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Overview of Microbiological Quality in Refillable Drinking Water Depots (DAMIU) in Barrang Lompo Island, Makassar City in 2024

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Abstract

BACKGROUND: The high demand for drinking water has driven the popularity of Refilled Drinking Water Station consumption. However, in terms of quality, water from refill stations is not always guaranteed to be clean, as it is at risk of bacterial contamination. AIM: This study aims to identify the presence of pathogenic bacteria in Refilled Drinking Water Station operating on Kodingareng Lompo Island, Barrang Caddi Island, and Lae-Lae Island, Makassar City. METHODS: This research is a quantitative observational study with a descriptive approach. The population of this study was all refill drinking water depots that are actively operating on Barrang Lompo Island, the research sample was based on inclusion criteria. RESULTS: The findings indicate that four out of six Refilled Drinking Water Station across these three islands are contaminated with pathogenic bacteria, specifically total coliform and Escherichia coli (E. coli). Four out of the six Refilled Drinking Water Station were contaminated with total coliform bacteria, with varying bacterial counts ranging from 2 to 243. The Refilled Drinking Water Station with the highest total coliform count was Depot E1, with 243 bacteria, while the Refilled Drinking Water Station with the lowest total coliform count (zero bacteria) were Depot B1 and Depot G1. One out of six Refilled Drinking Water Station was contaminated with E. coli, specifically Depot E1, which had an E. coli count of 11. The four contaminated Refilled Drinking Water Station failed to meet the standards set by Permenkes No. 43 of 2014 regarding building location, depot equipment, and hygiene and sanitation of depot handlers, with feasibility scores below 70%. CONCLUSION: All Refilled Drinking Water Station use bore wells and reverse osmosis for water treatment. However, some Refilled Drinking Water Station remain contaminated with total coliform and E. coli, with factors such as location, equipment, and hygiene and sanitation of Refilled Drinking Water Station handlers contributing to this contamination.

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INTRODUCTION

Water is a basic human need that plays an important role in daily life, including for consumption, cooking and bathing. Water that is safe for consumption must meet health standards to be safe for humans and not cause disease (1). However, there are still many people who do not have access to proper drinking water. According to the UNICEF-WHO report, around 844 million people in the world still use unprotected water sources, while WHO data in 2022 reported that 1.7 billion people consume water contaminated with feces, causing the spread of diarrhea, cholera, typhoid, and other diseases (2).

The need for drinking water continues to increase with an average consumption of 2-2.5 liters per person per day in Indonesia (3). Based on data from the Central Statistics Agency (BPS) shows that household access to clean drinking water increased from 74.95% in 2022 to 78.72% in 2024 (4). People tend to choose refill drinking water because of its more abundant contents, economical prices and easy access, especially in urban areas and large islands such as Sumatra, Java, Kalimantan, Sulawesi, and Papua.1 However, the increase in the number of refill drinking water depots is not always followed by a guarantee that the quality of drinking water produced is adequate according to health standards (5).

The development of refill drinking water faces serious challenges related to the hygiene and quality of the water produced. Many refill drinking water depots do not implement procedures and standards in accordance with Permenkes No. 2 Year 2023, thus increasing the risk of Escherichia coli and Total Coliform bacterial contamination (6). Lack of supervision can lead to people consuming unsafe and health-risky water, especially since drinking water contaminated with feces can cause gastrointestinal infectious diseases (7).

According to WHO in 2022 stated that approximately 505,000 deaths from diarrhea each year are caused by the consumption of unfit water (8).

Barrang Lompo Island is one of the islands in Makassar City. There are limited clean water sources experienced by the islands so that in fulfilling daily drinking water consumption, the community is very dependent on refill drinking water. However, there is no comprehensive data on the quality of drinking water produced by all depots operating on the island. Previous research found that refill drinking water in the islands has the potential to be contaminated with E. coli and Total Coliform due to the influence of sanitation, handler hygiene, and the depot environment (9).

Data from the Barrang Lompo Island Community Health Center (Puskesmas) explains that diarrhea is one of the ten most common diseases that occur every year. In 2024, the number of new cases of diarrhea increased significantly to 143 cases. This surge indicates the presence of recurring risk factors, especially those related to the quality of drinking water consumed by the community. Escherichia coli and total coliform bacterial contamination in refill drinking water is suspected to be one of the main factors in the high incidence of diarrhea, considering that the majority of Barrang Lompo Island residents use Depot Air Minum Isi Ulang (DAMIU) as their main source of drinking water (10).

In line with previous findings, research by Ainun et al. in 2022 showed that refillable drinking water depots in the working area of Puskesmas Antang, Makassar, contained E. coli, indicating a high risk of microbiological contamination (11). Therefore, testing the quality of refillable drinking water must be carried out periodically at least every three months for bacteriological parameters and every six months for chemical parameters in an accredited laboratory (12). However, supervision of refillable drinking water depots on Barrang Lompo Island is still less than optimal, so the safety of drinking water consumed by the community is not fully safe and suitable for consumption.

The purpose of this study was to identify the microbiological quality of refillable drinking water depots (DAMIU) on Barrang Lompo Island, Makassar City, namely Escherichia coli and total coliform bacteria. The results of this study are expected to provide an overview of the level of quality and safety of refill drinking water consumed by the community as well as a basis for increasing supervision and improving the sanitation system of drinking water depots on Barrang Lompo Island.

METHOD

This type of research is quantitative observational with a descriptive approach. Laboratory testing was conducted to identify the presence and number of total Coliform and Escherichia Coli bacteria in refill drinking water depots. This research will be conducted in December 2024 - February 2025 on Barrang Lompo Island, Sangkarrang Islands District, Makassar City and Makassar City Public Health Laboratory Center (BLKM). The population in this study were all refill drinking water depots actively operating on Barrang Lompo Island and the sample of this study was 3 refill drinking water depots that met the inclusion criteria. The observation sheet used was adopted from Permenkes RI No. 43 of 2014 concerning Sanitation Hygiene of Depots.13 If the inspection value reaches 70 or more, then the depot is declared to meet the physical feasibility requirements. If the inspection score is below 70, then the depot is declared not to meet the physical fitness requirements and the depot manager is asked to fix the problematic objects.

Data collection in this study is divided into two types, namely primary data and secondary data. Primary data was obtained directly through laboratory examination of bacteriological counts of refill drinking water depot samples. Meanwhile, secondary data was obtained from related research, literature studies, and information obtained from agencies relevant to this research. The collected data were then processed and presented descriptively. The results of field observations and laboratory examinations are presented in tabular form supplemented with narratives and explanations of the variables studied.

RESULTS AND DISCUSSION

This study was conducted at the Refillable Drinking Water Depot (DAMIU) located on Barrang Lompo Island, Sangkarrang Islands District, Makassar City. Observation of hygiene and sanitation of the depots was conducted at different times with sampling of refill drinking water depots. Water sample examination was conducted at the Makassar City Public Health Laboratory (BLKM). This study aims to identify the

microbiological quality, namely total Coliform and Escherichia coli in the Refillable Drinking Water Depot (DAMIU) on Barrang Lompo Island, Makassar City.

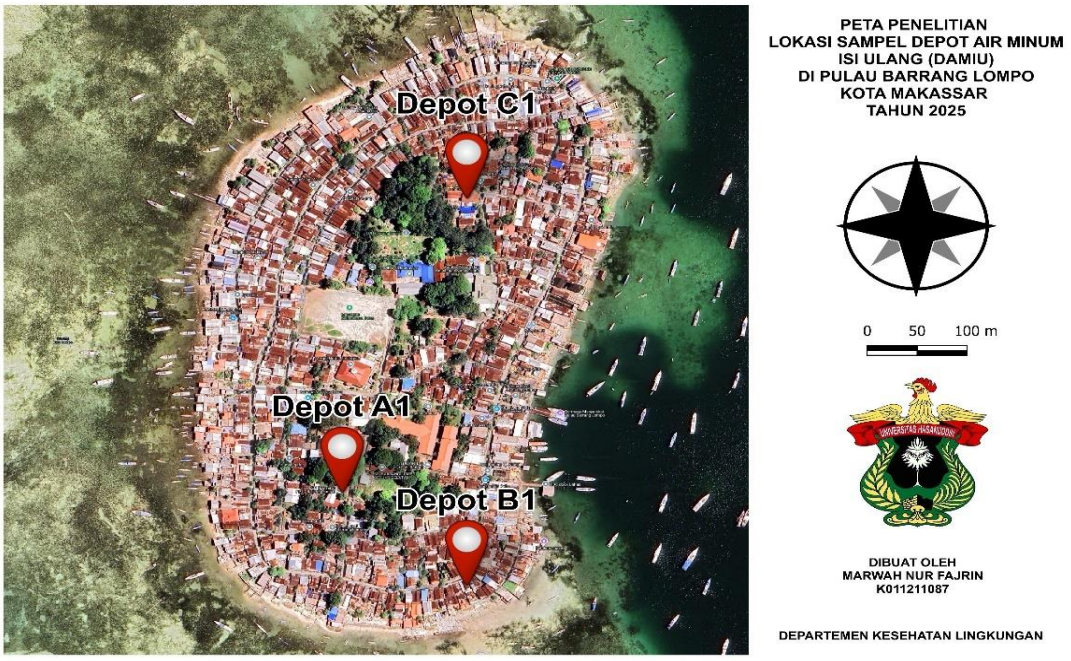

Figure 1.
Map of Sampling Location of Refillable Drinking Water Depots (DAMIU) on Barrang Lompo Island, Makassar City in 2025.

Figure 1 shows the sampling locations of refillable drinking water depots spread across 3 RW of Barrang Lompo Island, namely point A1 in RW 1, Point B1 in RW 2, point C1 in RW 3. This map illustrates the existence of drinking water depots that are still actively operating.

Table 1.
Location and Time of Sampling of Refillable Drinking Water Depots on Barrang Lompo Island, Makassar City in 2025.

No	Sampling Location	Coordinate Point	Sampling Time (WITA)
1	**RW 1 (Depot A1)**	-5.050405 LS 119.3286706 BT	17.25
2	**RW 2 (Depot B1)**	-5.051107 LS 19.329632036 BT	17.11
3	**RW 3 (Depot C1)**	-5.0473074 LS 119.3299193 BT	17.37

Based on table 1, it shows that sampling of refill drinking water depots on Barrang Lompo Island, Makassar City, was carried out in three different locations. Samples were taken from A1 in RW 1 with coordinates -5.050405 N-S and 119.3286706 E at 17:25 WITA. Another sample was obtained from B1 in RW 2 at coordinates -5.051107 N-S and 19.329632036 E at 5:11 pm. Depot C1 in RW 3 has coordinates of -5.0473074 LS and 119.3299193 East with a sampling time of 17.37 WITA. Sampling was conducted at a relatively close time to ensure uniform environmental conditions. Refillable drinking water samples were taken in the afternoon due to the lack of electricity on Barrang Lompo Island.

Table 2.
Bacteriological Quality of Drinking Water based on Escherichia coli Content in Refillable Drinking Water Depots on Barrang Lompo Island in 2025

Depot	Bacteriological Quality of Drinking Water MPN/100ml	
	Escherichia coli	
	Hasil	Kriteria
Depot A1	10	TS
Depot B1	0	MS
Depot C1	130	TS

Based on Table 2, it is known that the results of the analysis of the bacteriological content of DAMIU at the Makassar Public Health Laboratory based on the total content of escherichia coli bacteria, namely 2 out of 3 refill drinking water depots are positive for escherichia coli bacteria. The highest Escherichia coli content was found in depot C1 at 130 CFU/100mL while the lowest Escherichia coli bacteria content was found in depot A1 at 10 CFU/100mL and depot B1 had no Escherichia coli bacteria. Depot B1 met the drinking water quality standard regarding E. coli, while Depot A1 and Depot C1 exceeded the set limit of 0 CFU/100mL. These results indicate that 2 out of 3 depots do not meet the requirements for safe drinking water quality according to the microbiological parameter of Escherichia coli based on Permenkes No. 2 of 2023 which is 0 CFU/100mL. The presence of E. coli in Depot A1 and Depot C1 indicates fecal contamination, which has the potential to pose a health risk to consumers.

Table 3.
Bacteriological Quality of Drinking Water based on Total Coliform Content at Barrang Lompo Island Refillable Drinking Water Depot in 2025.

Depot	Bacteriological Quality of Drinking Water MPN/100ml	
	Total coliform	
	Hasil	Kriteria
Depot A1	41	TS
Depot B1	900	TS
Depot C1	2400	TS

Table 3 shows the results of the analysis of total coliform content in refill drinking water in the three depots exceeded the safe limit. All refill drinking water depots were positive for total coliform. The highest total Coliform content was found in depot C1 at 2,400 CFU/100mL while the lowest total Coliform bacteria content was found in depot A1 at 41 CFU/100mL, while depot B1 was 900 MPN/100ml. These results indicate that the three depots do not meet the requirements for safe drinking water quality according to the total Coliform microbiological parameter based on Permenkes No. 2 of 2023 which is 0 CFU/100mL.

Table 4.
Results of Sanitary Hygiene Observations Based on Raw Water Source, Type of Processing, Depot Location, Depot Equipment, Sanitation Hygiene of Handlers and Raw Water at Barrang Lompo Island Refillable Drinking Water Depot Makassar City in 2025.

No.	Depot Location	Raw Water		Depot Location		Depot Equipment		Handler Hygiene and Sanitation		Raw Water and Drinking Water	
		Source	Treatment	%	MS/ TMS	%	MS/ TMS	%	MS/TMS	%	MS/TMS
1.	Depot A1	Air Sumur Bor	*Reverse Osmosis*	50 %	TMS	72%	MS	71%	MS	16%	TMS
2.	Depot B1	Air Sumur Bor	*Reverse Osmosis*	71 %	MS	72%	MS	71%	MS	16%	TMS

3.	Depot C1	Air Sumur Bor	*Reverse Osmosis*	28 %	TMS	63%	TMS	71%	MS	16%	TMS

Based on Table 4, all refill drinking water depots on Barrang Lompo Island use raw water from boreholes (100%) with Reverse Osmosis (RO) method (100%). However, depot sanitation and hygiene varied. Depot A1 met most indicators, including depot equipment (72%), sanitary hygiene of handlers (71%), but did not meet depot location requirements (50%) and did not meet raw water and drinking water requirements (16%). Depot B1 met the requirements for location (71%), equipment (72%), and sanitary hygiene of handlers (71%), but did not meet the requirements for raw water sources (16%). Depot C1 only qualified on the hygiene and sanitation of the handlers (71%). Overall, none of the depots met all indicators of DAMIU sanitary hygiene, only the hygiene and sanitation of the handler indicators were met by all three depots.

Table 5.
Distribution of Accumulated Hygiene and Sanitation Assessment Results at Refillable Drinking Water Depots (DAMIU) on Barrang Lompo Island in 2025.

No	DAMIU	Total Score	Assessment Result
1	Depot A1	55%	TMS
2	Depot B1	55%	TMS
3	Depot C1	41%	TMS

Description: MS if the examination score reaches 70 or more, TMS if the examination score is below 70 (The calculation method refers to Permenkes RI No.43 Year 2014)

Based on Table 5, the accumulated results of the hygiene and sanitation assessment of DAMIUs on Barrang Lompo Island in 2025, all depots studied obtained Unqualified (TMS) results based on the standards set out in Permenkes RI No. 43/2014. Depot A1 scored 55%, Depot B1 55%, and Depot C1 only reached 41%. All three depots scored below the 70% threshold, which is the eligibility standard for the DAMIU physical requirements category. These results indicate that the hygiene and sanitation conditions at all depots do not meet the required health standards, potentially increasing the risk of contamination of drinking water and thus affecting the quality of drinking water produced.

Safe and quality drinking water is a basic requirement for public health. Depot of Refillable Drinking Water (DAMIU) is the main choice in Indonesia, including in Barrang Lompo Island, Makassar City. This is due to easy access and affordable prices. However, the quality of refill drinking water produced is often contaminated with microorganisms such as Escherichia coli and total Coliform which can be influenced by factors such as raw water source, hygiene and sanitation conditions, equipment, and cleanliness of the handlers. Previous studies found that depot location and equipment were significantly associated with the presence of Coliform bacteria in refill drinking water (14).

The presence of bacteria in refill drinking water is influenced by hygiene and sanitation factors of the depot. Research conducted by Arumsari & Darundiati in 2021 showed a relationship between the sanitary condition of the place and the presence of Escherichia coli bacteria in refill drinking water. However, no significant relationship was found between equipment sanitation and the presence of these bacteria. In addition, the hygiene of water handlers contributed to the level of Escherichia coli contamination in drinking water produced by the depot (15).

The quality of refillable drinking water can be measured based on the number of bacteria contained in it. Poor sanitation risks degrading water quality and negatively affecting public health. One important parameter in the assessment of drinking water quality is the presence of total coliform bacteria and Escherichia coli. Based on the Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023, safe drinking water must be free of both types of bacteria, with a maximum limit of 0 CFU/100 mL (5).

The results of the examination conducted at the Makassar City Environmental Health Laboratory (BLKM) on refill drinking water samples on Barrang Lompo Island showed that depot C1 had the highest E. coli content at 130 CFU/100 mL, and Depot A1 at 10 CFU/100 mL, while Depot B1 did not detect E. coli. While the laboratory results for the examination of the highest total coliform content were also found in Depot

C1 at 2400 CFU/100 mL, and Depot B1 at 900 CFU/100 mL, and Depot A1 at 41 CFU/100 mL. These results indicate that the quality of drinking water produced by DAMIUs on Barrang Lompo Island has not met the drinking water requirements set by Permenkes No. 2 of 2023, namely the number of *E. coli* bacteria and total coliform of 0 CFU/100 mL (5).

The high number of bacteria is caused by several factors, such as the dense population on Barrang Lompo Island, so there is a high possibility of potential pollution from septic tanks built too close to boreholes which can affect the quality of groundwater as a source of raw water for the depot. Septic tank leaks can cause Coliform bacteria contamination. The presence of Coliform bacteria in well water indicates that groundwater has been contaminated by bacteria, viruses or other pathogens.

One of the causes of the presence of pathogenic bacteria in water sources is the high number and density of population. The majority of people use boreholes as a source of clean water, but often do not pay attention to the safe distance between boreholes and septic tanks. The density of settlements means that septic tanks are built too close to boreholes, increasing the potential for contamination of well water with pathogenic bacteria. Septic tank leaks can cause Coliform bacteria contamination. The presence of Coliform bacteria in well water indicates that groundwater has been contaminated by bacteria, viruses or other pathogens (16).

The presence of E. coli and total coliform bacteria in drinking water indicates fecal contamination that increases the risk of diarrhea for the community. The high number of bacteria in the samples is due to the storage of treated drinking water which is then stored in a water storage area that will later be distributed to consumers through a hose that is channeled directly into gallons. The results of field observations show that all depots store water in storage at night due to limited electricity, so that the disinfection process with ultraviolet light can only be done when the electricity is on, namely at night.

The storage of water that has been treated and then accommodated in water storage has the potential to become a source of microbiological contamination in drinking water distributed to the community. Research by Smith et al., 2022 found changes in the microbiological and chemical quality of drinking water stored for a long time, where the number of bacteria increased and the chemical composition of water changed after being stored for more than 24 hours (17). This is also in line with previous research which also found the same thing, where there is an impact of long-term storage of drinking water on public health. The results showed that storage of drinking water for more than 48 hours can increase the risk of bacterial contamination and cause a decrease in water quality (18).

Data from Puskesmas Barrang Lompo Island in 2024, diarrhea is one of the 10 main diseases that occur every year, with an increase of 143 new cases in 2024. This increase indicates the presence of recurrent risk factors, especially related to drinking water quality. Escherichia coli and total coliform bacterial contamination in refill drinking water may be one of the causes of high diarrhea cases, given the large number of people who depend on Depot Air Minum Isi Ulang (DAMIU) as the main source of water.

Based on observations during the study, all depots studied used the same water source, namely borehole wells. Boreholes are the only main water source in the Barrang Lompo Island area due to limited access to other water sources. Boreholes that originate from soil layers close to the surface are vulnerable to pollution from human, animal and household waste (19).

All water depots use the same treatment method, reverse osmosis (RO). Reverse Osmosis (RO) is a water purification method that works by applying pressure higher than osmotic pressure, so that water can pass through a semi-permeable membrane. RO technology has several advantages, including not changing the phase of the separated components, requiring low process temperatures, and not requiring the addition of chemicals or large energy consumption (20).

Factors that influence pathogenic bacterial contamination in the refill drinking water treatment process are poor sanitation and hygiene.21 This is consistent with the results of hygiene and sanitation observations of depots found that none of the depots met the hygiene and sanitation requirements of refill drinking water according to Permenkes No. 43 of 2014. The three depots obtained a final score below 70% from the hygiene and sanitation observation results. This shows that there are still depots that do not meet the requirements for location/building, depot equipment, cleanliness of depot handlers and the source of raw water used. It is likely

that this is one of the factors causing the high number of *E. coli* and total coliform bacteria found in refill drinking water samples.

The hygiene and sanitation of the location of drinking water depots must be free from environmental pollution such as close to landfills, and other places that are suspected of causing pollution (13). The results showed that one depot did not meet the requirements of the hygiene and sanitation aspect of the depot location. This is because the depot location is quite close to the Reuse, Reduce, and Recyle Waste Disposal Site (TPS 3R), so there is a high potential for environmental pollution around the depot location.

Conditions that occur in the field, most depots directly refill into gallons brought by consumers without carrying out the gallon cleaning and sterilization process first. The lack of disinfection using ultraviolet light is due to the limited use of electricity on Barrang Lompo Island, which only functions in the afternoon and evening. Gallons that are not properly sterilized are also a source of contamination.22 The filtration process is the second stage in water purification, which is very important to reduce the number of bacteria to around 98-99% in the resulting water (23).

Obsertion results revealed that one refill depot failed to meet flooring standards due to being non-waterproof, cracked, and rough. Furthermore, two depots did not comply with wall and roof requirements, making them susceptible to contamination. All depots failed to meet spatial layout standards, particularly the separation of processing, storage, and consumer waiting areas, as mandated by the Indonesian Ministry of Health Regulation No. 43 of 2014 (22). None of the depots met the requirements for closed waste bins and handwashing facilities equipped with running water and soap, increasing the risk of contamination from flies. These conditions potentially compromise the hygiene of the refill drinking water. This finding is consistent with a study by Badun (2021), which reported that 73% of drinking water refill stations (DAMIU) in Kendari failed to meet hygiene and sanitation standards, particularly regarding handwashing facilities and waste management (24).

All depots utilized equipment made from food-grade materials that remained in good condition. However, one depot was found to store filled water gallons for more than 24 hours. None of the depots employed reverse washing processes, although they did use tiered microfilters effective for filtration. Ultraviolet sterilization equipment was not functioning optimally across all depots due to electrical limitations, increasing the risk of microbiological contamination in the drinking water (25). The hygiene practices of the depot handlers were also suboptimal, despite all handlers being in good health. Handwashing prior to serving consumers was not practiced, and there was an absence of routine health checks and hygiene-sanitation training. The lack of knowledge and training among handlers was significantly associated with poor hygiene-sanitation practices (26).

Moreover, all depots failed to meet the requirements for raw water transportation and lacked supporting documentation, such as guarantees of water supply and raw water certification. Contaminated raw water sources pose a potential risk of pathogenic bacterial contamination in the final drinking water product (27).

Based on Tables 4 and 5, none of the depots met the hygiene and sanitation feasibility standards outlined in the Ministry of Health Regulation No. 43 of 2014, with final scores below 70% (22). This was primarily due to the absence of basic sanitation facilities, including closed waste bins and handwashing facilities at all depots. The hygiene of the handlers also remained a major concern, as none were observed washing their hands before handling gallons. Furthermore, depots did not conduct reverse washing or clean the gallons before filling, and the filling process was not conducted in an enclosed space. Water was dispensed directly into the gallons through hoses connected to the storage tanks. Improper sterilization of the gallons was also identified as a source of contamination (22).

CONCLUSION

This study concludes that all investigated refill drinking water depots failed to meet the safety standards for drinking water quality as stipulated in the Indonesian Ministry of Health Regulation No. 2 of 2023, particularly regarding the presence of Escherichia coli and total coliform bacteria, despite employing reverse osmosis as a treatment method. This finding indicates suboptimal water treatment processes and inadequate sanitation practices within the depots. The hygiene and sanitation conditions of the depots in Barrang Lompo Island also did not meet acceptable physical standards, with final assessment scores below 70%. As a recommendation, this study proposes a Standard Operating Procedure (SOP) for hygiene and sanitation

maintenance across all refill drinking water depots. Depot owners are advised to ensure cleanliness and conduct routine inspections of raw water sources every 3 to 6 months. Furthermore, government authorities should monitor and enforce compliance among depots that fail to meet the drinking water safety standards in accordance with Regulation No. 2 of 2023. Future researchers are encouraged to investigate factors contributing to the presence of pathogenic bacteria in drinking water, as well as the chemical and physical parameters of drinking water and their potential impacts on public health.

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