Evaluation of the Effects of Water Quality on the Health of Some Selected Communities in Maiduguri Metropolis.

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Abstract:

Since water is the primary resource needed to support all human endeavors, it must be of the proper quantity and quality, making the development of effective, economical, and efficient water purification techniques for the community crucial to human survival and development on a global scale. Assessing the drinking water quality in the Gwange district, Dala ward, and Balori II ward, respectively, is the main goal of the current cross-sectional study. This covers the impact it has on human health as reported by the local population. Numerous tests were performed on the water samples that were taken from the study area, including microbiological, chemical, and physical evaluations. The physical parameters of the samples were all found to be within the Who is acceptable limits, and the chemical parameters showed that the zinc and chromium levels ranged from 0.22 to 0.31 mg/l and 0.04 to 0.20 mg/l, which are above the WHO maximum standard limit of 0 mg/l. Most of the wards showed a limitless number of microbial contents, with the worst being Gwange ward. This might be due to the favorable conditions like temperature, pH, etc. A high value of MPN indicates that water is not suitable for drinking purposes. The study argues that water purification and water management systems are necessary and important in the modern era, even though the majority of people living in these areas did not suffer from various waterborne diseases.

Keywords: *microbial, pollution, cross-sectional study, chromium, and water quality.*

1.0 Introduction

The quality of water over the decade had been defined by its being colorless, odorless, and tasteless and by its transparent atmosphere. It is a basic resource necessary for sustaining all human activities, so its provision in desired quantity and quality is of utmost significance (Nuri & Adamu, 2023), Water covers about 71% of the earth's surface and is a very essential natural resource for people (Mishra, 2023), However, only 2.5 percent of the water on Earth is fresh enough to drink. Furthermore, over two-thirds of that 2.5 percent is trapped in glaciers and unable to contribute significantly to meeting society's expanding needs. (Yadav & Jadon, 2023). Water pollution, which affects drinking water, rivers, lakes, and oceans worldwide, is a fundamental human right (Edo *et al.*, 2024), Sewage and wastewater, industrial waste, oil pollution, marine dumping, atmospheric deposition, radioactive waste, subterranean storage leaks, global warming, and eutrophication are some of the causes of this harmful condition that affects both the environment and human health (Khan *et al.*, 2023)

Water poisoning may not affect a person's health right away, but it can eventually be fatal. Industrial processes may pollute nearby lakes and rivers with heavy metals, endangering marine life, other animals that drink the toxic water, and humans who eat animal products (Dippong *et al.*, 2024), Industrial waste contains toxins that can lead to acute poisoning, immunological suppression, or reproductive failure. The main causes of infant mortality, infectious disorders like cholera and typhoid fever, are frequently brought on by microbial contaminants from sewage. Water pollution can have a negative economic impact since it can be expensive to treat and avoid contamination. Non-biodegradable garbage accumulates in the earth's fluids before eventually entering the oceans (Dayananda *et al.*, 2025), In addition to being a serious health issue in underdeveloped nations, diarrheal illnesses pose a serious risk to tourists visiting these nations. (Chandra *et al.*, 2022), Over two million people die each year from diarrheal infections, according to conservative estimates. (1.7 to 2.5 million deaths), making them the third leading cause of infectious disease-related mortality globally. (Black *et al.*, 2024), Children under the age of five account for the majority of these deaths. It has been found that children have an average of 3.2 episodes of diarrhea a year, while in certain cases in developing countries, this number might reach 12 episodes annually. (Behera & Mishra, 2022), There is mounting evidence of the long-term effects of such a high disease load in early childhood on children's physical and mental development, which could ultimately result in an expensive impairment of human fitness and productivity as an adult (Hanson & Gluckman, 2014), Furthermore, cholera, shigellosis, and typhoid fever epidemics typically strike developing nations, increasing the disease burden among the most vulnerable, including internally displaced people, refugees, and slum dwellers. (Jaber *et al.*, 2024), By preventing contaminants from contaminating neighboring waters, water contamination can be avoided. Numerous water treatment methods, including sand filters, chemical additives, and biological filters, are used to stop pollution (Kordbacheh & Heidari, 2023), Although maintaining these easy methods costs money, preventing water pollution is far less expensive than cleaning up after it has already happened. (Nuri & Adamu), In light of the aforementioned facts, this study was conducted to evaluate the water quality of three communities that were chosen for the study and its impact on people's health with regard to water-related illnesses.

2.0 Method

2.1 Research tool

Informed consent was obtained from the participants prior to the interview, and a self-designed, pre-tested, semi-structured questionnaire was used to interview 150 participants in total. The purpose of the questionnaire was to gather descriptive information about the respondent's daily routines, water use, water storage practices, personal hygiene routines, and illness experiences. The Statistical Package for Social Sciences (SPSS 21) was used to statistically evaluate the gathered data.

2.1.2 Sampling

Water samples were collected from the wards using sterile test tubes as the first step in the three-month trial, which ran from March 2025 to June 2025. For the microbiological sampling, water samples were brought to the laboratory in clean, sterile test tubes and analyzed within 24 hours. Common water sources, or the places where the majority of residents get their water, are where these samples were collected. Therefore, it would be beneficial and resource-efficient to test water samples from these common sources, such as water tanks, tube wells, wells, and common water taps. Nine (9) water samples were taken—one from each ward's public water tanks, one from each residence (picked at random), and one from the common taps (selected at random) in order to determine the physical, chemical, and microbiological quality of the drinking water in the chosen wards. The household sites were chosen randomly using a random sampling technique. Using standard techniques, physical parameters were measured at the water's sampling site. The chemical concentrations of copper, chromium, and zinc were determined using standard photometric analysis. Utilizing the colony count and most likely number methods, microbial evaluation was performed using nutrient agar and MacConkey agar for both presumed and proven coliform counts.

3.0 Results and Discussions

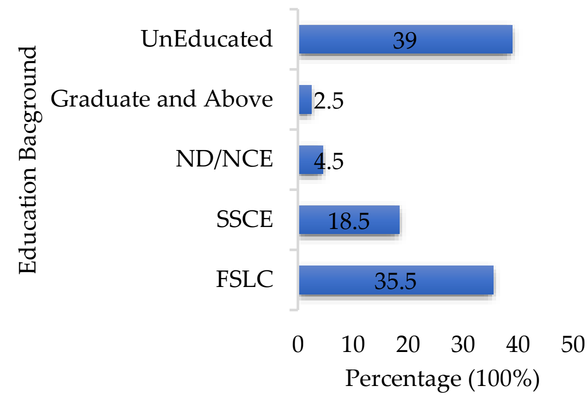

Figure.1, Educational Background of the Respondents

Sources: *field survey, 2025*

Figure 1 highlights the education status of the respondents. According to the data collected, 39% of the respondents were uneducated, while 35.5% had a first school leaving certificate (FSLC). Also, the secondary school level is at 18.5%, while 4.5% and 2.5% had ND/NCE and graduate degrees and above, respectively. So, the level of uneducated was very high among the respondents in the study area; this suggests that the individuals with lower or zero education levels are likely to be less informed about the water quality assessment and the impact on health. Therefore, educational initiatives might need to target less-educated members of the communities more effectively, as they may be more vulnerable to water-related disease issues.

Table 1. Age Distribution of the Respondent.

Age Group	Percentage (%)
18–22	3
23–27	6.8
28-32	6.1
33–37	39.7
38-42	26.3
43-47	8.7
48-52	4.6
53 - above	2.8

***Sources:** field survey, 2025*

The age distribution of people interviewed is given in Table 1 above, which shows that 39.7% were within the ages of 33 and 37, which is the highest age range of the participants. This suggests that the younger working-age population is most engaged with the issue related to water quality assessment. The next largest group, 38–42, at 26.3%, also represents an active segment of the population, which is likely involved in both communities' leadership and family responsibilities. And the lowest representation of individuals is above 53 at 2.8%; this may indicate that older members of the communities are less involved in or affected by the water assessment survey.

3.1 Water sources

Drinking water came from a variety of sources, including tap water (15.5%), wells (14.0%), tube wells (14.0%), and community water sources (58%). Boiling (4.0%) and muslin cloth (7.5%) were the methods used to purify the drinking water, while 88.5% did not use any method at all.

3.1.1 The Storage of Drinking Water

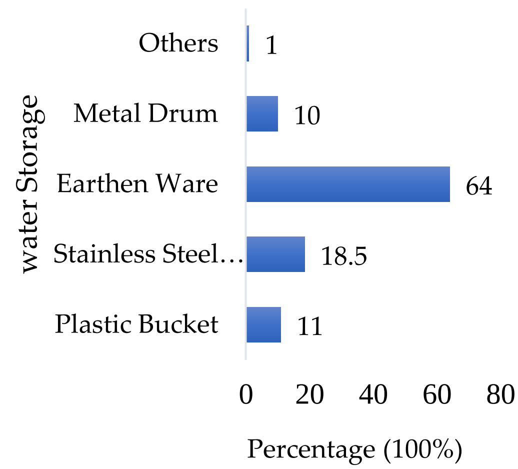

Figure. 2, Storage of Drinking Water

***Source:** field survey, 2025*

As seen in Figure 2 above, around 64% of the drinking water was stored in earthenware pots, 18.5% in stainless steel containers, 11.5% in plastic buckets, 10.0% in metal drums, and 1.0% in other containers. They also did not take any special precautions when storing the water. When removing water from the containers, the majority of them did not use a separate glass. Before removing water from the storage container, the resident's children in particular did not practice basic hygiene practices, such as washing their hands. While some individuals wash their water-storage utensils every two to three months, the majority told us they only wash them once a month. The majority of them were unaware of the many safety measures that should be followed both before and after storing water in order to avoid waterborne illnesses.

3.1.2 The Respondent Medical Conditions

As seen in Figure 2 below, around 51.5% experienced medical conditions such as diarrhea, vomiting, headache, stomachache, dizziness, fever, etc., whereas 48.5% did not.

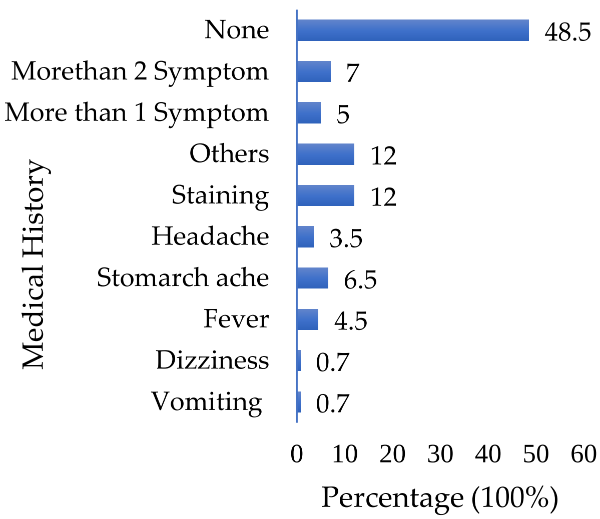

Figure. 3 Past Medical History of The Respondents.

Source: *field survey, 2025*

4.0 Laboratory results

Table 2. Physical Parameters

Characteristics	Gwange	Dala Ward	Bolori II ward	WHO
pH	7.7	8.1	8.5	**8.2–8.8**
Temperature	38	36	28	**23–40**
Turbidity (NTU)	0.4	2.3	1.7	**5**
Colour (Hazen/TCU)	3.3	3.8	1.2	**5**

Source: *Fieldwork (March–June 2025).*

The results of the physical parameters that were evaluated are displayed in Table 2 above; every value fell within the maximum allowable range except pH value for Gwange ward in which the average value records fall below range specified by the World Health Organization (WHO) for drinking water, as such the water samples are tempted. These results were consistent with the previous report by (Nuri & Adamu, 2023), as they observed a pH of between 6.43 and 8.18 for the well water, which incidentally is located in Bali L.G.A., Taraba State, Nigeria. Furthermore, the present study agrees strongly with the report of (Igwe *et al.*, 2021), whose investigation obtained a range of values between 6.8 and 6.9, while the control samples had a range from 6.0 to 7.1. In a related study, (Sani, 2022) reported ranges between pH 6.6 and 8.3 for shallow well water and pH 6.5 and 8.4 for borehole water, while the WHO permissible limit is 6.5–8.5. pH is generally considered to have no direct impact on humans. Temperature: The study showed that the temperature ranged from 28°C to 38°C. The highest temperature was recorded in Gwange and the lowest at Bolori II ward. According to (Nuri & Adamu), the temperature of the well is influenced by the ambient temperature, the time of day when it's recorded, the presence and number of vegetation, and the amount of dissolved solids in the sources of water in the study area.

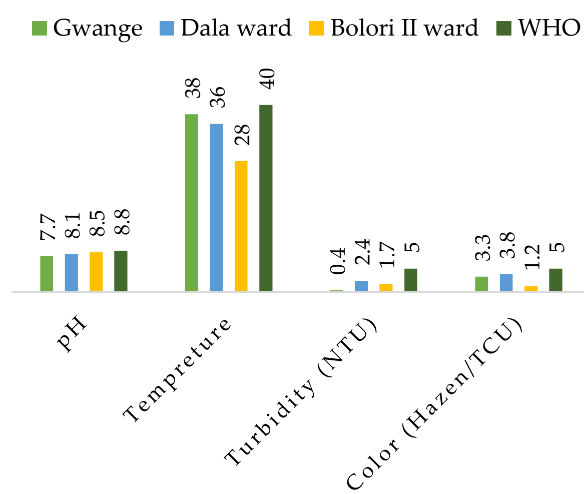

Figure. 4 above, summarize the physical parameters of all the study area

Table 3. Chemical Parameters

Chemical Assessment	Gwange	Dala Ward	Bolori II ward	WHO
Copper (mg/l)	0	0	0	**2**
Chromium (mg/l)	0.13	0.20	0.04	-
Zinc (mg/l)	0.22	0.31	0.23	-

Sources: *Laboratory Analysis (March–June 2025).*

According to the study, rigorous monitoring of the input, movements, and effects of such pollutants is necessary since the buildup of certain heavy metals over extended periods of time and over wide areas can cause cumulative harm to living things.

4.1.1 Copper

Table 3 above showed that the copper concentration was 0 mg/l, which is below 2mg/L recommended by WHO as maximum permissible concentration for drinking water, which render the water safe from copper concentration in the water samples. according to (Nuri & Adamu, 2023), Copper is included in trace amounts in agricultural chemicals. Copper levels in water are influenced by flow rate as well as water properties like pH and hardness.

4.1.2 Chromium

The Chromium concentration in the water sample of all the communities where all above the recommended value of 0mg/L set by WHO as the values rage between 0.04mg/L to 0.31mg/L respectively, as such rendered the water unsafe for consumption. Chromium is also essential to organisms as a micronutrient in traces from fat and carbohydrate metabolism (Islam *et al.*, 2023), Chromium is also more harmful in its lower oxidation state (III). Chromium and chromates are potential carcinogens. The limit of chromium in drinking water is 0.0 mg/l, according to WHO (Georgaki *et al.*, 2023), Each and every water sample had a chromium content that exceeded the WHO maximum allowable limit. The relevant authorities ought to investigate this since it poses a significant risk to public health.

4.1.3 Zinc

Although zinc is a very important micronutrient for humans, excessive amounts of it can have harmful effects. Zinc compounds are caustic and astringent to mucous membranes, skin, and eyes. They are the cause of "zinc pox," a unique kind of dermatitis. Additionally, zinc irritates the digestive system, which can result in nausea and vomiting. According to the World Health Organization (WHO), the highest quantity of zinc that can be present in drinking water is 0 mg/l. All of the study's water samples had zinc contents that were higher than the WHO's maximum allowable limit. This result is not surprising, as the rate of flow and water characteristics such as pH and hardness influence the levels of zinc in water. Additionally, the findings demonstrate that the agricultural operations in the research area are responsible for the observed zinc levels at sample locations, as farmers employ various chemical preparations in agro production that contain traces of zinc.(Nuri & Adamu, 2023),

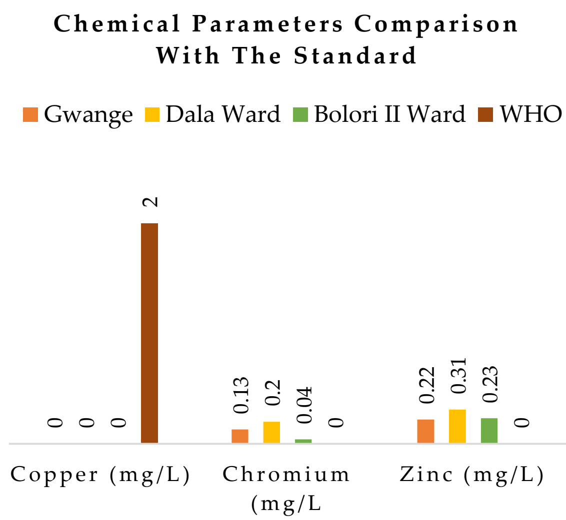

Figure. 5, shows the summary of the chemical parameters of all the study area

Table 4. Microbial Parameters

Microbial Assessment		
Wards	Nutrient agar (Colonies/100 ml of Water)	MacConkey Agar (Colonies/100 ml of Water)
+Control	Infinite	Infinite
-Control	-	-
Gwange Ward	Infinite	Infinite
Dala Ward	7.3	4.2
Bolori ii Ward	Infinite	Infinite
WHO	0	0

Source: *Laboratory Analysis (March–June 2025).*

Table 4 above proves that the most probable numbers (MPN) are a useful and popular way to assess the level of water's microbiological purity. Most of the wards showed an unlimited number of microbial contents, with the worst being Gwange ward. This might be due to the favorable conditions like temperature, pH, etc. A high value of MPN indicates that water is not suitable for drinking purposes. This result is not surprising, as most bacteria grow between pH 4 and 10 and exhibit optimum growth in the range of pH 6.5 to 7.5 (Razmi *et al.*, 2023), The vast majority of people (about 72%) lack hygienic toilets and do not clean their water in any way. Another widespread practice in the communities is open-air defecation, which can contaminate the water supply system and cause epidemics of diarrheal illnesses. The aforementioned survey also found that most communities (68.5%) lacked adequate awareness regarding the availability and necessity of safe drinking water and did not employ any means for purifying it. This result agrees with the findings of (Nuri & Adamu, 2023), in their studies. The detection of *E. coli* in the water sample indicates that there was a recent fecal contamination. The contamination could be as a result of contamination from pit latrines close to the well water site, which is close to the refuse disposal site (Yahaya *et al.*, 2023).

Localized wastewater collections and open drains were prevalent in the research area, which lacked an organized sewage infrastructure. Animal excrement was scattered on the streets and at homes where animals were chained. On the streets, children were observed urinating. Feces were also occasionally seen in the sewage drains and around the localized wastewater collection locations. In several locations, there was no mechanism in place for the collection and disposal of waste. They may have developed protection against numerous waterborne bacterial and viral infections, which may have contributed to the increased risk of diarrheal disorders in some areas where rubbish was inseparable from human and animal feces. Another explanation might be that people are not aware of these symptoms, their significance, or the significance of reporting them. Therefore, their underreporting of certain illnesses and symptoms may have been caused by their ignorance about them.

5.1 Conclusion

Since no natural water is completely free of pollutants, the WHO has established minimal requirements to ensure that water is safe to consume. Every physical parameter that was examined fell within permissible bounds. However, some of them had chemical values that were greater than the suggested limits. All the parameters analyzed for microbial were higher than the recommended limits; it can therefore be concluded that all the water samples analyzed in the study area were *feacally* contaminated, as the values recorded were above the recommended values set by WHO. It is revealed that the sources of water were under some attack by anthropogenic sources. Therefore, actions that damage surface and subsurface water sources, like improper waste management and excessive use of chemicals and fertilizers, must be prevented. Protecting water sources from harmful runoff from waste disposal facilities, intense agricultural communities, and polluted places is crucial. Above all, additional studies at various water sources throughout the metropolis must be looked at in order to verify the quality of the water sources.

5.2 Recommendations

- This awareness of water quality evaluation can be spread by widespread advocacy and education. The long-term viability of these and their cost-effectiveness in local communities are still debatable, though. Chlorine use for water filtration was not common in the current investigation.
- To ensure high water quality standards in urban populations, the authorities responsible for water quality evaluation must regularly or continuously inspect the water sources at least every two years. This will facilitate the early detection of contamination and allow for the implementation of corrective action.
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Data Collection: Authors 1-2 (A. Adamu and B. Mustapha): Collected water samples from selected communities in Maiduguri Metropolis and gathered relevant health data.
Laboratory Analysis: Authors 2-3 (B. Mustapha and A. A. Hamman): Conducted physicochemical and bacteriological analysis of water samples following standard procedures.
Data Analysis: Authors1-2 (A. Adamu and B. Mustapha): Performed statistical and comparative analysis of water quality parameters and health outcomes.
Interpretation of Results: Authors 1-3 (A. Adamu and A. A. Hamman): Interpreted findings in the context of public health and local environmental conditions.
Manuscript Preparation: (All Authors): Drafted the initial manuscript and incorporated feedback from all co-authors.
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Conflict of Interest: Regarding this manuscript, the authors disclose no conflicts of interest.

References

Behera, D. K., & Mishra, S. (2022). The burden of diarrhea, etiologies, and risk factors in India from 1990 to 2019: evidence from the global burden of disease study. *BMC public health, 22*, 1-9.

Black, R. E., Perin, J., Yeung, D., Rajeev, T., Miller, J., Elwood, S. E., & Platts-Mills, J. A. (2024). Estimated global and regional causes of deaths from diarrhoea in children younger than 5 years during 2000–21: a systematic review and Bayesian multinomial analysis. *The Lancet Global Health*.

Chandra, R., Supehia, S., Nath, B., Chhetri, C., Kumari, R., Joshi, K. D., . . . Bhatta, R. (2022). Effects of sanitation and hygiene perceptions on international travelers' health, travel plans and trip experiences in India. *Frontiers in public health, 10*, 1042880.

Dayananda, N. R., Wijesinghe, J., Botheju, S. M., Perera, W., & Liyanage, J. (2025). Ocean Warming, Acidification, Plastic Pollution, and Water Quality Deterioration: A Multifaceted Crisis Unveiled. *Coastal and Marine Pollution: Source to Sink, Mitigation and Management*, 111-138.

Dippong, T., Senila, M., Cadar, O., & Resz, M.-A. (2024). Assessment of the heavy metal pollution degree and potential health risk implications in lakes and fish from northern Romania. *Journal of Environmental Chemical Engineering, 12*(2), 112217.

Edo, G. I., Itoje-akpokiniovo, L. O., Obasohan, P., Ikpekoro, V. O., Samuel, P. O., Jikah, A. N., . . . Oghroro, E. E. A. (2024). Impact of environmental pollution from human activities on water, air quality and climate change. *Ecological Frontiers*.

Georgaki, M.-N., Charalambous, M., Kazakis, N., Talias, M. A., Georgakis, C., Papamitsou, T., & Mytiglaki, C. (2023). Chromium in water and carcinogenic human health risk. *Environments, 10*(2), 33.

Hanson, M. a., & Gluckman, P. (2014). Early developmental conditioning of later health and disease: physiology or pathophysiology? *Physiological reviews, 94*(4), 1027-1076.

Igwe, E. O., Ede, C. O., Nnabo, P. N., & Ukpai, S. N. (2021). Impact of heavy metals dispersion on water supplies around Oshiri and Ishiagu mine districts of Southern Benue Trough, Nigeria. *Modeling Earth Systems and Environment, 7*(3), 2015-2030.

Islam, M. R., Akash, S., Jony, M. H., Alam, M. N., Nowrin, F. T., Rahman, M. M., . . . Thiruvengadam, M. (2023). Exploring the potential function of trace elements in human health: a therapeutic perspective. *Molecular and cellular biochemistry, 478*(10), 2141-2171.

Jaber, T., Boelee, E., Bleser, J., & Bartram, J. K. (2024). Outbreaks of faecal-orally transmitted diseases in displacement camps: A scoping review of pathogens, risk factors, exposure routes, and drivers of transmission. *Global Public Health, 19*(1), 2380847.

Khan, W. U., Ahmed, S., Dhoble, Y., & Madhav, S. (2023). A critical review of hazardous waste generation from textile industries and associated ecological impacts. *Journal of the Indian Chemical Society, 100*(1), 100829.

Kordbacheh, F., & Heidari, G. (2023). Water pollutants and approaches for their removal. *Materials Chemistry Horizons, 2*(2), 139-153.

Mishra, R. K. (2023). Fresh water availability and its global challenge. *British Journal of Multidisciplinary and Advanced Studies, 4*(3), 1-78.

Nuri, N., & Adamu, A. Microbial quality assessment of selected wells water samples in Bali Metropolis, Taraba State.

Nuri, N., & Adamu, A. (2023). Physicochemical analysis of different well water samples used for drinking and domestic purposes in Bali Metropolis, Taraba State. *International Journal of Advanced Academic Research, 9*(10), 12-21.

Razmi, N., Lazouskaya, M., Pajcin, I., Petrovic, B., Grahovac, J., Simic, M., . . . Stojanovic, G. M. (2023). Monitoring the effect of pH on the growth of pathogenic bacteria using electrical impedance spectroscopy. *Results in Engineering, 20*, 101425.

SANI, S. A. (2022). EFFECT OF ON-SITE SANITATION SYSTEMS ON WATER FROM SHALLOW WELLS-A CASE STUDY OF KADUNA METROPOLIS. *NAU DEPARTMENT OF CIVIL ENGINEERING FINAL YEAR PROJECT & POSTGRADUATE PORTAL, 1*(1).

Yadav, B., & Jadon, A. (2023). Global Warming's Unrelenting Impact: Urgent Concerns Surrounding Glacial Melting. *Contemporary Advances in Science and Technology, 6*(1), 21-26.

Yahaya, T. O., Bashar, D. M., Liman, U. U., Umar, J. a., Abdulrahim, A., & Gomo, C. B. (2023). Effects of Pit Latrines on Borehole and Well water in Maryland, Lagos, Nigeria. *Journal of Advances in Environmental Health Research, 11*(1), 20-27.