

Groundwater Quality Assessment: Physicochemical and Bacteriological Evidences from Hand-Dug Wells in Gaya Town, Nigeria.

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Abstract

Access to potable water is a huge challenge to the people of Gaya town who solely depend on hand-dug wells as their main source of drinking water. This study was conducted to examine the quality of water manually drawn from existing hand-dug wells in Gaya, North-western Nigeria. Systematic random sampling was adopted in collecting water samples from four (4) hand-dug wells that were purposively selected based on population of users and rate of usage. Water samples collected were subsequently analysed for physicochemical and bacteriological assays using standard methods. Results of physicochemical parameters indicated that pH ranged from 6.43 to 7.12; temperature (29.6^oC to 31.7^oC); electrical conductivity (207 μ S/cm to 657 μ S/cm); turbidity (0NTU to 4.85NTU); Calcium (0.23mg/L to 0.87mg/L); Chloride (5.9 mg/L to 17.5mg/L) and Magnesium (0.10 mg/L to 0.36 mg/L) respectively. All the measured physicochemical parameters were within permissible standards set by water regulating bodies. However, total coliform and *E. coli* counts ranging from 0 to 34 cfu/100ml and 0.24 to 0.32 x 10²cfu/100mL were recorded respectively. The results obtained in this study have clearly indicated that the water drawn from the hand-dug wells is not free from pollution and therefore not fit for drinking. It is therefore recommended that hand-dug well water in this locality should be subjected to sanitary treatment before drinking with a view to averting eminent public health crisis.

Keywords: Hand-dug well, total coliform counts, water quality, drinking water, Gaya.

1. Introduction

In Nigeria, it is a common practice for residents in the rural settlements to depend on available hand-dug wells, streams and rivers for drinking and domestic purposes. Water is a vital indicator that existence of life depends on as it is employed for numerous domestic, agricultural, power generation, industrial and recreational activities (Pritchard *et al.*, 2007; Amoo *et al.*, 2018a; Umar *et al.*, 2020). According to Shryer (2007); Mack and Nadel (2011); Offei- Ansah (2012); Amoo *et al.* (2018b), water is considered the most significant nutrient that is vital for the survival of humanity as it is involved in the effective functioning of the body which is made up of about 75% of total weight. Adefemi (2012); Bakobie *et al.* (2015), reported safe drinking water as a human birth right coupled with clean air. Regrettably, reports in the literature have indicated that most of the world's population, especially Africans living in remote villages and sometimes in the so-called big cities do not have access to safe drinking water.

It has been reported by Ayantobo *et al.* (2012); Adeleye *et al.* (2018) that hand-dug wells function as a solution to the provision of cheap and low technology water meant to ameliorate shortages in rural and urban supply of water. These days, the bacteriological qualities of groundwater sources in Nigeria have been reported to be unsatisfactory due to the presence of coliform counts that are far beyond the recommended limits (Dada *et al.*, 1999a, 1999b, Edema *et al.*, 2001; Hassan *et al.*, 2018). Groundwater bodies are now known to be prone to contaminations from both anthropogenic and natural activities (Okuo *et al.*, 2007; Amoo *et al.*, 2018b). Regarding

the safety of water, research evidences have shown over the years that numerous low earning countries are off-track in terms of attaining the target of the millennium development goals for water supply and sanitation, which focused on reducing half of the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 (WHO, 2011). A good number of the population in developing countries dies yearly as a result of water borne diseases such as cholera, typhoid, hepatitis, diarrhoea and so on (WHO, 2008). Access to clean water is the key to sustainable development in agriculture as it ensures food production and poverty alleviation (Gadgil, 1998; Bakobie *et al.*, 2015).

The widespread reports on pollutants in groundwater have increased in recent years and have resulted to augmented public concern about the quality of groundwater. The seepage of waste buried underground such as pit toilets or leachate from fertilizer applications can produce harmful effects on ground water quality especially in areas that are long known for extensive agricultural practice. It is against these backdrops that this study was conducted to assess the quality of the groundwater consumed by the residents of Gaya town, North-western Nigeria with view to comparing the results of examined parameters with acceptable standards.

2. Materials and Methodologies

Study Area

Gaya town is the headquarter of Gaya Local Government Area and the newly created Gaya Emirate in Kano State. According to 2006 census, it has a population of 201,016 and covers an area of 613km². The town lies between longitude 9° 02¹E and latitude 1° 52¹N, and situated at 65 kilometres east of Kano metropolis (Figure 1). From the north, the local government shares boarder with Ajingi Local Government and extends southward to Albasu local government. It equally borders Wudil Local Government from the west (Wada *et al.*, 2019).

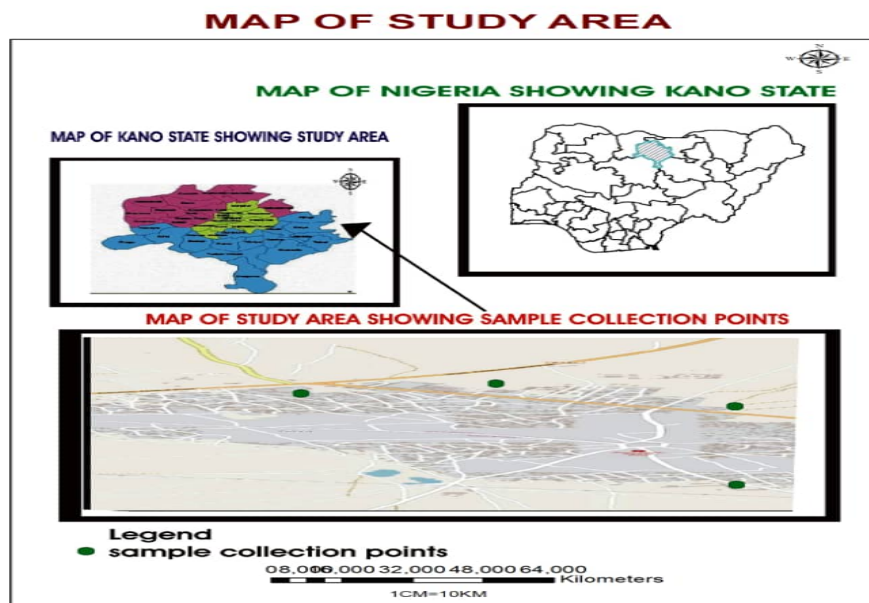


Figure 1: Location of the sampling points in Gaya town

Water Sampling

As done by Hassan *et al.* (2018), systematic random sampling method was adopted in collecting water samples from four (4) different hand-dug wells designated as Hand-dug well A (HWA), Hand-dug well B (HWB), Hand-dug well C (HWC) and Hand-dug well D (HWD). These hand-dug wells were chosen for sampling due to their rate of usage coupled with being strategically located in thickly populated areas in Gaya town. Field sampling was done at the beginning of wet season in July, 2019. Water samples were singly collected in sterile one (1) litre plastic



containers and prior to collection as part of our quality control measures, all the bottles were washed with non-ionic detergent and rinsed with de-ionized water prior to usage (USFDA, 2018). Before the final water sampling was done, the bottles were rinsed three times with distilled water at the point of collection. The pH, temperature, turbidity of the water samples were measured on-site with HANNA Germany HI-8014 portable pH meter, thermometer and turbidity meter respectively. Each bottle was labeled according to sampling location while all the samples were preserved with ice packs and immediately transported to the laboratory until analyses were completed within 14 days. The determinations of the other physicochemical properties of the water samples were performed on the same day of sampling. Water assay for bacteria was conducted within 6 hours of sampling while that for anions was within 14 days.

Physiochemical analyses

The determinations of Magnesium (Mg) and Calcium (Ca) concentrations were done by complexometric titration using EDTA. The determination of Chloride (Cl⁻) concentrations was completed using argentometric titration. The electrical conductivity (EC) was determined by a means of a multifunctional WTW[®] cond. 730 series, conductivity meter EC-215, HANNAH Germany (APHA, 1995).

Bacteriological analyses

Standard methods described by USEPA (2002) for the determination of total coliforms and *Escherichia coli* were employed.

Data analysis

Descriptive statistics in form of tables and bar charts were used to summarize the variations in the physicochemical parameters of the sampled water and sampled sites coupled with their comparisons with regulating standards.

Results

The results of the physicochemical attributes of the water samples derived from all the hand dug wells are presented in Table 1.

Table 1: Results of physiochemical characteristics of hand-dug wells with their coordinates

Parameters	HWA	HWB	HWC	HWD
Latitude	0500618	0500681	0500871	0500472
Longitude	1311683	1311589	1311421	1311753
pH	6.53	7.12	6.50	6.43
Calcium (mg/L)	0.86	0.64	0.28	0.23
Turbidity (NTU)	2.95	0.05	4.85	0
Chloride (mg/L)	9.7	6.4	17.5	5.9
Magnesium (mg/L)	0.36	0.26	0.11	0.10
Temp. (°C)	30.1	30.9	29.6	31.7
EC (µS/mL)	277	356	657	207
Nitrate (mg/L)	0.13	0	0	0

The results obtained as regards the comparison of the physicochemical properties of the sampled hand-dug well water with regulated standards are presented in Figures 2 and 3 below:

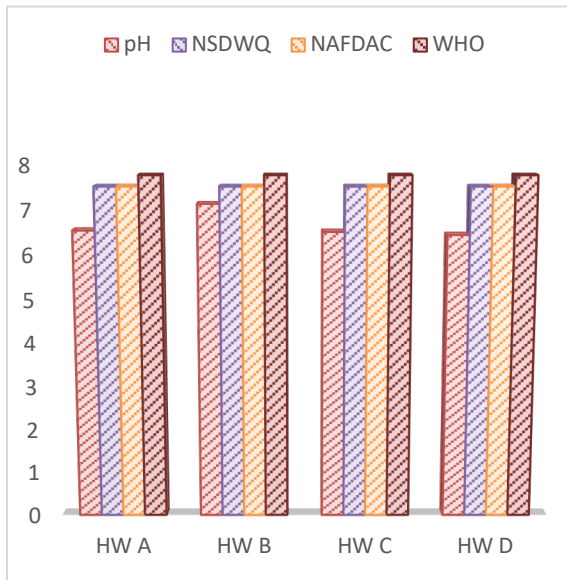


Figure 2: Comparison of mean pH means of hand-dug well water samples with standards.

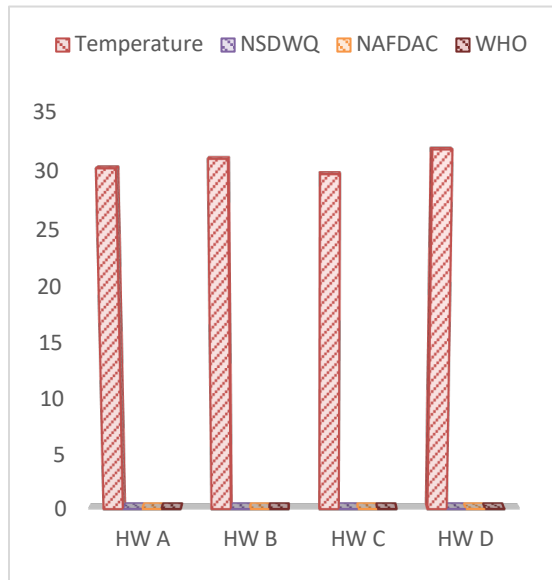


Figure 3: Comparison of mean temperature of the hand-dug well water samples with standards.

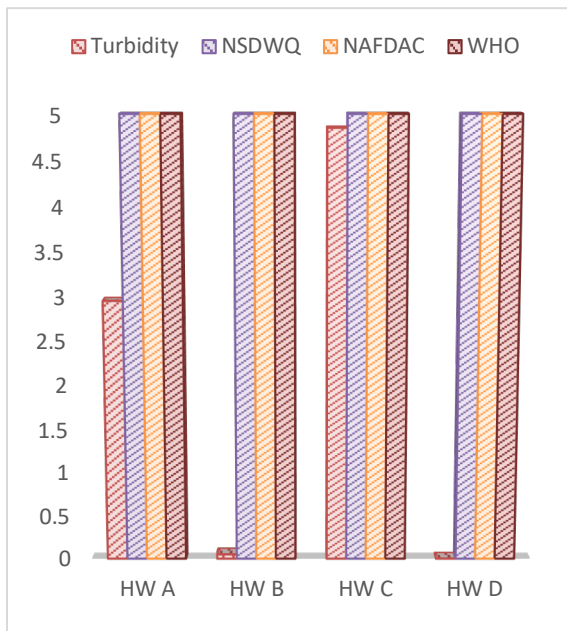


Figure 4: Comparison of turbidity means of the hand-dug well water samples with standards.

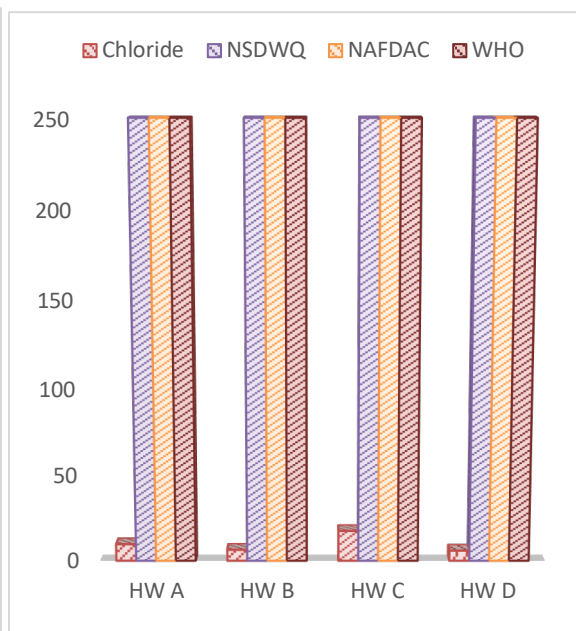


Figure 5: Comparison of Cl⁻ mean concentrations of the hand dug well water samples with standards.

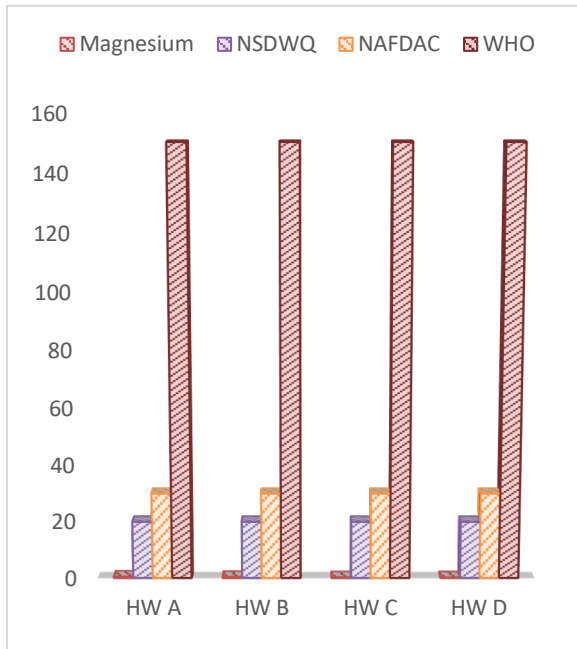


Figure 6: Comparison of mean Mg concentrations of hand dug well water samples

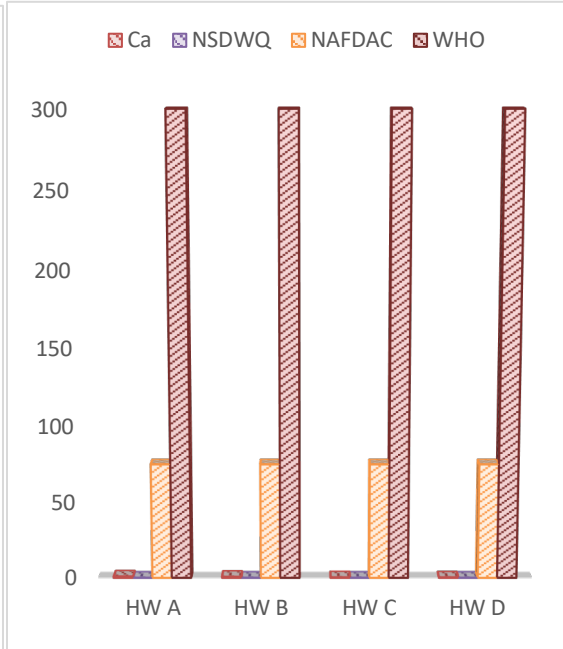


Figure 7: Comparison of mean Ca concentrations for hand-dug well water samples with standards.

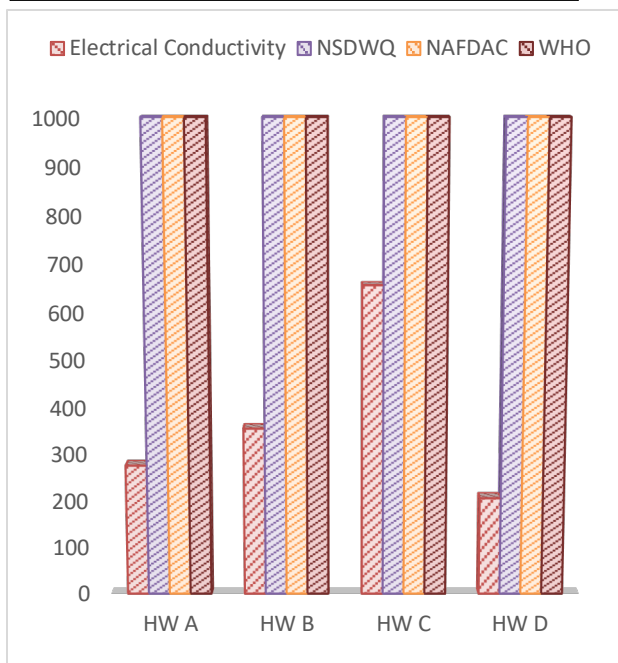


Figure 8: Comparison of EC means of the hand-dug well water samples with standards

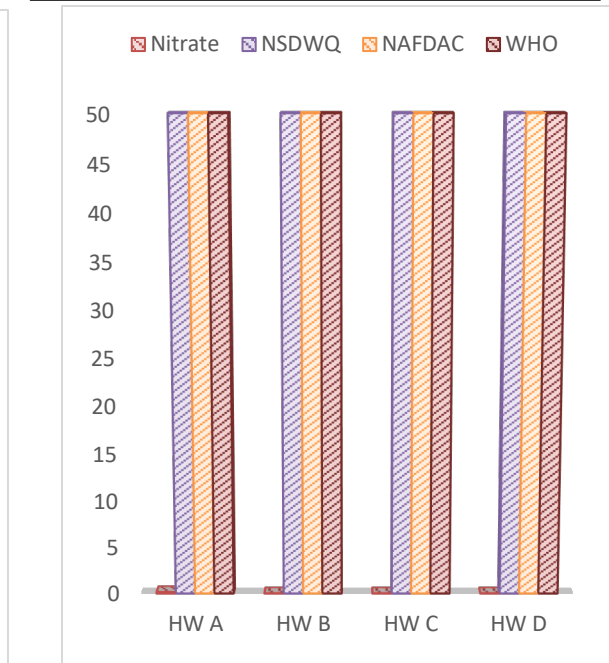


Figure 9: Comparison of nitrate concentration means of the hand-dug well water samples with standards.

The results of the bacteriological attributes of the water samples derived from all the hand dug wells are presented in Table 2.



Table 2: Total coliform counts and *E. coli* counts in the sampled water from the hand-dug wells

Parameters	HW A	HW B	HW C	HW D	NSDWQ	WHO	NAFDAC
<i>Escherichia coli</i> (cfu/mL)	32	24	34	24	0	0	ND
Total coliform (cfu/mL)	3	1	12	24	10	0	ND

Note: HW= Hand-dug well; ND = Not Detected; NSDWQ = Nigeria Standard for Drinking Water Quality; NAFDAC = National Agency for Food and Drug Administration and Control; WHO = World Health Organisation.

Discussion

In this study, the pH values of the sampled water (HWA, HWB, HWC, and HWD) ranged from 6.43 - 7.12, indicating that the groundwater is weakly acidic to alkaline. These values are within the allowable limits (6.5–8.5) set by NSDWQ, NAFDAC and WHO (Figure 2). According to Cox (1995), waters that present slight acidity may be due to leaching of organic acids from decaying vegetation and/or soil, hydrolysis of ferruginized sandstones or dissolution of CO₂ from the atmosphere to form carbonic acid. Similar to this study, Nkansah *et al.* (2010) also reported a pH range of 6.3 and 7.7 in their study.

Based on the results obtained in this study, the values of temperature for all sampling points ranged between 29.6°C – 31.7°C (Figure 3). Interestingly, similar temperature differences have been reported by Thilza *et al.* (2018). However, results obtained from the turbidity of the water samples indicated that it ranged from 0.00 NTU to 4.85 NTU (Figure 4). Remarkably, all the water samples were within the standard limit of 5.0 NTU set by NSDWQ, NAFDAC and WHO. According to WHO (2011), turbidity can seriously impede the efficiency of disinfection by providing protection for organisms thereby necessitating the utmost need to ensure the removal of particulate matter before disinfection in the treatment plant.

Results presented in Figure 5 indicate that the values of Cl⁻ concentration in the water samples ranged from 0.23 mg/L to 0.86 mg/L. These values are below the NSDWQ, NAFDAC and WHO quality standard for drinking water of 250 mg/L. The low values indicate that the groundwater in Gaya town conforms to the permissible limit of Cl⁻ as WHO (2008) did stipulate 250mg/L as the limit of Cl⁻ in drinking water primarily for reasons of taste.

In this study, Mg ranged between 0.10 – 0.36 mg/l while Ca ranged between 0.23 – 0.86 mg/L (Figures 6 and 7). It can be seen that both were below the permissible limits of 300 mg/L set by NAFDAC and WHO for potable water meant for human consumption. Specifically, WHO (1984), classified water hardness as follows; soft (0 to 50 mg CaCO₃/L), moderate soft (50 to 100 mg CaCO₃/L, slightly hard (100 to 150 mg CaCO₃/L), moderate hard (150 to 200 mg CaCO₃/L), hard (200 to 300 mg CaCO₃/L) and very hard (over 300mg CaCO₃/L).

The values of EC for the sampled water ranged from 207µS/mL to 657µS/mL (Figure 8). These values are within the allowable limits (1000.0 µS/cm) set by WHO and NSDWQ. In contrast to this current study, Onwughara *et al.* (2013) reported EC value (9.32 µS/cm) which is way below the recommended limit of NSDWQ in their study while Karpagam and Ramesh (2015) also reported values of pre-monsoon from 1050 to 2990 µS/cm and post monsoon from 1320 to 2140 µS/cm, in their respective study areas. According to Langeneggar (1990), EC measures the degree of salinity in water, which greatly affects taste and thus has a significant impact on the user's acceptance of the water.

The present study recorded nitrate concentrations ranging from 0.00mg/L to 0.13mg/L (Figure 9). These values are within the recommended limits of 50mg/L set by NSDWQ, WHO and NAFDAC for potable water. The results obtained in this study are also in line with the finding of Amoo *et al.* (2017) regarding the concentration of nitrate (NO₃) obtainable in the groundwater of Kano and its environs. Similar research conducted by Onwughara *et al.* (2013) reported a mean concentration (0.6 mg/L) in their study area. However, low level of nitrate in our study area may be attributed to the less anthropogenic activity involving nitrate pollution of the groundwater.

E. coli counts recorded in this study ranged between 0.24 to 0.32 x 10² cfu/100mL (Table 2). These results strongly indicate that *E. coli* counts in the hand-dug wells were above WHO permissible limit (0 cfu/100mL) set for potable water meant for human consumption. According to WHO (2004), the presence of *E. coli* in human and animal faeces provides conclusive evidence of fresh faecal pollution of any water sample. *E. coli* has been implicated by Baveja (2013) to cause many health problems ranging from food poisoning, urinary tract infections, pyogenic infections, septicemia to diarrhoea if found in any drinking water. Hence, the revelation of its presence in



the hand-dug wells assayed in this study poses potential health risks to the residents of Gaya town who drink such water.

The total coliform counts recorded in this study ranged from 0.01 to 2.40×10^3 cfu/ 100 mL (Table 2). The results indicate that these values are above the recommended limits set by WHO. However, HWC and HWD recorded high total coliform counts (Table 2). The high coliform counts recorded by the water sampled from HWC and HWD may be attributed to their proximity to a popular refuse dump in the community. Generally, during water sampling, it was observed that all the hand-dug wells were operated under extremely poor sanitary conditions as domestic wastes such as food waste, and other particles were deposited indiscriminately.

The detection of high total coliform counts coupled with physical examination conducted in this study in terms poor handling and environmental abuse that the hand-dug wells are subjected to is in agreement with the report of Egbulem (2003); Hassan *et al.* (2018) on the possibility of groundwater being compromised due to location, construction and operation of wells. According to Adetunde *et al.* (2011); Adeleye *et al.* (2018), the use of various water drawers witnessed during water sampling with a view to fetching water may be another source of contamination that might have led to the contamination levels recorded in this study.

Conclusions

In this study, the results obtained have revealed that all the physiochemical parameters are within minimum standards set by NSDWQ, WHO and NAFDAC. However, regarding the bacteriological assessment of the water samples, *E. coli* counts in all the sampling water were found to be above WHO and NSDWQ maximum permissible limit for potable water meant for human consumption. In the same vein, total coliform counts in two of the assayed hand dug wells were above the permissible limit for drinking water. This has indicated that the water is not fit for human consumption as it might pose serious health risks for the inhabitants. It is therefore recommended that water drawn for drinking purpose from these hand-dug wells must be subjected to sanitary treatment with a view to ensuring its safety for human consumption. Again, citing of pit toilets should be discouraged particularly in houses built close to the locations of these hand-dug wells.

Reference

- Adefemi, S. O. (2012). Physicochemical and microbiological assessment of groundwater from Ijan-Ekiti South Western Nigeria. *Environ. Res. Jour.*, 6: 316-320.
- Adeleye, A. O., Orifah, M. O., Amoo, A. O., Ijanu, E. M., Shuaibu, S. J. and Hassan, A. (2018). Artisans' Knowledge and Perception on Hand-Dug Well Waterborne Related Diseases in Dutse Mechanic Village North-West, Nigeria. *Journal of applied science and environmental management*, 22 (10): 1603–1607.
- Adetunde, L. A., Glover, R. L. K. and Oguntola, G. O. (2011). Assessment of the groundwater quality in Ogbomoso township of Oyo state of Nigeria. *IJRRAS*, 8 (1): 115-122.
- American Public Health Association. (APHA) (1995). Standard methods for the examination of water and wastewater, 19th ed. American Public Health Association, Washington, D.C.
- Amoo, A. O., Adeleye, A. O., Bate, G. B., Okunlola, I. A. and Hambali, I. B. (2018b). Water Quality Assessment of Selected Boreholes in Federal University Dutse Campus North-West, Nigeria. *Umaru Musa Yaradua University Journal of Microbiology Research*, 3 (2):20 – 26.
- Amoo, A. O., Gambo, Y. H., Adeleye, A. O. and Amoo, N. B. (2018a). Assessment of Groundwater Quality in Sharada Industrial Area of Kano, North-Western Nigeria. *FUW Trends in Science & Technology Journal*, 3 (2A): 407 – 411.



- Amoo, A. O., Zakari, A. W., Ijanu, E. M., Adeleye, A. O. and Amoo, N. B. (2017). Physicochemical and bacteriological assessment of surface water quality: A case study of Jakara River, North-western Nigeria. *Int. J. Appl. Res. & Techn.* 6 (9): 65 – 74.
- Ayantobo, O. O., Oluwasanya, G. O., Idowu, O. A. and Eruola, A. O. (2012). Water Quality Evaluation of Hand-dug Wells in Ibadan, Oyo State, Nigeria. Hydrology for Disaster Management. *Special Publication of the Nigerian Association of Hydrological Sciences.* 231-239.
- Bakobie, N., Fuseini, M. A. and Abudu B. D. (2015). Water quality assessment of hand-dug wells in Janga, Ghana. *International Research Journal of Public and Environmental Health*, 2(12): 197-205.
- Baveja, C. (2013). Text Book of Microbiology Fourth Edition. New Delhi: Arya Publications.
- Cox, P.A. (1995). The Elements on Earth: Inorganic Chemistry in the Environment. Oxford University Press Inc. New York 235.
- Dada, O. O., Okuofu, C. A. and Obele, E. (1990a). Fecal pollution of well water in Zaria City, Nigeria, *Savannah*, 10: 1-5.
- Dada, O. O., Okuofu, C. A. and Yusuf, Z. (1990b). The relationship between residual chlorine and bacteriological quality of tap water in the water distribution system of Zaria Nigeria. *Savannah*, 10(2): 95-101.
- Edema, M. O., Omemu, A. M. and Fapetu, O. M. (2008). Microbiology and Physicochemical Analysis of Different sources of drinking water in Abeokuta, Nigeria. *Niger Jour. Microbio.* 15 (1): 57-61.
- Egbulem, B. N. (2003). Shallow groundwater monitoring. Proceedings of the 29th Water, Engineering and Development Centre - UK. (WEDC) International conference, held in Abuja– Nigeria. Published by WEDC, London. Pp 188 – 189.
- Gadgil, A. (1998). Drinking water in developing countries. *Annual Review of Energy and the Environment*, 23: 253-286.
- Hassan, A., Kura, N. U., Amoo, A. O., Adeleye, A. O., Ijanu, E. M., Bate, G. B. Amoo, N. B. and Okunlola, I. A. (2018). Assessment of Landfill Induced Ground Water Pollution of Selected Boreholes and Hand-Dug Wells around Ultra-Modern Market Dutse North-West, Nigeria. *The Environmental Studies*, 1 (4): 1-10.
- Karpagam, V. and Ramesh, K. (2015). Assessments of groundwater quality of Chrompet industrial area. *Int. J. Engr. Techn., Mgt. & Appl. Sci.*, 3 (7): 2349-4476.
- Langeneggar, O. (1990). Groundwater Quality in Rural Areas of Western Africa. UNDP Project 81-026:10p.
- Mark, G. W. and Nadel, E. R. (2011). Body Fluid Balance during Heat Stress in Human. Supplement 14: Handbook of Physiology, Environmental Physiology. Available at <http://www.comprehensivephysiology.com/WileyCDA/CompPhysArticle/refIdcp040110>.
- Nkansah, M. A., Boadu, N. O. and Badu, M. (2010). Assessment of quality of water from hand dug wells in Ghana. *Environmental health insight*, 4: 7- 12.
- Offei-Ansah, C. (2012). Food habits and preferences as a factor in the choice of meals by students in Cape Coast University. *Nutrition and health* 21 (3): 151-172.
- Okuo, J. M., Okonji, E. J. and Omoyerere, F. R. (2007). Hydro-physicochemical Assessment of the Warri Coastal Aquifer, Southern Nigeria. *Journal of Chemical Society*, 32 (1): 53- 64.
- Onwughara, N. I, Ajiwe, V. I. E. and Nria, B. (2013). Physicochemical Studies of water from selected boreholes in Umahia North, LGA of Abia State, Nigeria. *Int. journal of Pure App. Biosci.* 1 (3): 34-44.
- Pritchard, M. Mkandawire, T. and O’Neil, J. G. (2007). Biological, Chemical and Physical drinking water quality from shallow wells in Malawi: Case study of Blantyre, Chiradzulu and Mulanje. *Physics and Chemistry of the Earth*, 27: 845-850.
- Shryer, D. (2007). Body Fuel: A Guide to Good Nutrition, Marshall Cavendish.
- Thliza, I. A., Gadzama, I. M. and Katsalla, I. A. (2018). Effect of Storage on the Physicochemical Properties of Some Brands of Sachet Water Sold in Ahmadu Bello University, Zaria, Nigeria. *American Journal of Chemistry and Applications*, 5 (2): 33-39.
- Umar, H. O., Okareh, O. T., Adeleye, A. O., Orifah, M. O., Amoo, A. O., Sabiu, N. and Gana, S.A. (2020). Consumers’ Perception of Municipal Water Quality in Barnawa Community of Kaduna State, Nigeria. *FUDMA Journal of Sciences (FJS)*, 4 (1): 13-23.



- United State Food and Drug Administration (USFDA). (2018). Bacteriological Analytical Manual (BAM) Chapter One: Food Sampling and Preparation of Sample Homogenate. Available at <https://www.fda.gov/food/foodscienceresearch/laboratorymethods/ucm063335.htm> Retrieved on 26th August 2018.
- United States Environmental Protection Agency (USEPA) (2002). Method 1604: Total Coliforms and *Escherichia coli* in Water by Membrane Filtration Using a Simultaneous Detection Technique (MI Medium). Available at https://www.epa.gov/sites/production/files/2015-08/documents/method_1604_2002.pdf. Assessed on May 15th, 2019.
- Wada A. F., Umar A. F., Bello U. M., Tasi'u M., Bilyaminu H., Mubarak M., Ibrahim M. I. and Abubakar, A. (2019). Assessment of Deforestation Level in Some Selected Forests in Nigeria. A Case Study of Duddurun Gaya Forest Reserve, Gaya Local Government Kano State, Nigeria. *Direct Research Journal of Public Health and Environmental Technology*, 4 (1): 1-7.
- World Health Organisation (WHO) (2004). Guidelines for Drinking-water Quality. Vol. 1 WHO
- World Health Organisation (WHO) (1984). Guidelines of drinking water quality, Vol. 1, Recommendations, WHO Geneva, Pp. 19-115.
- World Health Organisation (WHO) (2008). Safe water and global health. Available at www.who.int/features/qa/70/en/index.htm. Accessed on June 12, 2013.
- World Health Organisation (WHO) (2011). Guidelines for Drinking-Water Quality. Available at https://www.epd.gov.hk/eia/register/report/eiareport/eia_2242014/EIA/app/ap02.02.pdf. Accessed on December 14, 2018.