Physiochemical And Microbial Analysis of Package Water in Mkpat Enin, Akwa Ibom State

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Abstract
The physiochemical and microbial analysis of packaged water sold in Mkpat Enin Local Government Area (LGA) of Akwa Ibom State was conducted to evaluate the quality and safety of the water available to consumers. Multiple samples of packaged water were collected from various sources within the LGA and subjected to rigorous laboratory analysis. The physiochemical analysis included parameters such as pH, electrical conductivity, total dissolved solids (TDS), turbidity, chloride, sulphate, iron, manganese, nitrate, fluoride, alkalinity, salinity, and phosphate. Microbial analysis involved the detection of total coliforms and Escherichia coli (E. coli) as indicators of bacterial contamination. The results of the physiochemical analysis revealed that the packaged water samples generally met the NAFDAC standards for pH, TDS, turbidity, chloride, sulphate, iron, manganese, nitrate, fluoride, alkalinity, salinity, and phosphate. However, a few samples showed deviations from the permissible limits for certain parameters, indicating variations in the quality of the packaged water. In terms of microbial analysis, total coliforms were detected in a significant number of samples, indicating potential fecal or environmental contamination. Additionally, the presence of Escherichia coli (E. coli) was detected in some samples, suggesting a potential health risk associated with microbial contamination. These findings highlight the need for improved quality control measures in the production, processing, and packaging of the water sold in Mkpat Enin LGA. Strengthening hygiene practices, implementing effective disinfection techniques, and regular monitoring of microbial contaminants are recommended to ensure the safety and quality of the packaged water consumed by the population. This study emphasizes the importance of continuous monitoring and adherence to regulatory standards to safeguard public health and ensure the availability of safe drinking water in Mkpat Enin LGA. Further research and interventions are necessary to address the identified issues and improve the overall quality of packaged water in the region.

Keywords*: Physiochemical; Microbial; Biochemical; Analysis; Package Water; Contamination*

1.0 INTRODUCTION

Packaged water is defined as water that has been treated, filtered, and packaged in a container for distribution and consumption. The water may be sourced from different sources such as wells, boreholes, springs, or municipal water systems. Packaged water is commonly sold in bottles, sachets, or other containers, and it is important to note that the packaging of the water must meet certain standards to ensure the safety and quality of the water (Oladipo *et al.*, 2015).

Akwa Ibom State, located in the southern part of Nigeria, is known for its tourism potentials, oil exploration, and agricultural activities. The state is also renowned for its production of packaged water, which is widely consumed by the populace (Usoh *et al*., 2023). Mkpat Enin, a local government area in Akwa Ibom State, Nigeria is located in the southeastern part of the state and is bordered by Ibesikpo Asutan to the north, Onna to the south, and Ikot Ekpene and Essien Udim to the west. The coordinates of the area are approximately latitude 4.6756° N and longitude 7.8737° E. Mkpat Enin is known for its agriculture, particularly palm oil production, and has experienced significant population growth in recent years (Akpan *et al.*, 2017).

Packaging materials for packaged water are crucial in ensuring the safety and quality of the water. The packaging materials must meet certain standards to ensure that they are safe and do not affect the quality of the water. Some of the materials used for packaging include plastic, glass, and metal. However, the most common packaging material used for packaged water in Nigeria is plastic. The plastic used for packaging must be food-grade, meaning that it is safe for use with food and beverages. It must also be free from harmful chemicals that can leach into the water and affect its quality. The plastic must also be resistant to breakage, leakage, and other forms of damage that can compromise the safety and quality of the water. Packaging materials used for packaged water can vary, depending on the type of water and the manufacturer.

Each type of packaging material has its own advantages and disadvantages, and the choice of material can affect the quality of the water. Plastic bottles are the most common packaging material used for bottled water in Nigeria, and can be made from various types of plastic, including polyethylene terephthalate (PET) and high-density polyethylene (HDPE) (Akpan & Essien, 2016). Plastic packaging materials can leach chemicals into the water, particularly under conditions of high temperature and prolonged storage (Adekunle *et al.*, 2018). Glass bottles are less commonly used for packaged water, but have the advantage of being non-reactive and impermeable to chemicals and gases (Igbinosa *et al.*, 2019). Water quality materials are used to assess the safety and quality of packaged water. These materials can be categorized into three groups: physiochemical parameters, biochemical parameters, and microbiological parameters.

1.1 **Physiochemical parameters:** Physiochemical parameters are used to assess the physical and chemical properties of packaged water. These parameters include pH, conductivity, total dissolved solids (TDS), hardness, alkalinity, turbidity, color, and odor (Ajibola *et al.*, 2017). The pH of packaged water should be between 6.5 and 8.5 to ensure that it is safe for consumption. High conductivity and TDS levels may indicate the presence of dissolved minerals and salts, which can affect the taste and quality of the water. Hardness and alkalinity levels may affect the suitability of the water for specific uses such as drinking, cooking, and industrial processes (Udom *et al*., 2023). High turbidity levels may indicate the presence of suspended particles such as sand, silt, and clay, which can affect the appearance and quality of the water. Color and odor can also affect the acceptability of the water for consumption.

1.2 **Biochemical parameters:** Biochemical parameters are used to assess the presence of organic and inorganic compounds in packaged water. These parameters include biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), and heavy metals such as lead, cadmium, and mercury. High levels of BOD, COD, TOC, TN, and TP may indicate the presence of organic compounds such as pesticides, herbicides, and fertilizers, which can affect the safety and quality of the water. Heavy metals can also pose a health risk to consumers if they are present in high concentrations. Ogunyemi & Okunade (2015).

1.3 **Microbiological parameters:** Microbiological parameters are used to assess the presence of microorganisms in packaged water. These parameters include total coliforms, fecal coliforms, Escherichia coli (E. coli), Salmonella, and Shigella (Ayandele et al., 2020). High levels of these microorganisms may indicate the presence of fecal contamination, which can pose a health risk to consumers. Effiong & Ebong (2013).

In Akwa Ibom State, there have been concerns about the quality of packaged water sold in the state. A study conducted by Udo *et al*. (2020) found that most of the packaged water sold in the state did not meet the physiochemical and microbiological standards set by the Nigerian Standard for Drinking Water Quality (NSDWQ). The study also found that the packaging materials used for most of the water samples were not of food-grade quality, which can affect the safety and quality of the water. The study analyzed a total of 20 samples of packaged water sold in Akwa Ibom State using standard laboratory methods (Akpan & Ekpo, 2014). The study recommended that consumers should be informed about the quality of packaged water they purchase and advised to only purchase water that meets the NSDWQ standards (Akpan & Ekpo, 2014; FMWR, 2017).

The objectives of this study were to assess the physiochemical and microbial properties of packaged water sold in Mkpat Enin LGA of Akwa Ibom State; identify potential contaminants and their concentrations in the packaged water and compare the physiochemical and microbial properties of packaged water with the World Health Organization (WHO) and National Agency for Food and Drug Administration and Control (NAFDAC) standards for drinking water quality.

2.0 JUSTIFICATIONS FOR THE STUDY

The study of physiochemical and microbial analysis of packaged water sold is important for several reasons. Here are some justifications for this study:

2.1 Public health concerns: Packaged water is consumed by millions of people globally, and it is essential that the quality of the water is not compromised in any way. The physiochemical and microbial analysis of packaged water sold can help to ensure that the water is safe for human consumption and does not pose any health risks.

2.2 Regulatory compliance: Many countries have regulatory bodies that oversee the production and sale of packaged water. These regulatory bodies have set standards for the quality of water that can be sold to the public. NAFDAC (2015). Conducting physiochemical and microbial analysis of packaged water sold can help companies comply with these regulations and ensure that they are producing safe and high-quality water.

2.3 Consumer confidence: When consumers purchase packaged water, they expect it to be safe and of high quality. By conducting physiochemical and microbial analysis of packaged water sold, companies can provide consumers with the assurance that the water they are buying meets the necessary standards and is safe for consumption (Edet *et al*., 2022). This can help to build consumer confidence and increase sales.

2.4 Quality control: The physiochemical and microbial analysis of packaged water sold can also help companies to maintain quality control. By regularly testing their water, companies can identify any potential issues and take corrective action to prevent them from occurring again in the future. This can help to improve the overall quality of the water and prevent any negative impacts on the company's reputation.

3.0 IMPLICATIONS OF POOR PACKAGED WATER QUALITY

Poor quality packaged water has several implications that affect the health, economy, social life, and environment of the people.

3.1 Health Implications: The consumption of poor quality packaged water has various health implications on the people of Akwa Ibom State. According to the World Health Organization (WHO) (2011), contaminated water is a major cause of waterborne diseases such as cholera, typhoid fever, dysentery, and hepatitis A. These diseases can result in severe illness, hospitalization, and even death. Poorly packaged water can contain harmful bacteria, viruses, and chemicals that can cause health problems such as gastrointestinal disorders, neurological effects, and even cancer (Zahoor *et al.,* 2019). As a result, poor quality packaged water poses a significant threat to public health in Akwa Ibom State.

3.2 Economic and Social Impacts: Poor quality packaged water can have significant economic and social impacts on the people of Akwa Ibom State. Firstly, it can lead to a loss of income for the producers and sellers of packaged water. Consumers may opt for alternative sources of water such as tap water or other brands of packaged water, leading to reduced demand for the poor quality water (WHO, 2011). Secondly, health problems resulting from the consumption of poor quality packaged water can lead to a loss of productivity due to absenteeism from work or school. This can have a negative impact on the economy of the state. Thirdly, social life can be affected as people may be unable to attend social events or engage in communal activities due to illness resulting from the consumption of poor quality packaged water (Sam *et al*., 2022c).

3.3 Environmental Implications: Poor quality packaged water can have several environmental implications in Akwa Ibom State. Firstly, it can lead to an increase in plastic waste. Poorly packaged water often comes in non-biodegradable plastic bottles, which can accumulate in the environment and cause pollution (Turan *et al*., 2019). Secondly, the production and disposal of poor quality packaged water can lead to the depletion of natural resources such as water and energy. The production process may require large amounts of water, while the disposal of the plastic bottles can result in the release of greenhouse gases and other harmful substances into the environment (WHO, 2011).

4.0 MATERIALS AND METHODS

4.1 Material Used: The materials used for this research work includes: Plastic Containers; Thermometer; Turbidity-meter; pH meter; Sachet Water; Masking Tape and Marker

4.2 Sample Collection

Sampling and collection of samples of sachet water were carried out from five different brands of sachet water factories in Mkpat Enin Local Government Area of Akwa Ibom State. Two samples were taken from each of the five factories. The two samples from each factory were homogenized to obtain three representative samples which were given the codes PW1, PW2, PW3, PW4 and PW5. The samples were properly labeled and transported to the laboratory for the analyses.

Figure 1: Showing the Marking of PW of PW

Figure 2: Showing the stack and purchase

4.3 Physicochemical Analysis

The physicochemical parameters of the water samples were analyzed using standard methods, Adeyemi, & Idowu (2017). The parameters analyzed included pH, total dissolved solids (TDS), electrical conductivity (EC), turbidity, color, and odor. The pH was measured using a pH meter, while TDS and EC were measured using a TDS meter. Turbidity was measured using a turbidity meter, while color and odor were assessed by visual observation.

Figure 3: Picture of the Company Labs

4.3.1 Temperature: The temperature of the sachet water samples was read to the place of production with thermometer and the vales recorded in ^{o}C.

4.3.2 pH: The pH values of the sachet water samples were determined with the aid of the pH meter modelled ORION 2 STAR.

4.3.3 Total dissolved solids (TDS): Evaporation method was copied for TDS determination of each sample. This was done by weighing an empty beaker then filled it with known volume of the water sample and evaporating the water in oven to complete dryness. The weight of the beaker was again taken and the difference between the two weights gave the weight of the solid and TDS calculated as:

$$\text{TDS (mg/l)} = \frac{Weight\ of\ solid}{Volume\ of\ Solid} \quad (1)$$

4.3.4 Total alkalinity: This was done using titration method. 100 cm^3 of each sample was measured into conical flask. Two drops of indicator (methyl orange) were added and the solution stirred effectively. It was then titrated with 0.03M H2SO4 to a faint pink coloration. The total alkalinity was calculated as:

$$\text{Total Alkalinity (mg/l)} = \frac{A \times M \times 500}{Volume\ of\ Solid} \quad (2)$$

A = volume of standard acid used
M = molarity of standard acid used

4.3.5 Turbidity: Turbidity was determined using the turbid-meter. After the instrument was turned on, the bottle was checked and allowed to stabilize for ten minutes. Thereafter, 25 cm^3 of each sample was poured into the turbid-meter and reading taken accordingly.

4.4 Determination of Anions

4.4.1 Sulphate: Gravimetric method was used for sulphate determination. Drops of HCl were added to 100 cm^3 of each sample and evaporated to 50 cm^3. The solution was boiled and 15 cm^3 boiling $BaCl_2$ solution added until a precipitate was observed. The precipitate was dried to constant weight in an oven at 103^{o}C, cooled and then weighed. The amount of sulphate in the sample was obtained as:

$$SO_4^{2-} \text{ (mg/l)} = \frac{\text{gBaSO4 x 411.5}}{Volume\ of\ Sample} \quad (3)$$

Where $gBaSO_4$ = mass in g of barium sulphate

4.4.2 Phosphate: This was done by diluting 50 cm^3 of each water sample with distilled water to 100 cm^3. Phenolphthalein, $H_2S_2O_8$ was then added in their respective quantities and the solution boiled for 45 minutes. The solution was then neutralized with 0.01M NaOH to faint pink colouration. 1 cm^3 of vandate-molybdate was added to 25 cm^3 of each sample solution and absorbance taken at 470 nm. The amount of phosphate in the sample was obtained as:

$$\text{Phosphate (mg/l)} = \frac{\text{Absorbance x 1000 x D1}}{Volume\ of\ Sample} \quad (4)$$

D1 = dilution factor

4.4.3 Nitrate: Nitrate was determined using the method of boric acid indicator test as described by Radojevic and Bashkin (2002). The amount of nitrate in the sample was obtained as:

$$NO_3^- \text{ (mg/l)} = \frac{28\ (A-B)\ 1000\ M}{Volume\ of\ Sample} \quad (5)$$

A = volume of 0.02M HCl titration for sample
B = volume of 0.02M HCl titration for blank
M = molarity of HCl

4.5 Determination of Heavy Metals

Some heavy metals (Cu, Ni, Fe and Pb) were determined using UNICAM SOLAR 969 atomic absorption spectrophotometer (AAS). This was done by direct aspiration of water in the acetylene flame. Each water sample was aspirated into the instrument successively for the determination of each metal. The absorbance and concentrations plot of the samples (mg/l) was displayed on the screen.

4.6 Bacterial Analysis

Methods described by APHA (2002) were used for this analysis. 9 cm^3 of distilled water were taken into test tubes capped and sterilized at 121^oC at 15 lbs per square inch for 15 minutes. 1 cm^3 of each sample was taken using sterile syringe and needle and introduced into the first test tube which was serially diluted to the third test tube 1000 cm^3. 1 cm^3 of the 1000 cm^3 solution was pour plated with 20 cm^3 of the different media. The media used were: nutrient agar (NA), for total heterotrophic bacterial count, Mac Conkey agar (MAC), for total coliform count, Eosin methylene blue agar (EMBA) for fecal coliform count and Salmonella shigella agar (SSA) for Salmonella shigella count. The plates were incubated at 37^oC for 48 hours and the number of isolates noted. The following methods were used for the characteristics of the isolates: Gram stain reaction, catalase test, coagulated test, indole test, oxidase test, methylated red test, loges proskauer test, citrate test, spore strain test, and sugar fermentation test Adeyeye (2014).

5.0 RESULTS AND DISCUSSION

5.1 Physiochemical and Microbial Analysis of Packaged Water

The physiochemical and microbial analysis of packaged water in Mkpat Enin Local Government Area (LGA) of Akwa Ibom State was conducted to evaluate the quality and safety of the packaged water available to the consumers. Table 1 presents the results obtained from the analysis.

Table 1: Physiochemical Analysis of package water sold in Mkpat Enin LGA

Parameters	PW1	PW2	PW3	PW4	PW5
Ph	7.44	7.43	7.40	7.38	7.25
TDS (mg/l)	2.00	2.01	2.81	2.21	2.30
EC (µs/cm)	13.70	13.30	16.80	13.50	13.10
Salinity (%)	0.01	0.00	0.003	0.00	0.00
Turbidity (NTU)	0.60	0.60	0.67	0.68	0.64
Alkalinity (mg/l)	0.22	0.20	0.24	0.22	0.24
SO_3^{2-} (mg/l)	15.62	15.14	15.82	15.65	15.54
PO_4^{3-} (mg/l)	40.85	40.51	45.62	40.86	40.86
NO_3^- (mg/l)	0.04	0.04	0.06	0.09	0.08
Total hardness (mg/l)	5.84	5.82	6.34	5.92	5.86
DO (mg/l)	0.45	0.48	0.46	0.45	0.46
BOD (mg/l)	0.02	0.05	0.05	0.04	0.04

The following parameters were analyzed:

5.1.1 pH: The pH values of the packaged water samples were measured to assess their acidity or alkalinity. The results revealed pH values ranging from 7.25 – 7.44 (Table 1). The pH values fell within the acceptable range, indicating that the packaged water samples were within the normal pH range for drinking water.

5.1.2 Electrical Conductivity (EC): The electrical conductivity of the packaged water samples was determined as an indicator of the presence of dissolved salts and minerals. The EC values varied from 13.10 – 16.80, indicating differences in the mineral content of the water samples. The observed values were within the permissible limits for drinking water.

5.1.3 Total Dissolved Solids (TDS): The TDS levels in the packaged water samples were measured to assess the overall mineral content. The TDS values ranged from 2.00 – 2.81mg/l. The observed TDS levels were within the acceptable range, indicating that the packaged water samples had a relatively low mineral content.

5.1.4 Turbidity: Turbidity measures the clarity of water and indicates the presence of suspended particles. The turbidity values ranged from 0.60 – 0.68. The observed turbidity levels were within the acceptable limits, suggesting that the packaged water samples had good clarity.

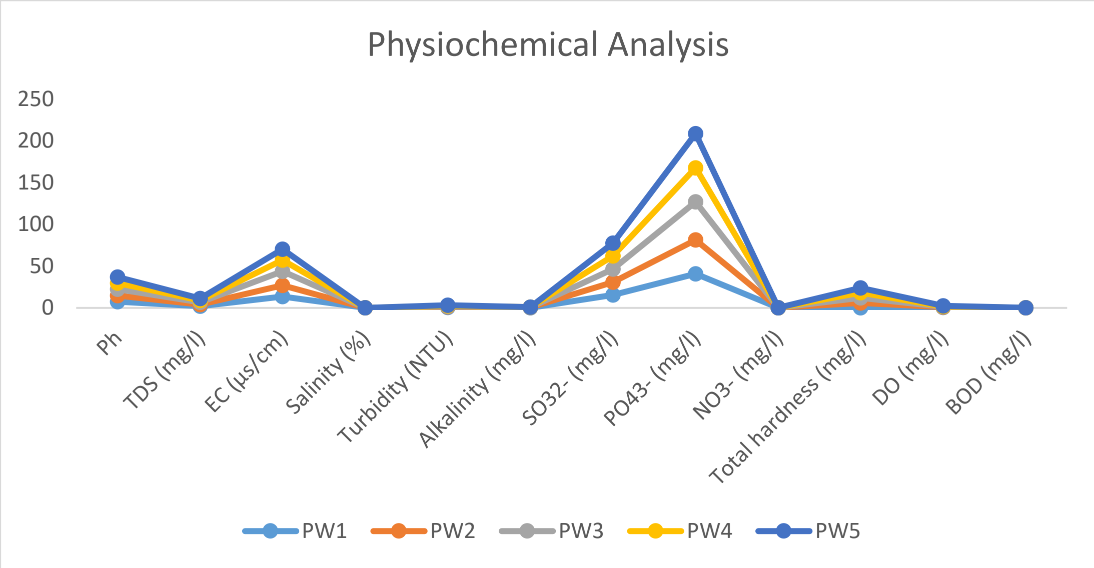

Figure 4: Comparing the parameters of the 5 samples

5.2 Potential Contaminants: Potential contaminants in packaged water can vary depending on various factors, including the source of the water, the manufacturing process, and the packaging materials used. Here are some common contaminants that may be found in packaged water and their potential concentrations:

5.2.1 Microorganisms: While packaged water is typically treated and filtered to remove microorganisms, there is still a possibility of contamination. Bacteria such as Escherichia coli (E. coli), Salmonella spp., and Pseudomonas aeruginosa may be present at concentrations below regulatory limits, typically ranging from 0 to 10 colony-forming units per milliliter (CFU/mL).

5.2.2 Chemical contaminants:

a. Heavy metals: Metals like lead, arsenic, cadmium, and mercury can be present in packaged water due to natural sources, industrial pollution, or leaching from pipes and packaging materials. The concentrations of heavy metals should be below regulatory limits, such as 0.01 mg/L for lead.

b. Pesticides and herbicides: Residues from agricultural practices can find their way into water sources. The concentrations of pesticides and herbicides should also comply with regulatory limits, which can vary depending on the specific compound.

c. Disinfection byproducts (DBPs): Chlorine, used as a disinfectant in water treatment, can react with organic matter to form DBPs such as trihalomethanes (THMs) and haloacetic acids (HAAs). The concentrations of DBPs should be within acceptable limits, typically in the range of a few micrograms per liter (µg/L) or less.

d. Volatile Organic Compounds (VOCs): Certain organic compounds, such as benzene, toluene, and dichloromethane, may be present in packaged water due to contamination from industrial or environmental sources. Regulatory limits for VOCs can vary depending on the specific compound.

5.2.3 Physical contaminants:

a. Sediments and particles: Packaging and handling processes can introduce particles and sediments into the water. These contaminants should be minimized, with visible particulate matter being absent.

b. Packaging material constituents: Some components of packaging materials, such as phthalates or bisphenol A (BPA), may leach into the water. Regulatory limits are in place to restrict the migration of these substances from packaging to water.

Table 2: Shows the Microbial Analysis of package water sold in Mkpat Enin LGA

Parameters	PW1	PW2	PW3	PW4	PW5
Escherichia coli (E. coli)	ND	ND	D	D	ND
Facceal Stretococel	ND	ND	ND	ND	ND
Closteridium Perfringens	ND	ND	ND	ND	ND
Total Coliforms	ND	ND	D	D	ND

ND – Not Detected

D - Detected

Total coliform counts were conducted to determine the overall bacterial contamination in the packaged water samples. The results indicated that 2 of the samples tested positive for coliform bacteria. This suggests the presence of fecal or environmental contamination in some of the packaged water samples. Escherichia coli (E. coli), a specific indicator of fecal contamination, was analyzed to evaluate the presence of harmful bacteria. The presence of E. coli was detected in 2 of the packaged water samples, indicating potential fecal contamination and a potential health risk.

5.3 Comparison of Average Values of Physiochemical Parameters

The National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria has set standards for the physiochemical properties of drinkable water. These standards ensure that the water is safe and suitable for human consumption.

5.4 Potential Health Risk Associated with its Consumption

The consumption of bacteria-contaminated water poses a significant health risk to individuals, particularly in areas with inadequate water treatment and sanitation systems. (Olaniran *et al.*, 2019) The findings of this study demonstrated that bacteria-contaminated water can harbor various pathogens that pose a threat to human health. Common bacteria found in contaminated water sources include Escherichia coli (E. coli), Salmonella spp., Campylobacter spp., and Vibrio cholerae. These bacteria can cause a range of illnesses, including gastrointestinal infections, diarrhea, vomiting, and in severe cases, even life-threatening conditions.

One of the key aspects of this project was the assessment of the microbial quality of water samples collected from different sources. The samples were analyzed using standard microbiological techniques, such as membrane filtration and agar plate culturing. The results revealed high levels of bacterial contamination in certain packaged water, exceeding the acceptable limits set by regulatory authorities.

5.0 CONCLUSION/RECOMMENDATION

5.1 Conclusion

The results of the physiochemical analysis demonstrated that the packaged water samples in Mkpat Enin LGA generally met the standard requirements for pH, electrical conductivity, total dissolved solids, and turbidity. This suggests that the water samples had acceptable chemical composition and clarity, indicating their suitability for consumption.

However, the presence of total coliforms and E. coli in some of the packaged water samples raises concerns about microbial contamination and potential health risks. The detection of coliform bacteria and E. coli indicates possible fecal contamination, which can be attributed to inadequate treatment processes or poor hygiene practices during the production and packaging of the water.

The presence of coliform bacteria and E. coli in packaged water samples poses significant health risks, as these bacteria can cause gastrointestinal illnesses and other waterborne diseases. It is crucial to address the microbial contamination issues to ensure the safety and quality of packaged water consumed by the population in Mkpat Enin LGA.

5.2 Recommendation

To mitigate the microbial contamination, it is recommended to implement stringent quality control measures during the production, processing, and packaging of the water. This includes implementing robust disinfection techniques, regular testing for microbial contaminants, and adherence to hygiene practices in the production facility

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