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Comparison Of Water Quality From Boreholes And Hand-Dug Wells Around And Within Malete, Kwara State, Nigeria

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Abstract
The increase in water consumption and health challenge in Malete as a result of increase in population of students and migrants cause an alarm. This study was carried out to compare the quality of selected machine drilled boreholes and hand dug wells for drinking. Samples were taken from six locations around and within Malete, Kwara State, Nigeria and tested for physicochemical and microbiological parameters using standard analytical methods. Range of values obtained for the various parameters for borehole samples are: Colour (9-57.00 PCU), turbidity (0.00 FTU), conductivity (101.14-303.38 FTU), total dissolved solids (TDS) (148.57-266.29 mg/L), total alkalinity (12.33-20.00 mg/L), Iron (0.01- 1.97 mg/L), Nitrate (2.89-8.11 mg/L), pH (3.86-6.08 mg/L), hardness (17.1-68.4 mg/L), Manganese (0-0.13 mg/L), Coliform (0.12-0.22 cfu/mL) and Escherichia coli (0 cfu/mL). While values obtained for well samples are: Colour (35-177.57 PCU), turbidity (6.25-45.86 FTU), conductivity (139.57-300.78 FTU), TDS (525.50-801.11 mg/L), total alkalinity (116.03-208.07 mg/L), Iron (0.04-0.21 mg/L), Nitrate (6.77- 12.01 mg/L), pH (4.76-5.95 mg/L), hardness (34.2-85.5 mg/L).. Borehole water had values for most parameters within the stipulated Nigerian standard for drinking water quality. However, pH values of borehole samples were very low, thus indicating that both borehole and well water require treatment before drinking.

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I. Introduction

Nigeria is divided into nine hydrogeological basins, with Kwara State situated within the Delta Basin. This basin is characterized by abundant water table aquifers composed of alternating layers of sands and clays. These aquifers exist in both upper and lower units, serving as local water sources. Significant groundwater reserves are commonly found at depths ranging between 80–100 meters and around 600 meters below ground level, providing water for public, industrial, and private use (Gray, 1994; Lasisi, 2023). Despite this groundwater potential, only about 10% of Kwara State's population is served by public water utilities. The remaining population relies on private boreholes or informal providers such as water vendors. Water accessibility is further compromised by factors including rapid population growth, climate change, unreliable electricity, poor regulatory enforcement, infrastructure leakages, and theft—leading to an estimated 60% loss of water through unaccounted-for means (APHA, 2002; Adeyemi et al., 2003; Egereonu and Ozuzu, 2005; Agbede and Akpen, 2008).

Groundwater, which refers to subsurface water located beneath the water table in saturated soil and rock formations, plays a crucial role in supplying safe drinking water. It accounts for approximately 88% of potable water in rural areas where population is dispersed and water infrastructure is limited (Horten, 1995;Yussuff, 2007; Alexander, 2008). Groundwater has several qualities that make it suitable for public supply: it is typically free from pathogens, has acceptable turbidity and color, and can often be consumed without prior treatment (Alexander, 2008; Jain et al., 1996; Milovanovic, 2007; Nafees, 2015; Okoro et al., 2012). However, groundwater quality can be affected by both natural and anthropogenic factors. Hardness in water arises from contact with mineral-laden geological formations or direct human-induced pollution (Awoyemi et al., 2014;olatunji et al., 2015; Okimiji et al., 2024). Additionally, Ifabiyi (2008) observed an inverse relationship between water hardness and nitrate concentrations, which may result from microbial processes. Urban groundwater quality in Nigeria is influenced by various factors including underlying geology, geochemical conditions, urbanization, industrial activities, seasonal variations, and contamination from heavy metals and pathogens (Ocheri et al., 2014; Eni et al., 2011; Adelara et al., 2008; Patil et al., 2012).

Boreholes, which are machine-drilled wells, typically range from 10 to 100 meters in depth and are constructed with 4–8 inch PVC casings and screens. Shallow boreholes are between 10–30 meters, while deeper ones range from 30–100 meters. In urban centers across Kwara State, boreholes are common sources of water for both domestic and industrial use (Standard, 2007; Adepelumi et al., 2008; Omeka et al., 2024). Compared to hand-dug wells, machine-drilled boreholes are generally regarded as more reliable sources of drinking water, especially in densely populated communities. Hand-dug wells, by contrast, are constructed manually using shovels or backhoes. They are usually shallow between 10 and 30 feet deep since excavation is limited by the groundwater table and the digger's ability to bail out water. These wells are lined with materials such as stones, bricks, or concrete to prevent collapse and are capped for protection. Due to their shallow nature, hand-dug wells are more susceptible to contamination. To reduce this risk, proper construction features are required to prevent contaminants from seeping in along or through the casing. To prevent collapse, these wells are usually lined with materials like stones, bricks, tiles, or concrete, and they are often capped with wood, stone, or concrete for added protection(Trivedy and Goel, 1986; Inanc et al., 1998; Spellman 2017; Nadarian et al., 2024; Zhang et al., 2025). In many communities across Kwara State, especially among residents who cannot afford the cost of sachet water, hand-dug wells and boreholes serve as the main sources of water supply. This study was therefore carried out to assess and compare the quality of water from selected machine-drilled boreholes and hand-dug wells in the vicinity of Kwara State University, Malete. The specific objectives of the study are to analyze the physicochemical characteristics of groundwater samples collected in and around the university and to compare the results with the Nigerian Standard for Drinking Water Quality (NIS 554) in order to determine their suitability for drinking and domestic purposes.

(a) (b)

Figure 1: (a) Borehole and (b) Local well

II. Materials And Method

This study was conducted to compare the quality of water from hand-dug wells and machine-drilled boreholes around Kwara State University, Malete, in Kwara State, Nigeria.

Sample Collection:

Borehole water samples were collected in sterile containers from two different locations around and within Kwara State University. The two sampling locations were Malete town and Safari community. These samples were carefully handled to avoid contamination before analysis.

Materials and Instruments Used:

Several instruments and materials were used for the analysis. The DR900 multiparameter photometer was used to test various chemical parameters. It is a portable colorimeter capable of analyzing up to 90 common water quality indicators. The HI 83200 multiparameter photometer was used to measure the color of the water samples. Before measurement, the samples were filtered using Whatman filter paper to remove suspended particles. Filter paper was used to remove fine solid particles from the samples, ensuring accurate photometric readings.

The Adwa conductivity meter (AD3000) was used to measure the electrical conductivity, total dissolved solids (TDS), and temperature of the water. This meter automatically adjusts for temperature and shows when a stable reading is reached. It also allows the user to assign an ID to each test result. The Hanna microprocessor turbidity meter was used to determine the clarity of the water. It works by shining a light through the sample and detecting the light scattered by particles in the water. The Beckman Coulter 350 pH meter was used to determine the pH of the water. It also measures temperature and electrical potential (mV), providing accurate results through automatic temperature compensation and stable reading detection. The HM digital TDS meter (TDS-3) was used to measure the total amount of dissolved solids in the water. It is a portable and convenient device widely used for water testing.

Water Sample Analysis:

For the chemical analysis, 10 ml of each water sample was dispensed into cuvettes, and the appropriate reagents were added according to the manufacturer's instructions. The results were read from the LCD display of the DR900 photometer. The color of the samples was measured using the HI 83200 photometer after filtering. Conductivity, turbidity, pH, and TDS were measured using the Adwa conductivity meter, Hanna turbidity meter, Beckman 350 pH meter, and HM digital TDS meter, respectively.

III. Results And Discussion

Table 1 shows the mean statistics of borehole water samples obtained from various locations around and within the Kwara State University, Malete; while Table 2 shows the mean statistics of hand-dug well water samples obtained from various locations around the Kwara State University, Malete.

Table 1: Mean statistics of various parameters for the borehole water samples.

S/N	**1**	**2**		**NIS554**
Sampling code	A	B	C	D
Sampling points	MALETE	SAFARI	MALETE	
Appearance	Clear and colorless	Clear and colorless	Clear and colorless	Unobjectionable
Odour	Nil	Nil	35.00 ± 12.09	
Colour (PCU)	13.00 ± 0.92	11.00 ± 0.71	7.66 ± 2.11	15
Turbidity (FTU)	0.00 ± 0.00	0.00 ± 0.00	139.57 ± 8.02	5
Conductivity(µS)	300.00 ± 21.86	303.38 ± 42.71	690.48 ± 11.11	1000
TDS (mg/L)	148.57 ± 11.26	266.29 ± 36.72	116.03 ± 5.09	500
Total alkalinity (mg/L)	16.67 ± 1.37	20.00 ± 2.86		200
Iron (mg/L)	0.01 ± 0.00	0.08 ± 0.01	0.04 ± 0.01	0.3
Nitrate (mg/L)	5.90 ± 0.55	8.11 ± 2.17	10.15 ± 0.11	50
Coliform (cfu/mL)	0.12 ± 0.73	0.22 ± 1.11	12.50 ± 0.12	10 cfu/ml
PH	6.5 ± 0.3	6.08 ± 1.24	5.41 ± 0.21	6.5 – 8.5
Hardness (CaCO3)	17.1 ± 1.18	34.2 ± 2.11	34.2 ± 5.00	150

Table 2: Mean statistics of various parameters for the well water samples

S/N	1	2		NIS554
Sampling code	A	B	C	D
Sampling points	MALETE	SAFARI	MALETE	
Appearance	colorless	colorless	Turbid	Unobjectionable
Odour	Nil	Nil	Nill	
Colour (PCU)	87.65 ± 3.89	35.00 ± 12.09	177.57 ± 32.05	15
Turbidity (FTU)	6.25 ± 0.98	7.66 ± 2.11	45.86 ± 9.55	5
Conductivity(µS)	152.09 ± 1.67	139.57 ± 8.02	300.78 ± 5.95	1000
TDS (mg/L)	525.50± 8.61	690.48 ± 11.11	801.11 ± 21.10	500
Total alkalinity (mg/L)	166.33 ± 2.77	116.03 ± 5.09	208.07 ± 12.56	200
Iron (mg/L)	0.16 ± 0.01	0.04 ± 0.01	0.21 ± 0.05	0.3
Nitrate (mg/L)	6.77 ± 0.51	10.15 ± 0.11	12.01 ± 0.11	50
Coliform (cfu/mL)	15.13 ± 0.51	12.50 ± 0.12	17.71 ± 4.99	10 cfu/ml
PH	4.76 ± 0.33	5.41 ± 0.21	5.95 ± 0.34	6.5 – 8.5
Hardness (CaCO3)	68.4 ± 5.00	34.2 ± 5.00	85.5 ± 5.00	150

The results in Table 1 present a comparative analysis of selected physicochemical and microbiological parameters of borehole and hand-dug well water samples collected from Malete and Safari communities near Kwara State University, in relation to the Nigerian Standard for Drinking Water Quality (NIS 554).

Appearance and Odour

All borehole water samples appeared clear and colorless with no objectionable odour, aligning with NIS requirements. However, one of the hand-dug well samples (Sampling code C – Malete) appeared turbid, indicating the presence of suspended particles, which may reduce acceptability and indicate possible contamination.

Colour and Turbidity

For boreholes, colour values ranged from 7.66 to 13.00 PCU, within the acceptable limit of 15 PCU. However, the hand-dug well samples showed significantly elevated colour values, reaching 177.57 PCU in Malete, far above the standard.

Similarly, turbidity in borehole water was consistently 0.00 FTU, while hand-dug wells had turbidity values as high as 45.86 FTU, far exceeding the recommended 5 FTU. This suggests that the hand-dug wells may be more exposed to suspended particles or organic matter.

Conductivity and Total Dissolved Solids (TDS)

Conductivity values for both water sources were within the 1,000 µS limit. However, while borehole water showed lower TDS values (116.03–266.29 mg/L), hand-dug wells had TDS concentrations up to 801.11 mg/L, surpassing the 500 mg/L standard. High TDS may affect taste and potentially indicate contamination or mineral buildup.

Total Alkalinity

Borehole samples had low total alkalinity (16.67–20.00 mg/L), whereas hand-dug well samples were much higher, reaching 208.07 mg/L in some cases. While these values are within the 200 mg/L limit, slightly elevated alkalinity could influence taste and buffering capacity.

Iron and Nitrate Concentrations

All water sources had iron concentrations well below the 0.3 mg/L standard, indicating no significant contamination from iron. Nitrate levels also remained low across all samples (5.90–12.01 mg/L), far below the permissible limit of 50 mg/L, suggesting minimal agricultural runoff or septic leakage.

pH and Hardness

The pH of borehole water was slightly acidic in some samples (6.08–6.5), while hand-dug wells were more acidic (4.76–5.95), falling short of the acceptable range (6.5–8.5). Acidic water may lead to corrosion of plumbing and leaching of metals.

Hardness was low in all borehole samples (17.1–34.2 mg/L), and higher but still within limits in hand-dug wells (68.4–85.5 mg/L), indicating no significant concern regarding scaling.

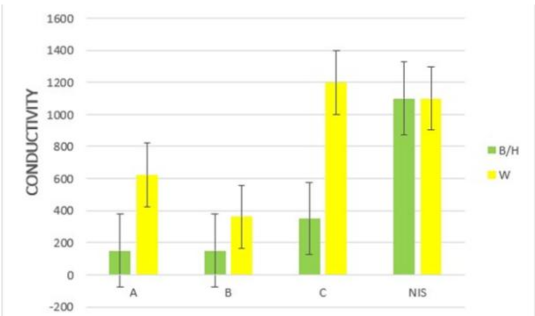

Figure 1: Conductivity values (µS) for borehole water.
A, Malete; B, Safari; C, Malete.

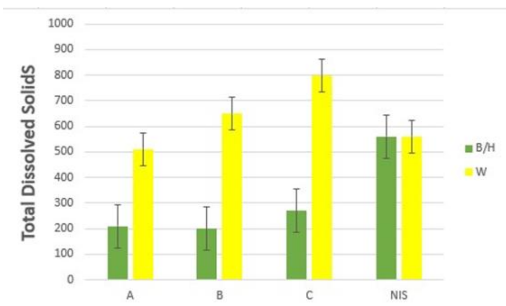

Figure 2: TDS values (mg/L) for borehole and well water.
A, Malete; B, Safari; C, Malete.

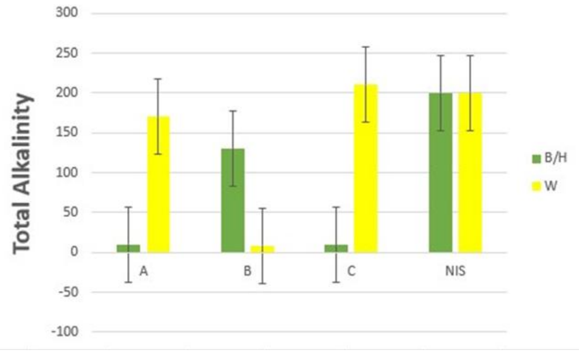

Figure 3: Total alkalinity values (mg/L) for borehole water.
A, Malete; B, Safari; C, Malete.

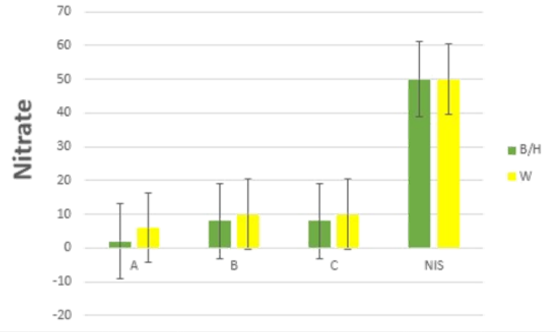

Figure 4: Nitrate values (mg/L) for borehole water.
A, Malete; B, Safari; C, Malete.

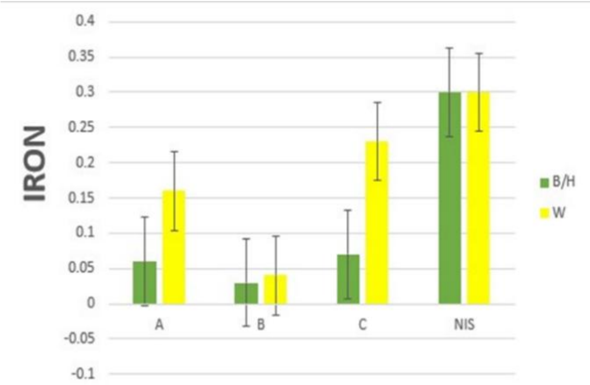

Figure 5: Iron values (mg/L) for borehole and well water.
A, Malete; B, Safari; C, Malete.

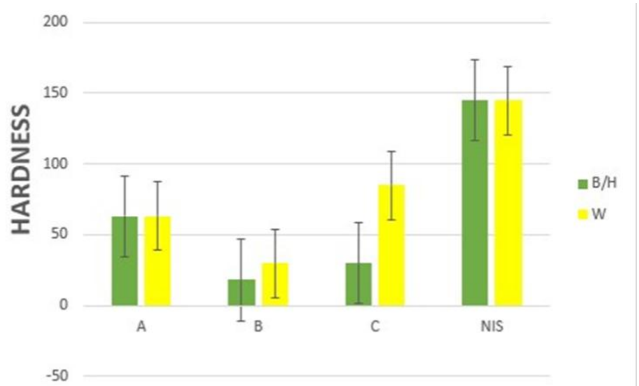

Figure 6: Hardness values (mg/L) for borehole and well water.
A, Malete; B, Safari; C, Malete.

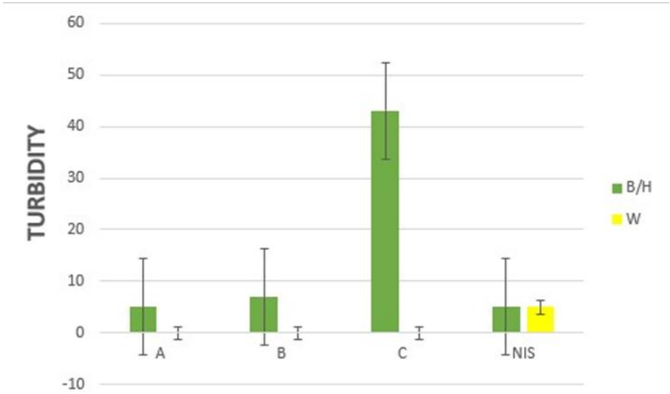

Figure 6: Turbidity values (NTU) for and well borehole and well water.
A, Malete; B, Safari; C, Malete

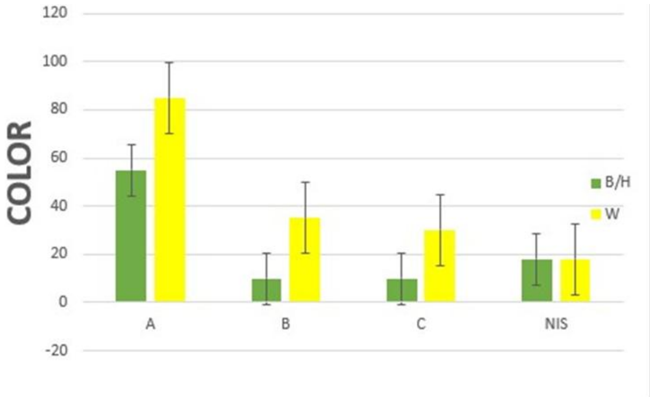

Figure 7: Color values (PCU) for borehole water.
A, Malete; B, Safari; C, Malete.

The samples were tested for water quality attributes and compared with the Nigerian standard for drinking water quality (NIS 554).

The colour of borehole samples ranges between 9.00 and 57.00 PCU while colour of well samples was between 35.00 and 177.57 PCU. Colour values for all well samples and borehole sample from Malete exceeded the limits stated in NIS 554 (15PCU). The variations in the colour values of well and borehole samples could be due to the fact that sand, silt or clay particles may be dislodged and washed into the well water which is at a shallow depth than borehole. The swampy nature of the area aggravates the distortion in colour and turbidity values of well samples because of the shallow depth.

Turbidity of all the borehole samples tested was 0.00 FTU. However, well samples had turbidity values between 6.25 and 45.86 FTU. Surface runoff and storm water from rainfall can transport pollutants from land surfaces into underground aquifers (Inanc et.al., 1998), thus increasing the colour and turbidity values.

Borehole samples had conductivity values ranging between 101.14 to 303.38 µS and TDS values between 148.57 to 252.52 mg/L; conductivity values of well samples (139.57 to 300.00 µS) were not different from those of borehole samples while TDS values of well samples (525.50-801.11mg/L) was higher and exceeded the NIS 554 limits (500 mg/L). TDS is used to describe the inorganic salts and small amounts of organic matter present in solution in water. The presence of dissolved solids in water may affect its taste.

Alkalinity of water is due to the presence of carbonates, bicarbonates, and hydroxides. Total alkalinity values obtained for borehole samples tested in this study was between 12.33 to 20.00 mg/L while well samples had values ranging between 116.03 and 208.7 mg/L. Well sample from Malete (208.07 mg/L) exceeded the stipulated limit by NIS 554 (200 mg/L). As observed in Figure 3, alkalinity values of borehole samples were lower than well samples from the same location. Alkalinity is not a harmful parameter to human beings (Trivedy *et.al.*, 1986).

The values of nitrate for both borehole (2.89 to 8.11 mg/L) and well (6.77 to 12.01 mg/L) and Hardness for borehole (17.1 to 68.4 mg/L) and well (34.2 to 85.5 mg/L) was within acceptable limits (NIS 554: 150 mg/L). Figure 4 shows that nitrate values for both borehole and well water at all the sampling locations were similar. Nitrate naturally occurs in low concentration in natural waters; pollution causes higher nitrate concentration in water.

IV. Conclusion

Most developing countries rely on local groundwater supplies such as hand-dug well and borehole. This study reveals that there is need to educate well owners about the quality of water obtained from these sources as there is a general belief that boreholes are better than hand dug wells.

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