ASSESSMENT OF PHYSICOCHEMICAL AND BACTERIOLOGICAL QUALITY OF DOMESTIC DRINKING WATER STORED IN CLAY POTS FROM BIRNIN KEBBI, NIGERIA.

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ABSTRACT

Drinking water can become contaminated after being collected from communal sources such as wells, tap stands, and boreholes, as well as while being stored at home. The physicochemical and bacteriological examination of drinking water stored in clay pots in Birnin Kebbi town was carried out in this study to determine the extent of the contamination. A total of twelve (12) water samples were randomly collected from various households. These water samples were tested for physicochemical properties and Bacteriological tests. The spread plate technique was used to determine the total viable count, while the multiple tube fermentation technique was used to determine the most probable number (MPN) of coliforms. All the sampled water was clear in appearance, the color was less than 1.0, mean temperature ranges from 19.25 °C to 20.26°C, mean pH ranges from 7.80 to 6.71, mean turbidity ranges from 10.7NTU – 4.50 NTU, and mean Total Dissolve Solids ranged from 62.53(Mg/L) to 41.66(Mg/L). When compared to World Health Organization (WHO) standards, pH, temperature, color, and appearance were all lower, while turbidity was higher. The mean range for the total coliform count was 150 cfu/100ml to 35 cfu/100ml while the mean range for the total viable count is 11.1×10^3 CFU/100 mL -1.4×10^3 CFU/100 mL. Five samples (41.70%) had coliform count above the recommended limit set by WHO whereas, seven samples (58.30%) were below the limits. The isolated organisms were identified as Escherichia coli, Enterococcus spp., Proteus spp., and Pseudomonas spp. The study found that coliform counts in some samples were within acceptable limits, while others exceeded them. As a result, precautions should be taken to avoid placing potentially contaminated items such as hands, cups, or ladles into stored water. Additionally, periodic cleaning and disinfection of storage pots are highly recommended to prevent contamination.

Keywords: *Coliform count, Contamination, Household drinking water, Total viable count*

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1. INTRODUCTION

Water, as a basic requirement of life, accounts for 80-85 percent of the body's composition and serves as a medium for the majority of the biochemical processes required for metabolism and growth. Life must exist on Earth. Almost all water-dependent forms of life would come to a halt if they were not present (Beyersmann and Hartwig, 2008). Because water is required to sustain life, everyone should have access to a sufficient (adequate, safe, and easily accessible) supply of drinking water. Every effort should be made to achieve good drinking water quality. Water quality is critical to human physiology, and man's continued existence is heavily reliant on its availability (Okarafor *et al*., 2012). Water storage is the process of storing water in a contained area for an extended period. Water storage can be either natural or artificial. Natural water storage occurs at all stages of the hydrologic cycle. Water can be stored in the atmosphere, on the Earth's surface, or below ground. Artificial water storage is done for a variety of reasons and on small and large scales (Stephe, 2008). The discontinuity of the drinking water supply in Nigeria impedes the distribution of water to those in need. (Kumpel and Nelson, 2016) This discontinuity necessitates the use of storage tanks. Similarly, in Birnin kebbi, irregular provision of piped water is common, and the presence of water storage containers is essential. Small to large clay water storage devices are known as 'Randa' are discovered and used as water storage containers.

Several studies on the physicochemical and bacteriological quality of drinking water from various sources conducted in Nigeria revealed that water sources were contaminated with pollution indicators such as fecal and total coliforms.(Adesakin *et al*., 2020; Agbo *et al*., 2019; Okarafor et al., 2012). The human pathogens that are present in drinking water include; *Salmonella species*, *Shigella species*, pathogenic *Escherichia coli*, *Vibro cholera*, *Yersinia entercolitica*, C*ampylobacter species*, *Klebsiella*, and various viruses such as Hepatitis A, Hepatitis E, Rota virus and parasites such as *Entamoeba histolytica*, and *Giardia* species(Adegboyega *et al*., 2015; Akani *et al*., 2021; Titilawo *et al*., 2020).

Even in many countries around the world, where piped supply is available, it frequently operates intermittently (Kumpel and Nelson, 2016). In areas where there is an intermittent or non-existent piped household supply, water is collected from taps in the home or at a distance from the home and stored until it is consumed (Rubino *et al*., 2019) Even if the water is of high quality when it arrives at the tap, storing it at home can lead to recontamination and regrowth (Matsinhe *et al*., 2014). The introduction of filthy hands into containers with large mouths is a major source of household water contamination. (Oswald *et al*., 2007). Unfortunately, there is a lack of data on the bacteriological and physiological quality of drinking water stored in clay pots in Birnin Kebbi, Kebbi State, Nigeria. As a result, the primary goal of this study was to evaluate the physicochemical and bacteriological qualities of drinking water stored in clay pots.

2. MATERIALS AND METHODS

2.1 Study Area

Birnin Kebbi, the study area, is Kebbi's state capital. This research was conducted in Birnin Kebbi, which is located between latitude 12° 27' 57.8808'' N and longitude 4° 11' 58.2864'' E. Birnin Kebbi is the capital of Kebbi state and the administrative center of the Gwandu emirate in northern Nigeria. It is located along the Sokoto Kebbi River, at the crossroads of roads leading from Argungu, Jega, and Bunza.

2.2 Sample collection

Four (4) areas (Tudun Wada, Rafin Atiku, Badariya, GRA) within Birnin kebbi were selected for the study. Three households were randomly selected from each of the above-mentioned areas. Three water samples were collected from each household into sterile containers under aseptic conditions and moved to Kebbi State University of science and technology's microbiology laboratory for analysis.

2.3 Physicochemical Analysis

Water samples were analyzed following the American Public Health Association's standard methods (APHA, 1995). Temperature, pH, turbidity, color, and total dissolved solids were the parameters studied.

2.4 Bacteriological Analyses

One milliliter of each water sample was transferred into nine (9 mL) of sterile distilled water in a separate test tube. Each water sample was diluted using logarithms ranging from 10^{-1} to 10^{-3}. 1 mL of the desired aliquot was transferred into sterile Petri dishes, and the viable plate count was determined using the pour plate method. (Cheesbrough, 2005). The multiple tube fermentation method was used, beginning with 250 mL flasks and using lactose broth for the presumptive test and brilliant green and EC (E. coli) broth for the confirmation tests, as described in (APHA, 1995). The Hoskins table was used to calculate the most probable number (MPN) of total coliform counts. According to, the bacteria isolates were characterized based on their cultural morphology and biochemical tests (Cheesbrough, 2005). The identification was carried out using the manual for identifying medical bacteria (Cowan and Steel). Grams reaction, motility test, catalase test, coagulase test, oxidase test, methyl-red test, Voges Proskaurer test, and sugar fermentation test are some of the biochemical tests used to characterize and identify bacteria.

2.5 Data Analysis

The data were statistically analyzed with the Statistical Package for Social Sciences (SPSS) International Business Machines (IBM) version 23.0 (SPSS Inc., Illinois Chicago, USA) and presented as mean+SD of triplicate determinations.

3 RESULTS

The present study examined the physicochemical and bacteriological quality of household water in Birnin Kebbi, Kebbi State, Nigeria, using 15 samples collected from clay pots. In triplicates, twelve stored drinking water samples were collected. The water quality observed during this study was compared to (WHO, 2006) acceptable levels in drinking water guidelines. All of the sampled water was clear in appearance, the color was less than 1.0, the temperature ranged from 19.25 °C to 20.26 °C, with Badariya water having the highest temperature, the mean pH ranged from 7.80 to 6.71, and the turbidity ranged from 10.7NTU - 4.50 NTU. Similarly, total dissolved solids for the samples tested ranged from 62.53 (Mg/L) to 41.66 (Mg/L). A summary of the result is shown in Table 1.

Figure 1- clay pots used for water storage

Table 1- Mean of Physicochemical Analysis of Sampled Water

Parameter	Tudun wada	Gra	Rafin atiku	Badariya	WHO(2011)
Appearance	Clear	Clear	Clear	Clear	Clear

COLOR	0.36± 0.05	0.41±0.17	0.5±0.60	0.53±0.05	20
P^H	7.26±0.15	6.71±2.52	7.3±0.1	7.80±0.52	6.5–8.5
Temperature (C^0)	20.86±1.69	19.25±7.42	19.26±0.80	22.76±1.56	20-30
Turbidity(NTU)	4.50±0.2	6.30±2.37	10.7±0.1	6.90±0.52	5
TDS(Mg/L)	41.66±1.51	46.16±20.13	62.53±0.1	45.06±1.33	600

The mean total coliform bacteria count and mean total viable count per 100 mL of sampled water were obtained in triplicate from twelve different drinking water sources, and the mean result is shown in Table 2. The mean range for total coliform bacteria in sampled clay pots stored water was 150 cfu/100ml to 35 cfu/100ml, with no coliform detected, while the mean range for total viable count is 11.1103 CFU/100 mL -1.4103 CFU/100 mL.

Table 2- Mean Bacteria Count for Sampled Bottled and Sachet Water

Samples Code	Total coliform counts (MPN/100 mL)	Total viable counts $\times 10^3$ (CFU/100 mL)
T1	105	6.4
T2	125	6.9
T3	42	5.6
G1	72	1.4
G2	35	1.9
G3	131	4.1
R1	44	5.3
R2	150	11.1
R3	59	6.3
B1	58	2.7
B2	111	4.5
B3	72	6.7

Keys: MPN: Most Probable Number. CFU: Coliform per unit

Pseudomonas spp. had the highest occurrence in the studied water sample at 44 percent, followed by Escherichia coli at 24 percent, Proteus spp. at 12 percent, and Enterococcus spp. at 20 percent. Table 3 displays the results.

Table 3- Percentage occurrence of bacteria from water samples

Bacteria	Total number of samples	Percentages

Escherichia coli	6	24
Pseudomonas spp	11	44
Enterococcus spp	5	20
Proteus spp.	3	12
Total	25	100

4 DISCUSSION

The physicochemical parameters and bacteriological analysis for various domestic water sources are discussed in relation to WHO drinking water quality guidelines. Drinking water should be clear and odorless (WHO, 2006). Color and odor in water samples can be linked to the presence of organic, inorganic, and biological contaminants in aquatic environments (Istifanus *et al*., 2013). A change in the color, taste, or odor of water could be an indication of a public health problem. As a result, any water that appears, smells, or tastes objectionable should not be consumed (WHO, 2006).

The mean pH value of the samples from the study areas was within the standard WHO (6.5-8.5) international limits. This finding is consistent with Shittu *et al*. (2008), Agbo *et al*. (2019), Sunday *et al*. (2014), and Titilawo *et al*. (2020) who reported a similar pH range for drinking water in Abeokuta, Calabar, Edo, and Ebonyi states in Nigeria. Changes in pH are known to be caused by processes such as photosynthesis, respiration, temperature exposure to air, industrial waste disposal, geology and mineral content of a catchment area, acid mine drainage, agricultural runoff, carbon dioxide concentration in the atmosphere, and the accumulation and decomposition of organic detritus in the water, all of which produce weak carbonic acids that influence pH. (Sibanda *et al*., 2013).

In terms of temperature, the mean water temperature observed during the study was within the WHO (2006) standard permissible limit. This is comparable to the findings of Oparaocha *et al*., (2010) and Adegboyega *et al*., (2015), who reported mean water temperature ranges within acceptable limits. This could be attributed to the cooling effect of the clay container and the pots' shady location in the study area. The temperature of drinking water should not exceed 15 degrees Celsius because coolness improves water palatability (WHO, 2006).

The current study's mean TDS values were above the desirable limits set by WHO standards. Water turbidity is critical because high levels of turbidity are frequently associated with higher levels of disease-causing microorganisms such as bacteria and other parasites (Manoj and Avinash, 2012). TDS is the total cation and anion concentration in water, which includes carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. TDS affects the taste of drinking water when it exceeds the WHO recommended level. Excess TDS in water can reduce clarity, allowing microorganisms of health importance to thriving. (Ewuzie *et al*., 2021).

The bacteriological analysis of the five water sources sampled revealed an unsanitary condition of some drinking water, with 5 samples (41.70 percent) having coliform counts above the WHO recommended limit. This finding is consistent with the findings of Adekunle *et al*., (2007) in Ibadan, Itah, and Akpan,(2005) in southern Nigeria, and Attahiru *et al*., (2016) in Sokoto. Similarly, Zvidzai *et al*., (2007) discovered fecal coliform and Escherichia coli in the study of microbial community analysis of drinking water sources from rural areas of Zimbabwe, which were attributed to poor water treatment handling. However, some studies have revealed that coliform bacteria are common in nature and do not always indicate fecal pollution.

The presence of coliform bacteria in stored water was most likely caused by unsanitary water-handling practices (i.e. unsanitary use of utensils and hands touching the water). This is consistent with previous research by Adesakin *et al*., 2020, Chalchisa *et al*., 2018, and Agbo, and Ogar, 2019, which found that the geometric design of household water storage containers was important in ensuring that stored drinking water was not contaminated by external factors such as dirty hands and utensils. Total viable count values found in stored water could be due to contamination from untidy or dirty storage facilities, the interaction of small children with the water, or the insertion of a dirty container to collect or remove contaminants.

5. CONCLUSION

Human consumption water is expected to be free of objectionable physical, chemical, and microbial contaminants. The study discovered that coliform counts were within acceptable limits in some samples while exceeding them in others. As a result, it is recommended that precautions be taken to avoid contaminating stored water, that storage pots be cleaned and disinfected regularly, and that domestic drinking water be monitored.

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