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ORIGINAL ARTICLE

# Self-Reported Assessment of Sources and Quality of Drinking Water: A Case Study of Sapele Local Government Area, Delta State, Nigeria

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**Keywords**

Drinking water; Access; Sources; Quality; Sapele; Nigeria

## ABSTRACT

**Background:** Water is a basic physiological requirement of the body with about 30–35 liters per capita per day required for each household, a situation which is far-fetched in most developing countries such as Nigeria. The study aimed to ascertain the sources, availability and accessibility of drinking water in Sapele Local Government Area of Delta State, Nigeria.

**Methods:** This was a descriptive cross-sectional study among 362 heads of household who were selected using a multi-stage sampling technique. A total of 360 wells from sampled households were examined to ascertain their compliance with WHO standards for improved/protected well. Data analysis was done using SPSS version 21.0 with statistical significance set at $p < 0.05$.

**Results:** The commonest source of drinking water during dry and wet seasons was sachet water, 99 (27.3%) and 89 (24.6%), respectively. Two hundred and ten (58%) respondents reported that their drinking water sources were located within 200 meters of their dwelling; 293 (82.3%) respondents had access to water supply all the time, while 25 (7%) had access to water supply twice a week. Majority, 354 (97.8%) of respondents reported that their water was colourless, 350 (96.7%), odourless and 208 (57.5%), tasteless. Only 21 (5.8%) of the wells examined met the WHO criteria for improved/protected well.

**Conclusion:** Sachet water is the commonest source of drinking water and most wells examined did not meet the requirement of an improved well. The Ministry of Water Resources should make more improved sources of water available for the residents of Sapele.

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## INTRODUCTION

The basic water physiological requirement of the body for sustenance and survival has been determined to be approximately two liters per capita per day.[1] Accordingly, it is recommended that 20 litres per person per day is often adequate for drinking, cooking, and other basic hygiene requirements.[1] However, the amount of water required by individuals varies depending on climate, standard of living, habit of the people and even age and sex. Although planet earth is made up predominantly of water, only 3% is freshwater and of this, 99% is trapped in ice caps and glaciers. Sadly, the remaining 1% of the freshwater that is accessible for human consumption is unevenly distributed.[2] Almost 2 billion people globally lack access to improved drinking water sources, while 3.6 billion persons do not have access to proper sanitation services, with a further 2.3 billion lacking basic hand washing facilities. Challenges in water supply and sanitation combined with growing populations, variability in rainfall due to climatic changes and population make water a major determinant in economic growth and sustainable development.[3]

Scarcity of water affects more than 40 per cent of the global population and is projected to increase while more than 1.7 billion people are currently living in river basins where water use exceeds recharge.[4] It has been opined that clean water shortage is a massive issue globally in relation to the current estimated world population of 8 billion people.[5] The demand on the water system is anticipated to increase by 2050 based on a projected global population increase between 9.4 and 10.2 billion, about 22 to 34% increase.[6]

There is also disparity in accessibility to drinking water between urban and rural dwellers. Urban areas have notably higher access to drinking water from improved sources compared to rural areas. In country sides, in most developing nations, access to drinking water from improved sources is abysmally low. Research data shows that less than 50% of the population in rural areas have access to potable drinking water in developing countries.[7] Over 50% of the water supplies are intermittent and some of the sources of improved drinking water are seasonal.[8]

Climatic factors and seasonal variations play major role in the availability of water in Nigeria.[9] Several communities in Nigeria depend on surface water, unimproved sources of water, or water that can take more than 30 minutes to collect.[10] In Nigeria, about two-thirds, 66% of households have access to an improved source of drinking water (74% in urban areas and 58% in rural areas).[11] Although two-thirds of Nigerians are reported to have access to a basic water service, more than half of these water sources are contaminated and only nine liters of water on average is available to a person daily.[10] Sustainable and equitable access to safe drinking water remains a huge problem in Nigeria, with over 86 per cent of the population lacking access to a safely managed drinking water source. The challenge is worsened by poor drinking water quality and lack of equity in access.[10] Access to safe water is vital in ensuring the development and management of water resources in Nigeria.[12] Water sources in both rural and urban areas in Nigeria also have a seasonal variation with sources varying according to raining or dry season and also what the water would be utilized for.[13] Water from varied origins are utilized for domestic purposes by residents of Sapele Local Government Area (LGA).[14] The adequacy of the drinking-water supply, can be assessed using accessibility, quantity, quality, continuity and affordability of drinking water.[1] It is imperative to assess the origins, frequency of availability and accessibility of drinking water in Sapele LGA to ascertain whether the water sources satisfy WHO recommendations as it relates to classification (improved/unimproved sources), frequency of availability and accessibility of drinking water sources. The objective of this study was to determine drinking water source(s) available to residents in Sapele LGA, ascertain whether the water is of improved source(s), as well as establish the frequency of availability, accessibility and quality of the drinking water.

## METHODOLOGY

### *Study area and study design*

This descriptive cross-sectional study was conducted in Sapele, the administrative headquarters of Sapele Local Government Area in the central senatorial zone of Delta State, Nigeria. The estimated population of Sapele LGA is 298,310 with Urhobo being the predominant ethnic group.[15] The average temperature in the LGA is put at 25 degrees centigrade with the Ethiope River flowing through the area. The LGA also has an estimated total precipitation of 3050 mm of rainfall per annum. [15] Tap/pipe borne water, wells and boreholes, which may be sited in close proximity to or far away from residential areas, rainwater, streams, rivers, ponds and sachet water popularly known as "*pure water*" are sources of drinking water in the LGA.[14]

***Study Population, Sample size and Sampling Technique***

The study population included heads of households or their representatives who were 18 years and above as well as wells within the study area.

The sample size for heads of households and wells was determined using the sample size formula for single proportions:[16]

$$n = \frac{z^2 pq}{d^2}$$

Where:

n= minimum sample size of respondents; p = proportion of respondents with access to improved water source which was 32.0% from a study on Trend in Access to Safe Water Supply in Nigeria;[12] q = 1.0 – p; z = standard normal deviate corresponding to confidence level; at 95% confidence level, z equals 1.96; d = error margin which equals 5%. A minimum sample size of 335 was computed for heads of households. The minimum sample size for wells to be studied was computed using the proportion of persons who use wells from the Nigeria Demographic Health Survey 2018,[11] which was 22.0%. The minimum sample size computed was 264; however, we went above this number during the eventual selection to match the number of households we intended to study.

Multistage sampling method was employed to choose the heads of households or their representatives. It was done in two stages as follows:

*Stage 1: Selection of Political wards* - Eight out of the eleven political wards in Sapele LGA were randomly selected using computer-generated numbers in Microsoft Excel 2013 for simple randomization function.

*Stage 2: Selection of communities* - One community was selected in each ward by simple random sampling using balloting from a list of communities that make up the selected political wards from stage 1.

*Stage 3: Selection of households* - Simple random sampling was employed to choose households from the selected communities. The name of the household in each selected community was written and coded in Microsoft Excel 2013, which was used to randomly select households from the selected community. The number of households selected from each community were proportional to the size for the communities selected. Where there were more than one household in a house, balloting was done to pick the household to study.

Also, the wells used in the study were selected using simple random sampling within the communities in the study area. The wells were randomly selected employing balloting technique from a list of wells within the study area. For the selected wells, the following properties were noted: construction patterns, well accessories (including conditions of fetchers) and drinking water quality in terms of potability.

**Instruments and Methods for Data Collection**

The instrument for data collection was a pre-tested structured questionnaire that contained demographic information, the prevalent drinking water source(s) during the dry and wet seasons, respondents' viewpoints on the availability and accessibility of water as well as the physical characteristics of the water such as taste, odour and colour. In addition, the tool elicited information such as knowledge on drinking water quality vis-à-vis sanitation (Water, Hygiene and Sanitation, WASH).

Selected wells were inspected to ascertain whether they were constructed in compliance with WHO benchmark for improved/protected wells (improved drinking water source). In this regard, WHO indicators for improved water sources were assessed. Improved water sources include household connections, boreholes, rainwater collection, safeguarded springs, safeguarded dug-wells and public standpipes that are safeguarded from outside contamination, particularly from faecal pollution.[17] Unimproved water sources of water include unprotected dug wells, unprotected springs and surface water.[11] A customized pump (manual or motorized), cement concrete lining and platform (or apron), head wall, cover and drainage channel were assessed as defining indicators for an improved/protected well.[17,18]

**Statistical analysis**

The data was collated, screened for completeness, coded and analyzed using Statistical Package for Social Sciences (SPSS) version 21.0 software. Continuous variables with normal distribution such as age and household size were summarized using means and standard deviation while categorical data such as sex, sources of water and characteristics of water were summarized as frequencies and proportions.

**Ethical considerations**

Ethical approval (No. ADM/E22/A/Vol. VII/14831195) was also obtained from the Ethics and Research Committee of the University Teaching Hospital Benin City before the commencement of this study. Permission was also obtained from the authorities of Local Government and the heads of the communities where the study was conducted

Informed consent was obtained from each participant and confidentiality maintained. Respondents were informed of their right to decline participation or to withdraw from the study at any time they desired. Study respondents were also informed that there were no penalties or loss of benefits for refusal to participate in the study or withdrawal from it. All data were kept secure and made available only to the researcher.

## RESULTS

A total of 362 heads of households were interviewed giving a response rate of 100%. In addition, 360 randomly selected wells located within the vicinity of the study population were inspected. The socio-demographic characteristics of the respondents are shown in Table 1. The mean age of the respondents was 42.3 ± 13.7 years with a range of 18-79 years. A higher proportion, 26.5% of respondents had ages between 28-37 years. There were more male respondents, 217 (59.9%) than females; 153 (42.3%) respondents had tertiary level of education, 43 (11.9%) had no formal education while 154 (42.5%) were traders. Slightly above one-third (34.3%) of the respondents were government employees, 47 (13%) were farmers and 37 (10.2%) belonged to other classes of occupation (artisans, entrepreneurs and private employees). The household size ranged from 1 - 9 persons with a mean of 4.5 ± 1.6.

Table 2 shows the origins of main water sources in dry and wet seasons for households. The commonest source of drinking water during dry and wet seasons was sachet water (pure water) with a total of 89 (24.6%) respondents utilizing sachet water during the dry season and 99 (27.3%) doing so during the rainy season, with no insignificant variation in the utilization of sachet water and borehole sources in both seasons.

**Table 1: Socio-demographic characteristics of the study participants**

| Variables | Frequency (n=362) | Percent |
|---|---|---|
| **Age group (years)** | | |
| 18-27 | 53 | 14.6 |
| 28-37 | 96 | 26.5 |
| 38-47 | 87 | 24.1 |
| 48-57 | 68 | 18.8 |
| 58-67 | 45 | 12.4 |
| 68 and above | 13 | 3.6 |
| **Mean ± SD Age** | 42.3 ± 13.7 years | |
| **Sex** | | |
| Male | 217 | 59.9 |
| Female | 145 | 40.1 |
| **Education** | | |
| No formal | 43 | 11.9 |
| Primary | 38 | 10.5 |
| Secondary | 128 | 35.4 |
| Tertiary | 153 | 42.3 |
| **Occupation** | | |
| Trader | 154 | 42.5 |
| Civil servant | 124 | 34.3 |
| Farmer | 47 | 13.0 |
| Others | 37 | 10.2 |
| **Household size** | | |
| 1 – 3 | 144 | 39.8 |
| 4 – 6 | 186 | 51.4 |
| 7 – 9 | 32 | 8.8 |
| Mean ± SD | 4.5 ± 1.6 | |

The proportions of respondents that utilized well water during dry and wet seasons were 59 (16.3%) and 40 (11.0%), respectively. Only 23 (6.4%) and 30 (8.3%) of them used a combination of tap in their residence and sachet water during the dry and wet seasons respectively. The utilization of a combination of well and public borehole during the dry season and wet seasons accounted for 6.4% and 5.8% respectively. During the dry season, 1.1% of interviewees utilized river/stream water for drinking purpose. This value however, increased to 2.2% during the rainy season.

Overall, 299 (82.6%) of respondents used an improved water source in the dry season while 292 (80.7%) used an improved water source in the raining season. Additionally, 298 (82.3%) respondents had access to water supply all the time, 25 (7.0%) had access to water supply twice a week, 19 (5.2%) had access once weekly, 12 (3.3%) once daily and 8 (2.2%) of interviewees had access to water supply irregularly.

**Table 2: Main source of drinking water in dry and wet seasons for households**

| Variables | Wet season (n=362) n (%) | Dry season (n=362) n (%) |
|---|---|---|
| **Sources of water** | | |
| Sachet water | 99 (27.3) | 89 (24.6) |
| Tap in residence | 59 (16.3) | 64 (17.7) |
| Public borehole | 55 (15.2) | 57 (15.5) |
| Well | 40 (11.0) | 59 (16.3) |
| Public tap | 38 (10.5) | 36 (9.9) |
| Tap in residence and sachet | 30 (8.3) | 23 (6.4) |
| Well and public borehole | 21 (5.8) | 30 (8.3) |
| Rain | 12 (3.3) | 0 (0.0) |
| River/stream | 8 (2.2) | 4 (1.1) |
| **Improved sources** | | |
| Yes | 299 (82.6) | 292 (80.7) |
| No | 63 (17.4) | 70 (19.3) |
| **Regularity of water supply (n=362)** | | |
| All the time | 298 (82.3) | |
| Once daily | 12 (3.3) | |
| Twice a week | 25 (7.0) | |
| Once a week | 19 (5.2) | |
| Irregular | 8 (2.2) | |

**Table 3: Self-reported distance of sources of water from dwelling places**

| Sources of water | Located within 200m (n=210) n (%) | Located more than 200 (n=152) n (%) |
|---|---|---|
| Sachet water | 73 (34.8) | 18 (11.8) |
| Borehole | 57 (27.1) | 46 (30.3) |
| Well | 38 (18.1) | 53 (34.9) |
| Tap water | 32 (15.2) | 7 (4.6) |
| Stream/River | 10 (4.8) | 28 (18.4) |

In Table 3, the self-reported distance of sources of water from household is presented. A higher proportion 210 (58%) of the respondents claimed they had their drinking water sources located within 200 meters of their dwelling compared to the 152 (42%) who had theirs located beyond 200 meters from their dwelling places.

In Table 4, physical properties of drinking water in terms of colour, odour and taste vis-à-vis respondents' viewpoints are presented. A majority, 354 (97.8%) of the respondents were of the view that their water was colourless, 350 (96.7%) reported that their water was odourless while 208 (57.5) opined that their water was tasteless. The proportion who reported that their water had taste was 154 (42.5%). Only 2.2% and 3.3% were of the view that their water had colour and odour, respectively.

Table 5 shows the sanitary status of the 360 inspected wells. One hundred and seventy-two (47.8%) had a cover present; 159 (44.2%) had a concrete lining; 147 (40.8%) had a fetcher present; 107 (29.7%) were sited more than 30 meters from a pit latrine/septic tank and 54 (15.0%) had a parapet present. Only 21 wells constituting 5.8% of the 360 wells examined, had all the qualities, and consequent upon, be considered as sanitary (improved/protected) based on WHO classification. Furthermore, it was observed that percolation of faeces, surface water runoff and filthy fetchers were prevalent in the study area.

**Table 4: Self-reported physical characteristics of drinking water in the households**

| Characteristics of water | Present Freq. (%) | Absent Freq. (%) |
|---|---|---|
| Colour | 8 (2.2) | 354 (97.8) |
| Odour | 12 (3.3) | 350 (96.7) |
| Taste | 154 (42.5) | 208 (57.5) |

**Table 5: Sanitary Conditions of Inspected Wells**

| Well properties* | Frequency (n=360) | Percent |
|---|---|---|
| Cover present | 172 | 47.8 |
| Concrete lining present | 159 | 44.2 |
| Fetcher present | 147 | 40.8 |
| ≥30m from pit latrine/septic tank | 107 | 29.7 |
| Parapet present | 54 | 15.0 |
| All properties present | 21 | 5.8 |

**Multiple response*

## DISCUSSION

The findings of the study show that the origins of water available to residents of Sapele LGA can broadly be grouped into five classes. These are river, rain, well, borehole and sachet, which can be grouped more broadly into surface and groundwater sources. The respondents primarily utilized these sources for drinking water. This result is similar to findings of a study conducted in Edo State, Nigeria on evaluation of water sources for household uses, which revealed that there were two major sources of water available to the people: surface and groundwater.[19] Similarly, this result is in consonance with the results of a study conducted on sources, availability and accessibility of potable water in Imo State, Nigeria which indicated that surface and groundwater were the primary source of drinking water.[20]

Furthermore, the result of the study indicates that Sapele LGA is an educationally inclined and well-educated community or settlement (approximately 80.5% of respondents had tertiary education). The fact that heads of households or their proxies in Sapele LGA were well educated or reasonably literate, may be attributed to the presence of secondary and tertiary institutions within and around Sapele metropolis. The finding of this study is similar to the results of a study on sources and accessibility of potable water in Yakurr LGA, Cross River State, Nigeria, in which the authors reported an educational level of 86.1%.[21] This finding suggests that a higher educational level may translate to an improved drinking water source choices and better health outcomes.

The slightly lower proportion of the respondents, who utilized well water in the wet season compared to the dry season, may be attributed to the culture of rainwater harvesting and storage, that is prevalent among residents in the study area, especially among rural dwellers during the wet season, thus saving it for use during the dry season. It was observed that there was no usage of rainwater for drinking purpose during the dry season obviously due to the absence of precipitation during this period. However, during the wet season, an insignificant number of residents (3.3%) in the LGA utilized rainwater for drinking purpose. The result from this study also showed an increase in the utilization of river/stream during the wet season. This might probably be as a result of the increase in water levels in river/streams during the wet season. Harvested rainwater can expose consumers to a myriad of gastrointestinal diseases especially when the storage reservoirs are not cleaned regularly or the water treated employing appropriate water treatment/purification methods. This assertion agrees with the findings of a study conducted on sanitary impact evaluation of drinking water in storage reservoirs in Morocco, which showed that a significant number of the interviewees had diarrhoeal diseases or hepatitis after drinking water from storage reservoirs.[22]

It is encouraging to note that a significant majority of the respondents had their sources of water located within two hundred meters of their houses. This result may be attributed to the rapid rural-urban migration with infrastructural development as well as provision of some of the much-needed social amenities like water supplies in dwelling places in some parts of the study area. This however does not imply that water from these sources is potable. It is therefore important that sewage and other possible sources of pollution be sited very far from drinking water sources to avoid seepage and pollution of these sources, thus safeguarding the water. Interestingly, this result also aligns with the results of a study conducted on sources, availability and accessibility of potable water in Imo State, Nigeria which indicated that a significant proportion of interviewees had their water sources within their compounds (within 200 meters of their house).[20]

Accessibility to water supply is a core component of SDG 6. In this study, majority of the respondents reported acceptable levels of accessibility to regular water supply; however, this does not translate to accessibility to safe and potable drinking water supply as evidenced by the fact that only 5.8% of the wells inspected met the WHO standard for a sanitary well. This finding of the study is at variance with a study carried out in Edo State on evaluation of water sources for household uses, where the authors stated that the sources of water for domestic use in these communities were inadequate owing to the challenges experienced by the people vis-à-vis accessibility to potable water supply.[19] Similarly, our result contrast sharply with the findings of a study conducted on rural water supply in Nigeria: policy gaps and future directions, in which the author reported that most of the sampled households (86.6%) lacked access to piped drinking sources occasioned by water system failure, which restricted regular access.[23]

The fact that high proportions of the respondents in this study reported the absence of colour, odour and moderately so for taste in the water utilized, may not be a definitive indication of safe drinking water. Water with colour, odour and obnoxious taste may be objectionable even when it seemingly may not portend or pose any harm to the health of users. Potable water should ideally have no colour, odour and obnoxious taste except for its insipient taste. The presence of colour, odour and taste in water therefore may suggest water with compromised quality. These assertions are well established in a study on drinking water quality in North-West Ethiopia in which taste was found to be the predominant and effortlessly observable water property indicator, when compared to colour and odour.[24] Furthermore, our assertions are buttressed in a study to analyze physical quality parameter of water and waste water. In the study, the author stated that odour and taste in water and waste water is induced by the presence of decaying organic matter, industrial effluents, household sewage, mineral salts and/or a combination of bacteria either dead or alive as well as dissolved gases such as hydrogen sulphide, methane etc.[25] Odour, colour and taste can be forestalled in cases where they pose health threat to consumers by utilizing traditional treatment approaches such as chlorination, coagulation and sedimentation. Also, aeration, granular or powdered activated carbon and ozonation can be employed to remove organic and inorganic chemicals.[26]

The results of this study revealed that most of the wells in the study area were insanitary and unprotected based on WHO recommendations. Pollution of well water through percolation of faeces, surface water runoff and filthy fetchers were prevalent in the study area. The implication of this for public health is grave because residents in this study area will be exposed to various water-borne and water-related illnesses, which in turn will affect other socio-economic aspects of living. When contaminants find their way into ground water, they can affect the quality and potability of drinking water, which in turn will affect human health. Long-term exposure to polluted water can induce chronic and short-term illnesses such as anaemia, diarrhea, dysentery, high blood pressure, septicaemia etc. This assertion is in agreement with the report from a study conducted on bacteriological analysis of well water sources in the Bambui student residential area where the authors stated that the high incidence of contamination of well waters by pathogens and the high morbidity induced by gastrointestinal illnesses such as diarrhea was attributable to the poor sanitary conditions of the wells and/or drawing water from the wells with polluted fetchers, a practice that was rife in their study area.[27] This finding is also in consonance with the results of a study on domestic wells and pit latrines in rural settlements in which the authors stated that unprotected wells can be presumed to act as auxiliary vectors and reservoirs for groundwater pollution. Again, defective practices such as leaving water containers to lie around wells were observed to be prevalent in their study.[28] In addition, the results of this study are similar to those of other studies on water quality of hand-dug wells, in which the authors stated that irrespective of the well classification (protected, unprotected and semi-protected), the utilization of bucket and rope in raising water from hand–dug wells may lead to increase in contamination of water in the wells.[29,30]

A limitation of this study was that the responses given by the respondents on potability and access to water sources, were based on self-reports. These responses could have been prone to recall bias especially questions relating to events in the wet or dry season.

In conclusion, residents of Sapele LGA primarily utilized water from river, rain, well, borehole and sachet for drinking purpose. Their access to these sources of water supply was perceived to be adequate but the potability based on the self-reported responses of interviewees was doubtful. There was the probable presence of contaminants in water from well origins in the study vicinity due to the large proportion of wells found to be insanitary (unimproved/protected) based on WHO recommendations.

There is need for more efforts by the government at the local, state and federal levels to make more improved, protected and sanitary sources of water available to the populace. The Ministry of Water Resources, Delta State should make more improved sources of water available for the residents of Sapele. Health education by public health authorities to residents of Sapele LGA on the need to ensure protection of available water sources is of utmost essence.

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## REFERENCES

1. World Health Organization. Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. WHO, Geneva. 2022. [Accessed December 14, 2022] Available at https://www.who.int/publications/i/item/9789240045064

2. Lukubye B, Andama M. Bacterial analysis of selected drinking water sources in Mbarara Municipality, Uganda. Journal of Water Resource and Protection. 2017; 9(8): 999-1013. DOI: 10.4236/jwarp.2017.98066

3. The World Bank Group. Water. World Bank, Washington DC. [Accessed October 30, 2022] Available at https://www.worldbank.org/en/topic/water/overview

4. United Nations. Sustainable development goals (SDG): Goal 6- clean water and sanitation. UN, Geneva. [Assessed July 3, 2022] Available at https://www.un.org/sustainabledevelopment/water-and-sanitation/

5. United Nations. World population to reach 8 billion on November 15 2022. [Accessed 23 December, 2022] Available at https://www.un.org/en/desa/world-population-reach-8-billion-15-november-2022

6. Boretti A, Rosa L. Reassessing the projections of the world water development report. NPJ Clean Water. 2019; 2(15): Available at https://doi.org/10.1038/s41545-019-0039-9

7. Durmishi BH, Ismaili M, Shabani A, Abduli S. Drinking water quality assessment in Tetova Region. American Journal of Environmental Sciences. 2012; 8(2): 162-169. Available at https://doi.org/10.3844/ajessp.2012.162.169

8. Kayser G, Moriarty P, Fonseca C, Bartram J. Domestic water service delivery indicators and frameworks for monitoring, evaluation, policy and planning: A review. International Journal of Environmental Research and Public Health. 2013; 10(10): 4812-4835. doi:10.3390/ijerph10104812

9. Shiru MS, Shahid S, and Park I. Projection of water availability and sustainability in Nigeria due to climate change. Journal of Sustainability. 2021; 13(11): 6284. https://doi.org/10.3390/su13116284

10. United Nations Children's Fund (UNICEF) Nigeria. Nearly one third of Nigerian children do not have enough water to meet their daily needs- Press release. 2021. [Accessed July 11, 2022] Available at https://www.unicef.org/nigeria/press-releases/nearly-one-third-nigerian-children-do-not-have-enough-water-meet-their-daily-needs

11. National Population Commission (NPC) and ICF. Nigeria demographic and health survey 2018. NPC and ICF, Abuja and Maryland. 2019: 11-13.

12. Egbinola CN. Trend in access to safe water supply in Nigeria. Journal of Environment and Earth Science. 2017; 7(8): 89-96.

13. Iduseri EO, Abbas II, Izunobi JU, Ogedegbe SO and Ogbonna DO. Access to safe drinking water in developing countries: A comparative analysis of the urban and rural areas of Zaria, Kaduna State, Nigeria. Journal of Applied Sciences and Environmental Management. 2021; 25(11): 1869-1878. DOI: 10.4314/jasem.v25i11.4

14. State Employment and Expenditure for Results (SEEFOR). Final report of the environmental social management plan (ESMP) for road rehabilitation project in Sapele, Delta State. SEEFOR, Asaba, Delta State. May, 2015.

15. Manpower Nigeria. About Sapele Local Government Area. [Accessed on July 3, 2022] Available at https://www.manpower.com.ng/places/lga/240/sapele

16. Cochrane WG. Sampling techniques, 3rd edition. New York: John Wiley and Sons. 1977: 72-85.

17. World Health organization (WHO)/United Nations International Children Fund. Joint monitoring programme (JMP) for water supply and sanitation. Geneva, 2015. [Accessed on December 29, 2022] Available at https://www.unwater.org/publications/who/unicef-joint-monitoring-program-water-supply-and-sanitation-jmp-2015-update

18. Ayantobo OO, Oluwasanya GO, Idowu OA, Eruola AO. Water quality evaluation of hand-dug wells in Ibadan, Oyo State, Nigeria. Global Journal of Science Frontier Research. 2013; 13(10): 1-8.

19. Okadigwe LO, Efe SI. Water sources assessment for Edo State, Nigeria [Internet]. 2018. [Accessed December 29, 2022] Available at https://www.ukessays.com/essays/geography/water-sources-assessment-edo-state-9199.php?vref=1

20. Iwuala CC, Amadi AN, Udujih OG, Udujih HI, Okereke SN. A study on sources, availability and accessibility of potable water in Imo State, Nigeria. World Journal of Social Sciences Research. 2020; 7(1): DOI: https://doi.org/10.22158/wjssr.v7n1p

21. Ibiang AO, Ozah HP, Inah SA. Sources and accessibility of potable water in Yakurr Local Government Area, Cross River State, Nigeria. International Research Journal of Public and Environmental Health. 2019; 6(5): 82-88. https://doi.org/10.15739/irjpeh.19.010

22. Aziz F, Mandi L. Sanitary impact evaluation of drinking water in storage reservoirs in Moroccan rural area. Saudi Journal of Biological Sciences. 2016; 24(4): 767-777. https://doi.org/10.1016/j.sbs.2016.01.034

23. Obeta MC. Rural water supply in Nigeria: policy gaps and future directions. Water Policy. 2018; 20(3): 597-616. https://doi.org/10.2166/wp.2018.129

24. Gebremichael SG, Yismaw E, Tsegaw BD, Shibeshi AD. Determinants of water source use, quality of water, sanitation and hygiene perceptions among urban households in North-West Ethiopia: A cross-sectional study. PLoS ONE. 2021; 16(4): e0239502. https://doi.org/10.1371/journal.pone.0239502

25. Khediya TD. Analysis of physical quality parameter of water and wastewater. International Journal of Scientific Development and Research. 2016; 1(8): 358-361.

26. World Health Organization (WHO). Guidelines for drinking water quality: fourth edition incorporating the first addendum. WHO, Geneva. 2017. [Accessed on December 29, 2022] Available at https://www.who.int/publications/i/item/9789241549950

27. Niba RN, Nchang C. Bacteriological analysis of well water sources in the Bambui student residential area. Journal of Water Resource and Protection. 2013; 05(11): 1013-1017. DOI: 10.4236/jwarp.2013.511106

28. Bahin EYB, Haida S. Hydrogeochemical Characterization of the dissolved load of the major elements downstream of the watershed of the Wadi Sebou, Morocco. Journal of Geoscience and Environment Protection. 2018; 6(7): 159-177. DOI: 10.4236/gep.2018.67011

29. Ayantobo OO, Oluwasanya GO, Idowu OA, Eruola AO. Water quality evaluation of hand-dug wells in Ibadan, Oyo State, Nigeria. Global Journal of Science Frontier Research. 2013; 13(10): 1-8.

30. Oluwasanya G, Smith J, Carter R. Self-supply systems: urban dug wells in Abeokuta, Nigeria. J. Water Sci. Technol. Water supply. 2011; 11(2): 172-178.