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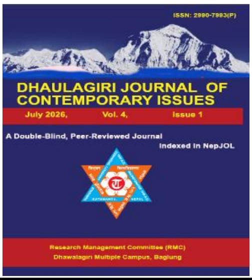

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Physicochemical Assessment of Bore-Well Water Quality in Pokhara Valley

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Abstract

Bore-well water is an important source of drinking water in Pokhara Valley, Nepal, and regular monitoring of water quality is necessary to safeguard public health. The objectives of this research are to study the physicochemical and microbial quality of bore-well water collected from Chhinedanda, Bagar, and Malepatan areas of Pokhara Valley. There is a lack of research on the physicochemical assessment of boring water in different areas in Pokhara. Three separate bore-well water samples were collected during the morning hours from each study site and analyzed according to the standard methods recommended by the American Public Health Association (APHA). The result of this study revealed that pH (7.0-7.56), EC (224-253 µS/cm), DO (7-8.5mg/L), total alkalinity (170-200mg/L), chloride (21.27-28.4), and free carbon dioxide (8.8-17.6mg/L). So that these results are acceptable by the World Health Organization (WHO) and the National Drinking Water Quality Standards (NDWQS). However, total hardness was 300-320mg/L and the hardness of water was higher than the WHO guideline value, and arsenic concentrations were in the range of 0.018-0.024mg/L and so the concentration of arsenic was higher than the WHO permissible range of 0.01mg/L. Furthermore, total coliform bacteria were detected in every water sample, indicating that the bore-well water is unsafe for drinking due to microbial contamination. The findings suggest that the studied bore-well water sources are not completely safe for direct drinking purposes without treatment and regular monitoring.

Keywords: Arsenic, Bore-well water, Microbial contamination, Physicochemical parameters, Pokhara Valley

Introduction

Water is present in every living organism. They get water from Oceans, rivers, lakes, groundwater, etc. There is water vapor present in the atmosphere too. Approximately 71% of Earth's surface and 5% in Nepal is covered with water (Sharma, 2008). Water is classified into fresh, saline, and borehole water. Water is an essential natural resource for all living organisms. Water plays an important role in biological processes, including photosynthesis in plants and metabolic activities in humans. Borehole water is a major source of drinking water in urban areas such as Pokhara and Kathmandu. Maintaining water quality is crucial for public health because groundwater can naturally contain a variety of substances. Some of them are beneficial, while others pose a risk to human health with excessive use (Ghaire et al., 2020). The quality of water has a direct influence on public health, agriculture, and industrial development. Arsenic is a naturally occurring contaminant that is found in borehole water. Higher concentration of Arsenic in water is a risk for health, including cancer (Ghaire et al., 2020). Electrical conductivity ranged from 70-145S/cm, hardness remained within 20-35mg/L, iron levels reached up to 0.35mg/L, no arsenic was detected, and 40% of the water sources were contaminated with total coliform bacteria were reported in Water supply of Baglung bazaar (Budhathoki & Sapkota, 2023). Additionally, microbial contamination is increasing for children especially. Water quality can deteriorate due to untreated industrial waste, geological factors, sewage, and poor waste management (Bhandari, et al., 2021).

Chemical Factors

Chemical factors are crucial for evaluating water quality, revealing its composition and potential effects. Key chemical factors include Alkalinity, which measures water's ability to neutralize acids, which is vital for aquatic life. Arsenic which is a harmful element that naturally occurs in groundwater. The pH of the water sample collected from Pokhara Valley was in the acceptable range of 6.5 to 8.5 for drinking. Higher concentrations of arsenic lead to health risks, including nausea and cancer. (World Health Organization, 2007). Hence, dissolved oxygen concentrations are essential for maintaining balanced ecosystems. Free CO_2, whose higher levels in water can increase acidity and indicate organic decomposition, is often higher in borehole water due to its interaction with soil. Hardness indicates the amount of dissolved calcium and magnesium. Borehole water tends to be harder due to prolonged contact with minerals. And finally, Nitrate, which results from fertilizers, can pose health risks, especially in drinking water.

Microbiological Factors

Microbial parameters play an important role in evaluating the safety and quality of drinking water. The assessment of total coliform count helps determine the microbial contamination in water. The detection of *Escherichia coli* (*E. coli*) indicates contamination from fecal sources and the presence of disease-causing pathogens. Many water consumers are shifting towards alternative water sources, such as bottled drinking water and jar water, due to a lack of regular water quality monitoring. This study provides valuable information on the safety of bore well water and helps determine whether alternative water sources, appropriate treatment, or monitoring are necessary to maintain water quality.

Electrical conductivity ranged from 70-145S/cm, hardness remained within 20-35 mg/L, iron levels reached up to 0.35 mg/L, no arsenic was detected, and 40% of the water sources were contaminated with total coliform bacteria, as reported in the water supply of Baglung bazaar (Budhathoki & Sapkota, 2023). There is a lack of research on the physicochemical assessment of bore water across different areas of Pokhara. Although several studies have assessed water quality in Nepal, site-specific evidence on bore-well water quality in Chhinedanda, Bagar, and Malepatan of Pokhara Valley remains limited. Poudel, R. K. (2022) reported the analysis of the physicochemical properties of Niureni Lake in Pokhara, Nepal, water, which were as pH (6.5-8.5), DO (5 mg/L), TH (500 mg/L), F-CO_2 (4-25 mg/L), TA (600 mg/L), Cl^- (150 mg/L), Ca (100 mg/L). Pant (2011) reported that the groundwater quality of the Kathmandu Valley, Nepal, was analyzed for total coliform (267 CFU/100 L), EC (875 µS/cm), turbidity (55 NTU), and Fe, which were higher than the WHO guideline (1.9 mg/L). Das, B. D., Mishra, R. K., & Choudhary, S. K. (2021) reported the quality of groundwater in Biratnagar, Morang, Nepal, with arsenic (As) nil (0 mg/L) and turbidity 2.1 ± 2.80 to 81. 46 ± 44.28, free carbon dioxide (12 ± 2.45 mg/L), Fe 0.45 mg/L to 5.99 mg/L, fecal coliform 3 to 25 MPN/100 ml). Bhandari, P., Banjara, M. R., Singh, A., Kandel, S., Pant, B. R., & Rawal, D. S. (2021) reported total hardness (TH), Cu, nitrate, sulphate, and turbidity were within the limit of NQWQS. Total coliform exceeded drinking water guideline. Gupta, D. K., Bhandari, D. B., Chaudhary, P. K., & Yadav, A. P. (2023) reported that the pH (7.16-8.50), Chloride (53-178mg/L). DO levels are good for the survival of aquatic life, and BOD levels in running water are higher than in tap water. Yadav, B., Maharjan, J., Chaudhary, S., Nath, D., Adhikari, M. K., Yadav, Y. P., ... & Bhattarai, A. (2025) reported pH (7.3 to 7.7), EC (1167 µS/cm), turbidity (1.5 mg/L), TH (422 mg/L), chloride (135.6 mg/L), Fe (0.11 mg/L), ammonia (1.2 mg /L), nitrate (17.7 mg/L), sulphate (10 mg /L), As (0.11mg/L). The objectives of this research is to study the physicochemical and microbial quality of bore-well water collected from Chhinedanda, Bagar, and Malepatan areas of Pokhara Valley.

Materials and Methods

The average altitude of Pokhara is 822 meters above sea level. The sample from Chhinedanda (Figure 1) was taken from 28º20'N,83º98" E. Bagar (Figure 2) was taken from 28º25'N,83º98'E. The Third sample from Malepatan was at 28º23'N, 83º97'E. (http://nationalgeoportal.gov.np/cadastral/).

Study Area

Figure 1: Chhinedanda Sampling Site

Figure 2: Bagar Sampling Site

Sample Collection

To ensure reliability and accuracy of results, all water samples were collected in triplicate. Sterile BOD bottles were used during sampling, and appropriate laboratory protocols were followed throughout collection, handling, and transport to prevent contamination. After collection, the samples were stored at low temperature and preserved in suitable conditions until laboratory analysis was performed.

All instruments were calibrated before use, and analytical procedures were carried out in accordance with the American Public Health Association (1999) standard methods to ensure the accuracy and reproducibility of the results. The water temperature was measured with a standard mercury thermometer at the sampling site. Electrical Conductivity was measured using the Electrical Conductivity Meter. Hydrogen Ion Concentration was measured using a microprocessor-based pH meter after calibration. Total Hardness was determined using the Ethylene Diamine Tetra-acetic Acid (EDTA) Titration Method. In this method, chemicals like EDTA, Solo chrome Black indicator, and Ammonia Buffer were used.

Winkler's Iodometric Titration method was used for the determination of amount of Dissolved Oxygen (DO) using chemicals like Sodium Thiosulfate, Manganese sulfate, Conc. Sulphuric acid and alkaline Potassium Iodide. Total Alkalinity was determined using phenolphthalein and methyl orange indicators and HCl (0.1N). Arsenic was determined using a calibration curve that was prepared with the help of a UV-visible spectrophotometer. Chemicals like Arsenic Trioxide, Hydrazine Hydrate, Ammonium molybdate, Ammonium Hepta-molybdate, Sulfuric Acid, and Potassium Permanganate were used during this process. Chloride content was measured using Argentometric Titration, where reagents like Silver nitrate and potassium chromate solution were used. Nitrate was determined qualitatively using Brown ring method where chemicals like Ferrous Sulfate and sulfuric acid were used. Free Carbon Dioxide (F-CO2) concentration was determined by volumetric analysis with the help of phenolphthalein indicator and 0.02N NaOH. Total Coliform Count was analyzed by the membrane filtration technique that used the membrane filter apparatus, 0.45-micrometer filter paper, Eosin Methylene Blue (EMB) agar media, rectified spirit, vacuum pump, and incubator.

All the calculations were performed by the concurrent data obtained during volumetric analysis of triplicate samples.

Table 1

Methods for Determining Different Parameters

Parameters	Units	Methods
1. pH	-	Microprocessor pH Meter
2. Temperature	ºC	Standard Mercury Thermometer
3. Electrical Conductivity	µS/cm	Electrical Conductivity Meter
4. Total Hardness	mg/L	EDTA Titration Method
5. Dissolved Oxygen(DO)	mg/L	Winkler's Iodometric Titration
6. Total Alkalinity	mg/L	Titration
7. Arsenic (As)	mg/L	Molybdenum Blue Method
8. Chloride (Cl^-)	mg/L	Argentometric Titration Method
9. Nitrate(NO_3^-)	mg/L	Qualitative Test by Brown Ring Method
10. Free CO_2	mg/L	NaOH Titration Method
11. Total Coliform	CFU/100ml	Membrane Filtration Technique

Source: APHA,1999

Except for Temperature and Total Coliform Count, all the other parameters were analyzed in the Chemistry Laboratory of Prithvi Narayan Campus(PNC), Pokhara, following the protocols provided by the American Public Health Association (APHA, 1999) for health and safety.

Table 2

Guidelines for Drinking Water Quality

12. Parameters	13. Unit	14. WHO limit	15. NDWQS limit
16. pH	17. -	18. 6.5-8.5	19. 6.5-8.5
20. Alkalinity	21. mg/L	22. -	23. 500
24. Chloride	25. mg/L	26. 250	27. 250
28. Total Hardness	29. mg/L	30. 200	31. 500
32. DO	33. mg/L	34. >5	35. -
36. Nitrate	37. mg/L	38. 50	39. 50
40. Arsenic	41. mg/L	42. 0.01	43. 0.05
44. Total Coliform	45. CFU/100 ml	46. 0	47. 0
48. Electrical Conductivity	49. µS/cm	50. -	51. 1500

Source: WHO (2008) and NDWQS (2006)

Total Coliform Count was analyzed in the Microbiology Laboratory of Regional College of Health Science and Technology, Nayabazar, Pokhara. Standard Reagents and Chemicals from Thermo-Fischer Scientific, VEB-Research, Nice Chemicals, SD Fine, LOBA Chemia, Fasarbhain, and Himedia Laboratory were used. All the required reagents were prepared in the lab using distilled water and a calculated amount of chemicals. The obtained values were evaluated as per the Guidelines of the World Health Organization(WHO) and Nepal Drinking Water Quality Standards (NDWQS) for Drinking water (Table 2).

Results and Discussion

The obtained numerical values of biotic and abiotic components of the bore-well samples are presented below;

S.N	Parameters	Units	Different sources of bore-well water		
			Chhinedanda	Bagar	Malepatan
1.	pH	-	7.56	7	7
2.	Temperature	^{0}C	24	23	23
3.	Conductivity	µS/cm	241	224	253
4.	Total Hardness	mg/L	320*	310*	300*
5.	Dissolved Oxygen (DO)	mg/L	7.5	7	8.5
6.	Total Alkalinity	mg/L	200	170	190
7.	Arsenic (As)	mg/L	0.024*	0.023*	0.018*
8.	Chloride (Cl)	mg/L	28.4	21.27	24.14
9.	Nitrate (NO_3^-)	mg/L	Absent	Absent	Absent
11.	Free CO_2	mg/L	17.6	13.2	8.8
12.	Total Coliform	CFU/100ml	Present*	Present*	Present*

*represent parameters' values that exceed WHO guidelines of Drinking Water Quality

pH

Values ranged from 7 to 7.56, all within WHO and NDWQS guidelines (6.5-8.5), indicating suitability for drinking and agricultural use. Extreme pH levels can affect health and pipe integrity.

Temperature

The bore well water samples was found temperatures ranging from 23°C to 24°C**.** So that the ore well water samples were slightly warmer than surface water due to geothermal heat. Higher temperature can influence microbial activity and solubility.

Electrical Conductivity

Measured 224 - 253 µS/cm with higher value in Malepatan, possibly due to higher concentration of dissolved salts. All samples met NDWQS's 1500 µS/cm standard.

Total Hardness

Total hardness level range from 300 - 320 mg/L, exceeding the World Health Organization (WHO) guideline value of 200 mg/L. This results indicates that the water is hard water. So this hard water affects the health of consumers and plumbing system.

Dissolved Oxygen

Ranged from 7 - 8.5 mg/L, suitable for drinking and aquatic life. Low levels can indicate potential water quality issues.

Total Alkalinity

Values ranged from 170 to 200 mg/L, within WHO and NDWQS limits, beneficial for stabilizing pH and preventing corrosion.

Nitrate

The nitrate was analyzed only qualitatively and at low concentrations, suggesting minimal risk from agricultural runoff.

Figure 3
Dissolved Oxygen (DO) Values (mg/L) at Different Sites

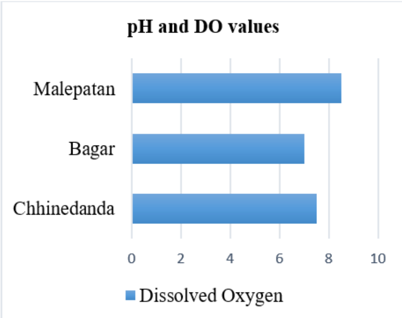
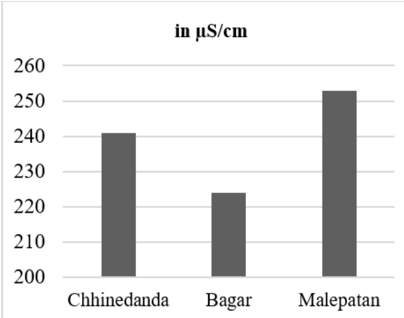


Figure 4
Values of Electrical Conductivity (Conductivity (µS/cm) of Different Sites



Arsenic

Concentrations ranged from 0.018 to 0.024 mg/L, exceeding WHO's 0.01 mg/L limit but under the NDWQS's 0.05 mg/L limit. The higher concentrations of arsenic observed in all sampling due to associated with natural geological conditions and prolonged interaction between ground water and arsenic. Long-term consumption of arsenic-contaminated water leads to serious health problems, including skin disorders, cardiovascular diseases, and cancer.

Chloride

Chloride concentrations of all samples from 21.27 to 28.4 mg/L and were within the specified acceptable limits recommended for drinking water quality.

Free CO2

The values of carbon dioxide in range of 8.8 to 17.6mg/L below the permitted limits of FAO for irrigation and drinking reasons. However, excessive concentrations may influence the pH balance of water and affect its overall quality.

Microbial Contamination

The detection of total coliform in all water samples shows that the water is unsafe for drinking without treatment and suggests possible contamination from

Figure 5
Bar Diagram of Arsenic Values (mg/L)

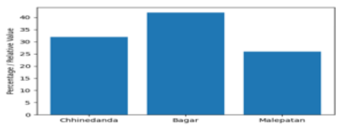


Figure 6
Bar Diagram of DO (mg/L) of Different sites

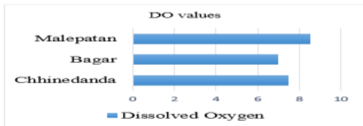


Figure 7
Total Hardness (mg/L) of Different Sites

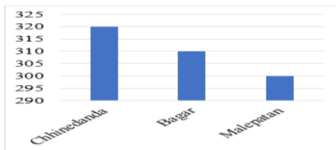
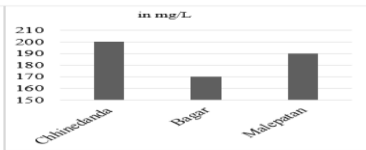


Figure 8
Total Alkalinity (mg/L) of All Sites



sewage leakage, inadequate sanitation practices, or the infiltration of surface runoff into groundwater sources, highlighting the need for further investigation and appropriate mitigation measures. From the experiment, it was clear that the sampling sites aren't providing quality drinking water to consumers, resulting in several health risks to the public. The values of Total Hardness (TH), Arsenic concentration and Total Coliform Count exceeded the permissible limit for drinking water. Higher levels of arsenic lead to serious health issues, including stomach problems and chronic diseases like skin and lung cancer, heart disease, diabetes, and respiratory problems. Some hardness in water is beneficial because it provides essential minerals. So that excessive hardness leads to kidney stones, digestive issues, and skin, and hair problems. Additionally, Total Coliform may result in diseases such as respiratory illnesses and gastrointestinal infections. E. Coli were present and pH (7.18 mg/L), EC (239.39 µS/cm), TH (310 mg/L), DO (7.66 mg/L), TA (186.66 mg/L), As (0 mg/L), free carbon dioxide (13.2 mg/L) were average value found in bore well water of Pokhara valley, Nepal.

Several studies have evaluated the physicochemical and microbiological quality of surface and groundwater in different regions of Nepal. The present findings are generally consistent with previous investigations, although variations among studies are attributable to differences in hydrogeological conditions, land use, seasonal variation, and anthropogenic activities. Poudel, R. K. (2022) reported that the water quality of Niureni Lake, Pokhara, was characterized by pH values ranging from 6.5 to 8.5, dissolved oxygen (DO) of approximately 5 mg/L, total hardness (TH) up to 500 mg/L, free carbon dioxide (F-CO_2) ranging from 4 to 25 mg/L, total alkalinity (TA) up to 600 mg/L, chloride up to 150 mg/L, and calcium up to 100 mg/L. The average values obtained in the recent research for bore-well water from Pokhara Valley pH (7.18), DO (7.66 mg/L), TH (310 mg/L), TA (186.66 mg/L), and free CO_2 (13.2 mg/L) were within acceptable drinking water standards and were generally lower than those reported for Niureni Lake, reflecting differences between groundwater and surface water systems. Pant, B. R. (2011) investigated groundwater quality in Kathmandu Valley and reported high electrical conductivity (875 µS/cm), turbidity (55 NTU), total coliform (267 CFU/100 mL), and iron concentration (1.9

mg/L), exceeding the World Health Organization (WHO) guideline values. In contrast, the bore-well water samples analyzed in the recent research exhibited considerably lower electrical conductivity (239.39 µS/cm) and iron concentration, indicating comparatively better groundwater quality.

Conclusion

Bore-well water is an important source of drinking water in the Pokhara Valley, Nepal, and regular monitoring of water quality is necessary to safeguard public health. The result of this study revealed that pH (7.0-7.56), EC (224-253 µS/cm), DO (7-8.5mg/L), total alkalinity (170-200mg/L), chloride (21.27-28.4), and free carbon dioxide (8.8-17.6mg/L). So that these results are acceptable by the World Health Organization (WHO) and the National Drinking Water Quality Standards (NDWQS). However, total hardness was 300-320mg/L and the hardness of water was higher than the WHO guideline value, and arsenic concentrations were in the range of 0.018-0.024mg/L and so the concentration of arsenic was higher than the WHO permissible range of 0.01mg/L. Furthermore, total coliform bacteria were detected in every water sample, indicating that the bore-well water is unsafe for drinking due to microbial contamination. The findings suggest that the studied bore-well water sources are not completely safe for direct drinking purposes without treatment and regular monitoring.

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Conflict of interest: The author does not have any conflict of interest with any institutions concerning this research
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