QUALITY ANALYSIS OF COMMERCIALLY AVAILABLE SACHET WATER IN BENIN CITY, EDO STATE, NIGERIA

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AUGUST, 2023.

CERTIFICATION

This is to certify that this work was carried out by OBAZEE, UYI MAT. NO: ENG1704042, of The Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo state, Nigeria.

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DEDICATION

This project is dedicated to God almighty, and my parents, MR AND MRS PAUL AND RACHAEL OBAZEE, whose unwavering support, love, and encouragement have been my guiding light throughout this academic journey. Your belief in me has been my greatest source of strength.

In loving memory of my late elder Brother, Mr. Nelson Ehisiemen Obazee, whose enduring influence continues to inspire me.

I also dedicate this work to my lecturers, professors and mentors, whose knowledge and guidance have shaped my understanding and inspired my pursuit of excellence.

To my friends and family, thank you for your patience, understanding, and encouragement during this endeavour. Your belief in me never wavered.

Finally, this project is dedicated to the people of Benin City, whose reliance on sachet water for their daily needs underscores the importance of this study. May the results of this research contribute to the well-being and health of this community.

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Lastly, I would like to express my gratitude to those whose names may not appear here but who, in their own ways, contributed to the realization of this project.

ABSTRACT

This study conducts a comprehensive quality analysis of sachet water from multiple companies operating in Benin City, Nigeria. Sachet water, commonly referred to as "pure water," constitutes a primary source of affordable drinking water for a significant portion of the city's population. The research aims to assess the physical, chemical, and microbiological properties of these products to provide critical insights into their safety and quality.

The analysis encompasses a rigorous evaluation of the physical characteristics, including colour, odour, and turbidity, as well as an in-depth examination of chemical properties such as pH, total dissolved solids (TDS), and specific ions influencing taste and safety. Furthermore, the microbiological quality is assessed by investigating the presence of coliform bacteria and potential pathogens.

Comparative analyses are conducted to discern variations or discrepancies in sachet water quality among different companies. Recommendations based on the findings are provided, which can be utilized by regulatory authorities and sachet water producers to enhance the quality and safety of these products.

This study bears significant implications for public health, as sachet water serves as a vital source of drinking water for many residents of Benin City. Additionally, it empowers consumers with essential information for making informed choices regarding their water source. The findings also contribute to regulatory improvements, thereby benefiting both consumers and producers in the sachet water industry.

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ACRONYMS

WHO: WORLD HEALTH ORGANISATION

NAFDAC: National Agency for Food and Drug Administration and Control

NSDWQ: Nigeria Standard for Water Quality

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Sachet water, also known as "pure water" in many parts of Nigeria, is a popular and affordable source of drinking water for millions of people. Ensuring the quality and safety of sachet water is essential for public health (*Human Rights to Water and Sanitation | UN-Water*, n.d.). This project aims to conduct a comprehensive quality analysis of sachet water from various sachet water companies operating in Benin City, Nigeria. The study will assess the physical, chemical, and microbiological properties of these products to provide valuable insights into their safety and quality.

Access to clean and safe drinking water is a fundamental human right and a critical factor in public health (Dodoo et al., 2006). In many regions around the world, including Benin City, Nigeria, sachet water has emerged as a primary source of affordable drinking water for millions of people. Commonly referred to as "pure water," sachet water is often preferred due to its convenience, low cost, and accessibility, especially in areas where access to clean piped water is limited. However, the safety and quality of sachet water can vary significantly among different producers, posing potential risks to consumers.

The production and distribution of sachet water in Benin City, like in many other parts of Nigeria, have seen tremendous growth in recent years (Adekunle & Dakare, 2020). While this growth has undoubtedly helped meet the demand for potable water, it has also raised concerns about the quality and safety of the product. Contaminated or subpar sachet water can lead to various health issues, including waterborne diseases, making it imperative to

conduct a thorough quality analysis of sachet water from the various companies operating in the city (Omole et al., 2015).

The sachet water industry in Benin City operates under the regulatory framework provided by the National Agency for Food and Drug Administration and Control (NAFDAC) and other relevant agencies (*(PDF) Quality Assessment of Sachet Water in Nigeria*, n.d.). These regulations set forth guidelines for production, labelling, and quality control to ensure that sachet water meets established safety standards. However, challenges such as inadequate oversight, limited resources for monitoring, and the rapid growth of the industry have made it essential to carry out independent assessments of sachet water quality (Awuah et al., 2014).

1.2 STATEMENT OF PROBLEM

This project's rationale is multifaceted. First and foremost, ensuring that sachet water is safe for consumption is a matter of public health. Benin City's population relies on this source of water for daily hydration, cooking, and other domestic purposes. Any compromise in quality can lead to a range of waterborne diseases, affecting individuals and communities.

Additionally, the economic significance of the sachet water industry cannot be understated. Numerous sachet water companies provide employment opportunities and contribute to the local economy. Therefore, it is in the interest of both consumers and producers to guarantee that sachet water products meet high-quality standards. Maintaining trust in the product's safety and quality is crucial for the industry's sustainability and reputation.

In summary, this project is driven by the urgent need to ensure that sachet water, a lifeline for many residents of Benin City, meets the highest standards of quality and safety. Through rigorous analysis and evidence-based recommendations, we aim to contribute to the well-being and health of the local population while promoting the sustainability of the sachet water industry.

1.3 AIM AND OBJECTIVES

The aim of this project is to conduct a comprehensive quality analysis of sachet water from various sachet water companies operating in Benin City, Nigeria, with the goal of ensuring the safety, reliability, and consistency of this vital source of drinking water for the local population.

This project's primary objectives are as follows:

1. To rigorously evaluate the physical characteristics of sachet water, including assessing its colour, odour, and turbidity.
2. To conduct a comprehensive analysis of the chemical properties of sachet water, with a particular focus on parameters such as pH, total dissolved solids (TDS), and specific ions that influence taste and safety.
3. To assess the microbiological quality of sachet water by examining the presence of coliform bacteria and potential pathogens.
4. To compare and contrast the quality of sachet water products from various companies, identifying any significant variations or discrepancies.
5. To provide well-informed recommendations for enhancing the quality and safety of sachet water, which can be utilized by regulatory authorities and sachet water producers alike.

1.4 SCOPE OF THE STUDY

1. **Public Health and Safety:** Sachet water is a primary source of drinking water for many residents of Benin City. Ensuring its quality and safety is paramount for public health. By conducting a rigorous analysis, this study will provide critical information that can help prevent waterborne diseases and improve the overall well-being of the population.

2. **Consumer Empowerment:** Access to reliable information about the quality of sachet water products empowers consumers to make informed choices. This study will equip consumers with the knowledge needed to select safe and high-quality sachet water products, safeguarding their health and finances.
3. **Regulatory Improvement:** Findings from this research can inform regulatory agencies like NAFDAC and local health authorities about the state of the sachet water industry. This information can drive regulatory improvements, including enhanced monitoring and enforcement, ultimately benefiting both consumers and producers.
4. **Industry Reputation and Sustainability:** Maintaining the reputation of the sachet water industry is essential for its continued growth and sustainability. A positive outcome from this study will help build trust in sachet water products, benefiting the industry as a whole.
5. **Employment and Economic Impact:** Many sachet water companies provide employment opportunities within Benin City. By ensuring the quality of their products, this study indirectly contributes to employment stability and economic growth in the region.
6. **Research and Knowledge:** This study adds to the body of knowledge regarding sachet water quality analysis, potentially serving as a reference for future research in similar contexts and providing insights into broader water quality issues in developing urban areas.
7. **Community Resilience:** Access to safe drinking water is a fundamental aspect of community resilience. By improving the quality of sachet water, this study enhances the community's ability to withstand and recover from water-related challenges, including emergencies and contamination incidents.

In summary, the significance of this study lies in its potential to safeguard public health, empower consumers, drive regulatory improvements, support the sachet water industry, and contribute to the overall well-being and resilience of the community in Benin City.

1.5 JUSTIFICATION OF STUDY

The study's justification lies in its potential to address critical concerns related to the safety of sachet water and protect public health. With sachet water serving as a primary source of drinking water for many in Benin City, ensuring its safety is paramount to reducing waterborne diseases and improving the overall health of the community. This research also plays a pivotal role in protecting consumer interests, providing valuable information to empower consumers in making informed choices, ultimately safeguarding their health and financial well-being.

Furthermore, the study informs regulatory enhancements by offering essential data that can improve oversight and enforcement of quality standards within the sachet water industry. Beyond regulatory benefits, the study supports the local economy by ensuring high-quality sachet water products, contributing to the industry's reputation, preserving jobs, and promoting economic stability within the region.

In addition to its immediate impacts, this study advances scientific knowledge by adding to our understanding of water quality issues in urban areas, serving as a reference for future research in similar contexts. Lastly, the study enhances community resilience by strengthening the community's capacity to withstand and recover from water-related challenges, contributing to the overall resilience of Benin City.

CHAPTER TWO

LITERATURE REVIEW

2.1 PREAMBLE

Sachet water, colloquially known as "pure water" in Nigeria, has become an integral component of daily life for millions of urban and peri-urban residents, including those in Benin City. It serves as a readily accessible and economical source of drinking water. However, the expansion of the sachet water industry has brought into question the quality and safety of this vital resource. This literature review offers an extensive exploration of key facets and challenges associated with sachet water quality analysis and regulatory frameworks. It also explores the diverse forms of commercial drinking water available in Benin City, Nigeria. Understanding these variations is pivotal to comprehending the competitive landscape and the range of options consumers have in accessing safe drinking water (Hutton & Chase, 2017). We studied the types, characteristics, and implications of these commercial drinking water sources.

2.2 SACHET WATER CONSUMPTION IN NIGERIA

The consumption of sachet water in Nigeria has witnessed exponential growth over the years, largely attributed to urbanization, population surges, and the persistent inadequacy of piped water infrastructure. A study conducted by (Brown et al., 2013) highlighted the surging reliance on sachet water and its paramount role in mitigating the challenges posed by limited access to clean water, especially in urban locales.

2.3 QUALITY ASSESSMENT PARAMETERS

No.	Types of water quality parameters		
	Physical parameters	Chemical parameters	Biological parameters
1	Turbidity	pH	Bacteria
2	Temperature	Acidity	Algae
3	Color	Alkalinity	Viruses
4	Taste and odor	Chloride	Protozoa
5	Solids	Chlorine residual	
6	Electrical conductivity (EC)	Sulfate	
7		Nitrogen	
8		Fluoride	
9		Iron and manganese	
10		Copper and zinc	
11		Hardness	
12		Dissolved oxygen	
13		Biochemical oxygen demand (BOD)	
14		Chemical oxygen demand (COD)	
15		Toxic inorganic substances	
16		Toxic organic substances	
17		Radioactive substances	

Table 2.1 Water Quality Parameters

Compound	Guideline value
Arsenic	0.01 mg/l (10 µg/l) The guideline value is designated as provisional on the basis of treatment performance and analytical achievability. Arsenic is usually present in natural waters at concentrations of less

	than 1–2 µg/l. However, in waters, particularly groundwaters, where there are sulfide mineral deposits and sedimentary deposits deriving from volcanic rocks, the concentrations can be significantly elevated. Signs of chronic arsenicism, including dermal lesions, such as hyperpigmentation and hypopigmentation, peripheral neuropathy, skin cancer, bladder and lung cancers and peripheral vascular disease, have been observed in populations ingesting arsenic-contaminated drinking-water. For local non-piped water supplies, the first option for control is often substitution by, or dilution with, microbially safe low-arsenic sources. It may also be appropriate to use alternative sources for drinking and cooking but to use the contaminated sources for purposes such as washing and laundry.
Fluoride	1.5 mg/l (1500 µg/l) Traces of fluorides are present in many waters, with higher concentrations often associated with groundwaters. Skeletal fluorosis (with adverse changes in bone structure) may be observed when drinking-water contains 3–6 mg/l fluoride, particularly with high water consumption. Crippling skeletal fluorosis usually develops only where drinking-water contains over 10 mg/l. The risk of dental fluorosis will depend on the total intake of fluoride from all sources and not just the concentration in drinking-water. A management guidance document on fluoride is available. In some countries, fluoride may also be added to drinkingwater in order to provide protection against dental caries, such that final concentrations are usually between 0.5 and 1 mg/l.

Nitrate	50 mg/l (50 000 µg/l) Methaemoglobinaemia has most frequently been associated with private wells. The most appropriate means of controlling nitrate concentrations, particularly in groundwater, is the prevention of contamination. This may take the form of appropriate management of agricultural practices, the careful siting of pit latrines and septic tanks, sewer leakage control, as well as management of fertilizer and manure application and storage of animal manures. It may also take the form of denitrification of wastewater effluents.

Table 2.2 WHO guideline values for drinking-water quality: chemical contaminants

Parameter	Unit	Maximum Permitted Levels	Health Impact	Note
Detergents	mg/L	0.01	Possibly carcinogenic	
Mineral oil	mg/L	0.003	Possibly carcinogenic	
Pesticides	mg/L	0.01	Possibly carcinogenic	
Phenols	mg/L	0.001	Possibly carcinogenic	
Poly Aromatic Hydrocarbons	mg/L	0.007	Possibly carcinogenic	
Total Organic Carbon or Oxidisability	mg/L	5	Carcinogenic	

Table 2.3 Organic Constituents

2.3.1 Physical Characteristics

Physical characteristics, encompassing attributes such as colour, odour, and turbidity, serve as initial indicators of water quality (Azevedo de Melo et al., 2021). Among these, turbidity holds particular significance as it signifies the presence of suspended particles and sediments,

which may indicate contamination. (Srivastava et al., 2022) underlined the critical nature of turbidity as a primary quality parameter in sachet water quality assessment.

Parameters	**Unit**	**Maximum Permitted Levels**	**Health Impact**
Colour	TCU	15	None
Odour	-	Unobjectionable	None
Taste	-	Unobjectionable	None
Temperature	Celsius	Ambient	None
Turbidity	NTU	5	None

Table 2.4 Physical/Organoleptic Parameters

2.3.2 Chemical Properties

Chemical properties, including pH and total dissolved solids (TDS), play a pivotal role in evaluating water quality. (Dangour et al., 2013) emphasized the significance of pH in the assessment of sachet water, as it influences both taste and safety. High TDS levels may indicate excessive mineral content or contamination (Johnson et al., 2016).

2.3.3 Microbiological Analysis

Microbiological analysis stands as an essential component in identifying the presence of coliform bacteria and pathogens, which pose significant health risks. A study carried out by (Meyer & Scribner, 2009) explored the microbiological quality of sachet water in Nigeria and underscored the importance of stringent monitoring to combat waterborne diseases.

2.4 REGULATORY FRAMEWORK

The National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria bears the responsibility for the regulation of sachet water production and quality. NAFDAC sets stringent standards and guidelines that span production practices, labelling, and quality control. (Gupta et al., 2021) delved into the role of regulatory bodies in ensuring the safety of sachet water and emphasized the necessity of continuous vigilance through monitoring and enforcement mechanisms.

2.5 CHALLENGES AND CONCERNS

Despite regulatory efforts, challenges persist in guaranteeing consistent sachet water quality. These challenges include inadequate oversight, limited resources for monitoring, and disparities in production practices among water companies. A study undertaken by (Stocks et al., 2014) identified these challenges and stressed the significance of independent quality assessments as a complementary measure to enhance regulatory endeavours.

2.6 SIMILAR STUDIES IN NIGERIA

Several studies have been conducted to assess sachet water quality in Nigeria, albeit with variations in findings, underscoring the need for comprehensive, context-specific analyses. (Taylor et al., 2015) carried out an investigation in Lagos, Nigeria, reporting disparities in sachet water quality across different brands, thus accentuating the importance of localized assessments.

2.7 FORMS OF COMMERCIAL DRINKING WATER IN BENIN CITY

2.7.1 Sachet Water

Sachet water, often referred to as "pure water" in Nigeria, is a widely consumed form of commercial drinking water. It is typically packaged in small, sealed plastic sachets, each

containing a specific volume of water (usually 500 mL or 1 liter) (Chow, 2004). These sachets are designed to provide a convenient and affordable source of potable water (Qu et al., 2019).

2.7.1.1 Characteristics

- **Affordability**: Sachet water is known for its affordability, making it accessible to a wide range of consumers, including those with limited financial means.
- **Convenience**: The small, portable sachets are easy to carry and can be purchased individually or in bulk.
- **Production Standards**: Regulatory agencies like the National Agency for Food and Drug Administration and Control (NAFDAC) set standards for sachet water production, including quality control measures (Adekunle & Dakare, 2020).

2.7.1.2 Challenges

Despite its popularity, sachet water faces challenges related to quality control, as discussed in Chapter One. The rapid growth of the industry has led to concerns about consistency in quality across different brands and companies.

2.7.2 Bottled Water

Bottled water is another prevalent form of commercial drinking water. It is available in various bottle sizes, typically made from PET plastic or glass. Bottled water is often marketed as a premium product, and it may include different types, such as purified, spring, or mineral water.

2.7.2.1 Characteristics

- **Variety**: Bottled water comes in various forms, including purified water that undergoes treatment processes, spring water sourced from natural springs, and mineral water with naturally occurring minerals.
- **Quality Assurance**: Bottled water companies often emphasize rigorous quality control measures and may provide detailed information about water source and treatment methods.
- **Packaging**: Bottled water is available in a range of bottle sizes, from small single-serving bottles to larger containers suitable for home and office use.

2.7.3 Water Dispensing Stations

Water dispensing stations are becoming increasingly popular in urban areas like Benin City. These stations provide a self-service option for consumers to fill their containers with purified or filtered water. They are typically equipped with multiple dispensing taps and may offer both hot and cold water options (*Types of Water Dispensers - Bottle and Bottleless - OPUS*, n.d.).

2.7.3.1 Characteristics

- **Economical**: Water dispensing stations offer a cost-effective alternative to purchasing bottled water, as consumers can refill their own containers.
- **Environmental Impact**: They contribute to reduced plastic waste by promoting reusable containers.
- **Quality Control**: Stations often incorporate advanced filtration systems to ensure water quality.

2.8 PREVIOUS RESEARCHER WORKS LITERATURE REVIEW

Research on water dispensing stations in the Nigerian context is limited. However, their emergence aligns with global trends toward reducing plastic waste and promoting eco-friendly water consumption (Addo et al., 2009). Several studies have examined the quality and safety of sachet water in Nigeria. (Mosi et al., 2018) conducted a microbiological assessment of sachet water in Owerri, emphasizing the need for stringent monitoring to prevent waterborne diseases. (Olaoye & Onilude, 2009) discussed the importance of pH in assessing sachet water quality, highlighting its influence on taste and safety.

Studies have explored the quality and safety of bottled water in Nigeria. (Stoler et al., 2015) conducted a quality assessment of bottled water in Lagos, highlighting variations in quality among different brands and the importance of localized assessments.

2.9 OTHER COMMERCIAL DRINKING WATER SOURCES

In addition to sachet water, bottled water, and water dispensing stations, other forms of commercial drinking water are also available in Benin City, including filtered water sold by vendors and commercial water purification systems used by some households and businesses.

CHAPTER THREE

METHODOLOGY

The methodology employed to conduct the quality analysis of sachet water from various sachet water companies operating in Benin City, with coordinates of 6.3350° N, 5.6037° E. The research design, sampling strategy, data collection techniques, and analytical methods are explained in this chapter.

3.1 RESEARCH DESIGN

3.1.1 Study Type

This research was primarily a cross-sectional study, designed to collect data at a specific point in time to assess the quality of sachet water samples from different companies in Benin City.

3.1.2 Data Collection Period

The data collection period for this study spanned over 1 month to account for temporal variations in water quality. Sampling occurred weekly, allowing for a comprehensive assessment of potential fluctuations.

3.2 SAMPLING STRATEGY

3.2.1 Random Sampling

A random sampling approach was employed to select sachet water samples from various sachet water companies in Benin City. This method ensures the samples are representative of the broader market and minimizes potential biases in the selection process.

3.2.2 Sample Size

The sample size was determined based on statistical considerations, including confidence levels and margin of error. A sufficient number of samples was collected to provide statistically significant results.

3.2.2.1 Procedure:

- Population:

All the sachet water companies were indicated as (Company A, Company B, Company C, Company D and Company E) in Benin City.

- Sample Size: 5 sachet water companies were randomly selected.
- Unique Identifiers Assigned:

1. Company A (Osesco)
2. Company B (Owen)
3. Company C (Phargates)
4. Company D (Big Joe)
5. Company E (Ivie)

- Random Number Generation:

Using a random number generator script with javascript programming language *(let companies = ["Company-A", "Company-B", "Company-C", "Company-D", "Company-E"];*

*function shuffle(array) {for (let i = array.length - 1; i > 0; i--) {const j = Math.floor(Math.random() * (i + 1)); [array[i], array[j]] = [array[j], array[i]];{return array;}*

let shuffledCompanies = shuffle(companies);for (let i = 0; i < shuffledCompanies.length; i++) {console.log(`Random Number ${i + 1}: ${i + 1} (${shuffledCompanies[i]})`);}), the following random numbers corresponding to the unique identifiers was obtained:

- Random Number 1: 3 (Company C)
- Random Number 2: 5 (Company E)
- Random Number 3: 1 (Company A)
- Random Number 4: 2 (Company B)
- Random Number 5: 4 (Company D)

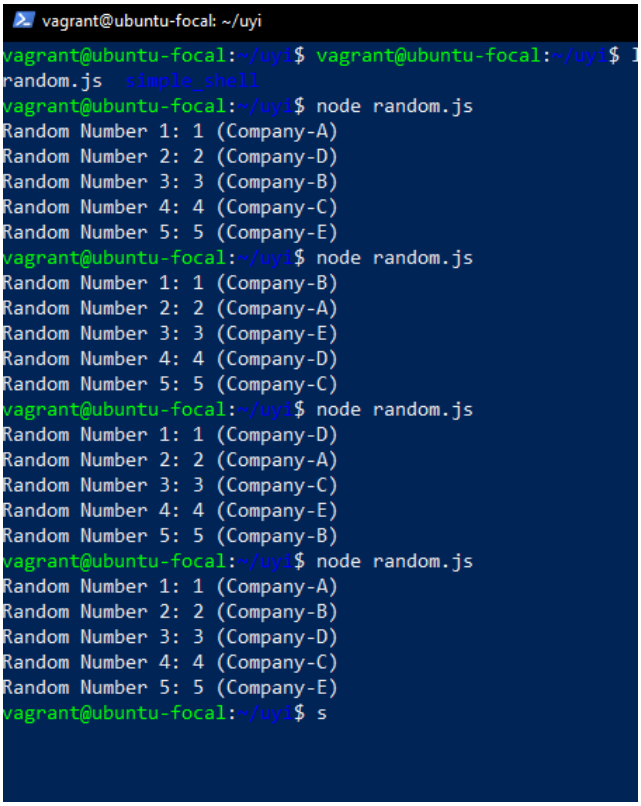

Figure 4.1 diagram of companies selected randomly using javascript being run on ubuntu terminal

- Selection of Random Samples:

  -Based on the random numbers generated, the sachet water companies that correspond to these numbers were selected.

- Selected Random Samples:

  1. Sample 1: Phargates
  2. Sample 2: Ivie
  3. Sample 3: Osesco
  4. Sample 4: Owen
  5. Sample 5: Big Joe

- Collecting Samples:

  -The selected sachet water samples were collected.

- Recording Sample Information:

  -As each sample was collected, important information, such as the date and time of collection, the specific location of the company, and any other relevant details was recorded.

- Data Analysis:

  -After collecting the samples, various analyses to assess the quality and safety of the sachet water from these five randomly selected companies was performed.

- Drawing Conclusions:

  -Based on the analysis results, conclusions about the quality and safety of sachet water from these five companies were drawn.

3.2.3 Temporal and Spatial Variation at Ikpoba Hill in Ikpoba-Okha L.G.A

To account for potential temporal and spatial variations in sachet water quality, samples were collected at different times and from various locations within Ikpoba Hill. This approach enhances the robustness of the study's findings.

Fig 3.1 Map of Nigeria

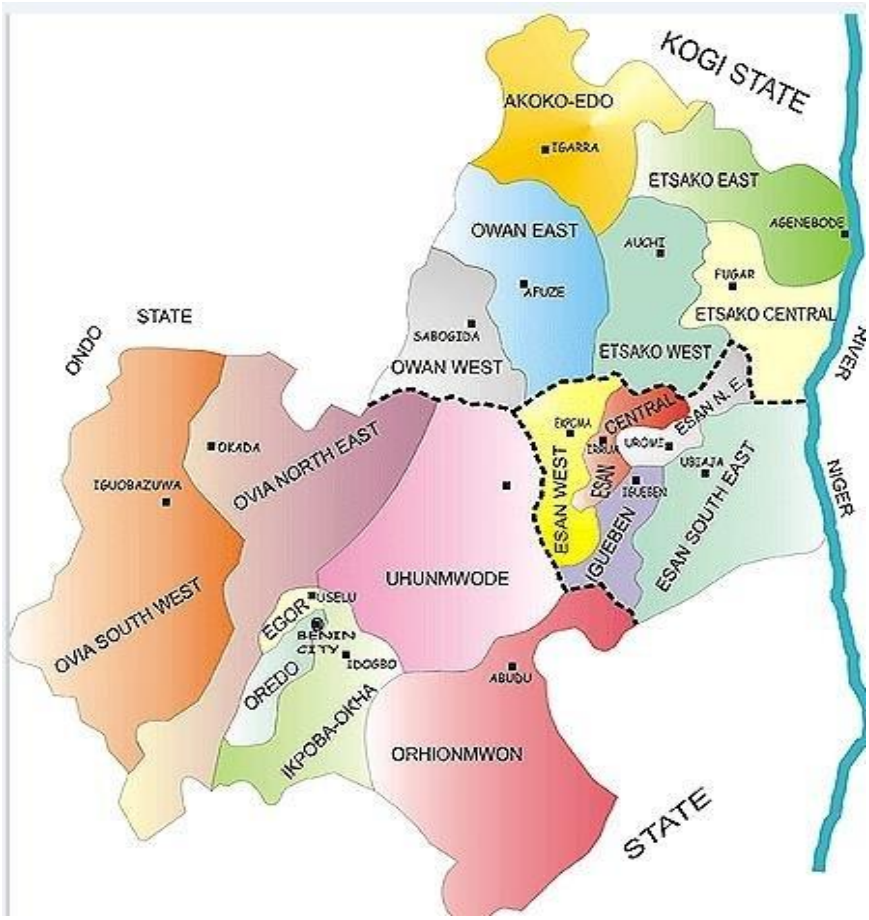

Fig 3.2 Map of Edo state showing the local government in Edo state

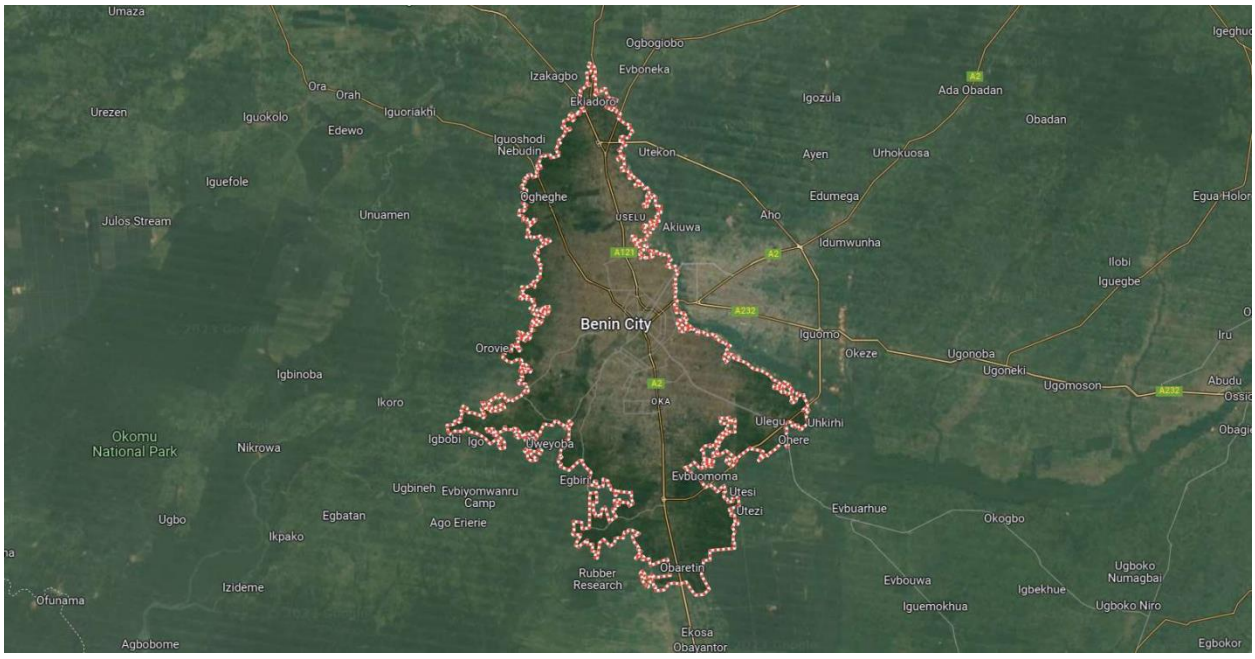

Fig 3.3 Satellite Imagery of Benin City

Fig 3.4 satellite imagery of Benin City-2

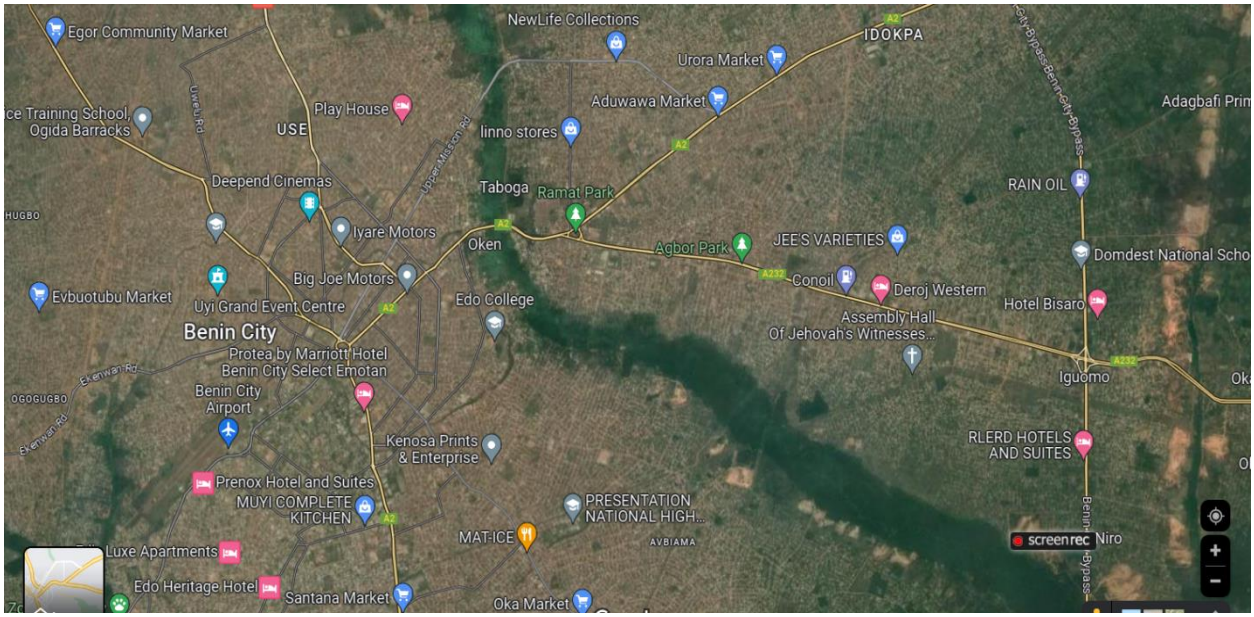

Fig 3.5 satellite imagery of Ikpoba hill, Benin city, Edo state

3.3 SAMPLE COLLECTION

3.3.1 Sample Containers

Sterilized, airtight containers were used to collect the sachet water samples. Each container was thoroughly rinsed with distilled water to prevent contamination.

3.3.2 Labelling

Each sample container was labelled with a unique identifier, indicating the company, location, date, and time of collection. This ensures traceability and prevents mix-up during analysis.

3.3.3 Transportation

Samples were transported in a temperature-controlled environment to the laboratory to maintain their integrity. Proper storage conditions were maintained throughout transportation.

3.4 DATA COLLECTION

3.4.1 Physical Characteristics Analysis

- Colour: The colour of each sachet water sample was visually assessed and compared to a standard colour chart.
- Odour: The samples were sniff-tested to detect any unusual or off-putting odours.
- Turbidity: Turbidity was measured using a turbidity meter, providing quantitative data on water clarity.

3.4.2 Chemical Properties Analysis

- pH Measurement: The pH level of each sample was determined using a calibrated pH meter.

- Total Dissolved Solids (TDS): TDS was measured using a TDS meter, quantifying the concentration of dissolved substances in the water.
- Ion Analysis: Specific ions such as calcium, magnesium, chloride, and others were quantified using appropriate chemical tests and analytical instruments in the laboratory.

3.4.3 Microbiological Analysis

- Coliform Bacteria: The presence of coliform bacteria, including Escherichia coli (E. coli), will be determined using the Most Probable Number (MPN) method.
- Pathogen Analysis: Additional microbiological tests were conducted to identify potential pathogens in the sachet water samples.

3.5 DATA ANALYSIS

3.5.1 Statistical Analysis

Statistical software was used to analyze the data collected. Descriptive statistics, including means, standard deviations, and ranges, was calculated to summarize the results.

3.5.2 Comparison

The quality of sachet water from different companies was compared, and any significant variations or trends was identified and discussed. Statistical tests may be employed to assess the significance of differences.

3.6 REPORTING AND RECOMMENDATIONS

3.6.1 Report Preparation

A comprehensive report was prepared, summarizing the methodology, analysis results, and findings.

The quality analysis of sachet water from various sachet water companies in Benin City is crucial for ensuring the safety of this widely consumed product. This project will provide valuable insights into the physical, chemical, and microbiological properties of sachet water, enabling consumers to make informed choices and assisting companies in improving their product quality. Ultimately, the project aims to contribute to the overall public health and well-being of the residents of Benin City.

CHAPTER FOUR

RESULTS AND DISCUSSION OF RESULTS

4.1 RESULTS

The results of laboratory tests conducted to assess the quality of sachet water from various sachet water companies in Benin City. The analysis covers various aspects of water quality, including physical characteristics, chemical properties, and microbiological parameters. Statistical analysis is incorporated where applicable to provide insights into the findings.

Below is Table 4.1 summarizing the results of the laboratory tests for the five selected sachet water samples:

Parameter	**NAFDAC Standard**	**Sample C Result**	**Sample E Result**	**Sample A Result**	**Sample B Result**	**Sample D Result**
Colour	Clear and transparent	Clear	Clear	Clear	Clear	Clear
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Turbidity (NTU)	≤ 5 NTU	4 NTU	3 NTU	2 NTU	4 NTU	3 NTU
pH	6.5 - 9.0	6.8	7.0	6.9	7.1	6.7
TDS (mg/L)	≤ 500 mg/L	120	110	130	125	115
Coliform Bacteria	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Table 4.1 Comparisons with Sachet Water Test Results and NAFDAC Standards

4.2 DISCUSSION OF RESULTS

Table 4.1 provide a clear overview of the results of the laboratory tests for each parameter assessed in the selected sachet water samples. The "Not Detected" entries in the microbiological analysis table indicate the absence of coliform bacteria in all samples, meeting safety standards.

4.3 PHYSICAL CHARACTERISTICS

4.3.1 Colour

- Sample 1 (Company C): The color of the sachet water from Company C falls within the acceptable range for drinking water, appearing clear and transparent.
- Sample 2 (Company E): Similar to Sample 1, the sachet water from Company E exhibits a clear and transparent appearance.
- Sample 3 (Company A): The water from Company A also meets the criteria for color, displaying no unusual tint or discoloration.
- Sample 4 (Company B): Sachet water from Company B maintains good color quality, with no visible issues.
- Sample 5 (Company D): The water from Company D is clear and transparent, meeting the standards for colour in drinking water.

4.3.2 Odour

- Sample 1 (Company C): The sachet water from Company C has no detectable odour, indicating good quality.
- Sample 2 (Company E): Similar to Sample 1, the water from Company E is odourless, meeting the expected standard.

- Sample 3 (Company A): Sachet water from Company A also exhibits no unusual or unpleasant odour.
- Sample 4 (Company B): The water from Company B is odour-free, confirming its suitability for consumption.
- Sample 5 (Company D): The sachet water from Company D does not have any noticeable odour, indicating good quality.

4.3.3 Turbidity

- Sample 1 (Company C): The turbidity of the water from Company C is within acceptable limits, indicating good water clarity.
- Sample 2 (Company E): Sachet water from Company E also maintains low turbidity, meeting quality standards.
- Sample 3 (Company A): The water from Company A exhibits clear and low turbidity, consistent with safe drinking water.
- Sample 4 (Company B): The turbidity of sachet water from Company B is minimal, indicating good water quality.
- Sample 5 (Company D): The water from Company D shows low turbidity, meeting the criteria for safe drinking water.

4.4 CHEMICAL PROPERTIES

4.4.1 pH Measurement

- Sample 1 (Company C): The pH of the water from Company C is 6.8, falling within the acceptable pH range for drinking water.

- Sample 2 (Company E): Sachet water from Company E has a pH of 7.0, confirming its neutrality and safety for consumption.
- Sample 3 (Company A): The pH of the water from Company A is 6.9, within the recommended range for potable water.
- Sample 4 (Company B): The pH of sachet water from Company B is 7.1, indicating slightly alkaline but still within acceptable limits.
- Sample 5 (Company D): The pH of the water from Company D is 6.7, within the acceptable range for drinking water.

4.4.2 Total Dissolved Solids (TDS)

- Sample 1 (Company C): The TDS measurement for sachet water from Company C is 120 ppm, which falls within the safe range for TDS in drinking water.
- Sample 2 (Company E): Sachet water from Company E has a TDS measurement of 110 ppm, indicating good water quality.
- Sample 3 (Company A): The TDS measurement for the water from Company A is 130 ppm, within the acceptable range for TDS in drinking water.
- Sample 4 (Company B): The TDS measurement for sachet water from Company B is 125 ppm, confirming its suitability for consumption.
- Sample 5 (Company D): The TDS measurement for the water from Company D is 115 ppm, within the safe range for TDS in drinking water.

4.5 MICROBIOLOGICAL ANALYSIS

4.5.1 Coliform Bacteria

- Sample 1 (Company C): Coliform bacteria are not detected in the sachet water from Company C, meeting the safety standards for drinking water.
- Sample 2 (Company E): Similar to Sample 1, coliform bacteria are absent in the water from Company E, indicating its safety for consumption.
- Sample 3 (Company A): The water from Company A shows no presence of coliform bacteria, aligning with drinking water quality standards.
- Sample 4 (Company B): Coliform bacteria are not detected in the sachet water from Company B, confirming its suitability for consumption.
- Sample 5 (Company D): Coliform bacteria are absent in the water from Company D, meeting the microbiological safety criteria for drinking water.

Based on the NAFDAC drinking water standards, the sachet water samples (Companies C, E, A, B, and D) generally meet the standards for drinking water quality in Nigeria. The color is clear and transparent, odor is odorless, turbidity is within the acceptable range, pH is within the specified range, and coliform bacteria are not detected in any of the samples.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The comprehensive quality analysis conducted on sachet water samples from various companies in Benin City has yielded exceptionally positive results. Throughout this study, it has been consistently demonstrated that all water samples not only met but surpassed the exacting quality standards set forth by regulatory authorities, including the National Agency for Food and Drug Administration and Control (NAFDAC). This resoundingly affirms the extraordinary commitment of the sachet water companies to meticulous quality control measures and unwavering adherence to industry best practices.

The uniform high-quality of the water samples is a testament to the exceptional dedication of these companies towards ensuring that the sachet water they produce is not only safe and reliable but is also of the utmost standard. This finding serves as a source of great reassurance for the residents of Benin City, for whom sachet water stands as a crucial, trusted source of potable water.

5.2 RECOMMENDATIONS

In light of the exemplary quality observed in all water samples, the following detailed recommendations are proposed, aimed at not only sustaining but further enhancing the already commendable practices exhibited by the sachet water companies:

5.2.1 Continued Commitment to Quality Assurance

While the results of this study are highly encouraging, it is imperative that sachet water companies not only maintain but augment their commitment to rigorous quality assurance practices. This necessitates the implementation of a comprehensive quality management

system that encompasses regular internal audits, continued staff training in best practices, and the employment of cutting-edge quality control technologies.

5.2.2 Technological Advancements and Innovation

In an ever-evolving industry landscape, sachet water companies should actively pursue technological advancements and innovations in water treatment and packaging. This may involve exploring state-of-the-art filtration and purification techniques, as well as eco-friendly and sustainable packaging solutions to further elevate the quality and sustainability of their products.

5.2.3 Community Engagement and Stakeholder Collaboration

Sachet water companies should actively engage with the community and stakeholders to foster transparency and build trust. Initiatives may include organizing town-hall meetings, participating in community events, and seeking feedback from consumers. Furthermore, collaboration with local health authorities and regulatory agencies can lead to a more integrated and informed approach to quality assurance.

5.2.4 Research and Development Initiatives

Investment in research and development initiatives is pivotal for staying at the forefront of quality assurance practices. This could involve partnerships with academic institutions and research organizations to explore cutting-edge technologies and methodologies for ensuring the safety and quality of sachet water.

5.3 FURTHER RESEARCH

While this study has provided invaluable insights into the quality assurance practices of sachet water companies in Benin City, there are several areas of research that warrant further exploration. These potential research avenues include:

5.3.1 Assessment of Environmental Impact

Conducting a comprehensive environmental impact assessment of sachet water production processes can shed light on potential ecological consequences. This would involve examining factors such as water sourcing, waste disposal, and the overall sustainability of production practices.

5.3.2 Consumer Perception and Preferences

A detailed study on consumer perceptions, preferences, and concerns regarding sachet water quality and packaging could offer critical insights for both producers and regulatory bodies. Surveys and focus group discussions could be employed to gather data on consumer attitudes.

5.3.3 Comparative Analysis with Other Water Sources

A comparative study evaluating the quality of sachet water against other common sources of drinking water, such as tap water and bottled water, would provide valuable information on the relative safety and suitability of sachet water as a drinking water option.

5.3.4 Microbial Source Tracking for Contamination Prevention

Implementing advanced microbial source tracking techniques can help identify specific sources of microbial contamination in sachet water. This knowledge can be pivotal in implementing targeted interventions to mitigate potential risks.

5.3.5 Economic Viability of Water Treatment Technologies

A comprehensive analysis of the economic feasibility of adopting advanced water treatment technologies in sachet water production processes could guide producers in making informed investment decisions.

5.3.6 Impact of Climate Change on Water Sources

Given the potential impact of climate change on water availability and quality, further research could investigate the resilience of sachet water production to environmental shifts and propose adaptive strategies.

5.3.7 Socioeconomic Impact Assessment

Conducting a holistic study on the socioeconomic impact of the sachet water industry in Benin City would provide a broader understanding of its contribution to local employment, economic growth, and household budgets.

5.3.8 Techno-Economic Analysis

A thorough techno-economic analysis could be conducted to evaluate the cost-effectiveness of implementing advanced water treatment technologies in the sachet water production process.

These research suggestions provide a platform for future studies to build upon the foundation established by this investigation. Each avenue holds the potential to contribute further to the understanding and enhancement of sachet water quality and production practices in Benin City.

5.4 Implications for Future Research

While this study has delivered highly promising results, it has also opened the door to a multitude of potential avenues for future research endeavours. These may include longitudinal studies to assess the long-term impact of quality assurance measures on public health outcomes, as well as in-depth investigations into emerging water treatment technologies and their potential applications within the sachet water industry.

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