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# WATER QUALITY, SANITATION AND HEALTH IN EVBUOTUBU COMMUNITY, EDO STATE, NIGERIA: IDENTIFYING GAPS AND SOLUTIONS

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**Abstract**
*Global interest has been in water, sanitation and hygiene practice due to its vital role in public health and environmental protection. This study evaluated the gaps in Water Quality, Sanitation and Health in Evbuotubu Community, Edo state, Nigeria. Physicochemical and bacteriological qualities of water samples were analyzed adopting standard analytical procedures and pour plate techniques respectively and structured questionnaires were administered. Findings revealed that the pH value ranged from 5.33 to 6.71, slightly acidic. Electrical Conductivity ranged from 14.67 to 142 µS/cm, well below WHO's 400 µS/cm guideline. Turbidity level extremely low (0.03 to 0.90 NTU), well below the WHO maximum of 5 NTU. Alkalinity ranged from 0.21 mg/L to 0.50 mg/L. Phosphates ranged from 0.09 mg/L to 1.99 mg/L, exceeding WHO's 0.1 mg/L limit. Nitrates ranged from 0.57 mg/L to 1.50 mg/L, well within the WHO limit of 50 mg/L. Sulphates ranged from 0.15 mg/L to 0.91 mg/L, very low compared to WHO's 250 mg/L guideline. $BOD_5$ ranged from 0.21 to 1.45 mg/L and COD from 0.02 to 0.56 mg/L, both extremely low. The total heterotrophic bacterial population ranged in values from 2.24 to 3.15 ($10^2$ cfu/ml) and the total coliform count ranged from 0.02 to 1.82 (cfu/ml). Using standard morphological characterization, the bacterial isolates obtained were Klebsiella oxytoca, Enterobacter aerogenes, Bacillus subtilis and Serratia marcescens. This study suggests the water quality is acceptable, however, needs for residents to address its acidity level, promoting hygiene and improving sanitation within Evbuotubu community is very important.*

**Key Words:** *Evaluate, Evbuotubu community, Hygiene, Sanitation, Water*

## Introduction

WaSH, an acronym for water, sanitation, and hygiene, is a crucial sector in public health within the realm of international development. It involves ensuring access to clean and safe water, providing sufficient sanitation, educating about and implementing hygiene practices (Johnson and Kumar, 2020). Access to clean water is limited in several regions, particularly in developing nations, leading to serious health issues and various diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid and polio (Smith *et al*., 2021).

In Nigeria, WaSH programme faces challenges due to limited access to clean water and proper sanitation. This lack impacts a substantial segment of the population, leading to health problems and impeding socio-economic progress. Factors like urbanization, poverty, and insufficient infrastructure investment further intensify these issues (Okeke and Adeoye, 2021).

Water quality refers to the physical, chemical and biological properties such as pH, salinity, the presence of bacteria and other microbes, as well as the amount of dissolved oxygen present in a large amount of water (Omer, 2019). Together, these properties are used to determine whether water is suitable for use in agriculture or industry, safe for consumption, cooking or bathing (Bassi *et al*., 2021). Nigeria with a population of over 199 million (Ewuzie *et al*., 2021), faces significant challenges in water quality, impacting both its surface and groundwater resources (Abubakar, 2019). Despite the seeming abundance of water resources, only 19% of Nigerians have access to safe drinking water (Ewuzie *et al*., 2021), primarily due to economic water scarcity. This type of scarcity is characterized by a lack of capacity to manage and utilize water resources effectively for both environmental sustainability and economic growth (Ighalo and Adeniyi, 2020). Nigeria, with its vast population spread across urban and rural areas, relies on surface water, groundwater, and rainwater as its primary sources of drinking water (Ighalo and Adeniyi, 2020). In spite of these available resources, Nigerians still face persistent issues with water pollution, especially in rural communities where water quality has seen little improvement over the years (Imarhiagbe and Oshoma, 2017). As of 2021, around 66.3 million Nigerians were without access to clean drinking water (Ewuzie *et al*., 2021), and the quality often deteriorates by the time it is used due to poor handling and contamination at the source (Onanuga *et al*., 2022). Several factors contribute to water pollution in Nigeria, including industrial, residential, and agricultural activities, commercial slaughterhouses, mining, and oil exploration (Ighalo and Adeniyi, 2020). This pollution has led to an increase in bio-magnification of pollutants in fish populations, which in turn affects human health (Onanuga *et al*., 2022). The consumption of contaminated water is linked to a rise in water-borne diseases like cholera, diarrhea, and other gastrointestinal infections. Therefore, regular monitoring and assessment of water quality are essential for identifying pollution issues and developing effective prevention and mitigation strategies (Ighalo and Adeniyi, 2020).

Proper sanitation involves providing facilities and services for the safe disposal of human waste; lack of adequate sanitation is a primary cause of disease globally and contributes to the propagation of waterborne illnesses; sanitation is essential for public health and upholding dignity and privacy, particularly for females (Bello and Emeka, 2021). Practices such as handwashing with soap are critical in preventing disease transmission, hygiene education and promotion play a key role in WaSH initiatives as they significantly reduce disease spread due to unclean hands (Okonji and Adekunle, 2022). According to the World Health Organization (WHO), sanitation is the provision of facilities and services for the safe disposal of human

urine and faeces (UNICEF and WHO, 2012). Poor sanitation is a significant global health issue, with improvements in this area known to substantially benefit both individual households and broader communities. Sanitation encompasses maintaining cleanliness through services like trash collection and wastewater treatment. Key aspects of environmental sanitation include solid and medical waste management, handling of sewage, food hygiene, inspection of premises for health standards, and the management of water supplies, among others. Proper waste management, including human waste, is crucial in safeguarding water sources and curbing disease proliferation (Bartram and Cairncross, 2010).

Mulogo *et al.* (2018) emphasized the importance of water, sanitation, and hygiene (WaSH) services in promoting healthy habits and laying the groundwork for community and family well-being. These services are crucial for achieving the 2030 sustainable development goals, especially in the realms of safe drinking water, health, nutrition, education, and gender equality, as noted by Shapu *et al*. (2021). Vector-borne diseases, notably malaria, are major health challenges in Nigeria, significantly affecting children under five and pregnant women, and contributing to economic losses that exacerbate poverty and hinder development. Other endemic diseases include Onchocerciasis, Filariasis, Schistosomiasis, Yellow Fever, and Trypanosomiasis, whose spread is facilitated by population growth, urbanization, and environmental changes. This study was carried out in Evbuotubu community located in Egor Local Government area of Edo state, it is a sub urban community with households, schools (primary, secondary and tertiary) and hospitals (public and private) with electricity supply and limited sources of clean water. The community has a population of about 35,200 (NPC, 2006) out of which farmers account for about 50%. The indigenes speak Bini, pidgin as well as English and their occupation is mainly farming and trading. The major natural resource in the community is land and their predominant farm produce are yam, cassava, cocoyam, vegetables and plantain. The condition of roads and facilities such as schools in Evbuotubu community is in poor condition due to flooding and erosion which is also a threat to life and property to some residents in the community. This study aimed at identifying the gaps in Water Quality, Sanitation and Health in Evbuotubu Community, Edo state, Nigeria.

## Materials and Methods

Sample points: The study area is Evbuotubu community, Egor local government area, Benin city 300103, Edo State. Water samples (existing boreholes and wells) were randomly collected from seven (7) locations in the community. The global positioning coordinates of the sample points were 6.3361°N 5.5925°E, 6.3390°N 5.5815°E, 6.3394°N 5.5749°E, 6.3383°N 5.5721°E, 6.3445°N 5.5842°E, 6.3359°N 5.5727°E, 6.3436°N 5.5655°E respectively. Simple random sampling method was used to collect the water samples (borehole and well) randomly within the community.

### *Questionnaire Administration*

This research utilized a well-structured WaSH status questionnaire designed by WHO/UNICEF (2016). Most of the inquires in the questionnaire were clarified after being pre-tested and

supplementary explanations were provided in pidgin English as the questions were being read to the survey participants by the interviewer. The questions included age and gender, type and distance of main water supply, number and type of usable toilets, separation of toilet facility by gender and availability of water and soap within the toilets. A total of 150 individuals out of 32,500 (NPC, 2006) people in the community participated in the survey.

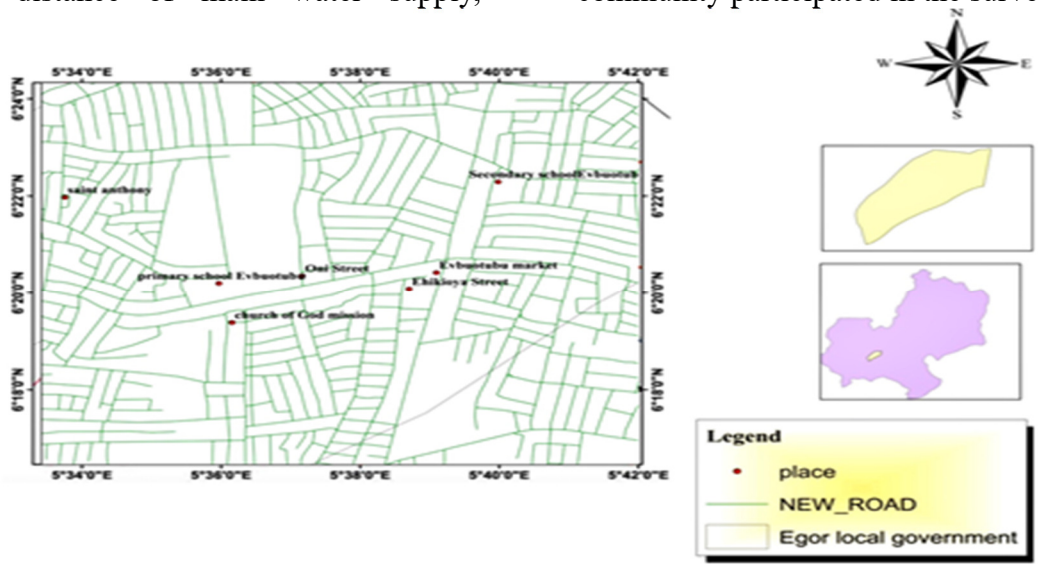


Fig 1: Map of sampling location

Water samples were randomly collected from seven different selected points within Evbuotubu community, Edo state. Descriptive report of the samples showed that point 1, 2, 3 and 4 were borehole water sources, while samples from point 5, 6 and 7 were well water sources. Samples were collected in well-labeled duplicate bottles and transported to the laboratory for physicochemical and bacteriological examinations.

***Analysis of Physicochemical Parameters of Water Samples***

Physicochemical parameters were analyzed according to APHA (2005) and Onyeonwu (2000) and conducted to ascertain the quality, suitability and safety for consumption as recommended by the Standard Organization of Nigeria (SON, 2017) and World Health Organization (WHO, 2017). The parameters were pH, salinity, Electrical Conductivity (EC), turbidity, nitrate, phosphate, sulphate, Biological oxygen demand ($BOD_5$) and Chemical oxygen demand (COD).

***Analysis of Bacteriological Parameters of Water Samples***

Membrane Filtration Technique: Water samples were filtered using cellulose nitrate membrane filters with a pore size of 0.45µm. The filters were then placed on prepared growth media and incubated. Colonies were counted using a colony counter, and results were recorded.

***Phenotypic Identification***

Bacterial isolates were identified using cultural, morphological, and biochemical methods, including Gram staining and several other tests (catalase, urease, indole, oxidase, citrate utilization).

***Biochemical Characterization of Bacterial Isolates***

Pure cultures of isolates were stored in Nutrient agar slant at $4^0$C for further characterization and identified using the taxonomic scheme of Bergey's manual of determinative bacteriology (Harley and Prescott, 2002; Cheesebrough, 2006). The following biochemical tests were carried out; indole, oxidase, catalase, citrate utilization urease.

***Data Analysis***

All results were analyzed using descriptive statistical methods, incorporating measures of central tendency and dispersion, such as the mean, standard deviation and coefficient of variation. The analysis was performed using SPSS and Excel software.

**Results and Discussion**

Tables 1-4 show the opinion survey of the respondents on socio-demography, water availability, sanitation and health status of residents in Evbuotubu community. It was observed that the respondents in the study were 64 % male and 36 % female; with majority of respondents being male which may affect how community needs are perceived and addressed. This could influence the focus of community programs or initiatives, potential overlooking of issues that are more relevant to women and children. The age distribution varied with a significant proportion (52 %) being students. Education levels are relatively high with 35.33 % of respondents holding tertiary degrees, which suggests the potential for economic and social development and it was also observed that the majority of the respondents were single (66.67 %). Survey further revealed that the households (66.67 %) have only one usable toilet for families of four to five persons which is inadequate for many users, most homes use flush/pour-flush toilets connected to sewer systems; insufficient number of toilets and high dependency on flush systems point to a need for improved sanitation infrastructure to accommodate the growing population and prevent disease spread and the use of flush toilets and regular cleaning indicates a foundation of good sanitation practices (Imarhiagbe and Eghomwanre, 2023). This study also documented high incidences of cholera (63.33 %) and typhoid (43.3 %), which indicate consumption of unclean water and contaminated food due to poor environmental sanitation practices. It was shown that the residents of Evboutubu community relied more on herbal medicine (51.33 %) over formal healthcare services which may indicate inaccessibility health Centre or cultural preferences, which could affect the effectiveness of health interventions (Onoh *et al*., 2022). It was further documented that the main source of water in the community is borehole (73.33 %) and majority (100%) agreed that water from main source is currently available, 72 % of the respondents stated that the water is used for washing and cooking, 28 % agreed that the water was used for drinking, cooking and washing. Findings show that sachet or bottle water was the alternate source of drinking water (72 % ) and 83.33 % disagreed that they boil the water before use, while 16.67 % agreed that they boil the water before use, 72 % indicated that the water from source has taste but no color (100 %), however, majority (72 %) stated that the water from source has visible impurities, while (28 %) disagreed that water from source has visible impurities, 90 % of respondents stated that available water taps are

adequate for intending users at daily intervals, majority (92 %) agreed that they have never taken their water to the laboratory for analysis, majorly because of no knowledge (87.3 %).

The results obtained from the physicochemical analysis of the water samples in table 5 to 7 show that the water pH value ranged from 5.33 - 6.71. Study by Akande *et al.* (2015), revealed that low pH influences pipe corrosion and metal leaching, thereby posing health risks. Electrical Conductivity ranged from 14.67 - 142 µS/cm. Salinity of water samples collected were observed to be low and ranged from 6.33 - 70.33 ppm. The turbidity level of the water samples ranged from 0.03 to 0.90 NTU and were observed to be within the WHO recommended limit (<5 NTU), this finding indicates presence of low organic matter and reduced risk of microbial contamination. The result of this study also revealed the range of alkalinity from 0.21 mg/L - 0.50 mg/L, lower than SON limits (SON, 2017); phosphates ranged from 0.09 mg/L to 1.99 mg/L, exceeding WHO's 0.1 mg/L limit. Study has revealed that low alkalinity can increase susceptibility to pH fluctuations and corrosion (Imarhiagbe and Oshoma, 2017) and high levels of phosphate in water body can lead to eutrophication, though not harmful to health (Akharame *et al*., 2017). Nitrates ranged from 0.57 mg/L - 1.50 mg/L, which is within the WHO limit of 50 mg/L (WHO, 2017) and sulphates ranged from 0.15 mg/L - 0.91 mg/L, which is very low compared to WHO's 250 mg/L guideline. Biological Oxygen Demand ($BOD_5$) and Chemical Oxygen Demand (COD) of the water samples ranged from 0.21 -1.45 mg/L and 0.02 - 0.56 mg/L respectively, both indicate minimal organic pollution and good water quality.

As shown in table 6 the total heterotrophic bacterial population in this study ranged in values from 2.24 to 3.15 ($10^2$ cfu/ml) and the total coliform count ranged from 0.02 to 1.82 ($10^2$ cfu/ml). Using standard morphological characterization, the bacterial isolates obtained were *Klebsiella oxytoca, Enterobacter aerogenes, Bacillus* sp*., and Serratia marcescens* as shown in table 7. These bacterial isolates are common and found in water, soil, and plant surfaces; can colonize human intestines without causing disease but may lead to infections like pneumonia, and wound infections, particularly in hospital settings (Harley and Prescott, 2002).

## Conclusion

Water, sanitation, and hygiene are critical global concerns and thus, a target in the United Nations Sustainable Development Goals (SDGs), with a focus on promoting environmental sustainability. The water quality from Evbuotubu community as adjudged by physicochemical and bacteriological investigation has been observed to be good. Proper waste management, sanitation and access to healthcare facilities in Evbuotubu community should be encouraged. Awareness on good hygiene practice such as regular handwashing and toilet cleanliness should be vigorously pursuit among the residents of Evbuotubu community.

Table 1: Socio-demographic of Participants in Evbuotubu community

| S/N | **Parameter** | **Category** | **Frequency (N)** | **Percentage (%)** |
|---|---|---|---|---|
| 1. | Sex | Female | 54 | 36 |
| | | Male | 96 | 64 |
| | | Total | 150 | 100% |
| 2. | Age | 15-17yrs | 16 | 10.67 |
| | | 18-20yrs | 38 | 25.33 |
| | | 21-24yrs | 39 | 26 |
| | | 25-30yrs | 28 | 18.67 |
| | | 31-40yrs | 14 | 9.33 |
| | | 41-50yrs | 10 | 6.67 |
| | | 50+ | 5 | 3.33 |
| | | Total | 150 | 100% |
| 3. | Level of education | No education | 20 | 13.33 |
| | | Vocational | 10 | 6.67 |
| | | Primary | 12 | 8 |
| | | Secondary | 38 | 25.33 |
| | | Tertiary | 70 | 46.67 |
| | | Total | 150 | 100% |
| 4. | Marital status | Married | 35 | 23.33 |
| | | Cohabiting | 10 | 6.67 |
| | | Single | 100 | 66.67 |
| | | Divorced | 5 | 3.33 |
| | | Total | 150 | 100% |
| 5. | Occupation | Salary earner | 5 | 3.33 |
| | | Business | 50 | 33.33 |
| | | owner | 12 | 8 |
| | | Govt. sector | 5 | 3.33 |
| | | Private sector | 78 | 52 |
| | | Student | 150 | 100% |
| | | Total | | |

Table 2: Water Availability Status of residents in Evbuotubu community

| **Variables** | **Frequency**(N=150) | **Percentage** (100%) |
|---|---|---|
| Main Water Source | | |
| Piped | 12 | 8 |
| Borehole | 110 | 73.33 |
| Protected Dug Well | 20 | 13.34 |
| Unprotected Dug Well | 8 | 5.33 |
| Protected Spring | 0 | 0 |
| Unprotected Spring | 0 | 0 |
| Surface Water (River, Lake) | 0 | 0 |
| No Water Source | 0 | 0 |
| Others | 0 | 0 |
| Main Water Source Is Located Within The Premises | 98 | 65.33 |
| Yes | 38 | 25.33 |
| Off Premises But Up To 500m | 14 | 9.34 |
| More Than 500m | | |
| Water From Main Source Is Currently Available | 150 | 100 |
| Yes | 0 | 0 |
| No | 0 | 0 |
| Uses Of Water | 42 | 28 |
| Drinking | 108 | 72 |
| Drinking, Washing And Cooking | 0 | 0 |
| Cooking And Washing Not For Drinking | | |
| Nothing | 108 | 72 |
| Alternate Source Of Drinking Water | 0 | 0 |
| Sachet/ Bottle Water | | |
| Vendor Supply | 25 | 16.67 |
| Do You Boil Water Before Use | 125 | 83.33 |
| Yes | | |
| No | 108 | 72 |
| Does The Water From Source Have Taste | 42 | 28 |
| Yes | | |
| No | 0 | 0 |
| Does The Water From Source Have Color | 150 | 100 |
| Yes | | |
| No | | |
| If Yes, What Is The Color | 108 | 72 |
| Does The Water Have Sand Particles and Other Impurities | 42 | 28 |
| Yes | | |
| No | | |
| Are the Available Water Taps Adequate for Intending Users at Daily Intervals | | |
| Yes | 135 | 90 |
| No | 15 | 10 |
| Have You Ever Taken Your Water To the Laboratory For Physiochemical and Microbiological Analysis | | |
| Yes | 12 | 8 |
| No | 138 | 92 |
| If No To the Above Question, Why? | | |
| No Knowledge | 131 | 87.3 |
| High Cost of Analyzing The Water | 7 | 4.67 |

Table 3: Sanitation status of residents in Evbuotubu community

| S/N | Parameters | Category | Freq.(N) | Percentage (%) |
|---|---|---|---|---|
| 1. | Number of usable toilets in the home | 1 | 100 | 66.67 |
| | | 2 | 30 | 20 |
| | | 3 | 20 | 13.33 |
| | | Total | 150 | 100% |
| 2. | Are usable toilet sufficient for intending users | Yes | 87 | 58 |
| | | No | 63 | 42 |
| | | Total | 150 | 100% |
| 3. | If NO should the owners build additional toilets | Yes | 130 | 86.67 |
| | | No | 20 | 13.33 |
| | | Total | 150 | 100% |
| 4. | Types of toilet/latrine | Flush/pour-flush to sewer | 80 | 53.33 |
| | | Flush/pour-flush to tank/pit | 30 | 20 |
| | | Flush/pour to open | 20 | 13.33 |
| | | Pit latrine without slab/open | 10 | 6.67 |
| | | Bucket | 10 | 6.67 |
| | Are the toilets separated for male and female | Total | 150 | 100% |
| | | Yes | 22 | 14.67 |
| 5. | | No | 128 | 85.33 |
| | | Total | 150 | 100% |
| 6. | Female toilets have facilities to manage menstrual hygiene needs(covered bin, and /or water and soap) | Yes | 80 | 53.33 |
| | | No | 70 | 46.67 |
| | | Total | 150 | 100% |
| 7. | Are the toilets frequently washed or maintained | Yes | 130 | 86.7 |
| | | No | 20 | 13.3 |
| | | Total | 150 | 100% |
| 8. | Are there functional drainage systems within your premises | Yes | 13 | 8.7 |
| | | No | 137 | 91.3 |
| | | Total | 150 | 100% |
| 9. | Who maintains the drainage system | Residents | 145 | 96.67 |
| | | Govt. agency | 5 | 3.33 |
| | | Total | 150 | 100% |
| 10. | General waste are safely separated into three bins | Yes | 9 | 6 |
| | | No | 141 | 94 |
| | | Total | 150 | 100% |

| | | | | |
|---|---|---|---|---|
| 11. | Waste are centrally collected and openly burnt | Yes<br>No<br>Total | 48<br>102<br>150 | 32<br>68<br>10% |
| 12. | Waste are centrally collected and burnt in closure. | Yes<br>No<br>Total | 37<br>113<br>150 | 24.67<br>75.33<br>100% |
| 13. | Solid waste generated from the facility premises are accumulated outside the fenced premises | Yes<br>No<br>Total | 59<br>91<br>150 | 39.3<br>60.7<br>100% |
| 14. | Accumulated waste are collected and evacuated by scavengers | Yes<br>No<br>Total | 65<br>85<br>150 | 43.33<br>56.67<br>100% |
| 15. | Waste are collected and evacuated by government management board | Yes<br>No<br>Total | 5<br>145<br>150 | 3.33<br>96.67<br>100% |

Table 4: Health Status of residents in Evbuotubu community

| S/N | Parameters | Category | Freq(N) | Percentage (%) |
|---|---|---|---|---|
| 1. | Cholera | Yes | 95 | 63.33 |
| | | No | 55 | 36.67 |
| | | Total | 150 | 100% |
| 2. | Typhoid | Yes | 65 | 43.3 |
| | | No | 85 | 56.7 |
| | | Total | 150 | 100% |
| 3. | Dysentery | Yes | 98 | 65.3 |
| | | No | 52 | 34.7 |
| | | Total | 150 | 100% |
| 4. | Dehydration | Yes | 111 | 74 |
| | | No | 39 | 26 |
| | | Total | 150 | 100% |
| 5. | Vomiting | Yes | 109 | 72.7 |
| | | No | 41 | 27.3 |
| | | Total | 150 | 100% |
| 6. | Type of health facility patronized for treatment | Hospital/clinic | 16 | 10.67 |
| | | Herbal preparation | 77 | 51.33 |
| | | Chemist | 25 | 16.67 |
| | | Self-medication | 32 | 21.33 |
| | | Total | 150 | 100% |
| 7. | How often do you visit the health facility | Frequently | 28 | 18.67 |
| | | Seldom | 44 | 29.33 |
| | | Don't | 78 | 52 |
| | | Total | 150 | 100% |

Table 5: Physicochemical result of water samples from Evbuotubu community

| **Parameters** | **Location 1** | **Location 2** | **Location 3** | **Location 4** | **Location 5** | **Location 6** | **Location 7** | **WHO (2017)** | **SON (2017)** |
|---|---|---|---|---|---|---|---|---|---|
| Tempt. (°C) | 29.13±1.03 | 29.60±0.36 | 28.83±1.04 | 29.00±1.00 | 27.67±0.58 | 28.20±1.31 | 28.67±1.15 | 15°C - 25°C | 5-25°c |
| pH | 6.33±0.58 | 5.33±0.58 | 6.00±0.50 | 5.63±0.55 | 6.46±0.02 | 6.53±0.16 | 6.71±0.04 | 6.5 - 8.5 | 6.5 - 8.5 |
| EC (µS/cm) | 14.67±0.58 | 142.00±1.00 | 15.67±0.58 | 37.00±1.00 | 27.00±1.00 | 86.33±1.53 | 114.00±2.00 | N.S | 100-1000 |
| Salinity (mg/L) | 7.67±0.58 | 70.33±0.58 | 6.33±0.58 | 17.00±1.73 | 13.67±1.53 | 42.67±0.58 | 59.33±1.15 | N.S | 100-500mg/L |
| Turbidity (NTU) | 0.27±0.04 | 0.63±0.15 | 0.27±0.04 | 0.43±0.25 | 0.11±0.19 | 0.90±0.04 | 0.03±0.00 | <5NTU | 0.5-5 NTU |
| Alkalinity (mg/L) | 0.24±0.01 | 0.41±0.11 | 0.21±0.01 | 0.41±0.11 | 0.43±0.03 | 0.40±0.05 | 0.50±0.05 | N.S | 30-200mg/L |
| Phosphate (mg/L) | 1.53±0.07 | 0.56±0.04 | 0.12±0.01 | 0.56±0.04 | 1.84±0.85 | 1.99±0.35 | 0.09±0.00 | <0.1mg/L | N.S |
| Nitrate (mg/L) | 1.12±0.09 | 0.95±0.05 | 0.67±0.01 | 0.95±0.05 | 1.05±0.15 | 1.50±0.05 | 0.57±0.25 | <50mg/L | 20-50mg/L |
| Sulphate (mg/L) | 0.15±0.05 | 0.53±0.10 | 0.82±0.03 | 0.75±0.05 | 0.82±0.03 | 0.91±0.09 | 0.79±0.00 | <250mg/L | 100-250mg/L |
| BOD (mg/L) | 0.74±0.04 | 0.21±0.12 | 0.84±0.06 | 1.45±0.7 | 0.27±0.04 | 0.63±0.15 | 0.21±0.12 | <3mg/L | N.S |
| COD (mg/L) | 0.48±0.06 | 0.02±0.00 | 0.36±0.01 | 0.41±0.05 | 0.56±0.05 | 0.50±0.01 | 0.26±0.05 | <10mg/L | N S |

Key: Temperature (temp), Electrical conductivity (EC), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), World Health Organization (WHO), location 1 (borehole water), location 2 (borehole water), location 3 (borehole water), location 4 (borehole water), location 5 (well water), location 6 (well water), location 7 (well water), N.S (not stated).

Table 6: Total heterotrophic bacterial count and total coliform count

| Location | THB ($10^2$ cfu/ml) | TC ($10^2$ cfu/ml) |
|---|---|---|
| 1 | 2.89 ± 0.61 | 0.34 ± 0.08 |
| 2 | 2.83 ± 0.09 | 1.82± 0.24 |
| 3 | 2.24 ± 0.33 | 0.20± 0.13 |
| 4 | 3.10± 0.14 | 0.52± 0.10 |
| 5 | 3.15 ± 0.02 | 0.33± 0.00 |
| 6 | 2.88 ± 0.21 | 0.52 ± 0.41 |
| 7 | 2.66 ± 0.09 | 0.70± 0.19 |

Key: Total Heterotrophic Bacterial Count (THB), Total Coliform (TC).

Table 7: Morphological and cultural characteristics of bacterial isolates from water samples collected from Evbotubu community.

| Characteristics | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Elevation | Flat | Flat | Flat | Raised |
| Margin | Entire | Undulate | Undulate | Entire |
| Color | Cream | Cream | Cream | Cream |
| Shape | Circular | Irregular | Irregular | Circular |
| Size | Small | Large | large | Medium |
| Gr. diff. agar | EMB | EMB | BCA | EMB |
| Colour | Pink | Pink | Straw | Opaque |
| Staining | | | | |
| Gram stain | - | - | + | - |
| cell type | Rod | Rod | Rod | Rod |
| Arrangement | Disperse | disperse | disperse | Disperse |
| Color | Pink | Pink | purple | Pink |
| Spore staining | - | - | + | - |
| Biochemical | | | | |
| KOH String Test | + | + | - | + |
| Catalase | + | + | + | + |
| Indole | - | - | - | - |
| Citrate | + | + | + | + |
| Oxidase | - | - | - | - |
| Motility | - | + | + | + |
| Urease | + | - | - | - |
| Glucose | + | + | + | + |
| Sucrose | + | + | + | + |
| Lactose | + | + | + | + |
| Mannitol | - | - | + | + |
| Gas formation | + | - | - | - |
| $H_2S$ formation | - | - | - | - |
| TSI (Slant/Butt) reaction | A/AG | A/A(K*)G* | A/A | K/A (*A/A) |
| Esculin Hydrolysis | + | + | - | - |
| Identity | *Klebsiella oxytoca* | *Enterobacter aerogenes* | *Bacillus* sp. | *Serratia marcescens* |

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