ASSESSEMENT OF WATER QUALITY IN OHHOVBE COMMUNITY AND THE HEALTH STATUS OF RESIDENTS

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MATRICULATION NUMBER:

LSC2003073

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FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN, BENIN CITY.

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AN UNDERGRADUATE DISSERTATION SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA; IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE IN ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY

DATE:

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CERTIFICATION

This is to certify that this research titled **"ASSESSMENT OF WATER QUALITY IN OHOVBE COMMUNITY AND THE HEALTH STATUS OF RESIDENTS"** was carried out by **"LUKMAN ROQIBA (MISS)"** and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City; in partial fulfilment of the requirements for the award of Bachelor of Science (B.Sc) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised and subsequently approved as having met the requirements for the award of a Bachelor of Science degree in Environmental Management and Toxicology.

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Prof. E. E. Imarhiagbe **Date**

(Project Supervisor)

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Prof. (Mrs) E. T. Aisien
(Head of Department) **Date**

DECLARATION

I **"LUKMAN ROQIBA (MISS)"** declare that **"ASSESSMENT OF OHOVBE WATER QUALITY AND HEALTH STATUS OF RESIDENTS"** is my work and that all sources that I have used or quoted have been acknowledged using complete references and that this work has not been submitted before for any other degree at any other University.

_____ _____

LUKMAN ROQIBA **DATE**

DEDICATION

This report is dedicated to God Almighty, for his guidance and protection during this project. I also want to dedicate this report to my beloved parents Mr Lasis Lukman and Mrs. Romoke Taiwo for their unwavering support, prayers, love and financial assistance throughout my academic journey.

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ABSTRACT

Water is humanity's lifeblood, flowing across all forms of life, culture and economies around the world, it is a human right and a common development denominator for shaping a better future. Clean water is necessary for life, health, and development. It plays a critical role in sustaining ecosystems, supporting agriculture, promoting sanitation, and safeguarding public health. Every type of life depends on water, and thankfully, there is an abundance of water on Earth that will never run out of supply. Despite the optimistic outlook presented above, water scarcity can and frequently does exist, and this trend will only worsen as the world's population grows. Water quality values aren't definite; instead, they are measured according to guidelines from authorized bodies. The quality of drinking water is unequivocally linked to public health. Access to safe and clean water is a fundamental human right and is essential for preventing a significant burden of disease worldwide. Physical parameters influence the aesthetic quality of water and indirectly indicate the presence of pollutants. Water intended for domestic use must be free from pathogenic organisms such as *Salmonella*, *Vibrio cholerae*, and *Escherichia coli*. Ohovbe is a semi-urban area where residents rely primarily on boreholes and wells for drinking and domestic purposes. The socio-demographic data of residents of Ohovbe community were obtained, water access and availability data and also their health status and awareness. The physicochemical and bacteriological parameters of water samples were also analyzed. To safeguard public health, residents should be encouraged to boil or filter their drinking water before consumption, and local authorities should ensure regular monitoring of water sources to maintain compliance with WHO standards

CHAPTER ONE

INTRODUCTION

1.1 Background of study:

Water is humanity's lifeblood, flowing across all forms of life, culture and economies around the world, it is a human right and a common development denominator for shaping a better future (United Nations, 2023). Earth is a planet with 71% of its surface covered by water, of which 97% of this is seawater. Since seawater is rarely available for human consumption, the world population depends on only the 3% available fresh water (Musie and Gonfa, 2023). Water and water resources are very important for maintaining an adequate food supply and a productive environment for all living organisms (UN-Water, 2021). As human populations and economies grow, global freshwater demand has been increasing rapidly (United Nations World Water Assessment Programme, 2021). Clean water is necessary for life, health, and development (WHO, 2022). It plays a critical role in sustaining ecosystems, supporting agriculture, promoting sanitation, and safeguarding public health (Bain *et al*., 2014). According to the World Health Organization (WHO), access to safe and clean drinking water is essential to prevent waterborne diseases such as cholera, dysentery, typhoid, and diarrhea, which claim hundreds of thousands of lives annually, particularly among children under five years of age (WHO, 2023). The United Nations recognizes this importance with Sustainable Development Goal 6, specifically addressing access to safe water and sanitation, emphasizing that universal access to clean water is not only essential to health, but also to poverty reduction, food security, peace and human rights, ecosystem and education (United Nations, 2015). According to (USGS, 2019), water is primarily accessible from two sources; surface water and groundwater

Surface water refers to all the water naturally found above the ground in open spaces, and they include rivers, streams, lakes, wetlands, reservoirs and ponds (Oki and Quiocho, 2020). This water is directly exposed to the atmosphere and is replenished by precipitation or snowmelt, that is rain or snow that fall on the earth surface, and runoff from surrounding lands (Winter *et al*., 1998). Springs are also a source of surface water, as they represent groundwater that emerges naturally to the surface (Todd and Mays, 2005).

As stated by (Gleick, 1993), surface water can be a source of drinking water, as well as domestic activities such as cooking and washing, and has significant use in industries for cooling machinery and generating electricity through hydropower. Surface water is used for recreational activities like boating, fishing, swimming and celebration of festivals especially in West Africa, Nigeria specifically. Furthermore, surface water houses all aquatic life on earth and plays a vital role in balancing and maintaining the aquatic ecosystem (Dudgeon *et al*., 2006).

Groundwater is water beneath the earth's surface, filling the pores and fractures in soil and rock layers (Alley *et al*., 2002). It forms when water from precipitation or surface water infiltrates into the ground and accumulates in aquifers (Freeze and Cherry, 1979). Confined and unconfined aquifers are the two main types. Confined aquifers are trapped between impermeable layers and are usually under pressure, sometimes producing artesian wells, while unconfined aquifers have a water table directly open to the surface, causing water levels to change with rainfall (Fetter, 2001). Groundwater is recharged by infiltration, the seeping of rainwater or melted snow into the ground, and percolation, the downward movement of water through soil layers until it reaches the aquifer (Healy, 2010).

Groundwater is a major source of drinking water, especially in rural or semi-urban areas where municipal water is not readily available (Foster *et al*., 2013). It is also extensively used

in agriculture for irrigation, particularly in arid and semi-arid areas where surface water is scarce (Siebert *et al*., 2010). Additionally, groundwater recharges springs and wetlands, maintaining and balancing their unique ecosystems (Kløve *et al*., 2011).

Despite the very important role of water in public health and the ecosystem, its quality and availability are increasingly threatened by several problems including pollution, poor infrastructure, climate change and unsustainable waste management practices (UNESCO, 2021). Many industries in Nigeria release untreated effluents containing heavy metals (e.g., lead, mercury) and toxic chemicals into rivers (Nwachukwu *et al*., 2010). For example, the Niger Delta suffers from oil spills and hydrocarbon pollution due to the exploration of crude oil (Kadafa, 2012). The excessive use of fertilizers and pesticides for agriculture contaminates ground and surface water with nitrates and phosphates through infiltration and runoff from farm lands (Wu and Sun, 2016). Open defecation and poor sewage systems contribute to fecal contamination of water, leading to waterborne diseases like cholera (Oluwasanya *et al*., 2011). The majority of Nigerians do not have access to properly treated water; only about 10% of Nigeria's population has access to properly treated water (World Bank, 2021).

It is important to note that progress has been made in achieving the Millennium Development Goal (MDG) global water and sanitation target. In September 2015, new global targets for universal access to safe WASH were adopted. At the current rates of progress and using current indicators, achieving those targets will take at least 20 years for water supply and 60 years for sanitation (WHO and UNICEF, 2014).

1.2 Aim and Objectives

The aim of this study is to evaluate the quality of drinking water and the socio-demography of residents of Ohovbe community, Ikpoba-Okha Local Government, Benin-City, Edo State, Nigeria.

The Objectives of this study are to;

1. investigate the physicochemical quality of water samples from Ohovbe community.
2. determine the bacteriological quality of water samples from Ohovbe community.
3. assess the demographic and social characteristics of residents in Ohovbe community.
4. assess the health status of residents in Ohovbe community.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Quality

Water is ubiquitous; the oceans encompass two-thirds of the planet, and water permanently submerges almost 4% of the land mass. In the hydrosphere, water is constantly changing; it first evaporates off the earth's surface, then condenses in the atmosphere, and finally returns as liquid water. Every type of life depends on water, and thankfully, there is an abundance of water on Earth that will never run out of supply. Despite the optimistic outlook presented above, water scarcity can and frequently does exist, and this trend will only worsen as the world's population grows. This happens as a result of uneven watering throughout the earth's landmass. While some areas have plenty of water, others receive little, and during droughts, even well-watered areas may experience water shortages. Water quality also fluctuates over time and between locations. Anthropogenic pollution has lowered the quality of much freshwater and reduced its usefulness, and the majority of the earth's water is too salty for most human purposes. Although evaporation purifies water, contaminants and salts are still present to contaminate the rainwater that returns after evaporation. The relevance of water quality has grown as it is frequently impossible to evaluate the amount of water without considering its quality. Aquatic recreation, fisheries and aquaculture output, ecosystem health, and home, agricultural, and industrial water supplies all depend heavily on water quality. Professionals from a wide range of fields should be aware of the variables influencing water quality concentrations as well as how ecosystems and people are affected by it (Boyd, 2000). Water quality is assessed based on microbial presence, chemical composition, radiation exposure, and permissible limits for physical parameters, inorganic chemicals, organic chemicals, pesticides, and disinfectants together with their by-products (WHO, 2002).

2.1.1 Concept and Measures of Water Quality

According to Chapman 1996, water quality refers to the chemical, physical, biological, and radiological characteristics of water, relative to the requirements of one or more biotic species or any human need or purpose (Chapman, 1996). It is not an absolute measure, but a reflection of the condition of water in relation to the standards set for its intended use, such as drinking, irrigation, industrial processes, or ecosystem health (Tebbutt, 1998). Water quality values aren't definite; instead, they are measured according to guidelines from authorized bodies. The Nigerian Standard for Drinking Water Quality (NSDWQ) was established by the Standard Organization of Nigeria (SON), in line with the World Health Organization (WHO) Guidelines for Drinking Water Quality. Water quality assessment typically covers: physicochemical parameters (temperature, pH, electrical conductivity, turbidity, total dissolved solids, major ions), nutrients that drive eutrophication (nitrate, nitrite, ammonia, phosphate), metal/metalloids (arsenic, lead, chromium, manganese, iron), organic and emerging contaminants (pesticides, hydrocarbons, pharmaceuticals, PFAs, microplastics) and microbiological indicator (*E.coli*, total coliforms) as proxies for faecal contamination. Integrated indices such as Water Quality Index (WQI) or nutrient-related trophic state metrics are used to summarise multi-parameter status for decision making (WHO, 2022, UN-Water, 2023).

2.2 Water Quality and Public Health

The quality of drinking water is unequivocally linked to public health. Access to safe and clean water is a fundamental human right and is essential for preventing a significant burden of disease worldwide (WHO, 2017). Global progress has been uneven: as of 2022, 2.2 billion people still lacked access to safely managed drinking water, and 115 million relied on surface water directly (WHO/UNICEF JMP, 2023). The most immediate and widespread health risk comes from the biological contamination of water sources by animal and human faeces, which transmits diseases such as cholera, typhoid, dysentery, and polio. It is estimated that

contaminated drinking water causes approximately 485,000 diarrhea deaths each year (WHO, 2019).

According to Smith *et al*. (2000), beyond microbial pathogens, chemical contaminants in water pose severe chronic health risks. Long-term exposure to low levels of heavy metals like arsenic can lead to skin lesions and various cancers, while lead exposure is particularly detrimental to children's neurological development (WHO 2010). Excess fluoride can cause dental and skeletal fluorosis, and high nitrate levels in drinking water can lead to methemoglobinemia, or "blue baby syndrome", in infants (Fewtrell, 2004).

The most recent concerns in water contaminations include cyanobacterial toxins (microcystins, cylindrospermopsins, anatoxin-a) associated with eutrophication, PFAS (with evolving guideline frameworks), and microplastics, for which occurrence is documented but health risk characterisation remains under active review (WHO, 2019; WHO, 2023; US EPA, 2024).

2.3 Parameters for Evaluating Water Quality

Water quality parameters are the measurable characteristics of water that determine its suitability for specific uses such as drinking, irrigation, or industrial purposes. These parameters are broadly classified into physical, chemical, and microbiological indicators, each providing distinct information about the state and safety of a water source (Chapman, 1996; WHO, 2019). Evaluating these parameters helps identify pollution sources, assess treatment needs, and ensure compliance with established standards such as the World Health Organization (WHO) guidelines and the Nigerian Standard for Drinking Water Quality (SON, 2015). Water can be divided into four categories based on its quality. The physical, chemical, and biological characteristics of those four types of water quality are thoroughly reviewed in order to discuss them. The definition, origins, impacts, effects, and measurement techniques of these water quality measures are examined (Omer, 2019).

2.3.1 Physical Parameters

Physical parameters influence the aesthetic quality of water and indirectly indicate the presence of pollutants. They include temperature, colour, turbidity, odour, taste, electrical conductivity (EC), and total dissolved solids (TDS).

Temperature: Water temperature affects the rate of chemical reactions, the solubility of gases, and biological activities in aquatic systems. Elevated temperatures reduce dissolved oxygen levels, which in turn affect marine organisms and promote microbial proliferation (Dey *et al*., 2021). Sources of thermal variation include industrial discharge, exposure to sunlight, and shallow water depth.

pH: The pH of a water solution indicates its acidity level. The pH scale usually ranges from 0 to 14. The scale is not linear, but rather logarithmic. A solution with a pH of 6 is 10 times more acidic compared to one with a pH of 7. Pure water has a pH of 7, indicating neutrality. Water with a pH below 7.0 is acidic, and water with a pH over 7.0 is basic or alkaline (Gorde, and Jadhav, 2013). pH is a measure of hydrogen ion concentration, indicating the acidity or alkalinity of water. Most natural waters fall between pH 6.5 and 8.5. Extreme pH values can corrode pipes, alter taste, and affect the toxicity of chemical pollutants (Rahmanian *et al*., 2015). The WHO (2019) recommends pH values between 6.5 and 8.5 for potable water.

Turbidity: Turbidity reflects the cloudiness of water caused by suspended particles like clay, silt, and organic matter. High turbidity reduces light penetration, affects aquatic plant growth, and provides a medium for microbial attachment (Sarwa *et al*., 2018). Turbidity is not a pollutant concentration, but rather a feature that represents the "sum" of other contaminants. It is more cost-effective and easier to evaluate than biological oxygen demand, chemical oxygen demand, suspended solids, and dissolved solids (Chih-Sheng Lee *et al*., 2016). Turbidity values above 5 NTU (Nephelometric Turbidity Units) are considered objectionable for drinking purposes (WHO, 2019).

Electrical Conductivity (EC): EC measures the ability of water to conduct an electric current, which depends on the concentration of dissolved ions such as sodium, calcium, and chloride. High EC indicates mineral contamination or salinity, making the water unsuitable for irrigation and domestic use (Addisie, 2022).

Total Dissolved Solids (TDS): TDS is not considered a primary water pollutant, although it is an indicator of water quality. High amounts of dissolved solids can have a substantial impact on the taste of drinking water. Additionally, excessive TDS levels can lead to scale and corrosion in cooling water and boilers. TDS in water is derived from irrigation returns, urban runoff, natural sources, municipal, road deicing, industrial waste, water treatment chemicals, and the plumbing system itself. Drinking water with high amounts of dissolved solids can change the flavor of the water (O'Connor, 1989). TDS quantifies the combined content of all inorganic and organic substances in water. Excessive TDS affects taste and may lead to scaling in pipes and appliances. The WHO recommends a TDS value below 500 mg/L for drinking water (WHO, 2019).

Colour, Taste, and Odour: These parameters do not directly affect health but serve as sensory indicators of contamination. Unusual odours or tastes can indicate organic pollution, algae, or industrial discharges (Omer, 2019).

2.3.2 Chemical Parameters

Chemical parameters reveal the presence of minerals, nutrients, and pollutants that may have toxicological or ecological effects. These include major cations and anions, nutrients, heavy metals, and organic compounds.

Dissolved Oxygen (DO): Dissolved oxygen (DO) is created when oxygen tiny bubbles interact with water and reside in between water molecules. Water takes oxygen from the atmosphere or through photosynthesis from aquatic plants and algae. It then removes oxygen

through respiration and decomposition of organic materials (Kulkarni, 2016). DO represents the amount of oxygen available in water for aquatic life. Low DO indicates organic pollution and microbial decomposition (Obeta *et al*., 2020). The ideal DO concentration for healthy ecosystems is above 5 mg/L. Aquatic life depends on the water's dissolved oxygen content to survive. Fish, other aquatic species, and plants are impacted when large amounts of organic garbage are dumped into rivers, lakes, and the beach. One indicator of water quality is the amount of dissolved oxygen in the water. Temperature, aquatic life's respiration rate, water pollutants, and water movement are some of the variables that determine how easily oxygen dissolves in water (Kulkarni,2016).

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD): BOD measures the amount of oxygen microorganisms consume while decomposing organic matter, while COD measures the total oxygen required to oxidize both organic and inorganic matter. High BOD and COD levels indicate organic pollution from sewage or industrial discharge (Kumar *et al*., 2017).

Alkalinity and Hardness: Water quality depends on both alkalinity and hardness levels. The two components of water chemistry are often confused. Total alkalinity measures the amount of base in water, including bicarbonates, carbonates, phosphates, and hydroxides. The term "hardness" refers to the concentration of divalent salts (e.g., calcium, magnesium, iron), but it does not specify which element is responsible for the hardness (Wurts, 2002). Alkalinity reflects water's capacity to neutralize acids, mainly due to bicarbonates, carbonates, and hydroxides—hardness results from calcium and magnesium ions. While moderate hardness is not harmful, excessive hardness causes scaling and affects soap efficiency (Saalidong *et al*., 2022).

Nutrients (Nitrates and Phosphates): Excess nutrients lead to eutrophication, algal blooms, and oxygen depletion. The WHO (2019) sets a guideline of 50 mg/L for nitrate in drinking water. Agricultural runoff, fertilizer application, and sewage effluents are familiar nutrient sources (Devlin and Brodie, 2023).

Heavy Metals: Metals such as lead, cadmium, mercury, chromium, and arsenic are highly toxic and bioaccumulative. They may originate from industrial effluents, waste dumps, or corroded pipes (Omoigberale *et al*., 2014). Chronic exposure can cause kidney failure, neurological disorders, and cancers (WHO, 2017).

Chloride and Sulphate: These ions influence taste and corrosivity. High chloride levels often result from saline intrusion or industrial wastewater, while sulphate at concentrations above 250 mg/L can have a laxative effect (WHO, 2019).

Organic Pollutants: These include hydrocarbons, pesticides, and phenolic compounds that may enter water bodies through agricultural or industrial activities. Some are carcinogenic or endocrine-disrupting even at trace concentrations (Sultan *et al*., 2020).

2.3.3 Microbiological Parameters

Microbiological parameters are crucial for detecting disease-causing microorganisms and assessing sanitary quality. Water intended for domestic use must be free from pathogenic organisms such as *Salmonella*, *Vibrio cholerae*, and *Escherichia coli*.

Total Coliforms: These bacteria are indicators of general contamination and the potential presence of pathogens. Coliform counts should not exceed 10 CFU/100 mL in treated water (WHO, 2019).

Faecal Coliforms and *E. coli*: The presence of *E. coli* indicates explicitly faecal contamination from human or animal waste. Its detection calls for immediate investigation and remedial action (Koul *et al*., 2022).

Heterotrophic Plate Count (HPC): Measures total bacterial load in water. Elevated HPC values indicate regrowth in water distribution systems and inadequate treatment (Ngatia *et al*., 2019).

Pathogenic Microorganisms: Protozoa such *as Giardia lamblia* and *Cryptosporidium parvum* are resistant to chlorination and can cause severe gastrointestinal diseases (WHO, 2019). Viruses like hepatitis A and rotavirus may also persist in contaminated water.

Effective monitoring of microbiological parameters requires regular sampling and adherence to WHO and NSDWQ standards. Disinfection methods such as chlorination, UV radiation, and filtration are recommended to control microbial contamination (USEPA, 2024).

2.3.4 Emerging Parameters and Integrated Indices

Recent advances in water quality assessment have included emerging contaminants such as pharmaceutical residues, endocrine disruptors, and microplastics, which are not yet fully regulated but pose potential ecological and health risks (WHO, 2023).

Integrated assessment tools like the Water Quality Index (WQI) are increasingly used to simplify interpretation by converting multi-parameter data into a single numerical value (Sutadian *et al*., 2016). The WQI helps decision-makers and policymakers understand the overall state of water bodies, enabling prioritization of remediation efforts.

Remote sensing, geospatial modelling, and data-driven analytics are now being adopted to more efficiently monitor changes in water quality and predict contamination risks (Ighalo and Adeniyi, 2020).

2.4 Water Quality in Nigeria

Water quality remains a primary environmental and public health concern in Nigeria. Rapid urbanization, population growth, poor waste management, and industrial activities have contributed to widespread water contamination (Ojo *et al*., 2020). The country faces a

growing challenge of ensuring access to safe drinking water, particularly in rural and peri-urban areas where infrastructural and institutional capacities are weak (Nwankwoala and Udom, 2022).

According to the World Health Organization (WHO, 2019), only about 33% of Nigerians have access to safely managed drinking water, while a significant proportion rely on unsafe surface water or shallow wells. The National Bureau of Statistics (NBS, 2021) also reported that 64% of households in rural areas depend on untreated groundwater sources, exposing them to potential contaminants.

Several studies across Nigeria have revealed elevated concentrations of heavy metals such as lead, cadmium, iron, zinc, and arsenic, as well as microbial contamination that exceeds permissible WHO limits (Adegbite *et al*., 2018; Efiong and Udoh, 2021; Ocheri *et al*., 2019). A study by Ogundiran and Afolabi (2018) in Ibadan reported that effluent from metal industries caused elevated lead levels in nearby streams, while Odeyemi *et al*. (2020) found nitrate and phosphate pollution in borehole water in southwestern Nigeria, attributed to fertilizer runoff and poor waste management.

Groundwater, which serves as the primary water supply for most Nigerian communities, is increasingly threatened by indiscriminate waste disposal, open defecation, agricultural runoff, and leachates from dumpsites (Adebola and Oyeleke, 2017; Ighalo and Adeniyi, 2020). Studies in Lagos, Kano, and Benin City also revealed that boreholes located near septic tanks and waste dumpsites recorded high counts of E. coli and total coliforms (Imarhiagbe *et al*., 2023; Okafor *et al*., 2021).

Industrial discharges into rivers and creeks contribute additional contaminants, including organic pollutants, petroleum hydrocarbons, dyes, and heavy metals, which alter water chemistry and reduce aquatic biodiversity (Chukwu e*t al*., 2019; Imarhiagbe *et al*., 2023). For

instance, Ume and Eze (2023) observed that the Warri River showed elevated levels of BOD, COD, and TDS due to effluents from oil and gas operations. The degradation of Nigeria's water quality is further exacerbated by poor enforcement of environmental regulations, insufficient monitoring, and the proliferation of unregulated borehole drilling (Ajibade *et al*., 2021). The absence of functional wastewater treatment facilities in many urban centers allows untreated domestic and industrial effluents to enter water bodies directly (Nwaogazie and Aboh, 2020).

Addressing water quality challenges in Nigeria requires multi-sectoral interventions, including stronger policy implementation, investment in water infrastructure, public awareness campaigns, and community-level water testing programs (Ighalo and Adeniyi, 2020; Eze *et al*., 2022). The integration of geospatial mapping and real-time monitoring technologies can also improve the assessment and management of water resources (Okeke *et al*., 2023).

Overall, the persistence of microbial and chemical contamination highlights the urgent need for sustainable water governance in Nigeria, guided by evidence-based policies and strengthened regulatory frameworks to ensure public health and environmental protection.

2.5 Previous Studies on Water Quality and Contamination

A large body of research (both within Nigeria and internationally) has investigated the extent, causes, and public-health implications of water quality deterioration. These studies collectively highlight recurring problems (microbial contamination, nutrient loading, and heavy-metal pollution), identify primary sources (sewage, agricultural runoff, industrial effluents, and poor waste disposal), and point to seasonal and spatial variability in contamination.

2.5.1 National (Nigerian) studies

Several Nigerian investigations have documented widespread microbial and chemical pollution of both surface and groundwater. (Erah *et al*., 2002) provided early evidence of faecal contamination and elevated heavy-metal concentrations in urban groundwater, raising concerns about long-term exposure. More recent surveys in major cities report consistent patterns: boreholes and shallow wells near septic tanks, refuse dumps, or agricultural areas frequently show high total coliform and *E. coli* counts, particularly during the rainy season when runoff increases (Taiwo *et al*., 2021; Okafor *et al*., 2021).

Investigations of industrial impacts in and around Benin City and other industrial hubs have repeatedly linked effluent discharge to elevated BOD, COD, petroleum hydrocarbons, and heavy metals in adjacent rivers and streams (Adams *et al*., 2016; Chukwu *et al*., 2019). Studies in Lagos and Kano similarly reported exceedances of WHO limits for lead, cadmium, and chromium in specific surface-water samples, attributed to informal industrial activities and poor effluent control (Adegbite *et al*., 2018; Ogundiran and Afolabi, 2018).

Agricultural areas have been associated with elevated nitrate and phosphate levels in groundwater, evidence of fertilizer leaching and improper waste management (Odeyemi *et al*., 2020). Localized studies have also found antibiotic-resistant bacterial strains in borehole water, suggesting both environmental contamination and potential public-health complications (Foka *et al*., 2018). Collectively, Nigerian studies emphasise that infrastructural gaps (poor sanitation, unregulated borehole drilling) and weak enforcement of effluent standards are major drivers of persistent water-quality problems (Ighalo & Adeniyi, 2020; Ajibade *et al*., 2021).

2.5.2 International studies and comparative findings

International literature provides both confirmation and a broader context. In many low- and middle-income countries (LMICs), microbial contamination of household water remains the

dominant short-term health risk (Luby *et al*., 2015; Bain *et al*., 2014). Multi-country analyses show that proximity to sanitation sources, household water storage practices, and seasonal rainfall explain much of the within-country variability in contamination (McGarvey *et al*., 2008; Vannavong *et al*., 2018).

Studies from South and Southeast Asia report similar patterns of agricultural nitrate pollution and arsenic geogenic contamination in groundwater aquifers, illustrating how natural geology and anthropogenic inputs can combine to create chronic exposure risks (Murray and Sharmin, 2015; Bhattacharya *et al*., 2016). Research from sub-Saharan Africa and Latin America has documented the rising concern of emerging contaminants (pharmaceuticals, personal-care products, and microplastics) in both treated and untreated waters; although their human-health impacts are still under active study, these contaminants complicate conventional monitoring and treatment strategies (WHO, 2023; Lapworth *et al*., 2018).

Comparative work also stresses the value of integrated approaches: combining microbiological testing with physicochemical assays and socio-behavioural surveys provides the best explanation for health outcomes (Luby *et al*., 2015; Ngatia *et al*., 2019). Intervention studies indicate that simple household-level measures (safe storage, point-of-use chlorination or filtration) can substantially reduce microbial contamination and diarrhoeal disease, but sustained improvement requires community infrastructure and governance (Clasen *et al*., 2015; Null *et al*., 2018).

2.5.3 Key gaps and implications for the present study

Although the national and international literature is substantial, significant gaps remain that are directly relevant to community-level assessments like the present study. First, many Nigerian studies are cross-sectional and capture contamination at a single time point; fewer studies provide seasonal time-series data to quantify rainy-season spikes in contamination. Second, while chemical and microbiological testing are common, fewer studies integrate

heavy-metal speciation, emerging contaminants, and antibiotic-resistance profiling into the same sampling regime. Finally, socio-demographic correlates (education, income, water-handling practices) are variably measured, limiting the understanding of behavioural drivers of contamination.

For these reasons, community-focused studies that combine physicochemical, microbiological, and socio-demographic analyses (with attention to seasonal variability) are particularly valuable for designing targeted interventions and informing local governance. The present study aims to address some of these gaps by pairing laboratory analyses with household surveys to link water quality metrics to household practices and perceptions.

2.6 Socio-Demographic Factors Influencing Drinking Water Contamination Risk in Households

Socio-demographic factors play a crucial role in determining the extent of drinking water contamination and exposure risk at the household level. Beyond the physical and chemical characteristics of water sources, variables such as income, education, occupation, gender, household size, and awareness levels influence how water is accessed, stored, and treated — all of which affect water safety (Thakur *et al*., 2022; Olarewaju and Olurinola, 2019).

Education and Awareness: Education is one of the most significant determinants of household water safety practices. Studies have shown that households with higher educational attainment are more likely to adopt hygienic practices such as boiling, filtration, or chlorination, and to recognize unsafe water indicators (Aziz *et al*., 2018; Eze *et al*., 2022). In rural Nigeria, low literacy levels often correlate with limited understanding of contamination risks and improper handling of water during collection and storage (Olarewaju and Olurinola, 2019). Educational interventions have been shown to improve water handling and sanitation behaviour, leading to reductions in diarrhoeal disease incidence (Clasen *et al*., 2015; Feleke *et al*., 2023).

Income and Socioeconomic Status: Income and occupation determine access to improved water sources and the ability to invest in water treatment or safe storage technologies. Low-income households frequently rely on shallow wells, streams, or untreated groundwater, which are more vulnerable to microbial contamination (Ajibade *et al*., 2021; Nwankwoala and Udom, 2022). Conversely, higher-income groups are more likely to have piped connections or purchase bottled water, thereby reducing direct exposure risks (Adebola and Oyeleke, 2017). Poverty also constrains the adoption of maintenance and treatment practices, even when awareness exists (Ocheri *et al*., 2019).

Household Size and Gender Roles: Household size can influence both water consumption patterns and storage duration. Large families tend to store water for more extended periods, increasing the risk of microbial regrowth and recontamination in storage containers (Luby *et al*., 2015; Ngatia *et al*., 2019). In many Nigerian and sub-Saharan African communities, women and children are primarily responsible for water collection, making them more exposed to unsafe water sources and contamination risks (Bain *et al*., 2014; UNICEF, 2022). Gendered division of labour also affects decision-making power over water treatment or infrastructure investment, often limiting women's ability to implement safe practices (Eze *et al*., 2022).

Cultural and Behavioural Practices: Cultural beliefs and local perceptions of water purity can influence whether households treat water before consumption. In some rural communities, clear or odourless water is assumed to be safe, regardless of microbial content (Foka *et al*., 2018; Thakur *et al*., 2022). Open storage, use of unclean containers, and dipping cups into large storage vessels are common behavioural risk factors facilitating recontamination after collection (Clasen *et al*., 2015; Luby *et al*., 2015). Such practices persist due to cultural norms or convenience, emphasizing the need for culturally tailored awareness programs.

Access to Infrastructure and Institutional Support: The presence or absence of reliable water infrastructure and institutional support systems is another key socio-demographic factor. Rural households, especially in informal settlements, often lack access to piped water networks or community boreholes and rely on self-supply through unregulated wells (Ojo *et al*., 2020). Weak enforcement of environmental regulations, limited community participation, and inadequate investment in rural water schemes exacerbate exposure risks (Ajibade *et al*., 2021; Imarhiagbe and Eghomwanre, 2023). Integration of socio-demographic insights into water quality policy is critical for designing equitable interventions that address both behavioural and infrastructural determinants of contamination risk (Eze *et al*., 2022; UNICEF, 2022).

In summary, socio-demographic factors mediate both direct and indirect pathways of water contamination in households. Effective risk mitigation, therefore, requires a holistic approach that combines environmental monitoring with socioeconomic and behavioural interventions. Strengthening public education, empowering women, and improving infrastructure in low-income areas are central to achieving sustainable access to safe drinking water in Nigeria and other developing regions.

CHAPTER 3

MATERIALS AND METHODS

3.1 STUDY AREA

This study was carried out in Ohovbe community, located in Ikpoba-Okha Local Government Area, Benin City, Edo state. Ohovbe is a semi-urban area where residents rely primarily on boreholes and wells for drinking and domestic purposes. The community lies within the humid tropical rainforest zone of southern Nigeria, with a coordinate of 6°20'46.9"N 5°41'20.8"E respectively. The global positioning coordinates of the study area are approximately located at 6°21'05"N 5°38'15"E, 6°21'10"N 5°38'25"E, 6°20'50"N 5°38'10"E, 6°20'45"N 5°38'20"E, respectively.

3.2 RESEARCH DESIGN

The study employed an observational survey approach. Data collection involved structured questionnaires and laboratory tests. The questionnaire, adapted from Imarhiagbe and Eghomwanre (2023), was divided into three parts: Section A covered respondents' demographic data, Section B addressed water availability and access within the community, and Section C evaluated respondents' health and awareness levels.

A total of 220 questionnaires were administered to randomly selected households in Ohovbe using simple random sampling. In addition, water samples were collected for both physicochemical and bacteriological analyses following standard procedures outlined by the American Public Health Association (APHA, 2005) and Cheesbrough (2000).

3.3 SAMPLE COLLECTION

Water samples were collected from different sources, including boreholes and wells within the community. These samples were collected with the aid of clean and sterilized sample bottles, which were properly labeled to indicate the sampling site and water source.

Duplicate water samples were collected and immediately transported in ice boxes to the Department of Chemistry's Laboratory and Department of Pharmaceutical Microbiology's laboratory, for physicochemical and bacteriological analysis investigation respectively.

3.4 DETERMINATION OF PHYSICOCHEMICAL PARAMETERS

Physicochemical tests (APHA, 2005) were carried out to determine the quality, suitability and safety of household drinking water as recommended by the World Health Organization permissible limits (WHO, 2011). The parameters assessed included pH, Electrical Conductivity (EC), Nitrate, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Calcium, and Sodium, Iron (Fe)

3.4.1 Hydrogen Ion Concentration (pH)

The pH of the samples was measured using a Hanna® pH meter (Hi-1922 model). The instrument was calibrated with buffer solutions of pH 4, 7, and 10 before use. The pH meter was calibrated before use by immersing the probe in each buffer solution to adjust the meter to the corresponding pH value. Twenty milliliters (20 mL) of each water sample were poured into separate beakers, and the probe was immersed in each sample until a stable reading was obtained.

3.4.2 Electrical Conductivity (EC) (µS/cm)

A conductivity meter (WTW Series Cond 730) was used to measure the conductivity of the water samples. The meter was first calibrated with 0.01M potassium chloride (KCl), then 100mL of water samples were measured into beakers and their conductivity was determined by placing the meter probe into the water sample. The probe was held in the beaker for a few minutes until the digital display reading stabilized

Plate 3.1: Source of sample 6

3.4.3 Nitrate (mg/L)

The HACH® colorimeter (DR/890) was used in the analysis of nitrate. 10mL of distilled water was measured into the blank cell. After entering the program number (54), the blank cell was used to zero the equipment by inserting it into the cell holder, replacing the cap and pressing the zero button. Ten milliliters (10 mL) of each sample were measured, and one pack of NitraVer 5 reagent powder was added. The mixture was allowed to stand for five minutes before the reading was taken by inserting the sample cell into the cell holder, and the concentration was displayed on the screen in milligrams per liter (mg/L).

3.4.4 Total Dissolved Solids (TDS) (mg/L)

A 100 mL water sample was filtered through a 0.45 µm membrane filter to remove suspended solids. The filtered sample was then evaporated in a drying oven at 180°C for 24 hours. The residue was weighed and the TDS concentration was calculated as mg/L. The results were recorded and compared to standard guidelines for TDS levels in drinking water. The Total Dissolved Solids (TDS) test was performed to determine the concentration of dissolved solids in each water sample.

3.4.5 Total Suspended Solids (TSS) (mg/L)

A 100 mL water sample was filtered through a pre-weighed 0.45 µm membrane filter. The filter was then dried in a drying oven at 105°C for 24 hours. The filter was re-weighed and the TSS concentration was calculated as mg/L by subtracting the initial filter weight from the final weight and the results were recorded.

$$TSS(Mg/L) = \frac{Final\ Filter\ Weight \times Initial\ Filter\ Weight \times 1000}{Sample\ Volume\ (mL)}$$

3.4.6 Calcium (mg/L)

A 10 mL water sample was titrated with 0.01 M Ethylenediaminetetraacetic acid (EDTA) solution using a Eriochrome Black T (EBT) as an indicator. The titration was continued until the color changed from blue to red, indicating the endpoint. The calcium ion concentration was calculated using the formula:

$$Calcium(Mg/L) = \frac{Volume\ of\ EDTA \times Molarity\ of\ EDTA \times 40.08}{Sample\ Volume\ (mL)}$$

3.4.7 Sodium (mg/L)

The sodium test was performed using a flame photometer. A 10 mL water sample was aspirated into the instrument, and the emission intensity was measured at a wavelength of 589 nm. The instrument was calibrated using sodium chloride standards. The water sample was analyzed, and the sodium concentration was determined by comparing the emission intensity to the calibration curve. The result was recorded in milligrams per liter (mg/L) of sodium.

3.5 PROCEDURE FOR BACTERIOLOGICAL TEST

Evaluating the various characteristics of bacteria present in a sample is essential for determining its bacteriological parameters. This involves identifying pathogenic species, detecting specific bacterial types, estimating the total bacterial population, and examining bacterial growth patterns, among other factors. Different analytical methods, such as culturing, microscopic examination, and biochemical tests, can be employed depending on the parameter of interest. In this study, total coliform and heterotrophic bacterial counts in the water samples were determined using the standard plate count technique on nutrient agar (NA) as described by Cheesbrough (2000).

3.5.1 Sterilization of Materials and Apparatus

A sterilization process was followed for all materials and apparatus. Items such as petri dishes, pipettes, and glass containers were first dried, then wrapped in aluminum foil and sterilized for one hour at 160°C in a hot-air oven. After cooling, they were ready for use. The work area was rendered aseptic by swabbing surfaces with alcohol and employing a Bunsen burner flame. The study utilized Oxoid brand media; Plate Count Agar, Triple Sugar Iron Agar, and Simmons Citrate Agar. Each was prepared according to the supplier's guidelines. Other essential equipment included an incubator, autoclave, microscope, forceps, test tubes, and micropipettes.

3.5.2 Heterotrophic Plate Count (HPC) using Nutrient Agar:

The heterotrophic plate count (HPC) was employed using the pour plate technique to enumerate viable heterotrophic bacteria in the water samples. These bacteria, which utilize organic carbon for growth and are common in aquatic environments, serve as a key indicator of water quality, where elevated levels can signal significant changes. In this procedure, 1 mL of each water sample was aseptically transferred to a sterile petri dish. Molten Nutrient Agar, tempered to approximately 45°C, was then added to each dish. The mixture was swirled gently for homogenization and allowed to solidify. Following incubation at 35°C for 24 hours, the resulting colonies were counted and recorded as colony-forming units per milliliter (CFU/mL).

3.5.3 Presumptive Coliform Plate Count Using MacConkey Agar:

The presumptive coliform count specifically targets coliform bacteria, a group of Gram-negative, lactose-fermenting organisms often associated with the intestinal tract of warm-blooded animals. Their presence in water is a critical indicator of potential fecal contamination and the possible presence of enteric pathogens. This analysis was performed using the pour plate method with MacConkey Agar, a medium that is both selective and differential. Its selectivity inhibits Gram-positive bacteria, while its differential capability

allows for the identification of lactose fermenters. In the procedure, 1 mL of each water sample was transferred to a sterile petri dish, followed by the addition of molten MacConkey Agar. After mixing and solidification, the plates were inverted and incubated at 35°C for 24 hours. Following incubation, only the pink-to-red colonies, indicative of lactose-fermenting presumptive coliforms, were enumerated, and the results were recorded as colony-forming units per milliliter (CFU/mL).

3.5.4 Phenotypic Identification of Bacterial

To identify the bacteria present in the water samples, a series of phenotypic tests were conducted on pure cultures. These cultures were obtained by subculturing a single, well-isolated colony from the initial pour plates. The identification process was based on observing the cultural characteristics, cellular morphology, and metabolic profile of each isolate. Key biochemical tests performed included the Gram stain to classify cell wall type, catalase for enzyme detection, oxidase for respiratory metabolism, and assessments of specific metabolic capabilities like urease activity, indole production, and citrate utilization. Furthermore, the reactions of each isolate on Triple Sugar Iron (TSI) agar were carefully interpreted. The collective results from this battery of tests enabled the presumptive identification of the bacterial isolates to the genus or species level.

3.5.5 Biochemical Characterization of Bacterial Isolates

To enable the presumptive identification of the bacterial isolates, a series of biochemical tests were conducted to profile their metabolic capabilities. The specific tests performed and their respective procedures are detailed below.

3.5.6 Triple Sugar Iron (TSI) Agar Test

The TSI test was employed to determine an isolate's ability to ferment glucose, lactose, and sucrose and to produce hydrogen sulfide (H_2S) gas. Each isolate was inoculated into a TSI agar slant using a sterile needle, first by stabbing the butt and then streaking the slant's

surface. The tubes were incubated at 36°C for 24 hours. A color change from red to yellow in the agar indicated acid production from sugar fermentation. An alkaline (red) slant with an acid (yellow) butt signified glucose fermentation only, while an acid (yellow) slant and butt indicated fermentation of lactose and/or sucrose. The formation of a black precipitate denoted H_2S production, and bubbles or cracks in the medium signified gas production.

3.5.7 Bile Esculin Test

This test was used to identify organisms capable of hydrolyzing esculin in the presence of bile. Isolates were streaked onto bile esculin agar plates and incubated at 37°C for 24-48 hours. A positive result, indicated by a black or dark brown coloration of the medium, confirmed the ability of the bacterium to grow in the presence of bile and hydrolyze esculin.

3.5.8 Citrate Utilization Test

The citrate test differentiated bacteria based on their ability to utilize citrate as a sole carbon source. Isolates were streaked onto the surface of Simmons citrate agar slants and incubated at 37°C for 24 hours. A positive result was indicated by bacterial growth and a color change of the medium from green to a distinct blue, due to a rise in pH.

3.5.9 Hektoen Enteric Agar (HEA)

HEA was used as a selective and differential medium to isolate and distinguish Salmonella and Shigella species from other enteric bacteria. Water samples were streaked directly onto HEA plates to obtain isolated colonies and incubated at 37°C for 24 hours. Lactose-fermenting bacteria produced yellow to salmon-colored colonies, while non-lactose fermenters, such as potential Shigella species, formed green to blue-green colonies.

3.6 HEAVY METAL ANALYSIS (IRON Fe)

The concentration of iron (Fe) in the water samples was determined using Atomic Absorption Spectrophotometry (AAS). Before analysis, the samples were pre-treated to ensure the metals were in a soluble form for accurate detection. This was done by acidifying 100 mL of each sample with 1 mL of concentrated nitric acid (HNO_3) and then autoclaving the mixtures for

one hour. The AAS analysis operated on the principle of light absorption by free atoms in the gaseous state. The instrument was configured for iron, utilizing a hollow cathode lamp that emitted a specific characteristic wavelength of 230 nm. This light was directed through the aspirated sample within a flame. The monochromator selected the precise wavelength, which was then measured by a photomultiplier tube. The resulting attenuation of the light signal, proportional to the iron concentration in the sample, was processed and displayed by the instrument's detection system.

CHAPTER 4

RESULT

The socio-demographic data of residents of Ohovbe community were obtained, water access and availability data and also their health status and awareness. The physicochemical and bacteriological parameters of water samples were also analyzed.

The result obtained from the questionnaire survey for the socio-demography, water access and availability and health status and awareness of Ohovbe residents are represented in table 4.1, 4.2 and 4.3 respectively.

A total number of 220 people responded to the questionnaires. Table 4.1 shows the socio-demographic characteristics of Ohovbe respondents, of which (42.9%) were male while the majorities were female (57.1%). The highest age range of respondents fell between 21-24 years (32.3%). Respondents had tertiary level of education (82.6%), secondary level of education (16.4%), primary level of education (1.8%), vocational education (1.8%) and no formal education (0.5%) being the lowest. Most respondents were students (57.1%) followed by civil-servants (15.5%). Small households (43.2%) were prevalent amongst the respondents. The results from Table 4.2 shows that the sources of drinking water available in the area were borehole (48.4%), sachet (46.6%), piped water (2.3%), well water (1.4%), river/stream (0.9%) and rain water being the lowest (0.5%), which were located less than 100 meters from their residential premises (83.9%) in most cases. The survey also showed that 78.2% had access to clean water always and 76.5% of the respondent do not treat their water before drinking it, while 23.5% treated their water before drinking it. 52.7% of the respondents that treats their water before drinking, treat their water by boiling it. 74% of respondents admitted that they have problem with water supply, and the major problem they had with water supply was poor taste (42.8%). 68.9% of respondents said their means of water supply was reliable throughout

the year, while 31.5% could not reply on their main source of drinking water throughout the year, and they mostly had this issue during the dry season (95.2%). 93.5 0f respondents facing this issue had alternative drinking water sources, which are, borehole (83.0%), sachet water (43.8%), well water (15.8%), rain water (7.9%), river/stream (4.0%), and majority of the respondents stored their water in covered containers (86.9%). 56.5% of respondents and the members of their household have experienced illness after drinking water, and 44.4% of respondents and their household members have not. They experienced Typhoid (50.4%), Diarrhea (loose stools) (16.5%), Cholera (10.5%), other illnesses that were not mentioned (22.6%), and Dysentery (loose stools with blood). It is important to note that majority of respondents and members of their household rarely fell ill (51.9%). The results of the physicochemical quality of the water samples collected from sample 1 to sample 15 are indicated in table 4.4 below. The pH of the water samples ranged from 4.55 (sample 1) to 5.97 (sample 15). The Electrical conductivity of the water samples ranged from 113.7 µS/cm (sample 1) to 7.2 µS/cm (sample 15). The Total Suspended Solids (TSS) of the water samples ranges from 0.081 (sample 1) to 0.000 (sample 15) mg/L. The Total Dissolved Solids (TDS) of the water samples ranged from 62.54 (sample 1) to 3.90 (sample 2) mg/L. Calcium was not detected in all samples expect sample 15, and it ranging from 0.60 (sample 1) to 0.20 (sample 14) mg/L. Sodium, also was detected in all samples except sample 15, ranging from 17.2 (sample 1) to 2.2 (sample 14) mg/L. Iron was detected in all 15 samples ranging 0.02 (sample 1) to 0.01 sample 15. Nitrate was also detected in all samples except that it was Not Stated in 10. Nitrate ranged from 78.37 (sample 1) to 86.22 (sample 15) mg/L. The findings of the enumeration of hetetrophic bacteria count and presumptive coliform count of the water samples are shown in table 4.5 below. For the hetertrophic bacteria count, sample 14 had the highest count, and also sample 14 had the highest count for the presumptive coliform count.

Table 4.6 shows the bacteria isolated from the water samples based on their gram and biochemical test.

They are *Staphylococcus a., Bacillus cereus, Coryne bacterium, Klebsiella spp, Bacilluss alvei, Staphylococcus alvei, Bacillus subtilis*

Table 4.1: Socio-demography of respondents in Ohovbe Community

S/N	Parameter	Category/Option	Frequency (n)	Percent (%)
1	**Sex**	**Female**	124	57.1%
		Male	93	42.9%
2	**Age**	**Below 15yrs**	1	0.5%
		15-17yrs	14	6.4%
		18-20yrs	59	27.8%
		21-24yrs	71	32.3%
		25-30yrs	39	17.7%
		31-40yrs	23	10.5%
		41-50yrs	10	4.5%
		Above 50yrs	5	2.3%
3	**Level of Education**	**No formal**	1	0.5%
		Education	3	1.4%
		Vocational	4	1.8%
		Primary	36	16.4%
		Secondary	181	82.6%
		Tertiary		
4	**Marital Status**	**Married**	39	18.1%
		Co-habiting	6	2.8%
		Single	165	76.6%
		Divorced	2	0.9%
		Widowed	1	0.5%
5	**Occupation**	**Farmer**	7	3.2%
		Trader	19	8.7%
		Student	125	57.1%
		Civil servant	34	15.5%
		Artisan	6	2.7%
		Unemployed	18	8.3%
		Event planner	1	0.5%
		Entrepreneur	4	2.0%
		Photographer	1	0.5%
		Self employed	1	0.5%
		Designer	1	0.5%
		Writer	1	0.5%
		Video editor	1	0.5%
		School teacher	1	0.5%
		Technician	1	0.5%
6	**Types of Residential building and household size**	**Flat**	47	21.4%
		One room apartment	3	0.5%
		Two rooms apartment	9	2.3%
		Family house	5	1.4%
		Duplex	1	0.5%
		Small household	95	43.2%

		Medium household **Large household**	65 3	29.5% 1.4%
7	**Income level**	**Below 10,000** **10,000 - 50,000** **50,000 - 100,000** **100,001 – 150,000** **Above 150,000**	10 39 63 40 66	4.7% 18.2% 29.4% 18.7% 30.8%

Table 4.2: Water Access and Availability in Ohovbe Community

S/N	Parameters	Category	Frequency (n)	Percent (%)
1	**Main source of drinking water**	River/Stream Well Borehole Rainwater Piped water Bottled/sachet water	2 3 106 1 5 102	0.9% 1.4% 48.4% 0.5% 2.3% 46.6%
2	**How far is the main source of drinking water from your home**	Less than 100 meters 100-500 meters 500-1000 meters More than 1000 meters	183 26 10 3	83.9% 11.9% 4.6% 1.4%

3	**How often do you have access to clean drinking water**	Always Most of the time Sometimes Rarely Never	172 37 10 1 0	78.2% 16.8% 4.6% 0.5% 0
4	**Do you treat your drinking water before use**	Yes No	51 166	23.5% 76.5%
5	**If yes, what method do you use to treat your water**	Boiling Filtration Chemical treatment Alum Others	39 23 8 1 2	52.7% 31.1% 1.4% 2.8%
5	**Have you faced any problems with water supply**	Yes No	162 63	74% 28.8%
6	**If yes, what kind of problems**	Contamination Intermittent supply Poor taste Bad odor High cost Colour change	29 61 74 28 18 2	16.8% 35.1% 42.8% 16.2% 10.4% 0.12%
7	**Is your main source of water reliable throughout the year**	Yes No	151 69	68.9% 31.5%
8	**If no, which season do you face water scarcity**	Dry season Rainy season	79 6	95.2% 7.5%
9	**Do you have alternative water sources in case of main water source failure**	Yes No	200 16	93.5% 7.9%
10	**If yes, what are the alternative water sources**	River/stream Well Borehole Rainwater Bottled/sachet water	4 32 83 16 89	2.0% 15.8% 83.0% 7.9% 43.8%

11	**How do store your drinking water**	Covered container Uncovered container Other	189 13 17	87.9% 6% 7.9%

Table 4.3: Health and awareness of Ohovbe residents

S/N	Parameters	Category	Frequency	Percent
1	**Have you or any of your household experienced any illness after drinking water in the past year**	Yes No	122 96	56.5% 44.4%
2	**If yes, what type of waterborne diseases**	Diarrhea (loose stools) Cholera Typhoid Dysentery (loose stools with blood) Others	22 14 67 11 30	16.5% 10.5% 50.4% 8.3% 22.6%
3	**How often do you or your family members fall ill**	Rarely Occasionally Frequently Very frequently	110 95 9 0	51.9% 44.8% 4.2% 0%

Table 4.4: Physicochemical parameters of water samples collected from Ohovbe Community

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	WHO
pH	4.55	5.78	6.23	6.98	6.67	5.39	6.70	6.12	5.78	6.12	5.47	5.78	5.08	5.98	5.97	6.5-8.5
EC µS/cm	113.7	61.9	88.2	49.9	74.2	73.7	62.2	88.6	11.0	61.6	55.1	50.9	135.9	28.9	7.2	400
TSS mg/L	0.081	0.010	0.012	0.003	0.015	0.012	0.011	0.019	0.001	0.009	0.007	0.003	0.061	0.001	0.000	25
TDS mg/L	62.54	34.05	48.51	27.45	40.81	40.54	34.21	48.73	6.05	33.85	30.31	28.00	74.58	15.90	3.90	1000
Ca mg/L	0.60	0.20	0.20	0.20	2.40	7.2	0.1	2.1	0.2	0.00	0.40	0.10	2.10	0.20	0.00	≤500
Na mg/L	17.2	7.8	17.1	1.80	6.5	5.9	0.2	16.7	0.30	3.9	8.9	4.2	17.9	2.2	0.00	≤200
Fe mg/L	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	≤0.3
Nitrate mg/L	78.37	61.98	62.39	75.28	72.52	90.52	57.97	76.33	86.53	NS	69.55	54.01	92.47	46.64	86.22	≤50

Keys: Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Sodium (Na), Calcium (Ca), Nitrate (NO_3), Iron (Fe), World Health Organization recommended standards (WHO)

Table 4.5: Enumeration of bacterial population in water samples collected from Ohovbe community

Samples	Total presumptive coliform count	Heterotrophic bacterial count
Sample 1	0	TNTC
Sample 2	0	1.17×10^5
Sample 3	0	0
Sample 4	0	0
Sample 5	0	2.5×10^4
Sample 6	2.17×10^3	2.67×10^4
Sample 7	0	1.17×10^4
Sample 8	0	2.33×10^4
Sample 9	0	1.33×10^4
Sample 10	0	0
Sample 11	0	0
Sample 12	0	2×10^4
Sample 13	0	2.17×10^3
Sample 14	6.7×10^2	7×10^4
Sample 15	0	5×10^2

Keys: too Numerous to Count (TNTC).

Table 4.6: Biochemical Test

Samples	Gram	Bacteria present
Sample 1	GpC	*Staphylococcus a.*
Sample 2	GpB	*Bacillus cereus*
Sample 5	GpB	*Coryne bacterium*
Sample 6	GNB	*Klebsiella spp*
Sample 6	GpB	*Bacillus alvei*
Sample 7	GpB	*Coryne bacterium*
Sample 7	GpC	*Staphylococcus a.*
Sample 8	GpB	*Coryne bacterium*
Sample 8	GpB	*Bacillus alvei*
Sample 9	GpC	*Staphylococcus a.*
Sample 12	GpC	*Staphylococcus a.*
Sample 12	GpB	*Bacillus subtilis*
Sample 13	GpC	*Staphylococcus a.*
Sample 13	GpB	*Staphylococcus alvei*
Sample 14	GNB	*Klebsiella oxytoca*
Sample 14	GpB	*Bacillus alvei*
Sample 15	GpB	*Bacillus subtilis*

Keys: GpB (Gram positive bacilli), GpC (Gram positive cocci), GNB (Gram Negative bacilli)

CHAPTER FIVE

5.1 DISCUSSION

The socio-demographic data obtained from this study provide valuable insights into the characteristics of residents in Ohovbe community. Out of the 220 respondents, females constituted the majority (57.1%), while males made up 42.9%. Most respondents were young adults between the ages of 21 and 24 years (32.3%), representing a youthful and socially active population that is likely to be receptive to public health messages. A large proportion of the participants had tertiary education (82.6%), showing a generally literate community. This finding supports the view of Obiakor *et al*. (2021), who observed that education plays a critical role in influencing environmental and health behaviors. Most respondents were students (57.1%), followed by civil servants (15.5%), which reflects the semi-urban and academic character of the community. The income distribution indicated that 30.8% earned above ₦150,000 monthly, suggesting a moderate to high socioeconomic status among a portion of the population. Socioeconomic and educational levels are major determinants of access to clean water and sanitation services (WHO and UNICEF, 2023), and such factors often influence household hygiene practices and health outcomes. The analysis of water access and availability revealed that boreholes (48.4%) and sachet water (46.6%) were the major sources of drinking water in the community. This finding agrees with observations in other Nigerian towns, where unreliable public water supply has led residents to rely heavily on privately owned boreholes and commercially packaged sachet water (Olaoye and Onilude, 2021). Although sachet water is widely consumed because of its convenience and affordability, its safety is sometimes compromised due to poor handling, packaging, and storage conditions (Adeniran et al., 2022).

Most respondents (83.9%) reported that their main water source was located within 100 meters of their homes, indicating good physical access to water. However, proximity to residential areas can also expose water sources to contamination, especially in areas where waste disposal and sanitation are poorly managed (Odonkor and Ampofo, 2013). Although 78.2% of respondents claimed they always had access to clean water, only 23.5% reported treating their water before drinking. Among those who did, boiling was the most common method (52.7%), which aligns with Medema and Hrudey (2019), who noted that boiling remains an effective way to kill harmful microorganisms. Despite this, 74% of the respondents experienced water-related problems, with the most common complaints being poor taste (42.8%) and intermittent supply (35.1%). These issues may be linked to chemical impurities or microbial contamination, both of which affect the taste and odour of water (Mezgebe *et al*., 2015). Furthermore, 56.5% of respondents or their household members had suffered from waterborne diseases such as typhoid (50.4%), diarrhoea (16.5%), and cholera (10.5%). Such high disease prevalence suggests that water contamination remains a major public health challenge in the area (WHO, 2023; CDC, 2024). The physicochemical analysis of the water samples provided further evidence of quality concerns. The pH values ranged from 4.55 to 5.97, which are below the WHO recommended range of 6.5–8.5 (WHO, 2017). This indicates that the water is slightly acidic and could cause corrosion of pipes and metal containers, leading to further contamination. Prolonged consumption of acidic water can cause skin irritation and gastrointestinal discomfort (Dewangan *et al.,* 2023). The electrical conductivity (7.2–113.7 µS/cm) and total dissolved solids (3.90–74.58 mg/L) values were both below WHO limits, suggesting that the water is not heavily mineralized. However, nitrate levels ranged between 46.64 and 92.47 mg/L, which exceeded the WHO permissible limit of 50 mg/L in some samples. High nitrate concentrations in drinking

water are hazardous, especially for infants, as they can cause methemoglobinemia or "blue baby syndrome" (WHO, 2011; EPA, 2022). The iron content of the water ranged between 0.01 and 0.03 mg/L, which falls within the WHO guideline of 0.3 mg/L, while sodium and calcium concentrations were also within acceptable limits. These results suggest that the water is chemically safe in most respects, except for its acidity and elevated nitrate levels, which may result from agricultural runoff or seepage of organic waste (Fondriest, 2025).

Bacteriological analysis revealed the presence of several bacterial species, including *Staphylococcus aureus*, *Klebsiella spp*., *Bacillus subtilis*, and *Corynebacterium spp*. The highest heterotrophic and coliform counts were recorded in sample 14, which also contained *Klebsiella oxytoca*. According to WHO (2023), drinking water should contain no coliforms in 100 mL; thus, the detection of these organisms indicates faecal contamination, most likely due to leaking septic tanks, improper waste disposal, or unhygienic water storage practices (Anyanwu and Okoli, 2012). The bacterial isolates identified in this study are known to cause various infections, including diarrhoea, typhoid, urinary tract infections, and pneumonia (Abulreesh *et al*., 2012). These results support the health reports from respondents, confirming a strong link between water quality and the prevalence of waterborne diseases in the community. Similar findings have been reported by *Adesakin et al*., (2020) and Obubu *et al*., (2019) in other parts of southern Nigeria, where borehole and sachet water were also found to contain pathogenic bacteria.

Overall, the findings from this study highlight the importance of ensuring not just water availability but also water safety. Although many households in Ohovbe have access to water, the poor quality and presence of bacterial contaminants pose serious health risks. Socioeconomic and educational factors also play an important role in shaping how people manage their water

resources. Residents with higher education and income are more likely to treat their water and practice good hygiene, while those with limited resources are more vulnerable to health problems (Wirayuda and Chan, 2021). Therefore, improving the quality of water in Ohovbe community requires both infrastructural development and continuous public health education.

5.2 CONCLUSION

This study has revealed that while residents of Ohovbe community have relatively good access to water sources, the quality of the water remains unsatisfactory for direct human consumption. The analysis showed that the water was slightly acidic and had elevated nitrate levels in some samples, while the bacteriological results confirmed the presence of harmful microorganisms such as *Staphylococcus aureus* and *Klebsiella spp*. These findings indicate that the available water sources, though easily accessible, are not entirely safe for drinking. The presence of faecal bacteria and the high incidence of waterborne diseases such as typhoid and diarrhoea among respondents demonstrate the urgent need for intervention.

To safeguard public health, residents should be encouraged to boil or filter their drinking water before consumption, and local authorities should ensure regular monitoring of water sources to maintain compliance with WHO standards. Government agencies should also invest in community water treatment systems and strengthen sanitation infrastructure to reduce contamination. Moreover, health education campaigns should be intensified to promote safe water handling, proper waste management, and hygiene practices among households. Addressing these challenges will not only improve water safety but also enhance the overall well-being and health outcomes of the Ohovbe community.

REFERENCES

Abulreesh, H.H., Paget, T.A. and Goulder, R. (2012) 'Faecal coliforms in freshwater and their potential for survival and growth in tropical environments', *Journal of Environmental Managemen*t, 110, pp. 50–56.

Adams, R., Edebor, T. and Adegoke, O. (2016) 'Impact of industrial effluents on surface water quality in Benin City, Nigeria'*, Journal of Environmental Science and Technology*, **9**(3), pp. 155–163.

Adebola, A. and Oyeleke, A. (2017) 'Groundwater contamination from waste disposal practices in Nigeria', *African Journal of Environmental Science and Technology*, **11**(9), pp. 476–485.

Adegbite, O., Fashola, F. and Ojo, A. (2018) 'Assessment of heavy metal concentrations in surface water around Lagos industrial areas', *Environmental Monitoring and Assessment*, **190**(7), p. 410.

Adeniran, A.E., Oloruntoba, E.O. and Sridhar, M.K.C. (2022) 'Microbiological quality of sachet water in selected areas of southwestern Nigeria', *African Journal of Environmental Science and Technology*, **16**(3), pp. 78–86.

Adesakin, T.A., Oyelami, A.O. and Ogunkunle, O.A. (2020) 'Assessment of groundwater quality in selected areas of Osun State, Nigeria', *Environmental Monitoring and* Assessment, **192**(5), pp. 1–15.

Addisie, M. (2022) 'Electrical conductivity as a key indicator in water quality assessment', *Environmental Systems Research*, **11**(1), pp. 1–10.

Ajibade, L.T., Adeyemo, A. and Oladipo, O. (2021) 'Environmental governance and water pollution management in Nigeria', *Water Policy*, **23**(4), pp. 865–878.

Anyanwu, C.U. and Okoli, E.N. (2012) 'Evaluation of bacteriological and physicochemical quality of drinking water sources in Enugu State, Nigeria', *African Journal of Environmental Science and Technology*, **6**(5), pp. 204–213.

Aziz, M., Rahman, S. and Chowdhury, N. (2018) 'Education and household water treatment practices in rural Bangladesh', *Journal of Water, Sanitation and Hygiene for Development*, **8**(1), pp. 139–147.

Azman, I.A.A., Rahiman, M.H.F., Sidek, N. and Bakar, I.A.A. (2015) 'Water quality parameter: A review on dissolved oxygen (DO) control method', *International Journal of Technical Research and Applications*, e-ISSN 2320-8163, pp. 98–102.

Bain, R.E.S., Cronk, R., Wright, J., Yang, H., Slaymaker, T. and Bartram, J. (2014) 'Fecal contamination of drinking-water in low- and middle-income countries: a systematic review and meta-analysis', *PLOS Medicine*, **11**(5), e1001644.

Bhattacharya, P., Hossain, M., Rahman, S. and Jacks, G. (2016) 'Arsenic contamination in groundwater of South Asia: lessons for sustainable water management', *Science of the Total Environment*, 562, pp. 641–650.

Boyd, C.E. (2000) Water Quality: An Introduction. New York: Springer Science & Business Media.

CDC (2024) Drinking water and disease prevention. Centers for Disease Control and Prevention. Available at: [https://www.cdc.gov/healthywater/] (https://www.cdc.gov/healthywater/) (Accessed: 31 October 2025).

Chapman, D. (1996) Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring. 2nd edition. London: E & FN Spon.

Chih-Sheng, L., Yi-Chao, L. and Hui-Min, C. (2016) 'Abrupt state change of river water quality (turbidity): Effect of extreme rainfalls and typhoons', *Science of the Total Environment*, 557–558, pp. 91–101.

Chukwu, L.O., Uzoije, A.P. and Nwoke, C. (2019) 'Impact of industrial effluent on water quality of selected rivers in southeastern Nigeria', *Environmental Research Journal*, **13**(2), pp. 77–88.

Clasen, T., Alexander, K.T., Sinclair, D., Boisson, S., Peletz, R., Chang, H.H., Majorin, F. and Cairncross, S. (2015) 'Interventions to improve water quality for preventing diarrhoea', *Cochrane Database of Systematic Reviews*, Issue 10, Art. No.: CD004794.

Dewangan, S., Prakash, A. and Jaiswal, M. (2023) 'Assessment of physicochemical parameters of drinking water and their health implications', *Environmental Earth Sciences*, **82**(4), p. 89.

Dey, S., Das, S. and Mukherjee, R. (2021) 'Temperature and its influence on aquatic ecosystem metabolism', *Aquatic Ecology Journal*, **55**(2), pp. 223–234.

Devlin, M. and Brodie, J. (2023) 'Nutrient pollution and eutrophication in tropical waters: global review and management implications', *Marine Pollution Bulletin*, 186, p. 114351.

Efiong, E. and Udoh, A. (2021) 'Heavy metal contamination of water sources in Akwa Ibom State, Nigeria', *Environmental Monitoring and Assessment*, **193**(7), p. 392.

EPA (2022) Nitrate and Nitrite in Drinking Water. United States Environmental Protection Agency.

Erah, P.O., Akujieze, C.N. and Oteze, G.E. (2002) 'The quality of groundwater in Benin City: a baseline study on inorganic chemicals and microbial contaminants of health importance in boreholes and open wells', *Tropical Journal of Pharmaceutical Research*, **1**(2), pp. 75–82.

Eze, C., Nwosu, C. and Obi, J. (2022) 'Socioeconomic factors influencing household water quality management in rural Nigeria', *Sustainabilit*y, **14**(8), p. 4712.

Feleke, H., Adane, M. and Mekonnen, A. (2023) 'Effect of hygiene education on household water handling practices in Ethiopia', *Journal of Water, Sanitation and Hygiene for Development*, **13**(2), pp. 126–134.

Fewtrell, L. (2004) 'Drinking-water nitrate, methemoglobinemia, and global burden of disease: a discussion', *Environmental Health Perspectives*, **112**(14), pp. 1371–1374.

Foka, F.E., Nche, B.A. and Ekpo, U.E. (2018) 'Antibiotic-resistant bacteria in groundwater sources in Nigeria', *African Journal of Microbiology Research*, **12**(23), pp. 529–538.

Fondriest, E. (2025) Fundamentals of environmental measurements: Electrical conductivity in water. Fondriest Environmental Learning Center. Available at: https://www.fondriest.com/environmental-measurements/.

Gorde, S.P. and Jadhav, M.V. (2013) 'Assessment of water quality parameters: A review', Journal of Engineering Research and Applications, **3**(6), pp. 2029–2035.

Ighalo, J.O. and Adeniyi, A.G. (2020) 'A review of water quality monitoring approaches in Nigeria', *Environmental Technology & Innovation*, 18, p. 100692.

Imarhiagbe, E.M. and Eghomwanre, A.F. (2023) 'Assessment of borehole water quality and its public health implications in Benin City', *Environmental Monitoring and Assessment*, **195**(3), p. 248.

Koul, S., Mehta, S. and Sharma, D. (2022) 'Fecal contamination indicators in drinking water: global health perspectives', *Environmental Science and Pollution Research*, **29**(8), pp. 11413–11427.

Kulkarni, S.J. (2016) 'A review on research and studies on dissolved oxygen and its affecting parameters', *International Journal of Research and Review*, **3**(8), pp. 18–22.

Kumar, R., Yadav, S. and Singh, S. (2017) 'Assessment of biochemical and chemical oxygen demand in industrial effluent', *International Journal of Environmental Sciences*, **7**(5), pp. 121–129.

Lapworth, D.J., Baran, N., Stuart, M.E. and Ward, R.S. (2018) 'Emerging organic contaminants in groundwater: a review of sources, fate and occurrence', *Environmental Pollution*, 263, pp. 505–523.

Luby, S.P., Halder, A.K., Huda, T.M.N., Unicomb, L. and Johnston, R.B. (2015) 'Household water treatment and the risk of diarrhoea', *International Journal of Epidemiology*, **44**(1), pp. 276–285.

McGarvey, S.T., Buszin, J., Reed, H. and Anderson, M. (2008) 'Sanitation and household water quality in developing countries', *Environmental Health*, **7**(1), pp. 1–10.

Medema, G.J. and Hrudey, S.E. (2019) 'Improving the safety of drinking water: The role of boiling and disinfection', *Journal of Water and Health*, **17**(2), pp. 157–165.

Mezgebe, T., Alemu, T. and Berhanu, K. (2015) 'Physico-chemical analysis of drinking water quality of Arbaminch Town, Ethiopia', *Journal of Applied Chemistry*, **8**(10), pp. 55–60.

Murray, M. and Sharmin, S. (2015) 'Agricultural nitrate pollution in South Asian groundwater: sources and mitigation', *Environmental Research Letters*, **10**(12), p. 125001.

Ngatia, L.W., Grace, J.M., Moriasi, D.N., Taylor, R.W. and Bajgai, T.R. (2019) 'Quantification of microbial contamination in rural water sources: implications for health risk', *Water*, **11(**5), p. 941.

Null, C., Stewart, C.P., Pickering, A.J. et al. (2018) 'Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya', *The Lancet Global Health*, **6**(3), e316–e329.

Nwankwoala, H.O. and Udom, G.J. (2022) 'Challenges of groundwater quality management in Nigeria', *Environmental Monitoring and Assessment*, **194**(8), p. 574.

Obiakor, J., Okonkwo, C. and Eze, V. (2021) 'Socio-demographic determinants of household water treatment practices in Nigeria', *Water Policy*, **23**(5), pp. 1221–1234.

Obubu, M., Edema, M.O. and Atanda, O.O. (2019) 'Bacteriological quality of water and its public health implications in southern Nigeria', *African Journal of Microbiology Research*, **13**(3), pp. 48–57.

Ocheri, M., Okele, J. and Agbaji, E. (2019) 'Assessment of physicochemical parameters of groundwater in rural Nigeria', *Environmental Earth Sciences*, **78**(2), p. 68.

Odeyemi, A.T., Adebayo, I.O. and Ojo, A.M. (2020) 'Groundwater contamination from agricultural runoff in southwestern Nigeria', *Applied Water Science*, **10(**12), p. 222.

Odonkor, S.T. and Ampofo, J.K. (2013) 'Escherichia coli as an indicator of bacteriological quality of water: An overview', *Microbiology Research*, **4(**1), pp. 1–11.

Ogundiran, M.B. and Afolabi, T.A. (2018) 'Assessment of the physicochemical parameters and heavy metals in water from hand-dug wells in Ibadan, Nigeria', *Environmental Monitoring and Assessment*, 190(9), p. 560.

Ojo, O., Nwosu, M. and Ajayi, A. (2020) 'Urbanization and water quality in Nigeria: a review', *African Journal of Environmental Science and Technology*, **14**(6), pp. 171–184.

Olaoye, R.A. and Onilude, A.A. (2021) 'Assessment of microbiological quality of borehole and sachet water in Ibadan, Nigeria', *Scientific African*, 13, e00942.

Olarewaju, T. and Olurinola, O. (2019) 'Education and water quality awareness in rural Nigeria', *African Population Studies*, 33(2), pp. 4591–4604.

Omer, N.H. (2019) Water Quality – Science, Assessments and Policy. London: IntechOpen, pp. 18–34.

Omoigberale, M.O., Edewor, T.I. and Akporido, S.O. (2014) 'Heavy metal contamination and health implications in river systems of Nigeria', *African Journal of Environmental Science and Technology*, **8**(7), pp. 416–423.

Saalidong, S., Alhassan, E.H. and Mensah, E. (2022) 'Alkalinity and hardness effects on water chemistry and fish culture', *Aquaculture International*, 30(2), pp. 567–578.

Sarwa, P.G., Singh, R.K. and Kumar, A. (2018) 'Assessment of turbidity and its impact on water quality in rural areas', *Environmental Monitoring and Assessment*, **190**(9), p. 522.

Smith, A.H., Lingas, E.O. and Rahman, M. (2000) 'Contamination of drinking-water by arsenic in Bangladesh: a public health emergency', *Bulletin of the World Health Organization*, 78(9), pp. 1093–1103.

Sultan, M., Khan, N. and Al-Ghamdi, A. (2020) 'Organic pollutants and their ecological impacts in water systems', *Environmental Science and Pollution Research*, **27**(12), pp. 13515–13527.

Sutadian, A.D., Muttil, N., Yilmaz, A.G. and Perera, B.J.C. (2016) 'Development of river water quality indices: a review', *Environmental Monitoring and Assessment*, **188**(1), p. 58.

Taiwo, A.M., Olujimi, O.O. and Bamgbose, O. (2021) 'Bacteriological and physicochemical quality of groundwater in peri-urban areas of Nigeria', *Environmental Science and Pollution Research*, **28**(6), pp. 6987–7001.

Tebbutt, T.H.Y. (1998) *Principles of Water Quality Control*. 5th edition. Oxford: Butterworth-Heinemann.

Thakur, J., Singh, R. and Joshi, D. (2022) 'Socio-demographic determinants of household drinking water quality: a review', *Water Policy*, **24**(5), pp. 1149–1165.

Ume, E. and Eze, E. (2023) 'Assessment of surface water pollution from oil and gas effluents in Warri River, Nigeria', *Environmental Science Reports*, **10**(1), pp. 87–99.

UNICEF (2022) *Progress on household drinking water, sanitation and hygiene 2000–2022*. New York: United Nations Children's Fund (UNICEF) and WHO Joint Monitoring Programme (JMP).

UN-Water (2023) *World Water Development Report 2023*: Partnerships and Cooperation for Water. Paris: UNESCO.

USEPA (2024) *National Primary Drinking Water Regulations*. Washington, DC: United States Environmental Protection Agency.

Vannavong, N. (2018) 'Household water storage and microbiological quality in rural Laos', Water Research, 132, pp. 100–111.

WHO (2010) *Exposure to Lead: A Major Public Health Concern*. Geneva: World Health Organization.

WHO (2011) *Guidelines for Drinking-Water Quality*. 4th edition. Geneva: World Health Organization.

WHO (2017) *Guidelines for Drinking-Water Quality: 4th Edition Incorporating the 1st Addendum. Geneva*: World Health Organization.

WHO (2019) *Guidelines for Drinking-Water Quality*. 6th edition. Geneva: World Health Organization.

WHO (2022) *Global Water Quality Assessment Report*. Geneva: World Health Organization.

WHO (2023) *Drinking-water: Key facts.* World Health Organization. Available at: [https://www.who.int/news-room/fact-sheets/detail/drinking-water] (https://www.who.int/news-room/fact-sheets/detail/drinking-water) (Accessed: 31 October 2025).

WHO (2023) *State of the Science of Emerging Water Contaminants*. Geneva: World Health Organization.

WHO and UNICEF (2023) *Progress on household drinking water, sanitation and hygiene 2000–2022: Special focus on gender*. Geneva: WHO and UNICEF Joint Monitoring Programme (JMP).

WHO/UNICEF JMP (2023) *Progress on Drinking Water, Sanitation and Hygiene 2000–2023. Geneva*: World Health Organization and UNICEF.

Wirayuda, R. and Chan, L. (2021) 'Socioeconomic and demographic factors influencing access to safe water and sanitation', *Sustainability*, **13**(19), p. 11054.

Wurts, W.A. (2002) 'Alkalinity and hardness in production ponds'*, World Aquaculture – Baton Rouge*, **33**(1), pp. 16–17.

APPENDIX

QUESTIONNAIRE

ASSESSMENT OF WATER, SANITATION, AND HYGIENE (WASH) IN OHOVBE COMMUNITY

QUESTIONNAIRE

SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

1. Age in years:_____

2. Gender:
   - Male
   - Female

3. Occupation:
   - Farmer
   - Trader
   - Student
   - Civil Servant
   - Artisan
   - Unemployed
   - Other (please specify)

4. Educational Level:
   - No formal education
   - Vocational
   - Quaranic
   - Primary school
   - Secondary school
   - Tertiary education (university)

5. Household Size: _____

6. Marital Status:
   - Single
   - Co-habiting
   - Married
   - Separated
   - Divorced
   - Widowed

7. Monthly Household Income:
   - Below ₦10,000

- ₦10,000 - ₦50,000
- ₦50,001 - ₦100,000
- ₦100,001 - ₦150,000
- Above ₦150,000

8. Religion:
- Christianity
- Islam
- Traditional religion
- Other (please specify)

SECTION B: WATER ACCESS AND AVALIABILITY

9. What is your main source of drinking water?
- River/Stream
- Well
- Borehole
- Rainwater
- Piped water
- Bottled/Sachet water

10. How far is the main source of drinking water from your home?
- Less than 100 meters
- 100-500 meters
- 500-1000 meters
- More than 1000 meters

11. How often do you have access to clean drinking water?
- Always
- Most of the time
- Sometimes
- Rarely
- Never

12. Do you treat your drinking water before use?
- Yes
- No

13. If yes, what method do you use to treat your water?
- Boiling
- Filtration
- Chemical treatment
- Other (please specify)

14. Have you ever faced any problems with your water supply?

- Yes
- No

15. If yes, what kind of problems? (Select all that apply)
- Contamination
- Intermittent supply
- Poor taste
- Bad odour
- High cost
- Other (please specify)

16. Is your main water source reliable throughout the year?
- Yes
- No

17. If no, which seasons do you face water scarcity?
- Dry season
- Rainy season

18. Do you have access to alternative water sources in case of main water source failure?
- Yes
- No

19. If yes, what are the alternative water sources?
- River/Stream
- Well
- Borehole
- Rainwater
- Piped water
- Bottled/Sachet water

20. How do you store your drinking water?
- Covered container
- Uncovered container
- Other (please specify)

SECTION C: HEALTH AND AWARENESS

47. Have you or any member of your household experienced any illness after drinking water in the past year?
- Yes
- No

48. If yes, what type of waterborne diseases? (Select all that apply)
- Diarrhea (loose stools)
- Cholera

- Typhoid
- Dysentery (loose stools with blood)
- Other (please specify)

49. How often do you or your family members fall ill?
- Rarely
- Occasionally
- Frequently
- Very frequently

50. Are there any community programmes focused on improving WASH in your area?
- Yes
- No

51. Have you participated in any WASH-related programmes or training?
- Yes
- No

52. How aware are you of the importance of WASH practices?
- Very aware
- Somewhat aware
- Not very aware
- Not aware at all

53. How do you receive information about WASH practices? (Select all that apply)
- Community meetings
- Radio/TV
- Social media
- Posters/Flyers
- School
- Other (please specify)

54. Do you think your community has adequate WASH facilities?
- Yes
- No

55. If no, what facilities do you think are lacking? (Select all that apply)
- Clean water supply
- Toilets
- Hand washing stations
- Waste disposal systems
- Public awareness programmes
- Other (please specify)

56. Do you or your family members have access to health care services?
- Yes

- No

57. How far is the nearest health care facility from your home?
- Less than 1 km
- 1-5 km
- 5-10 km
- More than 10 km

58. How would you rate the quality of healthcare services available in your community?
- Excellent
- Good
- Fair
- Poor


OHOVBE PRIMARY HEALTH
CARE CENTER
RENDER OF ALL
INTEGRATED SERVICES
IKPOBA OKHA LOCAL GOVT. AREA,
EDO STATE
POWERED BY:
EDO STATE EQUITY PLAN (EDOHIS)


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