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Common parasites in domestic water sources in students' hostels at Ishieke, Ebonyi State, Nigeria

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Abstract

The provision of clean and safe water is crucial for public health, particularly in densely populated areas like student hostels. This study was to determine the common parasites in domestic water sources used by students in hostels at Ishieke, Ebonyi State, Nigeria. Thirty water samples each were collected from four domestic water sources (hand dug well, pond, borehole and harvested rainwater) in clean sterile well labelled sample bottles. Samples were analysed in Department of Applied Biology Laboratory, Ebonyi State University, for the presence of parasites, using Calcium Carbonate Flocculation method, Lugol's iodine stain, Ziehl-Nelson technique and centrifugation. The results showed that all the water sources haboured different parasites, totaling 76 in number, including cysts forms of *Giardia lamblia* 32(42.1%), *Entamoeba histolytica* 22 (28.9%), *Balantidium coli* 16(21.0%) and oocysts of *Cryptosporidium parvum* 6 (7.9%). Parasites were more prevalent in hand dug well-water samples (29) than other water sources, and they were least (9) in harvested rainwater samples. The total percentage prevalence of *Giardia lamblia* was highest (42.1%) and oocyst of *Cryptosporidium parvum* was the least (7.9%). Preventing water borne contamination through provision of safe and portable drinking water is vital to the students' health.

Introduction

Water is important to human life, animals and plants. It is of equal importance with the air we breathe in maintaining the vital processes of life, and it makes up 60% of body weight in human body (Simon-Oke *et al* 2020). Water is an essential resource for life. Water is used by everyone, every day. Not only do all people need drinking water to survive, but water plays an important role in almost every aspect of our lives from recreation to manufacturing, to performing medical procedures. Access to quality-water is essential to health and is a basic human right (WHO 2011; USEPA 2024).

Water is inevitably the source of life on earth and without it, life sustenance becomes difficult (Sargen and Utter 2019). Water of good quality is of basic importance to human physiology, and man's continued existence depends very much on its availability (Okonko *et al* 2008b; Popkin *et al* 2010). Drinking water could be gotten from sources such as borehole/tap water, well water, dams, rivers, streams, lakes, municipal water, and rainwater. Every community of humans, animals, or plants has one or more of these as their source of drinking water (Odikamnoro *et al* 2016*;* Ejike *et al* 2021).

When water becomes contaminated with parasites, it can cause a variety of illnesses when ingested (WHO 2011; Omarova *et al* 2018; Titcomb *et al* 2021; CDC 2024). Galadima *et al* (2011) noted that the significance of water to human and other biological systems cannot be over emphasized. He further reiterates that water shortage or its pollution can cause severe decrease in productivity and deaths of living species. The common sources of water that are available to local communities in Nigeria are fast being severed by several anthropogenic factors of which pollution remain the most dominant problem (Galadima *et al* 2011; Ayobalam *et al* 2014; Akhtar *et al* 2021). Muimba-Kankolongo *et al* (2022) reported that water pollution occurs when unwanted materials with potentials to threaten human lives and other natural systems enter rivers, lakes, wells, streams, boreholes or even reserved fresh water in homes and industries. Water-borne parasitic infections are considered a threat and of public health importance especially in developing countries (Oyedeji *et al* 2010; Simon-Oke *et al* 2020).

Contamination of water with pathogenic microorganisms is generally believed to be a consequence of migration or introduction of faecal material either from humans or animals into the subsurface. Faecal pollution can reach groundwater from many concentrated pond sources such as cesspools, landfills, leaking sewer lines, and filled septic systems (Talabi and Kayode 2019).

Parasites are organisms that have adapted themselves in or on another organism known as the host, and lives at the expenses of the tissue and fluid of the host deriving their nutrient and protection from the host, thereby harming or being of no advantage to the host. This includes protozoans, platyhelminths, nematodes and arthropods that inhabit and continuously insult, at some

stage during their life cycle, the body of human (Ezigbo 1990; Olano *et al* 2011). They increase their fitness by exploiting the host for food, habitat, and dispersal. Parasites may be transmitted from animals to humans, from humans to humans, or from humans to animals. Several parasites have emerged as significant cause of food borne, and water-borne diseases in the whole world. Over the recent years, concerns have been raised over the microbial quality of drinking water and water for domestic chores (Khaniki *et al* 2010; Udo *et al* 2021). In several countries, waterborne parasites and protozoan pathogens such as *Cryptosporidium, Giardia lamblia, Entamoeba histolytica* and many others are frequently associated with morbidity particularly in children. These parasites are the most common cause of infections worldwide (Hemphill *et al* 2019). The prevalence of infections with the causative agent, *Entamoeba histolytica* worldwide is estimated to be 50 million cases each year. The World Health Organization estimates that 88% of that burden is attributable to unsafe water supply, sanitation and hygiene. The aim of this study was to determine the common parasites in domestic water sources used by students in hostels at Ishieke, Ebonyi State, Nigeria.

Materials and methods

Study area

Ishieke is a town in Ebonyi Local Government Area, Ebonyi State, Nigeria. Ishieke is located within 6.3850°N, 8.0274°E. Ishieke is mainly a student residential area with different kinds of accommodations. It is a peri urban town with a market at the centre and student hostels clustered around. The main sources of water for students are boreholes, hand-dug wells, ponds and rainwater. Most of the students' lodges and hostels lack potable water sources and so the students patronize water hawkers and outsource from other hostels. Non-students that live amongst the students, source water from nearby ponds and canals to sell to the students. Many human activities that go around these water sources include washing of clothing and domestic utensils, and bathing. Individuals also defecate around the water sources too, because of the unsanitary surroundings. The vegetation around the water sources are mostly green grasses.

Collection of water samples

A total of 120 water samples were collected from four different water sources, which were well-water, pond, borehole, and harvested rainwater, respectively, in clean sterile sample bottles. The samples were labelled with the name of subject, date and time of collection, nature and source of water, and the location of collection. They were placed in an insulated cold box and transported to the Applied Biology Laboratory, Ebonyi State University for examination. Samples that were not processed on the day of collection were preserved by adding 2 drops of ethanol in each (Bezooijen 2006).

Laboratory analysis

In the laboratory, calcium carbonate flocculation method was used for pH and alkalinity adjustment and for construction aggregate. Each sample was treated with 20ml of calcium chloride solution, 20ml of sodium bicarbonate solution, 20ml of sodium hydroxide respectively, to raise the pH to 10. The solution was mixed thoroughly and allowed to settle for 24 hours at room temperature. At the end of 24 hours, the supernatant was discarded, and 40ml of 10% sulphuric acid was added to the sludge so formed in each sample bottle, and centrifuged at 3000rpm for 15minutes and the supernatant was discarded. Another 50ml of 10% sulphuric acid was added and centrifuged at 2500rpm for 5 minutes. The sludge in each sample was used to prepare three smeared slides. Lugol's iodine stain was added to help in differentiating parasitic cysts from other particles and Ziehl-Nelson technique applied to help in identification of possible *Taenia* species (Machrummizar *et al* 2022). All the smeared slides were microscopically examined for the presence of parasite ova and cysts using ×10 and ×40 objectives (Cheesbrough 2000). Physico-chemical parameters of the water; including hardness, taste, dissolved oxygen, pH, turbidity and temperature were measured with WHO Standard (WHO 2011, 2017).

Results

Table 1 shows that from the total number of 76 parasites encountered, 11(9.2%) were from borehole; 29 (24.1%) from well-water, 27(22.5%) from pond and 9(7.5%) from rainwater. The parasites belong to four different species, *Giardia* sp., *Balantidium coli, Entamoeba histolytica* and *Cryptosporidium parvum*. The table further shows that from the four different species of parasites identified from the water samples, *Giardia* sp. had the highest, 32(26.7%) occurrences followed by *Entamoeba histolytica,* 22(18.3%), then *Balantidium coli* 16(13.3%) and the least was *Cryptosporidium parvum* 6 (5%). The total percentage parasite occurrence was 63.3%.

Table 2 shows the parasite prevalence by water sources location. Out of the eleven locations, the results showed that Kurumba Pond had the highest number of parasites (14), followed by Neophonic Pond (13), while Miracle and Bishop lodges' boreholes had the least number of parasites (3). *Giardia* sp. was the most frequent (6) in Kurumba Pond followed by *Balantidium coli* (5) whereas in Goshen Lodge Well, *Giardia* sp. occurred the least (1)**.** The occurrence of *Entamoeba histolytica* in Neophonic Pond was the highest overall (7), but it occurred one (1) each, in Bishops lodge borehole, City lodge Well and Miracle lodge Borehole.

Table 3. shows the physico-chemical parameters of the four water sources sampled, including hardness, taste, dissolve oxygen, pH, turbidity, conductivity and temperature. The results showed that the water in the four water sources were in conformity with the WHO standard for good quality water for total hardness (10-500mg $CaCO_3$/l) colour (colourless), odour (odourless), dissolve oxygen (6.5-8mg/l) and pH (6.5-9.0).

Discussion

The four different types of parasitic protozoans identified in the different locations sampled revealed that all the

water sources were contaminated with parasites and therefore unhealthy for human consumption, especially for the students of Ebonyi State University, who depended solely on these water sources for daily uses. The observation in this study corroborates other studies on domestic water sources; Simon-Oke *et al* (2020) in Akure, Ejike *et al* (2021) in Aba, Tula *et al* (2023) in Maiduguri, Nigeria and Richard *et al* (2016) in Malaysia. This suggests that these students and all others who depended on these water sources for drinking and daily chores are at risk of contracting waterborne diseases caused by these parasites.

Table 1: Parasites identified from the water sources

		Species and number of parasites observed				
Water Source	Number examined	*Giardia sp.*	*Balantidium coli*	*E. histolytica*	*C. parvum*	Total (%)
Borehole	30	7	2	2	0	11 (9.2%)
Well water	30	12	6	8	3	29 (24.1%)
Pond	30	9	7	9	2	27 (22.5%)
Rainwater	30	4	1	3	1	9 (7.5%)
Total	120	32(42.1%)	16(21.1%)	22(28.9%)	6(7.9%)	76 (63.3%)

Table 2: Parasites prevalence by locations

Location of water source	Sample type	*Giardia sp*	*E. histolytica*	*C. parvum*	*Balantidium coli*	Total No. of parasites by location
Neophonic	Pond	3	7	1	2	13 (10.8%)
Bishops lodge	Borehole	2	1	0	0	3 (2.5%)
Kurumba	Pond	6	2	1	5	14 (11.7%)
Equity lodge	Rainwater	3	0	0	1	4 (3.3%)
Goshen lodge	Well	1	2	0	1	4 (3.3%)
Scorpion lodge	Well	4	3	0	2	9 (7.5%)
Peace hostel	Rainwater	1	3	1	0	5 (4.2%)
City lodge	Well	3	1	2	0	6 (5%)
Cannan lodge	Borehole	3	0	0	2	5 (4.2%)
Miracle lodge	Borehole	2	1	0	0	3 (2.5%)
Nwali lodge	Well	4	2	1	3	10 (8.3%)
Total		32(42.1%)	22(28.9%)	6(7.9%)	16(21.1%)	76 (63.3%)

Table 3: Comparison of physicochemical parameters of the four water sources with WHO Standard

Parameter	Well water	Pond water	Borehole water	Harvested rainwater	WHO 2017
Total hardness (mg/$CaCO_3$)	50	70	45	55	10-500
Colour	colourless	colourless	colourless	colourless	colourless
Taste	salty	salty	salty	salty	tasteless
Odour	odourless	odourless	odourless	odourless	odourless
Dissolved Oxygen (mg/l)	4	4	4	4	6.5-8
pH	7	8	8.6	7	6.5-90
Turbidity (NUT)	0	40	40	0	<5
Temperature (˚C)	28	28	28	28	25

World Health Organization (2018) stressed that when water sources become contaminated by parasites, it can course a variety of illnesses. Galadima *et al* (2011) reiterated that water pollution can cause severe decrease in productivity and deaths of living species. Research findings show that if water contains unsafe levels of contaminants, it can cause health effects, such as gastrointestinal illnesses (EPA 2024; Okafor 2024). The 42.1% occurrence of *Giardia* species found in this study is high and it depicts that the possible users are vulnerable to water-borne diseases. The protozoans, *Giardia* and *Cryptosporidium* are responsible for most water-borne diseases worldwide (Hamdy *et al* 2019). *Giardia* cyst has durability under good environmental condition, and having this percentage (42.1%) in water source is really alarming.

A 28.9% occurrence of *E. histolytica* recorded in this study is equally on a very high side because, Shirley *et al* (2018) noted that even a single protozoan parasite, *E. histolytica* can infect about 50 million people worldwide. The 21.1% occurrence of *B. coli* in this study shows that the water sources are exposed to both pigs and human unsanitary activities, leading to the water possibly being contaminated by human fecal matters and pigs excrement. This poses health threat to the possible users because they could be vulnerable to ciliary dysentery.

According to Aninagyei *et al* (2021), *Balantidium* (largest protozoan parasite) is the only ciliate capable of infecting humans. He noted that when it infects the human intestine, it causes complications leading to balantidiasis also known as ciliary dysentery.

Results from this study shows that sampled water from hand-dug well was the most contaminated of all the water sources examined. This could be because of the location of these hand-dug wells. During the study, it was observed that these hand-dug wells are constructed downhill of pollution sources, close to potential contamination sources and were not properly covered. Ayantobo *et al* (2013) observed that a well that is downhill of pollution sources has greater risk of contamination than a well uphill of pollution sources, and the greater the distance a well is from a potential contamination source, the less likely the well will be contaminated by the source. The Mississippi State Department of Health (MSDH) requires that a well should be sited at least 15.24m away from a septic tank. Uncovered well water can be contaminated by human and other animals' faecal matter as well as agricultural effluent (Ejike *et al* 2021).

It was observed in this study that other water sources examined (pond water, borehole, and harvested rainwater) were not free from parasite contamination. This might be as a result of improper waste-water drainage system planning and a possible continual mixing of wastewater with potable water. Results of this study further showed that all the water sources examined conformed with all the WHO physico-chemical parameters measured, except for taste and dissolved oxygen. According to WHO (2017), the standard for physico-chemical parameters of good quality water are: total hardness should be 10-500mg of calcium carbonate/l; good quality water should be colourless, odourless; tasteless, dissolve oxygen should be 6.5-8mg/l; pH 6.5-9.0; turbidity not more than 5NUT and ideally less than 1NUT and temperature 25ºC. It was observed in this study that the results of total hardness, colour, odour, pH and turbidity of the water in all the water sources examined were in conformity with these WHO (2017) standard for physico-chemical parameters of good quality water. However, all the water sources deviated from the WHO (2017) standard for good quality water for taste and dissolved oxygen. Results showed that all the water sampled tasted salty against WHO standard (tasteless), had temperature 28ºC higher than WHO minimum standard (25ºC) for water, and the dissolved oxygen (DO) values were below 4mg/l. Healthy water should generally have dissolved oxygen concentrations above 6.5-8mg/l (WHO 2017).

The low level of dissolved oxygen in the water sources is a sign of contamination and is an important factor in determining water quality, pollution control and treatment process. According to USEPA (2024), low levels of DO (hypoxia) or no DO (anoxia) can occur in water sources when excess organic materials such as large algal blooms, are decomposed by microorganisms. During this decomposition process, DO in the water is consumed by the microorganisms. If DO levels of a body of water drops below 6.5 mg/l, it's likely that the water is contaminated and may be unsafe to drink (US EPA 2024).

The physical examination of these water sources for taste, showed that all water samples examined tasted salty and therefore is contrary to the WHO standard, and hence unfit for drinking. For water to be drinkable, it must be devoid of unpleasant tastes, odour, colour and maintained a reasonable and acceptable limit of temperature because high temperature promotes growth of pathogens (Okafor *et al* 2024). There is need to increase awareness of the community towards the dangers associated with the use of contaminated water, hence the danger in constructing pit latrines and septic tanks near a water source and vice versa. The use of rust-free polyvinyl chloride (PVC) pipes for water distribution and treatment of water by boiling and filtering before use for drinking and cooking purposes is necessary.

Conclusion

All the drinking water sources surveyed were found to harbour one or more parasites (*Giardia* sp., *Balantidium coli* and/or *Entamoeba histolytic*). Therefore, preventing water borne contamination through provision of safe and potable drinking water is vital since access to safe drinking water is a required cornerstone of public health.

The provision of potable drinking water which is devoid of microorganisms for humans and their environment is recommended. There is need to boil and treat drinking water adequately before use to reduce its harmful effects on human health. The hostel owners in collaboration with local health authorities should provide adequate potable water and sanitation facilities to the surveyed areas and mount effective health education campaigns against unhygienic practices that may endanger the health of the hostel users. Frequent water treatment before use will bring huge economic and health benefits to users in the affected student hostels.

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Conflict of interests

The authors have no conflicting interest.

References

Akhtar, N., Ishak, M.I.S., Bhawani, S.A., and Uma, K. 2021. Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. *Water 13*(*19*): 2660.

Aninagyei, E., Nanga, S., Acheampong, D.O. 2021. Prevalence and risk factors of human *Balantidium coli* infection and its association with hematological and biochemical parameters in Ga West Municipality, Ghana. *BMC Infect. Dis. 21* (*1047*): 31-2

Ayantobo, O.O., Oluwasanya, G.O., Idowu, O.A. 2013. Water Quality Evaluation of Hand-Dug Wells in Ibadan, Oyo State, Nigeria. *Global J. Sci. Front. Res. Agric. Vert. 13*(*10*): 2249-4626.

Ayobahan, S.U., Ezenwa, I.M., Orogun, E.E. 2014. Assessment of Anthropogenic Activities on Water Quality of Benin River. *J. App. Soc. Environ. Manage. 18*(*4*): 629-636.

Azide, W. 1997. Dissolved Oxygen (DO) - Azide Modification of Winkler Method Buret Titration. 1997 Edition of the Hach Water Analysis Handbook https://www.nemi.gov/methods/method_summary/4786/. Accessed: May 20, 2025

Washington State Department of Ecology. See http://www.ecy.wa.gov/copyright.htm. Accessed: May 20, 2025

Bezooijen, J.V. 2006. Methods and Techniques for Nematology. https://www.nematologia.com.br/files/tematicos/5.pdf. Accessed: May 20, 2025

Burlingame, G.A., Doty, R.I. and Dietrich, A.M. 2017. Humans as sensors to evaluate water taste and odor. *American Water Works Association*, 109(11): 13-24

Center for Diseases Control. 2024. Water: What Causes Parasitic Diseases. https://www.cdc.gov/parasites/causes/index.html#:~:text=Common%20global%20water%2Drelated%20diseases,been%20contaminated%20by%20certain%20parasites. Updated April 9, 2024. Accessed May 20, 2025

Cheesbrough, M. 2000. District laboratory practice in tropical countries Part. Two (2nd Ed). Cambridge University Press. UK pp 123-201.

Environmental Agency (EPA). 2024. Drinking Water: What are the trends in the quality of drinking water and their effects on human health? https://www.epa.gov/report-environment/drinking-water. Last updated on July 8, 2024. Accessed May 20, 2025.

Ejike, B.U., Ohaeri, C.C. Amaechi, E.C. 2021. Parasitic Contamination of Local Drinking Water Sources in Aba Metropolis, Abia State, Nigeria. *SQU J. Sci. 26*(*1*): 1-7.

Ezigbo, J.C. 1990. Parasites and Parasitic Associations. In Ezigbo, J.C (Ed.). *Parasitology for Medical Students.* New Frontier Publishers Limited, Nigeria, 107pp.

Flaschka, H.A. 1959. EDTA Titrations: An Introduction to Theory and Practice. Macmillan, 1959, University of Minnesota, 138 pp.

Galadima, A., Garba, Z.N., Leke, L. *et al.* 2011. Domestic water pollution among local communities in Nigeria: Courses and Consequences. *Eu. J. Sc. Res. 52*(*4*): 592-603.

Hamdy, D., Badry, A. El Wahab, W.A. 2019. Assessment of *Giardia* and *Cryptosporidium* assemblages/species and their viability in potable tap water in Beni-Suef, Egypt using nested PCR/RFLP and staining. *Iran J. Parasitol. 14*(*3*): 368–378.

Hemphill, A., Muller, N. Muller, J. 2019. Comparative pathobiology of the intestinal protozoan parasites *Giardia lamblia*, *Entamoeba histolytica*, and *Cryptosporidium parvum. Pathogens*. *8*(*3*): 116.

Khaniki, G.R.J., Zarei, A., Kamkar, A. 2010. Bacteriological evaluation in bottled water from domestic brands in tehran markets. *World App. Sc. J. 8*(*3*):274-278.

Machrummizar, M., Devita, A., Yuliana, Y. 2022. Application of Ziehl Neelsen Staining Method for *Taenia* spp. Eggs Differentiation. *Iran J. Parasitol. 17*(*3*): 332-338.

Mimba-Kankolongo, A., Nkulu, C.B.L., Kampemba, F. M. 2022. Impacts of trace metals pollution of water, food crops, and ambient air on population health in Zambia and the DR Congo. *J. Environ. Pub. Health.* 4515115.

Odikamnoro, O.O., Okeaguale, B.O. Eyankware, U.R.O. 2016. Survey of Parasites in Water Sources in Ishieke and Its Environs Ebonyi State, Southeastern, Nigeria. *Int. J. Sc. Healthcare Res. 1*(*2*): 2455-7587.

Okafor, C.O., Ude, I.U., Okoh, F.N., 2024. "Safe Drinking Water**:** The Need and Challenges in Developing Countries". Water Quality – New Perspectives, (eds) (2024), *Intech Open*, January 24, 2024.

Okonkwo, I.O., Ogun, A.A., Adejoye, O.D. 2008b. Comparative studies and microbial risk assessment of different water sample used for processing frozen seafood in Ijora-Lagos state, Nigeria. *Af. J. Biotech. 7*(*10*):2902-2907.

Olano, J.P., Weller, P.F., Guerrant, R.L. and Walker, D.H. 2011. Principles of Parasitism: Host-Parasite Interactions (3rd ed.). In: R.L. Guerrant, D.H Walker, P.F. Weller (eds.), *Tropical Infectious Diseases: Principles, Pathogens and Practice.* Elsevier, China, 1-7. https://doi.org/10.1016/B978-0-7020-3935-5.00001-X.

Omarova, A., Tussupova, K., Bemdtsson, R. 2018. Protozoan Parasites in Drinking Water: A System Approach for Improved Water, Sanitation and Hygiene in Developing Countries. *Int. J. Environ. Res. Pub. Health. 15*(*3*): 495.

Oyedeji, O., Olutiola, P.O. Mononuola, M.A. 2010. Microbiological quality of packaged drinking water brands marketed in Ibadan metropolis and Ile-Ile city in Southwestern Nigeria. *J. Microbiol. Res. 4*(*1*): 96-102.

Popkin, B.M., D'Anci, K.E. Rosenberg, I.H. 2010. Water Hydration and Health. *Nutr. Rev. 68*(*8*): 439-458.

Richard, R.L., Ithoi, I., Majid, M.A.B. 2016. Monitoring of waterborne parasites in two drinking water treatment plants: A study in Sarawak, Malaysia. *Int. J. Environ. Res. Pub. Health. 13*(*7*): 641.

Sargen, M., Utter, D. 2019. Biological roles of water: Why is water necessary for life? *Science* in the News, https://sitn.hms.harvard.edu/uncategorized/2019/bi

ological-roles-of-water-why-is-water-necessary-for-life. Accessed May 20, 2025.

Shirley, D. T., Farr, L., Watanabe, K., and Moonah, S. 2018. *A Review of the Global Burden, New Diagnostics, and Current Therapeutics for Amebiasis. Open Forum Infect. Dis.* 5(*7*): ofy161.

Simon-Oke, I.A., Afolabi, O.J., Obimakinde, 2020. Parasitic contamination of water sources in Akure, Ondo State, Nigeria. *J. Basic App. Zool. 81*(*50*):2-8.

Talabi, A.O. Kayode, T.J. 2019. Groundwater pollution and remediation. *J. Water Res. Protect. 11*(*1*): 4465.

Titcomb, G., Mantas, J.N., Hulke, J. 2021. Water sources aggregate parasites with increasing effects in more arid conditions. *Nat. Communic. 12*(*7066*): 21-27.

Tula, M.Y., Enabulele, O.I., Ophori, E.A. 2023. Parasitological contamination of two water sources in Adamawa-North Senatorial Zone, Adamawa State, Nigeria. *Arid Zone J. Basic App. Res. 2*(*1)*: 203-212

Udo, A., Lawal, B.K., Akpan, M. 2021. Microbial contamination of packaged drinking water in Nigeria. *Eu. J. Trop. Med. Int. Health. 26*(*11*): 1378-1400.

US Environmental Protection Agency. 2024. WaterSense: How we use water. https://www.epa.gov/watersense/how-we-use-water Last updated April 3, 2024. Accessed May 20, 2025.

World Health Organization. 2009. Hardness in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality. WHO/HSE/WSH/09.01/10.

World Health Organisation. 2011. Guidelines for drinking water quality – 4th ed. *WHO Library Cataloguing-in-Publication Data.*

World Health Organisation. 2017. Water quality and health: Review of turbidity: Information for regulators and water suppliers.: WHO/FWC/WSH/17.01.

World Health Organization. 2018. Monitoring health for the, sustainable development goals (SDGs) The Global Health Observatory (GHO). https://iris.who.int/bitstream/handle/10665/272596/9789241565585-eng.pdf. Accessed May 20, 2025

Yen, T.F. 2008. *Chemistry of Engineers*. Imperial College Press, London, 558pp.

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