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Assessment of Physicochemical Parameters of Drinking Water in the Schools of Bagnashkali, Palpa, Nepal

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Abstract

This study aims to assess the physicochemical parameters of drinking water in schools in the Bagnashkali Rural Municipality in Nepal according to standard methods. Physicochemical analysis was performed at the Department of Chemistry at Tribhuvan Multiple Campus, Palpa, in March 2022 using samples collected randomly from different schools. The study found that water samples from schools in Bagnashkali meet NDWQS and WHO guidelines as pH (7.28-7.98), hardness(60-140 mg/L), conductivity (65.3-173.2 µs/cm), alkalinity (46-96.6 mg/L), chloride (0.3-0.7 mg/L), dissolved oxygen (9.12-12.6 mg/L), total dissolved solids (9.12-12.6 mg/L), free CO_2 (7.04-10.56 mg/L) and iron (0.017-0.068 mg/L) which were all except for temperature within acceptable limits. The temperature of the water samples in this study ranged from 21°C to 28°C. The study found that the water quality in the selected schools was good and met the acceptable standards in terms of physicochemical parameters.

Keywords: physicochemical *parameters*, rural areas, safe drinking water, water quality, WHO

Introduction

The right to access safe and clean drinking water is a fundamental human right, but a large population worldwide lacks safe and reliable sources of drinking water (WHO, 2003). Limited access to clean drinking water is a significant problem in Nepal, especially in rural regions, and has been associated with various health problems (Shrestha et al., 2017). The World Health Organization (WHO) states that polluted water can lead to the spread of waterborne illnesses, such as cholera, typhoid, and dysentery (WHO & UNICEF, 2013). Schools are important institutions in any community as they educate young people and shape their futures. However, the quality of drinking water in schools is often neglected, which can adversely affect the health and well-being of students and teachers. Water quality is a major global concern (Luvhimbi et al., 2022), and several studies have been conducted to evaluate the physicochemical parameters of drinking water in various regions of the world. The physicochemical properties include the physical and chemical characteristics of the substance. The quality of water should have physicochemical parameters such as pH, temperature, conductivity, TDS, alkalinity, and chlorine within the NDWQS value and WHO value. Knowing details about different physicochemical parameters is necessary for testing the water quality (Patil. et al.,2012)). Nepal established the National Drinking Water Quality Standards (NDWQS) in 2005 and followed the guidelines set by the WHO to maintain drinking water quality. However, several studies have shown that water quality in Nepal does not meet these standards, especially in rural areas.

An assessment of the water quality from various sources in Nepal indicated that the majority of these sources were contaminated with fecal matter and failed to meet the NDWQS (Joshi et al., 2022). This emphasizes the importance of consistent and methodical checking of water sources to ensure the quality of drinking water. Most of the physicochemical parameters tested were within the recommended range in the Kailali District of Nepal (Gurung et al., 2015). However, a few samples showed high levels of certain heavy metals, such as Al, Pb, Cd, Fe, As, and Mn, which could pose a potential threat to the community. Similarly, another study conducted by Maharjan et al. (2020) highlighted the poor quality of groundwater in the Kathmandu Valley, emphasizing the need for regular monitoring, treatment, and improvement of the water supply infrastructure to reduce the risk of waterborne diseases. However, the study also found that water quality was influenced by seasonal variations, and there were occasional instances of contamination due to human activities. Thapa and Khadka (2017) collected water samples from various natural sources, reservoirs, and tap water to investigate the quality of drinking water in Tansen Municipality. They measured various parameters and found that most were within the 2005 NDWQS guidelines. However, the pH of water from Narayansthan and Teendhara was more acidic than the National Standards.

Based on the available literature, it appears that it is important to regularly monitor and evaluate the physicochemical parameters of drinking water in Nepal, especially in rural regions and schools. This study aimed to contribute to the existing literature by assessing the physicochemical parameters of drinking water in schools in the Bagnashkali Rural Municipality of Nepal. This study will provide essential insights into the quality of drinking water in schools, enabling local authorities to take requisite steps to ensure that schoolchildren have access to safe drinking water.

Materials and Methods

The research was carried out in the Bagnashkali Rural Municipality in the Palpa district, with water samples collected randomly from different schools in March 2022. For all the water samples, sterile polyethene bottles were utilized (labelled as SC1, SC 2, SC 3, SC 4 and SC 5) collected from Siddi Secondary School, Baganaskali-3, Aryavanjyang, Sagarmatha Samudayik shaikshik Pratisthan, Bagnaskali-3, Aryavanjyang, Gyan Jyoti Community School, Bagnaskali-

2, Pokharathok, Gramya Secondary School, Bagnaskali-1, Gaptung and Ram Basic School, Bagnaskali-1, Gaptung respectively from taps that were used for drinking purposes. A laboratory experiment was conducted at the Department of Chemistry at the Tribhuvan Multiple Campus. Physicochemical analysis was performed using standard methods and techniques

Chemicals and Reagents Used

Sodium thiosulphate solution, Magnesium sulfate solution, Alkaline KI solution, Oxalic acid solution, Sodium hydroxide solution, Potassium chromate indicator solution, Silver nitrate indicator solution, NaCl solution, HCl, Sodium carbonate, EDTA, 1,10 Phenanthroline, Hydroxylamine hydrochloride, Sodium acetate, Sulphuric acid, Ferrous ammonium sulfate hexahydrate (Mohr's salt). All laboratory-grade chemicals were used as received, without further purification.

Physicochemical Analysis of Water Samples

Determination of pH

The pH was measured using a Deluxe pH meter (EI model 101). The pH meter was first calibrated with a standard buffer solution of pH 7.0 and 9.0.

Determination of Temperature

The temperature of the water samples was recorded during the sampling period. To determine the temperature, a Mercury-filled Celsius thermometer was immersed in the water sample.

Determination of Electrical Conductivity

Conductivity was measured using a digital conductivity meter (EI alpha-6). The electrode and 250 mL beaker were washed with distilled water, and 100 mL of the water sample was placed in a beaker. The electrode was then immersed into the sample and gently stirred, and the glass electrode was placed in the water sample until a stable reading was noted. Before every measurement of the water sample, the glass electrode was washed with distilled water and rinsed.

Determination of Dissolved Oxygen

First, the sample was carefully collected in a 300 mL BOD bottle, and any kind of bubbling and trapping of air bubbles should be avoided. Five mL of water sample was discarded from the bottle, 2 mL of 50% $MnSO_4$ solution from the pipette, and 2 mL of alkaline 20 % KI solution was added well below the surface from the wall of the bottle. A precipitate was observed. The stopper was then placed tightly, and the bottle was shaken to ensure proper mixing of the contents.

The bottle was allowed to stand for some time to settle down the precipitate, and 2 mL of 85% phosphoric acid was added and shaken well to dissolve the precipitate. The stopper was placed tightly, and the bottle was shaken, turning it upside down three to four times. The brown precipitate was dissolved. Then 50 mL of the sample was taken in a conical flask and titrated against M/80 ($Na_2S_2O_3$) Sodium thiosulphate solution by adding 2 mL of starch solution until the initial blue colour changed to colourless.

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

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

V_2= volume of a part of content titrated

V= volume of $MnSO_4$ and KI added

Determination of CO_2

Free CO_2 in water was determined by the titration method. First, the burette was filled up with previously standardized N/50 NaOH solution and titrated against 50 mL of a water sample using two drops of phenolphthalein indicator until the pink colour had just appeared. The colour change indicated the endpoint of the titration.

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

Where A= Volume of NaOH used in mL

Determination of Chloride

The chloride present in the water samples was measured by argentometric titration. First, the burette was filled with standard $AgNO_3$ and titrated with 2 mL of 2% K_2CrO_4 in 50 mL of water until a faint red colour ppt appeared. Chloride was precipitated as silver chloride, and the potassium chromate indicator marked the end point of titration by a colour change from yellow to pinkish-yellow.

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

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

Determination of Alkalinity

First, 50 mL of the water sample was placed in a 250 mL conical flask and two drops of phenolphthalein indicator were added. The urette was filled with Standard HCl and titrated against this solution until the pink colour appeared.

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

Where, a= Volume of standard HCl consumed in titration

N= Normality of HCl used

Determination of Hardness

First, the burette was filled with 0.01 N EDTA solution and titrated against a mixture of 50 mL of the water sample, 2 mL of previously prepared buffer solution, and a few drops of solo-chrome black T indicator, until the wine red colour appeared. The colour change indicated the endpoint of the titration.

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

Determination of Total Dissolved Solids

First, a 100 mL clean dry beaker was taken. The weight of the beaker was measured. Then 50mL of the water sample was placed in a beaker and heated until the water sample completely evaporated. After complete evaporation, the beaker was cooled and weighed again. The weight of the dissolved solids in the beaker was calculated by subtracting the weight of the empty beaker.

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

Where, A= weight of dried residue and beaker

B= weight of the empty beaker

Determination of Iron

The iron content of the water samples was determined using a scanning visible spectrophotometer (Model El-2306). To this, 50mL of the water sample was placed in a conical flask. Two mL conc. HCl and 1 mL of hydroxylamine hydrochloride were then added. The contents were heated on a hot plate until the volume became half. It was then cooled to room temperature, and 10 mL of buffer (pH =4) was added. After that 5mL of the 1,10-phenanthroline solution indicator was added. An orange-red colour appeared. The orange and red colours indicate the iron content in the water. The volume was made up to 100 mL by adding distilled water and left for 10 min. A calibration curve was plotted against the absorbance values of the standard iron solutions and their respective concentrations. The slopes and intercepts of the calibration curves were then calculated. The absorbance of the water samples was then determined at 510 nm using a spectrophotometer. The iron concentration in the sample was calculated using the calibration curve and the formula: iron concentration (mg/L) = (absorbance of sample - intercept) / slope.

Results and Discussion

The table below displays the findings of the physicochemical parameters related to drinking water quality in the schools of Bagnashkali Rural Municipality.

Test parameter	Unit	Experimental Range	WHO Value	NDWQS value
pH	-	7.28 - 7.98	6.5 - 8.5	6.5 - 8.5
Temperature	°C	21 - 28	15	-
Conductivity	µs/cm	65.3 - 173.2	1500	1500
Alkalinity	mg/L	46 - 96.6	200	-
Hardness	mg/L of $CaCO_3$	60 - 140	200	500
Chloride	mg/L	0.3 - 0.7	250	250
Dissolved oxygen	mg/L	9.12 - 12.6	>5	-
Total dissolved solids	mg/L	0.6 - 1.2	500	1000
Carbon dioxide	mg/L	7.04 - 10.56	10	-
Iron content	mg/L	0.017- 0.068	0.3	-

Determination of pH

The experimental range for pH is 7.28-7.98, indicating a slightly basic to neutral pH. The WHO and NDWQS values for pH are between 6.5 and 8.5, indicating the acceptable range for pH in drinking water. The monitoring of pH levels in water bodies and drinking water sources is crucial to ensure human and environmental safety.

Determination of Temperature

The observed values for the temperature of different samples are ranging from 21°C to 28°C. These values indicate that the samples were measured at room temperature, which typically falls within this range. The WHO standard for temperature is 15°C, which is significantly lower than the experimental values mentioned. This standard represents the ideal temperature for drinking water storage and distribution, as it helps to prevent bacterial growth and maintain water quality. Notably, fluctuations in temperature can impact the chemical and biological features of water (Verma et al.,2015). Hence, monitoring temperature levels in water bodies.

Determination of Electrical Conductivity

The ability of a solution to conduct electricity is measured by its conductivity. The experimental values for the conductivity of different samples range from 65.3 to 173.2 µS/cm. These values suggest that the samples have different levels of dissolved ions or minerals, which affect their ability to conduct electricity. The WHO standard for conductivity in drinking water is 1500 µS/cm, which is much higher than the experimental values mentioned. This standard represents the maximum acceptable limit for drinking water conductivity, as higher levels can indicate the presence of contaminants such as salts or heavy metals.

Determination of Alkalinity

The experimental values for alkalinity fall within the acceptable range of WHO (200 mg/L) but are significantly lower than the WHO standard for drinking water. This standard represents the maximum acceptable limit for alkalinity in drinking water, as higher levels, can cause scaling in pipes and interfere with water treatment processes. These experimental values suggest that the samples have varying levels of bicarbonates, carbonates, and hydroxides, which contribute to their alkalinity.

Determination of Hardness

While water hardness is typically not seen as a health hazard for people, it can impact the taste and overall quality of drinking water. This is because hard water may produce unpleasant tastes or odours and it can also cause the accumulation of mineral deposits in plumbing, which can potentially lead to issues with water flow and quality. Water is considered moderately hard to hard when it has a $CaCO_3$ hardness level of 60-140 mg/L. This level is not harmful to human health and is generally safe to drink. However, it may affect the taste, odour, and appearance of the water, which can impact its overall palatability.

Determination of Chloride

The experimental range for chloride is mentioned as 0.3-0.7 mg/, indicating a relatively low level of chloride ions in the samples. Both the World Health Organization (WHO) and the National Drinking Water Quality Standards (NDWQS) have set the allowable limit for chloride in drinking water at 250 mg/L, which is considerably greater than the experimental range. This standard represents the maximum acceptable limit for chloride in drinking water, as higher levels, can affect the taste and smell of water and have potential health effects. The levels of chloride in water can fluctuate due to various factors such as the source of water and the existence of either natural or human-induced sources of contamination.

Determination of Dissolved Oxygen

The samples have a relatively high level of dissolved oxygen, as indicated by the experimental range of 9.12-12.6 mg/L. This range is significantly higher than the WHO value for dissolved oxygen in drinking water, which is greater than 5 mg/L. This standard represents the minimum acceptable limit for dissolved oxygen in drinking water, as lower levels can affect aquatic life and the taste and odour of water. There is no NDWQS value mentioned for dissolved oxygen, which indicates that it may not be considered a critical parameter for drinking water uality assessment.

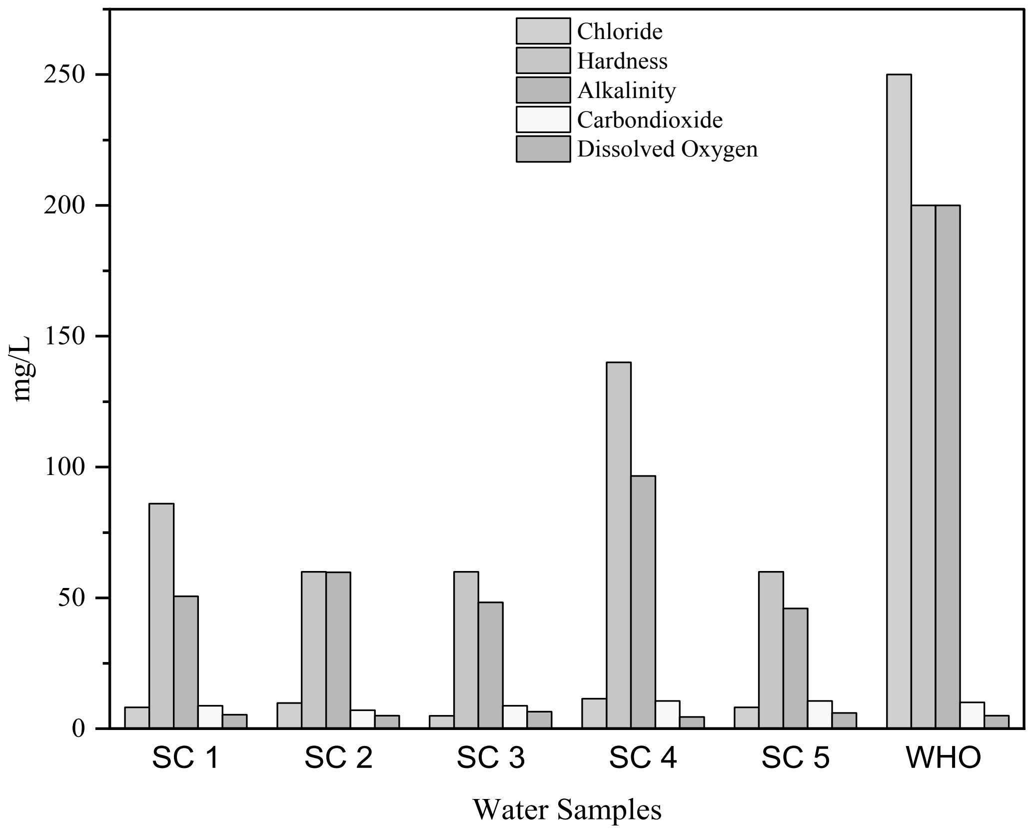

Figure 1:*Comparison of physicochemical parameters in water samples with WHO Standards*

Determination of CO_2

The water samples studied showed carbon dioxide concentrations ranging from 7.04 to 10.56 mg/L, which is within the acceptable range set by both the national and WHO standards. High concentrations of free carbon dioxide may indicate pollution from domestic sewage and industrial sources (Budhathoki, 2010).

Determination of Total Dissolved Solids (TDS)

The WHO and NDWQS values for TDS are 500 and 1000 mg/L, respectively. The experimental range which is 60-120 mg/L, suggests that the samples have TDS levels that are considerably lower than the maximum acceptable limits for TDS in drinking water, as set by the WHO and NDWQS. TDS levels can vary depending on factors such as the source of water, geological conditions, and human activities.

Determination of Iron

The experimental range for iron content is 0.017-0.068 mg/L, indicating a relatively low level of iron in the samples. The experimental values for iron content fall considerably below the WHO-recommended value of 0.3 mg/L. This standard represents the maximum acceptable limit for iron content in drinking water

Conclusion

The experimental values for pH, conductivity, alkalinity, chloride, dissolved oxygen, TDS, carbon dioxide, and iron content found in the analysed water samples are considered to be within the acceptable limits specified by the WHO and NDWQS regulations for drinking water. The temperature of the water samples measured was higher than the ideal temperature for drinking water storage and distribution set by WHO The present study tested only the physicochemical parameters of the water samples, which indicated good water quality.

It is crucial to provide safe and good quality water to children as they are susceptible to various health problems if exposed to contaminated water. Therefore, school authorities have a moral responsibility to ensure a safe and hygienic water supply for schools. Access to a quality water supply is one of the fundamental requirements for school children.

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Conflict of Interest

This work does not involve any conflicts of interest for the authors.

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