WATER, SANITATION AND HYGIENE STATUS OF USELU, USEH and OGIDA MARKET in EDO STATE, NIGERIA

BY

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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.

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CERTIFICATION

This is to certify that this research titled "Water, Sanitation and Hygiene Status of Uselu, Useh and Ogida Markets in Edo State, Nigeria" was carried out by "**Aisosa Gloria OSAYANDE**" 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.

DR. E. E. IMARHIAGBE **DATE**

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DECLARATION

I “Aisosa Gloria Osayande” declare that “Water, Sanitation and Hygiene of Uselu, Ogida and Useh market" is my work and that all sources that I have used or quoted have been acknowledged through complete references and that this work has not been submitted before for any other degree at any other University.

Aisosa Gloria Osayande

…………………………

Date

DEDICATION

This work is dedicated to God Almighty who has always been my support, guide, help and provider. Also, to my lovely family who have been a blessing to me.

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ABSTRACT

Water, Sanitation and Hygiene is a growing field that supports the Sustainable Development Goal 6 which seeks to ensure water and sanitation for all. This study determined the WASH status of Uselu, Ogida and Useh markets in Egor Local Government Area. Water samples were collected from two points at Uselu and Ogida markets and analyzed for physicochemical and microbiological qualities, adopting standard analytical procedures and microbiological techniques respectively. Findings showed results as pH ranged from 4.70 to 5.00 (Usleu) and 5.10 to 6.29 (Ogida), Chlorine, 24.85 mg/l to 28.4 mg/l (Ogida) and 35.5 mg/ to 46.15 mg/l (Uselu), Nitrate, 0.68 mg/l to 1.31 mg/l (Uselu) and 1.85 mg/l to 3.19 mg/l (Ogida), BOD_5, 0.33 mg/l to 0.55 mg/l (Uselu) and 1.85 mg/l to 2.60 mg/l (Ogida). The heavy metal concentrations determined showed that iron was not detected in both markets, lead was not detected in one of the Uselu samples while the second read 0.04 mg/l and Ogida samples ranged from to 0.01 mg/l to 0.04 mg/l. Chromium ranged from 0.01mg/l to 0.04mg/l (Ogida) and 0.04 mg/l to 0.07mg/l (Uselu). The total heterotrophic bacterial counts ranged from 4.0 × 10 cfu/ml to 5.5 × 10 cfu/ml (Uselu) and 12 × 10 cfu/ml to 13 × 10 cfu/ml (Ogida). The total coliform counts ranged from 9MPN/100ml to 15MPN/100ml (Uselu) and from 6MPN/100ml to 7 MPN/100ml (Ogida). Fungi counts ranged from 0.33× 10 cfu/ml to 0.66 ×10 cfu/ml (Uselu) and from 1.33 × 10 cfu/ml to 1.67 × 10 cfu/ml (Ogida). From the questionnaire survey, it was discovered that boreholes and toilet facilities were available at Uselu and Ogida market (100% respectively) while none was found at Useh (100%). In Uselu and Ogida markets, hygiene was poor due to lack of soap materials (100% respectively) while at Useh, poor hygiene practices could be attributed to the lack of water as well as soap materials. At Uselu market, wastes were seldom evacuated by the waste management board (50%) and totally neglected in the environs of Ogida and Useh market (100% respectively). The results therefore show the need for an improvement of the WASH sectors of the three markets, especially Useh market, in order to protect the health and well-being of the traders and buyers.

CHAPTER ONE

1.1 INTRODUCTION

Human existence on the planet Earth is plagued by several health issues brought about by man's living conditions. It has been established by scientists that some conditions, such as a lack of clean water, sanitation and poor hygiene are harmful to an individual's health, social, and economic well-being, as well as that of his family or society in which they live (Eneji, *et al*., 2015).

WASH (Water, Sanitation, and Hygiene) is a set of activities that people of all culture and race engage in to maintain their health standards and prevent the spread of a variety of infectious diseases, hence protecting one's health (Roshini *et al*., 2020). These three fundamental issues have been grouped together to represent a developing sector due to their interconnection. Despite the fact that each is a distinct area of study, they are all dependent on the presence of the other (Shanmugam *et al*., 2018). Without toilets, for example, water supplies become contaminated, and fundamental hygiene practices are impossible to follow without clean water (UNICEF, 2017).

Water is vital for sustaining a productive environment for all living species, and it has a significant impact on public health and living standards because we depend on it for daily necessities such as detoxification and healthy body system functioning (Kilic, 2020). Water resources in the world are found in air, sea, land, rivers, lakes and oceans in varying proportions and they move between the earth and the atmosphere in a continuous cycle known as the hydrological cycle (Pimentel *et al*., 2004).

Sanitation refers to the activities, actions, and efforts that are undertaken to make all human settlements clean, safe, and comfortable to live in (Olowoporoku, 2017). Sanitation is concerned with the proper disposal of human waste, water supply management, and solid waste disposal, with the goal of guaranteeing environmental safety (Olowoporoku, 2013).

Hygiene is defined by The World Health Organization as activities aimed at securing health and checking the transmission of infections and these actions include efforts to clean one's body and surroundings (Curtis *et al*., 2003). Owing to the fact that bacteria can live on our bodies as well as in our surroundings, causing illnesses and diseases, effective interventions to promote personal cleanliness and disinfect the environment are frequently required to improve public health (Staniford and Schmidtke, 2020). According to the World Health Organization (WHO), 2.5 billion people, which is more than one-third of the global population, have never had access to basic sanitation. In Nigeria, there are poor records on general access to clean water supply and sanitation facilities, which further exacerbates poor hygiene (UNICEF, 2017; Nwankwoala, 2011).

According to Pruss-Ustun, (2019), disease outbreaks such as diarrhoea, respiratory virus infections, malaria, soil-transmitted helminth, schistosomiasis, and trachoma are caused by a lack of clean water and sanitation services, as well as inadequate hygiene habits. The United Nations, of which Nigeria is a member, devised seventeen sustainable development goals of which goal 6 (SDG 6) was created to specifically address the problem of lack of access to clean water, sanitation, and hygiene (Wada *et al*., 2021). Goal 6 drives towards ensuring access to clean water, proper sanitation and hygiene by setting out to achieve the following objectives; ensuring that clean water is accessible by everyone at a cost-effective rate; ensuring that there is the provision of sanitation and hygiene facilities that are efficient in proper disposal of human and solid wastes;

proffering solution to water scarcity by the establishment of developed water sources thereby increasing water efficiency in all sectors (UN, 2017; Torres, 2020).

Water, sanitation, and hygiene development can be divided into four categories (Fewtrell *et al*., 2005). Such improvements include; the provision of more developed water sources such as piped water and borehole water which safeguards water from contamination, enhancement of water quality through safe water storage and treatment of water to eliminate microbial contamination and other impurities, provision of improved sanitation facilities such as toilets, bathrooms and waste bins for safe disposal of human wastes and solid wastes respectively and hygiene improvements which provide facilities for hygiene practices and also educate the public on the relevance of good hygiene practices and human(Waddington and Snilstrent, 2009).

Water, sanitation and hygiene interventions create barriers to pathogens transmitted from feces into the body through fingers, flies, fields, food, and filthy water, thereby preventing water-borne illnesses such as diarrhea, dysentery, and cholera (Eneji *et al*., 2015).

Water shortages and contamination, as well as poor sanitation and hygiene, must be addressed immediately, particularly in developing countries like Nigeria, where waterborne illnesses such as cholera, diarrhea, and typhoid are common due to poor living conditions and sanitation (Coleman *et al*., 2013; Igbinosa and Aighewi, 2017).

1.2. AIM AND OBJECTIVES OF STUDY

The aim of this study is to determine the water, sanitation and hygiene (WASH) status of three major markets in Benin City, Edo State, Nigeria.

The objectives of the study were to;

1. Determine the physicochemical quality of the water from Uselu, Ogida and Useh markets.
2. Determine the microbial quality of the water.
3. Determine the concentration of heavy metals in the water.
4. Evaluate the sanitation and hygiene facilities available in the markets.

CHAPTER TWO

LITERATURE REVIEW

2.1 WATER, SANITATION AND HYGIENE (WASH)

The provision of safe and sufficient water, adequate sanitation and hygiene facilities is essential for good health and well- being of the society (Chakravarty *et al*., 2017). It is no coincidence that the acronym WASH points to solutions for addressing the spread of disease (Cairncross *et al*., 2010). It includes water use, sanitation and hygiene, which are components that need to be put in place in order to prevent contamination. For example, hands washing with soap, treating water and appropriate disposal of excreta have resulted in diarrhoea risk reductions (Ginja *et al*., 2021). WASH services therefore entail the provision of high-quality and readily available water, sanitation facilities for the safe disposal of human waste as well as solid waste management, and the availability of soap and water for hand washing (Kayiwa *et al*., 2020).

Recent research continues to prove that hindered access to clean water, sanitation and hygiene, poses a threat to human health (Nayebare *et al*., 2020). Hence, the field of environmental public health also focusses on water, sanitation and hygiene services, all in a bid to prevent and control diseases (Orimoloye *et al*., 2015). This was expressed in a study by Kayiwa *et al*. (2020) who assessed the availability of WASH services in health care facilities in Kampala, Uganda. The assessment was based on the indicators of the World Health Organisation which seeks to verify the availability of improved sources of water supply, the presence of separate toilets for male and female and the availability of hand washing stations with soap and alcohol-based rubs, within a facility. The findings had it that many of the health care facilities had limited WASH services.

Inadequate water, sanitation and hygiene (WASH) have remained an intractable problem in many parts of the world (Ginja *et al*., 2019). Poor WASH conditions are linked to 6.6% of the global burden of disease as well as 2.4 million fatalities annually from diarrhea and cholera (Ngure *et al*., 2014). A study carried out by Wada *et al*. (2021), recorded great improvement in global WASH from year 2000 to 2017. Basic water service coverage in cities increased from 95% to 97%, while rural coverage increased from 69 % to 81 %. The global rate of open defecation fell from 21% to 9%, reducing the number of individuals who do so from 1.3 billion to 673 million. However, the WASH situation in Nigeria, the world's largest Black Country, appears to be appalling.

According to a recent World Bank assessment, Nigeria is considerably underperforming in the WASH sector, and it was concluded that proactive actions needed to be taken to ensure appropriate access to basic WASH facilities. In September 2018, the Nigerian government then declared an emergency in the WASH sector due to the abysmal status of the country's water, sanitation, and hygiene services (Wada *et al*., 2021).

Umahi *et al*. (2020) assessed the WASH status of households in Kofi Community, Taraba State, to determine the appropriate public health interventions for the community. It was discovered that the WASH practices of the community were under transition, although open defecation was still observed. However, it was concluded that with more WASH interventions, open defecation would be totally eradicated from the community. Further WASH interventions are therefore needed in the country, to improve access to safe and sufficient water, adequate sanitation and hygiene facilities in order to safeguard public health and reduce risk of contracting water and food borne diseases (Jeyakumar *et al*., 2020). According to Shanmugam *et al*. (2018), WASH interventions focus on the provision of an improved water source, with source or point-of-use water treatment, improved sanitation technologies, that isolates feces and urine, while also providing a dignified and comfortable experience and finally, hygienic technologies that enable people to perform basic and personal hygiene practices by the use of hand washing stations, soap and water.

2.1.1 Water Sanitation and Hygiene Components

There are two components of water, sanitation, and hygiene and they are; technical/structural and human development components. The available water source, waste management equipment, hand washing and toilet facilities are all part of the technical component while individual actions and behaviours that aid in the prevention of water, sanitation and hygiene-related illnesses are the human development components (Ratnaprabha *et al*., 2018).

2.1.2 Importance of Water, Sanitation and Hygiene

Water, sanitation and hygiene services provide for water availability and quality, presence of sanitation facilities, and availability of soap and water for hand washing (Mulogo *et al*., 2018). Access to safe and portable water, sanitation and hygiene do not only promote good hygiene practice, but they are fundamental components of a healthy family and community and are drivers of achieving the 2030 sustainable development goal on access to safe drinking water including health, nutrition, education and gender equality in general (Shapu *et al*., 2021).

Globally, improving water, sanitation, and hygiene has the potential to prevent at least 9.1% of the disease burden or 6.3% of all deaths (Mulogo *et al*., 2018). A report by the World Health Organisation suggests that higher levels of Water, sanitation and hygiene services can significantly reduce diarrheal illness (Chakravarty *et al*., 2017). The availability of WASH services at health care facilities, schools, markets and other public places are essential for preventing the spread of diseases, therefore reducing the global disease burden (Cronk *et al*., 2018).

2.1.3 Challenges of Water Sanitation and Hygiene Services

Despite significant increases in access to water, sanitation, and hygiene (WASH) services over the last thirty years, an estimated 2.3 billion people throughout the world still lack these fundamental human necessities (Valcourt *et al*., 2020). Monitoring trends also demonstrate that WASH services fail to work as planned over time for individuals who have obtained access (Foster *et al*., 2018). Despite a highly uniform and proven set of technologies and practices developed over decades in the WASH sector, the problem of service sustainability persists (Valcourt *et al*., 2020). In Sub-Saharan African countries alone, up to 70% of rural water schemes are estimated to be non-functional or intermittently functional at any given time (Foster *et al*., 2018). Worldwide, low service sustainability of WASH contributes to nearly two million preventable deaths each year (Prus-ustun *et al*., 2014). These impacts disproportionately affect communities that are rural, poor, and resource-limited (Oliveira *et al*., 2015). Accordingly, service sustainability is identified as a critical barrier that must be addressed in order for WASH hardware and software investments to achieve their intended public health outcomes (Carter, 2013).

2.2 WATER

Water is an indispensable natural resource on earth. All living organisms depend on water for multiple uses as a result of its unique properties (Majumber and Dutta, 2014; Singh, 2014). Water can be defined as a compound of two elements; hydrogen and oxygen atoms, which have a chemical formula of H_2O. It is colourless, transparent, odourless and tasteless (Atuanya *et al.*, 2018). Water as a resource is of great importance to the economy and human life as it meets the demand for drinking, washing, irrigation, basic hygiene and cleaning purposes (Al-Khafaji and Al - Taee, 2020).

There are three main sources of water which are surface water, groundwater and rainwater. Surface water includes rivers, streams and lakes while groundwater sources include boreholes and hand-dug wells (Kale, 2016). A borehole is a hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer (Eze and Eze, 2015). According to Nwinyi *et al*. (2020), improved water sources are sources that are properly designed in such a way that it is safeguarded from fecal matter and other foreign contaminants. Hence, piped and non -piped water sources such as hand dug wells, boreholes springs and water vendors are referred to as improved water sources while other sources such as streams, rivers, lakes and ponds are classified as unimproved sources.

In Nigeria, a lot of people in urban areas depend on groundwater which is abstracted through boreholes for private or public use due to the dearth of piped water, owing to poor planning, lack of choice of appropriate technology, corruption, lack of maintenance and stakeholder involvement which have led to failed attempts in meeting water requirements of communities (Fubara-Manuel and Jumbo, 2014; Idibie *et al*., 2018).

2.2.1 Water Availability in Nigeria

Water can be said to be adequate and available when an individual is availed a quantity of 50 litres or at least 30 litres per day (Nnjoku *et al*., 2017). The unavailability of water in required proportion for man's use has assumed global crises dimension and only 20 percent of the global population has access to running water while over 1 billion people still lack access to clean water (Njoku *et al*., 2017). While physical water scarcity affects people all across the world, economic water scarcity is largely determined by the socioeconomic condition of different countries (Baloye, 2020). In Nigeria for instance, water shortages are exacerbated by the government's failure to ensure a consistent supply of water to the country's growing population (Bozorg-Haddad *et al*., 2016; Raimi *et al*., 2018).

In Nigeria, public water supply dates back to the 19th century, starting with the construction of public wells in certain areas of Lagos which later evolved into public water systems in Lagos, Abeokuta, Ijebu-Ode, Calabar, Kano, and Enugu (Akpor and Muchie, 2011). The demand for potable water increased dramatically across the country as a result of the emergence of more states, increased urbanization, and population growth, particularly among the socio-economic nodes of towns and cities (Baloye, 2020). As the population of cities grew, so did the demand for water, particularly for home usage (Balogun *et al*., 2017). Due to increased population, unbalanced infrastructure distribution, and rising maintenance costs amidst diminishing government budget, regular public water supply has become almost non- existent in many urban centers around the country, resulting in water scarcity (Baloye, 2020; Njoku *et al*., 2017). In Nigeria, an estimated 90 million people lacked access to safe and sufficient water by 2015, making the 2015 Millennium Development Goal objective on safe water a big dream (Baloye, 2020).

Alternative water supplies, such as rainwater harvesting, hand dug wells, and boreholes, have sprung up as a desperate response to the shortage of potable water supply in almost all Nigerian cities (Baloye, 2020). Boreholes, in particular, have risen to become the most reliable and prevalent alternative supply of water in the country to public piped water (Raimi *et al*., 2018; Healy *et al*., 2020).

2.2.2 Water Quality

Although there seems to be an increase in access to water over the years, the populace still faces an invisible crisis of poor water quality which threatens human health and well-being. Water must be of sufficient quantity and acceptable quality to fully meet one's needs and ensure good health and well-being (Boretti and Rosa, 2019). Water quality is a term that describes how water's physical, chemical, and biological qualities compare to a set of standards (Obilonu *et al*., 2013). The suitability of water for a range of applications is frequently determined by its quality (Madilonga *et al*., 2021). As a result, determining the water use potential of any water resource necessitates doing a water quality survey (Madilonga *et al*., 2021). According to Manga *et al*. (2021), water quality is determined by the evaluation of the physical, chemical and biological aspects of the water.

Physio-chemical properties of water

Some of the common physio-chemical contamination indicators used in characterizing water quality include; pH, temperature, dissolved oxygen, biological oxygen demand and heavy metal concentration (Manga *et al*., 2021).

pH

According to Halim *et al*. (2018), pH is the hydrogen ion concentration which is defined by -log[H^+]. pH refers to the degree of acidity or basicity of water. pH value ranges from 0-14; pH 7 is neutral, pH < 7 is acidic and pH > 7 is basic. Low pH values will corrode or dissolve metals while high pH will form scales and deposits. pH is an essential parameter in determining water quality. It determines the solubility and biological availability of chemical nutrients and heavy metals. In the case of heavy metals, the pH of water determines the degree of solubility which in turn determines the level of toxicity. The pH of water also determines the effectiveness of disinfection with chlorine; the optimum range for chlorine disinfection is between pH 5.5 – 7.5. The World Health Organization, acceptable pH range of drinking water is 6.5 – 8.5 (Kale, 2016).

Temperature

Temperature is defined as the degree of hotness or coldness of a solution. Temperature is an important water quality parameter because it influences water chemistry. The rate of chemical reactions generally increases with temperature. Groundwater with high temperatures can dissolve more minerals from rocks hence having high electrical conductivity. It is measured by a thermometer in degrees Celsius (Kale, 2016).

Biological Oxygen Demand

According to Patil *et al*. (2012), biological oxygen demand (BOD) is determined by the amount of organic matter that is present in water. It is defined as the measure of dissolved oxygen used up by microorganisms for the decomposition of organic compounds and also the oxidation of inorganic materials such as iron and sulfites. Biological oxygen demand is measured in mg/l and it is conducted over a five-day period. The Word Health Organisation standard for biological oxygen demand of drinking water is 6 mg/l.

Chlorides

Chlorides are inorganic compounds formed by the reaction of chlorine gas with a metal. Chlorine (Cl_2) is a gas that is frequently employed as a disinfectant. Chloride in surface and groundwater could be from both natural and artificial sources, such as de-icing salt run-off, inorganic fertilizer use, landfill leachates, and septic systems. Chloride levels in public drinking water must not exceed 200 mg/l, according to WHO guidelines (Kumar *et al*., 2012).

Nitrate

Nitrate and nitrite are naturally occurring ions that are part of the nitrogen cycle. The nitrate ion (NO^{3-}) is the stable form of combined nitrogen for oxygenated systems. Although chemically unreactive, it can be reduced by microbial action. The nitrite ion (NO^{2-}) contains nitrogen in a relatively unstable oxidation state. When nitrate level in drinking water exceeds 50 mg/l, drinking water becomes the main source of total nitrate intake. The presence of nitrate indicates an old contamination provide nitrites are absent (Kumar and Puri, 2012).

Heavy Metals

The presence of hazardous metals and metalloids in groundwater poses a threat to human health as well as the natural environment. Chemical elements widely detected in groundwater include metals, such as lead (Pb), chromium (Cr), iron (Fe), zinc (Zn), mercury (Hg), and cadmium (Cd), and metalloids, such as selenium (Se) and arsenic (As). Although some of these elements are required micronutrients at smaller amounts, excessive concentrations can cause severe toxicity (Hashim *et al*. 2011). Kale (2016) further added that heavy metals like lead (Pb), Chromium (Cr) and Iron (Fe) are of special concern because they easily result in water poisoning.

According to Tiwari *et al*. (2013), lead is a microelement that occurs naturally in trace amounts. It could be found in the earth, air, and the water. Unless there is a source of pollution or possible leakage from plumbing components that contain lead, large concentrations of lead are unlikely to be found in water sources. Using atomic absorption spectrometry, the content of lead in water is determined in micrograms per litre. The World Health Organisation standard for lead in drinking water is 10 μg/L. High blood pressure, decreased fertility, stunted growth and mental development in children and brain damage are all linked to lead exposure.

Iron is a mineral that can be found in nature all over the world. It is usually present in both surface and groundwater sources because it dissolves in ground water as water filters through surrounding rock (El-Sharaa and El-Turki, 2017). According to Adebayo *et al*. (2011), high levels of iron in water can promote the growth of iron-dependent bacteria, giving the water a disagreeable odor and a metallic taste, as well as rendering it hazardous. As a result, the World Health Organization (WHO) recommends a maximum iron concentration of 0.3 mg/l in drinking water. Atomic absorption spectrometry or colorimetric reagents combined with an ultraviolet/visible light (UV/Vis) spectrophotometer can be used to determine the iron concentration in water.

According to Alemu and Gabbiye (2017) chromium (Cr) is an element which also occurs naturally in two states such as Cr (III) and Cr (VI) the earth's crust in compound form or as ions in water. It is therefore a common contaminant of ground and surface water. The WHO standard for chromium in water is 0.05milligrams per litre (0.05 mg/l) and it is measured using atomic absorption spectrometry or inductively coupled plasma optical emission spectroscopy (ICP-OES).

2.2.3 Microbial Indicators of Water Quality

The most studied group of microorganisms with respect to microbial quality of water is bacteria (Cabral, 2010). The absence or presence of total and fecal coliform bacteria is currently used as an indicator to determine the microbiological safety of water supplies (Diaz *et al*., 2014; Khan *et al*., 2017). The total coliform group is made up of numerous species of bacteria, while the fecal coliform group is a subset of total coliforms with fewer bacteria types (Abdul *et al*., 2012). The presence of Escherichia coli (E. coli) in water is regarded a significant indicator of fecal contamination of water, and the majority of water quality analyses used across the world primarily incorporate the investigation of Escherichia coli presence in water to determine water contamination (Khan *et al*., 2017). The heterotrophic plate counts expressed as colony forming units is also one of the standard techniques for microbial water quality testing (Zige *et al*., 2019). Fungi are also an indicator organism in water which is frequently disregarded, yet they can pose a long-term concern in drinking water distribution systems (Hageskal *et al*., 2009).

In the World Health Organisation standard for clean water, the total coliform count that is allowed in water is 10CFU/ 100 ml, Total heterotrophic bacteria count allowed is 100 CFU/ml while faecal coliform bacteria such as E. coli bacteria, have zero tolerance. That means 0 CFU/ml (Fubara Manuel and Jumbo, 2014; Ogbeifun *et al*., 2019). Schools of thought have it that the threshold level for numbers of fungi that can cause problem, may be around 10^2 -10^3 CFU per liter (Yousefi *et al*., 2013).

2.2.4 Groundwater Contamination

Groundwater is generally a clean source of water, but it is, however, prone to contamination as a result of man's activities (Eze and Eze, 2015). One of the common sources of groundwater contamination is the proximity of septic systems to boreholes without regard for the World Health Organization standard safe distance of thirty to fourty meters (30 m – 40 m) and United

Nations International Children's Emergency Fund standard of borehole depth of hundred to one hundred and fifty meters (100 m -150 m) (Eze and Eze, 2015; Fubara-Manuel and Jumbo, 2014). In a case of close siting of boreholes to sewer systems, effluent from the sewer system which is discharged unto the subsurface percolates into the same aquifer tapped into for water supply, resulting in microbial contamination (Banda *et al*., 2014).

Water storage in tanks is common in many Nigerian communities and it is associated with many problems which eventually affects the quality of water (Nnaji *et al*., 2019). Chia *et al*. (2013) carried out a study in which he found a significant relationship between the duration of water storage and the level of contamination. It was discovered that microbial growth increases in water as the residence storage time increase also. Manga *et al*. (2021) also explains that the colour, location, cleaning frequency of water storage tanks and water retention time also affects the quality of water. The outdoor location of the water tanks exposes them to solar radiation which generates heat in the enclosure, providing a favorable environment for microbial growth which could lead to the outbreak of water-borne diseases (Manga *et al*., 2021; Ogbozigbe *et al*., 2018).

In a study, Chia *et al*. (2013) discovered that the colour of water storage tanks have a significant association with physio-chemical parameters such as dissolved oxygen and biological oxygen demand. The darker the colour, the higher the amount of heat absorbed, which provides a favorable environment for bacterial growth, hence leading to reduced dissolved oxygen and increased biological oxygen demand.

Cleaning practices of water storage tanks also have an impact on water quality. An assemblage of microbial cells referred to as biofilms, together with non-cellular materials such as mineral crystals, clay or silt particles and corrosion particles could build up in storage tanks if not properly and regularly cleaned, contributing to microbiological contamination of stored water especially if particles from the film become dislodged into and ingested with the water (Nnaji *et al*., 2019).

2.2.5 Water Treatment

The most important step in minimizing water and foodborne infections is probably disinfecting potable water (Ghernaout, 2017). Water disinfection entails the destruction of microorganisms such as viruses, bacteria, and protozoan parasites that can cause disease (Ghernaout *et al*., 2011). Until now, chlorine is the most largely utilized killing agent in water and wastewater treatment factories. It is utilized as gas, hypochlorite solution, or onsite-produced hypochlorite (Collivignarelli *et al*., 2017).

2.3 SANITATION

Environmental sanitation is a well-known tool that contributes significantly to national development in countries all over the world. It encompasses all actions and efforts aimed at creating and maintaining a clean, safe, and enjoyable physical environment in all forms of human settlements (Olowoporoku, 2017). The World Health Organization (WHO) defines sanitation as "the provision of facilities and services necessary for the safe disposal of human excrement and urine" (WHO, 2018).

Environmental sanitation includes the management of human waste, solid waste, sewage, urban drainage, and the provision of hygiene facilities, all of which work together to provide a sanitary environment (Ikeke, 2014). Individual's participation in the provision, use, and maintenance of environmental sanitation facilities and services, as well as adherence to environmental legislation, are referred to as environmental sanitation practices (Daramola and Olowoporoku, 2016). Fagbemi *et al*. (2020) in a recent study, examined the participation of individuals in the conduct of environmental sanitation exercise in two major markets in selected cites of Nigeria and it was concluded that environmental sanitation practices go beyond sweeping of market environments and while sanitation facilities in markets are grossly inadequate, the existing ones are not properly managed. Open dumping of solid waste, wastewater, open defecation, and a lack of maintenance for drainage systems and sanitation facilities as a whole are common examples of poor environmental sanitation practices, which contribute significantly to infant and child mortality (Mmon and Mmon, 2011). These actions are in direct opposition to the concept of environmental sanitation, which attempts to create and maintain a clean, safe, and pleasant physical environment in all human communities (Ikeke, 2014).

The provision of adequate environmental sanitation facilities and services could at best be referred to as means to an end while the attitude and behavioural practices of the stakeholders determine the end (Daramola and Olowoporoku, 2016). In order to achieve proper environmental sanitation practices, good sanitation behaviour and availability of facilities and services must work in unison (Mmom and Mmom, 2011). According to Ezeudu (2019) sanitation interventions are very necessary because they minimize people’s exposure to diseases by providing a healthy living environment which interrupts the cycle of diseases. Such interventions refer to the provision of sanitation facilities and sanitation practices which operate closely to form a hygienic environment.

2.3.1 Background of Sanitation in Nigeria

According to Ezeudu (2019), after a global preliminary study in 1990, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) executed the first known nationwide survey on sanitation access in Nigeria. In 1991, 35 % of Nigerians (including rural and urban) had access to sanitation, out of a total population of 88.5 million. While the 1993 monitoring report stated that Nigeria's access rate was 36 % of the total population, with 61% urban and 21% rural and sanitation access was defined as the proportion of the population with sanitary means of excreta disposal (sanitary facility) in the dwelling or within a convenient distance from the user's dwelling in the report. Sanitation facilities were not graded according to efficiency or development, and other sanitation core processes involving post-management activities were not included.

More recent surveys conducted in 2008 (International Year of Sanitation) by the United Nations revealed that just 27% of Nigerian households used upgraded toilet systems. Seven in every ten households used unimproved sanitary facilities and 69% were in the urban area. In all, 32% of the entire population that had no access to toilet facilities and 14% of urban dwellers lacked sanitation (Ezeudu, 2019). According to a water and sanitation provisional plan note developed by the World Bank in partnership with the federal government in the year 2000, it was stated that excluding Abuja and a small region of Lagos, no other urban area had a sewerage system. It was also stated that sewage are either left unattended or disposed of through a storm water drainage system (Kanu and Achi, 2011; Akpabio, 2012).

According to Ezeudu (2019), Nigeria achieved 69% water supply coverage and 29% sanitation coverage at the conclusion of the Millennium Development Goals in 2015, which is less than half of the target. This revealed that the sanitation sector was in a critical condition, and that the country's sanitation provision had deteriorated in general. Access to improved sanitation in urban and rural areas was 35% and 38% respectively in 1993 but it decreased to 33% and 25% in 2015.

Open defecation, on the other hand, has more than doubled in metropolitan areas, from 7% in 1990 to 15% in 2015.

2.3.2 Current Status of Sanitation in Nigeria

In Nigeria, adequate environmental sanitation practices have not been ensured (Daramola and Olowoporoku, 2017). This is characterized by lack of basic amenities and inadequate sanitary habits (Ademiluyi and Odugbesan, 2008). Citizen's access to environmental sanitation facilities and services are still relatively limited (Akpabio, 2012). Nigerian cities are characterized by rapid population growth which is not accompanied by a corresponding increase in the provision of environmental sanitation facilities and services capable of improving environmental sanitation practices (Daramola and Olowoporoku, 2016). The resultant effects of these are unsanitary and unhealthy environmental conditions that are prevalent in Nigerian urban centres (Daramola, 2012).

Currently, approximately 58 million people in Nigeria's metropolitan areas lack basic sanitation, while 13.5 million people defecate in the open throughout Nigeria's towns and cities (Ezeudu, 2019). Water supply, which is an inextricably linked constituent of sanitation, is also not guaranteed as there is no Nigerian city, including Abuja, the country's capital, which has a hundred percent water supply (Balogun and Redina, 2019).

Nigeria is faced with challenges regarding urban sanitation because sanitation is rated of low importance in the priorities of the government and it is expressed in the political manifestoes and slogans of political parties which emphasizes on the provision of water but always omits sanitation (Mshida *et al*., 2020). Till date, no formidable strategy has been taken by the government to address the issue of poor sanitation in the country and Nigeria is now ranked third in Sub-Saharan Africa and last in the world in terms of access to urban sanitation (Olowoporuku, 2017).

2.3.3 Sanitation in Market Places

The word "market" refers to a designated area of land, with or without buildings, that is utilized for trading and commerce (Daramola *et al*., 2017). Markets play a vital role in the lives of people in various regions of the world (Fakere and Fadamiro, 2012). Despite the various social and economic benefits that markets provide, activities in markets are however associated with a number of environmental issues (Daramola and Olowoporoku, 2016). To begin with, activities in market places are known to generate enormous amounts of solid waste (Lade *et al*., 2012, Abajegah *et al*. 2013). It is quite common to observe mountains of refuse at market places and these heaps of refuse provide ideal breeding grounds for vectors of communicable diseases such as rodents and insects (Daramola and Olowoporoku, 2016).

Unsanitary environmental actions such as open urination and defecation are still practiced in marketplaces in Nigeria (Butu and Mshelia, 2014; Olowopuruku, 2017). This is due to the fact that proper sanitation and hygiene in markets has not been a major consideration; hence, markets spring up sporadically without any attention to provision of proper refuse dumps and public toilets (Daramola and Olowoporoku, 2016; Fagbemi *et al*., 2020; Daramola *et al*., 2017). Sanitation issues are common in unplanned and overcrowded market places, particularly in developing nations, and this poses hazards such as pollution of the environment and deterioration of the city landscapes (Fakere and Fadamiro, 2012). Apart from the destruction of the aesthetic quality of the environment, heaps of refuse serve as sources of unpleasant odour and they can flow into nearby public drains, canals, streams and rivers among others during rainfall (Olowoporoku, 2017).

Sanitation in any settlement including marketplaces should cover not just excreta disposal and management, but also solid waste management, drainage management and hygiene practices (Olowoporoku, 2017). Environmental sanitation in markets is important not only from the point of view of urban aesthetics but also because of the pathogenic organisms which the liquid and solid wastes contain and transmit by direct handling of water and food or through insects or rodents (Fakere and Fadamiro, 2012). The negative health impact of poor sanitation includes exposure to illnesses such as diarrhea, cholera, dysentery, typhoid, and hepatitis A, due to contamination of food and drinking water sources (Abubakhar, 2017).

2.3.4 Sanitation Practices

Sanitation practices involve hygienic disposal of human excreta, proper management of solid waste and drainages, and provision of hygiene facilities for personal and domestic hygiene which work together to create a hygienic environment (Daramola and Olowoporoku, 2016). Reducing waste produced at the end of the day in the marketplace, recycling waste and reusing materials forms sustainable waste management (Samiha, 2013). Solid wastes should be managed through sorting, disposal to trash cans which are emptied into larger containers, and lastly from the containers to the trucks which ultimately disposes the waste (Rauzi *et al*., 2021). The state of urban drainage is of great concern because of the health implications and environmental dangers that it poses (Olukanni *et al*., 2014). Hence efficient waste management is required to prevent drainage blockage (Olukanni *et al*., 2014). To maintain a healthy and secure environment, feces must be properly disposed of using improved toilet facilities (Ahuma-Smith *et al*., 2020).

2.3.5 Types of toilet sanitation facilities

Toilet sanitation facilities are classified as either improved or unimproved (Exley *et al*., 2015). In line with the World Health Organisation/ United Nations International Children's Emergency

Fund Joint Monitoring Programme (WHO/UNICEF JMP), Kabange and Nkansah (2015) defines improved sanitation facilities as sanitation systems in which excreta are disposed of in such a way that reduces the risk of fecal-oral transmission to its users and the environment. These facilities include flush or pour-flush to a piped sewer system, septic tank or pit latrine, ventilated improved pit latrine, pit latrine with slab, and composting toilet. While Kvarnstrom *et al*. (2011) and Akpakli *et al*. (2018) define unimproved sanitation facilities as sanitation systems that do not ensure sanitary isolation of human excreta from human contact. Forms of unimproved sanitation facilities include open defecation and bucket latrines.

2.3.6 Factors influencing environmental sanitation

Environmental sanitation practices are influenced by various factors which includes social, economic and demographic attributes, such as age, income, gender, education, household structure, situational conditions. Others include level of information, religious participation, enabling law and place of residence (Vicente and Reis, 2008).

2.3.7 Benefits of Sanitation

Improved environmental condition positively affects a wide range of development indices. Thus, environmental sanitation is a channel to improved quality of life of the individuals and a contributor to their social, economic and physical growth (Olowoporoku, 2013). Various studies have demonstrated that the incidence of many diseases is lowered when people have access to and make regular use of adequate sanitary installations (Aremu, 2012; Mmon and Mmon, 2011; Nwankwoala, 2011). The economic benefits of improved sanitation include lower health system costs, fewer days lost at work or at school through illness (Mara *et al*., 2010).

2.4 HYGIENE

Staniford and Schmidtke (2020) describe hygiene practices as actions that help to maintain health by preventing the spread of diseases. These actions include disinfection of one's body and surrounding environment through hand washing and cleaning of one's surrounding with the use of soap and water (Ashraf *et al*., 2020). Hygiene is an important barrier against a myriad of communicable diseases, promoting excellent health and well-being (Kumar *et al*., 2020). Water treatment and water storage in clean containers, proper excreta and wastewater disposal, and proper hand washing are all examples of good hygiene practices (Kumar *et al*., 2020).

Personal hygiene, household hygiene and community hygiene are the three phases of hygiene which must be employed in unison to effectively promote public health (Nath, 2003). Personal hygiene is the process of taking care of oneself, keeping one's external body clean and groomed in order to safeguard and promote one's general health and well-being (Nuredeen and Toyin, 2020). Bathing on a regular basis, regular hand washing, especially before handling food or after using the restroom, wearing clean clothes, washing one's hair, teeth, and maintaining tidy finger nails, among other things, are all part of it (Kumar *et al*., 2020).

Household hygiene entails keeping the home and toilet clean, disposing of rubbish and solid waste safely, maintaining cleanliness in food storage and preparation spaces, and ensuring that food and drinking water are kept covered and uncontaminated (Phaswanan, 2008). Unhygienic disposal of domestic waste (such as bottle tops, matches, brushes, small bottles, sanitary towels, toilet paper, newspaper, tampons, plastic/paper packets) has serious health and environmental consequences, resulting in exposure and increased risks to personal safety while also polluting the environment (Phaswanan, 2006).

Community hygiene is primarily concerned with appropriate public management of excreta, sullage, solid waste (refuse), and liquid waste, as well as hygiene education (Nath, 2003). Poor excreta, sullage, solid waste (refuse), and liquid waste disposal in public places has a negative impact on community health, causing diseases such as typhoid, bilharzias, malaria, cholera, parasitic infections, eye infections, skin diseases, and an increased risk of bacterial infections and disease for people with weakened immune systems (Mara, 2017; Wajim, 2020; Eguvbe and Obielumani, 2021).

2.4.1 Hand hygiene

Hand hygiene is defined as the cleaning of hands with water and soap, water and soap with antiseptic action, or the application of disinfectants in various forms directly to the hands (Alefragkis *et al*., 2019). It is the most critical measure for preventing the spread of harmful germs and diseases, and it is at the heart of all infection prevention and control strategies (Goldberg, 2017; Chun and Kim, 2018). Hand-hygiene interventions ensure the provision of hand washing stations, soap, water and alcohol-based cleaning products to encourage good hygiene practices (Ashraf *et al*., 2017). Hence, many hand-hygiene interventions have been established to increase hand-hygiene practices and disinfection activities in the environment (Staniford and Schmidtke, 2020). Fewtrell *et al*. (2005) explains that hygiene interventions could be in the form of hygiene and health education or the provision of facilities that would encourage hand washing behaviours.

Hand washing is an act of cleaning one's hands with the aid of soap and water to remove microorganisms such as bacteria, viruses or other harmful substances from the surface of one's hands (Kumar *et al*., 2020). Research has shown that due to the ubiquitous nature of microorganisms, their presence on the body, especially the hands, is inevitable (Alonso *et al*., 2013). As a result, the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) have emphasized the importance of using non-pharmaceutical interventions such as proper hand washing with soap and water and other effective hand hygiene practices to prevent disease transmission (Felembam *et al*., 2012; Alonso *et al*., 2013). Hand washing with soap is therefore effective in minimizing hand contamination, and it is strongly recommended after fecal contact and before eating and handling food (Ashraf *et al*., 2017).

Over a century ago, research by a Hungarian physician Ignaz Philipp Semmelweis and an American physician Oliver Wendel Holmes demonstrated the efficacy of hand washing with soap in the prevention of infections, including hospital-acquired (nosocomial) infections (Alonso *et al*., 2012). Since then, hand washing has become a globally recognized phenomena for minimizing the transmission of diseases caused by bacteria (Bliss-Holtz, 2010). Effective hand hygiene techniques are acknowledged as a model of one of the few infection control measures with proven evidence of efficacy, and they continue to be the foundation of global efforts to reduce the risk of infection (Savolainen-Kopra *et al*., 2012)

2.4.2 Factors Influencing Hand washing Behaviours

According to Hulland *et al*. (2013), factors influencing hand washing behaviours are grouped into two categories; environmental and cognitive factors. The environmental factors include social, physical and biological influences and the physical factors in particular incudes the cost of soap, water and access to hand washing stations (Curtis *et al*., 2009). The cognitive factors include an individual’s habits, planning and motivation for behavioural change (Hulland *et al*., 2013).

2.4.3 Barriers to Hand Hygiene Practices

Despite people's knowledge about the importance of hygiene practices, most times, hygienic behaviours are not habitually practiced (Curtis *et al*., 2009). One of the main hindrances to adopting a hand washing habit is the absence of environments that aid regular practice of hand washing; for instance, the absence of soap or water (Horng *et al*., 2016). Hulland *et al*. (2013) added that the cost of soap needed and the time required for hand washing is also an important barrier to hand hygiene. Ssemugabo *et al*. (2021) ascertained that establishing hand washing stations far from sanitation facilities such as toilets could also deter people from washing their hands, thereby increasing the risks of contracting food and waterborne diseases such as cholera and diarrhea.

2.4.4 Promoting Hand Hygiene

Hygiene promotion is required to encourage hand washing after using the toilet, before and after handling food, changing a child's diapers, touching animals, and before eating (Ashwini *et al*., 2019). According to Luby *et al*. (2020), the main step to improve hand washing settings in a public environment is for institutions to develop and maintain the infrastructure and supply the consumable materials to facilitate hand washing. Hulland *et al*. (2013) in a previous study, defined hand washing stations as a dedicated and convenient location where soap and water are made available for hand washing and stated that the provision of hand washing stations is very likely to facilitate good hygiene behaviour due to easy access to soap and water, especially when located in areas where hand washing behaviours are mostly required. An example of such is siting hand washing stations very close to toilet facilities.

Water sources that are not polluted by human feces should be made available in both public and private sectors especially in hospitals, schools, and food markets. Food markets are particularly essential target locations to prevent transmission because contaminated water typically contaminates food (Luby *et al*., 2020). Hulland *et al*. (2020) prescribed that using soapy water from low-cost detergent or developing other intensive approaches can help address barriers that hinder hand hygiene practices.

Approaches other than soap and water, such as the use of alcohol-based hand sanitizers may be useful to extend the reach of hand hygiene to water scarce regions (Luby, 2020). Alcohol-based hand sanitizers have proven effective in eradicating bacteria, fungi, and viruses from the hands by peeling away the outer oily layer on the skin's surface, preventing bacteria from sticking to the hand from the environment (Abruquah and Lambon, 2014). Abruquah and Lambon (2014) further added that public enlightenment and campaigns on appropriate hand hygiene habits is of crucial importance in promoting hand hygiene practices and such campaigns should include intensive education about the dangers of poor hand hygiene habits and practical instructions on good hand hygiene techniques.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Study Area

The study was carried out in three major markets in Benin City, Edo State, Nigeria. Benin City is the capital and largest City of Edo State in southern Nigeria with a total population of 1,782,000 inhabitants and a total of eighteen local government areas. It covers a distance of 1,204 km² and its geographical location is at 6° 20' 5.9496" N and 5° 36' 13.4856" E. The study was designed to evaluate the water, sanitation and hygiene status of Uselu, Ogida and Useh markets which are all in Egor Local Government Area (Figure 1, Plate 3.1 – 3.10). The global positioning system coordinates of the studied markets were 6º22'.32. 358" N 5º36'49.392" E, 6º21'.33. 0552" N 5º35'59.0748" E, 6º21'.52. 3188" N 5º35'10.536" E respectively.

3.2 Administration of Questionnaire and Water Samples Collection.

A survey was carried out in the aforementioned markets with the aid of questionnaires to determine the availability of water and their sanitation and hygiene status.

Water samples were collected from Uselu and Ogida Markets with the aid of sterile sampling bottles which were filled to the brim and capped. The water samples for microbial analyses were then stored in a cooler containing ice while the samples for physiochemical analyses were wrapped with foil paper (to prevent reaction with sunlight) and then transported to the laboratory for analyses.

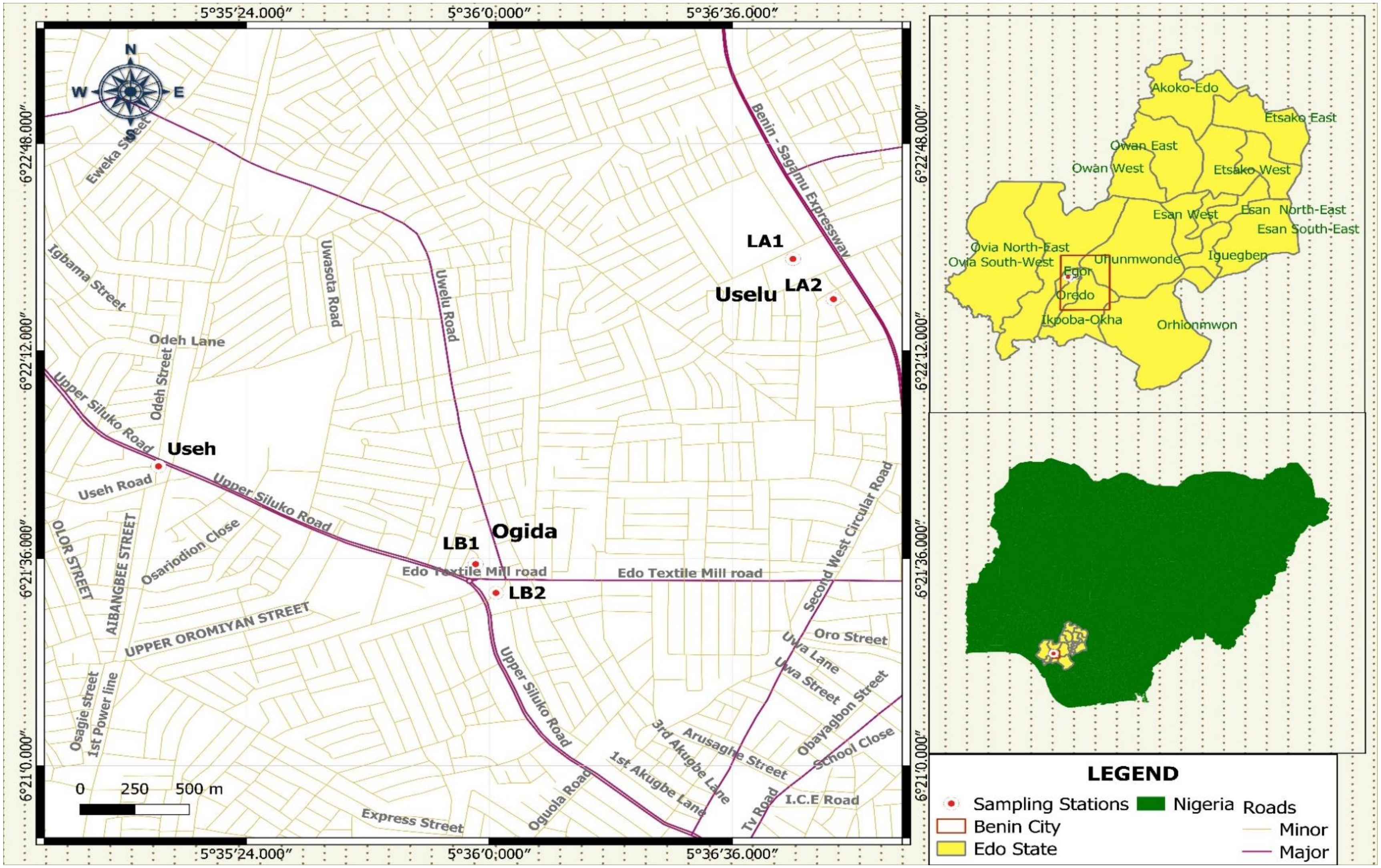

Figure 3.1: A map showing the sites of sample collection.

Plate 3.1: Borehole water source at Uselu market

Plate 3.2: Uselu market toilet facility

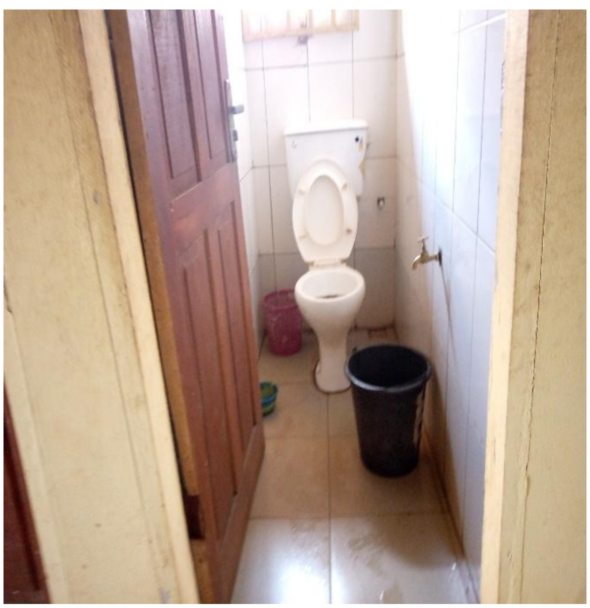

Plate 3.3: Flush toilet at Uselu market

Plate 3.4: Open dump of waste at Uselu market

Plate 3.5: Non- functioning hand washing basins at Uselu market

Plate 3.6: Borehole water source at Ogida market

Plate 3.7: Water collection point at Ogida

Plate 3.8: Ogida market toilet facility

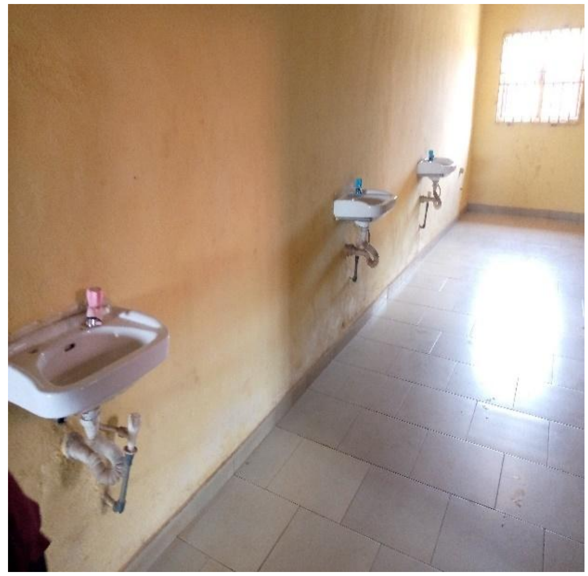

Plate 3.9: Flush toilet at Ogida toilet facility

Plate 3.10: Nonfunctioning hand washing stations at Ogida market

Plate 3.11: Wastes indiscriminately disposed at Ogida market

Plate 3.12: Waste dump in Useh market

3.3 Physiochemical Analysis

pH

Twenty (20) ml of distilled water was poured into a beaker and the pH meter was inserted into the beaker and the pH reading was recorded (Ben- Chioma *et al*., 2015).

Chloride

A 10ml aliquot from the sample was measured into a 250ml conical flask. Three (3) drops of potassium chromate indicator was added and the solution was titrated with a standard of 0.05M silver nitrate until a slight red precipitate occurred. A blank solution was also treated with 9ml of the potassium chromate indicator and titrated (Shukla and Arya, 2018). The chloride concentration of the sample was realized with the formular below:

$$Cl^{-}(mg/l) = \frac{\text{Molarity} \times \text{Titre} \times \text{Mol.Wt} \times 1000}{\text{Aliquot taken.}}$$

Nitrate

Ten (10) ml of the test sample was placed into a 50ml flask. 2ml of Brucine was added after which ten (10) ml of sulphuric acid was added rapidly. The solution was properly mixed and allowed to stand for 10 minutes. A blank solution was also treated similarly. The amount of nitrate present was measured using ultraviolet visible spectrophotometry and the absorbance was measured at 470nm. The difference between the two readings gave the nitrate concentration (Shamar and Kaur, 2017).

Biological oxygen demand (Bod)

The dissolved oxygen in the sample was measured immediately after collection (initial). One ml each of Winkler A (manganous sulphate) and B (potassium oxide azide) solutions were added to the sample and it was incubated in the dark for five (5) days. The amount of dissolved oxygen after this time was measured (final). The difference between the initial and final dissolved oxygen values was the biochemical oxygen demand (Jouanneau *et al*., 2013).

Iron

To 10 ml each of the water samples, a drop of sulphuric acid was added. The concentration of iron in the water sample was determined by the use of atomic absorption techniques for comparison (El-Sharaa and El-Turki, 2017).

Chromium

For the determination of chromium, spectrophotometric method with diphenyl carbazide (DPC) was adopted. 2 ml of the water samples were transferred to a glass vial. Sulphuric acid (0.2 M, 1 mL) and 1, 5-diphenylcarbazide (0.5% w/v, 1 mL) was added, and the mixture was gently shaken and left for five minutes. The absorbance was measured with a Spectrophotometer at 543 nm against reagent blank (Lace *et al*., 2019).

Lead

Each of the 5.0 liters samples was evaporated to dryness using Pyrex beaker and hot plate. The residues were digested with $50cm^3$ of $0.25moldm^3$ nitric acid and transferred into $120cm^3$ plastic containers and then analyzed using atomic absorption spectrometry (AAS). Metals concentrations were extrapolated from the standard calibration curve (Giwa *et al*., 2014).

3.4 Microbiological Analysis

Microbiological analyses were carried out on the water samples to determine the quality of the water. Total heterotrophic bacterial counts, total coliform counts and total fungi counts were carried out to detect and enumerate the microorganisms in the water and to determine if the water is suitable for drinking and other uses. Antimicrobial susceptibility tests were also carried out to determine if the microorganisms identified could be eradicated with the aid of water treatment.

Sterilization of materials used

All glassware and media used were sterilized by autoclaving. The media were prepared in a conical flask, plugged with a cotton wool and wrapped with aluminum foil and then autoclaving was carried out at 121ºC for 15 minutes.

Preparation of Culture Media

All media were prepared in accordance with the manufacturer's instruction. The media used in this study includes MacConkey broth, Nutrient agar, Potato dextrose agar, Eosin methylene blue agar and Mueller hinton agar.

MacConkey broth

Twenty grams (20g) of macconkey broth was weighed into a conical flask and dissolved with 1 litre of distilled water to make a single strength solution while twenty (20g) of the same media was dissolved in half a litre of distilled water for double strength solution. It was mixed thoroughly and dispensed aseptically into test tubes. 10mls of double strength solution of macconkey broth was dispensed into three (3) test tubes and 5mls of the single strength broth was dispensed into two sets of 3 test tubes each. The double and single strength solution contained in the test tubes was sterilized by autoclaving at 121ºC for 15 minutes.

Nutrient agar

Twenty- eight grams (28g) of nutrient agar was dissolved in 1 litre of distilled water in a conical flask, covered with cotton wool and aluminum foil. It was sterilized by autoclaving at 121ºC for 15minutes. The media was allowed to cool and then aseptically dispensed into sterile petri dishes.

Potato dextrose agar

Thirty- nine grams (39g) of potato dextrose powder was dissolved in 1 litre of distilled water in a conical flask covered with cotton wool and aluminium foil paper. It was mixed properly and sterilized by autoclaving at 121ºC for 15 minutes. The medium was allowed to cool and then dispensed aseptically into sterile petri dishes.

Eosine methylene blue agar

Thirty- six grams(36g) of eosine methylene blue agar was dissolved in 1 litre of distilled water. The media was heated up to dissolve the medium completely. The media was sterilized by autoclaving at 121ºC for 15 minutes. It was then dispensed aseptically into petri dishes and allowed to solidify.

Mueller hinton agar

Thirty- eight grams (38g) of the Mueller Hinton agar was weighed into a conical flask and dissolved in 1litre of distilled water. The medium was sterilized by autoclaving at 121ºC for 15 minutes. Upon cooling, it was aseptically dispensed into petri dishes.

3.4.1 Procedure for Total Heterotrophic Counts

This is a quantitative analysis which employs a number of techniques, one of which is the pour plate method which is used to enumerate bacteria in a sample. 1ml of each test sample was pipetted aseptically into sterile petri dishes. Molten nutrient agar was poured aseptically into the sterile petri dishes for bacteria isolation. The plates were then swirled immediately and allowed to solidify. Upon solidification, the petri dishes containing nutrient agar were inverted and incubated at a temperature of 37ºC for 24 hours. After incubation, all emergent colonies were counted and recorded (Ahmed *et al*., 2013).

3.4.2 Procedure for Total Coliform Counts

This is a qualitative analysis which indicates the presence of coliforms in water. It is usually carried out through the use of the most probable number method (MPN). Unlike the quantitative test, this qualitative test is used for indicating only the presence of coliforms, not their numerical presentation. This test is carried out in three continuous stages: presumptive test (Multiple tube technique), confirmatory test (Triple sugar Iron Test) and completed test which involves streaking of isolated colonies on petri dishes containing eosine methylene bromide (Ahmed *et al*., 2013).

Multiple tube technique

Coliform presumptive tests were carried out by introducing 10ml of the test samples into the double strength tubes, 1ml and 0.1ml into the single strength test tubes. The test tubes were incubated at a temperature of 37ºC for 48 hours. The tubes showing acid production indicated by a colour change to yellow, were recorded as positive, to be used in the determination of the most probable number (Ahmed *et al*., 2013).

Triple Sugar Iron test (TSI)

10ml of eosine triple sugar iron agar was dispensed into four (4) test tubes and covered with cotton wool and aluminium foil paper and then sterilized by autoclaving at 121ºC for 15 minutes. The test tubes were then placed in a slanted position and allowed to solidify. With the use of an inoculation loop, isolated colonies were introduced into the test tubes by stabbing through the center of the medium to the bottom of the tube and then incubated at 37ºC for 24 hours.

Eosin methylene blue test

With the use of a sterile inoculating loop, a loopful of a sample from each positive test tube is streaked on petri dishes containing solidified eosin methylene blue media. The plates were incubated afterwards at 37ºC for 24 hours. Following incubation, all plates were examined for the presence of typical colonies (Ahmed *et al*., 2013).

3.4.3 Procedure for Total Fungi Counts

1ml of each test sample was pipetted aseptically into sterile petri dishes. Potato dextrose agar was poured aseptically into the sterile petri dishes for fungi isolation. The plates were then swirled immediately and allowed to solidify and upon solidification, the petri dishes with the potato dextrose agar were incubated at 25ºC for 3-5 days. After incubation, all emergent colonies were counted and recorded (Al- Ibraheem and Al-Zeadei, 2021).

3.5 Identification of bacterial isolates

Subculturing

The mixed microbial culture isolates from the nutrient agar were streaked on freshly prepared nutrient agar plates aseptically, to obtain a pure culture of the microorganisms. The plates were incubated at 37ºC for 24 hours, after which it was stored in a refrigerator to be used for further biochemical tests.

Microbiological techniques used for the identification of bacterial species include Gram staining, colonial and morphological characterization for the analyses of the physical and structural features of the organisms and biochemical tests such as catalase, oxidase, indole and citrate tests (Ayitso and Onyango, 2016).

Morphological Test

Gram stain

Smears of 24-hour culture were made on clean grease free slides with the use of a sterile wire loop and then heat fixed. Crystal violet solution was poured on the slides and allowed to stand for a minute and then rinsed gently with distilled water. The smear was then flooded with Gram's iodine for a minute, followed by an immediate rinsing with distilled water and subsequent decolourization by flooding slides with 95% ethanol. The slides were rinsed again with distilled water and counterstained with safranin for a minute after which the slides were rinsed with distilled water. The slides were air dried, after which a drop of immersion oil was applied to the slides in order to be observed under the microscope (Smith and Hussey, 2005).

Biochemical Tests

Oxidase

According to Dharmappa *et al*. (2022), oxidase test was carried out to detect organisms that has cytochrome oxidase enzyme. Such organisms are capable of utilizing oxygen as the final hydrogen receptor, the end product of which is water or hydrogen peroxide. To carry out this test, a piece of No.1 Whatman's filter paper was soaked in oxidase reagent (tetrametyl-pphenylenediamine), drained for 30 seconds and placed in a petri dish. The colony to be tested was picked up from the pure culture, with the use of a sterile loop and a smear was made on the filter paper. The production of purple colouration within five to seconds indicated the presence of the oxidase enzyme.

Catalase

The catalase test helps to determine the isolates that have the catalase enzyme which releases oxygen from hydrogen peroxide (H_2O_2). The production of gas is as a result of the breakdown of hydrogen peroxide to water and oxygen (Breaking down H_2O_2 to $H_2O + O_2$). This test is usually used to differentiate catalase positive organisms like streptococci from catalase negative species like streptococci (Khatoon *et al*., 2022). To carry out this test, a loopful of pure culture was transferred onto a clean glass slide and a drop of hydrogen peroxide was added. Immediate gas production indicated by the production of bubbles confirmed the presence of catalase and the absence of bubbles indicated the absence of the catalase enzyme.

$2H_2O_2 \longrightarrow 2H_2O + O_2$

Indole

This test is used to determine the isolates that have the ability to utilize tryptophan, producing a metabolite called indole. The indole produced during the reaction is detected by adding Kovac's reagent which produces a cherry-red reagent layer (Patidar *et al*., 2021). In carrying out this test, 5ml of tryptophan broth was dispensed into test tubes and sterilized at 121ºC for 15 minutes and then allowed to cool. The tubes were inoculated aseptically with isolates from the pure culture, after which they were incubated at 37ºC for 24 hours. 4 drops of Kovac reagent were added to the tube culture and observed for the presence or absence of a red ring.

Citrate

Citrate utilization test is done to differentiate among enteric organisms based on the presence of the citrate permease enzyme which gives the organisms the ability to ferment citrate as a sole source of carbon. Following incubation, citrate positive culture was recognized by the presence of growth on the surface of the slant of Simmons citrate agar and deep prussian blue coloration of the medium (Ferdous *et al*., 2013).

5ml of Simon's citrate agar was dispensed into test tubes and sterilized at 121ºC for 15 minutes at 15 pounds per square inch and then allowed to cool. Isolates of the pure culture were introduced into the agar and the tubes were incubated at 37ºC for 24 hours. After incubation, a change in the colour of the agar from green to blue indicated citrate positive isolates while a negative result was indicated by the retention of the original colour of the agar.

Urease test

This is used to test organisms that have the abilities to produce the enzyme urease which catalyzes the breakdown of urea to produce ammonia. The test is usually used to differentiate organisms like *Proteus mirabilis* from non-urease positive organism. A sterilized medium was dispensed into test tubes aseptically and the test bacteria isolated were inoculated into the medium and incubated at 37ºC for 24 hours. A change in colour from yellow to red-pink confirmed the presence of urease (Dahlen *et* al., 2018).

3.6 Identification of fungal isolates

Pure cultures of fungi isolates were established using single sporing method. Identification of the fungi isolates was based on colonial morphology (which includes its colour, growth pattern and mycelia texture) and microscopy which included hyphae structure and spore appearance (type, colour and shapes) (Alsohaili and Bani- Hassan, 2018).

3.7 Antibiotic Susceptibility Test

The Kirby-Bauer disc diffusion method was used for the determination of antimicrobial resistance of the identified isolates. The isolates were streaked on agar plates containing Muller-Hinton agar and Kirby-Bauer disks were placed on the agar plates, using a sterile forcep. The antibiotics used for the determination of antimicrobial resistance in *Enterobacter* sp., *Staphylococcus aureus, Salmonella* sp., *Bacillus* sp., *Pseudomonas* sp. *and Shigella* sp. are Colistin 10 µg, Gentamicin 10 µg (GEN 10), Erythromycin 15 µg (ERY 15), Ciproflaxocin, 5µg (CIP 5), Tetracycline 30 µg (TE 30), Metronidazole 2 µg, Clindamycin 2 µg (CD 2), Augumentin 2 µg (Aug 2). The plates were inverted and incubated at a temperature of 37ºC for 24 hours, after which the zones of inhibition were measured using a graduated ruler and the bacteria were classified as resistant or sensitive (Imarhiagbe and Onwudime, 2021).

3.8 Statistical Analysis

The data obtained from the laboratory analyses were subjected to descriptive statistical analysis. Statistical measures of central tendency and dispersion (mean, standard deviation, coefficient of variation), SPSS and Excel packages were used for the statistical analysis.

CHAPTER FOUR

4.0 RESULTS

The results of the physicochemical quality of the water samples collected from Uselu and Ogida markets are revealed on Table 4.1 below. The pH of the water samples from Uselu point A and B ranged from 4.70±0.15 to 5.00 ±0.00 while Ogida samples A and B ranged from 6.29±0.14 to 5.10±0.05. The chloride concentration of samples A and B from Uselu market was found to be between 46.15±0.07 mg/l to 35.3±0.20 mg/l respectively, while Ogida sample A and B ranged from 28.4±0.20 mg/l to 24.85±0.20 mg/l. The concentration of Nitrate in Uselu water samples A and B ranged from 0.675±0.03 mg/l to 1.309±0.00 mg/l while Samples A and B from Ogida ranged from 3.186±0.00 mg/l to 1.85±0.62 mg/l. The Biological oxygen demand $(BOD)_5$ levels of Uselu water samples A and B ranged from 0.55±0.62 mg/l to 0.33±0.08 mg/l and that of Ogida samples A and B ranged from 1.85±0.77 mg/l to 2.60±0.40 mg/l . As shown in Table 2, Iron (Fe) was not detected in all four water samples from both markets. Lead was not detected in Uselu water sample A but Uselu sample B had a concentration of 0.04±0.02 mg/l while Ogida samples A and B ranged from 0.01±0.01 mg/l to 0.03±0.01 mg/l. Chromium (Cr) levels of Uselu water samples A and B were detected to range from 0.07±0.02 mg/l to 0.04±0.00 mg/l respectively while Samples A and B from Ogida market ranged from 0.04 ±0.00 mg/l to 0.01±0.00 mg/l.

The result of the enumeration of bacterial and fungal population of the water samples are presented in Table 4.3 below. The total viable mean heterotrophic bacterial counts of Uselu water samples A and B ranged from 4.0×10±1.00 cfu/ml to 5.5×10±1.20 cfu/ml while Ogida sample A and B ranged from 12×10±0.33 cfu/ml to 13×10±1.00 cfu/ml respectively. The total coliform counts of Uselu water samples A and B had values of 15 mpn/100ml and 9 mpn/100ml respectively while the counts of Sample A and B from Ogida were 7 mpn/100ml and 6 mpn/100ml respectively. The fungal counts for Uselu water samples A and B ranged from $1.333\times10\pm0.33$ cfu/ml to $1.667\times10\pm0.33$ cfu/ml respectively while Ogida samples A and B ranged from $0.33\times 10 - 0.66\times10\pm0.33$ cfu/ml. As presented in table 4.5, the bacteria isolated based on their cultural characteristics, gram staining and biochemical tests were identified to be *Pseudomonas* sp, *Salmonella* sp., *Staphylococcus* sp., *Enterobacter* sp., *Bacillus* sp., *Shigella* sp. The fungal isolates were *Aspergillus niger, Aspergillus flavus, Penicillium chrysogenum*, and *Mucor* sp. The results of antimicrobial resistance testing for *Enterobacter* sp., *Staphylococcus aureus, Salmonella* sp., *Bacillus* sp., *Pseudomonas sp. and Shigella* sp. *using* selected antibiotics are revealed in Table 4.6 below. *Enterobacter* sp. was found to be sensitive to colistin, augmentin and intermediate to ciprofloxacin, and resistant to gentamicin, erythromycin, tetracycline, metronidazole and clindamycin. *Staphylococcus* sp. was intermediate to ciprofloxacin, tetracycline and clindamycin, susceptible to colistin, gentamicin, and erythromycin and resistant to metronidazole and augmentin. *Shigella* sp. was found to be resistant to colistin, ciprofloxacin, erythromycin, tetracycline, metronidazole and clindamycin and sensitive to gentamycin and augmentin. *Salmonella* sp. was found to be resistant to ciprofloxacin, gentamycin, erythromycin and clindamycin, intermediate to tetracycline and sensitive to colistin, augmentin. *Pseudomonas sp.* was sensitive to ciprofloxacin, gentamicin, and augmentin, intermediate to metronidazole and resistant to colistin, erythromycin, tetracycline and clindamycin. *Bacillus* sp was sensitive ciprofloxacin, gentamicin, tetracycline and metronidazole, intermediate to erythromycin and resistant to clindamycin and augmentin.

The results obtained from the questionnaire survey of the water sanitation and hygiene status of the three markets are presented from tables 4.7 to 4.17. A total number of 50 persons responded to the questionnaires from each of the markets; Uselu, Ogida and Useh markets. Table 4.7 shows the background characteristics of Uselu survey respondents of which the majority were females (72%) while the minorities were males (28%). The highest percentages of respondents fell within the age range of 31 to 35 years (40%), were married traders (66%) and had a secondary level education (26%). In Table 4.8, the results showed that the source of water at the market was a borehole (100%) which was cited on the market premises (100%). 56% of the respondents strongly agreed that water was currently available at the market, 30% agreed, 6% were uncertain, 4% disagreed and 4% strongly disagreed. As shown in Table 4.9, 100% of the respondents stated that the type of toilets available at Uselu were flush to pit toilets. 38% of the respondents indicated a range of 1-5 functional toilets, 88% indicated that there were 5-10 functional toilets while 18% indicated that there were above 10 functional toilets. 80% strongly agreed that the toilets were separated for male and female use and 34% strongly disagreed that the toilets had the facilities to manage menstrual hygiene. The results of the hand hygiene status of the market are presented in Table 4.10 below. All respondents (100%) stated that there was no available soap at the toilet premises for hand washing but 52% of the respondents strongly agreed that staff was employed to clean the toilets with water and soap daily. 100% of the respondents stated that the wastes generated from the markets were neither sorted nor disposed in appropriate bins but openly dumped in a central location in the market. 30% of the respondents strongly agreed that the Waste Management Board do not recover the wastes from the market consistently while 60% strongly agreed that scavengers evacuates wastes from the market.

The background characteristics of Ogida survey respondents are presented on Table 4.11. Majority of the respondents were females (90%) while the minorities were males (5%). The highest percentages of respondents fell within the age range of 31 to 35 years (46%), were married (80%) and had a primary level education (26%). In Table 4.12, the results showed that the source of water at the market was a borehole (100%) which was cited on the market premises (100%) and majority (70%) strongly agreed that water was currently available at the market. 50% of the respondents strongly agreed that water was currently available at the market, 20% agreed, 14% were uncertain, 9% disagreed and 7% strongly disagreed. As shown in Table 4.13, 100% of the respondents stated that the type of toilets available at Ogida were flush to pit toilets. 12% of the respondents indicated a range of 1-5 functional toilets, 88% indicated that there were 5-10 functional toilets while no respondents indicated that there were above 10 functional toilets. 70% strongly agreed that the toilets were separated for male and female use and no respondent (0%) strongly disagreed that the toilets had the facilities to manage menstrual hygiene. The results of the hand hygiene status of the market are presented in Table 4.14 below. All respondents (100%) stated that there was no available soap at the toilet premises for hand washing, 30% of the respondents strongly agreed that staff was employed to clean the toilets with water and soap daily, 34% also agreed, 10% were uncertain, 18 % disagreed while 8% strongly disagreed. 100% of the respondents stated that the wastes generated from the markets were neither sorted nor disposed in appropriate bins but openly dumped in a central location in the market. 100% of the respondents strongly agreed that the Waste Management Board do not recover the wastes from the market at all. 72% of the respondents strongly agreed that wastes are centrally collected and openly burnt in the market while 80% strongly disagreed that scavengers evacuates wastes from the market.

As shown on Table 4.15 Majority of the respondents at Useh market were females (74%) while the lesser percentage of the respondents were males (26%). The highest percentages of respondents fell within the age range of 36 to 40 years (30%), were married (70%) and had vocational education (32%). In Table 4.16, the results showed that 100% of the respondents reported that there was no source of water at market and as revealed on Table 4.17, 100% of the respondents also indicated that there was also no toilet facility at the market. With regards to the hand hygiene status of the market which is revealed on Table 4.18 below, 100% of the respondents did not have a good hygiene practice as soap and water was not available for hand washing. 100% of the respondents stated that the wastes generated from the markets were neither sorted nor disposed in appropriate bins but openly dumped in a central location in the market. 100% of the respondents strongly disagreed to the statement that the Waste Management Board recovers the wastes from the market. 50% of the respondents strongly agreed that wastes are centrally collected and openly burnt in the market. Regarding the response to wastes being evacuated by scavengers, 50% strongly agreed that scavengers evacuate wastes from the market.

Table 4.1: Physicochemical Results of Water Samples

PARAMETRS	USELU SA	USELU SB	OGIDA SA	OGIDA SB	USEH SA AND SB	WHO

pH	4.70±0.15[a]	5.00±0.00[a]	6.29±0.14[a]	5.10±0.05[a]	NS	6.5-8.5
Chloride (Cl)	46.15±0.07[c]	35.5±0.25[c]	24.85±0.42[b]	28.4±0.20[b]	NS	200mg/l
Nitrate (NO_3)	0.68±0.03[a]	1.31±0.00[a]	3.19±0.00[a]	1.85±0.62[a]	NS	10mg/l
Biological Oxygen Demand (BOD)	0.55±0.62[a]	0.33±0.08[a]	1.85±0.77[a]	2.60±0.40[a]	NS	6mg/l

KEY: NS- Not sampled (No available water source), SA- Sample A, SB- Sample B

Table 4.2: Heavy Metals Results of Water Samples

HEAVY METALS	USELU A	USELU B	OGIDA A	OGIDA B	USEH SA AND SB	WHO

Iron (Fe)	ND	ND	ND	ND	NS	1.00 mg/l
Lead (Pb)	ND	0.04±0.02[a]	0.01±0.01[a]	0.03±0.01[a]	NS	0.01 mg/l
Chromium (Cr)	0.07±0.02[a]	0.04±0.00[a]	0.04±0.00[a]	0.01±0.00[a]	NS	0.005mg/l

Values are expressed as Mean ± Standard Error. Mean values with similar superscript are not significantly different from each other ($p > 0.05$). KEYS: ND- Not detected, NS- Not sampled (No available water source), SA- Sample A, SB- Sample B

Table 4.3: Enumeration of bacterial and fungal population of water samples

Samples	THB(×10CFU/ml)	TCC (MPN/100ml)	TF (×10 CFU/ml)
USELU SA	4.0 × 10 ±1.00	15	0.33× 10±0.33
USELU SB	5.5 × 10 ±1.20	9	0.66 ×10±0.33
OGIDA SA	12 × 10 ±0.33	7	1.667 ×10±0.33
OGIDA SB	13 × 10 ±1.00	6	1.333× 10±0.33

KEY: THB- Total heterotrophic bacteria, TCC- Total coliform count, TF- Total fungi, MPN- Most probable number.

Table 4.4: Cultural and Morphological Characteristics of Bacterial Isolates

Cultural characteristics	1	2	3	4	5	6
Colour	Cream	Cream	Golden yellow	Cream	Cream	Yellow
Shape	Circular	Circular	Circular	Circular	Circular	Circular
Elevation	Convex	Convex	Convex	Convex	Convex	Convex
Margin	Entire	Entire	Entire	Entire	Entire	Entire
Size	Small	Small	Small	Small	Small	Small
Morphological characteristics						
KOH	+	+	-	-	-	-
Gram stain	-	-	+	+	-	-
Cell morphology	Rod	Rod	Cocci	Rod	Rod	Rod
Cell arrangement	Single	Single	Clusters	Single	Chains	Clusters
Biochemical characteristics						
Catalase	+	+	+	+	+	+
Indole	-	-	-	-	-	-
Oxidase	-	-	-	-	+	-
Citrate	+	-	+	+	+	-
Urease	+	-	+	-	-	-
H2S production	-	+	-	-	-	-
Glucose	+	+	+	+	-	+
Lactose	+	-	+	-	-	-
Sucrose	+	-	+	+	-	-
Mannitol	+	+	+	+	+	-
Identity	*Enterobacter* sp.	*Salmonella* sp.	*S. aureus*	*Bacillus* sp.	*Pseudomonas* sp.	*Shigella* sp.

Table 4.5: Cultural and Morphological Identification of Fungi

	1	2	3	4
Cultural characteristics of Fungi Isolates	Black fluffy colony with reverse side yellow	Felty, green with bright yellow pigment exuded into the agar, reverse is yellow	Cotton candy texture, white with pale yellowish brown reverse colour	Cotton candy texture, white with pale yellowish brown reverse colour
Name of Hyphae	Septate	Septate	Septate	Septate
Colour of spores	Brown	blue-green	White	Brown
Types of Spores	conidiospore	Conidiospore	Conidiospore	Conidiospore
Possible Isolates	*Aspergillus niger*	*Penicillium chrysogenum*	*Mucor* sp.	*Aspergillus flavus*

Table 4.6: Resistance and Sensitivity of Bacteria to Antibiotics

ISOLATES	CS	CIP	GEN	E	TE	M	CD	AG
Enterobacter sp.	21(S)	14(R)	10(R)	3(R)	0(R)	9(R)	0(R)	14(S)
Staphylococcus sp.	9(R)	21(S)	17 (S)	8(R)	18(I)	10(R)	21(S)	15(S)
Bacillus sp.	0(R)	18(S)	17(S)	10(I)	21(S)	23(S)	0(R)	9(R)
Shigella sp.	4(R)	6(R)	19(S)	10(R)	8(R)	5(R)	10(R)	15(S)
Pseudomonas sp.	5(R)	17(S)	21(S)	0(R)	0(R)	13 (I)	0(R)	14(S)
Salmonella sp.	22(S)	0(R)	7(R)	0(R)	15(I)	0(R)	0(R)	18(S)

KEY: Resistance (R), Susceptible (S), Intermediate (I), Colistin (CS), Ciprofloxacin (Cip), Gentamicin (Gen), Erythromycin (E), Tetracycline (Te), Metronidazole (M), Clindamycin (Cd), Augmentin (Ag).

Table 4.7 Socio-demographic Characteristics of Uselu Respondents

Variables	Frequency (N=50)	Percentage (100%)

Sex of respondents		
Male	14	28
Female	36	72
Age of respondent		
<20 years	2	4
21-25 years	3	6
26-30 years	13	26
31-35 years	20	40
36-40 years	3	6
>40 years	9	18
Level of Education		
No Formal Education	12	24
Vocational	11	22
Quaranic studies	1	2
Primary	6	12
Secondary	13	26
Higher	7	14
Marital Status		
Married	33	66
Co-habiting	0	0
Single	9	18
Divorced	0	0
Separated	1	2
Widow/widower	0	0

Table 4.8 Water Availability Status of Uselu Market

Variables	Frequency (N=50)	Percentage (100%)
Main water source		
Borehole	50	100
Main water source is on premises		
Yes	50	100
Water from main source is currently available		
Strongly Agree	28	56
Agree	15	30
Uncertain	3	6
Disagree	2	4
Strongly Disagree	2	4

Table 4.9 Sanitation Status of Uselu Market

Variables	Frequency (N=50)	Percentage (100%)
Number of usable toilets within the market		
1-5 toilets	19	38
5-10 toilets	44	88
>10 toilets	9	18
Type of toilets		
Flush/pour-flush to tank or pit	50	100
Toilets are separated for male and female		
Strongly Agree	40	80
Agree	3	6
Uncertain	2	4
Disagree	3	6
Strongly Disagree	2	4
Toilet has facilities to manage menstrual hygiene		
Strongly Agree	0	0
Agree	8	16
Uncertain	10	20
Disagree	15	30
Strongly Disagree	17	34

Table 4.10 Hygiene Status of Uselu Market

Variables	Frequency (N=50)	Percentage (100%)
Soap and water are currently available in premises		
Yes	0	0
Partially (water is available)	50	100
No	0	0
Soap and water are currently available at the toilets		
Yes, within 5m of the toilets	0	0
Yes, more than 5m from the toilet	0	0
No soap / no water	50	100
Staff are employed to clean the toilets		
Strongly Agree	26	52
Agree	9	18
Uncertain	6	12
Disagree	7	14
Strongly Disagree	2	4
General wastes are safely separated into three bins		
Yes	0	0
Somewhat	0	0
No	50	100

Table 4.10 Hygiene Status of Uselu Market (Continued)

Variables	Frequency (N=50)	Percentage (100%)
Wastes are collected and openly burnt		
Strongly Agree	0	0
Agree	0	0
Uncertain	3	6
Disagree	7	14
Strongly Disagree	40	80
Wastes are centrally collected and burnt in closure		
Strongly Agree	0	0
Agree	0	0
Uncertain	9	18
Disagree	25	50
Strongly Disagree	16	32
Wastes are evacuated by the waste management board		
Strongly Agree	15	30
Agree	10	20
Uncertain	7	14
Disagree	6	12
Strongly Disagree	12	24
Wastes are evacuated by Scavengers		
Strongly Agree	30	60
Agree	9	18
Uncertain	1	2
Disagree	1	2
Strongly Disagree	2	4

Table 4.11 Socio-demographic Characteristics of Ogida Respondents

Variables	Frequency (N=50)	Percentage (100%)
Sex of respondents		
Male	5	10
Female	45	90
Age of respondent		
<20 years	3	6
21-25 years	2	4
26-30 years	7	14
31-35 years	23	46
36-40 years	9	18
>40 years	6	12
Level of Education		
No Formal Education	14	28
Vocational	6	12
Quaranic studies	0	0
Primary	16	32
Secondary	8	16
Higher	5	10
Marital Status		
Married	40	80
Co-habiting	0	0
Single	9	18
Divorced	0	0
Separated	1	2
Widow/widower	0	0

Table 4.12 Water Availability Status of Ogida Market

Variables	Frequency (N=50)	Percentage (100%)
Main water source		
Borehole	50	100
Main water source is on premises		
Yes	50	100
Water from main source is currently available		
Strongly Agree	25	50
Agree	10	20
Uncertain	7	14
Disagree	4	9
Strongly Disagree	4	7

Table 4.13 Sanitation Status of Ogida Market

Variables	Frequency (N=50)	Percentage (100%)
Number of usable toilets within the market		
1-5 toilets	2	4
5-10 toilets	48	96
Type of toilets		
Flush/pour-flush to tank or pit	50	100
Toilets are separated for male and female		
Strongly Agree	37	74
Agree	5	10
Uncertain	3	6
Disagree	3	6
Strongly Disagree	2	4
Toilets have facilities to manage menstrual hygiene		
Strongly Agree	0	0
Agree	0	0
Uncertain	5	10
Disagree	15	30
Strongly Disagree	30	60

Table 4.14 Hygiene Status of Ogida Market

Variables	Frequency (N=50)	Percentage (100%)
Soap and water are currently available in premises		
Yes	0	0
Partially(water is available)	50	100
No	0	0
Soap and water are currently available at the toilets		
Yes, within 5m of the toilets	0	0
Yes, more than 5m from the toilet	0	0
No, no soap and/or no water	50	100
Staff are employed to clean the toilets		
Strongly Agree	15	30
Agree	17	34
Uncertain	5	10
Disagree	9	18
Strongly Disagree	4	8
General wastes are safely separated into three bins		
Yes	0	0
Somewhat	0	0
No	50	100

Table 4.14 Hygiene Status of Ogida Market (Continued)

Variables	Frequency (N=50)	Percentage (100%)
Wastes are centrally collected and openly burnt		
Strongly Agree	36	72
Agree	12	24
Uncertain	2	4
Disagree	0	0
Strongly Disagree	0	0
Wastes are centrally collected and burnt in closure		
Strongly Agree	0	0
Agree	0	0
Uncertain	0	0
Disagree	0	0
Strongly Disagree	50	100
Wastes are evacuated by waste management board		
Strongly Agree	0	0
Agree	0	0
Uncertain	0	0
Disagree	0	0
Strongly Disagree	50	100
Wastes are collected and evacuated by scavengers?		
Strongly Agree	0	0
Agree	0	0
Uncertain	7	14
Disagree	40	80
Strongly Disagree	10	20

Table 4.15 Socio-demographic Characteristics of Useh Respondents

Variables	Frequency (N=50)	Percentage (100%)
Sex of respondents		
Male	13	26
Female	37	74
Age of respondent		
<20 years	2	4
21-25 years	6	12
26-30 years	12	24
31-35 years	8	16
36-40 years	15	30
>40 years	7	14
Level of Education		
No Formal Education	11	22
Vocational	16	32
Quaranic studies	0	0
Primary	10	20
Secondary	8	16
Higher	5	10
Marital Status		
Married	35	70
Co-habiting	0	0
Single	14	28
Divorced	0	0
Separated	1	2
Widow/widower	0	0

Table 4. 16 Water Availability Status of Useh Market

Variables	Frequency (N=50)	Percentage (100%)
Main water source		
No water sources	50	100

Table 4.17 Sanitation Status of Useh Market

Characteristics	Frequency (N=50)	Percentage (100%)
Number of usable toilets within the market		
None	50	100
Type of toilets		
None	50	100

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Table 4.18 Hygiene Status of Useh Market

Variables	Frequency (N=50)	Percentage (100%)
Soap and water are currently available in premises		
Yes	0	0
Partially	0	0
No	50	100
General waste are safely separated into three bins		
Yes	0	0
Somewhat	0	0
No	50	100
Wastes are centrally collected and openly burnt		
Strongly Agree	28	56
Agree	15	30
Uncertain	5	10
Disagree	2	4
Strongly Disagree	0	0
Wastes are centrally collected and burnt in closure		
Strongly Agree	0	0
Agree	0	0
Uncertain	0	0
Disagree	0	0
Strongly Disagree	50	100

Table 4.18 Hygiene Status of Useh Market (Continued)

Variables	Frequency (N=50)	Percentage (100%)
Wastes are evacuated by waste management board		
Strongly Agree	0	0
Agree	0	0
Uncertain	0	0
Disagree	0	0
Strongly Disagree	50	100
Wastes are collected and evacuated by scavengers		
Strongly Agree	25	50
Agree	15	30
Uncertain	4	8
Disagree	4	8
Strongly Disagree	2	4

CHAPTER FIVE

DISCUSSION

5.1 DISCUSSION

Carrying out studies and research in the Water Sanitation Hygiene (WASH) sector has been recognized as the first step toward achieving Sustainable Development Goal 6 which seeks to establish a good WASH status for all (Setty *et al*., 2020; Fayomi *et al*., 2018).

The results obtained from the physicochemical analysis of the water samples are presented in Table 4.1. It shows that the pH of Uselu water sample A and B ranged from 4.70 to 5.00 respectively while that of Ogida sample A and B ranged from 5.10 to 6.29 respectively, similar to that of Ogbeifun *et al*. (2019). This range indicates that water is acidic and not good for consumption as it can be corrosive and exacerbate existing skin conditions (Engwa *et al*., 2015). On the other hand, consuming water with elevated pH levels can cause skin, eye and mucous membrane irritation (Engwa *et al*., 2015). Thus, our finding shows that pH is not in agreement with the World Health Organisation recommendation of 6.5 – 8.5 range for potable water as they are below the required standard and so the water is considered unfit for consumption due to the potential health effects over a long period (WHO, 2011). This finding could be attributed to the geology of the Benin soil which has been discovered to be within the acidic range by many researchers (Akpankpo and Igboekwe, 2012). Acidic water may occur naturally as a result of mixture of volcanic gases, gaseous emanations in geothermal areas or due to alteration of groundwater (Okhuebor and Izeubwa, 2020). To avert this effect would require water treatment measures to increase the pH to an acceptable level. The Chloride concentration of the water samples A and B from Uselu market was found to range from 46.15 mg/l to 35.5 mg/l while water samples A and B from Ogida market ranged from 24.85 mg/l to 28.4 mg/l respectively. These concentrations were within the WHO acceptable limit of less than 200mg/l just like that of

Ogbeifun *et al*. (2019). The concentration of Nitrate in the water samples A and B from Uselu ranged from 0.675 mg/l to 1.309 mg/l while that of Ogida sample A and B ranged from 3.186 mg/l to 1.85 mg/l and these findings were not so different from that of Morka *et al*. (2021). The concentrations of the water samples from both markets were within the WHO range of less than 10mg/l. The Biological Oxygen Demand of the water samples A and B from Uselu market was between 0.55 mg/l to 0.33 mg/l while the water samples A and B from Ogida market ranged from 1.85 mg/l to 2.60 mg/l. These findings were found to be lower than that of Morka *et al*. (2021) and they within the WHO acceptable limit of less than 6mg/l. As shown in Table 4. 2, Iron was not detected in the water samples. This finding was similar to the findings of Ogbeifun *et al*. (2019) where Iron concentrations were also not detected at one of the points while two other samples read very low concentrations. Following Ogbeifun *et al*. (2019) lead concentrations were not detected in water sample A from Uselu market but water sample B from Uselu and samples A and B from Ogida market had concentrations of 0.04 mg/l, 0.01 mg/l and 0.03 mg/l respectively and all concentrations were within the WHO acceptable limits (0.01mg/l). Water samples A and B from Uselu market ranged from 0.04 mg/l to 0.07 mg/l respectively while the water samples A and B from Ogida market ranged from 0.01 mg/l to 0.04 mg/l respectively. These concentrations largely exceeded the WHO reference standards of 0.005 mg/l as in the case of Erah *et al*. (2002). According to the International Agency for Research on Cancer, Chromium is very toxic and has been characterized as carcinogenic to humans (Group I), producing liver and kidney damage, internal hemorrhage and respiratory disorders (Tumolo *et al*., 2020). In a study, Achmad and Auerkeri (2017) stated that a lasting and continuative exposure to Chromium even at low concentrations could pose health risks such as damage to skin, eyes, blood, respiratory and immune systems.

The findings of the total coliform count, total heterotrophic counts and total fungi counts are presented in Table 4.3. The mean of the total bacterial counts (TBC) for Uselu water sample A and B ranged from 40 cfu/ml to 55 cfu/ml while water samples A and B from Ogida market ranged from 126 cfu/ml to 130 cfu/ml. These results were very different from that of Ogbeifun *et al*. (2019) which had zero counts and far less than the counts of Morka *et al*. (2021). The water samples from Uselu market were within the WHO limits of not more than 100 cfu/ml while the counts from Ogida water samples showed that they were not within the WHO limit. The presence of bacteria counts exceeding the WHO limits indicated that the water samples contain bacteria that could make the water unsafe for drinking and domestic purposes. The high values obtained could be due to poor environmental conditions and the presence of stagnant water around the borehole which provides an excellent breeding ground for bacteria (Okhuebor and Izeubwa, 2020).

The results showed that the total coliform count (mpn/ml) for the borehole water samples A and B from Uselu and Ogida markets were 15 mpn/100ml, 9 mpn/100ml, 7 mpn/100ml and 6 mpn/100ml respectively. This result is far lower than that of Adebiyi *et al*. (2021) but higher than Ogbeifun *et al*. (2019). The WHO standard for bacteria in potable water states this is unacceptable because the WHO standard of potable water states that no coliform should be present in any drinking water. Total coliform bacteria are known as "indicator organisms" meaning that their presence indicates that other disease-causing organisms may also be present in the water body. They are the commonest bacteria responsible for a range of water-related diseases such as typhoid, dysentery, diarrhea, etc. with global mortality attributed to its consumption especially in Africa (Enemor *et al*., 2020). The presence of coliform in the water could be as a result of the close siting of boreholes to soak -away pit in the market (Okhuebor and Izeubwa, 2020). The fungi results showed that the fungi counts for Uselu market water samples A and B ranged from 3.3 cfu/ml to 6.6 cfu/ml respectively while Ogida water samples A and B ranged from 16.7 cfu/ml to 13.3 cfu/ ml. As recommended by WHO, fungi in water does not really cause serious infections but it could pose some health related risk in immune-suppressed individuals (Mirshekar *et al*., 2019). Hence, cleaning processes to remove biofilm from water and the addition of chlorine to water could decrease fungi contamination from a water distribution system (Mirshekar *et al*., 2019).

Public sanitary facilities are crucial infrastructure necessary for the social well-being and dignity of the inhabitants of any settlement (Jerry *et al*., 2019). As shown in Tables 4.9 and 4.13, the toilet facilities available at Uselu and Ogida markets were improved facilities such as flush-to-pit systems and as indicated by a majority of respondents (88% and 96% respectively), the toilets were within the range of 5-10 toilets. Oyinloye and Oluwadare (2015) observed that there is still a lack of improved public convenience facilities in most public places in Nigerian cities and unfortunately, Useh market happens to be one of such places. The lack of toilet facilities was a huge concern at Useh market, resulting in open defecation, which has become a common practice of the traders. According to Jerry *et al*. (2019), this is usually a major health issue for the community at large. Fortunately, the respondents have a positive perception regarding good toilet facilities and are willing to stop open defecation if sanitation facilities are made available. Research suggests that women fear sharing toilets with men and/or prefer toilets with separate gender stalls (Pearson and Mcphedran, 2008; Greed 2016). This is because women have a greater vulnerability to Gender Based Violence (GBV), experiencing sanitation-related psychosocial stress and fear of sexual violence (Sahoo *et al*., 2015). Although having available toilet facilities is important, the segregation of the toilet facilities on a gender basis is now being viewed as equally paramount because of the issues women face due to lack of access to safe and private toilets are now recognized within the WASH sector (Jalali, 2021). Similar to the findings of Eremutha *et al*. (2016), it was discovered that the toilets at Uselu and Ogida markets had segregated toilet facilities for male and female use.

Schimitt *et al*. (2018) went further to explain in a recent study, that toilet facilities which have been segregated on a gender basis should also be made female-friendly for women and girls as they must be able to use clean materials to absorb or collect menstrual fluid, and change them regularly and in privacy. They must have access to water and soap to wash the blood off their hands and body and facilities to dispose of menstrual materials like pads, cups, cloths and tampons safely and hygienically. Contrary to this report, water was the most abundant material in the available toilets at both Uselu and Ogida markets as in the case of Jerry *et al*. (2019). Soap and other hand rubs as well as waste bins for pad disposal were unavailable. The lack of soap and hand rubs within the toilet blocks could be attributed to the lack of funds to purchase enough soap because soap was only bought for keeping the toilet facility clean but none was provided for hand washing after toilet use. This observed practice from the traders was very similar to that of Phillips *et al*. (2015), where hand washing with only water was a common practice. Research has it that such practices are not as effective as hand washing with soap; hence it could lead to disease outbreaks (Amin *et al*., 2014).

Abney *et al*. (2021) explained the importance of using soap, water and disinfectants in maintaining toilet facilities in order to prevent and control both enteric and respiratory pathogens-associated illnesses both in public toilets and private toilets. As discovered during this study, the toilets at Uselu and Ogida markets were cleaned properly and frequently with soap and water by women who have been employed to clean the toilet facility daily. During this study, interaction with the traders at Uselu market revealed that they had to pay a token of thirty naira (₦ 30) to make use of the toilet facility.

Despite the great risk to public health and environmental difficulties posed by the waste in the market place, waste management practices in African urban marketplaces have been greatly neglected (Olufunlola *et al*., 2018). Similar to the case of Olufunlola *et al*. (2018), wastes generated from the three markets were disposed of in polythene bags and sacs instead of waste bins. It was observed that the wastes generated from Uselu market were seldom evacuated by the waste management board, hence wastes could be seen heaped around corners of the market until they get evacuated by unaccredited waste handlers with the use of wheelbarrows to the nearest dumpsite from which the trucks of the waste management board seldom pick up the discharge. At Ogida market, it was reported that despite paying a fee of two thousand naira (₦ 2000) to the local government council every month, their wastes never get evacuated by the government waste management board. It was the same case for Useh market but unlike Ogida market where the traders also made use of unaccredited handlers, the traders at Useh resorted to open dumping and burning of wastes in the market as in the case of Amalu and Ajake (2014). Burning of wastes often leads to the prevalence of acute and chronic respiratory diseases, hypersensitivity of the airways and lung cancer (Tito and Salvino, 2019). The findings of this study clearly show the need to improve waste collection, storage, and disposal in the marketplace to reduce the potential for the spread of diseases and environmental degradation.

CONCLUSION

At the end of this study, it was discovered that Uselu and Ogida markets had improved source of water while there was no main water source at Useh Market. The water available at both markets were acidic with high Chromium levels as well as high coliform and total heterotrophic bacteria counts which exceeded the drinking water guidelines of the World Health Organisation. The water is therefore unfit for drinking and other market activities such as washing of food items. There was no toilet facility at Useh market while the toilet facilities at Uselu and Ogida were improved facilities which were flush to pit toilets and hand washing basins were available at Uselu and Ogida markets but only that of Ogida market was functional. It was discovered that the toilets were gender separate which were maintained by cleaners daily but unfortunately, the toilets were not female friendly as they did not meet the menstrual needs of females. The wastes generated from the markets were not being managed properly and the traders did not really have a very good hygiene practice due to lack of soap and other hand washing materials.

It is recommended therefore, that a borehole should be made available at Useh market because good levels of sanitation and hygiene cannot be established without the provision of potable water. There should be regular cleaning of the water tanks so as to reduce the bacteria load in the water. Improved toilet facilities which are female friendly should be provided at markets so as to cater for female sanitation and hygiene needs as well. The local government councils should ensure that the waste management boards pick up wastes regularly as at when due, to prevent improper waste disposal which leads to contamination of the water source and spread of diseases.

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APPENDICES

APPENDIX 1 SURVEY QUESTIONNAIRE

WATER, SANITATION AND HYGIENE (WASH) ASSESSMENT TOOL

Instruction: Please tick the most appropriate response for all the questions

Name of LGA……………………………………………………………………….

Name of Market………………………………………………………….........

Name of Community…………………………………………………………………

Date questionnaire was completed……………………………………………….

BACKGROUND CHARACTERISTICS		
Q1	**Sex of Respondent**	Female………….1 Male ……………2
Q2	**Age range**	Below 20……………….1 21-25…..……………...2 26-30……..…………..…3 31-35…..………………4 36-40……………...……5 Above 40…..……….....6

Q3	**Level of Education**	No Education………......1 Vocational…………..…2 Qur'anic only………......3 Primary………........…..4 Secondary…….……......5 Higher…………......…..6
Q4	**Marital Status**	Married…………………1 Co-habiting…………..…2 Single………………..….3 Divorced……………..…4 Separated……………..…5 Widow/Widower……..…6

PART A

Instruction: Please tick ☐ the most appropriate response for all the questions

1. Main water source (select one): □ Piped □ Borehole □ protected dug well □ unprotected dug well □ protected spring □ unprotected spring □ surface water (River/Lake/Canal) □ no water source □other: ___________
2. Main water source is on premises: □Yes□ Off premises but up to 500m□ more than 500m
3. Water from main source is currently available: □strongly agree □ agree □uncertain □disagree □strongly disagree

<u>**Core sanitation question**</u>

4. Number of usable (available, functional, private) toilets within the market____ (insert number)
5. Type of toilets/latrines (select one – most common): □Flush/Pour-flush to sewer □ flush/ pour –flush to tank or pit □ flush/Pour-flush to open □ not latrine with slab/covered □ Pit latrine without slab/open □ Bucket □ Hanging toilet/latrine □ None
6. Toilet separated for male and female □strongly agree □ agree □uncertain □disagree □strongly disagree
7. Female toilet has facilities to manage menstrual hygiene needs (covered bin, and /or water and soap): □strongly agree □ agree □uncertain □disagree □strongly disagree

Core hand hygiene question

8. Soap and water (or alcohol- based hand rub) currently available in premises□ Yes □ partially (e.g., lacking materials) □ No
9. Soap and water currently available at toilets: □ Yes, within 5m of toilets □ Yes, more than 5m from toilets □ No, no soap and/ or no water
10. Are employed staffs to clean the toilets? □strongly agree □ agree □uncertain □disagree □strongly disagree
11. General waste is safely separated into three bins □ Yes □ somewhat (bins full, include other waste, or only 1or 2 available) □ No
12. Wastes are centrally collected and openly burnt □strongly agree □ agree □uncertain □disagree □strongly disagree
13. Wastes are centrally collected and burnt in closure □strongly agree □ agree □uncertain □disagree □strongly disagree
14. Wastes are collected and evacuated by Government waste management board □strongly agree □ agree □uncertain □disagree □strongly disagree
15. Wastes are collected and evacuated by scavengers (local boys) □strongly agree □ agree □uncertain □disagree □strongly disagree