

## **POTABLE DRINKING WATER IN NIGERIA'S COASTAL COMMUNITIES: INSIGHTS FROM PHYSICO-CHEMICAL AND BACTERIOLOGICAL PROPERTIES ASSESSMENT OF KURUTIE'S WATER AND DISTRIBUTION SYSTEMS**

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### **Abstract**

*Access to clean and safe water is not only crucial for maintaining good health but also plays a pivotal role in driving socio-economic progress for the population. In this study, we sampled portable water sources from Kurutie's community to assess the physical, chemical, and bacteriological attributes of the water whether it meets the water quality criteria for human consumption using standard laboratory procedure. The results of physicochemical parameters like pH ( $6.60 \pm 0.08$ ), conductivity ( $241.01 \pm 4.36 \mu\text{S/cm}$ ), total dissolved solids ( $127.36 \pm 0.27 \text{ mg/l}$ ), dissolved oxygen ( $4.68 \pm 0.45 \text{ mg/l}$ ), temperature ( $27.04 \pm 0.06 \text{ }^\circ\text{C}$ ), chlorine ( $0.21 \pm 0.2 \text{ mg/l}$ ), salinity ( $49.67 \pm 0.34 \text{ mg/l}$ ) and total petroleum hydrocarbons ( $0.04 \pm 0.05 \text{ mg/l}$ ) were within national and international limits, while turbidity ( $9.12 \pm 0.35 \text{ NTU}$ ), total (22 CFU/100 ml) and faecal coliforms (1 CFU/100 ml) were found to have exceeded the recommended limits of 5 NTU, and 0 CFU/ML respectively in Kurutie's groundwater and distribution systems. The total coliform counts indicated bacterial contamination. Isolates reported include *Shigella*, *Escherichia*, *Salmonella*, *Enterobacter*, *Pseudomonas*, *Proteus*, *Staphylococcus*, and *Bacillus*. Poor waste management practices like open defecation and indiscriminate waste disposal could result in the elevated turbidity and coliform counts observed. In light of this result, water from the only borehole serving the community could be deemed unfit for human consumption as it relates to health risks and safety. It is imperative that regular surveillance of the groundwater and the distribution channel is necessary to ensure clean and safe water for the human population in Niger Delta communities.*

**Key Words:** Water quality, Niger Delta, WASH, Open defecation

### **Introduction**

Water quality poses a significant concern in coastal areas, where growing population and industrial activities lead to severe environmental challenges like pollution of coastal waters, disturbance of

marine ecosystems, and coastal erosion resulting from human-made structures (Wang *et al.*, 2023). Within Nigeria's Niger Delta region, a significant portion of river pollution caused by heavy metals can be attributed to crude oil spills (Iwegbue

*et al.*, 2023). While these pollutants might not be readily apparent compared to various other types of water contaminants because of their high solubility, their slow metabolic rate indicates that their elimination through natural self-purification mechanisms will be minimal (Iwegbue *et al.*, 2023). The majority of reported cases of water contamination in the Niger Delta region of Nigeria are linked to legacy and persistent contaminants (Chris and Ekperusi, 2021).

In November 2018, the Nigerian authorities announced a state of emergency for the water, sanitation, and hygiene sectors. This declaration was a strategic step taken to address the escalating degradation of water resources and the surge in waterborne disease (Wada *et al.*, 2021). Nevertheless, this endeavour has not yet produced the expected results due to insufficient funding, subpar service provision, inadequate cooperation among stakeholders, and an unplanned approach to implementation (Musa *et al.*, 2021). Across the country, towns and local communities provide potable drinking water for themselves with little support from the government. As a result, every household in the Niger Delta, provides its own water without government supervision, monitoring or even inspection at the point of installation (UNEP, 2011).

Water contamination is a notable environmental problem within the Niger Delta region. A significant portion of the Nigerian population relies on sources such as borehole water, streams, rivers, rainfall, and excavated pits to meet their domestic water needs. Consumption of such polluted water alongside insufficient hygiene practices and substandard sanitation conditions has contributed to

the global disease burden and deaths particularly in developing economies (WHO, 2022). One of the primary environmental worries in developing nations is the alteration of water quality resulting from municipal and industrial pollution (Tekile, 2023). Water quality can be influenced by both natural and human actions (Han *et al.* 2020; Liu and You, 2023). Gaining insight into the condition of drinking water quality through practical methods offers scientific support for making informed decisions aimed at safeguarding and overseeing water quality. Swift action can be taken when needed based on this understanding. Thus, necessitating the utilization of proficient techniques for evaluating water quality and predicting pollution, ensuring dependable outcomes and bolstering trust in managerial choices. Various methods for evaluating water quality have been formulated and put into practice. As water quality significantly impacts human health, the consumption of water tainted by either biological or chemical factors could potentially result in significant health hazards for the general population. About 2.3 billion individuals worldwide experience waterborne illnesses, as highlighted by Ahmed *et al.* (2020). Furthermore, contaminated drinking water leads to approximately 485,000 annual deaths due to diarrhoea (WHO, 2019). These illnesses have led to challenges in public health and have placed burdens on the Nigerian populace. Microorganisms associated with waterborne diseases such as *Salmonella* sp., *Shigella* sp., *Escherichia coli*, and *Vibrio cholerae* have been reported to significantly contribute to the quality of water (Adetunde and Glover, 2010). As a result, waterborne diseases have become a

serious threat to public health, especially in developing nations with poor public health, sanitation, and water treatment infrastructures. When the provision of clean water and sufficient sanitation facilities becomes accessible to everyone, regardless of varying living conditions, a notable triumph over various diseases will be accomplished (Butchart *et al.*, 2010).

Nigeria aims to ensure complete availability of clean water and sanitation, targeting full coverage by 2030, particularly emphasizing rural areas. While the primary emphasis has been on addressing biological pollutants, realizing this goal will demand substantial investments in constructing essential infrastructure, keeping current systems, and raising awareness. Furthermore, it will necessitate rigorous monitoring of chemical and microbial pollutants as they play a significant role in the contamination of water. In relation to financial commitment, Nigeria is projected to require approximately 2.69 billion USD to accomplish the established objectives by 2030, with the government anticipated to contribute 25% of the funds, while 75% will be covered by households for constructing sanitation facilities. Given the prevailing economic challenges, households are currently prioritizing fundamental necessities like housing and sustenance, which could potentially lead to the persistence of open defecation in the foreseeable future (Musa *et al.*, 2021).

The Niger Delta region of Nigeria is overwrought with industrial activities including crude oil exploration and exploitation; this poses a challenge to accessing potable drinking water. Kurutie, one of the communities in the Niger Delta

is facing such a situation. This has led most people to rely extensively on untreated water from the only available personal boreholes and uncovered shallow wells. Therefore, this present study is designed to assess the physicochemical and bacteriological quality of the Kurutie borehole treatment plant and the distribution systems.

## **Materials and Methods**

### ***Study Area***

Kurutie community (Figure 1) is one of the Ijaw-speaking Island communities in the Gbaramatu kingdom located in Warri South-west Local Government Area of Delta State, Nigeria. The community is blessed with abundant natural resources. The community is situated on the left side of the Escravos River which is a major shipping route for vessels carrying cargoes and petroleum products to Warri Port, inland water transportation and fishing activities. The vegetation in the area is dominated by mangroves (*Rhizophora racemosa* and *Rhizophora mangle*). Other plant species include *Paspalum viginatum* and *Achrostichum aureum*. The region is characterized by two distinct seasons. A wet (April - October) and dry season (November - March). The main occupation of the people includes fishing, fish processing, and marketing. Additional occupation includes the production of palm wine, local gin, palm oil, and wooden canoe. The community had a limited number of people, however, the commencement of the Nigeria Maritime University (NMU) in 2018 resulted in exponential population growth as a result of students' admission into the University on the small Island.

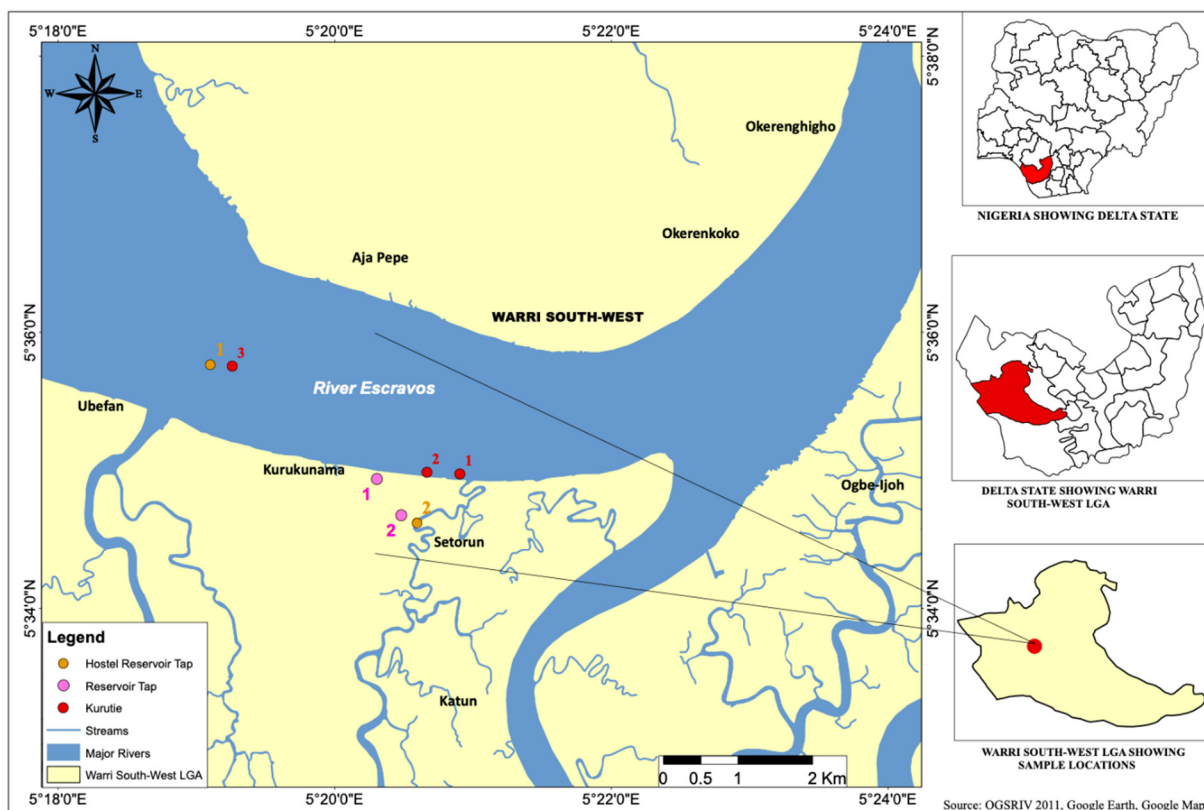


Fig. 1: Kurutie community showing the study area and sample collection points

### Sample Collection

Water was sampled from taps within the community. A cotton ball soaked in 70% ethanol was used to sterilize the tap nozzle and the tap water was allowed to run for about 5 minutes before collecting water samples (Table 1). Three replicates of samples were collected into a sterile 250ml plastic bottle with screw caps. The sampling procedure followed methods outlined by APHA (2005). Samples were labelled, placed in ice packs, and promptly transported to the laboratory for analysis.

### Physicochemical Analysis

At the sampling stations, physicochemical parameters such as pH, temperature, salinity, electrical conductivity (EC), and total dissolved solid (TDS) were measured *in situ* with the aid of Hanna instruments after

calibration following the manufacturer's instruction. At the lab, parameters such as free residual chlorine, turbidity, dissolved oxygen (DO), and total petroleum hydrocarbon (TPH) using Winkler's method, a nephelometer and fluorometrically (Fluorescence Analyzer Fluorat-02-04/Fluorat-02-5M) respectively.

### Enumeration of Total Viable Count

For the enumeration of total viable count, dilution of 1 to 10 parts of the samples were prepared using peptone water. A triplicate 1ml aliquots of the different dilutions were then inoculated into 10ml of molten plate count agar and incubated at 37°C for 24 h. Petri-dishes with 30-300 distinct colonies were counted (Idomeh *et al.*, 2017).

Table 1. Sample collection points in borehole water from Kurutie community

| Sampling Code | Location/Description                       |
|---------------|--------------------------------------------|
| Sample 1 (S1) | Reservoir Tap I (direct from the borehole) |
| Sample 2 (S2) | Reservoir Tap II (after filtration)        |
| Sample 3 (S3) | Female student hostel                      |
| Sample 4 (S4) | Male student hostel                        |
| Sample 5 (S5) | Kurutie I                                  |
| Sample 6 (S6) | Kurutie II (OMOH compound)                 |
| Sample 7 (S7) | Kurutie III (JEI JEI compound)             |
| Sample 8 (S8) | Hotel I Reservoir Tap                      |
| Sample 9 (S9) | Hotel II Reservoir Tap                     |

### **Enumeration of Total and Faecal Coliform Bacteria**

For total and faecal coliform count, the most probable number (MPN) technique was used for the enumeration of total and faecal coliform bacteria (Dhawale and LaMaster, 2003). This is because bacteriological analysis is indispensable for assessing and addressing environmental issues in rural communities. It provides valuable insights into the quality of water, soil, and air, enabling effective management of natural resources, safeguarding public health, and promoting sustainable practices (Streimikis and Baležentis, 2020).

**Presumptive test:** The enumeration of both total and faecal coliforms was carried out through multiple tube fermentation tests. The coliform count was determined using the MPN technique by employing a three-tube assay with MacConkey broth (Oxoid). In the initial group of three tubes, there was 10 ml of sterile double-strength lactose broth (DSLb), whereas the subsequent two sets contained 10 ml of single-strength lactose broth (SSLb). The tubes containing water samples were incubated for 24 - 48 hours at 37°C for estimation of total coliform and at 44.5°C for faecal coliform and then examined for acid and gas production.

**Confirmed test:** Confirmed analysis was done by inoculating a tube of brilliant green lactose bile (BGLB) broth (Oxoid) with Durham tubes with a loopful of culture from a positive tube of the presumptive test. The tubes were incubated for 24 - 48 hours at 37°C for total coliform and 44.5°C for faecal coliform and gas production was observed.

**Completed test:** For the completed test, a loopful of broth from a positive tube was streaked onto an Eosine methylene blue (EMB) agar plate to isolate pure colonies. These plates were then placed in an incubator at 37°C for 24 - 48 hours. Colonies that formed on the EMB agar would be additionally distinguished as faecal coliforms (*Escherichia coli*) due to their distinctive green metallic sheen.

**Characterization of isolates:** Physical morphology and biochemical tests were used in the identification of all isolates and matched with Bergey's Manual of Determinative Bacteriology for confirmation (Buchanan and Gibbons, 1974).

### **Data Analysis**

Data were summarised using Statistical Package for Social Sciences (SPSS) version 20. The difference between the means in the various stations was tested using a one-way analysis of variance

(ANOVA) at a probability level of  $p < 0.05$ , Microsoft Excel was employed for the creation of charts.

## Results

### Physicochemical Analysis

The physicochemical parameters of water samples are presented in Table 2. The results of physicochemical parameters such as pH, conductivity, total dissolved solids, dissolved oxygen, temperature, chlorine, salinity, and total petroleum hydrocarbons were within national and WHO limits, while turbidity exceeded the limits. Results of ANOVA showed that there was no significant difference ( $P < 0.05$ ) in the mean values of the physicochemical parameters across the studied stations except for pH (stations

7 and 8), EC and TDS (stations 4 - 9), and salinity (stations 7 - 9).

The pH, temperature, conductivity, TDS, DO, chlorine, salinity, turbidity and TPH ranges from 6.39 to 6.6, 26.94 to 27.04 °C, 217.33 to 241.01  $\mu\text{S}/\text{cm}$ , 116.25 to 127.20  $\text{mg}/\text{L}$ , 4.19 to 4.68  $\text{mg}/\text{L}$ , 0.19 to 0.21  $\text{mg}/\text{L}$ , 42.54 to 49.63  $\text{mg}/\text{L}$ , 1.86 to 9.12 NTU, and  $< 0.01$  to 0.04  $\text{mg}/\text{L}$  with a mean of  $6.47 \pm 0.05$ ,  $26.99 \pm 0.16^\circ\text{C}$ ,  $226.86 \pm 2.18 \mu\text{S}/\text{cm}$ ,  $122.41 \pm 0.71 \text{ mg}/\text{L}$ ,  $4.55 \pm 0.42 \text{ mg}/\text{L}$ ,  $0.199 \pm 0.04 \text{ mg}/\text{L}$ ,  $47.12 \pm 0.38 \text{ mg}/\text{L}$ ,  $6.66 \pm 0.22 \text{ NTU}$  and  $0.023 \pm 0.02 \text{ mg}/\text{L}$  respectively (Table 2). Among the sampled location, station 7 (Kurutie III) had the highest pH, while station 3 (Female hostel) had the highest conductivity. Temperature was uniformly distributed across the stations.

Table 2. Physicochemical parameters of the water samples (Mean $\pm$ SD) collected from Kurutie

| Sample | pH               | EC<br>( $\mu\text{S}/\text{cm}$ ) | TDS<br>( $\text{mg}/\text{L}$ ) | DO<br>( $\text{mg}/\text{L}$ ) | Temp<br>( $^\circ\text{C}$ ) | Turbidity<br>(NTU) | Chlorine<br>( $\text{mg}/\text{L}$ ) | Salinity<br>( $\text{mg}/\text{L}$ ) | TPH             |
|--------|------------------|-----------------------------------|---------------------------------|--------------------------------|------------------------------|--------------------|--------------------------------------|--------------------------------------|-----------------|
| S1     | 6.40 $\pm$ 0.02  | 240.07 $\pm$ 1.73                 | 127.20 $\pm$ 0.26               | 4.68 $\pm$ 0.45                | 26.96 $\pm$ 0.20             | 9.03 $\pm$ 0.10    | 0.20 $\pm$ 0.00                      | 49.63 $\pm$ 0.35                     | 0.04 $\pm$ 0.05 |
| S2     | 6.41 $\pm$ 0.02  | 238.33 $\pm$ 1.53                 | 127.01 $\pm$ 0.17               | 4.65 $\pm$ 0.40                | 26.94 $\pm$ 0.31             | 9.03 $\pm$ 0.13    | 0.21 $\pm$ 0.2                       | 49.62 $\pm$ 0.38                     | 0.01 $\pm$ 0.00 |
| S3     | 6.39 $\pm$ 0.02  | 241.01 $\pm$ 4.36                 | 127.36 $\pm$ 0.27               | 4.66 $\pm$ 0.44                | 26.96 $\pm$ 0.23             | 9.02 $\pm$ 0.07    | 0.19 $\pm$ 0.01                      | 49.67 $\pm$ 0.34                     | 0.01 $\pm$ 0.00 |
| S4     | 6.44 $\pm$ 0.08  | 221.97 $\pm$ 1.76*                | 123.93 $\pm$ 1.04*              | 4.40 $\pm$ 0.32                | 27.00 $\pm$ 0.00             | 9.10 $\pm$ 0.41    | 0.20 $\pm$ 0.02                      | 49.23 $\pm$ 0.33                     | 0.03 $\pm$ 0.04 |
| S5     | 6.45 $\pm$ 0.05  | 221.33 $\pm$ 2.08*                | 123.55 $\pm$ 1.18*              | 4.42 $\pm$ 0.28                | 27.04 $\pm$ 0.06             | 9.12 $\pm$ 0.35    | 0.19 $\pm$ 0.03                      | 49.22 $\pm$ 0.31                     | 0.01 $\pm$ 0.00 |
| S6     | 6.42 $\pm$ 0.04  | 221.33 $\pm$ 1.53*                | 123.31 $\pm$ 0.73*              | 4.19 $\pm$ 0.44                | 26.98 $\pm$ 0.07             | 9.10 $\pm$ 0.44    | 0.21 $\pm$ 0.01                      | 49.03 $\pm$ 0.05                     | 0.03 $\pm$ 0.03 |
| S7     | 6.60 $\pm$ 0.08* | 220.00 $\pm$ 2.00*                | 116.60 $\pm$ 0.53*              | 4.66 $\pm$ 0.50                | 27.00 $\pm$ 0.18             | 1.86 $\pm$ 0.15*   | 0.20 $\pm$ 0.01                      | 42.54 $\pm$ 0.58*                    | 0.03 $\pm$ 0.03 |
| S8     | 6.58 $\pm$ 0.03* | 217.33 $\pm$ 1.53*                | 116.52 $\pm$ 0.66*              | 4.63 $\pm$ 0.40                | 27.03 $\pm$ 0.17             | 1.86 $\pm$ 0.19*   | 0.20 $\pm$ 0.02                      | 42.57 $\pm$ 0.57*                    | 0.01 $\pm$ 0.00 |
| S9     | 6.54 $\pm$ 0.10  | 220.33 $\pm$ 3.06*                | 116.25 $\pm$ 1.54*              | 4.66 $\pm$ 0.54                | 26.99 $\pm$ 0.22             | 1.86 $\pm$ 0.17*   | 0.19 $\pm$ 0.02                      | 42.56 $\pm$ 0.52*                    | 0.04 $\pm$ 0.05 |
| SON    | 6.5 – 8.5        | 1000                              | 500                             | NA                             | Ambient                      | 5.0                | 0.2                                  | 100                                  | 0.002           |
| WHO    | 7.0 – 8.5        | NA                                | 1500                            | NA                             | NA                           | 5.0                | NA                                   | 200                                  | NA              |
| WHO    | 8.5 – 9.2        | NA                                | 1500                            | NA                             | NA                           | 5.0                | NA                                   | 600                                  | NA              |

\* Significant at  $P < 0.05$

### Microbial Load

In this study, the total and faecal coliforms exceeded the recommended limits for drinking water quality. As indicated in Table 3, the total viable count, total and faecal coliforms ranged from 57 to 209 CFU/ml, 3 to 22 MPN/100ml, and 0 to 1 MPN/100ml with a mean of 140.22

CFU/ml, 9.67 MPN/100ml and 0.11 MPN/100ml respectively. Among the samples, the highest coliform count of 22 MPN/100ml was detected in the water sample from the female hostel, followed by the male hostel with 19 MPN/100ml and Kurutie II with 11 MPN/100 ml, respectively, while for faecal coliform

counts, the highest was in Kurutie III. Eight genera of bacteria were identified during this study from 68 isolates. The genera include *Shigella*, *Escherichia*, *Salmonella*, *Enterobacter*, *Pseudomonas*,

*Proteus*, *Staphylococcus*, and *Bacillus* (Figure 2). *Enterobacter* recorded 18% of the total identified genera, followed by *Proteus* sp. (17%) while the least was *Escherichia* (5%).

Table 3. Bacteria load in borehole water collected from Kurutie community

| Sample | Location/Description   | Total Counts (CFU/ml) | Total Coliform (CFU/100ml) | Faecal Coliform (CFU/100ml) |
|--------|------------------------|-----------------------|----------------------------|-----------------------------|
| S1     | Reservoir Tap I        | 57                    | 3                          | 0                           |
| S2     | Reservoir Tap II       | 64                    | 8                          | 0                           |
| S3     | Female student hostel  | 103                   | 22                         | 0                           |
| S4     | Male student hostel    | 93                    | 19                         | 0                           |
| S5     | Kurutie I              | 179                   | 5                          | 0                           |
| S6     | Kurutie II             | 156                   | 11                         | 0                           |
| S7     | Kurutie III            | 211                   | 7                          | 1                           |
| S8     | Hotel I Reservoir Tap  | 190                   | 4                          | 0                           |
| S9     | Hotel II Reservoir Tap | 209                   | 8                          | 0                           |

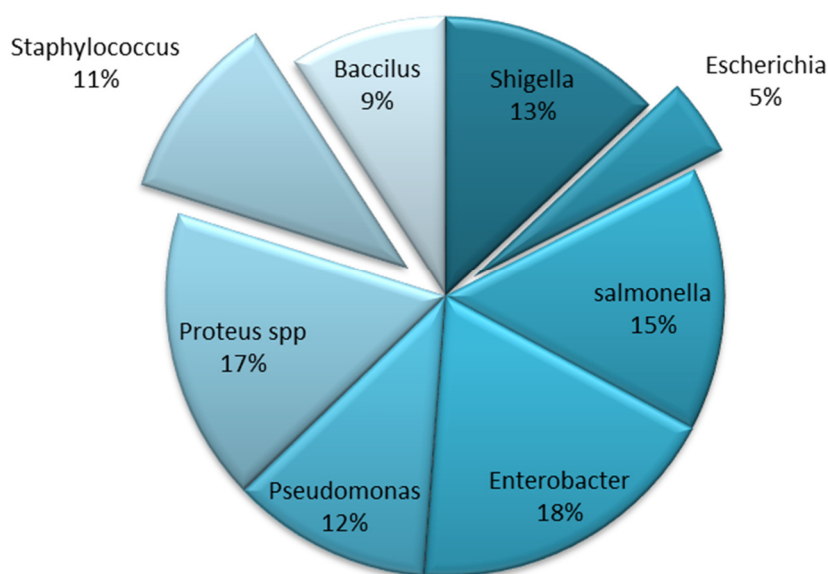


Fig. 2: Percentage frequency of isolated bacteria genera from water in Kurutie community

## Discussion

The World Health Organization (WHO) and the Standard Organization of Nigeria (SON) have established groundwater quality standards. These standards outline permissible limits for

physical, chemical, and microbial components that safe drinking water must meet. Water exceeding these limits is classified as contaminated and unsafe for human consumption (WHO, 2003; Oko *et al.*, 2014). In this study, the mean values

of turbidity, total and faecal coliforms in Kurutie's groundwater and its distribution system were found to be above the recommended limits for human consumption. The mean values of pH, electrical conductivity, total dissolved solids, dissolved oxygen, temperature, chlorine, salinity, and total petroleum hydrocarbon on the other hand were within the safe limits (WHO, 2003; Akinola *et al.*, 2018).

The mean value of pH (6.47) in the present study suggests the groundwater is slightly acidic. This is consistent with groundwater in the region which is slightly acidic as a result of widespread episodes of acid rain deposition associated with gas flaring from petrochemical activities in the region (Oki and Akana, 2016). The increased level of electrical conductivity in the water samples indicated ionic inputs into the groundwater system. The present study recorded a value greater than 9 NTU for turbidity. High turbidity could mean many colloidal particles entering the system which may interfere with water treatment systems leading to poor water treatment. Turbid water indicates the presence of organic matter and water that is unclean for drinking. Elevated water turbidity could involve the existence of pathogens that cause diseases (Oki and Akana, 2016).

The total number of microorganisms recorded in the water samples reflected the decreased dissolved oxygen reported in this study. An increase in microorganisms decreases the dissolved oxygen content of water. Spietz and colleagues (2015) reached comparable findings in their investigation of the impact of diminishing dissolved oxygen levels on bacteria. They analyzed changes in the structure of

bacterial communities across various locations and time periods, revealing a correlation between bacterial diversity and dissolved oxygen where lower levels were linked to reduced bacterial richness. In aquatic environments, when dissolved oxygen measurements decrease to 3 or 4 mg/L, fish and other aquatic organisms will start encountering stress, particularly if there is a sudden decline in oxygen levels. Only a limited number of organisms can survive in water with dissolved oxygen concentrations below 2 mg/L (Lakewatch, 2004).

There is no uncertainty regarding the potential contamination of groundwater within the aquifer, as water has the capability to dissolve and carry substantial quantities of organic substances (Megchun-Garcia *et al.*, 2015). The presence of total coliforms and *E. coli* in some of the samples implies that the water is contaminated. The water obtained from some of the distribution systems of Kurutie's community borehole did not meet up with some of WHO and SON's recommendations for some parameters needed for potable drinking water; this was expected as most homes in this Niger Delta community did not have a functional toilet facility and practice open defecation or pit latrines. This was similar to the report by Isa *et al* (2013) in the Maiduguri Metropolis where pH, total dissolved solids, turbidity, and total coliforms far exceeded WHO safe recommendations during the physicochemical and bacteriological assessment of drinking water.

Polluted water could contribute to the high incidence of waterborne illnesses within the community. As per the World Health Organization's drinking water quality guidelines, the acceptable limit for

total coliform is less than 1 MPN/100 ml of water, and there should be no presence of faecal coliforms in 1 ml of water (WHO, 2003). The result of our study indicates that the groundwater is unsuitable for drinking purposes as described by the previous report (Oloweb *et al.*, 2016).

Eight important known human pathogens were identified in this study (*Shigella*, *Escherichia*, *Salmonella*, *Enterobacter*, *Pseudomonas*, *Proteus*, *Staphylococcus*, and *Bacillus*) and have been previously reported (Akpoveta *et al.*, 2011; Uzoigwe and Agwa, 2012). In contrast to the report of Okafor (1985), our study reported the presence of *Escherichia*, *Streptococcus*, and *Enterobacter* in some of the water samples, which could be an indication of poor hygiene. These organisms may not actually constitute a public health hazard in healthy individuals, but their presence is an indication of other pathogenic microbes that may cause diseases ranging from diarrhoea, cholera and dysentery (Nwandkor and Obeagu 2015; Adetunde and Glover 2011).

Open defecation is prevalent in developing economies. In 2014, India outlined a five-year plan to end open defecation in the country (Spears, 2020). This was to be achieved by building millions of toilets and sensitization for achieving behavioral changes towards WASH services. As India assesses the attainment of its targets for eliminating open defecation, attention is being drawn to Nigeria as one in four Nigerians is involved in open defecation (WHO/UNICEF, 2015; Kalu and Okon, 2020; Ebimgbo *et al.*, 2019; Ngwu, 2017; SarkinGobir and SarkinGobir, 2019).

Despite declaring a state of emergency in the water, sanitization, and hygiene sector in 2018 by the Nigerian government, there is little investment in the sector, particularly in the provision of social amenities to the citizens. As a result, many communities still defecate in the same streams where they access drinking water, and many coastal communities such as Kurutie still swim in rivers on which open latrines are constructed and used. This practice continually exposes coastal communities to multiple risk pathways and makes them vulnerable to avoidable epidemics particularly those lethargic to children of specific ages (WHO/UNICEF, 2015). Reports suggest that open defecation is associated with fatalities caused by conditions like diarrhoea, cholera, and typhoid. Prior to the declared state of emergency, in 2016, Nigeria launched an action plan to end open defecation in 2025 (Kalu and Okon, 2020). The plan included expanding and ensuring equitable access to WASH services and strengthening tailored community approaches to total sanitation. However, with funding difficulties, this plan is yet to be achieved.

It is therefore imperative for the Nigerian government to back policies with actions in its efforts to improve WASH conditions across the country, particularly in coastal communities where open defecation is a norm. To achieve this, the federal government needs to partner with the local government to buy into the declared state of emergency and channel appropriate funds and actions towards improving WASH infrastructures at the local levels. It would also be helpful if the state government took the policies of the federal government in this regard seriously, to ensure concerted efforts

towards achieving zero open defecation, even as this is achievable.

Evidence from the results indicates that governments at the federal, state, and local levels need to prioritize water and sanitation needs of local communities in the Niger Delta region. It will be difficult for Nigeria to meet the United Nations sustainable development goals if adequate funding, competent regulators, and a well-sensitized population are not prioritized. There is also the need to end gas flaring in Nigeria. The Nigerian government has on many occasions since 1984, shifted set timelines for ending gas flaring in the country: the latest being 2020, which has also been moved to 2030 - without a blueprint for developing the necessary infrastructure for ending the menace. If gas flaring continues, water quality in coastal communities in the Niger Delta will continue to be acidic with significant health implications.

### Conclusion

The fluctuations and higher concentrations identified in the physicochemical and bacteriological properties of water samples collected from different boreholes can be ascribed to a combination of natural and human-induced factors. These factors encompass characteristics of the aquifer material, the speed of groundwater movement, the aquifer's permeability, instances of open defecation, the presence of oil contaminants, and patterns of waste disposal, among other influences. However, the elevated increase is specifically ascribed to the poor waste management in the community, and contaminated waterbed due to enormous anthropogenic stressors around the environs.

This investigation, therefore, revealed that the borehole water servicing the Kurutie community is not fit for human consumption and thus needs further treatment before consumption. The inability of the Nigerian government to supply safe and drinkable water to the expanding population, particularly in the Niger Delta area, is a matter of concern. It is suggested that the populace in this community should treat their water for drinking (boiling or filtering), treat water sources regularly with chlorine, chlorine oxides, and potassium permanganate to reduce microbial contamination and also put pressure on the government, well-meaning Nigerians and non-governmental organizations to supply safe potable water.

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