ENSURING SAFE DRINKING WATER IN BENIN CITY: AN ASSESSMENT OF WATER PURIFICATION, QUALITY AND TREATMENT SERVICES IN BENIN CITY

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CERTIFICATION

This dissertation by Fortune Ogbeide-Ikponmwosa Eloghosa, is accepted in its present form as satisfying the dissertation requirement of the degree of Doctor of Pharmacy (PharmD) of the faculty of Pharmacy, University of Benin.

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DEDICATION

This work is dedicated to Jehovah God, for His wisdom, love and guidance

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ABSTRACT

Background: Access to safe drinking water is a critical global concern. In Benin City, Nigeria, the quality of drinking water has been a recurring issue due to pollution and inadequate treatment facilities. This study investigates the water purity situation in Benin City and explores potential solutions.

Objective: To investigate the quality of drinking water and water purification methods employed.

Methods: This was a cross-sectional study involving assessment of water purification, quality and treatment services of 125 participants from five local government area. A semi-structured questionnaire sequel to obtaining ethical approval and patient's consent was employed to collect qualitative data from 125 participants in order to gather information on current water treatment practices and community perceptions.

Results: From the study, seventy-seven participants 61.6% (n=77) did not use water treatment method at home and out of the 38.4% that treated their water, 58.9% used boiling as a method of water treatment. Surveys revealed that participants (84%, n=105) were convinced that their water should be free off any form of contamination, but a low adoption of water treatment methods at home among residents.

Conclusion: The quality of drinking water among majority of individuals is below standard and the practice of water purification is poor. Addressing these issues is essential for safeguarding public health and enhancing the overall quality of life in the city.

Keywords: *Water, water purity, safe drinking water, water quality, water treatment, water purification, access to clean water.*

CHAPTER ONE

1.1 BACKGROUND OF STUDY

Water is necessary for human life, and its significance for both the health of a person and the welfare of a country cannot be overemphasized. The primary sources of safe water for domestic use, sustainable development, and human life are freshwater resources. They are necessary for the development of society and civilization (Orubu, 2006) and include water from lakes, hand-dug wells, taps, boreholes, streams, rivers and their plains, wetlands, and that which is stored in underground reservoirs.

Over 52% of Nigerians lack access to drinkable water, despite the government's significant spending in water supply initiatives (Ayantobo et al, 2012). The local population's access to fresh water sources is either dangerous or challenging. Women and children may occasionally have to walk for hours to collect simple drinking water. According to estimates, 140 million people regularly consume water contaminated with numerous bacteria, heavy metals, pathogens, and dust particles that can lead to various diseases (Galadima et al, 2011).

1.2 LITERATURE REVIEW

1.2.1 WATER QUALITY AND HEALTH IMPLICATIONS

Water is one of the most essential resources for life on earth, and ensuring its purity is critical for public health and well-being. Access to safe and clean drinking water is a basic human right, and yet in many countries, including Nigeria, this fundamental need is not met. The country faces a number of challenges in ensuring that its citizens have access to clean water, including poor water quality, lack of infrastructure, and inadequate treatment.

The United Nations General Assembly (UNGA) declared the right to access clean water and sanitary facilities as a fundamental human right in 2010 and urged governments to step up efforts to meet this goal (Winkler, 2017). Additionally, the United Nations' Member States ratified the 2030 Agenda for Sustainable Development in 2015, which includes Goal 6: "Ensure availability and sustainable management of water and sanitation for all" (Brookes and Carey, 2015).

A total of 489 million people worldwide lacked access to better drinking water facilities by 2020, including 122 million people who relied on surface water (rivers, dams, lakes, ponds, streams, canals, or irrigation canals) for their water supply (WHO, 2021; UNICEF, 2018). Over the years 2000 to 2020 according to WHO, (2021), more people had access to better sanitation facilities, which were created to hygienically segregate human touch from excrement. 494 million individuals were still using open defecation in 2020, nevertheless. Furthermore,670 million individuals lack access to facilities for washing their hands using soap and water (WHO, 2021).

The transmission of diseases and other symptoms like cholera, bacillary diarrhoea, viral hepatitis A, typhoid, polio, and acute respiratory infections, among others, has been linked to contaminated water and poor sanitation, according to the findings (Wolf et al, 2018; Ashraf et al, 2020; WHO, 2019). Nearly 2 million deaths per year, mostly among children, are attributed to a lack of access to Water, Sanitation, and Hygiene (WASH) services, according to the World Health Organization (WHO) (WHO, 2019). With 60% and 53% of all disability-adjusted life years (DALYs) and fatalities, respectively, attributed to inadequate WASH facilities, Sub-Saharan Africa continues to bear the brunt of this problem (WHO, 2019).

1.2.2 METRICS OF WATER PURITY

1.2.2.1 Turbidity and Total Dissolved Solids (TDS):

Turbidity is a measure of water clarity caused by the presence of suspended particles such as sediment, algae, and organic matter. High turbidity can interfere with light penetration, affecting photosynthesis in aquatic plants and disrupting the aquatic food chain. Additionally, turbid water can clog filters and reduce the efficiency of water treatment processes (Kothari et al., 2021).

TDS represents the concentration of minerals, salts, and other dissolved substances in water. It affects the taste of water and can have implications for industrial processes, agriculture, and drinking water quality. High TDS levels can also cause scale buildup in pipes, equipment and levels of dissolved oxygen (OD). Aquatic species depend on sufficient DO to survive. Due to microbial breakdown, DO is lower in warmer water and in water with high organic loading. In aquatic environments, low DO levels can cause "dead zones" where oxygen-demanding contaminants build up and aquatic life cannot survive (Rahmanian et al., 2015).

1.2.2.2 Colour:

Water colour can be indicative of the presence of dissolved and suspended substances. Natural organic matter from decaying vegetation can cause a tea-like colour, while industrial discharges and chemical pollution can lead to more vivid colours. Monitoring colour levels helps identify potential sources of contamination and assess the effectiveness of water treatment methods (Menon et al., 2021).

1.2.2.3 pH:

pH levels influence the solubility and behaviour of chemical compounds in water. Extreme pH values can harm aquatic life and alter the availability of essential nutrients. Acidic water can leach metals from pipes and soils, while alkaline conditions can lead to the precipitation of minerals.

A rising pH level poses a threat to the aquatic ecology. The pH of a pond or lake should be between 6.0 and 8.0, but certain things, such pollution and an overgrowth of algae, can change the pH of the water and raise the quantities of poisonous ammonia. Water test kits that offer a wide range of pH measurement and are color-coded can be used to measure pH. These kits are the most effective at illuminating the pH range that the water falls into. Electronic pH sensors, on the other hand, provide measurement values up to two decimal places for precise pH readings. Another element that needs to be watched is the hardness of the water (a gauge of carbonate and bicarbonate levels) (Kothari et al., 2021).

1.2.2.4 Bioindicators:

Living things such as plants, planktons, animals, and bacteria that are dependent on a certain aquatic environment for survival are referred to as bioindicators. These organisms can be utilized as indirect markers of water quality and as indications of water contamination since they are extremely sensitive to environmental changes.

Plankton have been found to be excellent biomarkers for determining water quality as well as good indicators of water pollution because they react quickly to changes in their environment, according to a study on bioindicators as a natural indicator of environmental pollution from the Gujarat Forensic Sciences University in India (Sharma et al., 2019)

It is not common practice to use bioindicators to evaluate the water quality of a site because doing so requires manually collecting and counting a variety of indicator species.

Coliform bacteria are commonly used as indicators of potential faecal contamination and the possible presence of pathogens. Elevated coliform levels suggest inadequate sanitation and the risk of waterborne diseases. *E. coli* is a specific type of coliform bacteria found in the intestines of warm-blooded animals. Its presence in water indicates recent fecal contamination, which can be a direct threat to human health (Mishra et al., 2018).

1.2.2.5 Nitrates And Nitrites

Nitrogen reacts with oxygen or ozone to generate nitrates and nitrites, which are naturally occurring forms of nitrogen. Wastewater treatment facilities, agriculture fertilizer, animal manure runoff, septic systems, and industrial discharge are some of the environmental sources of these nitrates.

Increased levels of nitrates and nitrate pollutants in water can hasten eutrophication and result in dramatic increases in the growth of aquatic plants like algal blooms. As a result, various aspects of water quality, including temperature and dissolved oxygen (excess nitrates can result in hypoxia), are changed. Also, when consumed in excess, nitrates are hazardous to people.

Using meters that employ a probe with an electrode sensor that senses nitrate activity in the water and converts this activity into millivolts, which can then be used to estimate the concentration of nitrates, it is possible to measure levels of nitrates in water similarly to DO. Nitrate levels can also be calculated using the calorimetric cadmium reduction method. In order to create a red colour whose intensity is proportional to the initial amount of nitrate, this method relies on the reduction of nitrates into nitrites when they come into contact with cadmium. Then, nitrites react with another reagent to produce a red color whose intensity is proportional to the original amount of nitrate. Nitrates have a maximum contamination limit (MCL) in water of 10 mg/L, and nitrites have an MCL of 1 mg/L, according to the US EPA (Beni et al., 2019).

1.2.2.6 Water Temperature:

Another indirect indicator that affects many other aspects of water quality, including pH, specific electrical conductivity, and dissolved oxygen concentration, is water temperature. The solubility, odour, viscosity, and solubility of water are all influenced by the temperature of the water. It impacts the biological oxygen demand (BOD), the chlorination and disinfection processes, and the level of toxicity of substances like cyanide and ammonia in water. A multi-parameter field water-quality meter or a regular thermometer from the same era that might be used to test for hot enough drinking water can be used to monitor water temperature with ease (Kothari et al., 2021).

1.2.2.7 Heavy Metals

Heavy metals, including lead, mercury, cadmium, and arsenic, can enter water through various sources such as industrial discharges, mining activities, and agricultural runoff. They accumulate in aquatic organisms and can pose serious health risks to humans and wildlife. Lead is a well-known toxic heavy metal that can enter water sources through various pathways, including corroded pipes, plumbing fixtures, and industrial discharges. Even at low concentrations, lead can be harmful, especially to children and pregnant women. Lead exposure can lead to neurological damage, developmental issues in children, cognitive deficits, and behavioural problems. It can also affect the cardiovascular and renal systems in adults especially when they enter the food chain. Regulatory standards for lead concentrations in drinking water are extremely stringent due to its known health risks. The US Environmental Protection Agency (EPA) mandates a maximum allowable lead concentration of 15 parts per billion (ppb) in drinking water (Beni et al., 2019)

Mercury is a heavy metal that exists in various forms, including elemental mercury, inorganic mercury compounds, and organic methylmercury (Kumar et al., 2019). It can enter water bodies through industrial processes, mining activities, and atmospheric deposition.

Methylmercury, the organic form of mercury, is particularly concerning. It accumulates in aquatic organisms and can enter the human food chain through fish consumption. It can lead to neurological and developmental issues, especially in foetuses and children. Many countries have set limits on mercury concentrations in water bodies and fish. Regulatory agencies often issue fish consumption advisories to protect public health.

1.2.3 WATER PURIFICATION METHODS

1.2.3.1 Boiling:

The cheapest and safest way to purify water is to boil it. Water may get contaminated by its distribution methods or water sources. For instance, parasites and bacteria may not be visible to the unaided eye, yet their consequences might be fatal.

Clean water should be heated to a rolling boil and maintained there for one to three minutes when using this approach. High-altitude residents should boil their water for a longer period of time than those who live at lower elevations. This is due to the fact that water boils more slowly at higher altitudes. Before drinking, boiled water should be covered and allowed to cool. Before filtering pure water for usage from well water, let the chemicals to settle (Nicole, 2021).

1.2.3.2 Filtration:

One of the most efficient methods of removing chemicals from water is filtering, especially when the proper multimedia filters are used. This procedure purifies water and makes it suitable for consumption by humans using chemical and physical methods. With a rapid and easy filtration procedure, filtration gets rid of both large chemicals and small, harmful pollutants that cause diseases. Water that has been filtered is thought to be healthier than water that has been treated in other ways since filtration does not eliminate all the mineral salts. It is one of the most efficient technologies for purifying water since it uses a chemical absorption process to remove impurities from the water (Lee et al., 2016).

Filtration is thought to be more successful than reverse osmosis at the selective removal of much smaller molecules like chlorine and pesticides. The fact that filtering doesn't require as much energy as reverse osmosis and distillation does contributes to its lower cost. Because minimal water is lost during the filtration process, it is a cost-effective method of water purification.

1.2.3.3 Distillation

The process of distillation collects pure water in the form of vapour by using heat to purify the water. Because water has a lower boiling point than other pollutants and disease-causing substances found in water, this technique works. The boiling point of water is reached by heating it up to that point. The substance is then maintained at the boiling point until it vaporizes. A condenser is used to cool this vapour. Cooling causes the vapour to turn back into pure, drinkable liquid water. The sediments in the container consist of additional chemicals with a higher boiling point.

The removal of bacteria, germs, salts, and other heavy metals including lead, mercury, and arsenic is accomplished using this technique. For folks who have access to untreated, uncooked water, distillation is perfect. There are benefits and drawbacks to this approach. The lengthy nature of the water purifying procedure is a noteworthy drawback. In addition, a heat source is necessary for the purification to function. Although inexpensive energy sources are being created, distillation is still a pricey method of water purification. It works best (and is least expensive) when purifying tiny amounts of water (It is not ideal for large scale, commercial or industrial purification) (Lee et al., 2016).

1.2.3.4 Chlorination:

Chlorine is a potent chemical that has long been used to purify water for domestic usage. Chlorination is a powerful water purification technique that can eliminate parasites, bacteria, and other disease-causing organisms from tap or ground water. With liquid chlorine or chlorine pills, water can be cleaned. Chlorine is a cost-effective and readily available water purification agent. Nonetheless, care should be exercised when treating drinking water with chlorine tablets or solutions. Those with thyroid issues, for instance, should consult a doctor before using this product. It is crucial to use hot water when applying chlorine pills since they dissolve best in water that is at least 21 degrees Celsius. Tablets of chlorine eliminate all bacteria leaving the water clean and safe (Mazhar et al., 2020).

1.2.3.5 Reverse Osmosis (RO):

Reverse osmosis is a water purification process that uses a semipermeable membrane to remove a wide range of contaminants from water. It is widely used for both residential and industrial water treatment due to its effectiveness in producing clean and safe drinking water. Water is forced through a semipermeable membrane under pressure. This membrane has extremely small pores that allow water molecules to pass through while blocking larger molecules and contaminants. The semipermeable membrane effectively removes impurities such as dissolved salts, minerals, heavy metals, bacteria, viruses, and other pollutants. These contaminants are flushed away, while the purified water (permeate) is collected. Many RO systems use multiple stages of filtration, including pre-filters to remove larger particles and activated carbon filters to address organic compounds and chlorine that could potentially damage the RO membrane.

This method is capable of removing a wide range of contaminants, making it highly effective in producing high-quality drinking water. It is also energy-efficient compared to some other water treatment methods, removes minerals and impurities that can affect the taste and odour of water (Wenten, 2016). Depending on the water source and specific contaminants, the configuration of pre-filters and post-filters can be customized.

1.2.3.6 Ultraviolet (UV) Purification:

UV purification is a chemical-free method that uses ultraviolet light to disinfect water by inactivating microorganisms such as bacteria, viruses, and protozoa. Water is exposed to UV-C light with a wavelength of around 254nm. This wavelength is lethal to the DNA and RNA of microorganisms, rendering them unable to replicate and causing their death. The UV light penetrates the cell walls of microorganisms, disrupting their genetic material. This prevents their ability to reproduce and infect humans. This technique does not introduce any chemicals or byproducts into the water, making it a safe and environmentally friendly method.

Advantages of UV Purification includes: effectively inactivates a wide range of microorganisms, including bacteria, viruses, and protozoa, purification doesn't require the use of chemicals like chlorine or ozone, which can leave residual tastes and odour and it is rapid and doesn't require a holding time, so water can be used immediately after treatment (Wang et al., 2022).

1.2.3.7 Ultra-filtration

Ultrafiltration is one of the best method of purifying water which is not commonly used in homes. This was mostly employed in industries because it involves the use of big and expensive purification equipment e.g. the polypropylene filters, ceramic water filters, calcium sulphite filter, activated carbon filter, KDF carbon filter, magnetic filter etc. A smaller replica of these filters have been created and imbedded into a small water cartridge that is effective for homes. This is called te 7-step ultrafiltration cartridge, which is a portable high tech ceramic filter cartridge that fits most faucets and taps. This cartridge is attached to the tap and provides complete purification to the water without the use of electricity. So it is cost effective and reliable. This 7 step ultra-filtration cartridge is capable of removing odour and taste from water which can't be achieved by other modes of purification. Ultrafiltration is an efficient method for removing heavy metals (A. Alpatova et al 2004)

1.2.4 LIMITS OF WATER QUALITY

The upper and lower limits within which various water quality parameters can be precisely and consistently assessed using particular testing techniques are referred to as the limits of water quality measurement. These limitations are determined by a number of variables, such as the measurement equipment's sensitivity and the parameter's concentration range. Obtaining relevant and accurate data for water quality assessments requires an understanding of these boundaries**.** Below is a table containing desirable limits of some common water pollutants that are measured.

Sl. No.	Parameters (unit)	Desirable limit	Reference
1	Potential of hydrogen, pH	6.5–8.5	IS:10500
2	Dissolved oxygen, DO (mg/L)	>5.0	IS:10500
3	Biological oxygen demand, BOD (mg/L)	2.0	
4	Chemical oxygen demand, COD (mg/L)	105.0	IS:10500
5	Magnesium, Mg^{++} (mg/L)	30.0	IS:10500
6	Acidity	–	
7	Sulfur, SO_4 (mg/L)	250.0	WHO 2008
8	Calcium, Ca^{++} (mg/L)	75.0	IS 10500:1991
9	Chloride, Cl^- (mg/L)	250.0	WHO 2008
10	Alkaline, Alk (mg/L)	200.0	IS 10500:1991
11	Total suspended solids, TSS (mg/L)	60.0	
12	Total hardness, TH (mg/L)	300.0	IS 10500:1991
13	Total solids, TS (mg/L)	–	
14	Total dissolved solids, TDS (mg/L)	500.0	IS:10500, and WHO 2008
15	Presumptive total coliform, PTC (MPN)	500.0	
16	Confirmed total coliform, CTC (MPN)	500.0	

WHO (2008) Guidelines for drinking-water quality, third edition incorporating, the first and second agenda—volume-1 recommendations

Table 1: Pandey and Kumar, (2015).

1.2.5 EMPERICAL REVIEWS OF STUDIES ON WATER QUALITY

A comprehensive study by Rahmanian et al., (2015) was conducted to assess the quality of drinking water in suspected areas of Perak state, Malaysia. The main objective was to ensure the consistent provision of clean and safe drinking water to safeguard public health. The investigation encompassed a detailed analysis of both physical and chemical properties of water samples collected from various residential and commercial zones within the state. Key parameters, including pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS), and heavy metal concentrations (such as Cu, Zn, Mg, Fe, Cd, Pb, Cr, As, Hg, and Sn), were thoroughly examined for each sample during winter and summer seasons. The results were then compared against established benchmarks, including the World Health Organization (WHO) and local National Drinking Water Quality Standard (NDWQS) values. Encouragingly, all parameter values fell within the safe limits outlined by both WHO and NDWQS standards. This collective data indicated that the drinking water across all locations was indeed suitable for consumption. However, it is advisable to continue investigating potential sources of contamination, spanning chemical, microbial, and radiological factors, over an extended duration.

Allaire et al., (2018) highlighted the United States faces a significant challenge in ensuring safe water supply due to aging infrastructure, compromised water sources, and financial constraints in communities. Following the Flint lead crisis, there's a pressing need to assess the current status of US drinking water. However, a comprehensive nationwide analysis of drinking water quality trends over the decades has not been carried out yet. Given that around 21 million people depended on community water systems violating health-based standards in 2015, nationwide efforts to curb violations are crucial. This study examined patterns of health-related violations under the Safe Drinking Water Act using data from 17,900 community water systems between 1982 and 2015. Vulnerability factors in communities and water systems were also identified through statistical analysis. Disturbingly, upward trends in violations and concentration of violations in certain states, especially in the Southwest, were observed. Repeated violations are common in these hotspots, indicating persistent challenges in these areas. The study found higher violation rates in rural regions compared to urbanized areas and notes that private ownership and purchased water sources correlate with compliance. These findings highlighted systems that needed support to consistently meet standards. The study delved into the reasons behind regional violation clusters and proposes strategies for enhancing national drinking water quality.

In Nigeria, access to clean and safe drinking water remains a challenge for many families. The lack of access to clean water has led to an increase in waterborne diseases, such as typhoid, diarrhoea, cholera etc and has caused premature death. In fact, every year 3.575 million people die from complications of diseases related to dirty and unsafe water. Due to potential effects on public health, the quality of drinking water has garnered a lot of attention worldwide ((Rawlings and Seghosime, 2022). In Nigeria, drinking water is frequently packaged in sachets. It is frequently available as a main supply of water at canteens and is sold by various food vendors throughout the nation. Since the majority of people consume it, it is necessary to evaluate the quality of sachet and borehole water in order to protect users' health. In underdeveloped nations, drinking water has been linked to several, widespread health hazards, the majority of which are biological in nature (Aruya and Aruya, 2022).

According to reports, among the 20 main risk factors for health burden in developing nations, including Nigeria, unsafe water, inadequate sanitation, and poor hygiene come in third place (Ademoroti, 1996). The international recommendations for high-quality drinking water are meant to serve as a model for national standards that, if followed to the letter, will guarantee the safety of the water supply (WHO, 2011).

Abubakar, (2016) in his study, employed qualitative methods to examine the quality of water supply services in Abuja, Nigeria. The study gathered data from extensive interviews with both residents and city officials, complemented by firsthand observations. The investigation revealed a range of issues hampering effective water service provision in the city, including unreliability, insufficient water pressure, ineffective billing processes, inadequate facility upkeep, unequal distribution of services, and limited public participation. In conclusion, the study proposed strategies to improve water service quality in Abuja and similar developing regions.

It suffices to highlight that numerous research have been conducted in Benin City, Edo State, and other locations in an effort to understand the acceptability and mobility of water for drinking and other uses. The water was severely contaminated with heavy metals, elements, and microbiological species, according to Erah et al.'s 2002 analysis of the water quality from six boreholes and three manually dug wells. Despite being portable for human use, the pH and total coliform count (TCC) of the water in the University of Benin (UNIBEN) water distribution network were found to be over recommended values by Agatemor and Okolo, (2007). Akpoveta et al. (2011) evaluated the water quality in a few places in Benin City and Agbor and found that, while meeting statutory requirements for drinking water, the water was substantially contaminated with calcium and manganese.

In storage tanks in Benin City, Edo State, Oshoma et al. (2018) looked into the bacteriological and physico-chemical characteristics of borehole water. The analysis discovered that water samples from storage tanks were contaminated with harmful physical and chemical components, microbes, and made the water unfit for ingestion by humans. Oria-Usifo and colleagues (2018) evaluated the quality of water samples taken from boreholes in Oredo, Benin City's municipal area. The research reported pH, nitrate, and coliform organism levels greater than predetermined limits in the analyzed water, whereas the physical and chemical components were within acceptable bounds. Foka et al. (2018) looked at the water's quality indicators in four Benin City boreholes that are situated in densely inhabited areas.

In five locations in Ugbowo, Benin City, Ezenweani and Ezenweani (2019) assessed the drinking water quality and discovered that 80% of the water samples were fit for human consumption. This was explained by the fact that while the water quality metrics were within permissible ranges, 20% of the microbial counts were beyond the allowable limits. To ensure their safety and wellness, Iabanga et al., (2020) recommended that students living in private hostels develop the habits of purifying water before consumption using the most basic techniques, such as boiling and filtration. A university water pollution and quality policy is also required, with requirements for regular water treatment and quality monitoring that are made available to private hostel operators. The university administration should also conduct a broad campaign of education on the health effects of drinking and supplying water of dubious and declining quality to students and commercial hostel developers.

Pharmacists have a critical role in ensuring water purity in Nigeria. They can contribute to this effort by educating patients, monitoring water quality, participating in community initiatives, promoting good hygiene practices, and advocating for policy changes that promote clean water and public health (Adje and Oparah, 2017).

1.2.6 STATEMENT OF PROBLEM

The availability of safe water for consumption is a crucial global concern, and Benin City, Nigeria, is no exception. The city faces enormous hurdles in providing its citizens with access to safe and clean drinking water because of its quickly expanding population, poor water management, and pollution sources. Waterborne disease transmission has been related to contaminated water sources, posing serious threats to the public's health, especially for vulnerable people (Adams et al, 2016)

Water quality problems persist despite the efforts of water utilities and governmental agencies, and there is a dearth of detailed information on the degree of contamination and the efficacy of current water treatment techniques. Furthermore, it is critical to pinpoint the major causes of water pollution and develop viable, fact-based solutions because the city is plagued by a variety of pollution sources, from poor waste disposal to industrial discharges (Odigie, 2014).

Community awareness and involvement in maintaining water purity are also essential factors for sustainable water management. The role of community members and local pharmacies in promoting safe drinking water practices remains understudied, hindering the development of inclusive and community-centred approaches.

1.2.7 JUSTIFICATION OF STUDY

Access to safe drinking water is a fundamental human right and a critical factor for public health and well-being. Unfortunately, in many parts of the world, including Benin City, Nigeria, the availability of clean and safe drinking water remains a significant challenge. Individuals are responsible in ensuring they obtain water for their use. Many have resorted to digging boreholes while others buy bags of sachet water and packs of bottled water. The purity of these sources have not been assured. As a result, there is a pressing need to investigate the water purity situation in Benin City and identify feasible solutions to ensure the provision of safe drinking water to its residents.

The study on supplying Benin City with safe drinking water is critical and essential. It addresses significant social, environmental, and public health challenges and has the ability to improve the quality of life for city people. Also, for developing community engagement and advancing responsible water practices, it is essential to comprehend the viewpoints and information held by the locals and pharmacists regarding safe drinking water. This research can direct policymakers and stakeholders toward a safer and healthier future for Benin City by identifying the causes of water contamination and offering practical remedies.

1.2.8 AIM OF THE STUDY

The aim of this study is to comprehensively analyse the water purity status in Benin City, Nigeria, and propose feasible solutions to ensure the provision of safe drinking water to its residents

1.2.9 SPECIFIC OBJECTIVES

- To assess the socio-demographic characteristics of the individuals enrolled in the study.
- To examine how participants utilize and consume water.
- To assess the perception of study participants regarding the quality of water.
- To identify the attitudes and beliefs of participants regarding water treatment.
- To evaluate the understanding of study participants regarding water contamination.
- To identify the feedback provided by participants regarding water services.

CHAPTER TWO

2. RESEARCH METHODOLOGY

The techniques and processes used in this study are thoroughly explained in this chapter. Study Design, Study Setting, Study Population, Sample Size Determination, Data Collection Instrument and Administration, Data Analysis, and Ethical Consideration are all included in this chapter.

2.1 STUDY DESIGN AND SETTING

A cross-sectional prospective study design that thoroughly evaluate all the factors that contribute to providing Benin City, Nigeria, with safe drinking water was carried out. Five local governments in Benin-City were the focus of this study: Egor, Oredo, Ikpoba Okha, Orionmwon and Ovia North East. The study's methodology enabled the collection of quantitative and qualitative data, resulting in a comprehensive understanding of the problem of water quality and potential remedies. Following approval from the Ministry of Health and informed consent from the study participants, a semi structured questionnaire was used to collect the following information from each study participant: socio-demographics, water usage (frequency and sources), water quality awareness, water contaminants and water service. Water samples were also taken from homes selected study participants for analysis in the laboratory.

2.3 STUDY POPULATION

The study was conducted among participants from various residences and neighborhood from five selected local governments: Egor, Oredo, Ikpoba Okha, Orionmwon and Ovia North East, in Benin City. The respondents for this study were residents, students and worker in these locations. All individuals in these local governments in Benin-city are part of the study population.

2.4 SAMPLE SIZE

Non-probability accidental sampling technique was used for selecting a representative sample from the population. The sample size for this study was calculated using the Taro Yamane formula from the sample population as stated below:

n= N/ (1+N (e) 2)

Where:

n = sample size

N = population under study

e = margin error (0.05)

Population size of Benin = 1,904,631 according to UN World Urbanization Prospects, (2019)

$N = 1,904,631/1+1,904,631(0.05)^2 = 399.96$ Approx. 400.

Due to limited study duration and unavoidable constraints that limited data collection, the samples used for the study were 125 study participants.

2.5 DATA COLLECTION

A self-structured questionnaire based on the study objectives and the examined literature served as the tool for this investigation. This structured questionnaire was given to over 125 participants in five local government area; Oredo, Ikpoba Okha, Orionmwon, and Ovia North East. The questions were broken down into six sections. Section one accessed socio-demographic data of participants, section two had five subsections and assessed participant's response on water usage (frequency and sources), section three showed water quality perception level of study participants while section four through to six evaluated participant's perception on water treatment, knowledge of respondents on water contamination and response on water service respectively. Incentives for participation in the study included a complimentary water purity test, which was conducted during the study. After the test, participants received a detailed explanation of the research objectives, and their informed consent was obtained before recording their responses. To ensure that participants fully understood the questions in each section, a brief and comprehensive explanation was provided before recording their responses. This explanatory session lasted between 5 to 10 minutes. In cases where necessary, the explanations were conducted in Nigerian Pidgin English, which is an English-based creole language spoken as a common language throughout Nigeria, to cater to the literacy level of the participants.

2.6 METHOD OF DATA ANALYSIS

The data when obtained were analyzed using the Statistical Package for social sciences (SPSS) software version 21. Descriptive statistics, Chi-square test, as well as ANOVA, were performed to summarize the data collected. The hypotheses were analyzed and interpreted. The information was presented in the form of tables, percentages, and mean statistical tools.

2.7 ETHICAL APPROVAL

Ethical approval was sought and obtained from the chairman, Dr (Mrs) Omonyemen Bosede Bello from the Ministry of Health, Edo-state (Protocol Number No- HA-737/23/D/08210154).

CHAPTER THREE

RESULTS

Table 3.1 shows the socio-demographic data of the study participants. Five local governments were used for the study. A total of 125 participants were included in the study, with 19.2%, 17.6%, 10.8%, 19.2%, and 23.2% representing Egor, Ikpoba Okha, Oredo, Orhiomwon, and Ovia-notheast respectively. Eighty-eight participants, that is, 70.4% (n=88) of the study participants representing a larger percent were single. Most (76.8%, n=96) of the study participants had a tertiary level of education, while 1.6% (n=2) reported not to have any form of formal education. Most (87.2%, n=109) of the study participants were employed, and 38.4% (n=48) had less than three persons in their homes and 4.8% (n=6) had more than twelve persons in their homes. The remainder had three to twelve persons in their homes.

Table 3.2 shows participant's response on water usage. At least 54.4% (n=68) consume water three to five times daily. Only 1.6% (n=2) never drink water from sources other than their home. Twenty-six participants, that is, 20.8% (n=26) drink water from borehole Majority (49.9%, n=62) stored their water in refrigerator. Sachet water serves as the source of drinking water for 66.4% (n=83). For cooking, 96.8% (n= 121) used borehole water.

Table 3.3 shows water quality perception level of study participants. One hundred and five participants, that is, 84% (n=105) never had their water tested for purity although 69.6% (n=87) had received education or training on water purification, and 90% (n=18) of the participants when had their water tested for purity did so through chemical test. Same 84.0% (n=105) agreed that drinking water free from contaminant was extremely important.

Table 3.4 shows participant's perception on water treatment. Only thirteen participants, 10.4% (n=13) believed that home water should be tested for purity once a year while 65.6%

(n=82) believed it should be tested every three to six months while 33.6% (n=42) had their tanks washed once a year. Also 61.6% (n=70) did not use water treatment method at home, 84.0% (n=105) never tested their water quality at home. However, 83.2% (n=104) believed that typhoid could be gotten from unpurified water.

Table 3.5 shows the knowledge of respondents on water contamination. Sixty-six participants, that is, 52.8% (n=66) believed that lead is a common contaminant of water, and 33.6% (n=42) attributed water contamination to pesticides and herbicides. Majority (83.2%, n=104) of the study participants believed that typhoid could be gotten from unpurified water.

Table3.6 shows the participants response on water service. Forty percent (40%, n=50) of the participants were very concerned about ensuring purity of the water they drink. Half (50.4%, n=63) of the participants think water purification methods are expensive. Majority (66.9%, n=83) of the participants were very likely to pay for a low-cost water testing service.

Table 3.1: Socio-demographic data of study participants

Variables	Frequency	Percent
Local Government		
Egor	24	19.2
Ikpoba Okha	22	17.6
Oredo	26	10.8
Orhiomwon	24	19.2
Ovia-northeast	29	23.2
Marital Status		
Single	88	70.4
Married	37	29.6
Educational level		
None	2	1.6
Primary	5	4.0
Secondary	22	17.6
Tertiary	96	76.8
Occupation		
Government employee	7	5.6
Private employee	55	44.0
Self employed	47	37.6
Unemployed	16	12.8
Number of persons in home		
Less than three	48	38.4
Three to six	49	39.2
Seven to twelve	22	17.6
Greater than twelve	6	4.8

Table 3.2: Participants responses on Water Consumption and Usage

Variables	Frequency	Percent
How often do you consume water daily?		
<3 times	5	4.0
3 – 5 times	68	54.4
6 – 10 times	38	30.4
>10 times	14	11.2
How often do you drink water from sources other than your home?		
Daily	65	52.0
Occasionally	37	29.6
Rarely	21	16.8
Never	2	1.6
How do you store your drinking water at home?		
In a covered container	44	35.2
In an uncovered container	4	3.2
In a refrigerator	62	49.6
Others	15	12.0
What is the source of your drinking water?		
Borehole	26	20.8
Water dispenser	5	4.0
Sachet water	83	66.4
Bottle water	11	8.8
What is the source of your cooking water		
Borehole	121	96.8
Water dispenser	1	0.8
Sachet water	1	0.8
Water board	2	1.6

Table 3.3: Perception of participants on water quality.

Variables	Frequency	Percent
Ever had your home water tested for purity?		
Yes	20	16.0
No	105	84.0
If yes, what method did you use to test the water?		
Chemical test	18	90.0
Laboratory test	2	10.0
Have you ever received any education or training on water purification?		
Yes	87	69.6
No	38	30.4
If yes, where did you receive the education or training?		
At work	5	5.7
In school	63	72.4
In a seminar	15	17.2
How important is it to you that your water is free from contamination?		
Extremely important	105	84.0
Somewhat important	18	14.4
Not very important	2	1.6
How do you currently ensure that the water you drink is safe?		
I rely on water utility company to ensure the safety of the water supply	43	34.4
I use a home water filter	19	15.2
I purchase bottled water	37	29.6
I do not take any specific precautions	26	20.8
What would motivate you to test your home's water purity?		
Concern about the quality of the local water supply	53	42.4
News of water contamination in the area	54	34.2
A government or community initiative to encourage water treating	26	20.8
Health threat related to contaminated water	49	39.2

Table 3.4: Perception of Participants on Water Purification.

Variables	Frequency	Percent
How frequently do you believe you should test your home's water purity?		
Once a year	13	10.4
Every 3 – 6 months	82	65.6
Only when there is a specific concern or event	12	9.6
Not sure	18	14.4
How often is your tank washed?		
Every 3 months or less	19	15.2
Every 6 months	30	24.0
Yearly	42	33.6
>yearly	34	27.2
Do you use water treatment method at home?		
Yes	48	38.4
No	77	61.6
If yes, what treatment do you use (n=48)?		
Boiling	28	58.3
Use of chlorine	8	16.7
Filtration	11	22.9
None	1	2.1
How long does your water treatment process take?		
<10 minutes	13	27.0
30 minutes	22	45.8
1 hour	8	16.7
>1 hour	5	10.4
How much do you spend on accessing drinking water daily?		
<1000 naira	58	46.4
1000 – 3000 naira	45	36.0
3000 – 6000 naira	13	10.4
>6000 naira	7	5.6

Table 3.5 Participant's Responses on Water Contaminants

Variables	Frequency	Percent
What do you think are common contaminant of borehole water?		
Lead	66	52.8
Chlorine	41	32.8
Mercury	26	20.8
Pesticides/herbicides	42	33.6
Others	8	6.4
What type of contaminants do you think are most in your water supply?		
Bacteria	89	71.2
Chemicals	52	41.6
Heavy metals	50	40.0
Pesticides	21	16.8
Others	1	0.8
What are the likely diseases you think can be gotten from unpurified water?		
Malaria	7	5.6
Thyphoid	104	83.2
Diarrhoea	75	40.0
Cholera	88	70.4
Which of these illnesses do you think you had from drinking water?		
Malaria	18	14.4
Typhoid	63	50.4
Diarrhoea	26	20.8
Cholera	6	4.5

Table 3.6: Participant Response on Water Treatment Services

Variables	Frequency	Percent
How concerned are you in ensuring purity of the water your drink?		
Very concerned	50	40.0
Somewhat concerned	40	32.0
Not very concerned	31	24.8
Not at all concerned	4	3.2
Do you think water purification methods are expensive?		
Yes	63	50.4
No	62	49.6
How likely are you to pay for a low-cost water testing?		
Very likely	83	66.4
Somewhat likely	24	19.2
Not very likely	12	9.6
Not at all likely	6	4.8
Are you aware of any local resources or services that provide water purity testing?		
Yes	15	12.0
No	110	88.0
Have you ever tested your water quality in your home?		
Yes	20	16.0
No	105	84.0
If yes, how frequent (n=20)		
Frequently	4	20.0
3 months interval	3	15.0
6 months interval	6	30.0

Yearly	7	35.0

CHAPTER FOUR

DISCUSSION

The present study sought to assess water purification, quality and treatments among individuals and families in Benin City. The socio-demographic finding indicated that most homes in Edo are made up of large number of persons.

On water usage and consumption, 54.4% (n=68) said they consumed water three to five times daily. On drinking of water outside home source, more than half of the participants that is 52.0% (n=65) drink water outside their homes daily. This finding could have been due to the reason that water being an essential need may be required at any time. Also most persons do not spend time in their homes as much as they do outside their homes such as work place, school, church, and even recreation. Therefore, when need for water arises, it becomes easy to get water from sources outside the home. In addition, concerning the storage of drinking water at home, 49.6% (n=62) of the study participants store their drinking water in a refrigerator while 35.2% (n=44) store there drinking water in a covered container. This finding shows a good drinking water storage attitude among dwellers in Edo. Storage of water in an uncovered container as represented by the small fraction of the sample under study may be due to reasons of locality, and economic reasons resulting in lack of refrigerator in these homes for storage of water. Care free attitude towards health and lack of proper education may also contribute to poor drinking water storage habit. The existence of bacteria in the storage containers and tanks water could pose a health risk to individuals who consume it (Adeleye et al 2022)

It has also been demonstrated in several recent research that storing water in containers made of metals such as copper, gold, silver, etc. causes the metals to leach into the water, improving its quality. Similar to how using metal and earthenware containers to store water can be advantageous for all living things, using plastics can be shown to be harmful to health on the other hand. It has been established that plastic and other metals can become poisonous and detrimental to the body if they leak more than the WHO-set limit. (Das et al 2021)

Majority of respondents reported that sachet water was their source of drinking water. Sachet water topped the list of sources of drinking water because sachet water is easily accessible and cheap to afford. Sachet water is often assumed to be treated. Sachet water is frequently referred to as "pure water" in layman's terms because of the misconception that the packaged water in sachets is completely clean and free of physicochemical and microbiological pollutants. (Omobolaji et al 2020)

Like many developing nations, Nigeria does not have an adequate supply of safe drinking water. Many people believe that the introduction of sachet water will solve the issue. This is due to the fact that a litter or more of it can be purchased for ten Naira or even less. Despite concerns being raised about its purity and potential toxicity, sachet water is a preferred option for the majority of people due to its accessibility and price. (Sani et al 2022)

Borehole water is however not left out since it is a common source of water in both rural and urban areas. Water dispenser was least patronised perhaps for reasons of cost and unstable electricity supply. On the flip side, borehole water was the most used source of cooking water among study participants. This could be due to the reason that using sachet water to cook would be less economical and one would get more volumes of water from a borehole which are commonly sunk in homes of individuals. Using borehole water to cook may also be based on the belief that boiling water will kill germs and reduce the risk of water contamination. A key tactic to raise water quality is to keep it free of contamination at the source and point of use. However, it's possible that rural communities won't implement water safety measures at the source and point of consumption. (Gizaw et al 2022)

On respondents response to water quality awareness, 16.0% (n=20) have had their home water tested for purity in the past. This reflects poor water testing practice by the participants under study. This may be due to poor awareness, accessibility of testing materials and experts and cost of test. The methods employed by participants for home water testing were predominantly chemical (90.0%) and laboratory (10.0%) tests. 69.6% (n=87) said they had received education and training in the past while 30.4% (n=38) did not. Sources of education and training included work, schools and seminars, with school taking the highest quota. Although the education and training on water purification was considerably high, the practice of water purification was however poor. One hundred and five participants that is 84.0% (n=105) indicated that it was extremely important to them that the water they drink is free from contamination. This finding suggest that the participants have good knowledge on water contamination and the possible effect it may have on their health, hence the high insistence on purity of drinking water. Also 34.4% (n=43) relied on water utility companies to ensure safety of water supply, while 15.2% (n=19) used home water filer to ensure that their drinking water is safe. 29.6% (n=37) by way of ensuring water safety purchase bottled water. The reliance on utility companies may be due to expectations, and cost consideration in ensuring water safety. 42.4% (n=53) had concerns on the quality of the local eater supply hence would be motivated to test their home water purity. News of water contamination accounting for 34.2% (n=54) would serve as a motivating factor to participants to test for their home's water purity. Fear of danger as a form of psychological mechanism may often serve as a driver of motivation towards actions, and in which case the course of action are usually preventive in nature. Health threat related to water contamination was also identified as one of the motivating factors that would drive participants to test for their home's water purity. Government and community initiatives are also among possible motivators. Humans are more likely to be motivated when they are supported than when they are not. Furthermore, concerning water purification measures/treatment, only 9.6% (n=12) believe that home water should be tested for purity when the need arises. While 14.4% (n=18) of the study participants were not sure, 76.0% (n=95) believed that water purity test should be carried out at least once a year. The survey findings suggest that while a significant portion of respondents advocate for annual water purity testing, there is a lack of consensus on the need for spontaneous testing when issues arise. This may indicate a gap in understanding the potential risks associated with intermittent water quality changes. Furthermore, the high levels of awareness regarding diseases like typhoid and cholera linked to unpurified water underscore the importance of education and awareness campaigns focusing on waterborne diseases and prevention measures. However, the misconception that malaria can result from unpurified water should be addressed through targeted health education efforts. In addition, 38.4% (n=48) of the study participants used water purification method at home, and some employed methods included boiling, use of chlorine, and filtration, with boiling being the most used method of water purification.

In Benin, the treatment is either carried out at the central source, that is, tanks or point of use site via chlorination, boiling and filtration. Boiling, as the most commonly used method, offers a reliable way to ensure safe drinking water. However, it may not be the most practical option for everyone due to energy requirements. Chlorine use and filtration are viable alternatives, with chlorine offering a convenient and effective method for disinfection, especially in areas with limited resources. In Chlorination, the user adds a measured quantity of sodium hypochlorite solution to the bottle or can of water gotten from the source and it is Shaked and a 30 minutes wait time is allowed before drinking. The disadvantage of this method is the risk of overdose which can cause kidney disorders and cancer if consumed at a high amount over a long period of time. (Natasha et al 2019).

Filtration, while beneficial for removing visible impurities, may require careful selection of appropriate filters to address specific water quality issues comprehensively.

On participant's responses on water contamination, sixty-three participants, that is, 50.4% (n=63) indicated that they had suffered typhoid due to unpurified water, while 20.8% (n=26) attributed it to diarrhoea.

The high prevalence of typhoid and diarrhoea cases attributed to unpurified water underscores the urgent need for improved water quality and purification practices. Household water purification methods play a crucial role in preventing waterborne diseases.

Bacterial illnesses like cholera, typhoid, and diarrhoea, protozoal illnesses like amoebiasis, and viral illnesses like retroviruses, hepatitis A, hepatitis E, and polio infections are among the common water-borne illnesses. Generally speaking, 1.8 million people every year pass away from waterborne illnesses like cholera, typhoid, UTIs, schistosomiasis, and other diarrheal illnesses. Waterborne diarrhoea, however, continues to be a major source of illness and death in children in underdeveloped countries, with 90% of diarrhoea fatalities happening in children under the age of five. By 2025, three billion people are projected to be under water stress because of a lack of access to clean water. (Shayo et al 2023)

Lead, chorine, mercury, pesticides/herbicides were some of the identified common contaminants of borehole water. Lead happened to be the most familiar while mercury was least. Lead in drinking water poses health risks, especially to children, with cognitive and behavioural effects. It also impacts the environment, incurs costs, and requires stringent regulation. Bacteria, was also identified as one of the leading contaminants of water supply which can cause diseases such as cholera, salmonellosis, *E. coli* infections, and more, leading to gastrointestinal issues, fever, and in severe cases, life-threatening conditions. Water safety is critical. While chemicals and heavy metals were also identified. This is evident in developing countries like Pakistan.

Due to Pakistan's excessive use of herbicides, insecticides, and fertilizers, water contamination is becoming an increasingly serious problem. The majority of Pakistan's population does not have access to clean, safe drinking water due to the presence of various types of pollutants, including pathogens, suspended solids, nutrients and agricultural pollutants, thermal, radioactive, and other pollutants. (Yasmeen et al 2023)

More than 1 billion people lack access to clean water, and over 2 billion people lack access to adequate sanitation and hygiene practices, according to UNICEF reports from 2015. In Nigeria, more than 100 million people lack access to better sanitation, and over 66 million people lack access to portable water. Water-related illnesses are the world's biggest cause of sickness and mortality, accounting for more than 3.4 million deaths per year (WHO, 2015). Nigeria spent 2.5 billion dollars on treating deaths from water-borne infections, whereas 191 million dollars were spent on treating diarrhoea. Similar to this, roughly half of patients receiving care at health facilities in Lagos State have conditions related to water. (Aminu and Folasade. 2023)

The survey findings underscore the varying levels of public awareness regarding common contaminants in borehole water. While lead and chlorine were recognized by a significant portion of participants, the lower familiarity with mercury suggests a need for targeted education and information dissemination. The recognition of bacteria as a leading contaminant reflects concerns about microbial water quality, emphasizing the importance of proper water treatment and disinfection. Additionally, the identification of chemicals and heavy metals as common contaminants highlights the multifaceted nature of water quality challenges and the need for comprehensive monitoring and mitigation strategies.

4.1 LIMITATION OF STUDY

Restricted Time: Carrying out a thorough investigation under a time limit may limit the breadth and depth of data collecting and analysis. Seasonal fluctuations or long-term trends in water quality and contaminants may not have been captured by the research.

Sample Size and Representativeness: Due to time and resource limitations, the sample size may be small, which may limit the generalizability of the results to Benin City's total population.

Data Collecting Bias: Relying on self-reporting through surveys and questionnaires may lead to response bias, in which individuals may give information that is inaccurately recalled or may not be socially acceptable.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The study revealed that more than half of the respondents obtained water from outside their homes, and sachet water was the primary source for most participants. While there was generally a positive attitude toward safe drinking water storage, a small fraction stored water in uncovered containers. Poor water testing practices were observed, with chemical tests being the dominant method. The study highlighted a consensus on the importance of annual water purity assessments, but a gap in understanding the necessity of periodic testing for emerging water concerns. Typhoid and cholera awareness was high, but misconceptions about malaria required targeted health education efforts. Many participants used water purification methods at home, with boiling being the most common. Concerns about water purity and willingness to invest in low-cost water testing services indicated poor engagement by participants, but perceived cost barriers must be addressed through affordable and accessible purification options and public awareness campaigns.

5.2 RECOMMENDATION

Based on the study, the following recommendations were made:

1. Government can offer free/subsidized water purification service to individuals to enable them know the purity status of their water regularly.
2. NGOs and pharmacists can play a role in providing educational and awareness campaigns geared towards sensitizing the public on the importance of accessing pure water and methods.
3. Since some known purification methods such as boiling, filtration e.t.c do not guarantee complete purity of water due to its inability to remove heavy metals , a better innovative method which is 7-step Ultra-filtration process should be introduced to the public
4. Private management of water treatment system with well-equipped labs for testing water should be encouraged.

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THE OBJECTIVE OF THIS STUDY IS TO ACCESS THE KNOWLEDGE AND LEVEL OF AWARENESS OF WATER PURITY AMONG INDIVIDUALS AND FAMILIES IN BENIN CITY THIS IS STRICTLY FOR RESEARCH USE AND WILL NOT BE USED FOR ANY OTHER PURPOSE

Personal Information

1. Marital Status -a. Single b. Married c. Divorced

2. What is your highest level of education? -a. None b. Primary c. Secondary d. Tertiary

3. Occupation:- a. Govt Employee b. Private Employee c. Self Employed d. Housewife

4. How many persons live in your home?- a. <3 b. 3-6 c. 7-12 d. >12

Water Usage

5. How often do you consume water daily? - a.< 3 times b. 3-5 times c.6-10 times d.>10 times

6. How often do you drink water from sources other than your home? - a. Daily b. Occasionally c. Rarely d. Never

7. How do you store your drinking water at home? - a. In a covered container b. In an uncovered container c. In a refrigerator d. Others(please specify)__________

8. What is the source of your drinking water? - a. borehole(tap water) b. water dispensers c. sachet water d. bottle water e. rain water f. water board

9. What is the source of your cooking water? - a. borehole(tap water) b. water dispensers c. sachet water d. bottle water e. rain water f. water board

10. If you use bottled water please, specify brand:____________

Water Quality Awareness

11. Have you ever had your home's water tested for purity? - a. Yes b. No

12. If Yes, what method did you use to test the water purity? - a. Chemical test kit b. Laboratory testing c. Others (please specify)__________

13. Have you ever received any education or training on water purification or water borne diseases? - a. Yes b. No

14. If Yes, where did you receive this education or training? - a. At Work b. In School c. In a seminar d. Others (please specify)__________

15. How important is it to you that the water you drink is free from contaminants? - a. Extremely important b. Somewhat important c. Not very important d. Not at all important

16. What types of contaminants do you think are most concerning in your water supply? (select all that apply) - a. Bacteria b. Chemicals c. Heavy metals d. Pesticides e. Other (please specify)

17. How do you currently ensure that the water you drink is safe?- a. I rely on the water utility company to ensure the safety of the water supply b. I use a home water filter c. I purchase bottled water d. I do not take any specific precautions

18. What would motivate you to test your home's water purity? (select all that applies) - a. Concerns about the quality of the local water supply b. News of water contamination in the area c. A government or community initiative to encourage water testing d. A health threat related to contaminated water e. Other (please specify)

19. How frequently do you believe you should test your home's water purity? - a. Once a year b. Every 3-6 months c. Only when there is a specific concern or event d. I'm not sure

20. How often is your tank washed? - a. every 3 months or less b. every 6 months c. yearly d. >yearly

21. What are the likely diseases you think can be gotten from unpurified water? (select all that applies) - a. Malaria b. Typhoid c. diarrhoea d. cholera

22. Which of these above illnesses have you had? ________________________

23. Do you use any water treatment method at home? - a.Yes b.No

24. If yes, What water treatment do you use in your home? - a. Boiling b. use of chlorine c. filtration d. none

25. How long does your water treatment process take ? - a. <10 mins b. 30mins c. 1hour d. >1hour

26. How much do you spend on accessing drinking water weekly? - a. <1000 naira b. 1000-3000 naira c. 3000-6000 naira d. >6000 naira

27. Are you aware of any local resources or services that provide water purity testing? - a. Yes b. No

28. If Yes, what's the name of the service provider: _____________

29. Have you ever tested your water quality in your home? - a. Yes b. No

30. If Yes, how frequently? ____________________

31. What do you think are common contaminants in borehole water? (select all that applies) - a.Lead b.Chlorine c.Mercury d.Pesticides/herbicides e.Others. Specify______________

32. How likely are you to pay for a low-cost water testing? - a. Very likely b. Somewhat likely c. Not very likely d. Not at all likely

33. Do you think water purification methods are expensive? - a. Yes b. No

34. How confident are you in your ability to ensure the purity of the water you drink? - a. Very confident b. Somewhat confident c. Not very confident d. Not at all confident

35. Do you have any other comments or concerns related to water purity in your area?

____

Thank you for your participation in this survey! Your responses will help us better understand the community's concerns and develop initiatives to promote safe and clean drinking water.

ETHICAL APPROVAL: Ethical approval will be obtained from the Ministry of Health. Written and informed consent will be obtained from the participants of the water purity campaign.