.

Standardization of N/50 $AgNO_3$ with N/50 NaCl solution:

10 mL of N/50 NaCl solution was pipetted out in a 250 mL conical flask and 1 mL of 2% K_2CrO_4 solution was added to this solution. $AgNO_3$ was taken in a burette and then titrated against this solution till a faint red color precipitate appeared.

Methodology

To proceed, fill the burette with standard $AgNO_3$ and titrate by adding 2 mL of 2% K_2CrO_4 to 50 mL of water sample until a faint red color precipitate emerged in the volumetric flask. It was noted how often $AgNO_3$ was required for this endpoint. The chloride was precipitated as silver chloride, and the titration was completed when the color of the potassium chromate indicator changed from yellow to pinkish yellow. Chloride calculated adopting the following formula:

$$\text{Chloride (mg/L)} = \frac{(a - b) \times N \times 35.5 \times 1000}{V}$$

Where, a= Volume of titrant (silver nitrate) for sample

b= Volume of titrant (silver nitrate) for blank

V= volume of the sample in mL

N= normality of silver nitrate

Table 1: Methods and instruments used for analyzing Physico-chemical parameters

S.N.	Parameters	Method	Instrument
1.	**Physical Parameters**		
A	pH	Potentiometry	pH meter
B	Temperature	_	Thermometer
C	Electrical Conductivity	Potentiometry	Conductivity meter
2.	**Chemical Parameters**		
A	Alkalinity	Tritrimetry	Burette, Pipette
B	Hardness	EDTA	Burette, Pipette
C	Chloride	Argentometry	Burette, Pipette
D	Dissolved Oxygen	Tritrimetry	Burette, Pipette
E	Total Dissolved Solid	Gravimetry	_
F	Free CO_2	Tritrimetry	Burette, Pipette

Determination of Alkalinity

Standardization of N/50 HCl with Na_2CO_3

In a 250 mL conical flask, 10 mL Na2CO3 solution was pipetted out and one or two drops of methyl orange indicator were added to this solution. The pink tint was achieved by titrating HCl against this solution in a burette.

Methodology

To begin, fill the burette halfway with normal acid and titrate it with 2 drops of phenolphthalein until the pink tint faded completely. The volume of acid required for this end point was recorded, and 2 drops of methyl orange were added to the same mixture, followed by another titration against standard acid until the yellow hue changed to pink. The amount of acid consumed was calculated for the second end point. Total Alkalinity calculated adopting the following formula:

$$\text{Total Alkalinity (mg/L)} = \frac{a \times N \times 1000 \times 50}{\text{ml of sample}}$$

Where, a= Volume of standard HCl consumed in titration

N= Normality of HCl used

Determination of Hardness

Preparation of 0.01N EDTA solution:

0.9306 g of EDTA was correctly weighed and dissolved in 500 mL of distilled water in a volumetric flask, and the volume was brought up to the mark with distilled water.

Methodology

Firstly, 50 mL water sample, 2 mL NH_4OH-NH_4Cl buffer solution, and a few drops of solochrome black T indicator were used to make the mixture. The mixture was then titrated against the burette's standard 0.01N EDTA solution until the wine red color turned blue at the end point. Total Hardness calculated adopting the following formula:

$$\text{Total Hardness (as } CaCO_3\text{, mg/L)} = \frac{\text{mL of EDTA Used} \times 1000}{\text{mL of Sample}}$$

Determination of Total Dissolved Solids

A clear dry beaker with a volume of 150 mL was weighted out. Then, 100 mL of water sample was then placed in a beaker and heated to the appropriate temperature until it entirely evaporated. The beaker was cooled and weighed after complete evaporation. The heating, cooling, and weighing process was repeated until the weight remained constant. Finally, the weight of the solids in the beaker was determined by subtracting the weight of the clean, empty beaker. Total Dissolved Solids calculated adopting the following formula:

$$\text{Dissolved Solids (mg/L)} = \frac{(A - B) \times 1000}{\text{mL of Sample}}$$

Where, A= weight of dried residue + beaker

B= weight of empty beaker

Results and Discussion

The Physico-chemical parameters such as pH, Temperature, Electrical Conductivity, Total Hardness, Chloride, Dissolved Oxygen, Total Dissolved Solids, CO_2 were analyzed in the water samples taken from Majkhola. Physicochemical parameter values for analyzed water samples were almost all within the NDWQS-2062. Table 2 shows the results of the physico-chemical parameters of Majkhola's drinking water quality.

Table 2: Physico-chemical parameters values for drinking water samples.

Test parameters	**Units**	**Experimental Range**	**WHO value**	**NDWQS**
pH	-	6.89-7.25	6.5- 8.5	6.5-8.5
Temperature	˚C	18-21	15	-
Conductivity	µs/cm	72.3-79.9	1500	1500
Alkalinity	mg/L	37.84- 44.27	200	-
Hardness	mg/L	60-72	200	500
Chloride	mg/L	2.51-3.76	250	250
Dissolved Oxygen	mg/L	0.8-1.3	>5	-
Total Dissolved Solids	mg/L	100-150	500	1000
Free CO_2	mg/L	2- 4	-	-

Temperature

Temperature is an essential water characteristic because it influences chemical and biological responses in aquatic organisms (Cairncross *et al*., 2010). The temperature of the water samples was determined to be between 18°C and 21°C. During the present investigation, there were no great differences between the temperatures of the four water samples. However, as shown in Fig. 2, none of these values are under the WHO criteria of 15°C. Water samples have values that are higher than those recommended by the WHO.

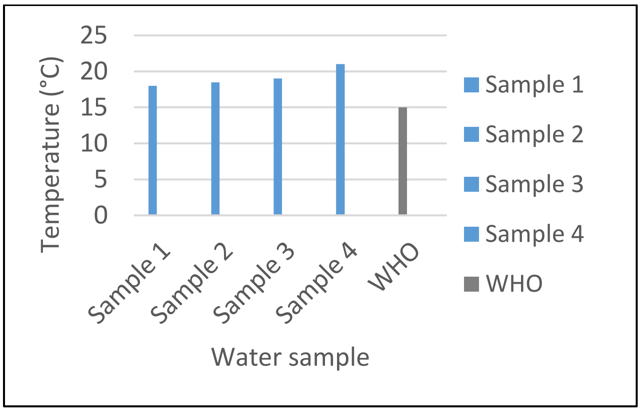

Fig.2: Comparison of temperature in four water samples with WHO value.

pH

Dissolved gases and industrial contaminants alter the pH of water, resulting in a change in the drinking water test (Yadav *et al*., 2015). The pH value of the water samples under investigation was determined to be within the normal range of 6.25–8.25. The pH maximum allowable limit has been set at 6.5–8.5 by the WHO. The pH value of the water sample was found to be in the range of 6.89 – 7.25, according to Fig. 3.

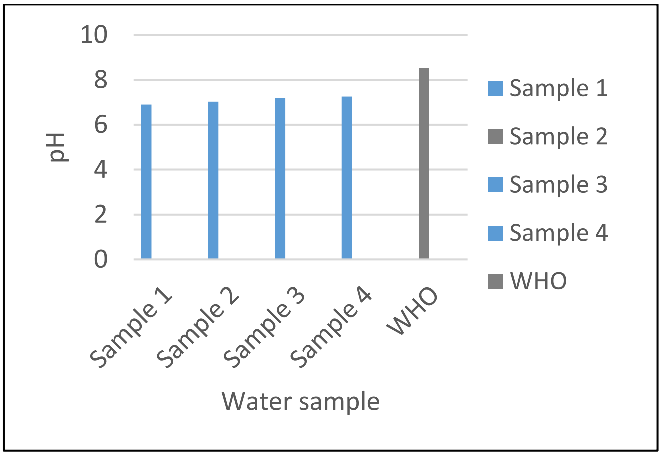

Fig. 3: Comparison of pH in four water samples with WHO value.

Electrical Conductivity

Electrical conductivity is a measurement of the total ion content of water in which the presence of salts and contaminants in wastewater increases the water's conductivity (Maharjan *et al*., 2018). The conductance values in four water samples range from 72.3µs/cm to 79.9 µs/cm, as indicated in the graph below. The electrical conductivity of the water samples understudy was measured and found to be within the NSQDW and WHO of 1500 μs/cm.

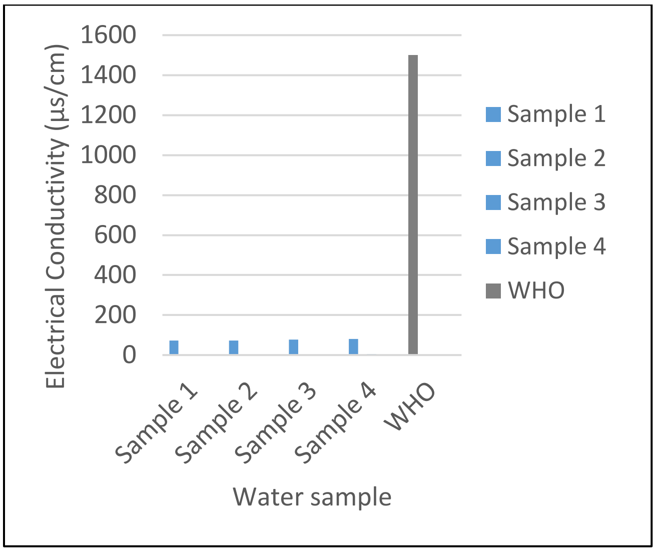

Fig. 4: Comparison of Electrical Conductivity in four water samples with WHO value.

Total Hardness

Hardness in water is caused by dissolved calcium and, to a lesser extent, magnesium, which can be found in sewage and industrial wastes (Joshi *et al*., 2014). In four water samples, the hardness value ranged from 60 to 72 mg/L. The WHO standard value of hardness requirement is 200 mg/L, which is well within acceptable limits (Fig. 5).

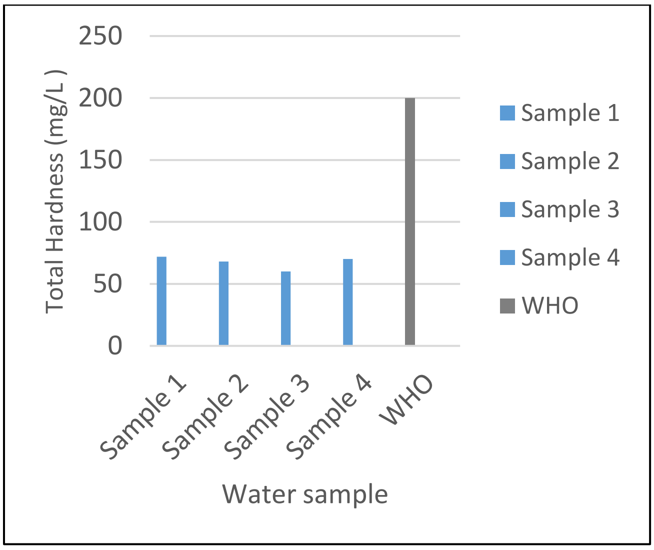

Fig. 5: Comparison of Total Hardness four water samples with WHO value.

Chloride

Natural sources, sewage and industrial effluents, urban runoff carrying de-ionizing salts, and saline intrusion are all sources of chloride in drinking water (Javana *et al*., 2009). Chloride levels in four water samples range from 2.509 to 3.76 mg/L, which is within NSDWQ and WHO guidelines. According to WHO, the allowable limit of chloride is 250 mg/L (Fig. 6).

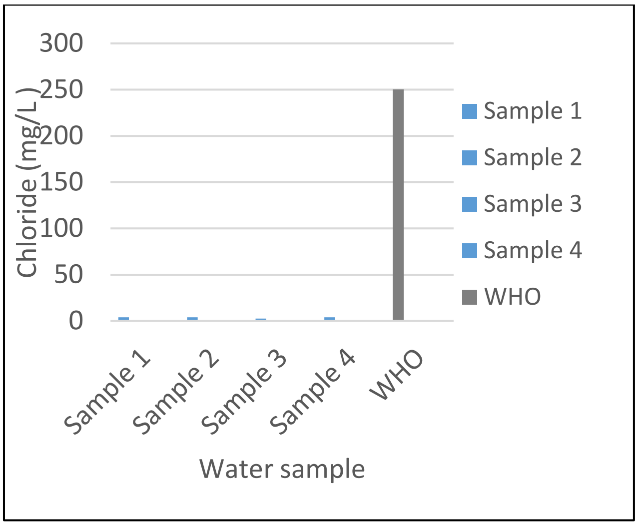

Fig. 6: Comparison of Chloride in four water samples with WHO value.

Dissolved Oxygen

The dissolved gaseous form of oxygen that enters the water via diffusion from the atmosphere and as a by-product of photosynthesis by algae and plants is known as dissolved oxygen (Gorde *et al*., 2013). The DO recommended value is >5 mg/L, as indicated in the diagram below. DO levels in water samples vary from 0.8 mg/L to 1.3 mg/L, which is lower than the NSDWQ and WHO standards. A low number indicates that there is very little oxygen dissolved in the water, whereas a high value shows that there is a lot of oxygen dissolved in the water.

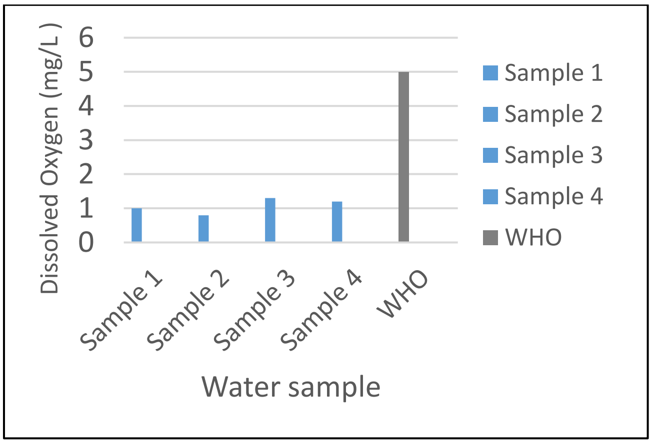

Fig. 7: Comparison of Dissolved Oxygen in four water samples with WHO value.

Total Dissolved Solids

The total dissolved solids are represented by several forms of water-soluble minerals and organic materials, so the amount of dissolved solids in water is a key factor in determining the quality of drinking water (Chakhtoura *et al*., 2015). All of the water samples in the study had analytical values ranging from 100 mg/L to 150 mg/L. According to Fig. 8, the TDS recommended value is 500 mg/L.

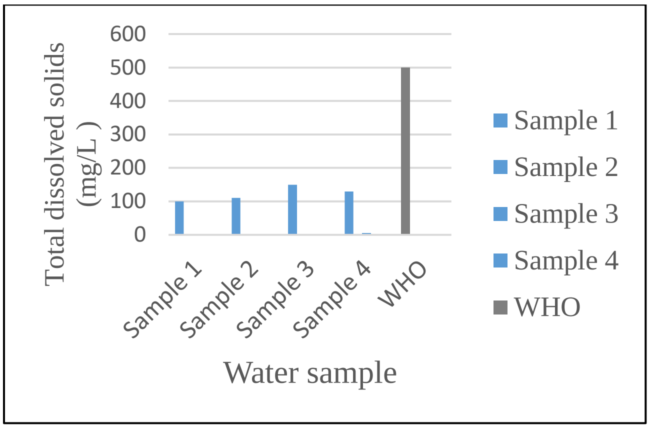

Fig. 8: Comparison of Total Dissolved Solids in four water samples with WHO value.

CO_2

According to the study, CO_2 levels in water samples range from 2 mg/L to 4 mg/L. There are no set limitations for free CO_2 in drinking water (Fig. 9), as free CO_2 has no physiological consequences, although excessive levels of free CO_2 suggest pollution from home sewage and industries (Budhathoki *et al*., 2010).

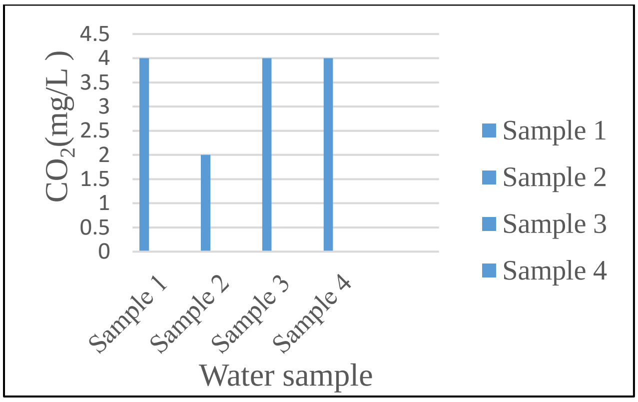

Fig. 9: Comparison of CO_2 in four water samples with WHO value.

Alkalinity

Carbonate, bicarbonates, phosphates, bicarbonates, nitrates, borax, silicate, etc. salts are the most common source of alkalinity with the hydroxyl ions in their free state (Jain *et al.*, 1996). As indicated in Fig. 10, the alkalinity concentration of the four samples was within NSDWQ and WHO limits. Alkalinity levels were found to vary, ranging from 37.84 mg/L to 44.27 mg/L. All of the values are within acceptable ranges, as the WHO recommended value for alkalinity is 200 mg/L.

The main purpose of this study was to assess the selected quality characteristics of water accessible in Majkhola to determine the water's quality. This study assessed the Physico-chemical quality of selected areas in Majkhola to determine the physical state, pollutants, and other dissolved chemical substances that affect water quality. The National Drinking Water and World Health Organization were used to judge the quality parameters.

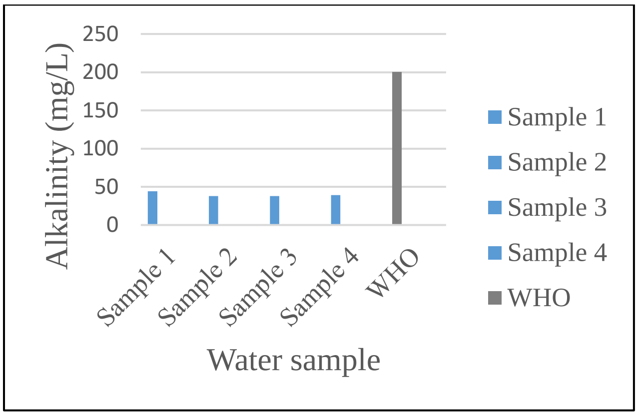

Fig. 10: Comparison of Alkalinity in four water samples with WHO value.

Conclusion

The Physico-chemical properties of water samples are influenced by a variety of causes, both directly and indirectly. Physico-chemical parameters such as pH, electrical conductivity, DO, CO_2, alkalinity, hardness, total dissolved solids, and chloride in water samples were found to be within national standards and WHO norms. However, the temperature and DO were found to be outside of the WHO guidelines. The temperature was over the WHO standard although DO was below it. The current study establishes a baseline for water conservation and monitoring in the Majhkhola area. Overall, the test findings revealed that the water in Majhkhola is safe to drink, however, microbial testing also should be performed to ensure that the water is safe to consume, which was not done in this study. Concerned authorities must take appropriate efforts for proper management, as well as adopt some practical measures to improve the drinking water quality by conserving water bodies and developing water quality management plans for this area. Based on Physico-chemical characteristics, the water quality was found to be suitable for domestic use. One of the most basic prerequisites for human survival is access to safe drinking water. People are vulnerable to a variety of health issues if they do not have access to safe, high-quality water. As a result, the current study may be effective in attaining the goal of raising public awareness about the importance of keeping water at its highest quality and purity levels.

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Author's Contribution

Both authors contributed equally at all stages of research and manuscript preparation. Final form of manuscript was approved by both authors.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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Appendix

Appendix A: Dissolved Oxygen content in four water samples

Sample No.	Obs.No.	Volume of water Sample containing liberated I_2 (mL)	Burette reading (Volume of NaOH in mL)				DO (mL)
			Initial	Final	Difference	Mean	
1	1	100	4.1	5.1	1	1	1
	2	100	5.1	6.1	1		
2	1	100	6.1	6.9	0.8	0.8	0.8
	2	100	6.9	7.7	0.8		
3	1	100	7.7	9	1.3	1.3	1.3
	2	100	9	10.3	1.3		
4	1	100	10.3	11.5	1.2	1.2	1.2
	2	100	11.5	12.7	1.2		

Appendix B: CO_2 content in four water samples

Sample No.	Obs. No.	Volume of water sample (mL)	Burette reading (Volume of NaOH in mL)				CO_2 (mg/L)
			Initial	Final	Difference	Mean	
1	1	50	0	0.2	0.2	0.2	4
	2	50	0.2	0.4	0.2		
2	1	50	0.4	0.5	0.1	0.1	2
	2	50	0.5	0.6	0.1		
3	1	50	0.6	0.8	0.2	0.2	4
	2	50	0.8	1.0	0.2		
4	1	50	1.0	1.2	0.2	0.2	4
	2	50	1.2	1.4	0.2		

Appendix C: Chloride content in four water samples

Sample No.	Obs. No.	Volume of water sample (mL)	Burette reading (Volume of $AgNO_3$ in mL)				Chloride (mg/L)
			Initial	Final	Difference	Mean	
1	1	50	0	0.3	0.3	0.3	3.76
	2	50	0.3	0.6	0.3		
2	1	50	0.6	0.9	0.3	0.3	3.76
	2	50	0.9	1.2	0.3		
3	1	50	1.2	1.4	0.2	0.2	2.509
	2	50	1.4	1.6	0.2		
4	1	50	1.6	1.9	0.3	0.3	3.76
	2	50	1.9	2.2	0.3		

Appendix D: Hardness content in four water samples

Sample No.	Obs. No.	Volume of water Sample	Burette reading (Volume of HCl in mL)				Hardness (mg/L)
			Initial	Final	Difference	Mean	
1	1	50	0	3.6	3.6	3.6	72
	2	50	3.6	7.2	3.6		
2	1	50	7.2	10.6	3.4	3.4	68
	2	50	10.6	14.0	3.4		
3	1	50	14.0	17.0	3	3	60
	2	50	17.0	20.0	3		
4	1	50	20.0	23.5	3.5	3.5	70
	2	50	23.5	27.0	3.5		

Appendix E: Alkalinity content in four water samples

Sample No.	Obs. No.	Volume of water Sample (mL)	Burette reading (Volume of Sodium Thiosulphate solution in mL)				Alkalinity (mg/L)
			Initial	**Final**	**Difference**	**Mean**	
1	1	100	0	6.2	6.2	6.2	44.27
	2	100	6.2	12.4	6.2		
2	1	100	12.4	17.7	5.3	5.3	37.84
	2	100	17.7	23	5.3		
3	1	100	23	28.3	5.3	5.3	7.84
	2	100	28.3	33.6	5.3		
4	1	100	33.6	39.4	5.8	5.8	39.27
	2	100	39.4	45.2	5.8		