ASSESSMENT OF WATER QUALITY AND HYGIENE PRACTICES: A CASE STUDY OF OGBÉLAKA HOUSEOLD AND ITS EVIRONS, BENIN CITY.

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NOVEMBER, 2025

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AN UNDERGRADUATE PROJECT 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.

NOVEMBER, 2025

CERTIFICATION

This is to certify that this research titled Assessment of water quality and hygiene practices: A case study of Ogbélaka and its environs, Benin city was carried out by Osazee David Obasuyi and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City; in partial fulfillment 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 Bachelor of Science degree in Environmental Management and Toxicology.

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PROF. (MRS) I. H. IGBINOSA **Date**
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PROF. (MRS) AISIEN E. T **Date**
Head of Department

DECLARATION

I, Osazee David Obasuyi declare that Assessment of water quality and hygiene practices: A case study of Ogbélaka and its environs, Benin city is my own work and that all sources that I have used or quoted have been acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other University.

Osazee David Obasuyi **Date**

DEDICATION

This project is dedicated to God Almighty, for his grace, wisdom, knowledge, understanding and strength throughout my undergraduate studies, to Him be all the glory and honor forever.

I do also want to dedicate this project to my beloved parents, MR. and MRS. OBASUYI for their immense support, parental care, love, prayers and advice.

ACKNOWLEDGEMENT

I want to return all glory to God Almighty, for unending love and strength throughout my undergraduate studies, to him be all the glory and honor forever.

I do also acknowledge the immense support and guidance of my beloved parents, **MR. and MRS. OBASUYI** for their parental care, financial support, love, prayers and advice.

I do also want to sincerely appreciate my Late Grandfather, Chief Obasuyi festus on whose bowel I drew strength from in pursuing a career in this prestigious university. You will forever remain in my heart.

My profound gratitude goes to my beloved Project Supervisor, Prof. (Mrs). I. H. Igbinosa, through whom I gathered all the materials, methods, and skills to complete this project work.

Lastly, I want to thank my siblings, Godwin, Cynthia, Efe for their encouraging words and support. I will not forget to mention my friends; favour, Prince, Tonia, Osas, Abraham, Lincoln, for their love and continuous support.

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ABSTRACT

Access to clean and safe water is fundamental to sustaining public health and ensuring community well-being. This study assessed the water quality and hygiene practices of households in Ogbelaka, Benin City, Edo State, Nigeria. The research aimed to determine the microbiological quality of household water, evaluate hygiene practices, and identify household-level factors contributing to contamination.

A cross-sectional design was employed, combining field sampling and survey methods. Water samples from selected households were analyzed for thermotolerant coliforms and Escherichia coli using standard microbiological procedures. Data on hygiene, sanitation, and water handling practices were collected through structured questionnaires.

Results indicated that a significant proportion of water samples showed microbial contamination exceeding WHO permissible limits, highlighting risks of waterborne diseases. Many households relied on untreated or poorly treated water sources such as boreholes and wells, with inadequate storage and handling practices contributing to contamination. Hygiene practices, particularly handwashing with soap at critical times, were suboptimal, and household water treatment methods were inconsistently applied.

The findings underscore the urgent need for public health interventions that promote community-based water treatment, improved sanitation, and sustained hygiene education. The study concludes that strengthening local water management, behavioral change communication, and enforcement of water quality standards are crucial steps toward achieving Sustainable Development Goal 6 (Clean Water and Sanitation) in Ogbelaka and similar semi-urban communities.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

One of the basic necessities for the sustenance of well-being or life is unrestricted access to water, sanitation and hygiene (Yaya et al., 2018). Globally, over 2.3 billion people lack access to basic portable/clean water while about 844 million individuals do not have access to sanitation facilities (WHO, 2017). This has resulted in approximately 842,000 deaths annually (WHO, 2017).

Access to clean water and proper hygiene practices are fundamental to public health. Unfortunately, many communities in Nigeria's states struggle with waterborne diseases due to poor water quality and inadequate hygiene traceable to their water sources and treatment practices. (Amur, 2023).

Globally, unsafe water, inadequate sanitation, and poor hygiene contribute to a large burden of disease, particularly in low- and middle-income countries including Nigeria (LMICs) (WHO/UNICEF, 2019). In Nigeria, these challenges are pronounced: only about 29% of the population uses safely managed drinking water services, 32% use safely managed sanitation services, and approximately 31% have access to handwashing facilities with soap and water at home. (Imarhiagbe, 2023)

Water quality assessment is crucial in identifying potential health risks. Studies have shown that poor water quality can lead to various health issues, including waterborne diseases. In Nigeria, for instance, research has highlighted the need for improved water treatment and hygiene practices to prevent such diseases to reduce mortality rate. (Pervaiz et al.,2024).

Despite national commitments under Sustainable Development Goal 6 (Clean Water and Sanitation), significant gaps remain. For example, the 2020 Water, Sanitation, and Hygiene National Outcome Routine Mapping (WASH NORM II) revealed that one-third of Nigerians drink contaminated water at home, and about 46 million people still practice open defecation to water bodies(UNICEF,2021).

Given this background, there is a clear need for localized studies particularly in Nigeria but specifically in Benin city, Edo State. Ogbelaka and its environs, like many semiurban or rural areas, may face unique challenges related to source contamination, storage practices, sanitation infrastructure, and behavioral determinants of hygiene. Yet, there is limited published data specifically for this area. Assessing the water quality and hygiene practices among households in Ogbelaka will help identify contamination risks, gaps in sanitation and hygiene, and inform interventions that are context appropriate to curb it's menace particularly on public health through spread of water borne diseases.

1.2 Statement of the problem

Despite the importance of access to clean water and proper hygiene practices for public health, many communities in Benin city, Edo State including Ogbelaka and environs, continue to struggle with waterborne diseases and poor sanitation. Studies have shown that microbiological contamination of drinking water is a significant problem in Benin city, with fecal coliform counts exceeding safe limits in many households (Wright et al., 2004; Clasen and Bastable, 2003). Poor water quality and hygiene practices have been linked to increased risk of diarrheal diseases, respiratory difficulties, and other health problems (Prüss et al., 2002). There is a need to assess the water quality and hygiene practices among households in Ogbelaka and environs to identify areas for improvement and inform targeted interventions to promote public health and well-being."

1.3 Research Questions

The study is guided by the following research questions:

What proportion of households have microbiologically contaminated drinking water at point-of-use?

What are the common water sources and storage/treatment practices used by households?

What is the level of knowledge and practice about handwashing and household water safety?

Which household factors are associated with presence of E. coli in drinking water?

1.4 Aims and Objectives of the study

The aim of this study is to assess the water quality and hygiene practices of households in Ogbelaka, Benin city, Edo State, Nigeria.

These specific objectives of the study are to:

- Evaluate the current state of water quality in Ogbelaka by determining the proportion of household water samples contaminated with thermotolerant coliforms / E. coli.
- Assess hygiene practices among households

- Identify factors contributing to poor water quality and hygiene practices by assessing water sources, storage and treatment practices.

-To identify household-level predictors of microbiological contamination in point-ofuse drinking water

- Provide recommendations for improvement

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1 Conceptual Clarifications

2.1.1 Concept of Water quality

Water is a transparent, tasteless, odorless, and nearly colorless chemical substance, essential for all known forms of life. Chemically, water is composed of two hydrogen atoms bonded to one oxygen atom (H_2O). It exists naturally in three physical states—solid (ice), liquid, and gas (water vapor)—and covers about 71% of the Earth's surface, mainly in oceans, rivers, lakes, and glaciers (Gleick, 2006). Water also makes up a large proportion of living organisms, averaging 60–70% of the human body (Chaplin, 2011).

Water quality refers to the chemical, physical, biological, and radiological characteristics of water that determine its suitability for human consumption, ecological health, and other uses such as agriculture, industry, and recreation (WHO, 2017). Good water quality means that the water is free from contaminants, pathogens, and pollutants, and it meets the standards set by organizations such as the World Health Organization (WHO) and the U.S. Environmental Protection Agency (EPA).

Key indicators of water quality include:

Physical parameters: color, taste, odor, temperature, turbidity.

Chemical parameters: pH, dissolved oxygen, nitrates, heavy metals, hardness, salinity.

Biological parameters: presence of bacteria (e.g., Escherichia coli), protozoa, and viruses.

Radiological parameters: radioactive contaminants like radon or uranium.

Safe water quality ensures public health, environmental sustainability, and economic development (UNESCO, 2020).

2.1.2 Concept of Water Quality Assessment

Water quality assessment is the systematic process of evaluating the physical, chemical, and biological characteristics of water to determine its suitability for various uses (such as drinking, agriculture, industry, and recreation) and to understand its impact on human health and the environment. It involves collecting water samples, analyzing key parameters, and comparing results against established water quality standards or guidelines (Kumir, 2012)

According to the World Health Organization (WHO, 2017), water quality assessment is essential for ensuring access to safe water and preventing waterborne diseases. It helps in detecting pollutants, monitoring environmental changes, and guiding water resource management.

The main components of water quality assessment include:

1. Physical parameters – such as temperature, turbidity, color, and odor.

2. Chemical parameters – such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), nutrients (nitrate, phosphate), heavy metals, and salinity.

3. Biological parameters – such as coliform bacteria, algae, and other microorganisms.

Water quality assessment is typically carried out using methods such as in-situ measurements, laboratory analyses, and remote sensing techniques, followed by comparison with standards from bodies like the WHO, the U.S. Environmental
Protection Agency (EPA), or the Nigerian Standards for Drinking Water Quality (USEPA, 2022).

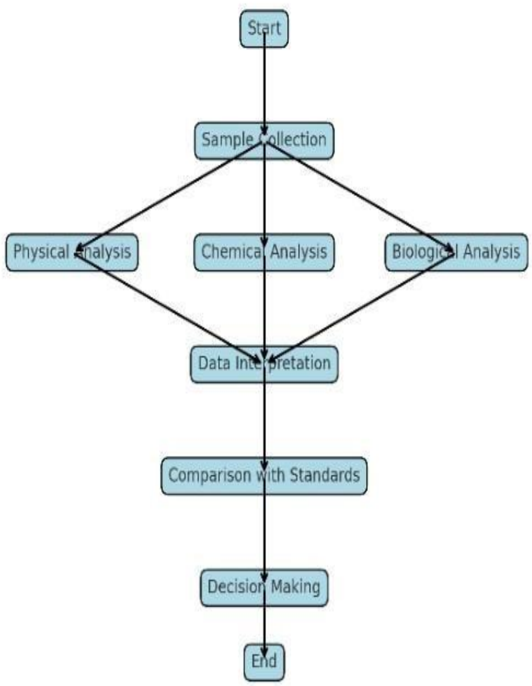

Figure 2.1 Flowchart of Water Quality Assessment.

2.1.3 Concept of WASH

WASH, an acronym for Water, Sanitation, and Hygiene, is a framework that emphasizes the interconnectedness of clean water supply, safe sanitation, and hygiene practices in promoting health and development. It is recognized globally as a foundation for reducing disease, ensuring dignity, and driving social and economic progress (UN Water, 2023). The World Health

Organization (WHO) and UNICEF highlight WASH as a core element of sustainable development and public health protection (WHO, 2023).

2.1.3.1 Components of WASH

1. Water:

Safe and sufficient water must be available, affordable, and physically accessible for domestic and drinking purposes. Water quality is central: it should be free from pathogens, toxic chemicals, and contaminants to prevent diseases such as diarrhea, cholera, and typhoid (WHO, 2023).

2. Sanitation

It Refers to the safe collection, treatment, and disposal of human excreta and wastewater. Effective sanitation systems reduce environmental contamination, control disease transmission, and support dignity, particularly for vulnerable populations (Unlimited Health, 2023).

3. Hygiene

Hygiene practices include handwashing with soap, menstrual hygiene management, safe food handling, and general cleanliness. These practices depend not only on awareness but also on infrastructure such as handwashing stations with soap and water (CDC, 2023).

Water quality is a pillar of WASH. Unsafe water contributes to millions of deaths annually, especially among children under five (WHO, 2023). Beyond microbial risks, chemical pollutants like arsenic, fluoride, and nitrates threaten health in many regions. Thus, WASH requires not only access to water but also monitoring and assurance of water quality to achieve safe standards (WHO, 2023).

2.1.3.2 Global concern on WASH

WASH is central to Sustainable Development Goal 6: "Ensure availability and sustainable management of water and sanitation for all." It is also critical for achieving goals on health, education, and gender equality. WHO and UNICEF's Joint Monitoring Programme tracks progress on WASH access worldwide (UN Water, 2023).

Water, Sanitation, and hygiene (WaSH) constitute a critical global environmental issue (WHO & UNICEF, 2017). In an effort to substantially improve global access to safe water and sanitation, the United Nations (UN) General Assembly, with 193 member states, adopted Sustainable Development Goal (SDG) six targeting drinking water, sanitation, and hygiene (United Nations, 2015). Sustainable Development Goal 6 encompasses two specific targets: (a) Target 6.1: by 2030, achieve universal and equitable access to safe and affordable drinking water for all; (b) Target 6.2: by 2030, achieve access to adequate and equitable sanitation and hygiene for all, end open defecation, and pay special attention to the needs of women, girls, and those in vulnerable situations (United Nations, 2015).

Despite the implementation of WaSH measures in households and public settings, such as schools and health care facilities, and the emphasis on sanitation and hygiene to prevent disease transmission during the coronavirus disease 2019 (COVID-19) pandemic (UNICEF & WHO, 2020), some regions continue to face challenges in accessing these services. Factors such as poverty, inequality, lack of basic water purification facilities, and limited health education contribute to these ongoing struggles (UN-Water, 2021).

Unsafe WaSH conditions have been well-documented to be associated with premature death and various diseases, including an increased risk of diarrhea (PrüssUstün et al., 2019), lower respiratory infections (Aiello & Larson, 2002), malaria (Yewhalaw et al., 2009), and soil-transmitted helminthiases (Strunz et al., 2014). Moreover, compromised WaSH conditions can also adversely impact economic outcomes (Hutton, 2012), educational attainment and cognitive development (Jasper et al., 2012), as well as overall well-being and mental health (Sclar et al., 2018).

Wolf et al. (2018) estimated that providing universal access to safe WaSH could prevent approximately 1.4 million deaths and 74 million disability-adjusted life years (DALYs), accounting for 2.5% of all global deaths and 2.9% of all DALYs. Notably, children under five years of age bore a disproportionate burden, representing 7.6% of all deaths and 7.5% of all DALYs attributable to unsafe WaSH (Wolf et al., 2018).

2.1.4 Household water handling and storage

2.1.4.1 Importance of Household Water Handling

Even when water is safe at its source, it is often re-contaminated before drinking due to unsafe handling, transport, and storage (Wright, Gundry, & Conroy, 2004). The World Health Organization (WHO, 2011) emphasizes that "household water storage, handling and treatment practices have a profound influence on the microbial safety of drinking water." Unsafe handling has been shown to account for the deterioration of microbiological quality between the point of collection and point of use in many low- and middle-income countries (String, Berendes, Raj, Koehler, & Brown, 2020). **2.1.4.2 Pathways of Contamination in the Household**

a) Collection and Transport

Collection containers: The type of container used during collection greatly influences water quality. Open buckets and dirty jerry cans introduce microbes at the time of collection, while narrow-neck, covered containers reduce contamination risks (String et al., 2020).

Transport: Long distances between the household and water source increase risks of contamination, especially when shared or poorly cleaned containers are used (Wright et al., 2004).

b) Storage Practices

Dipping vs. pouring: The method of withdrawing stored water is critical. Dipping cups, ladles, or hands into stored water repeatedly contaminates it, whereas households that pour from narrow-neck containers or use spigots have significantly lower faecal coliform counts (Levy, Nelson, Hubbard, & Eisenberg, 2008; Wright et al., 2004).

Container design: Covered, narrow-mouth containers fitted with taps or spouts reduce exposure of stored water to hands, utensils, flies, and dust. In contrast, wide-mouth vessels are consistently associated with higher contamination (Mintz, Bartram, Lochery, & Wegelin, 2001).

Cleaning frequency: Irregular or ineffective washing of containers allows biofilms to form on container walls, which can reintroduce pathogens into stored water even after treatment. Regular cleaning with soap and drying significantly reduces risks (String et al., 2020).

Storage time and location: Prolonged storage without residual disinfectant worsens microbial water quality. Studies recommend storing water in shaded, cool places with fitted lids to slow deterioration (WHO, 2011).

In Nigeria, Ibadan stored household water showed much higher coliform counts than the original source water, especially in households where cups or ladles were dipped into storage vessels (Omole, Ndambuki, & Balogun, 2015).

In Edo State, it was reported that 63% of households did not treat their drinking water; common storage vessels included plastic buckets, tanks, and clay pots, many of which were cleaned only monthly or less (Oloruntoba, Folarin, & Ayede, 2014).

In Osun State, clay pots were widely used for storage, but these sometimes leached chemicals into the water and supported microbial growth compared with plastic containers (Ademola & Olajire, 2019).

2.1.5 Hygiene Practices and Disease transmission

Households are the first line of defense against infectious diseases, but inadequate hygiene practices create multiple transmission pathways. Poor hand hygiene, unsafe water handling, and inadequate sanitation facilitate the spread of pathogens, especially through the fecal–oral route. The World Health Organization (WHO, 2022) estimates that unsafe water, poor sanitation, and inadequate hygiene account for around 829,000 annual deaths from diarrhea worldwide.

2.1.5.1 Key Hygiene Practices in Households

2.1.5.1.1 Hand Hygiene

Proper handwashing with soap can reduce diarrhea disease risk by 30–47% (Curtis & Cairncross, 2003; Ejemot-Nwadiaro et al., 2015).

Critical times include after defecation, after cleaning children's faeces, before preparing food, and before eating (WHO, 2011).

Poor compliance leads to household-level transmission of diarrhea pathogens such as E. coli, Rotavirus, and Shigella (Aiello et al., 2008).

2.1.5.1.2 Household Water Handling

Even when water is safe at its source, it is often re-contaminated during transport and storage in uncovered or unclean containers (Wright, Gundry, & Conroy, 2004).

Use of narrow-necked, covered containers and household water treatment methods (boiling, chlorination, filtration) significantly reduces microbial contamination (Sobsey et al., 2008).

2.5.1.3 Food Hygiene

Unsafe food preparation and handling spread pathogens such as Salmonella and Vibrio cholerae. Washing hands before cooking and using clean utensils reduces household exposure to foodborne diseases (WHO, 2015).

2.1.5.4 Sanitation and Environmental Hygiene

Open defecation and poorly maintained latrines contaminate household environments and nearby water sources, increasing diarrheal and parasitic infections (UNICEF & WHO, 2019).

Safe disposal of human and animal waste prevents transmission of helminths, protozoa, and bacterial infections (Prüss-Ustün et al., 2014).

2.1.5.5 Personal and Domestic Hygiene

Practices such as regular bathing, nail trimming, and safe menstrual hygiene prevent skin, eye, and urogenital infections (Bartram & Cairncross, 2010).

Clean household surroundings reduce vector breeding sites for diseases like malaria and dengue (WHO, 2017).

2.1.5.2 Disease Transmission Pathways in Households

(a) Fecal–oral transmission: via contaminated water, food, and hands (e.g., diarrhea, cholera, typhoid).

(b) Person-to-person contact: through shared surfaces, lack of handwashing, and poor personal hygiene (e.g., respiratory infections, helminths).

(c) Vector-mediated: poor waste management creates breeding grounds for flies and mosquitoes, aiding disease spread (Esrey et al., 1991).

Household hygiene practices play a decisive role in either interrupting or sustaining disease transmission. Evidence consistently shows that interventions promoting handwashing with soap, safe water handling, improved sanitation, and proper food hygiene significantly reduce diarrheal and other infectious diseases. Sustainable health improvements require not only infrastructure but also behavioral change at the household level.

2.1.5.3 Household hygiene and water storage

Household hygiene practices are closely linked to water safety. Poor practices increase the risk of contamination and waterborne infections. Common aspects of household hygiene include:

(1) Water handling and storage – use of clean containers with covers reduces contamination risk (Sobsey et al., 2008).

(2) Household water treatment – boiling, chlorination, solar disinfection (SODIS), or filtration (Clasen et al., 2015).

(3) Hand hygiene – proper handwashing with soap at critical times (before eating, after using the toilet, before food preparation) significantly reduces diarrheal diseases (Curtis & Cairncross, 2003).

(4) Sanitation facilities – access to improved toilets reduces fecal contamination of household environments.

2.1.5.4 Health Implications

Unsafe household water and poor hygiene are linked to diarrheal diseases, cholera, typhoid fever, dysentery, and parasitic infections. According to WHO (2022), contaminated drinking water causes over 500,000 diarrheal deaths annually. Children under five are the most affected.

2.1.6 Water treatment methods

2.1.6.1 Household Water Treatment (HWT) and Safe Storage

(1) **Boiling**

Microbiology: Effectively inactivates bacteria, viruses, protozoa.

Limitations: Recontamination after boiling is frequent; fuel use and indoor air pollution are barriers.

(2) **Chlorination**

Strengths: Effective against most bacteria and viruses; residual chlorine protects water during storage.

Limitations: Taste/odor issues and lower effectiveness against protozoa.

(3) **Filtration**

Strengths: Ceramic and biosand filters can remove bacteria and protozoa effectively; when maintained, reduce diarrhea disease.

Limitations: Clogging, need for cleaning/replacement; no residual disinfectant.

(4) **Solar Disinfection (SODIS)**

Strengths: Low-cost, effective in sunny conditions for bacteria and some viruses.

Limitations: Requires clear, low-turbidity water; no residual protection.

2.6.1.2 Water Treatment Methods

Water treatment involves a series of processes designed to remove physical, chemical, and biological contaminants from raw water to make it safe for human consumption. Conventional treatment methods typically include coagulation, flocculation, sedimentation, filtration, and disinfection (CDC, 2024).

Coagulation and flocculation are the first stages, where chemicals such as aluminum sulfate (alum) are added to destabilize suspended particles and form flocs that can be more easily removed (Malvern Panalytical, 2023). These flocs then settle out of the water during sedimentation, reducing turbidity and microbial load (CDC, 2024).

Following sedimentation, filtration is applied using sand, gravel, activated carbon, or advanced membranes to remove remaining suspended solids, bacteria, and protozoa (WHO, 2017). After filtration, disinfection is critical to inactivate pathogenic microorganisms such as Escherichia coli, Giardia lamblia, and viruses. Common disinfectants include chlorine, chloramine, ozone, and ultraviolet (UV) light (CDC, 2024; WHO, 2017).

Beyond conventional systems, advanced treatment technologies are increasingly used. Membrane technologies such as microfiltration, ultrafiltration, nanofiltration, and reverse osmosis provide higher removal efficiency for dissolved salts and contaminants (Water.co.id, 2023). Advanced Oxidation Processes (AOPs), which generate hydroxyl radicals through ozone, hydrogen peroxide, or UV, are employed to degrade persistent organic pollutants (Water.co.id, 2023).

For regions with saline or brackish water, desalination via reverse osmosis or distillation is essential (Water.co.id, 2023). In wastewater treatment, biological methods such as activated sludge systems, trickling filters, and membrane bioreactors are used to degrade organic matter (Tchobanoglous et al., 2014). Low-tech options such as waste stabilization ponds remain effective in tropical and low-resource settings (Shilton, 2005).

Finally, emerging concepts such as Zero Liquid Discharge (ZLD) aim to recover nearly all water and minimize effluent, though they are energy intensive and costly (Giwa et al., 2017).

2.6.1.2.1 Major steps in conventional treatment processes

Typical drinking water treatment plants use a series of stages to make raw water safe:

(a) Coagulation: To destabilize suspended particles (sediments, colloids) so they aggregate. Helps remove turbidity, color, pathogens bound to particles.

(b) Flocculation: Gentle mixing to allow small destabilized particles to gather into larger flocs.

(c) Sedimentation (settling): Allow flocs (heavier aggregates) to settle out by gravity, separating solids from water.

(d) Filtration: To remove remaining particles, microbes, and other impurities via physical media or membranes.

(e) Disinfection: To kill/inactivate pathogens — bacteria, viruses, parasites. Common disinfectants: chlorine, chloramine, chlorine dioxide, UV light, ozone.

(f) pH Adjustment / Chemical Additions: Adjusting pH for taste, corrosion control; adding fluoride (in some regions) for dental health; sometimes adding chemicals to remove specific contaminants.

2.6.1.2.2 Modern / advanced / supplementary methods

To tackle more difficult issues (e.g. very fine contaminants, high salinity, organic micropollutants), additional or specialized treatment methods are used.

Membrane Filtration Technologies

Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF), Reverse Osmosis (RO) — these use semipermeable membranes to separate particles, dissolved ions, etc.

Electrode ionization (EDI) — used for producing ultrapure water, often as polishing after RO.

Advanced Oxidation Processes (AOPs): Use of strong oxidants (ozone, hydroxyl radicals) often combined with UV or other catalysts to degrade organic pollutants, micropollutants, etc.

Desalination: For salt water or brackish water — using RO, or thermal processes to remove salts.

2.6.1.2.3 Biological Treatment

For wastewater: activated sludge, trickling filters, ponds. Microorganisms degrade organic matter.

Biological membrane reactors (MBRs) combine membrane filtration and biological treatment.

Waste Stabilization Ponds: Simple, low-tech biological treatment approach; especially useful in warm climates and areas with lower infrastructure.

Dissolved Air Flotation (DAF): Used to remove suspended matter (including oil, greases) by floating them to the surface via tiny air bubbles, which are then skimmed off. Useful for wastewater or industrial effluents.

2.1.7 Concept of Water Quality Assessment in Nigeria.

Nigeria is the most populated black nation in the world with about 199 million people. About 66.3 million Nigerians do not have access to safe drinking water. (SeyiOlajide and Ameh, 2020). There are still grave enforcement issues in Nigeria as quality guidelines are still being contravened at no cost to the infringer due to the corrupt sociopolitical circumstances of the country. The quality of surface water was generally poor. Groundwater pollution has come due to landfill leachate, oil and gas exploration and production, sewage and hydrogeological interactions of the groundwater with the base rock. The hydrogeological effect has led to the observation of lead and barium in groundwater in many locations across the country. The main issue with rainwater in Nigeria is the low pH but it was observed to be fairly clean. Commercially available water (bottled or sachet) is currently the best source of drinking water for the Nigerian populace. Bottled water quality is higher than for sachet water and the latter largely influenced by microbe contamination. Future perspectives in water quality monitoring and assessment are suggested in the evaluation of emerging contaminants and micropollutants and the utilization of internet-enabled technologies. The classes of drinking water source available to her gigantic population (in both urban and rural areas) are surface water, groundwater and rainwater.

Nigeria has had a long history of water pollution issues dating back to her inception in 1960 (Adelegan, 2004; Omole and Isiorho, 2011). Generally, the quality of water supply in urban cities have improved but the water quality in the rural areas is still poor (Akinde et al., 2019; Kaoje et al., 2018). About 66.3 million Nigerians do not have access to safe drinking water (Akinde et al., 2019). Besides the pollution of the water at the sources, there is also a significant deterioration of its quality by the time it gets to the point of use due to improper handling (Onabolu et al., 2011). Water pollution in Nigeria has been due to oil exploration (Aghalino and Eyinla, 2009; Seiyaboh and Izah, 2017), agricultural activities (Galadima et al., 2011), mining activities (Izah and Srivastav, 2015), commercial slaughter-houses/abattoirs (Akan et al., 2010; Bello and Oyedemi, 2009; Benka-Coker and Ojior, 1995), domestic activities (Galadima et al., 2011) and other industrial activities (Yusuff and Sonibare, 2004). Water pollution in Nigeria has led to the proliferation of pollutants into fishes (Adeyemo, 2003), and their subsequent bio-magnification into the human system. Besides, intake of polluted water itself has led to the outbreak of water-borne diseases in Nigeria such as includes diarrhea, cholera and other gastrointestinal illnesses (Forstinus et al., 2016; Oguntoke et al., 2009). The monitoring and assessment of water quality is an important aspect of inventorying the required data for accurate determination of water pollution issues and for devising appropriate prevention and mitigation strategies (Aisien et al., 2010; Eletta, 2012).

Over the past two decades, much research effort has been spent on monitoring and assessing the quality of these classes of the drinking water source. The classes of drinking water source in both urban and rural Nigeria is surface water, groundwater and rainwater and the discussion in this work were divided along these lines.

As for the geology of Nigeria, it is quite diverse (Aizebeokhai, 2011). About half the landmass of Nigeria is occupied by ancient pre-Cambrian rocks that were deformed during Pan African orogeny. It outcrops in the south-east (plateau bordering Cameroon), north-central (Bauchi–Kano–Anka–Kontagora) and in the west (Lokoja–Abeokuta– Babana) (Aizebeokhai, 2011). The base rocks are usually schists, gneisses, calcsilicates and migmatites. The remaining parts of the country are covered by Mesozoic sedimentary rocks. The Benue basin is filled with younger sedimentary rocks. We have sandstone and clay lenses in the Bida Basin. The central region of Kabba has in magnetite and haematite rich base rocks while the Jos plateau has younger granite and tin (cassiterite) mineralisation. In the south, the Niger Delta is formed from the eroded rocks by the river Niger and has been protruding outwards since the late Cretaceous era. It is filled with tertiary and quaternary sediments which gradually decreases in age moving southwards. In the east, there is the Bende-Ameki Formation, Nsukka formation, Benin formation, and the Mamu formation (Ewuzie et al., 2020; Nnorom et al., 2019). These rock formations are majorly made of sandstone, shales, mudstone and sandy shale with coal seams at several horizons (Ewuzie et al., 2020). In the west, there is the east Dahomey basin that has the Ewekoro. Ilaro and Abeokuta rock formations (Aladejana et al., 2020).

As for surface water in Nigeria, the nation blessed with abundant resources. The two major rivers are the river Niger originating from the Fouta Djallon highlands in Guinea (Onafeso and Olusola, 2018) and the river Benue originating from the Adamawa plateau in northern

Cameroun mountains (Ajiboye et al., 2017). These come together to form a confluence at Kogi state, flowing together into the Atlantic Ocean and creating a huge delta along the way that spans a large part of the southern part of the country. Besides these, Nigeria is also one of the four countries that border the lake Chad alongside Cameroun, Niger and Chad (Amao, 2020). Surface water in Nigeria exists in the form of rivers, lakes, natural springs, creeks, dam/reservoir and lagoon. The four major drainage systems in Nigeria are listed below (Taiwo et al., 2012).

2.1.7.1 Standards for drinking water quality in Nigeria

In Nigeria, the legally recognized standard for drinking water quality is The Nigerian Standard for Water Quality (NSDWQ). This stipulates the acceptable values of the different water parameters (which must not be exceeded) before it can be considered to be safe for drinking. However, indigenous researchers do not base their assessment on it alone but also compare with World Health Organization (WHO, 2003) standards. In some studies, they also do a comparison with the standards by the United

2.1.8 Global burden of unsafe water and hygiene

Water, sanitation, and hygiene (WaSH) constitute a critical global environmental issue (Watson et al., 2022). In an effort to substantially improve global access to safe water and sanitation, the United Nations (UN) General Assembly, with 193 member states, adopted Sustainable Development Goal (SDG) six targeting drinking water, sanitation, and hygiene (Assembly, 2015). Sustainable Development Goal 6 encompasses two specific targets: (a) Target 6.1: by 2030, achieve universal and equitable access to safe and affordable drinking water for all; (b) Target 6.2: by 2030, achieve access to adequate and equitable sanitation and hygiene for all, end open defecation, and pay special attention to the needs of women, girls, and those in vulnerable situations.

Despite the implementation of WaSH measures in households and public settings, such as schools and health care facilities, and the emphasis on sanitation and hygiene to prevent disease transmission during the coronavirus disease 2019 pandemic (Donde et al.,2020), some regions continue to face challenges in accessing these services. Factors such as poverty, inequality, lack of basic water purification facilities, and limited health education contribute to these ongoing struggles (Sahoo et al., 2022). Unsafe WaSH conditions have been well-documented to be associated with premature death and various diseases, including an increased risk of diarrhoea (Wolf et al., 2022), lower respiratory infections (Ross et al., 2023) malaria (Daily et al., 2022), and soil transmitted helminthiases (Jordan et al., 2022). Moreover, compromised WaSH conditions can also adversely impact economic outcomes, educational attainment, cognitive development, and overall well-being, including mental health.

(Wolf et al., 2022) estimated that providing universal access to safe WaSH could prevent approximately 1.4 million deaths and 74 million disability-adjusted life years (DALYs), accounting for 2.5% of all global deaths and 2.9% of all DALYs. Notably, children under five years of age bore a disproportionate burden, representing 7.6% of all deaths and 7.5% of all DALYs attributable to unsafe WaSH.

Millions of people globally do not have access to safe drinking-water, sanitation and hygiene (WASH) services and consequently suffer from or are exposed to a multitude of preventable illnesses. Unsafe WASH is associated with infectious diseases, health risks from exposure to chemicals and other contaminants in drinking-water, as well as impacts on well-being. WHO estimates the burden of disease attributable to unsafe

WASH for key health outcomes and report on SDG indicator 3.9.2.

Mortality: 1.4 million deaths could have been prevented with safe WASH in 2019

Morbidity: 74 million DALYs* could have been prevented with safe WASH in 2019

Attributable fraction: 69% of all diarrhea deaths in 2019 were attributed to unsafe

WASH

services

Diarrhea deaths >1 million died from diarrhea due to unsafe WASH in 2019

Acute respiratory infections deaths: 356 000 died from acute respiratory infections due to unsafe hand hygiene practices in 2019.

2.1.9 Water quality indicators and health effects

The indicators fall into physical, chemical, and biological categories. Each indicator is measurable, and when outside safe limits, can lead to specific health risks.

2.1.9.1 Physical Indicators

Indicator	What it measures/source	Health effects
1. Turbidity	Cloudiness of water caused by suspended solids, particles, sediments. May originate from soil runoff, erosion, or inadequate filtration	High turbidity is associated with increased presence of pathogens (bacteria, viruses, parasites), because particles can protect them from disinfection. Exposure may lead to gastrointestinal illnesses: diarrhea, cramps, vomiting.
2. Temperature	Water temperature affects chemical reactions, microbial growth, solubility of gases (e.g. oxygen) etc.	Elevated temperatures can increase bacterial/viral growth rates, reduce dissolved oxygen, potentially causing harm to aquatic life or enabling pathogens to multiply. While direct human health effects are more indirect (e.g. via increased pathogen load), temperature also influences chemical toxicity. (Not always quantified in WHO guidelines, but discussed in water quality scien**ce).**

2.1.9.2. Chemical Indicators

Indicator	What it Measures/Common sources	Health Effects
1. pH	Acidity/alkalinity; influenced by geological material, industrial discharge, acid rain, etc.	Very low (acidic) or high (alkaline) pH can irritate skin, eyes, mucous membranes; can corrode pipes, potentially mobilizing heavy metals. Prolonged exposure to extremes is harmful.
2. Nitrate/Nitrite	From agricultural runoff (fertilizers), sewage, decaying organic matter, animal wastes.	Infants are especially vulnerable: high nitrate in drinking water can cause methemoglobinemia ("blue-baby syndrome") by reducing the blood's ability to carry oxygen. Also, recent studies suggest long-term exposure even at lower levels may be associated with adverse pregnancy outcomes, thyroid issues, and certain cancers (e.g. colorectal) though more evidence is needed.
3.Heavy Metals(Lead, Arsenic, Cadmium, Mercury etc.)	Naturally occurring in rocks and soils; or from anthropogenic sources: mining, industrial waste,	Chronic exposure can lead to various health impacts: neurological damage (especially in

	plumbing.	children, from lead and mercury), skin lesions, cancer (arsenic), kidney damage, cardiovascular disease. Even relatively low exposures over time are harmful.
4. Fluoride	Naturally present in groundwater in many regions; also from industrial pollution	In small amounts, fluoride prevents dental caries; but excess fluoride causes dental fluorosis (staining, tooth damage) and skeletal fluorosis (joint pain, bone damage).
5.Disinfection byproducts (e.g., trihalomethanes, halo acetic acids)	Formed when disinfectants (chlorine, etc.) react with organic matter in water, or during	Long-term exposure is linked with increased cancer risk (e.g. bladder, possibly other organs),
	treatment processes	liver / kidney / nervous system issues. Also, some by-products may cause reproductive or developmental effects.

2.1.9.3. Biological Indicators

Indicators	**What measures/Common sources**	**Health Effects**
1) Coliform Bacteria/ *E.*coli	Indication of fecal contamination (humans or	Presence means risk of waterborne pathogens:
	animals), sewage leaks, runoff.	causes of diarrhoea, dysentery, typhoid, cholera. Acute gastrointestinal illness; in severe cases dehydration, death (especially for children)
2) Pathogens (viruses, protozoa, parasites)	From untreated or poorly treated sewage, animal waste, contaminated water sources.	Symptoms include severe diarrhea, vomiting, fever; in immunocompromised or young children can be life-threatening
3) Algal toxins / Cyanobacteria	Overgrowth (blooms) of cyanobacteria (blue-green algae) often due to nutrient pollution (e.g., phosphorus, nitrogen), warm temperatures.	Toxins (e.g., microcystins) can cause skin irritation, liver damage, gastrointestinal symptoms; in high exposures or chronic exposure may have serious health implications. WHO provides guidelines
		for microcystins.

2.1.10 Health Impacts of Poor Water Quality

Acute health effects: diarrhea and gastrointestinal diseases, often rapid in onset; skin, eye irritation; respiratory symptoms in some cases.

Infant/child health: dehydration, malnutrition due to repeated diarrhea; developmental delays; methemoglobinemia in infants from nitrate exposure.

Chronic health effects: cancers (from arsenic, nitrates, disinfection by-products), neurological damage (lead, mercury), kidney and liver diseases, reproductive problems.

Indirect effects: reduced nutrient absorption; increased susceptibility to other diseases; increased mortality especially among vulnerable populations; burden on healthcare systems.

2.2 Review of Empirical Studies

2.2.1 Case Studies from Edo State and Nigeria

Empirical studies have documented serious lapses in water quality and household hygiene in various Nigerian settings.

2.2.1.1Groundwater quality of the Benin City urban aquifer (Benin Formation) — Akujieze et al. 2006.

Aim / scope: Investigated groundwater quality across the Benin City urban aquifer to evaluate effects of anthropogenic contamination (heavy metals, major ions) from multiple boreholes.

Methods: Multi-borehole sampling (reported sample set ~25 boreholes in the paper), laboratory chemical analyses for heavy metals and physico-chemical parameters, statistical summary.

Key findings: Elevated lead (Pb) in several boreholes (mean ~0.044 mg/L; some > WHO guideline of 0.05 mg/L reported as anomalous), with other parameters showing evidence of anthropogenic influence in parts of the aquifer.

2.2.1.2 Groundwater quality in Ugbowo (Benin City) — Oria-Usifo, E. E, 2025.

Aim / scope: Assessment of groundwater quality in Ugbowo neighborhood (boreholes/open wells), calculation of Water Quality Index (WQI), and seasonal comparison (dry vs wet).

Methods: Sampling across seasons, analysis for metals (Mn, Pb, Cd, Ni, Cr), major ions, WQI computation and multivariate statistics.

Key findings: Overall WQI indicated generally good/excellent quality in many samples, but Manganese and Chloride exceeded WHO limits in some samples (Mn notably above WHO limit in dry season). Heavy metals largely within limits but seasonal variability observed.

2.2.1.3 Qualitative assessment of bottled drinking water sold in Benin City — Odiana et al. 2019

Aim / scope: Evaluated physical and chemical quality of commercially sold bottled water brands in Benin City retail outlets.

Methods: Collected ~25 brands, performed standard physio-chemical tests and compared results to WHO and Nigerian standards.

Key findings: Levels varied by brand; the study highlighted the need for routine monitoring and regulatory enforcement of packaged drinking-water producers (some brands showed non-compliance on specific parameters).

2.2.1.4 Ikpoba Reservoir (surface water) Evaluation — Egun et al. 2022 (Surface Water Quality / WQI)

Aim / scope: Evaluated surface water quality of Ikpoba Reservoir (Benin City) for suitability for human use and ecosystem health.

Methods: Periodic sampling, physio-chemical parameter analyses, application of WQI and other indices to interpret suitability.

Key findings: Results showed the reservoir's water quality was impacted by urban runoff and point-source pollution; certain indicators suggested the reservoir is under stress and needs management to protect downstream users.

Other case studies in Nigeria, includes in a rural community in Sokoto State, many households perceived their water sources as safe, but substantial levels of Escherichia coli were detected in water from tap points, boreholes, and wells. Only 37% of respondents used soap and water regularly when washing hands, even though handwashing after toilet use was more common. Diarrheal disease was identified as the most common health problem, with a prevalence rate of 61%.

In another study in Abeokuta City, water quality assessment revealed that without point-of-use treatment, water sources (especially boreholes, wells, and surface water) are not always safe for potable use. Elevated levels of hardness and microbial contamination were found across multiple sources. Further, a comprehensive review of water quality monitoring in Nigeria over the past two decades noted widespread violations of water quality guidelines, especially in surface water, groundwater, and commercially available water, largely due to pollution sources like sewage, industrial effluents, and poor waste management.

In Ibadan, many households rely on wells as water sources; water quality deteriorated after collection and during storage due to poor handling, with bacterial contamination higher in the wet season.

In Ikpoba-Okha, Edo State, 83.6% of households used boreholes, 9.5% used wells, and only a minority treated their drinking water (about 37% treated water), indicating treatment by only ~37% of households, raising concerns for disease risk.

In Kogi State (Ijumu LGA), although handwashing is widely practiced (~93% of respondents), many use water only without soap, which reduces efficacy. Also, there was a positive correlation between improved water source and reduced disease incidence. These findings underscore that availability of water sources does not necessarily equate with safe water or good hygiene practice. Contamination— microbiological, and sometimes chemical—often occurs at point of use (storage and handling), while sanitation infrastructure and behavioral practices (e.g. handwashing with soap, safe disposal of human waste) are frequently inadequate. These factors lead to a high burden of waterborne disease, especially among children.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

This study was conducted in Ogbelaka and its environs off Sapele road in Benin City, Edo state. Benin City is located in Edo state, in southern Nigeria. Its geographic location is latitudes 6° 11' and 6° 29'N, and longitudes 5° 33' and 5° 47'E. Benin City has an average elevation of 77.8m above sea level in the humid tropical rainforest belt of

Nigeria. This study was specifically conducted in three different areas namely Awo Lane, Ogbelaka Street and Awo Street at Oredo local government area in Benin city, field sampling will be carried out at 25 strategically selected water points representing the major water sources used by residents (e.g., boreholes, wells, public taps, surface runoff collection points, and packaged water where applicable).

Ogbelaka is a neighborhood in Oredo Local Government Area (Benin City), Edo State. Local livelihoods are dominated by urban informal trade and services; many households rely on non-piped sources (boreholes, wells, sachet/packaged water) because reliable piped supply is limited. Household composition and education are mixed household types; education levels vary but urban households typically have higher school attendance than rural counterparts. For local projects assume heterogeneity in household head education and wealth.

Poverty and vulnerability by State-level analyses and NGO fact sheets report sizable poverty and informal-sector dependence in Edo State; poorer households are less likely to have safely managed WASH services. This creates equity issues for water access in urban neighborhoods like Ogbelaka.

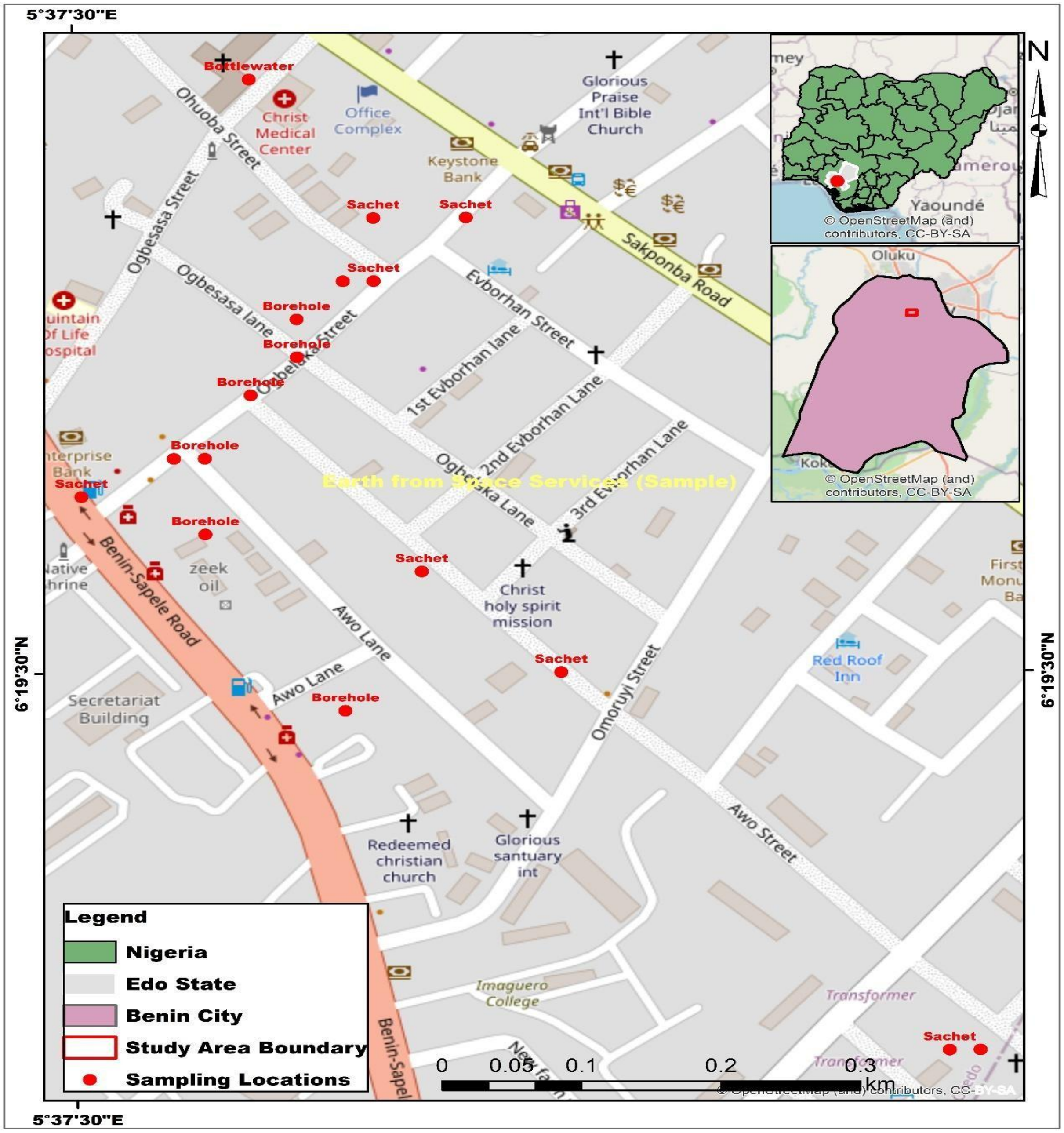

Figure 3.1 A map of the study area showing the sampling locations

3.2.1 Study design

This study used a descriptive cross-sectional design to assess the physical, chemical, and microbiological quality of drinking water sources in Ogbelaka, Benin City. A cross-sectional approach provides a snapshot of water quality at the time of sampling and allows comparison across multiple sampling points within the study area.

3.2.2 Study population and eligibility

The study population consists of water sources used by households and public facilities in Ogbelaka. The unit of analysis is the water sample collected from each source. Where necessary, information about the source (type, owner, usage) will be recorded using a brief field questionnaire administered to the source owner or a representative.

3.2.3 Sample size calculation

A total of 25 water samples was collected. The sampling frame comprises all accessible drinking-water points in Ogbelaka street, Awo Lane and Awo Street identified during a preliminary reconnaissance survey and local consultations. Sampling points was chosen to represent different source types, varying proximity to potential pollution sources, and spatial distribution as illustrated in the map above

3.2.4 Sample location

This study was conducted in households at in Ogbelaka Community, Benin City. in Ogbelaka Community is located in Oredo Local Government Area, Benin City, Edo State, Nigeria.

3.3 Questionnaire Survey

A structured questionnaire survey was employed to assess household water quality practices and hygiene behaviors. The questionnaire was designed to collect data on sources of water, storage methods, treatment practices, and sanitation habits. It was pretested to ensure clarity and reliability before data collection. Respondents were selected using a random sampling technique, ensuring representation across households. The collected data were coded and analyzed using descriptive and inferential statistical methods. A total of 80 households were visited and assessed.

3.4 Sample Collection

The study assessed water samples obtained from twenty-five (25) drinking water samples using sterile plastic bottles. The samples were labeled appropriately and transported to the laboratory immediately for analysis.

3.5 Preparation of Culture Media

Nutrient agar (NA) (Lab M, Lancashire, United Kingdom) was prepared by dissolving 28 g of the agar powder in 1000 mL of distilled water and subsequently sterilized by autoclaving at 121^{o}C for 15 minutes. Chromogenic coliform agar (CCA) (Lab M, Lancashire, United Kingdom) was prepared by dissolving 26.5g of the agar powder in 1000mL of distilled water and subsequently heat to boil with frequent agitation by a magnetic stirrer added in the agar on a heating mantle in order to dissolve the media completely. CCA was not autoclaved or allowed to overheat.

3.6 Determination of physicochemical parameters

Physicochemical parameters which include pH, temperature, electrical conductivity, salinity and total dissolved solids were assessed using digital water quality tester (MWC - TDS2355, China) according to the manufacturer's instructions. The equipment was first calibrated using standard buffer solutions and adjusted according. After calibration, the electrode was rinsed with distilled water. The sensor electrode then immersed in the samples and allowed for 2-5 minutes for a stable reading to be obtained.

3.7 Enumeration of Total Heterotrophic Bacteria

The water samples were inoculated directly on the agar media without dilution. Total heterotrophic bacterial count was determined using the spread plate method by inoculating 200 µL of each sample into separate sterile nutrient agar plates (Lab M, Lancashire, United Kingdom) which were subsequently incubated at 37^{o}C for 18-24 h. Enumeration of the bacterial isolates was carried out and the mean counts were expressed as colony-forming units per millilitre (CFU/mL).

3.8 Cultural Characterization and Enumeration of Total Coliforms and Escherichia coli

The total coliform and *Escherichia coli* counts was determined using the spread plate method by inoculating 200 µL of each sample into separate sterile chromogenic coliform agar (Lab M, Lancashire, United Kingdom). The aliquot was spread evenly on the agar plate using a sterile glass spreader and subsequently incubated at 44^{o}C for 18-24 h. Enumeration of bacterial isolates was carried out and the mean counts were expressed as colony-forming units per millilitre (CFU/mL). Distinct blue or violet colonies were considered to be presumptive *Escherichia coli* (fecal coliforms). Distinct pink or red colonies were considered to be other coliforms (non-fecal coliforms). Presumptive bacteria were counted and the mean counts were expressed in colony-forming units per millilitre (CFU/mL). Presumptive isolates were purified by subculturing on nutrient agar plate and stored on nutrient agar slants.

3.9 Biochemical Characterization of Coliform Bacteria

The presumptive coliform isolates were screened using Gram reaction with potassium hydroxide (3% KOH) test, oxidase test and catalase test. KOH test was carried out using sterilizing wire loop to smear 2-3 drops of 3% KOH (potassium hydroxide) on a glass slide. The indication of a slimy reaction in the solution indicates a positive KOH reaction. Catalase test was conducted to detect the presence or absence of catalase enzyme. A few drops of freshly prepared 3% hydrogen peroxide were added onto the bacterial isolates smeared on a slide. The production of gas bubble indicated catalase enzyme positive. Oxidase test was conducted using a piece of filter paper in which 2-3 drops of freshly prepared oxidase reagent was added then presumptive colonies were smeared on the filter paper. A positive result for oxidase gave a purple-blue coloration after about 10 seconds while a negative result gave no such color after 10 seconds. Presumptive coliforms were KOH positive, catalase positive and oxidase negative.

3.10 Data Analysis

Data obtained in this study were collected and analyzed using Microsoft excel and by statistical package for social scientist (SPSS) version 22.0 (SPSS Inc., Chicago, IL, USA). Normal distributed data was expressed as mean ± standard deviation.

CHAPTER FOUR

4.0 RESULTS

Table 4.1 presents the demographic and environmental characteristics of the 80 participating households. In terms of gender distribution, males constituted 56.2%, while females accounted for 43.8%. The age structure showed that most respondents were within the 38–47 years (32.5%) category, followed by 18–27 years (25.0%). The marital status data revealed that the majority were married (55.0%), while 38.8% were single. Regarding religion, 91.3% of respondents identified as Christians, followed by 7.5% Muslims and 1.2% traditionalists. In terms of educational status, a significant 73.7% had tertiary education, while only 2.5% had no formal education.

Occupationally, civil servants formed the largest group (23.8%), followed by traders/business owners (20.0%) and students (17.5%). A smaller proportion were artisans (16.3%), private sector employees (16.3%), farmers (3.8%), and unemployed (2.5%). Household size was fairly large, with most homes having 7–9 members (35.0%) and 1–3 or 4–6 members (each 31.3%). Correspondingly, monthly household income varied widely, with 30.0% earning between ₦50,000–₦99,999, while 26.3% earned less than ₦20,000. The majority of households (93.8%) reported having a waste dump site nearby, and 45.0% lived within 50 meters of such sites, while another 43.8% lived within 50–100 meters. Furthermore, 68.8% of respondents acknowledged the presence of open sewage or stagnant water. In all, 60.0% of the household surroundings can de described as moderately clean, 25.0% as clean, and 15.0% as dirty.

Table 4.1. Demographics and Environmental Observations of Households

Parameters		**Frequency (n=80)**	**Percentage (%)**
Sex	Male	45	56.2
	Female	35	43.8
Age in years	18-27	20	25.0
	28-37	17	21.3
	38-47	26	32.5
	48-57	10	12.5
	58 and above	7	8.7
Marital status	Single	31	38.8
	Married	44	55.0
	Divorced	3	3.7
	Widowed	2	2.5
Religion	Christianity	73	91.3
	Islam	6	7.5
	Traditional	1	1.2
Educational Level Attained	No Formal Education	2	2.5
	Vocational	5	6.3
	Quranic	2	2.5
	Primary School	4	5.0
	Secondary School	8	10.0
	Tertiary Education	59	73.7
Occupation	**Student**	14	17.5
	Private sector Employee	13	16.3
	Trader/Business Owner	16	20.0
	Civil Servant	19	23.8
	Artisan/Skilled Worker	13	16.3
	Farmer	3	3.8
	Unemployed	2	2.5
Household Size	1-3	25	31.3
	4-6	25	31.3
	7-9	28	35.0
	10 and above	2	2.5
Monthly Household	<20,000	21	26.3
	20,000-49,999	10	12.5

Income (₦)	50,000-99,999	24	30.0
	100,000-149,999	15	18.8
	≥150,000	10	12.5
Is there a waste dump site near the household?	Yes	75	93.8
	No	5	6.2
Estimated distance of their residence to the nearest waste dump site	<50m	36	45.0
	50-100m	35	43.8
	>100m	9	11.3
Is there any open sewage or stagnant water nearby?	Yes	25	68.8
	No	55	31.2
General condition of the surroundings	Clean	20	25.0
	Moderately clean	48	60.0
	Dirty	12	15.0

The assessment of household water sources and quality in Table 4.2 revealed that the main source of drinking water for most households was sachet water (52.5%), followed equally by borehole (23.8%) and bottled water (23.8%). As a secondary source, boreholes were used by 57.5%, sachet water by 31.3%, and bottled water by 10.0%. A small fraction (1.3%) reported using rivers or streams. Regarding distance to water sources, the majority (65.0%) had their main sources located within 100 meters of their homes, while 18.8% were between 100–500 meters and 16.2% between 500–1000 meters. The assessment of water treatment practices revealed that 82.5% of respondents treating their water before consumption. The most common treatment method was boiling (56.1%), followed by boiling combined with filtration (25.8%), and less frequent use of chlorination (4.5%), boiling with alum (1.5%), or filtration alone (12.1%).

All respondents (100%) reported storing water for drinking. The most common storage methods were covered containers (46.3%) and jerry cans (38.8%), while a few used overhead tanks (12.5%), freezers (1.3%), or uncovered containers (1.3%). For water collection from storage, 82.4% used cups with handles, while 8.8% each used cups without handles or bowls. Concerning container cleaning frequency, 51.2% cleaned their containers weekly, 33.8% daily, while a smaller number (8.8%) cleaned monthly and 6.3% rarely. Availability of water showed that 88.8% have their source available year-round, although 65.0% had faced problems with their supply. The major issues were intermittent supply (61.5%), poor taste (13.5%), bad odour (13.5%), and high cost or combined issues (11.6%). Also, 82.5% of respondents believed people could get sick from the water they drink, and 42.5% had experienced water-related illnesses within six months. The predominant illnesses reported were diarrhea (58.8%) and typhoid (38.2%), while a few (2.9%) had both. Finally, 87.5% of respondents noted no unpleasant physical characteristics in their water, though 10.0% mentioned taste issues and 2.5% reported color problems.

Table 4.2. Water Source and Quality Assessment of Households

Parameters		Frequency (n=80)	Percentage (%)
Main source of drinking water?	Borehole	19	23.8
	Bottled Water	19	23.8
	Sachet Water	42	52.5
Secondary source of drinking water?	Borehole	46	57.5
	Bottled Water	8	10.0
	Sachet Water	25	31.3
	River/Stream	1	1.3
Distance of main source of drinking water from home?	<100m	52	65.0
	100-500m	15	18.8
	500-1000m	13	16.2
	>1000m	0	0.0
Do you treat your water before drinking?	**Yes**	66	82.5
	No	14	17.7
If yes, what treatment method do you use?	Boiling	37	56.1
	Boiling, Filtration	17	25.8
	Boiling, Chlorination	3	4.5
	Boiling, Use of alum	1	1.5
	Filtration	8	12.1
Do you store water for drinking purpose?	Yes	80	100.0
	No	0	0.0
If yes, how do you store your drinking water?	Covered container	37	46.3
	Jerry can	31	38.8
	Uncovered container	1	1.3
	Overhead tank	10	12.5
	Freezer	1	1.3
How do you collect water from the storage container?	Cup with handles	66	82.4
	Cup without handles	7	8.8
	Bowl	7	8.8
How frequently do you clean your water storage containers?	Daily	27	33.8
	Weekly	41	51.2
	Monthly	7	8.8
	Rarely	5	6.3
Is your source available year-round?	Yes	71	88.8
	No	9	11.2
Have you faced any problem with your water supply recently?	Yes	52	65.0
	No	28	35.0
If yes, what kind of problems?	High cost	3	5.8
	Intermittent supply	32	61.5
	Poor taste	7	13.5
	Bad odour	7	13.5

	Poor taste, Bad odour	3	5.8
Can people get sick with the water they drink?	Yes	66	82.5
	No	14	17.5
Have your household experienced water-related illness in the past 6 months?	Yes	34	42.5
	No	46	57.5
If yes, which illness(es)?	Diarrhea	20	58.8
	Typhoid	13	38.2
	Diarrhea, Typhoid	1	2.9
Any unpleasant physical characteristics associated with your water? If yes, name them	No	70	87.5
	Colour	2	2.5
	Taste	8	10.0

The findings in Table 4.3 revealed that most households (73.8%) had access to flush toilets while 26.2% relied on pit latrines. Notably, no respondents practiced open defecation. Regarding the type of toilet flooring, 61.2% had tiled floors, 20.0% had wooden floors, and 18.8% used concrete floors. However, a majority (63.7%) of respondents shared toilet facilities with other households, while 36.3% used private toilets. Access to regular handwashing facilities near toilets was reported by 66.2%, while 33.8% lacked such access. In terms of toilet cleaning frequency, 71.3% of households cleaned their facilities weekly, while 27.5% cleaned them daily. Only 1.3% reported monthly cleaning, and none said they rarely cleaned.

As regards hand hygiene practices, 100% of respondents reported always washing their hands after toilet use, and 97.5% also always washed their hands before preparing food. When asked about handwashing frequency, 73.8% said they washed their hands whenever dirty, 13.8% washed 1–3 times per day, and 11.3% 4–6 times per day. With respect to soap use during handwashing, responses were nearly balanced: 51.2% reported always using soap, while 48.8% used soap sometimes. Personal hygiene habits were also strong, with 97.5% of respondents bathing daily, while only 2.5% did not. Regarding waste disposal, the vast majority (96.2%) used formal waste management services, while a small fraction (3.8%) resorted to burning waste. No respondents reported dumping waste in open spaces. For environmental sanitation, 57.5% cleaned their surroundings daily, and 41.3% did so weekly, while only 1.3% cleaned occasionally. Awareness of Water, Sanitation, and Hygiene (WASH) observed 66.3% being very aware, 31.3% somewhat aware, and only 2.5% not aware. However, only 16.3% reported any recent water quality testing programs in their area, while 70.0% said no testing had occurred, and 13.8% were unsure. Notably, 98.8% of respondents expressed willingness to have their water sources tested.

Table 4.3. Sanitation and Hygiene Practices of Households

Parameters		**Frequency (n=80)**	**Percentage (%)**
What type of toilet facility is available to your household?	Flush toilet	59	73.8
	Pit latrine	21	26.2
	Open defecation	0	0.0
Type of floor in the toilet?	Concrete	15	18.8
	Wooden	16	20.0
	Tiles	49	61.2
Is the toilet shared with other households?	**Yes**	51	63.7
	No	29	36.3
Do you have access to regular handwashing facility near the toilet?	**Yes**	53	66.2
	No	27	33.8
How often is the toilet facility cleaned?	Daily	22	27.5
	Weekly	57	71.3
	Monthly	1	1.3
	Rarely	0	0.0
How often do you wash your hands after using the toilet?	Always	80	100.0
	Sometimes	0	0.0
How often do you wash your hands per day?	1-3 times	11	13.8
	4-6 times	9	11.3
	Whenever hands are dirty	59	73.8
	Not sure	1	1.3
How often do you wash your hands before preparing food?	Always	78	97.5
	Sometimes	2	2.5
How often do you use soap when you wash your hands?	Always	41	51.2
	Sometimes	39	48.8
	When available	0	0.0
Do you bath daily?	**Yes**	78	97.5
	No	2	2.5
How do you dispose your household waste?	Waste management services	77	96.2
	Burning	3	3.8
	Buried	0	0.0
	Dump in Open Space	0	0.0
How often do you clean your surroundings?	Daily	46	57.5
	Weekly	33	41.3
	Occasionally	1	1.3
Are you aware of the importance of safe water, sanitation, and hygiene (WASH)?	Very aware	53	66.3
	Somewhat aware	25	31.3
	Not aware	2	2.5
Have there been any water quality testing programs in your area recently?	Yes	13	16.3
	No	56	70.0
	Don't know	11	13.8
Would you consent to having your water source tested for quality parameters?	Yes	79	98.8
	No	1	1.2

The physicochemical profile of drinking water samples presented in Table 4.4 revealed that the temperature of the samples ranged between 26.0°C and 29.7°C, with a mean value close to 27.8°C. The pH values ranged from 5.8 to 8.1 with a few slightly acidic samples (pH 5.8) and slightly alkaline samples (pH 8.1). Total Dissolved Solids (TDS) values varied widely, from 26 mg/L to 163 mg/L. The Electrical Conductivity (EC) values ranged from 60 µS/cm to 307 µS/cm. Salinity levels were consistently low across all samples, ranging from 0.00% to 0.03%. The Oxidation-Reduction Potential (ORP), ranged between 133 mV and 299 mV. Hydrogen content was uniformly low, between 0.0 and 0.7 ppb. All samples recorded a specific gravity of 1.0, consistent with pure water. The resistivity values varied considerably, from 43 Ω·m to 181 Ω·m.

The mean total heterotrophic bacterial counts (THBC) of drinking water samples presented in Table 4.5 and Figure 4.1. Borehole water samples had THBC values ranging from 0 to 34×10^0 CFU/mL, with an overall mean of 18×10^0 CFU/mL. Sachet water samples showed THBC values ranging from 0 to 11×10^0 CFU/mL, with a mean count of about 3×10^0 CFU/mL. Most sachet water samples had no bacterial growth. Bottled water samples consistently recorded 0 CFU/mL across all cases, giving a mean count of 0×10^0 CFU/mL.

The results presented in Table 4.6, Figure 4.2 and Figure 4.3 showed the distribution of total coliform and *Escherichia coli* (*E. coli*) counts in drinking water samples. The borehole water samples showed total coliform counts ranging from 0 to 17×10^0 CFU/mL, with a mean value of approximately 10×10^0 CFU/mL, while *E. coli* was absent in all samples. In contrast, sachet water samples generally exhibited lower microbial counts, with total coliform values ranging between 0 and 15×10^0 CFU/mL and a mean of about 2×10^0 CFU/mL, while *E. coli* remained undetected across all samples. In bottled water samples, both total coliform and *E. coli* counts were absent (0×10^0 CFU/mL) across all samples.

Table 4.4. Physicochemical Profile of Drinking Water Samples from Households

Sample Codes	Parameters								
	Temperature (℃)	pH	TDS (mg/L)	EC (µs/cm)	Salinity (%)	ORP (mv)	Hydrogen (ppb)	Specific Gravity	Resistivity (Ω .m)
AWL005	27.5±0.1	6.3±0.4	39±3.2	66±5.6	0.00±0.0	156±3.3	0.0±0.0	1.0±0.0	181±2.0
AWL012	27.0±0.2	7.0±0.2	31±2.2	84±7.1	0.00±.0.0	159±.4.1	0.2±0.0	1.0±0.0	121±.3.3
AWS015	28.0±1.2	6.0±0.5	30±4.3	71±3.9	0.00±0.0	201±2.9	0.0±0.0	1.0±0.0	139±2.6
AWS019	28.0±0.0	5.8±0.0	38±2.1	80±7.2	0.01±0.0	299±3.7	0.0±0.0	1.0±0.0	153±3.1
AWS020	26.0±0.3	6.4±0.3	26±3.9	89±6.8	0.00±0.0	248±2.7	0.0±0.0	1.0±0.0	120±2.5
AWS033	29.7±0.1	7.3±0.6	54±2.7	76±9.2	0.00±0.0	231±3.8	0.3±0.0	1.0±0.0	161±2.3
AWS034	27.0±0.1	6.5±0.4	51±2.2	95±3.7	0.00±0.0	241±3.5	0.0±0.0	1.0±0.0	157±2.6
AWS046	28.1±1.2	8.1±0.5	26±1.6	73±6.4	0.00±0.0	207±2.6	0.2±0.0	1.0±0.0	161±4.5
OGBE001	27.7±0.2	7.6±0.1	137±6.4	94±7.1	0.00±0.0	133±3.0	0.2±0.0	1.0±0.0	81±6.1
OGBE004	28.1±0.0	7.7±0.0	51±2.7	102±6.9	0.00±0.0	281±3.4	0.0±0.0	1.0±0.0	93±2.3
OGBE006	26.9±0.0	8.0±0.0	112±6.1	131±5.4	0.02±0.0	226±2.7	0.0±0.0	1.0±0.0	95±4.5
OGBE011	28.4±0.0	7.9±0.0	148±4.2	101±3.8	0.00±0.0	293±8.3	0.0±0.0	1.0±0.0	97±4.6
OGBE015	28.3±0.1	6.5±0.4	115±5.6	231±4.1	0.00±0.0	251±2.8	0.1±0.0	1.0±0.0	48±3.5
OGBE017	27.9±0.2	7.3±0.2	73±2.0	173±2.4	0.00±0.0	263±8.2	0.0±0.0	1.0±0.0	56±5.3

OGBE019	28.2±0.5	6.8±0.5	36±5.7	60±5.2	0.00±0.0	265±4.5	0.0±0.0	1.0±0.0	105±2.6
OGBE020	28.7±0.0	7.4±0.0	87±4.9	147±5.8	0.00±0.0	263±5.0	0.0±0.0	1.0±0.0	84±3.1
OGBE022	26.9±0.3	6.8±0.3	73±3.5	240±9.3	0.03±0.0	260±6.3	0.0±0.0	1.0±0.0	87±3.5
OGBE023	27.9±0.1	7.3±0.6	131±6.4	131±6.4	0.00±0.0	231±5.1	0.1±0.0	1.0±0.0	90±3.4
OGBE024	27.4±0.8	7.5±0.4	45±4.7	145±4.7	0.00±0.0	235±4.8	0.3±0.0	1.0±0.0	89±2.7
OGBE030	27.6±1.2	8.1±0.5	151±5.5	151±5.1	0.00±0.0	214±2.7	0.7±0.0	1.0±0.0	91±2.8
OGBE038	28.2±0.2	6.3±0.1	34±6.1	269±7.1	0.01±0.0	210±3.6	0.6±0.0	1.0±0.0	50±3.7
OGBE042	29.0±0.0	6.2±0.0	153±7.0	307±6.8	0.00±0.0	196±2.6	0.3±0.0	1.0±0.0	43±1.2
OGBE046	27.6±0.0	0.0±0.0	163±3.2	201±4.2	0.00±0.0	233±3.5	0.0±0.0	1.0±0.0	44±5.0
0GBE053	27.0±0.0	0.0±0.0	53±6.1	146±3.8	0.00±0.0	261±1.8	0.2±0.0	1.0±0.0	117±4.2
OGBE057	29.0±0.2	7.3±0.5	113±5.7	227±5.2	0.01±0.0	194±3.9	0.0±0.0	1.0±0.0	103±2.8

KEY: TDS = Total dissolved solids; EC= Electrical conductivity; ORP= Oxidation-Reduction Potential

Table 4.5. Mean Total Heterotrophic Counts of Drinking Water Samples from Households

Sample Code	Sample Source	Mean Counts of Heterotrophic Bacteria CFU/mL $\times 10^0$
AWL005	Borehole Water	0±0.0
AWL012	Borehole Water	28±2.9
AWS015	Borehole Water	15±2.0
AWS019	Sachet Water	0±0.0
AWS020	Borehole Water	27±4.3
AWS033	Sachet Water	8±1.3
AWS034	Bottled Water	0±0.0
AWS046	Sachet Water	11±3.7
OGBE001	Sachet Water	0±0.0
OGBE004	Bottled Water	0±0.0
OGBE006	Borehole Water	29±2.0
OGBE011	Borehole Water	0±0.0
OGBE015	Borehole Water	34±2.7
OGBE017	Borehole Water	0±0.0
OGBE019	Borehole Water	31±1.5
OGBE020	Sachet Water	0±0.0
OGBE022	Bottled Water	0±0.0
OGBE023	Bottled Water	0±0.0
OGBE024	Sachet Water	0±0.0
OGBE030	Sachet Water	0±0.0
OGBE038	Sachet Water	7±1.6
OGBE042	Borehole Water	12±1.2
OGBE046	Borehole Water	18±2.3
0GBE053	Sachet Water	0±0.0
OGBE057	Bottled Water	0±0.0

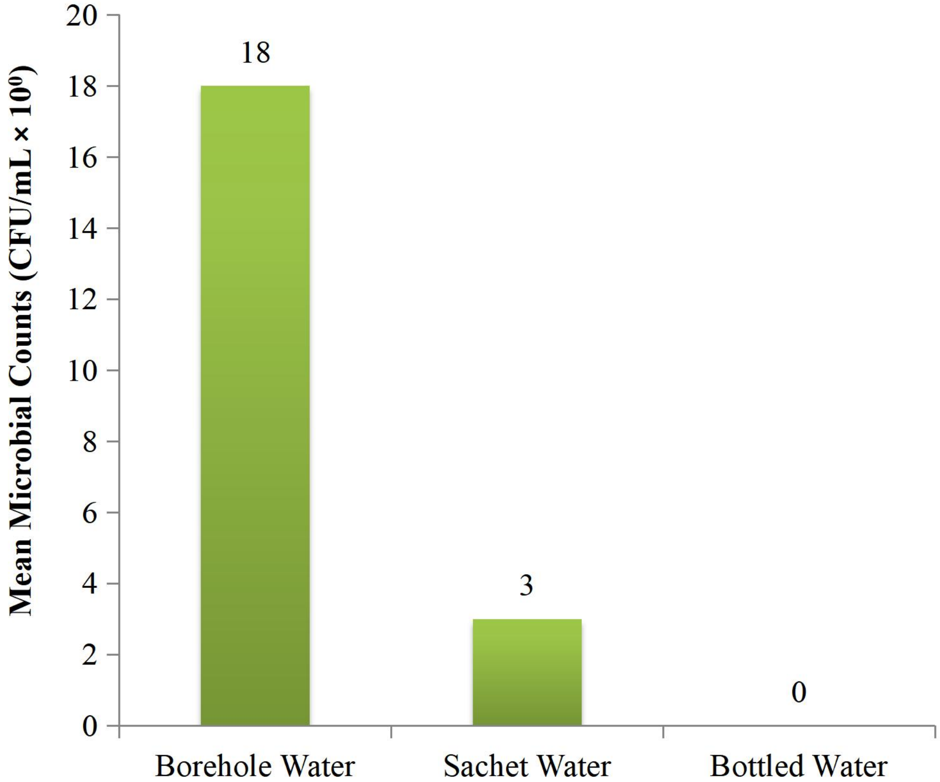

Figure 4.1. Distribution of Heterotrophic Bacterial Based on Sample Sources

Table 4.6. Coliforms and *Escherichia coli* Counts in Water Samples from Households

Sample Codes	Sample Sources	Total Coliform Count (CFU/mL $\times 10^0$)	*Escherichia coli* Count (CFU/mL $\times 10^0$)
AWL005	Borehole Water	0±0.0	0±0.0
AWL012	Borehole Water	0±0.0	0±0.0
AWS015	Borehole Water	9±1.5	0±0.0
AWS019	Sachet Water	0±0.0	0±0.0
AWS020	Borehole Water	0±0.0	0±0.0
AWS033	Sachet Water	0±0.0	0±0.0
AWS034	Bottled Water	0±0.0	0±0.0
AWS046	Sachet Water	0±0.0	0±0.0
OGBE001	Sachet Water	0±0.0	0±0.0
OGBE004	Bottled Water	0±0.0	0±0.0
OGBE006	Borehole Water	11±1.0	0±0.0
OGBE011	Borehole Water	0±0.0	0±0.0
OGBE015	Borehole Water	12±2.2	0±0.0
OGBE017	Borehole Water	0±0.0	0±0.0
OGBE019	Borehole Water	17±1.9	0±0.0
OGBE020	Sachet Water	0±0.0	0±0.0
OGBE022	Bottled Water	0±0.0	0±0.0
OGBE023	Bottled Water	0±0.0	0±0.0
OGBE024	Sachet Water	0±0.0	0±0.0
OGBE030	Sachet Water	0±0.0	0±0.0
OGBE038	Sachet Water	15±2.0	0±0.0
OGBE042	Borehole Water	9±1.8	0±0.0
OGBE046	Borehole Water	13±2.1	0±0.0
0GBE053	Sachet Water	0±0.0	0±0.0
OGBE057	Bottled Water	0±0.0	0±0.0

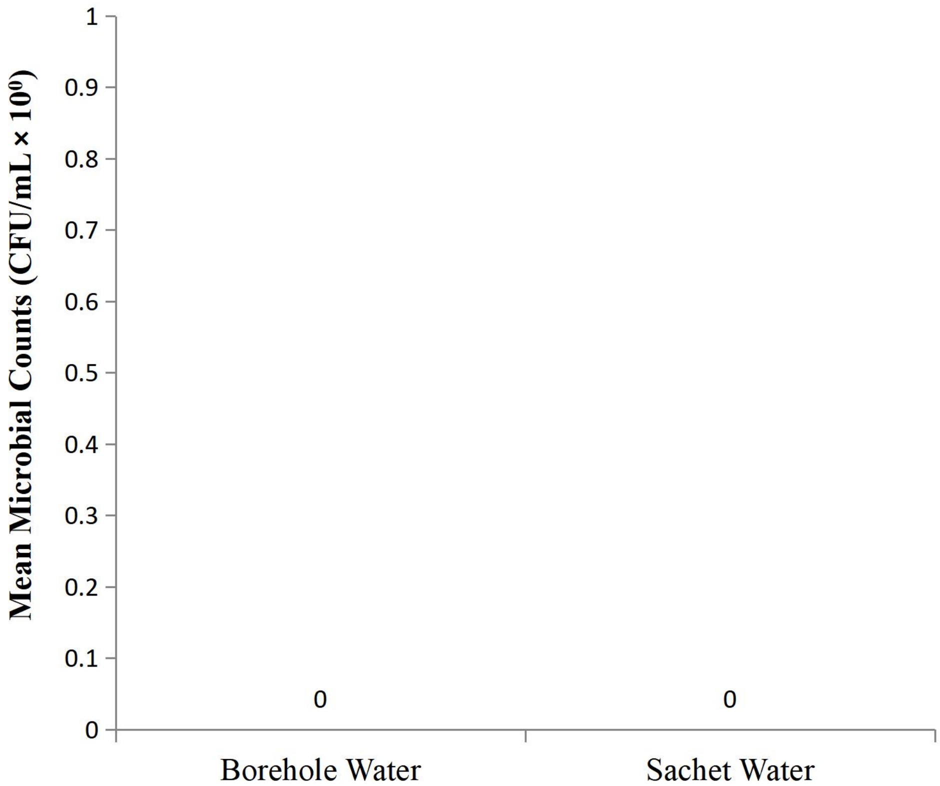

Figure 4.2. Distribution of *Escherichia coli* in Drinking Water Samples from Households

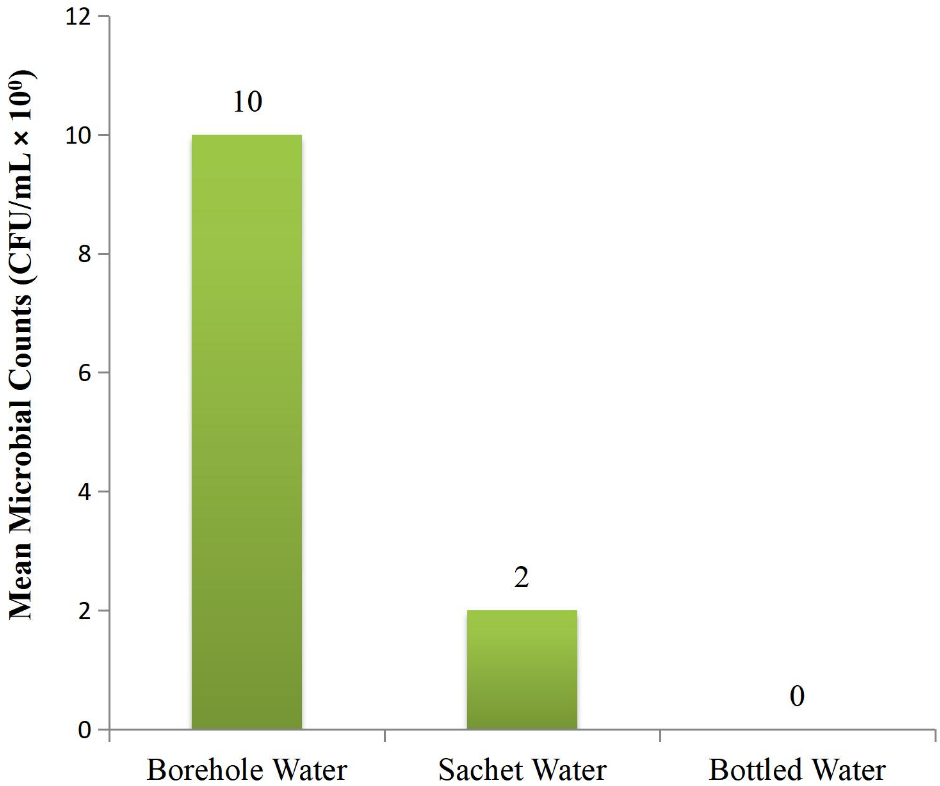

Figure 4.3. Distribution of Total Coliforms Based on Sample Sources

CHAPTER FIVE

Summary, Discussion, Conclusion and Recommendations

5.1 Summary

This study examined the water quality and hygiene practices among households in Ogbelaka, Benin City, Edo State. It was motivated by the persistent challenges of unsafe drinking water, poor sanitation, and inadequate hygiene in Nigeria despite global and national commitments to Sustainable Development Goal 6 (Clean Water and Sanitation). The study aimed to assess the microbiological quality of household water, evaluate hygiene and sanitation practices, and identify household-level predictors of contamination.

The literature review showed that poor water quality, unsafe storage, and inadequate hygiene are major contributors to waterborne diseases such as diarrhea, cholera, and typhoid fever. Studies across Nigeria, including Edo State, indicate widespread contamination of water sources and post-collection water handling issues.

Findings from this study confirmed that most household water samples in Ogbelaka were contaminated with thermotolerant coliforms and *Escherichia coli* beyond the WHO permissible limits for potable water. Many households depended on untreated borehole or well water, while a minority practiced effective water treatment methods such as boiling or chlorination. Unsafe storage practices — such as using open containers or dipping utensils into stored water — increased the likelihood of secondary contamination.

Although awareness of hygiene was fairly high, practice remained poor and inconsistent. Many households did not regularly wash hands with soap at critical times, and environmental sanitation around water sources was unsatisfactory. These findings highlight the combined effects of infrastructural deficiencies, poor behavioral practices, and limited public awareness on water safety.

5.2 Discussion

The findings of this study align with previous research emphasizing that microbial contamination of domestic water remains a serious public health issue in Nigeria (Wright et al., 2004; Omole et al., 2015). The detection of *E. coli* and thermotolerant coliforms in household water samples from Ogbelaka confirms that most of the drinking water does not meet WHO or Nigerian Standard for Drinking Water Quality (NSDWQ) guidelines. This microbial presence signifies fecal contamination — often from unsafe handling, inadequate sanitation, or direct seepage from poorly maintained sources.

Similar patterns have been observed in other regions, including Ibadan and Osun States, where contamination increased between collection and storage stages (Omole et al., 2015; Ademola & Olajire, 2019). The situation in Ogbelaka thus reflects a broader national challenge of unsafe household water handling.

The study also revealed low adoption of water treatment methods, consistent with Oloruntoba et al. (2014), who found that over 60% of households in Edo State did not treat their drinking water.

This poor adoption rate is likely due to low awareness, perceived cost, and lack of understanding of the health implications of untreated water.

Hygiene practices were similarly suboptimal, echoing WHO (2022) estimates that unsafe water, poor sanitation, and inadequate hygiene account for hundreds of thousands of annual diarrheal deaths worldwide. The limited handwashing compliance observed mirrors findings by Ejemot-Nwadiaro et al. (2015), who noted that knowledge of hand hygiene often fails to translate into consistent behavior without continuous education and infrastructure support.

The prevalence of waterborne diseases reported by respondents further validates the established relationship between poor WASH (Water, Sanitation and Hygiene) practices and public health outcomes. In line with Wolf et al. (2018), the results reinforce that improving hygiene and ensuring safe water could prevent a large proportion of diarrheal and infectious disease burdens in developing contexts.

Environmental and infrastructural factors also contributed significantly. Many homes lacked proper drainage or waste disposal systems, allowing surface runoff and fecal matter to contaminate open wells or boreholes. These observations are consistent with reports by WHO and UNICEF (2019) indicating that poor sanitation and open defecation remain major contamination pathways in Nigeria.

Overall, the discussion demonstrates that the challenges in Ogbelaka are not merely technical but behavioral and systemic. Addressing them requires integrated interventions involving public education, local government action, and sustainable water management systems.

5.3 Conclusion

The study concludes that the quality of household drinking water in Ogbelaka, Benin City, is below acceptable standards due to microbial contamination and poor hygiene practices. Unsafe handling, inadequate sanitation, and inconsistent hygiene behaviors are major contributors to the public health risks observed. Without urgent intervention, communities will continue to face high exposure to waterborne diseases such as diarrhea, cholera, and typhoid fever.

Improving water quality requires a holistic approach that combines infrastructure development, behavioral change, and policy enforcement. Community-based awareness, continuous monitoring, and provision of affordable treatment technologies are vital for ensuring safe drinking water and reducing disease prevalence.

5.4 Recommendations

1. Community Education:
   Government and NGOs should intensify community-level education programs focusing on hygiene, safe water handling, and sanitation practices.

2. Household Water Treatment:
   Households should be encouraged to use simple, affordable treatment methods like boiling, chlorination, or filtration before consumption.

3. Improved Storage Practices:
   Promote the use of covered, narrow-mouth containers or tanks fitted with taps to prevent recontamination after water collection.

4. Regular Water Quality Monitoring:
   The Edo State Ministry of Environment should conduct regular microbiological and chemical analyses of domestic water sources and enforce compliance with WHO and NSDWQ standards.

5. Infrastructure Development:
   Expand access to safe and treated municipal water systems and provide improved sanitation infrastructure, particularly in semi-urban and peri-urban areas like Ogbelaka.

6. Behavioral Change Communication:
   Public health campaigns should integrate culturally sensitive communication strategies to promote handwashing with soap and proper sanitation habits.

7. Policy and Enforcement:
   Strengthen local water management policies and ensure strict enforcement against indiscriminate waste disposal and open defecation near water sources.

8. Further Research:
   Future studies should assess seasonal variations, include chemical contaminant analysis, and cover wider communities to provide more comprehensive insights into water safety and hygiene behavior patterns.

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APPENDIX I

Code	pH	Temp °C	TDS(ppm)	EC(ns/cm)	Salinity(%)	ORP (mv)	hydrogen(ppb)	specific gravity	Resistivity	Source
AWL005	6.98	28	300	601	0.03	35	0	1	26.4	borehole
AWL012	6.9	28.2	295	580	0.02	37	0	1	27	borehole
AWS015	6.94	27.3	292	578	0.02	33	0	1	25.7	borehole
AWS019	7.2	26.7	23	44	0	225	0	1	328.7	sachet
AWS020	6.89	27.8	301	605	0.03	40	0	1	25.6	borehole
AWS033	7.4	27	26	44	0	223	0	1	315.7	sachet
AWS034	6.3	26.5	302	605	0.03	115	0	1	24	bottle water
AWS046	7.34	26.5	24	46	0	220	0	1	308.7	sachet
OGBE001	7.4	27	26	43	0	223	0	1	318.4	sachet
OGBE004	6.3	25.7	301	605	0.03	115	0	1	25	bottle water
OGBE006	6.88	28	305	601	0.02	38	0	1	27	borehole
OGBE011	6.98	28.2	295	595	0.03	32	0	1	26.5	borehole
OGBE015	6.93	27	290	582	0.02	33	0	1	25.64	borehole
OGBE017	6.95	27.8	299	598	0.02	30	0	1	24.9	borehole

OGBE019	6.89	28.1	301	599	0.03	35	0	1	26.45	borehole
OGBE020	6.9	27.6	296	600	0.02	37	0	1	25.6	sachet
OGBE022	6.25	26.6	309	605	0.03	116	0	1	26	bottle water
OGBE023	6.26	26	305	607	0.03	110	0	1	24.7	bottle water
OGBE024	6.95	27.8	299	589	0.02	46	0	1	26	sachet
OGBE030	6.98	28.4	294	588	0.02	44	0	1	25.56	sachet
OGBE038	6.89	27	289	598	0.02	43	0	1	26.2	sachet
OGBE042	6.94	27.6	300	590	0.02	32	0	1	26.45	borehole
OGBE046	6.95	28.1	291	582	0.02	31	0	1	26	borehole
OGBE053	6.57	28.4	22	44	0	3.41	0	1	324.7	sachet
OGBE057	6.25	26.5	302	600	0.03	111	0	1	25	bottle water

Table 1. Readings from multimeter probe of Physio-Chemical parameters

APPENDIX II SECTION A: DEMOGRAPHIC INFORMATION

Please tick (✓) the appropriate option.

Variable Options

Sex: a) Male [ ] b) Female [ ]

Age: a) Less than 20 [ ] b) 21–30 [ ] c) 31–40 [ ] d) Above 40 [ ]

Marital Status: a) Single [ ] b) Married [ ] c) Divorced [ ] d) Widow/Widower [ ]

Religion: a) Christianity [ ] b) Islam [ ] c) Others [ ]

Educational Level: a) Primary [ ] b) Secondary [ ] c) Tertiary [ ] d) No Formal Education [ ]

Occupation: ______________________________

SECTION B: WATER QUALITY AND HYGIENE PRACTICES

Kindly tick (✓) the column that best indicates your opinion.

YES = Agree NO = Disagree

I. Water Quality

1 Do you have access to clean and safe drinking water in your household? [ ] [ ]
2 Do you boil your water before drinking it? [ ] [ ]
3 Is rainwater the safest water to drink? [ ] [ ]
4 Is pipe-borne water the safest to drink? [ ] [ ]
5 Do you believe that the water quality in your community is good? [ ] [ ]

II. Water Quality Assessment

6 Do you take measures to prevent waterborne diseases in your household? [ ] [ ]
7 Do you use boiling as a treatment method for water? [ ] [ ]
8 Do you use chlorination as a treatment method for water? [ ] [ ]
9 Do you believe that the government is doing enough to provide clean water and sanitation services in your community? [ ] [ ]
10 Would you adopt improved water treatment and hygiene practices if they were more affordable and accessible? [ ] [ ]

III. Hygiene Practices

11 Do you store your drinking water in a clean and covered container? [ ] [ ]
12 Do you clean your toilet facility regularly to prevent the spread of diseases? [ ] [ ]
13 Do you believe that poor water quality is a major health risk and a major cause of waterborne diseases in your community? [ ] [ ]
14 Have you received education or training on good hygiene practices? [ ] [ ]
15 Does your household have a regular waste disposal schedule? [ ] [ ]
16 Do you prioritize handwashing with soap and water over other hygiene practices? [ ] [ ]
17 Do you believe that community involvement is essential for improving water quality and hygiene practices? [ ] [ ]
18 Would you be willing to pay more for improved water and sanitation services? [ ] [ ]
19 Do you believe that your household's hygiene practices are better than those of your neighbors? [ ] [ ]
20 Do you think that water quality and hygiene practices are essential for maintaining good health? [ ] [ ]