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Comparison of water quality from boreholes and hand-dug wells around and within the University of Lagos, Lagos, Nigeria

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ABSTRACT

The supply of drinking water in densely populated urban communities in Lagos is a challenge. Machine-drilled boreholes are believed to be better sources of drinking water than hand-dug wells. This study was carried out to compare the quality of selected machine drilled boreholes and hand dug wells for drinking. Samples were taken from five locations around and within the University of Lagos main campus, Akoka, Lagos 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), Coliform (12.50-17.71 cfu/mL) and *E. coli* (3.01-7.66 cfu/mL). 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.

INTRODUCTION

Nigeria is sub-divided into nine different hydrogeological basins and Lagos is located within the Delta basin within which water table aquifers are abundant. These aquifers are made up of alternating sequence of sands and clays. The upper and lower aquifer units have been identified as local water sources while additional significant aquifers are generally encountered between 80 and 100 m and at about 600 m below ground and these provide water for public water supplies, industry and private supplies (Lasisi, 2011).

Only 10% of the population in Lagos is being served by the public water utility, Lagos Water Corporation. The rest of the population gain access to water either from private boreholes or from informal private sector participants such as water vendors. This situation is further worsened by certain factors such as rapid population growth, climate change, unreliable electricity, inadequate enforcement, water leakages and theft that cause 60% unaccounted-for-water losses (Jideonwo, 2014).

Groundwater is a term usually used for subsurface water that occurs beneath the water-table in soils and geologic formations that are fully saturated. Groundwater accounts for about 88% safe drinking water in rural areas

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where there is widely dispersed population and water treatment infrastructure and transportation does not exist (Alexander, 2008).

Ground waters have unique features which make them suitable for public water supply. They are usually free from pathogens, have acceptable colour and turbidity and can be consumed directly without treatment (Alexander, 2008; Jain et al., 1996). Water hardness is caused by natural accumulation of salts from contact with soil and geological formation or through direct pollution by human activities (Awoyemi et al., 2014). Ifabiyi (2008) reported an inverse relationship between hardness and nitrate resulting from microbial activities.

Studies have shown that Nigeria urban groundwater quality is influenced by the geology and geochemistry of the environment, rate of urbanization, industrialization, heavy metals/bacteriological pollution and effect of seasons (Ocheri et al., 2014; Eni et al., 2011; Adelara et al., 2008).

A borehole is a machine drilled well with depth ranging from 10-100 m and installed with 4-8" PVC (polyvinyl chloride) casing/screens. Deep borehole ranges between 30-100 m while shallow borehole ranges between 10-30 m. Boreholes are very common features in the city of Lagos and most residents depend on borehole water for both domestic and industrial usage (Adepelumi et al., 2008).

However, a large population of residents that cannot afford the high cost of boreholes get water supply from hand dug wells which are relatively cheaper.

This study was aimed at comparing the physico-chemical parameters of selected boreholes and hand-dug wells around the University of Lagos, Akoka campus. The qualities of water from these sources were compared with Nigerian Standard for drinking water (NIS 554) in order to determine their suitability for consumption and domestic applications.

MATERIALS AND METHODS

Study area

The University of Lagos lies on latitude 6° 30.40' N and 3° 24.52' E longitude. It lies on marshland of vast mangrove and freshwater swamps, surrounding a small and much dissected table land consisting of freshwater swamp forest, mangrove swamp forest, sandy plain vegetation and rainforest vegetation (Ayolabi, 2004).

The Lagos lagoon borders the University campus to the east and south. Bariga borders it to the north while Yaba lies towards the west. A canal runs along almost the whole of the western stretch of the university, while a marsh which has an open connection to the lagoon encompasses the whole of the northern stretch of the University, linking up with the canal in the west (Oyedele and Momoh, 2009).

Sampling

Borehole water samples were taken in sterile containers from five different locations around and within the University of Lagos namely: Pako-Bariga, Abule-Oja, Onike, Ransome Kuti road and Service Area within the University of Lagos Campus. Hand-dug well water samples were taken from Pako-Bariga, Abule-Oja and Onike as there are no hand-dug wells within the University of Lagos campus.

Water samples (in triplicates) were taken twice in a week for three months (December to February). These months were chosen by practicalities as studies have shown that seasonal water quality and patterns are variable and depend on localities (Yusuf, 2007).

Samples were transported to the Quality Control Laboratory, University of Lagos for immediate analyses. The analysis of the quality of each of the selected parameters were carried out with the use of DR900 multi-parameter photometer (Hach, USA). For each of the chemical parameters, 10 ml of the sample was dispensed into the cuvettes and the corresponding chemical reagents added (in accordance with the manufacturer's specification). Corresponding measurements were read-off the LCD display. The colour of the sample was measure with the HI 83200 multi-parameter photometer after filtering using Whatman No. 42 filter paper. The conductivity, turbidity, pH and total dissolved solids were also measured using the Adwa conductivity meter, Hanna microprocessor turbidity meter, Beckman 350 pH meter and HM digital TDS meter, respectively. The coliform and *Escherichia coli* counts were enumerated using the colilert-18 microbiological test kit. All equipments were calibrated according to manufacturer's instructions.

RESULTS AND DISCUSSION

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

The samples were tested for physicochemical and microbiological attributes and compared with the Nigerian standard for drinking water quality (NIS 554). All borehole samples from the five locations (Pako-Bariga, Abule-Oja, Onike, Ransome Kuti road and Service area, University of Lagos campus) and well samples from Pako-Bariga and Abule-Oja were clear, colourless and odourless while well sample from Onike appeared turbid and had foul odour. 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 Pako-Bariga

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

S/N	1	2	3	4	5	NIS 554
Sampling code	A	B	C	D	E	
Sampling points	Pako-Bariga	Abule-Oja	Onike	Ransome Kuti UNILAG	Service Area UNILAG	
Appearance	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Unobjectionable
Odour	Nil	Nil	Nil	Nil	Nil	
Taste	Nil	Nil	Nil	Nil	Nil	
Colour (PCU)	57.00 ± 6.61	11.00 ± 0.56	11.00 ± 0.71	13.00 ± 0.92	9.00 ± 0.36	15
Turbidity (FTU)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	5
Conductivity(µS)	152.09 ± 27.63	139.57 ± 36.22	300.00 ± 21.86	101.14 ± 13.68	303.38 ± 42.71	1000
TDS (mg/L)	205.81± 31.66	190.48 ± 19.01	266.29 ± 36.72	148.57 ± 11.26	252.52 ± 17.81	500
Total alkalinity (mg/L)	16.33 ± 2.77	12.33 ± 2.14	20.00 ± 2.86	16.67 ± 1.37	17.00 ± 2.05	200
Iron (mg/L)	0.06 ± 0.01	0.03 ± 0.00	0.08 ± 0.01	0.01 ± 0.00	1.97 ± 0.72	0.3
Nitrate (mg/L)	2.89 ± 0.88	7.85 ± 2.16	8.11 ± 2.17	5.90 ± 0.55	3.83 ± 0.04	50
Coliform (cfu/mL)	0.13 ± 0.55	0.12 ± 1.06	0.22 ± 1.11	0.12 ± 0.73	0.17 ± 0.21	10 cfu/ml
E. coli (cfu/100mL)	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0
pH	6.08 ± 1.24	3.86 ± 0.97	3.98 ± 0.81	4.47 ± 1.01	4.56 ± 1.36	6.5 – 8.5
Hardness ($CaCO_3$)	68.4 ± 3.21	17.1 ± 2.07	34.2 ± 2.11	17.1 ± 1.18	17.1 ± 2.07	150

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

S/N	1	2	3	NIS 554
Sampling code	A	B	C	
Sampling points	Pako-Bariga	Abule-Oja	Onike	
Appearance	Colourless	Colourless	Turbid	Unobjectionable
Odour	Nil	Nil	objectionable	
Taste	Nil	Nil	Nil	
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
E. coli (cfu/100mL)	3.01 ± 0.01	2.89 ± 0.75	7.66 ± 0.31	0
pH	4.76 ± 0.33	5.41 ± 0.21	5.95 ± 0.34	6.5 – 8.5
Hardness ($CaCO_3$)	68.4 ± 5.00	34.2 ± 5.00	85.5 ± 5.00	150

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

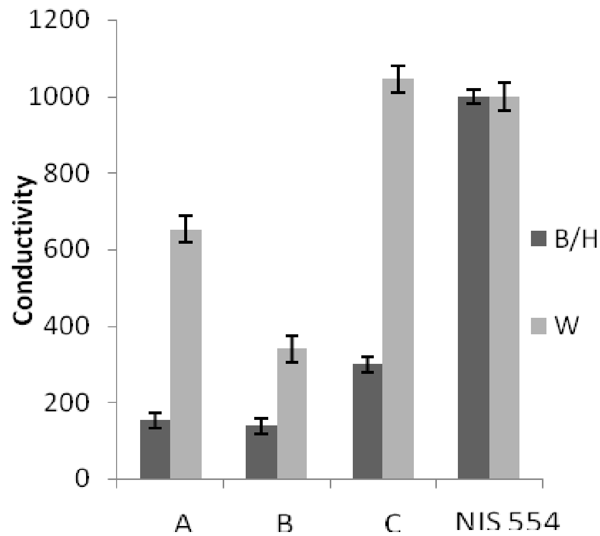

Figure 1. Conductivity values (µS) for borehole water.
A, Pako-Bariga; B, Abule-Oja; C, Onike.

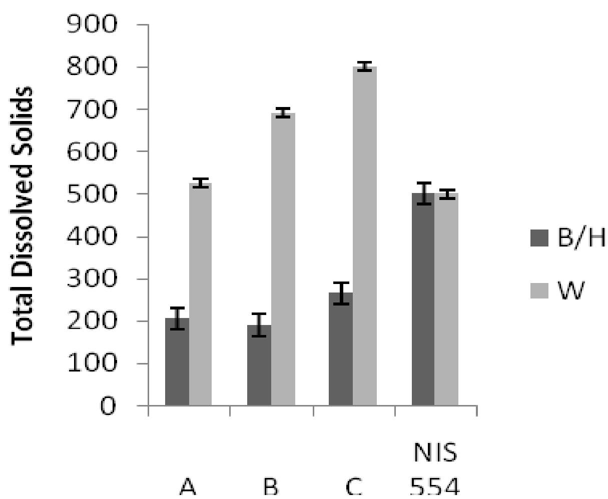

Figure 2. TDS values (mg/L) for borehole and well water.

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) was 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. High TDS values in well water may be due to pollution by leaching especially since the study area is of close proximity to the lagoon. Conductivity values as seen in Figure 1 are a reflection of TDS values (Figure 2).

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 Onike (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

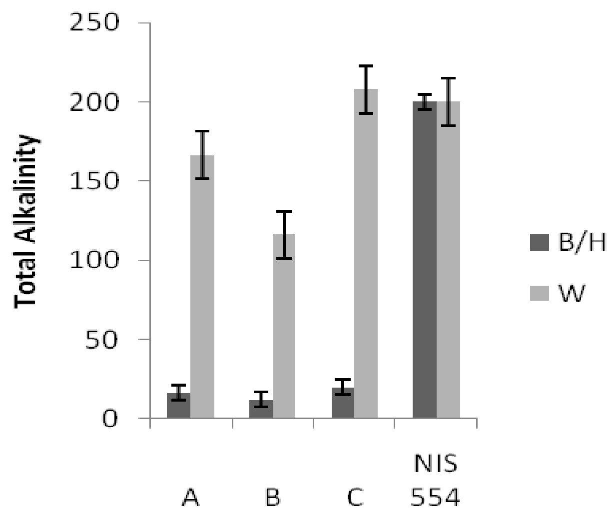

Figure 3. Total alkalinity values (mg/L) for borehole water.

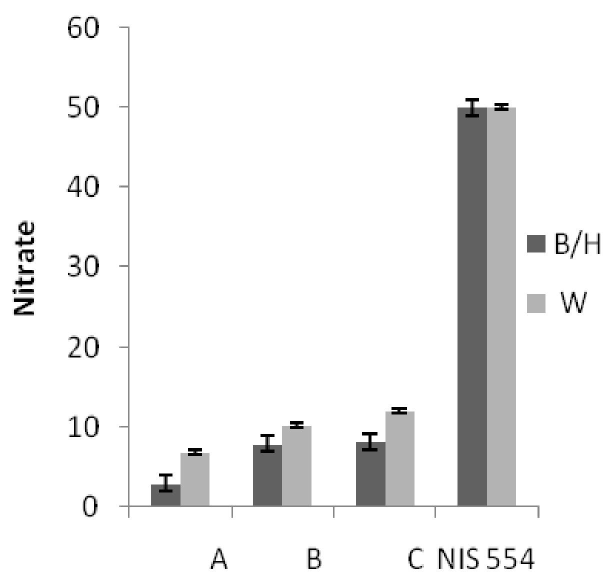

Figure 4. Nitrate values (mg/L) for borehole water.

lower than well samples from the same location. Alkalinity is not an harmful parameter to human beings (Trivedy and Goel, 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.

All borehole and well water samples analysed had hardness values below the stipulated NIS 554 standard. As observed in Figure 5, well and borehole samples at Pako-Bariga had similar water hardness values while samples from Abule-Oja and Onike had lower hardness values in borehole samples than well samples.

Values obtained for iron content of both borehole (0.01 to 0.08 mg/L) and well (0.04 to 0.21mg/L) was also within acceptable NIS 554 limits (0.3 mg/L) except for the iron content of Service Area, University of Lagos borehole (1.97 mg/L). High iron content observed in well water sample at Pako-Bariga (Figure 6) could also be the

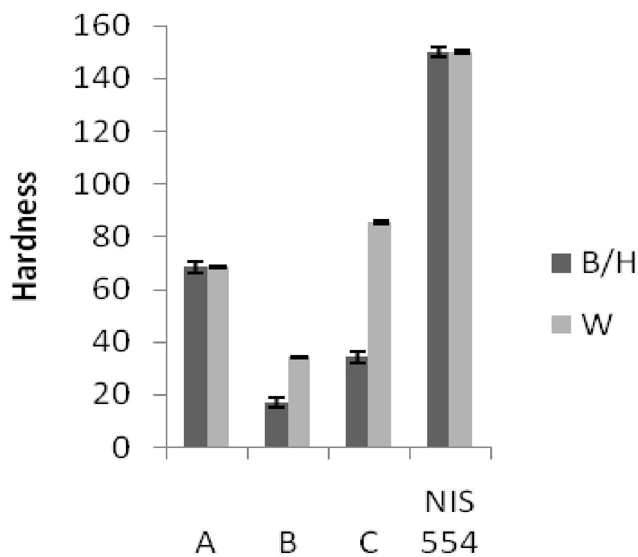

Figure 5. Hardness values (mg/L) for borehole and well water.

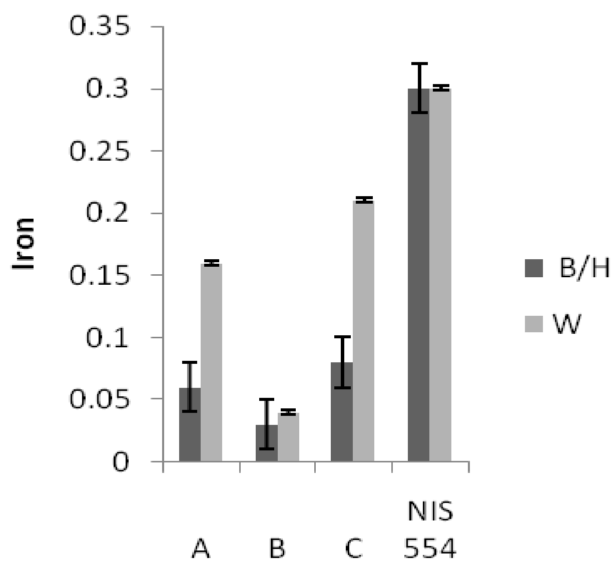

Figure 6. Iron values (mg/L) for borehole and well water.

reason for the increased colour and turbidity values of the samples (Figure 7 and 8). Results from field tests show that the iron concentrations in shallow wells range between 0.1 and 1.22 mg/L whilst deep boreholes have values between 0.45 and 6.0 mg/L (Kachali, 2011 unpublished). The recommended WHO guideline value for iron in drinking water is less than 0.3 mg/L. Iron is a very common problem in drinking water and has a direct relationship with water hardness. Iron can cause staining (laundry and plumbing), unpleasant taste and colour.

The microbiological survey for coliforms revealed that all borehole samples had coliform values (0.12 to 0.22 cfu/mL) lower than the acceptable limits stipulated by NIS 554 (10 cfu/mL) while all the well samples had coliform values that exceeded the stipulated limits (12.50 to 17.71 cfu/mL) (Figure 9). Agbede and Akpen (2008) found that wells located in floodplains with shallow depth were polluted by faecal bacteria. No *E. coli* was found in all borehole samples except the sample from Onike (Figure 10) while all well samples had *E. coli* ranging from 2.89 to 7.66 cfu/mL. Coliforms are generally indicators of faecal contamination in water. Efe (2008) observed that the longer water travels through soil formation the cleaner it

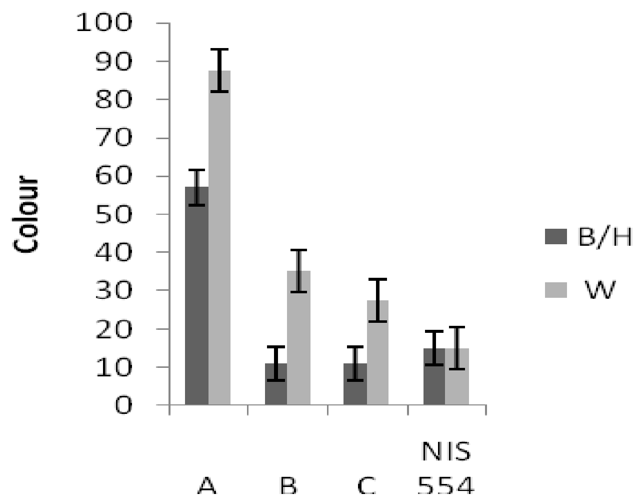

Figure 7. Colour values (PCU) for borehole water.

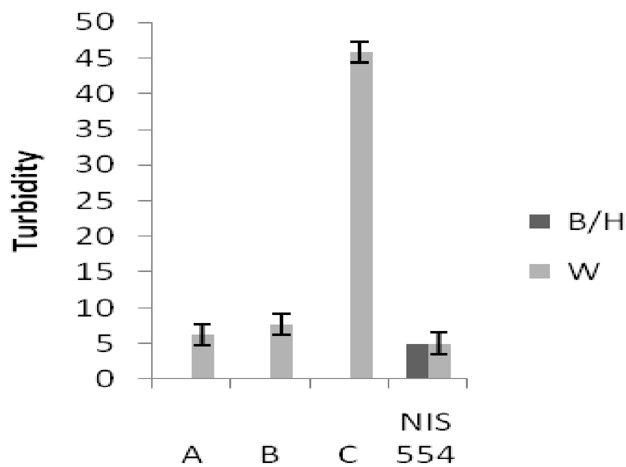

Figure 8. Turbidity values (NTU) for and well borehole and well water.

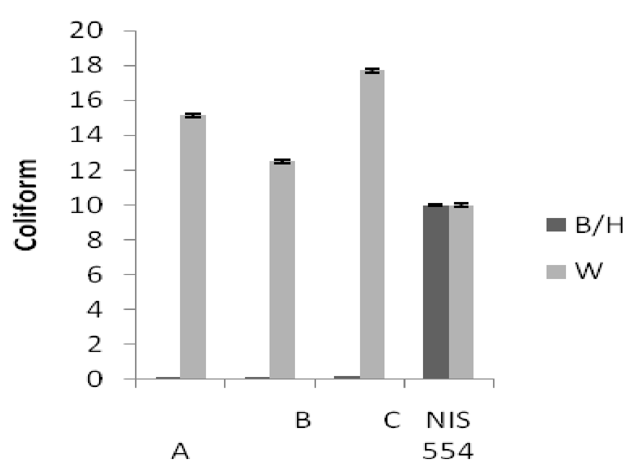

Figure 9. Coliform count (cfu/100 ml) for borehole water.

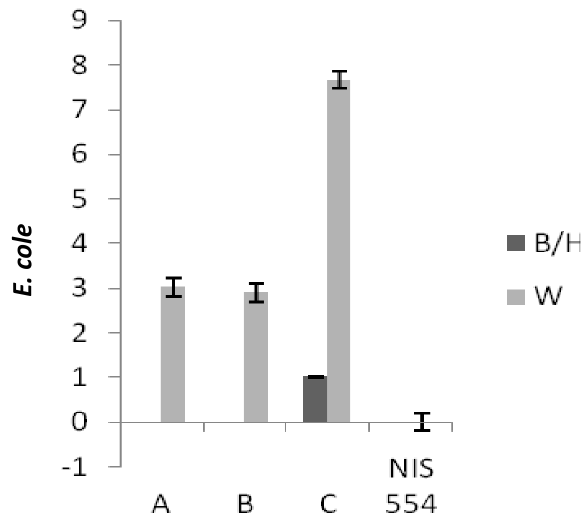

Figure 10. *E. coli* count (cfu/ml) for borehole and well water.

becomes; this could account for the better quality of borehole water which is at higher depth than well water.

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.

The pH of well and borehole water samples (3.86-6.08) from this study shows the need for treatment before drinking. Depth of well is considered to be an important factor as most of the parameters that conformed to the stipulated standards were from borehole samples which are generally deeper than hand-dug wells.

Borehole water samples had values for most parameters especially the microbiological parameters (Coliform and *E. coli*) within the stipulated Nigerian Standard for Drinking water Quality as these are of importance to health.

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