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DOMESTIC WATER QUALITY AND THE DISCRIMINATORY INFLUENCE OF SOCIO-ECONOMIC STRATIFICATION ON ACCESSIBILITY TO SAFE WATER IN A PART OF OSUN STATE, NIGERIA

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Abstract

The status of the water supplied to households in an urban local government area in southwest Nigeria was examined. Specific objectives were to characterize household water sources, assess the per capita usage of potable water sources and examine the quality of the household water in the area. The purposively selected study area, Olorunda local government area in Osun State, Nigeria (being an urban local government area) was stratified into 'urban core' (central business district, CBD or high population density area), 'transition' (medium population density area but with less social infrastructure) and 'sub-urban' (typically government reserved area and low population density area) based on household density and associative socio-economic status. The methods were a mix of questionnaire administration to heads of 120 households (40 per stratum) and collection of the drinking water samples from the supply sources at four randomly selected households in each stratum. The water samples were analyzed for the concentrations of nitrite (NO_2^-), nitrate (NO_3^-), fluoride (F^-), lead (Pb), and arsenic (As) as well as *E-coli* bacteria contents based on their importance in determining water quality in urban areas. The results showed that domestic water sources are mainly hand dug well (55.8%), boreholes (37.5%), and pipe borne (6.7%). Residents averagely consumed at most 4L of water per day. Furthermore, the investigated chemical parameters varied as NO_2 (0.37-0.94 mg/l), NO_3 (0.29-0.70 mg/l), and F^- (0.003-0.97 mg/l). As and Pb occurred in trace quantities, and there were no pollution threats to consumers. The amount of *E coli* and total coliform contents were however outside the safe limits for residents, suggesting contamination of household water by the bacteria sources. The study concluded communities with a low socio-economic status that do not have access to state-provided tap water sources are more likely to consume polluted water than those with high socioeconomic status or that are supplied with state-provided tap water. The study advocates improving urban water management for urban fringe dwellers.

Keywords: Water accessibility, Urban core, Urban Transition Zone, Household water supply, Urban water quality

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1. INTRODUCTION

Sustainable water management is most often defined as the enablement to provide for the water demands of both the present time and the future time or adequate provision of water resources (see Eludoyin, 2016; Eludoyin & Olanrewaju, 2020). It is estimated that an individual would have an easy to a minimum of 20 to 50 liters of daily water for sustenance (Mulligan et al., 2020). Issues relating to water sustainability have been a major issue of concern that has received the attention of policymakers for many years (Sanstrom, 1997). Water resources were part of the focus of the Millennium Development Goals (Connor, 2015), and caused an increase of people with access to potable water by 11% (61%-71%) between 2005 and 2015; albeit with 785 million people without adequate basic potable water service (WHO/UNICEF, 2017). Consequently, Sustainable Development Goal 6 is targeted at achieving safe and affordable drinking water for all by 2030 (Bain et al., 2018). It is however unclear how many countries have performed with this goal, but a review of the activities in sub-Saharan Africa has revealed the need for more household interventions and evaluations (see Eludoyin & Olanrewaju, 2020; Eludoyin, 2020).

Household or domestic water refers to water that is used for various domestic purposes such as drinking, food preparation, and personal hygiene (Howard *et al.*, 2003). The main sources of household water supply include rainfall harvesting, surface (lakes, streams/rivers, springs, and, reservoirs) as well as groundwater sources (machine-drilled boreholes and hand-dug wells), piped water supply, or water vendors. In terms of quality, the water sources are categorized as improved or protected (considered to be free from surface contamination) and unprotected sources (unprotected wells, unprotected springs, rivers) (World Health Organization, 2006). Access to a particular category of water source is often a factor of time, energy, and/ or financial investments (Ehindero, 2006; Eludoyin, 2020).

Many residents of both rural and urban areas in developing countries, including Nigeria lack adequate access to safe potable water. Poor water and sanitation often leave women and children in queues for several hours or are forced to travel long distances for water (Sule & Okeola, 2010). Consequently, many mothers are prevented from working because of the need to fetch water for the family (Ingold, 2010). In addition, water-borne diseases have caused a number of deaths among many communities in sub-Saharan Africa (Bos, 2016). Many urban settlements have developed without adequate consideration for wastewater management, and this has increased the vulnerability of groundwater resources to contamination (Oyeku & Eludoyin, 2010, de Joode et al., 2016). The UN-Water/ Africa (Mwanza, 2005) classifies the sub-Saharan African region as water-poor, indicating low accessibility to safe drinking water. In many countries in this region, pipe-borne water supply service is characterized by interrupted service; communities are either not provided with water or water is provided for a limited number of hours per day. According to Tatlock (2006), 64% of Africans rely on water that is limited and highly variable and roughly 25% of Africa's population suffers from water stress.

A typical community is characterized by segregated populations that are distinguished by varying common traits as explained by different models of urban settlement patterns; concentric, sectoral, and multiple-nuclei models (Burgess, 1925; Hoyt, 1939; Harris & Ullman, 1945). All the models recognize that the structuring and growth of residential neighbourhoods involve some levels of spatially bound and varying socio-economic and/or demographic discriminations. Consequently, Friedmann's core-periphery model, which is based on the differences between regions and development policy (Friedmann, 1966) is considered suitable for this study. The core-periphery model targets that the allocation of public resources ought to be optimum, balanced, and stable. The core-periphery model has been to explain how the core urban tends to attract government focus for the development of public utilities at the expense of the periphery (outskirts) and transitional region (see Omodanisi et al., 2013; Adekola, 2016). The study area is a typical community in southwest Nigeria, where concerns have increased about the impact of urbanization on water supply and use; information on the spatial distribution of water sources is required to plan for efficient and quality water, hence this study. Specific objectives are to characterize potable water sources in the area, assess the per capita usage of potable water sources; and examine selected chemical and microbiological parameters of water samples in the study area.

2. STUDY AREA

The study area is, Olorunda, one of the 137 local government areas, in southwestern Nigeria is in the heart of Osogbo, the administrative capital city of Osun State, Nigeria (Figure 1). A local government area is a unit of governance that is composed of a number of political government areas in a unit of governance in Nigeria. The human population in the area as of 1991 was 83, 347, and by 2006, it became 131,761 by 2006 (NPC, 2006), estimated at 181, 300 in 2016 and predicted as about 329, 917 in 2050; if the population growth rate would be the same based on the annual growth rate of 3% per year.

Based on Koppen – Geiger classification, the study area lies within the tropical climate (*Aw*) region. It has a tropical dry and wet climate. The wet season starts in April and ends in early October, while the dry season spans between November and March. The months of December through January are characterized by a dry–cold dust harmattan wind from the Sahara Desert. The rainfall pattern has double peaks in June / July and September. The two peaks are separated by a period of a short dry span of August break. The highest rainfall usually occurs between June and July while the mean annual rainfall is about 1, 241 mm. The mean annual temperature is 26.1 °C and the relative humidity for the area is between 92% and 99% (Aguda and Adegboyega, 2013).

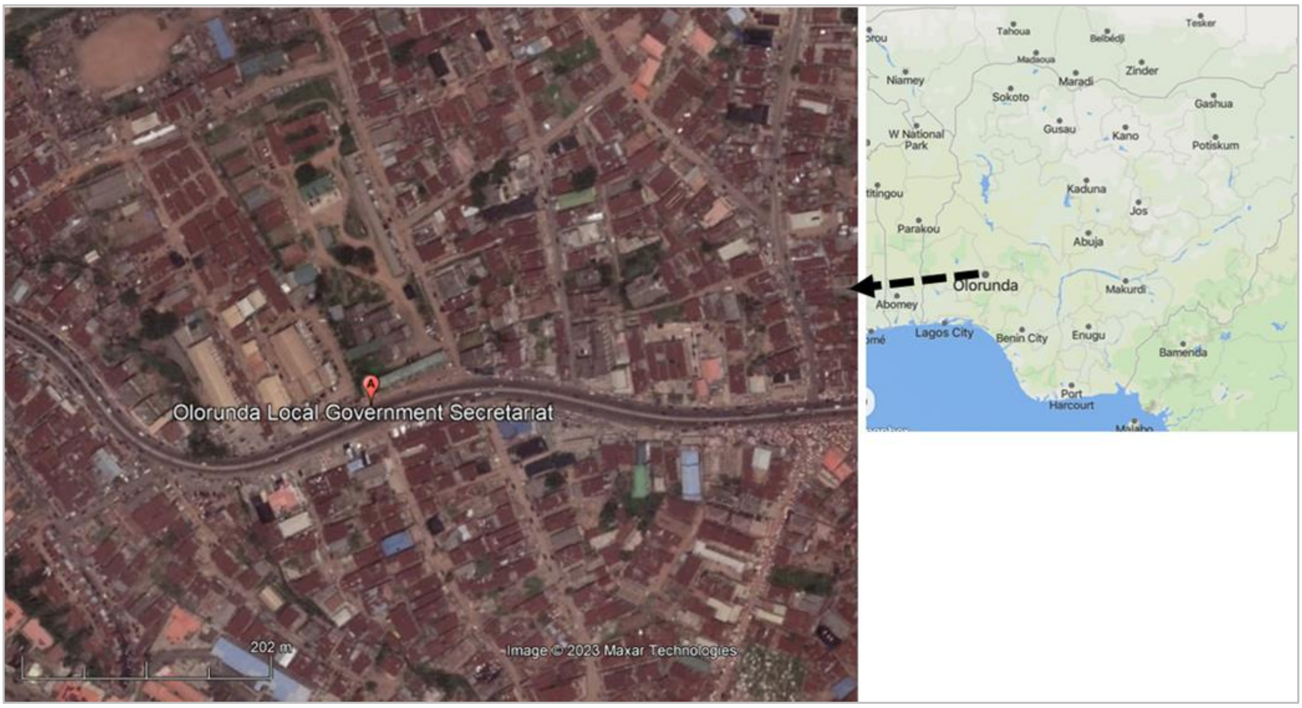

Figure 1- The study area, Olorunda Local Government Area, Osogbo in Southwest Nigeria

3. MATERIALS AND METHODS

3.1. Research design

The study area was first delineated into three homogeneous residential density zones using the concept of core-periphery into urban core (central business district, CBD or high population density area), transition (medium population density area but with less social infrastructure), and sub-urban (typically government reserved area and low population density area) for easier categorization density and associative socio-economic status. In the study area, the communities in the urban core were Sabo and Igbona while those in the transition were Ayekale and Ota-Efun. Sub-urban communities were Government Reserved Area (GRA) and Federal Housing. The core in the study area is predominantly occupied by the natives or indigenes and the buildings are close to one another. The buildings/houses which often followed the traditional courtyard system are also mostly connected by footpaths, and they mostly have basic infrastructure, including toilets, borehole, among others. The sub-urban on the other hand is characterized by well-defined layouts, and the buildings were mostly flats and duplexes with better facilities than the core. The transition residential zone is in-between, with more flats and communal ('Face-Me-I-face-you') bungalows and story-buildings, with easier road accessibilities (than either core or sub-urban) and better sanitation (than the core).

Grouped the study area into three major regions of core, transition, and suburban were respectively associated with high, medium, and low residential areas. Each of the regions was further divided into groups of lowland (< 250 m) and highland; (at lowest 250 m above sea level). One representative of each group of population density was then identified for the study. Twenty (20) households in each of the sub-area were randomly selected using a random sampling technique for questionnaire administration, making a total of 120 copies of the semi-structured questionnaire. Copies of a set of questionnaires were administered to purposively selected adults in charge of water supply to the selected households, on their sources of water. The sources were characterized in terms of types (protected hand-dug well, borehole, and piped water), and location (x, y, and z coordinates, which were determined by GPS). Furthermore, water samples were collected from two households in each of the sub-area; this made a total of 12 water samples.

3.2. Data

Data used for the study included

(a) on the status of the selected water sources in terms of location (how far are the sources sited from potential pollution sources such as latrines and septic tanks), level of protection (are the hand-dug wells protected), and some physical characteristics such as colour, taste and odour;
(b) characteristics of selected water sources (in terms of types; borehole, hand–dug well and pipe borne);
(c) socio-economic factors that affect accessibility and utilization of domestic water and;
(d) chemical and microbiological qualities of the water sources across the study area.

The data were obtained through field and laboratory work. The fieldwork involved data collection using in-depth interviews and laboratory data of water samples for selected chemical and microbiological properties. Water sources from each of the selected households were characterized in terms of types (hand dug well, borehole, pipe borne) whose location coordinated were recorded using a downloaded GPS software application. Water samples were collected from two accessible households, with the water source in their compounds and which gave access for their water samples to be obtained, in each of the sub-area (it is not all the households that have water sources in their compounds, and some disallowed sampling their water sources). In all, 12 water samples were obtained (Figure 2). Water samples were collected from the main sources of water used for household consumption. Each water sample was collected in a 1L polyethylene bottle (for both microbiological and chemical analyses); the bottles were rinsed well three times with distilled water and were allowed to dry. A label was attached to the samples indicating date, drinking water system, number, and location. The bottles were capped immediately after collecting the samples. Samples were transported in ice packs and coolers to Obafemi Awolowo University (OAU) Central Laboratory, Ile-Ife, Osun State.

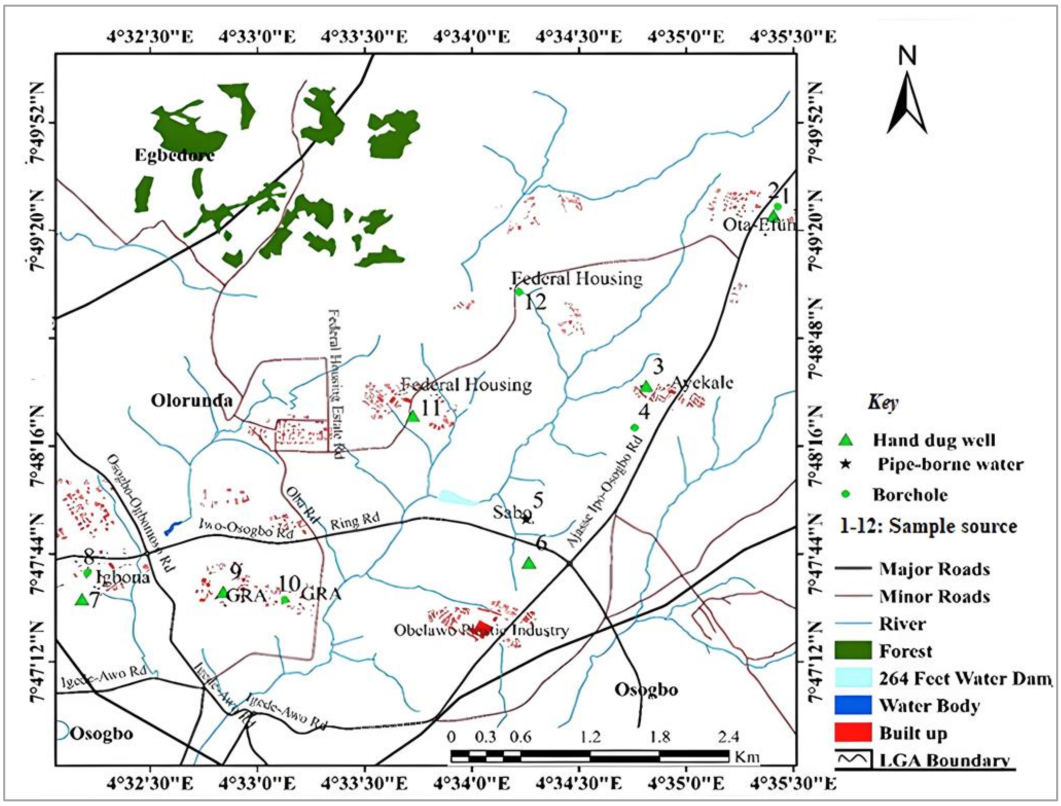

Figure 2- The study area, showing sampling locations in Olorunda local government area, Osun State, Nigeria

In addition, the questionnaire method was chosen and combined with a short interview with selected residents in the household where water samples were collected on topics ranging from sources of drinking water, quantity and quality of water, distance covered and time taken to get water, availability of water throughout the year and utilization of water.

Water samples were analyzed for their chemical and microbiological constituents at the Central Laboratory and Microbiology Laboratory at the Obafemi Awolowo University, Ile-Ife. Concentrations of Pb and As were determined using Flame Atomic Absorption Spectroscopy (AAS) technology (AA-650 model, Shimadzu Co. Ltd., Japan) while NO_3^- and NO_2^- were determined using Automated Cadmium Reduction method 4500 as described in APHA (1998). The concentration of F^- was determined using the Colorimetric method while the membrane filtration method was used for the estimation of total coliform counts (TC) and *Escherichia coli* (*E coli*) in the water samples.

4. RESULTS

4.1. Sources of domestic water

Hand-dug well, boreholes and pipe-borne supply are the main sources of domestic water sources in the study area. Boreholes dominated the households of the sub- urban while hand dug wells mostly served the households in other regions of core and transition. Households at the core, were also served with a public pipe-borne water supply (Figure 3). The distribution of the water sources however varies with the socio-economic status of the resident's average economic status in the residents' units. Figure 3 suggests that residents of GRA appear better served with borehole wells than others and are only followed by residents of the Federal Housing Estate of a distance over 20% difference. Figure 4 also indicates that even within the same economic level (based on income group) access to water differs. The least income (below #10,000 per month) earnings represented in Igbona although claimed that borehole source existed but used water from hand dug well because the borehole was not adequately accessible.

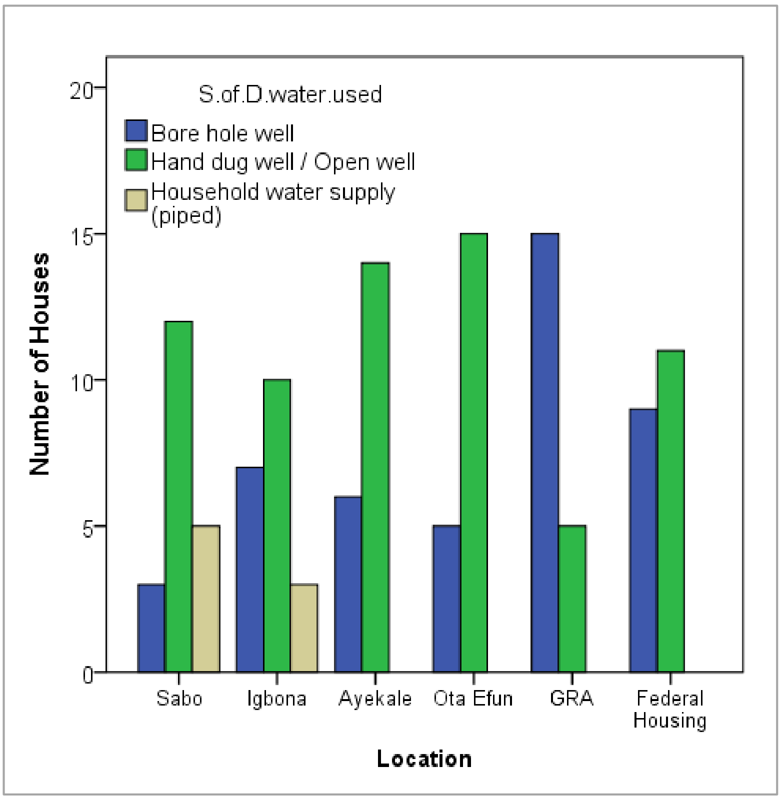

Figure 3- Distribution of sources of domestic water supplies at different households

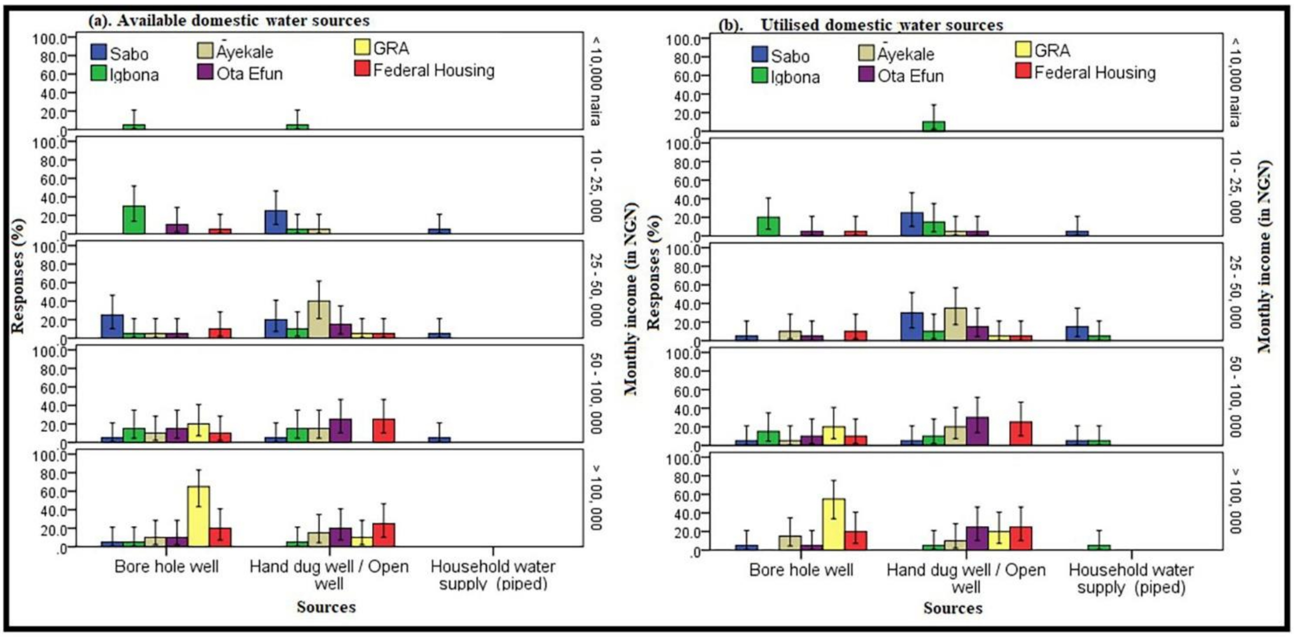

Figure 4- Available and utilized water sources for domestic purposes

In addition, only the core (Sabo and Igbona) residence had access to public pipe borne water supply as at the time of the study. Field investigation indicated that the hand dug wells at GRA and Federal Housing Estate were well designed by well-lining, head well, cover and concretized floor around them while those mostly around the core region were to a larger extent close to pollution sources (such as toilets and septic tanks) and in other cases were deficient by head wells and users made use of not-so-clean bucket that was attached to a rope as fetcher. The core region of the study area is served by pipe-borne water benefited from the Erinle Dam, and the storage facilities at Oke- Ayepe and Oke-Baale reinforced the water supply of the areas that use public pipe borne water supply as at the time of the study.

4.2. Per capita usage of domestic water

Analysis of the responses across the study area revealed that most residents consume 2-4 litres of water per day, except at Ayekale where a slight majority claimed to drink less than 2 litres per day (Figure 5). Factor analysis used indicated that accessibility was the principal factor of consideration, and then was followed by availability. The result of the scattered diagram revealed that both factors (accessibility and availability) clustered in relative isolation from other factors (Figure 6). Figure 6 also reveals that income was mostly correlated with consideration for taste, suggesting the importance of water accessibility and availability over the consideration for quality despite its importance.

Existing studies have shown that water may become an agent of disaster when it is not safe or secure as they exert implication for diseases and infections, yet its availability is essential for sustenance of life. The individual contribution of the selected variables is presented in Table 1. The variables in factors 1 and 2 that were used to plot the scattered diagram shown in Figure 6 explains a total of 36.6% of the total variance while the entire five factors explained 69.9%. This result suggests that about 21% of the explanatory variables have not been considered in this study. Consequently, further studies will be advocated at the end of this report to investigate the missing link. Consequently, the per capita usage of water in the study area can be interpreted to vary with accessibility and availability rather than income or consideration for any other factor in the variables considered. Also, none of the respondents claimed to pay for water.

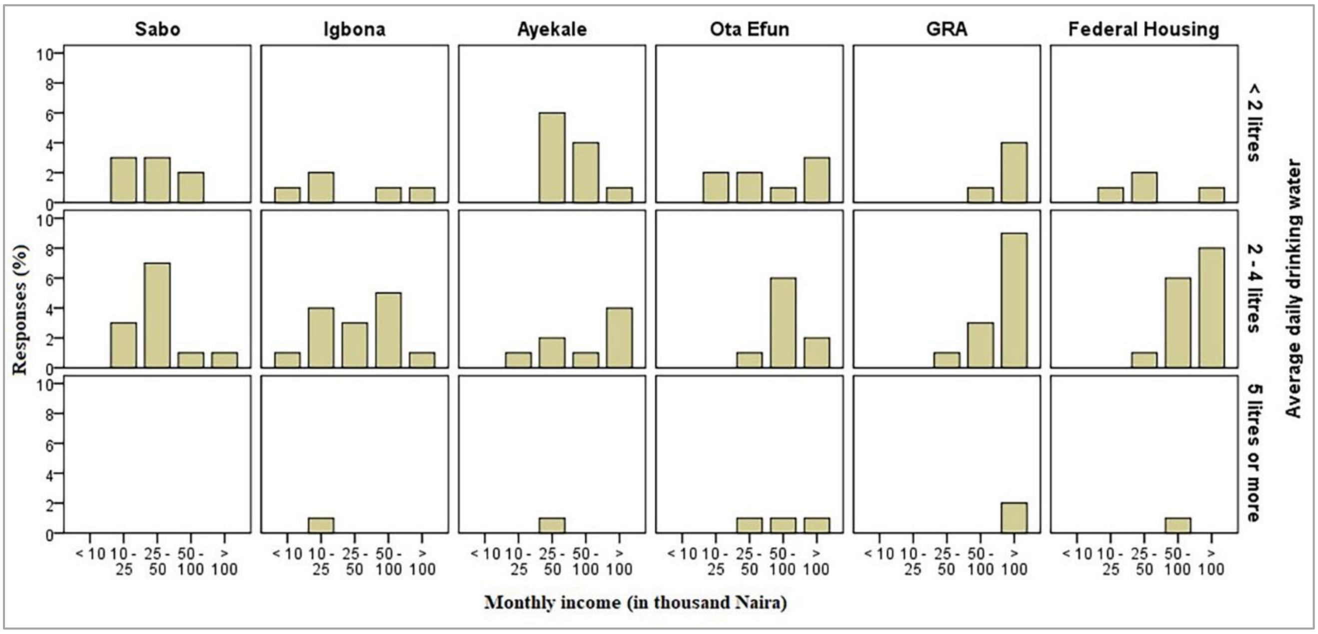

Figure 5- Drinking water demand at different locations and monthly income

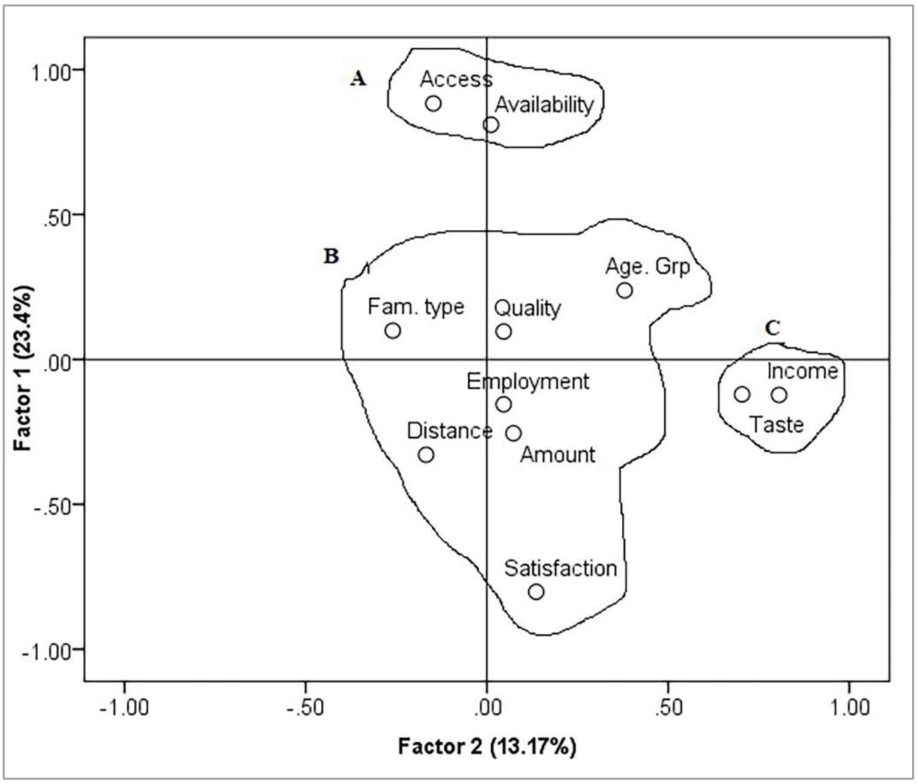

Figure 6- Factors influencing usage of and spending on potable water in the study area

Table 1- Result of rotated factors used for isolation of the explaining variables of water usage

S/N	Variable	Factor (variable explained is in parenthesis)				
		1 (23.4%)	2 (13.2%)	3 (12.1%)	4 (11.5%)	5 (9.8%)
1	Age group	0.238	0.38	0.253	0.718	-0.057
2	Family type	0.099	-0.26	-0.122	0.799	0.123
3	Number of employed members of household	-0.155	0.046	-0.276	0.282	0.779
4	Monthly income	-0.123	0.806	-0.059	0.081	-0.255
5	Water availability	0.81	0.011	0.033	0.061	-0.005
6	Distance from water source	-0.329	-0.168	0.714	0.151	-0.063
7	Adequacy of water quality	0.096	0.046	0.732	-0.061	0.02
8	Taste of water	-0.121	0.704	-0.036	-0.121	0.228
9	Level of satisfaction	-0.802	0.136	0.01	-0.078	-0.034
10	Access to water	0.883	-0.148	-0.1	0.126	0.011
11	Average daily consumption (litre)	-0.255	0.073	-0.372	0.188	-0.655

4.3 Assessment of domestic water quality

Results of the laboratory analysis of water samples from the paramount water sources in the study area are presented in Table 2. Table 2 shows the mean values obtained in all the water supply sources across the study area. The mean values obtained for nitrate from the water sources were lower than the World Health Organisation's (WHO/UNICEF, 2017) permissible limits for drinking water. Nitrates however were noted in low concentrations within the range of 0.37-0.94 0.40 mg/l water and fell within the WHO water quality target of 10 mg/l. This implies that analyzed samples contained a low level of oxidized organic matter. With regards to the extremely low values obtained for nitrate, the waters could be suitable for sundry purposes.

Table 2- Concentrations of selected chemical variables in the water sources

Selected Parameters	Borehole wells	Hand-dug wells	Pipe– borne water
Nitrite (mg/l)	0.62±0.9	0.72±0.22	0.40
Nitrate (mg/l)	0.49±0.6	0.52±0.99	0.41
Fluoride (mg/l)	0.36±0.1	0.21±0.18	0.27
Lead (mg/l)	ND	ND	ND
Arsenic (mg/l)	ND	ND	ND

Abbreviations: ND – Not Detected

Table 2 also shows that the water sources contain detectable nitrate but at values far below the 10 mg/L maximum allowable concentration by WHO.

Furthermore, concentrations of nitrate and nitrite were lowest in the pipe-water source and highest in hand-dug wells. In addition, the spatial distribution of the chemical constituents in the study area showed that most of the water sources were richer in nitrogen compounds than in fluoride (Figure 7). Excessive concentrations of nitrogen compounds are associated with water sources that are vulnerable to nitrogenous wastes from agricultural, commercial, and domestic wastes (Eludoyin *et al.*, 2004). Fluoride ion, on the other hand, is not as common in most environment as nitrogenous compounds (Chapman, 2021), and this probably accounted for their low availability in the study area. Nonetheless, the relatively higher concentration of fluoride in the sampled water at Ota-Efun requires further investigation. Table 3 indicates that *E coli* was present in the sampled hand-dug well at Ota Efun, making it to be a potential source of water-borne diseases, including diarrhea, and cholera, among others. Similarly, the assessment of the total coliform count (which according to the WHO standard criteria, is scaled < 1 = conformity, 1 – 10 = low risk, 1 – 100 = intermediate risk, and >100 = high risk; WHO/UNICEF, 2017) revealed that consuming the water sources possess intermediate – to – high risk to the residents.

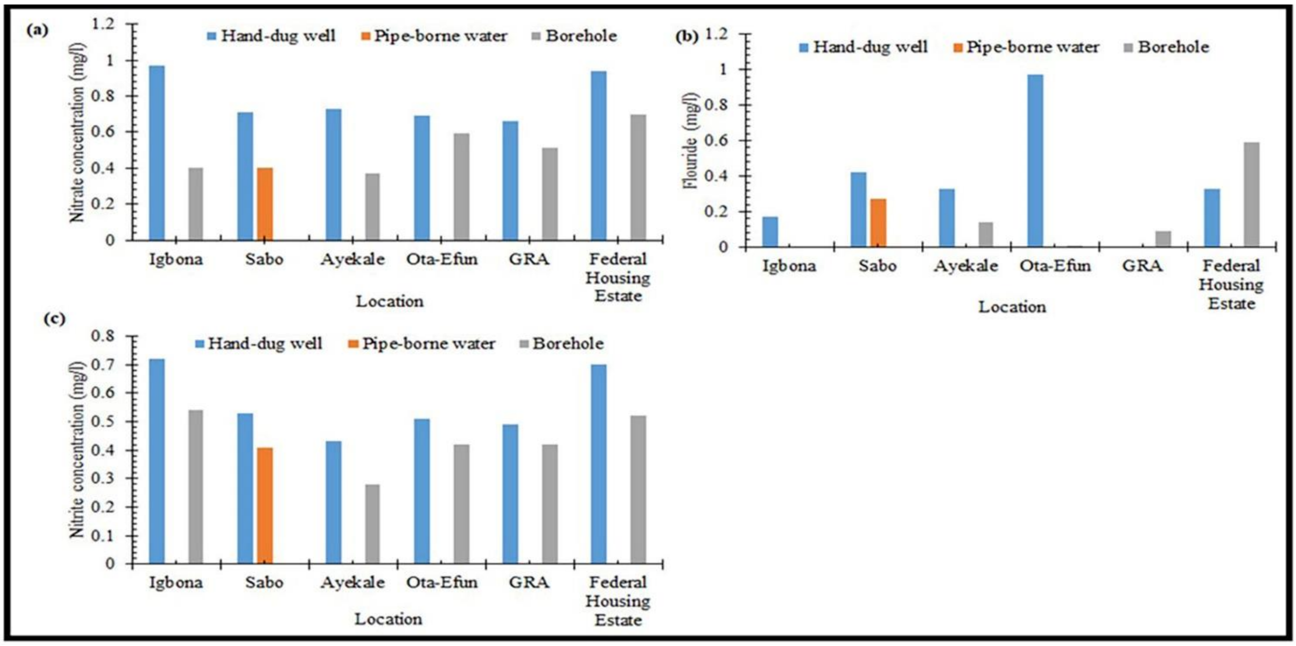

Figure 7- Concentrations of selected chemical variables (nitrate, nitrite, and fluoride) in drinking water sources across the study area

Table 3- Concentrations of the total coliform count and test for E coli in the water sources in the study area

Location	Water Source type	TCC (CFU/100ml)	*E -coli*
Igbona	borehole well	>1.1 X 10^3	Absent
	hand dug well	1.1 X 10^3	Absent
Sabo	borehole well	1.1 X 10^2	Absent
	pipe borne	>1.1 X 10^2	Absent
Ayekale	borehole well	75.0	Absent
	hand dug well	>1.1 X 10^3	Absent
Ota Efun	borehole well	>1.1 X 10^3	Absent
	hand dug well	>1.1 X 10^3	Present
GRA	borehole well	4.6 X 10^2	Absent
	hand dug well	43.0	Absent
Federal Housing Estate	borehole well	>1.1 X 10^3	Absent
	hand dug well	1.1 X 10^3	Absent

5. DISCUSSION

The study showed that an average of 55.8% of the residents in the area depend on hand–dug wells, a result that is similar to the report of Tearfund, Water Aid (2008) and WHO/UNICEF (2017); 37.5% and 6.7% respectively depended on boreholes and pipe-borne supply. This result probably suggests that no significant improvement may have occurred in water infrastructure in many parts of the country, inspired by the increasing population and urban growth. Studies also indicated that many residents of some of the communities also seek water from hand–dug wells which often are not covered (e.g., Olajuyigbe, 2010) while more privileged residents of the urban areas may rely more heavily on machine-drilled borehole wells, protected hand – dug wells and rainwater harvesting (Eludoyin et al., 2007; Eludoyin et al., 2021). In the study area, machine-drilled boreholes were mostly found in newer neighborhoods but more people still depend on hand–dug wells. The result of the study also showed that pipe–borne water supply should have been a better alternative to hand–dug wells, but the supply is inconsistent. As of 2012, the report of WHO/UNICEF (2014) indicated that only 25% of Nigerians, in both urban and rural areas, have had access to pipe-borne water supply and that 90% of all existing water schemes in the country are urban-based, and it is not equitably distributed among communities; while some neighborhood appeared favoured, others lack this privileged water infrastructure. On-site investigation during the course of the study showed that even where the pipes were in good working conditions, water supply is rationalized, i.e., only supplied at a particular time of the day or week. Furthermore, the entire local government area is supplied only 10,000 m^3/day, and this is far less than the estimated water requirement (33,154,800 m^3, based on household population) required as daily consumption by residents. The study area is not isolated in the problem of water shortage, especially as Kelkar & Perez (2002), among others reported a 5 hours/day period of water supply in Panji city, India. Fadare & Olawuni (2008) as well as a report from the Osun State Water Corporation (2021, *pers. com.*) also noted a reduction in water supply from the main water works in the state, despite the increasing population and urban growth in the state. Studies have reported a reduction in reservoirs storage capacity due to siltation, increased pollution, poor power supply due to unstable electricity supply, and outdated water and operational infrastructure as main problems facing water supply from the waterworks in the State (Oyebanjo et al., 2012; Babatimehin et al, 2020). Consequently, many households are required to seek alternative water supply sources in the area.

Whereas most water from machine-drilled boreholes is preferred for their quality by many residents that were not supplied with public pipe-borne water, the boreholes are not available for every household in the area. Many of the households in the low-economic communities, with restricted access to boreholes, made use of water from hand–dug wells, and streams. This assertion was supported by the results of the factor analysis and PCA, which showed accessibility to water sources and availability of the source as principal factors for water usage by the residents. Previous studies from the states have shown that water from surface water and hand-dug wells is heavily prone to surface contamination (Eludoyin et al., 2004; Oyeku and Eludoyin, 2010). Nnenna (2014) in a study of Owerri in southeastern Nigeria also found that residents would travel for over one hour to access borehole but less than 30 minutes for hand-dug wells and that this distance made the less pristine hand-dug wells more favorite for many poor residents. Conversely, Erah et al., (2018) showed that the relatively low cost of drilling boreholes in Benin City, due to the shallow aquifer, has encouraged boreholes to be widespread, and therefore promote access to more pristine water from borehole wells than hand–dug wells.

The study also showed that even within the same economic level (based on income group) average daily drinking water differs. Average water consumption per capita was found to be 3L per person per day at no cost because none of the respondents claimed to pay for water. More than 60% of the residents attained the average daily water need for survival (2.5 liters per person (capita) per day, Lpcd) and the basic water need of 50 Lpcd (see Gleick, 1996). The World Health Organisation however recommended 50 - 100 liters per person per day for basic needs. It therefore might not be incorrect to note that the residents struggle to meet up their water needs despite the challenges, but further study will be required to investigate the impact on their sanitation needs in the area.

While the study did not show excessive concentrations of nitrite, nitrate, fluoride, arsenic, total coliform count, or *E coli* in the water sources, studies have however shown that bioaccumulation of these materials in the body may become harmful over time, especially with continuous consumption (see Dubrovsky et al., 2010). Also, given the WHO recommendation of the maximum contaminant level (MCL) of nitrate in drinking water as 10 mg/l and nitrite as 1 mg/l, some of the water sources may be described as unsafe and unhealthy to consume. Nitrite and nitrate occurred in very low concentrations in the pipe-borne water but high in hand–dug wells. WHO/UNICEF (2017) documents that there has been increasing evidence that nitrate levels in many aquifers are rising and that the problem of increased exposure of the world population to high nitrate inputs will become more alarming in the nearest. Similarly, an estimate has shown that in more than 150 countries (Nigeria, inclusive), nitrate from the application of fertilizers has seeped into water wells especially shallow wells (Goldsmith & Hildyard, 1988). According to Sampson (2008), nitrates and salt have the potential of polluting water supplies especially shallow wells, farms, and other land use activities as well as poor waste management. According to Adelana et al. (2003), the occurrence and distribution of nitrate in the Nigerian groundwater system are higher in hand–dug wells than in boreholes or piped water. Arsenic and Lead were both found absent in all the sources. The study also showed that *E. coli* was present in one of the sampled hand-dug wells. On-site observation as regards this was that there was a soak away situated less than 10m away from the well. This contradicts the minimum distance of 30m adopted by the World Health Organization. Assessment of the total coliform count (according to the WHO criteria for risk) showed that all the sources are not fit for drinking without treatment. This is because all the water sources can be scaled to pose a high risk of contamination to the users as the concentration of almost all the sources are not only greater than counts of hundreds but even thousand counts.

6. CONCLUSION AND RECOMMENDATIONS

All sampled households use either piped water, hand dug well, or boreholes as their main source of drinking water. The chemical quality of all systems tested was within WHO permissible limit for drinking water; this implies that the chemical constituents determined still exist in safe levels in the sampled water sources across the study area. The water sources are however inadequately protected and are apparently unsustainable at the time of the study. The study showed that the water samples from the sources were bacteriologically contaminated as the bacteriological qualities of all systems tested were not within an acceptable range (0 to 10 CFU/100 ml); the most contaminated being a hand-dug well in Ota-Efun, one of the communities in the transition areas, although none of the water sources were chemically contaminated. Nonetheless, microbiological quality is as essential as the chemical quality, hence the domestic water sources in the study area – whose water system may be typical of many urban local government areas in the country essentially require a significant level of bacteriological treatment before the water can be consumed. Meanwhile, there is no evidence that the majority of the households, except in the sub-urban communities treat such water before they are consumed. Also, the study noted that the important influence of accessibility on water utilization and that of the varying socio-economic status of the users made water supply of the required quality impossible for all in the study area. Consequently, the study recommends improved awareness of the consequences of drinking contaminated water at the household level for the residents, as well as enhanced communal and governmental efforts to assist the poor communities in the provision of quality water in line with the targets of Sustainable Development Goals (6).

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