

# Epidemiological surveillance of microbial contamination in water facilities amongst Nigerian states

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**Abstract:** Epidemiological surveillance of microbial and physicochemical contamination in drinking water is important for monitoring the quality of water available nationwide. Thus resulting in targeted initiatives to aid the health and well-being of residents. This research aimed at detecting the main drinking water sources used by households in different states in Nigeria and the level of *E. coli* contamination in water facilities per state in Nigeria.

Data was obtained from the Federal Ministry of Water Resources: Water Sanitation, and Hygiene National Outcome Routine Mapping for the years 2019 and 2021. Selected water sources were: piped (water piped directly into dwelling), Sachet water, Borehole, and surface water (ie, river, stream, dam, lake, etc.)

Lagos was observed to have the highest uncontested household use of sachet water at a level of over 50% while other states were below 30%. Of the selected forms of drinking water sources, the highest used in households across states in Nigeria is borehole, with 21 states out of 36 having over 30% household usage. Followed by surface water: stream, river, etc.

For both years combined, 6 states showed 100% *E. coli* positive results, most of which were Northern states. Only Kwara state was observed to record 100% *E. coli* negative results in 2019. Though 2021 showed a national improvement as 6 more states joined in having 100% *E. coli* negative results. A number of states had unresolved results with respect to *E. coli* contamination in water facilities.

The study identified geographic inequalities with respect to the accessibilities of improved drinking water sources amongst Nigerian states. Also, the observed 100% *E. coli* contamination of water facilities gives an inclination of the possibility of other microbial and physicochemical contaminants. This could pose a disease risk to residents. Confirming the necessity for targeted policies and metrics that reach the most marginalized population in states with high surface water use and *E. coli* contaminated water facilities

**Keywords:** Epidemiological surveillance, microbial and physicochemical contamination, drinking water.

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## 1. INTRODUCTION

The quality of drinking water is essential to life, arguably even more than food. Thus, a national/ global seasonal evaluation on the suitability of the available water sources for drinking is of immense importance to the health and well-being of the nation/globe.

Nigeria is a developing country, over the years, it has developed different water sources used by residents for drinking. The accessibility to various forms of water is dependent on the wealth quintile of the individual /community. Thus, there is no predominant national drinking water form as it is dependent on the state and community. However, the predominance of a certain form of drinking water within a community does not reflect the quality and suitability of that form of water for consumption, but its ease of accessibility.

A Review Article stated that some drinking water sources observed as safe for consumption across Nigeria are actually not fit for human consumption. These stems from observation of the presence of microbes in drinking water, especially *E. coli* which were reported in 70 percent of the studies reviewed. It is, however worth noting that the methodology involved a critical review of only ten randomly selected studies to identify the major bacterial contaminants of drinking water in Nigeria and their distribution. Thus, future reviews may want to increase the number of sampled papers. *E. coli* was identified amongst an array of other bacterial contaminants, which was reported to be a health hazard, especially the presence of toxin-producing strains of *E. coli*, like the O157: H7, in drinking water, was stated to possibly result in fatal consequences like hemorrhagic diarrhea and kidney failure. (Otorokpa, 2019)

An experimental study sampling one brand of bottled water and eight brands of sachet water was also observed to have a mean Total heterotrophic bacteria plate counts (HPC) greater than 100 per milliliter water, below the United States Environmental Protection Agency (USEPA) and World Health Organisation (WHO) drinking water standard of 100 HPC per milliliter of water. (Oyedeji et al, 2010)

This research involved one hundred and eight samples comprising 16 bottled and 20 sachet water brands purchased randomly in South Western Nigeria specifically Ibadan and Ile-Ife cities. The packaged water was analyzed for the presence of bacterial indicators of water quality. All brands of sachet water (100%) had total coliforms, *E. coli* was detected in 20% of the sachet water brands, while *Enterococcus faecalis* was recovered from 10% of the brands (Oyedeji, et al, 2010). Bacterial contaminants were also detected from sachet and bottled water consumed by undergraduates of Federal University of Technology, Owerri (Innocent et al, 2022). In addition, Sachet water samples stored on the floor were observed to have the highest abundances of microbial species as observed in a research investigating the effect of long-term storage conditions on the physicochemical and microbial quality of selected sachet water brands sold within the Samaru community and its health implications for consumers (Adesakin, et al, 2022).

The sachet water industry is on the rise, but a review of about 50 publications reported that improvement calls made by previous studies, regarding the quality of water produced, have not been implemented. The article also stated that the intake of contaminated sachet water exposes the citizens to waterborne and carcinogenic diseases (Agbasi et al, 2024).

The water samples collected from three water sources: Ogo borehole, Ogbuku, and Ugwuiyi at Afikpo North LGA, Ebonyi State, Nigeria, had some parameters that deviated from set standards such as chemical oxygen demand, turbidity, phosphate, and NH<sub>4</sub> which could be improved by adequate water treatment. *Escherichia coli*, *Shigella*, *Klebsiella*, *Salmonella*, *Vibrio cholera*, and *Proteus spp* were amongst the identified isolates from the water samples. The presence of these microbes depicts fecal contamination which could lead to diseased conditions in individuals that use it as a drinking source (Alum et al, 2023).

It was also recommended that sachet and tap water supply in Port Harcourt Metropolis should be properly treated before human consumption and other domestic purpose since it was observed that the drinking water sources did not meet the approved acceptable limits of WHO for drinking water irrespective of the absence of growth of indicator organisms in the samples and no difference in the physicochemical variables (Agi et al 2022).

A total of six borehole water samples and a freshwater sample were as well, obtained from the Okerenkoko community in Delta State, Nigeria. Microbes reported were *Bacillus sp.*, *Escherichia sp.*, *Staphylococcus sp.*, *Streptococcus sp.*, *Shigella sp.*, *Proteus sp.*, *Pseudomonas sp.*, *Klebsiella sp.*, *Vibrio sp.* and *Micrococcus sp.* Thus showing an urgent need to source-track the pollutants (Asionye et al, 2023)

In addition to the presence of microbial contaminants in water sources in different states and communities in Nigeria, some of the microbes observed have been reported to be antibiotic-resistant. Twenty-five *E. coli* isolates obtained from the water samples analyzed for suitability for household use, were observed to be resistant to most antibacterial agents used. However, four of the *E. coli* isolates were sensitive to Cefotaxime. Polymerase chain reaction (PCR) revealed that 11 out of 25 *E. coli* isolates (44%) screened for ESBL resistance genes had TEM genes, while four of the isolates (16%) had SHV genes. Thus showing that drinking water could be a source of exposure to antibiotic-resistant *E. coli* (Adedirani, et al, 2025).

Similarly, the physicochemical and bacteriological properties of borehole water samples from agricultural, animal farm, and residential areas in Benin City, Edo State were assessed. *Shigella sp.* (23.29%) and *Bacillus cereus* (21.92%) were the two isolates that occurred most in the study. Antibiotic resistant microbes were observed thus showing that the borehole water requires proper treatment before use (Obuekwe et al, 2021). Antibiotic resistant microbial contaminants were also isolated from water samples isolated from public taps located at Finima, Hospital Road, Oguede, Akiama, and By-Pass over a five-month period in Bonny Island, Rivers State, Nigeria (Wilcox et al, 2023).

Fungal contamination of water sources has been identified alongside bacterial contaminants. Five (5) bore-hole water samples from stored-water tanks in hostels in Ifite-Awka metropolis were evaluated to ascertain the physicochemical parameters and the presence of bacterial and fungal groups presence. *E. coli* and *Aspergillus spp.* were observed to be the most predominant of the isolates detected. These microbes observed in water meant for municipalities, show fecal contamination. Improved sanitary conditions of reservoir tanks in these locations is therefore urgently required (Okafor et al, 2023).

Furthermore, past research has observed the diverse use of different drinking water sources within communities in Nigeria, thus also affecting the level of microbial contamination ingested while drinking from these sources. The most common source of water reported in a research done at Ibadan was well (53.2%), followed by borehole (34%) as the source of household water across five municipal local government areas (LGAs) in Ibadan, in southwest Nigeria. None of the households used municipal tap water. *Escherichia coli spp.*, was isolated from 115 (25.7%) of the household water sources. Thirty three *Salmonella*, four enteroaggregative *E. coli*, and four enterotoxigenic *E. coli* isolates. Study reported lack of treated tap water and the poor quality of alternative sources with detectable pathogens in municipal Ibadan, which could result in an increase in feco-orally transmitted infections (Alabi et al, 2024). Forty water samples were also collected from river, rain, well, borehole, and sachet water sources in Sapele, Delta State. and examined for physicochemical and bacteriological characteristics. Though physicochemical parameters were within the stipulated standards, but the biological parameters revealed water sources with contamination. It is recommended that consumers of water from these different sources employ measures to purify their drinking water to forestall potential health risks (Edeki et al, 2023)

Well water sources collected from 13 wards at Oyi L.G.A of Anambra State to be utilized for domestic purpose, such as cooking, were analyzed, *Escherichia coli* was the most frequently occurring isolate of all the bacteria identified. Other isolates include *Streptococcus spp.*, *Staphylococcus aureus*, *Shigella spp.*, *Enterococcus spp.*, *Salmonella spp.*, *Pseudomonas spp.*, *Proteus spp.* and *Bacillus spp.* The majority of these organisms are Gram-negative microorganisms, which are most times implicated in gastrointestinal abnormalities. Due to the high contamination, treatment is required before use (Nvene, et al, 2024)

The efficacy of solar disinfection (SODIS) of selected drinking well water was studied. It was reported to be a relatively cheap method of purifying water. Thirty wells were randomly sampled from six (6) local government areas in Benin City.

It was observed that SODIS is slightly more bactericidal, eliminating above 95% of microbial contaminants, as compared to being fungicidal. The use of SODIS did not completely eliminate all the faecal coliforms isolated in the studied well water, therefore making it unfit for drinking. Thus, a combined purification process is required (Adebisi, et al, 2021)

A study was conducted with the objective of evaluating the bacteriological quality of water sources accessible to students within Nasarawa State University Keffi. *Escherichia coli*, *Klebsiella pneumonia*, *Enterobacter aerogens*, and *Citrobacter sp* were isolated, making it unsuitable for consumption (Elijah et al, 2023). Microbial contamination was also observed in hand-dug wells and boreholes in the Achusa community, Benue State, Nigeria (Ekejiuba, et al, 2023).

Vending water in plastic jerry cans for domestic use has become a major source of household drinking water in Zaria due to inadequate pipe-borne water. Bacteriological quality of vended water from jerry cans in Zaria city, Kaduna state, Nigeria was examined the bacterial loads associated with the jerry cans observed were above WHO standard limit with *E. coli* as the most predominant (Nura et al, 2022).

The above literature has shown contaminated water sources in different states of Nigeria, covering the North, South, West, and East regions, irrespective of the source type. Thus, this research is aimed at determining the most prevalent source of drinking water amongst the 36 states of Nigeria, analyzing selected water sources.

2. MATERIALS AND METHOD

Data was obtained from Federal Ministry of Water Resources: Water Sanitation and Hygiene National Outcome Routine Mapping for years 2019 and 2021. Selected water sources were: piped (water piped directly into dwelling), Sachet water, Borehole and surface water (ie River, stream, dam, lake etc)

These were compared for each state in Nigeria to observe which was most used per state as a drinking water source. Analysis was done using Excel.

*E. coli* contamination report of water sources per state was also compared for year s 2019 and 2021

3. RESULTS

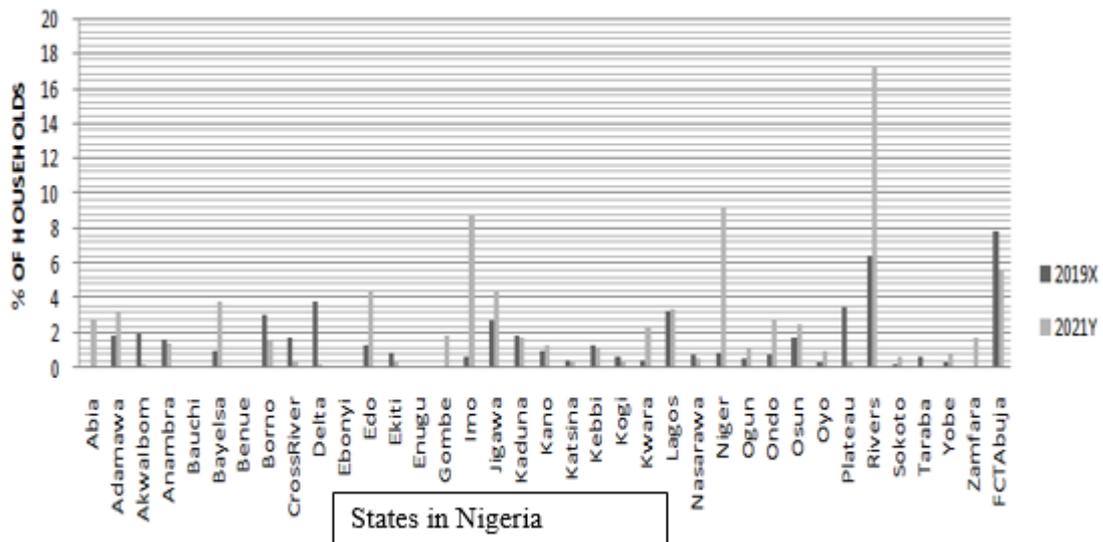


Fig 1: Different states households’ usage frequency of Piped water into dwelling for main drinking source. That is households within the state with their main source of drinking water as piped water connected into their dwelling

Less than 10% of the Nigerian population for 2019/2020 have piped bone water piped directly into their dwelling available for drinking water with the highest in Rivers State with improvement to over 15% only in 2021 figure 1. The number of states over 5% of households using this facility as a drinking source in 2019 was 2 states and 4 states in 2021

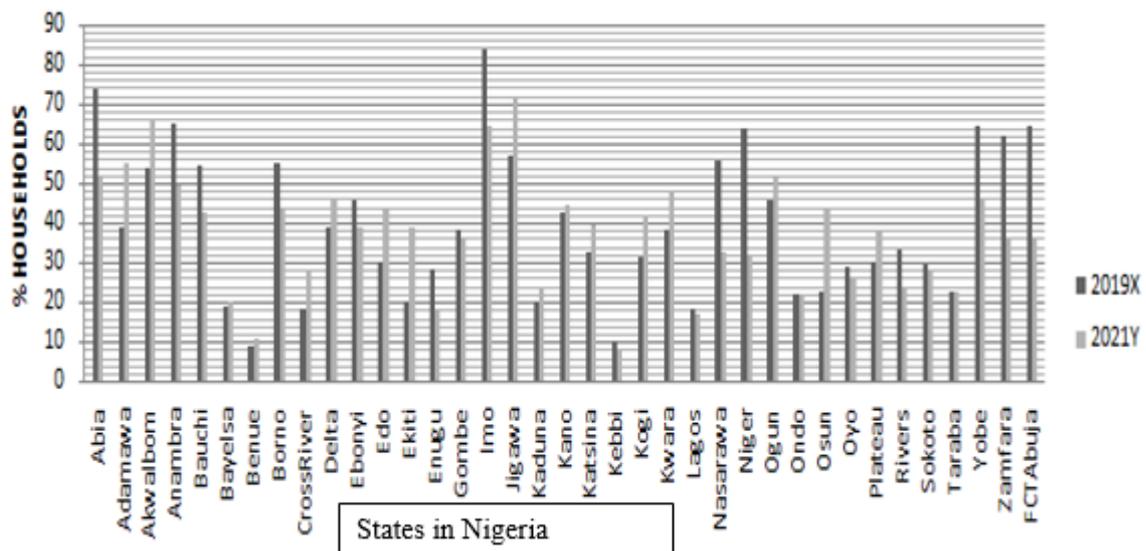
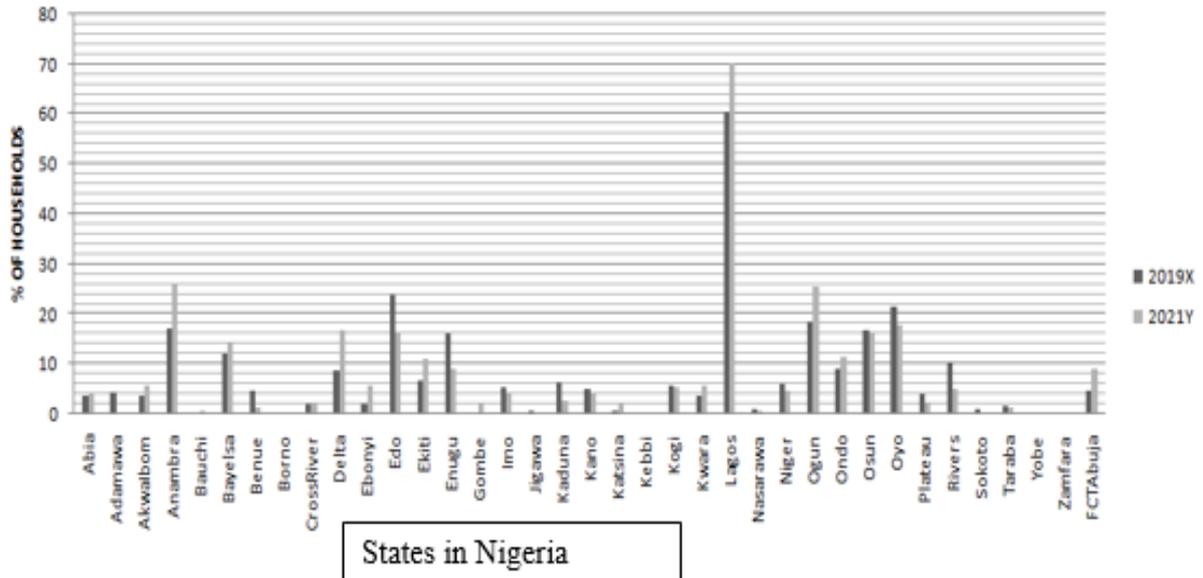


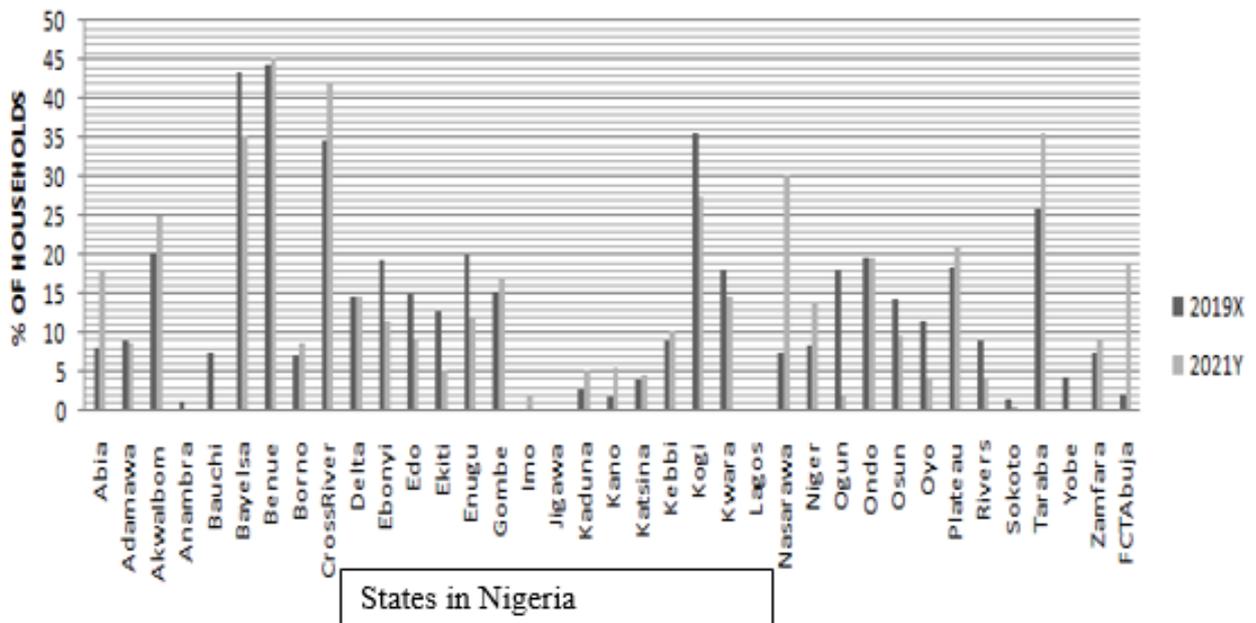
Fig 2: Different states households’ usage frequency of Borehole water as main source of drinking water. That is households within the state with their main source of drinking water as Borehole water

21 out of 37 states had over 30% of households using bore hole as main drinking water source for both years. Over 50% of households using boreholes as their main drinking source was observed in 12 states in 2019 and 6 states in 2021. Only 2 states were at the border of 10%



**Fig 3: Different states households usage frequency of Sachet water as main source of drinking water. That is households within the state with their main source of drinking water as Sachet water**

Lagos had the highest level of households over 50% that use sachet water as their drinking source. Other states in the country had less than 30% of households that use sachet water as their drinking source for both years analyzed fig 3. Out of 36 states, 8 states had over 10% of households using sachet water as their drinking water source at 2019 and 9 states at 2021.



**Fig 4: Different states households usage frequency of Surface water as main source of drinking water. That is households within the state with their main source of drinking water as Surface water.**

At the year 2019/2021, surface water was used by over 30% of households in 4 states. Surface water was used by over 10% of households in 18 states in 2019 and 17 states in 2021.

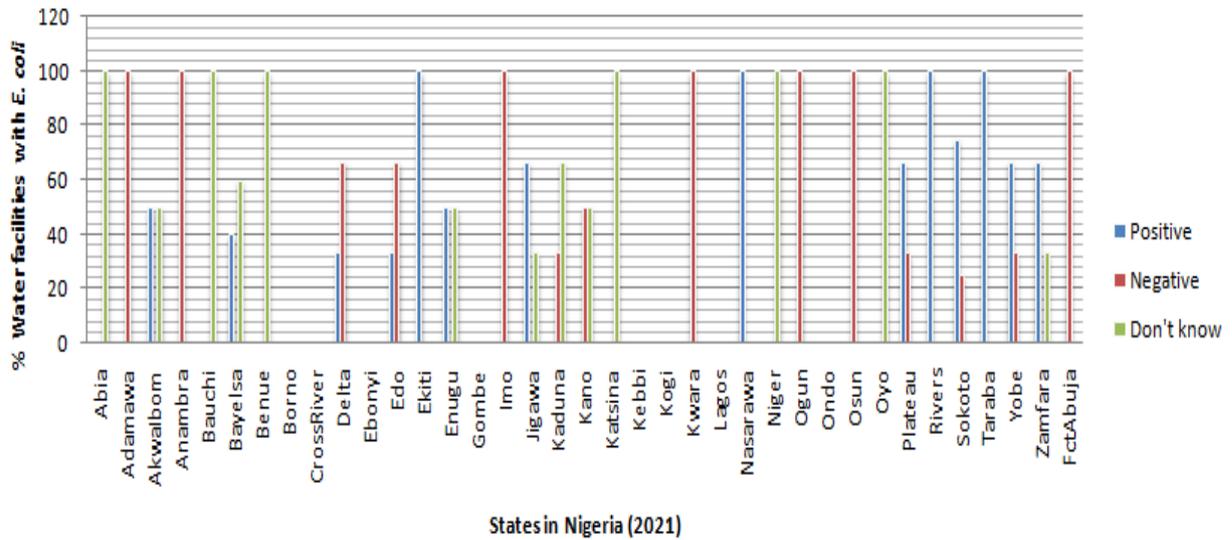


Fig 5: *E. coli* prevalence in water facilities in different states in Nigeria in year 2021

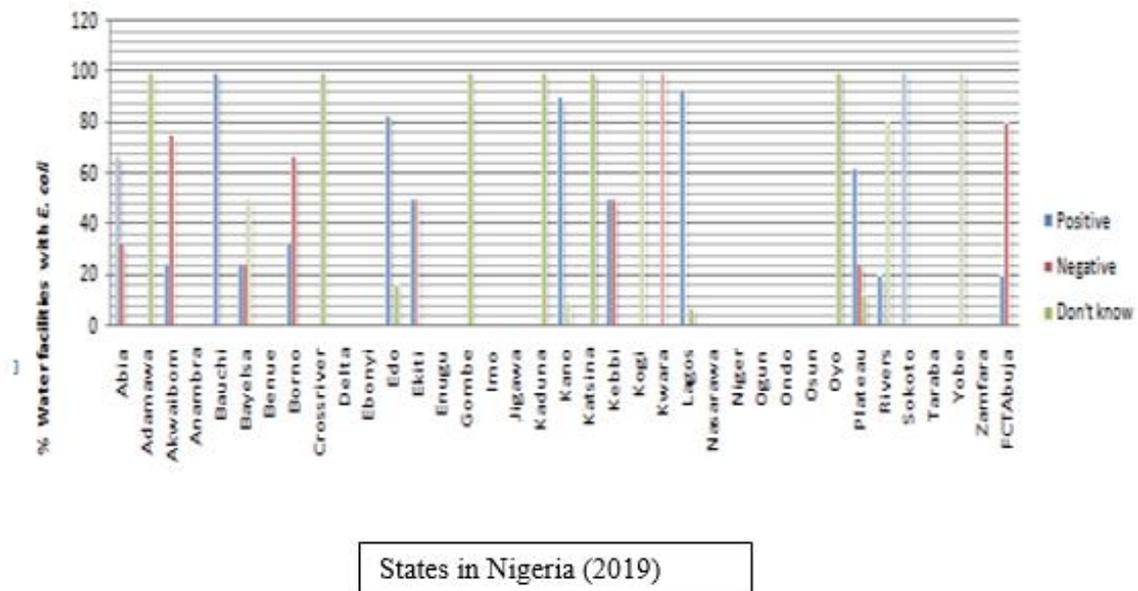


Fig 6: *E. coli* prevalence in water facilities in different states in Nigeria in year 2019

#### 4. DISCUSSION

Lagos was observed to have a more focused use of sachet water compared to other water sources in this research. While Benue had the highest use of surface water for drinking purposes among other sources analysed, which were low in Benue or nonexistent.

More specifically, states with over 10% of households using sachet water as their main drinking source were 9 states in 2021, which means 27 states did not have up to 10% of their population using pure water as their main drinking source figure 3. This depicts that though the sachet water production is on the rise (Agbasi et al, 2024), there are barriers to its use by a staggering large population of the Nigerian community. These barriers could range from the increasing price, accessibility, and quality trust (Agbasi et al, 2024)

It can be observed that amongst the water sources analyzed in this research, the most common source of drinking water is borehole in Nigeria, and the least common source is piped borne water directed into the dwelling of households (Fig. 1, 2). This is in line with a previous research stating that the second most common source of water borehole (34%) which was

observed as source of household water across five municipal local government areas (LGAs) in Ibadan, in southwest Nigeria. None of the households used municipal tap water (Alabi et al, 2024).

Furthermore, this present research observed that Bauchi and Sokoto had 100% *E. coli* contamination in 2019, while Ekiti, Nasarawa, Rivers, and Taraba had 100% *E. coli* contamination in 2021 in water facilities. The *E. coli* contamination observed was in line with previous research observed in similar states: Nasarawa (Elijah et al, 2023), Rivers State, Nigeria (Wilcox et al, 2023) and other northern regions. Most of the states observed in this research, with 100% contamination of water facilities, are in the Northern region. Some states like Kaduna, in past literature reported to have *E. coli* as its most predominant contaminant (Nura et al, 2022) were observed to have unresolved results; thus its bacteriological contamination of water facilities may not have been treated. Lagos, with the highest use of sachet water, had over 80% of *E. coli* contamination in 2019. It is important to note that the specific water facilities tested for *E. coli* contamination were not noted.

Kwara was the only state that had 100% negative result for *E. coli* contamination in water facilities, and this result was maintained in 2021. Other states with lower quality in 2019 improved by 2021 to 100%: Adamawa, Imo, Anambra, Ogun, Osun, and FCT Abuja. Thus depicting the state's consciousness of improving water quality. Though this research showed that 30 states either had positive *E. coli* water contamination or unresolved issues.

In conclusion, the improved drinking water accessibility in Nigeria is low and government policies need to be directed to aid communities still using surface water as their main source of drinking water. Then interventions lowering the microbial load of drinking water have to be a national focus to improve the health of Nigerians. States with 100% *E. coli* negative results need to be scrutinized for other common bacterial and fungal contamination, and their intervention that led to reduced *E. coli* contamination can be copied by other states.

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