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BACTERIOLOGY ANALYSIS OF RESERVIOR WATER IN MAIRI KUWAIT MAIDUGURI BORNO STATE NIGERIA

Authors Details

Anthonia David[1]
Department of Microbiology, Faculty of Science, University of Maiduguri, Maiduguri, Borno State, Nigeria.

Elvis Obi Besong[2]
Department of Haematology, Faculty of Medical Laboratory Science, University of Calabar, Nigeria.

Shella Obi Besong[3]
Department of Nursing Science, Faculty of Allied Health Sciences. University of Maiduguri. Nigeria.

Blessing Imade[4]
Department: of Medical Laboratory Science, University: University of Benin, Benin, Edo State, Nigeria.

Olawuyi Boluwatife Comfort[5]
Department of Microbiology, Osun State University, Osogbo. Osun State Nigeria.

Oluwatimilehin Sileola Johnson[6]
Department of Biomedical Technology Faculty of Basic Medical Sciences Federal University of Technology Akure, Ondo State, Nigeria.

Moses Sunkanmi Oladokun[7]
Department of Chemical Sciences, Faculty of Science, Anchor University, Lagos, Nigeria.

Micheal Abimbola Oladosu[8*]
Department of Chemical Sciences, Faculty of Science, Anchor University Lagos, Ayobo, Lagos, Nigeria.

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Moses Adondua Abah[9]
Department of Biochemistry, Faculty of Pure and Applied Sciences, Federal University of Wukari, Wukari, Taraba State, Nigeria.

Stephen Zakka Bayero[10]
Department of medicine and surgery, faculty of medicine. Ahmadu Bello University Zaria. Kaduna State, Nigeria.

Adedapo Olosunde[11]
Department of Chemistry and Biochemistry, University of Toledo, Toledo, OH 43606, USA.

Mesoma Princess Onyekwere[12]
Department of Dentistry, Faculty of Dentistry, College of Medicine, University of Nigeria, Enugu Campus, Enugu State, Nigeria.

Corresponding Author: *Micheal Abimbola Oladosu*

Abstract: Water is a critical resource for human survival, and ensuring its safety for consumption is paramount. The study was carried out to assess the bacteriological quality of reservoir water in Mairi Kuwait and its potential implications for public health. The investigation revealed a diverse range of characteristics in the morphological quality of 50 water samples, indicating significant variability in microbial contamination. The presence of pathogenic organisms, including *Klebsiella pneumonia* which has the highest occurrence with 40%, *Staphylococcus aureus* with 26%, *Escherichia coli* with 20.8%, *Salmonella typhi,* with 6.6% and *Proteus bulgarus* 6.6% respectively was identified, highlighting the unsuitability of this water for human consumption. The study demonstrated a correlation between high heterotrophic counts and coliform counts, suggesting the presence of fecal coliforms. The proximity of a pit latrine to one of the boreholes, combined with unsanitary environmental conditions around the water source, likely contributed to elevated microbial contamination. The water samples were found to be slightly acidic, falling within the acceptable pH range recommended by the World Health Organization (WHO). This research underscores the urgent need for comprehensive water quality management strategies to mitigate microbial contamination and ensure the health and safety of the local

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population. Adherence to international and national water quality standards is imperative to safeguard public health. The findings presented here provide a basis for informed decision-making and targeted interventions to improve the quality of reservoir water in Mairi Kuwait and protect the well-being of the community.

Keywords: *Water quality, Bacteriological assessment, Microbial contamination, Heterotrophic count, Sanitary conditions*.

INTRODUCTION

In many developing countries, including Nigeria, rural communities rely on rivers, streams, wells, and boreholes for drinking and domestic water use. While groundwater is generally considered safe, improper siting, construction, and operation can lead to contamination from industrial, domestic, and agricultural sources (Chukwurah, 2001; Wagner and Lanoix, 1969). Industrial pollutants, such as heavy metals and chemicals, may seep into boreholes, while domestic waste from septic tanks and latrines can introduce fecal contamination. Agricultural runoff also contributes to pollution through fertilizers, pesticides, and animal waste. Environmental pollution, such as seawater intrusion, further affects water quality. The WHO recommends that boreholes should be located at least 30m from latrines and 17m from septic tanks (Chukwurah, 2001).

Microbial contaminants of concern in waterborne diseases include bacteria such as *Salmonella* spp., *Shigella* spp., *Escherichia coli*, and *Vibrio cholerae* (Birmingham et al., 1997). Protozoa such as *Entamoeba histolytica, Giardia lamblia, Balantidium coli,* and *Cryptosporidium parvum* (Jawetz et al., 1991; Kelly et al., 1997) can also cause diarrhea. Additionally, enteroviruses like Poliovirus, Rotavirus, and Hepatitis A virus are transmitted through water (Hejkal et al., 1982). The presence of fecal coliforms, particularly *E. coli*, serves as an indicator of waterborne pathogens (Chukwurah, 2001; Okafor, 1985; Okpokwasili and Akujobi, 1996), with WHO recommending zero fecal coliforms in 100ml of drinking water.

Water is an essential natural resource with unique physical and chemical properties, vital for all living organisms (Onifade et al., 2008). However, in many areas, water sources are consumed without proper assessment of their safety (Ajewole et al., 2005; Obi et al., 2007). Contaminated water, especially with fecal matter, poses serious health risks,

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contributing to diseases such as diarrhea, typhoid, and cholera. WHO estimates that 80% of diseases globally are linked to unsafe water and inadequate sanitation, affecting millions of people annually (WHO, 2004, 2010). Inorganic toxins in water may also cause long-term health issues, including cancer, birth defects, and organ damage (Erah et al., 2002).

In Maiduguri, groundwater is a primary source of drinking water due to the lack of surface water. Although Lake Alau was dammed for drinking water supply in the late 1980s (Rudiger, 2002), the increasing population has led to an unstable and unpredictable public water supply. Many boreholes have been drilled, but due to cost and accessibility issues, most are at shallow depths (<30.48m), making them more vulnerable to contamination from domestic waste and sewage infiltration (Obi and Okacha, 2007). These waste materials may enter boreholes through percolating rainwater or via well walls and drilling materials.

This study investigates the bacteriological quality of borehole water in Mairi Kuwait, Maiduguri, to determine its safety for consumption and recommend necessary interventions to prevent contamination and protect public health.

MATERIALS AND METHODS

- **Study Area**: Mairi Kuwait was a settlement located behind the Federal Government College Maiduguri under Jere LGA of Borno State. Jere LGA was situated in the town of Khaddamari, consisting of several towns and 12 wards, covering an area of 868 km² with a total population of 211,204 as recorded in the 2006 census.
- **Study Design:** This research was experimental. All samples collected were analyzed in the Microbiology Laboratory at the University of Maiduguri.

I. MATERIALS: The materials used in this study included Petri dishes, wire loops, an autoclave, conical flasks, test tubes, a Bunsen burner, a weighing balance, foil paper, water samples, culture media (Nutrient agar, MacConkey agar), distilled water, measuring cylinders, an incubator, cotton wool, hand gloves, face masks, glass slides, and syringes.

II. METHODS

i. Collection of Water Samples

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The water samples were collected from Mairi Kuwait household reservoirs using clean and sterile plastic bottles with fitted covers. These samples were immediately transferred to the laboratory. The physicochemical analysis of water samples was performed, and total bacterial count and total coliform counts were taken for the raw water samples (Chioma et al., 2020).

ii. Media Preparation

The media used in the study were Nutrient agar and MacConkey agar, which were prepared according to the manufacturer's instructions. The appropriate quantities of the dehydrated powder were measured in conical flasks, and the required amount of water was added. For Nutrient agar, 2.8g was weighed using a measuring scale and added to 100ml of water, while for MacConkey agar, 4.85g was weighed and added to 100ml of water. The mixtures were homogenized in a water bath and sterilized in an autoclave for 15 minutes at 121°C (Chioma et al., 2020).

iii. Physicochemical Analysis

The physicochemical analysis of the water samples was carried out to determine parameters such as pH, temperature, odor, and appearance (Chioma et al., 2020).

- Determination of pH: The pH meter was calibrated by dipping it into a beaker containing 100ml of buffer solution (pH 7.0). The electrode was removed from the buffer solution, rinsed with sterile water, and then used to measure the pH of the water sample.
- Determination of Temperature: A thermometer was dipped into the water samples and left for some time before the reading was recorded in °C (Chioma et al., 2020).
- Determination of Odor and Appearance: The odor of the samples was assessed using the human sense of smell, while the physical appearance was evaluated visually.

iv. Total Bacterial Count

The total plate count was determined using the Pour Plate Technique. 9ml of clean water was dispensed into ten test tubes and sterilized in an autoclave at 121°C for 15 minutes. Using a sterile syringe, 1ml of the water sample was aseptically added to the 9ml sterile solution blank to create a 10^{-1} dilution. Serial dilution was carried out,

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and 1ml was withdrawn from the last dilution and poured into a sterile molten Nutrient agar plate, which had been cooled to approximately 45°C. The samples were poured into Petri dishes and left to set on the bench. The plates were inverted and incubated at 37°C for 24 hours. After incubation, the colonies were counted using a Colony Counter, and microbial load per sample was calculated by multiplying the colony count by the dilution factor, expressed as colony-forming units per ml (CFU/ml) (Chioma et al., 2020).

v. Total Coliform Count

The total coliform count was determined using the Pour Plate Technique. 9ml of clean water was dispensed into ten test tubes and sterilized in an autoclave at 121°C for 15 minutes. Using a sterile syringe, 1ml of the water sample was aseptically added to the 9ml sterile solution blank to create a 10^{-1} dilution. Serial dilution was performed, and 1ml was withdrawn from the last dilution and poured into a sterile Petri dish containing sterile MacConkey agar, which had been cooled to about 45°C. The plates were left to set on the bench, inverted, and incubated at 37°C for 24 hours. After incubation, the colonies were counted using a Colony Counter, and microbial load per sample was calculated by multiplying the colony count by the dilution factor, expressed as CFU/ml (Chioma et al., 2020).

vi. Morphological and Biochemical Characterization of Isolates

The bacterial isolates were characterized based on their morphology, staining, and biochemical tests. These tests were carried out following the methods prescribed by Cappuccino and Sherman (2007).

- Gram Staining: A loopful of bacterial culture was picked using a sterile wire loop and emulsified in a drop of distilled water on a clean, grease-free glass slide. The smear was allowed to air dry before heat-fixing it over a flame. The slide was then flooded with crystal violet for 1 minute, rinsed under slow running tap water, and treated with acetone to decolorize the stain. Safranin was applied as a counterstain for 30 seconds, then washed off and air-dried at room temperature. The slides were examined under an oil immersion objective (Oyeleke and Manga, 2008).
- Biochemical Tests

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I. Catalase Test: A drop of hydrogen peroxide was placed on a clean grease-free slide and mixed with the test organism using a sterile wire loop. Bubble formation indicated a positive reaction (Oyeleke and Manga, 2008).

II. Indole Test: The test was performed by inoculating one loopful of each test isolate separately into pre-sterilized Bijou bottles containing 3ml of tryptone water. After incubation at 37°C for 48 hours, 0.5ml of Kovac's reagent was added. A red color development in the reagent surface layer within 10 minutes indicated a positive result, while a yellow color indicated a negative result (Parija, 2006).

III. Citrate Utilization Test: The test used Simmon's medium, prepared according to the manufacturer's instructions and solidified in slanting slopes. Cultures of the isolates were inoculated and incubated at 37°C for 48 hours. A color change from green to blue indicated a positive result (Parija, 2006).

IV. Oxidase Test: A filter paper was placed in a clean Petri dish, and 2-3 drops of freshly prepared oxidase reagent were added. A wire loop was used to remove a colony of the test organism and smeared onto the filter paper. A blue-purple color indicated a positive result (Cheesbrough, 2006).

V. Urease Test: A dense milky suspension of the test organism was prepared in 0.25ml of physiological saline in a small tube. A urease tablet was added, and the tube was incubated at 35–37°C in a water bath overnight. A color change indicated urease activity (Cheesbrough, 2006).

VI. Data Analysis. The results were analyzed using SPSS and presented in tables.

RESULTS

Identification of bacteria isolated from the water sample analyzed based on morphological and biochemical characteristics showed the presence of *E coli, klebsiellaspp, salmonella spp* and *staphylococcus.*

Table1 summarizes the characteristics of various bacterial strains, including their morphology, Gram reaction, and various biochemical tests. The presence or absence of certain traits indicates their potential pathogenicity. While Figure 1 Presents the Percentage

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occurrence of pathogenic bacteria isolated from reservoir water samples in Mairi Kuwait, Maiduguri, Borno State, Nigeria,

Table 1: Gram reaction and biochemical

S/N	Colour	Shape	Gram reaction	Citrate	Indule	Methyl rate	Catalase	Oxidase	Coagulase	Pathogenic bacteria
1	Pink	Rod	-	+	+	+	+		-	*Proteus bulgarus*
2	Purple	Cocci	+	+	-	+	+		+	*Staphylococus aureus*
3	Pink	Rod	-	+	-	-	+	-	-	*Klebsiellapneumoniea*
4	Pink	Rod	-	-	+	+	+	-	-	*E.coli*
5	Purple	Rod	+	-	-		-	-	-	*E.coli*
6	Pink	Rod	-	+	-	-	+	-	-	*Klebsiellapneumoniea*
7	Pink	Rod	-	-	+	+	+	-	-	*E.colli*
8	Pink	Rod	-	+	-	-	+	-	-	*Klebsiellapneumoniea*
9	Purple	Cocci	+	+		+	+		+	*Staphylococuaureus*
10	Purple	Rod	+	+	-	+	+	-	+	*Staphylococusaureus*
11	Pink	Rod	-	+	-	-	+	-	-	*Klebsiellapneumoniea*
12	Pink	Rod	-	+	-	-	+	-	-	*Klebsiellapneumoniea*
13	Pink	Rod	-	+	-	-	+	-	-	*Klebsiellapneumoniea*
14	Pink	Rod	-	-	+	-	+	-	-	*E.coli*
15	Pink	Rod	-	-	-	-	+	-	-	*Salmonellatytthypi*

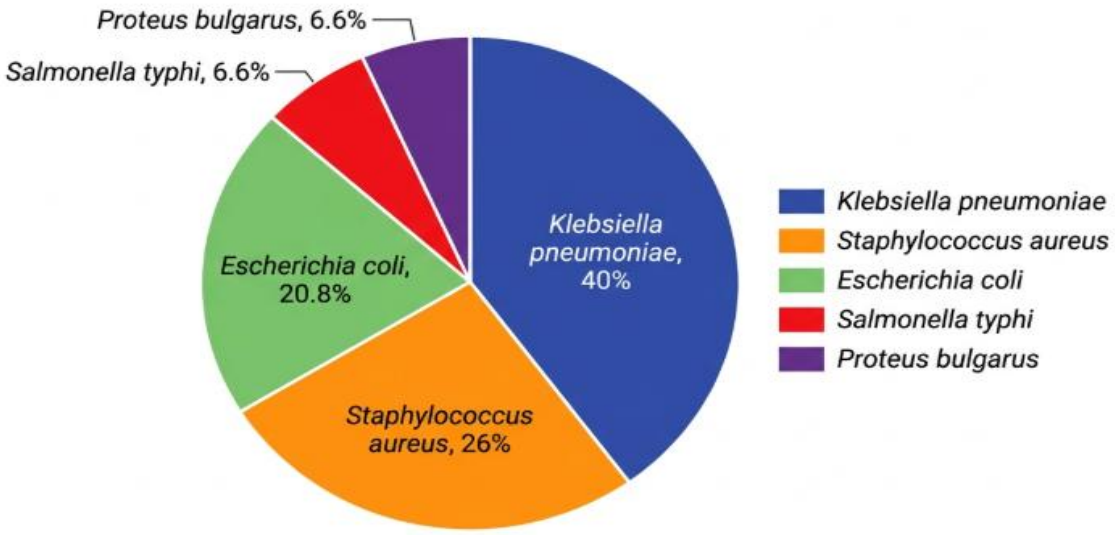

Figure 1. *Percentage occurrence of pathogenic bacteria isolated from reservoir water samples in Mairi Kuwait, Maiduguri, Borno State, Nigeria*

Table 2 shows samples having a high concentration of total coliforms, potentially indicating poor water quality and a possible presence of fecal contamination. Samples marked as "TFTC" indicate that the coliform count is too numerous to be accurately quantified, implying a very high level of contamination. Samples with specific count

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values provide information about the number of coliforms in terms of CFU per unit volume.Figure 2 gives the Total coliform counts (CFU/ml) of reservoir water samples from Mairi Kuwait; TFTC = Too Few to Count; dashed line denotes WHO permissible limit (zero coliforms/100 ml).

Table 2: Total coliform Count

S/N	Number of Factor	Number of Count	CFU
1.	10^5	TFTC	-
2.	10^5	33	$33x10^{-5}$
3.	10^5	TFTC	-
4	10^5	62	$62x10^{-5}$
5.	10^5	48	$48x10^{-5}$
6.	10^5	TFTC	-
7.	10^5	TFTC	-
8.	10^5	30	$30x10^{-5}$
9.	10^5	TFTC	-
10.	10^5	40	$40x10^{-5}$

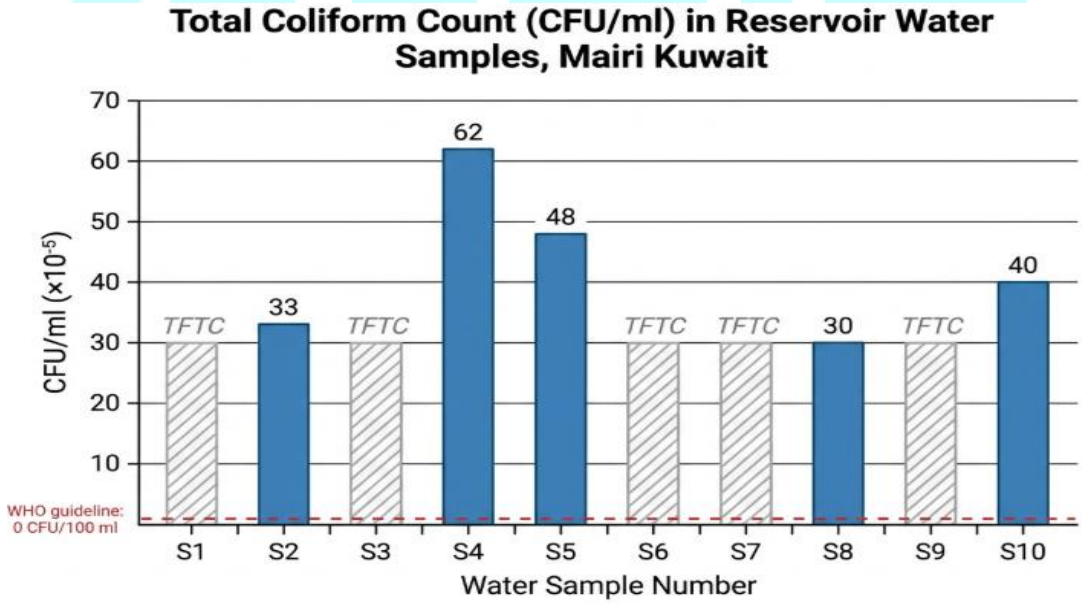

Figure 2. *Total coliform counts (CFU/ml) of reservoir water samples from Mairi Kuwait; TFTC = Too Few to Count; dashed line denotes WHO permissible limit (zero coliforms/100 ml).*

Data source: WHO Guidelines for Drinking-Water Quality, 3rd ed. (WHO, 2004).

As seen in Table 3, table below provides insights into the microbial population in each sample. Complex growth patterns, excessively high counts, and numerous counts that cannot be accurately quantified suggest variations in microbial loads among the samples,

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with some potentially indicating high microbial contamination.Figure 3 presents the pH values of reservoir water samples from Mairi Kuwait compared to WHO recommended drinking water pH range (6.5–8.5). Values below 6.5 are associated with potential health risks including acidosis and enhanced heavy metal toxicity.

Table 3: Total Viable Count

S/N	Number of factors	Number of counts	CFU/ml
1.	10^4 10^5	75 53	$3.0x10^{-5}$
2.	10^4 10^5	Complex growth 81	$81X10^{-5}$
3.	10^4 10^5	51 TFTC	$51X10^{-5}$
4.	10^4 10^5	Complex growth Complex growth	-
5.	10^4 10^5	TNTC 97	$97X10^{-5}$
6.	10^4 10^5	64 38	$22x10^{-5}$
7	10^4 10^5	38 41	$41X10^{-5}$
8.	10^4 10^5	TFTC Complex growth	$48x10^{-5}$ -
9.	10^4 10^5	48	$32x10^{-5}$
10.	10^4 10^5	TNTC 98	- $98X10^{-5}$

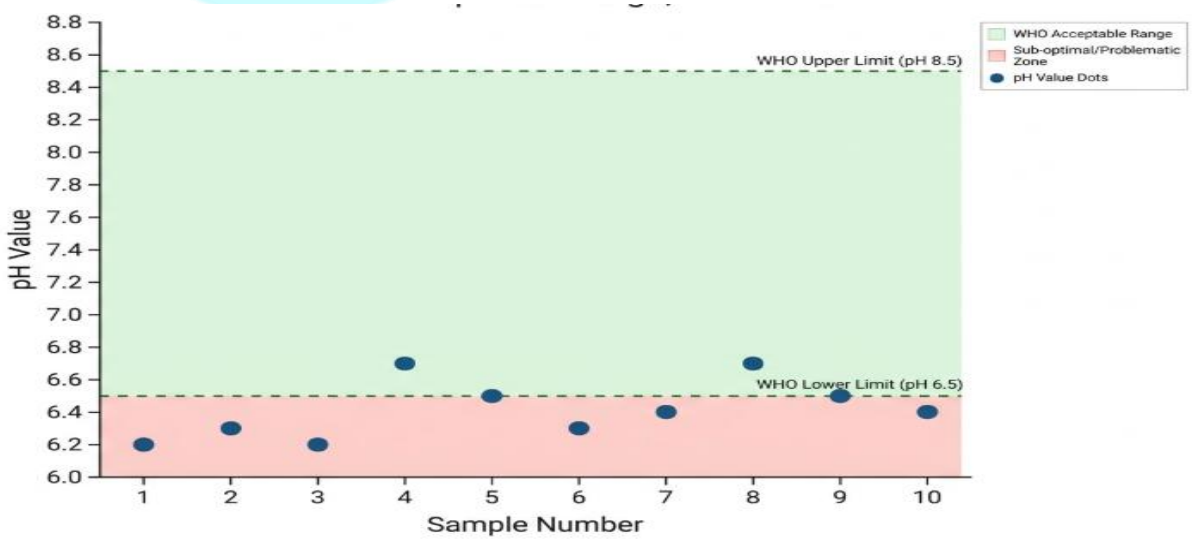

Figure 3. *pH values of reservoir water samples from Mairi Kuwait compared to WHO recommended drinking water pH range (6.5–8.5). Values below 6.5 are associated with potential health risks including acidosis and enhanced heavy metal toxicity.*

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Data sources: WHO Guidelines for Drinking-Water Quality (WHO, 2004); Shittu et al. (2008), *African Journal of Biomedical Research, 11(1):285–290; Hems (1985), Environmental Water Quality Reports*.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS.

Discussion

The pathogenic bacteriological quality of reservoir water in Mairi Kuwait was the central focus of investigation in this study. The study aimed to assess the presence of potentially harmful microorganisms in the reservoir water that could pose a risk to human health. The results obtained from the analysis revealed a diverse range of characteristics in terms of the morphological quality of the water from the Mairi Kuwait reservoirs. The data indicated that the water samples exhibited significant variability in terms of microbial contamination. Specifically, the presence of at least one type of coliform or pathogenic organism was identified, rendering the water unsafe and unsuitable for human consumption. Among the isolated bacteria, *Escherichia coli, Klebsiellapneumoniea, Staphylococcus aureus*, and *Salmonella typhi* were identified. These bacteria have the potential to cause various severe diseases in humans, acting as opportunistic pathogens.

For water to be deemed suitable for human consumption (potable water), it must be devoid of disease-causing organisms or high numbers of non-pathogenic organisms. The results of this study further underlined the correlation between high heterotrophic counts and coliform counts, suggesting the presence of fecal coliforms. The elevated faecal coliform count in one of the samples, could potentially be attributed to its proximity to a pit latrine situated less than the recommended 30 meters distance from a borehole, as recommended by the World Health Organization (WHO). Additionally, the unsanitary environment surrounding the borehole, possibly facilitated by rusty water distribution pipes, could have contributed to the elevated microbial contamination. To gain a comprehensive understanding of the quality of water from different domestic sources, the study explored physico-chemical parameters and conducted bacteriological analyses. These assessments were juxtaposed against the established guidelines set forth by the World Health Organization (WHO) and the Standards Organization of Nigeria (SON) for drinking water quality. The hydrogen ion concentration, or pH, of water emerged as a pivotal parameter influencing both chemical reactions and biological activities. The pH values recorded for

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tap water samples revealed a slightly acidic trend, consistent with the acceptable range of 6.5–8.5 set by the WHO. This finding aligns with the observations of Shittu et al. (2008), who identified a similar pH range for water intended for drinking and recreational purposes in Abeokuta, Nigeria. However, values below 6.5 were flagged as potentially problematic due to the associated health concerns, such as acidosis infections. Furthermore, the low pH was found to intensify the toxic effects of heavy metals in water bodies.

The pH value ranged of 6.2–6.7 (6.40 ± 0.11) indicating that the borehole water is slightly acidic. However, it falls within the range of pH of 5.5–9.0 of natural waters (Hems, 1985). The pH value recorded for borehole water are similar with the results of Ogbonna et al. (2010) for various groundwater samples who reported that pH of groundwater could be determined by type of soil and free carbon (IV) oxide level in the water. The fluctuations in optimum pH ranges may result in increase or decrease in the toxicity of poisons in water bodies (Okonko et al. 2008). Well water had pH values varying between 6.24-6.40 (6.31 ± 0.03) which fell within stipulated permissible limit of WHO and SON for drinking water. This could be due to fluctuations in the carbon oxide/bicarbonate/carbonate equilibrium and consequently affect the bacterial counts. Brady (1998) reports that similar quality of water is mostly govern by function of the mineralogical and geochemical characteristics of the rocks underlying of that area. Most minerals in rocks are soluble under appropriate geochemical condition and ground water flows screens out most bacteria's through different types of soil layers. Many unseen dissolved minerals and organic constituents are present in ground water in various concentrations. Most are harmless or even beneficial while others are harmful and a few may be highly toxic. Sojobi et al. (2014) attributed the acidic nature to the geological formation of the area. The pH range of 6.24–6.40 and 7.02 to 7.73 observed for reservoir and river water sample in this present study was within the range reported for some Nigerian rivers such as the River Asa (6.8–8.9) (Otobo, 1995) and the River Kaduna (6.4–7.2) (*Samuel et al*. 2015). Similarly, the observed pH values fell within the range of Class II (Acceptable Quality) as classified by Prati et al. (1971). The pH values were slightly acidic and alkaline. The variation of pH ranged observed in the reservoir can be explainable in terms of vegetation decay and higher influx into the basin (Ikhile, 2004; *Tyokumbur et al*. 2002) (Awba stream and Reservoir); *Ikomi et al*. (2003 (River Adofi). However, pH values obtained in surface waterbody could be linked to the

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predominant soil type in the area or possibly to the built-up of organic material from runoff.

Conclusion

The findings of this study emphasized the precarious state of pathogenic bacterial contamination in the reservoir water of Mairi Kuwait. The implications are profound, indicating an urgent need for comprehensive water quality management strategies to mitigate microbial contamination and ensure the health and safety of the local population. These results underscore the critical importance of adhering to international and national water quality standards to safeguard public health and well-being.

Recommendation

This study has observed that the Mairi Kuwait reservoir is not safe for drinking, although it can be safe to drink after boiling. The quantity of the source of water is by no means poor due to the demonstrated contamination by total faecal and non faecal coliforms, an indication of inadequate treatment, caution should be taken by boiling the water and allowing it to cool before consumption.

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