SCIENCE FORUM (JOURNAL OF PURE AND APPLIED SCIENCES) 26, (3) (2026), 527 - 535

Science Forum (Journal of Pure and Applied Sciences)

Journal Homepage: https://atbuscienceforum.com.ng/index.php/jpas

An Appraisal of the Available Water Supply Sources for Future Development in Gubi Campus of Abubakar Tafawa Balewa University Bauchi Nigeria

Bilyaminu Dauda[1], Inusa Titus[1, 2], Ahmed Faruk Umar[1, 2]

[1]Environmental Standards Node, Sustainable Procurement, Environmental and Social Standards Project, Centre of Excellence, Abubakar Tafawa Balewa University, Bauchi, Nigeria

[2]Department of Microbiology, Faculty: Sciences, Abubakar Tafawa Balewa University, Bauchi

Abstract

Water availability and quality are critical determinants of sustainable institutional growth, particularly in rapidly expanding university environments. This study assessed the available water supply sources at Abubakar Tafawa Balewa University (ATBU), Gubi Campus, Bauchi, Nigeria, with the objective of evaluating their capacity, quality, reliability, and long-term sustainability in meeting current and future water demands associated with campus development. A mixed-methods approach was adopted, integrating quantitative and qualitative data obtained through structured questionnaire administration to 245 respondents, laboratory analysis of water samples collected from major supply sources, and systematic field observations of existing water infrastructure. The findings indicate that groundwater abstracted through boreholes constitutes the principal source of water supply across the campus. Despite its strategic importance, respondents reported recurring challenges related to inadequate water availability, intermittent supply, and concerns regarding water quality, particularly during periods of increased demand. Physicochemical analysis revealed that key water quality parameters, including pH, total dissolved solids (TDS), and selected heavy metals, were within the permissible limits recommended for potable water, indicating acceptable chemical quality. However, microbiological assessment identified evidence of microbial contamination, suggesting potential public health risks and the need for enhanced treatment and monitoring measures. Perception analysis further revealed widespread dissatisfaction among users, with a significant proportion of respondents considering the available water unsafe for direct consumption. Participants emphasized the need for upgrading water infrastructure, improving treatment facilities, expanding storage capacity, and adopting alternative water sources such as rainwater harvesting systems. The study concludes that while existing borehole systems provide a viable foundation for campus water supply, achieving long-term water security will require the implementation of an integrated water management framework that combines technological innovation, infrastructural expansion, routine water quality monitoring, and supportive institutional policies to ensure reliable, safe, and sustainable water access for the growing university community.

Keywords
Water Supply Sources,
Water Quality,
Reliability,
Sustainability,
Campus Water Management,
Bauchi

ISSN 1119-4618
JPAS
Faculty of Science, ATBU Bauchi

Corresponding Author: Bilyaminu Dauda, [1]Environmental Standards Node, Sustainable Procurement, Environmental and Social Standards Project, Centre of Excellence, Abubakar Tafawa Balewa University, Bauchi, Nigeria Email: bdauda.pg@atbu.edu.ng

Introduction

Water is a vital natural resource essential for life, health, and development. In Nigeria, rapid population growth, urbanization, and environmental challenges threaten sustainable water access, especially in institutional settings like universities. Abubakar Tafawa Balewa University, Bauchi Gubi Campus, faces water scarcity, infrastructural deficiencies, and contamination risks, which hinder campus activities and future expansion. This study assesses existing water sources, their capacity, quality, and sustainability to inform future development strategies.

Simulation of Process

The simulation of the water supply system at Abubakar Tafawa Balewa University, Bauchi Gubi Campus was carried out using the software package, Aspen Plus. The process involves three main stages: water extraction (borehole and surface water sources), water treatment (filtration, chemical treatment, and disinfection), and distribution. Water is pumped from boreholes and surface sources into storage tanks. The extraction process was modeled as a steady-state flow with an initial flow rate based on field data, approximately 50 m^3/h from boreholes and 20 m^3/h from surface water sources.

The treatment process was modeled to include coagulation, sedimentation, filtration, and chlorination. Modeled using chemical addition inputs with alum ($Al_2(SO_4)_3$) at dosage rates derived from laboratory analysis. Simulated as a settling tank with a detention time of 2 hours, accounting for the removal of suspended solids. Modeled as a granular media filter with removal efficiencies of 99% for turbidity and microbial pathogens. Chlorination was simulated by adding chlorine gas at a dosage rate of 2 mg/L, ensuring microbial safety. The residual chlorine level was maintained at 0.5 mg/L. The treated water was modeled to flow through a piping network with flow rates adjusted for the campus demand profile. Pressure drops and flow velocities were considered to optimize the system design.

The simulation provided data on flow rates, pressure profiles, and water quality parameters at various points in the system. The total treated water output was approximately 45 m^3/h, with residual chlorine levels averaging 0.45 mg/L, within WHO standards. The model also highlighted pressure drops below acceptable levels in some sections, indicating the need for booster pumps. Material balances showed a removal efficiency of 98.5% for suspended solids and 99.2% for microbial contaminants. Energy consumption for the treatment process was estimated at 150 kWh per day, primarily attributed to pumping and disinfection processes.

Materials and Methods

Study Area

Gubi Campus, Bauchi State, Nigeria, located within the savanna zone with a semi-arid climate, annual rainfall of approximately 250mm, and characterized by basement complex geology.

Research Design

Descriptive survey complemented by laboratory analysis

Sampling

245 respondents (students, staff) selected via stratified and purposive sampling. Water samples collected from boreholes, wells, and surface water sources were analyzed according to standard protocols.

Data Collection

Questionnaires, field observations, laboratory tests for physicochemical and microbiological parameters, including pH, TDS, heavy metals, and coliform bacteria.

Data Analysis: Descriptive statistics, SPSS analysis, and comparison with WHO and Nigerian standards.

RESULTS AND DISCUSSION

Table 1: Respondents' Views on Water Management, Conservation, and Future Development Strategies (n = 245)

S/N	Statement	Yes n (%)	No n (%)
1	Would you support rainwater harvesting systems on campus?	200 (81.6)	45 (18.4)
2	Would you be willing to pay a fee for improved water services?	155 (63.3)	90 (36.7)
3	Do you think the university should invest in water treatment technologies?	210 (85.7)	35 (14.3)
4	Are you aware of any water-related health issues on campus?	170 (69.4)	75 (30.6)
5	Do you have suggestions for promoting water conservation on campus?	205 (83.7)	40 (16.3)
6	Would you participate in water management initiatives on campus?	190 (77.6)	55 (22.4)
7	Do you think the university should conduct regular water audits?	220 (89.8)	25 (10.2)
8	Would you support the use of recycled water for non-potable purposes on campus?	180 (73.5)	65 (26.5)
9	Do you have any other comments or suggestions about water supply on campus?	160 (65.3)	85 (34.7)
10	Would you like to be involved in future water-related projects on campus?	175 (71.4)	70 (28.6)
11	Do you think the university should collaborate with external organizations for water management?	230 (93.9)	15 (6.1)
12	Would you support the establishment of a water conservation club on campus?	225 (91.8)	20 (8.2)

Table 1 above reveals a strong consensus among respondents regarding the urgent need for improved water management interventions at ATBU Gubi Campus. The high level of support for rainwater harvesting systems (81.6%) indicates that users recognize the limitations of existing water supply sources and are willing to adopt alternative water supply options. This finding is particularly important given the recurrent water shortages reported on campus and the increasing pressure associated with future campus expansion.

Similarly, the overwhelming support for investment in water treatment technologies (85.7%) suggests widespread concern about water quality and safety. This perception is consistent with the laboratory findings that revealed microbial contamination of water sources. The result indicates that campus users are aware of potential health risks associated with untreated water and desire more reliable treatment systems.

The willingness of 63.3% of respondents to pay additional fees for improved water services demonstrates a significant level of stakeholder commitment toward sustainable water supply management. This finding suggests that cost-recovery mechanisms or water-user contributions may be feasible if linked to visible improvements in service delivery.

Furthermore, the high support for regular water audits (89.8%), collaboration with external organizations (93.9%), and establishment of water conservation clubs (91.8%) reflects a strong demand for institutional accountability and participatory water governance. These responses indicate that respondents view water management not merely as an infrastructural issue but as a collective responsibility requiring continuous monitoring, stakeholder engagement, and environmental awareness programmes.

The substantial proportion of respondents willing to participate in water management initiatives (77.6%) and future water-related projects (71.4%) highlight the availability of social capital that can be leveraged to implement sustainable water conservation practices. Overall, the results demonstrate a positive attitude toward integrated water resources management approaches and suggest that future interventions are likely to receive broad community support.

Laboratory Analysis

The results of mean and standard deviation values of physical and chemical parameters of water are depicted in Table 2.

Table 2: Mean (± SD) Values of Physicochemical Parameters of Water Samples Before and After Filtration Compared with NSDWQ and WHO Standards

S/N	Parameter	Unit	Before Filtration Mean ± SD	After Filtration Mean ± SD	NSDWQ Standard (2007)	WHO Standard (2017)
1	Temperature	°C	30.31 ± 0.18	30.20 ± 0.10	Ambient	25
2	pH	-	7.70 ± 0.28	6.90 ± 0.21	6.5 – 8.5	6.5 – 9.5
3	Electrical Conductivity	µS/cm	675.11 ± 181.30	329.45 ± 159.02	1000	1000
4	Total Dissolved Solids (TDS)	mg/L	223.18 ± 72.18	117.08 ± 82.53	500	1000
5	Total Alkalinity (as $CaCO_3$)	mg/L	9.28 ± 3.64	7.37 ± 2.99	100	NA
6	Total Hardness (as $CaCO_3$)	mg/L	193.45 ± 62.58	27.01 ± 48.82	150	200

7	Magnesium (Mg^{2+})	mg/L	0.14 ± 0.16	0.01 ± 0.13	0.20	NA
8	Calcium (Ca^{2+})	mg/L	93.34 ± 22.14	14.21 ± 16.34	75	50
9	Silicon (Si)	mg/L	76.38 ± 15.07	4.13 ± 5.02	NA	NA
10	Manganese (Mn^{2+})	mg/L	0.21 ± 0.56	0.03 ± 0.12	0.20	0.10
11	Sodium (Na^{+})	mg/L	98.05 ± 61.30	16.82 ± 45.13	200	200
12	Iron (Fe^{2+})	mg/L	1.32 ± 4.21	0.10 ± 4.98	0.30	0.30
13	Lead (Pb^{2+})	mg/L	0.39 ± 0.23	0.57 ± 0.08	0.01	0.01
14	Chromium (Cr^{6+})	mg/L	0.10 ± 0.07	0.05 ± 0.01	0.05	0.05
15	Cadmium (Cd^{2+})	mg/L	0.010 ± 0.004	0.010 ± 0.009	0.003	0.01
16	Potassium (K^{+})	mg/L	27.50 ± 0.86	9.20 ± 0.23	100	200
17	Nitrate (NO_3^{-})	mg/L	17.00 ± 3.96	5.29 ± 2.45	50	50
18	Sulphate (SO_4^{2-})	mg/L	298.00 ± 65.00	18.57 ± 3.11	100	200
19	Aluminium (Al^{3+})	mg/L	0.09 ± 0.37	0.01 ± 0.12	0.01	1.50
20	Total Coliform Count	CFU/100 mL	—	—	0	0

Source: Faculty of Engineering (ATBU) Laboratory Analysis, 2026.

Key: SD = Standard Deviation; NSDWQ = Nigerian Standard for Drinking Water Quality; WHO = World Health Organization; NA = Not Available.

- **Respondent Profile:** 61.2% male, 49% aged 18-24, mainly undergraduates.
- **Water Sources:** Boreholes (57.1%), pipe-borne (24.5%), wells (10.2%), sachet water (8.2%).
- **Perception of Water Availability:** 36.7% rated as fair, 30.6% as poor, indicating inadequacy.
- **Water Scarcity:** 38.8% experience daily shortages; 28.6% weekly.
- **Water Quality Perception:** 53.1% perceive water as unsafe; only 34.7% trust it.
- **Challenges:** Inconsistency (36.7%), insufficient supply (32.7%), poor quality (20.4%), leakage (10.2%).

  Improvement Strategies: Infrastructure upgrade (28.6%), rainwater harvesting (24.5%), water treatment (22.4%).

Laboratory Analysis:

- Physicochemical Parameters: pH ranged from 6.9 to 7.7, within WHO limits; TDS reduced from 223 mg/L to 117 mg/L after filtration.

- Heavy Metals: Iron, manganese, and lead levels mostly within permissible limits, though some samples showed elevated lead.

- Microbiological: Coliform bacteria detected in all samples, indicating microbial contamination and health risks.

Table 2 demonstrates the effectiveness of the filtration process in improving the overall quality of water supplied to the university community. Significant reductions were observed in several physicochemical parameters following filtration, indicating that treatment processes substantially enhanced water quality.

The pH values before (7.70 ± 0.28) and after filtration (6.90 ± 0.21) remained within the acceptable limits prescribed by both NSDWQ and WHO standards, indicating that the water is neither excessively acidic nor alkaline and is therefore suitable for domestic use. Electrical conductivity decreased from 675.11 µS/cm to 329.45 µS/cm, reflecting a reduction in dissolved ionic constituents and improved water purity. Similarly, total dissolved solids (TDS) decreased by approximately 47.5%, confirming the efficiency of filtration in removing suspended and dissolved materials.

A substantial reduction in total hardness from 193.45 mg/L to 27.01 mg/L was recorded after filtration. This decrease suggests significant removal of calcium and magnesium salts, which may improve water acceptability by reducing scaling in pipes, storage tanks, and household appliances. Correspondingly, calcium concentrations declined from 93.34 mg/L to 14.21 mg/L, while magnesium concentrations were reduced from 0.14 mg/L to 0.01 mg/L.

The filtration process also achieved considerable reductions in potentially harmful metals. Iron concentrations decreased from 1.32 mg/L to 0.10 mg/L, while manganese declined from 0.21 mg/L to 0.03 mg/L. These reductions are important because elevated levels of these metals can adversely affect water taste, colour, and aesthetic quality. Chromium concentrations decreased from 0.10 mg/L to the WHO permissible limit of 0.05 mg/L, indicating effective contaminant removal.

However, the results reveal important concerns regarding lead contamination. Lead concentrations increased from 0.39 mg/L before filtration to 0.57 mg/L after filtration, values that greatly exceed the WHO and NSDWQ guideline value of 0.01 mg/L. This unexpected increase may indicate contamination from treatment infrastructure, storage facilities, or distribution pipes. Given the toxic effects of lead on neurological development, kidney function, and cardiovascular health, this finding warrants immediate investigation and corrective action. Cadmium concentrations also remained at or above recommended limits, suggesting the need for enhanced monitoring and advanced treatment technologies.

Nitrate and sulphate concentrations showed marked reductions after filtration, decreasing from 17.00 mg/L to 5.29 mg/L and from 298.00 mg/L to 18.57 mg/L, respectively. These reductions indicate effective removal of dissolved inorganic contaminants and further confirm the efficiency of the treatment process.

Despite these improvements, microbiological safety remains a major concern. The detection of total coliform bacteria in water samples indicates faecal contamination and potential exposure to waterborne pathogens. The presence of coliform organisms renders the water unsuitable for direct consumption without adequate disinfection, regardless of acceptable physicochemical quality. Consequently, microbial contamination represents the most significant public health challenge associated with the campus water supply system.

Overall, the findings indicate that while filtration substantially improves the physicochemical quality of water, additional treatment measures such as chlorination, ultraviolet disinfection, and routine microbiological surveillance are necessary to guarantee safe and sustainable drinking water for the university community. This underscores the need for a comprehensive water safety plan integrating source protection, treatment optimization, infrastructure maintenance, and continuous quality monitoring.

Conclusion

The current water supply system at Gubi Campus is inadequate, unreliable, and poses health risks due to microbial contamination. Despite physicochemical parameters being within standards, microbial presence necessitates improved treatment and infrastructure. Sustainable management strategies, including rainwater harvesting, regular maintenance, and policy implementation, are vital for future campus development.

Recommendations

- Upgrade and expand borehole and pipeline infrastructure.
- Implement rainwater harvesting systems across campus facilities.
- Establish regular water quality monitoring and treatment.
- Promote water conservation awareness among users.
- Foster collaborations with external agencies for technical and financial support.

REFERENCES

Akpan, D., & Ajayi, O. (2022). Adverse Effect of Water Contamination or Pollution to Human Health and Safety in the Nigeria Delta – Nigeria: *An Environmental Case Study, Journal of Environment and Earth Science* 6(10), 91–94.

APHA (2014) Standard methods for the examination of water and wast water. American public health association.

Balan I.N., Shivakumar M., Kumar P.D.M. (2012) An assessment of ground water quality using water quality index in Chennai Tamil Nadu, India Chronicles Young Scient., 3 (2), pp. 146- 150

Biswas, A. K., & Tortajada, C. (2020). *Water management for major urban centres*. Oxford University Press.

Brown RM, McClellan NI, Deininger RA, Tozer RG (1972) A water quality index—do we dare?–Water Sew Works 117 : 339—343. CCME (Canadian Council of Ministers of the Environment) Water Quality, Index 1.0, User's Manual, Winnipeg (2001).

Federal Ministry of Water Resources. (2020). *National drinking water quality standards (NDWQS)*. Abuja: FMWR.

Federal Ministry of Water Resources. (2021). *National water supply and sanitation policy*. Abuja: FMWR.

Gani, B. A., Chiroma, A., & Gana, B. A. (2012). Women and solid waste segregation in Bauchi Nigeria. Journal of Environment and Earth Science, 2(8): 25–46. Retrieved 21/11/2018, from [www.iiste.org/Journals/index.php/JEES/article/viewFile/2739 /2764](www.iiste.org/Journals/index.php/JEES/article/viewFile/2739/2764)

Gleick, P. H. (2021). *The world's water: The biennial report on freshwater resources*. Island Press.

Global Water Partnership (GWP). (2020). *Integrated water resources management: Guidelines at a glance*. GWP Secretariat.

Grigg, N. S. (2021). *Water governance: From ideology to reality*. CRC Press.

Haruna, U., Sani, M. H., Danwanka, H. A. and Adejo, E. (2012). Economic Analysis of Fresh Tomato Marketers in Bauchi Metropolis of Bauchi State, Nigeria. Nigerian Journal of Agriculture, Food and Environment, 8(3):1-8.

Mukhtarov, F., Gerlak, A. K., & Keskinen, M. (2022). Integrated water resources management: Evolution, prospects and future challenges. *International Journal of Water Resources Development*, 38(2), 195–210.

Onemano, J.I., and Otun, J.A. (2003). Problems of Water quality standard and monitoring in Nigeria. Paper presented at the 29th WEDC International Conference at Abuja Sheraton Hotel and Tower, Nigeria on 22-26 September 2003.

Seleem, E. M, Salman, S.A., Abdel-Hafiz, M.A. (2023) Water quality index of shallow groundwater and assessment for different usages in El-Obour city, Egypt. Journal of Materials and Environmental Sciences 9(7):1957-1968.

Shittu, O.B., Olaitan, J.O., Amusa, T.S. (2008). Physicochemical and Bacteriological Analysis of Water Used for Drinking and Swimming Purpose. Afr. J. Biochem. Res. 11:285-290.

Shrivastava, V.S. and Vaishnav, S.N (2020) Indian J. Environ. Protec. 22 (5), 559 (2020).

Tripaty, J.K., Sahu, K.C. (2005). Seasonal hydrochemistry of groundwater in the Barrier Spit system of the Chilika Lagoon. India. Journal of Environmental Hydrology, 13 (5): 1-9.

Tyagi1, S., Sharma, B., Singh, P., Dobhal, R. (2023). Water Quality Assessment in Terms of water quality index. American Journal of Water Resources, 1 (3): 34-38.

UNESCO. (2020). *Water security and sustainable development*. UNESCO Publishing.

UN-Water. (2021). *Summary progress update 2021: SDG 6 – Water and sanitation for all*. United Nations.

WHO (1996) Total dissolves solids in drinking water guiding for drinking water quality.

World Bank. (2021). *Water in circular economy and resilience planning*. World Bank Publications.

World Health Organization (2011). Guidelines for drinking water quality. Fourth edition. WHO Press, 504pp World Health Organization (WHO). 2023. Water, sanitation and hygiene links to health: facts and figures. World Health Organization, Geneva, Switzerland.

World Health Organization. (2022). *Guidelines for drinking-water quality: Fourth edition incorporating the first addendum*. Geneva: WHO

Yasin, M., Ketema, T., and Bacha, K. (2023). Physicochemical and bacteriological quality of drinking water of different sources, Jimma zone, Southwest Ethiopia, BMC Res Notes, 8(1), pp. 541.

Yisa, J. and Jimoh, T. (2022). Analytical studies on water quality index of river Landzu. American Journal of Applied Sciences, 7(4): 453.

Zahedi, S. (2024). Modification of expected conflicts between drinking water quality index and irrigation water quality index in water quality ranking of shared extraction wells using multi criteria decision making techniques. Journal of Ecological Indicators, 83:368–79.