E. Coli in Drinking Water Sources and the Role of Community Sanitation in Ensuring Water Quality

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Abstract. Safe drinking water is a vital indicator of environmental and public health. However, contamination by pathogenic bacteria such as Escherichia coli (E. coli) remains a challenge in some areas, posing health risks including diarrhea. This research aims to identify the presence of E. coli in various drinking water sources and evaluate the role of community sanitation in maintaining water safety. A descriptive method was employed, involving the analysis of 8 water samples tested for E. coli contamination at the Provincial Health Laboratory of East Kalimantan. Additionally, 185 respondents were surveyed using stratified random sampling to assess sanitation practices. The results showed that 4 out of 8 water samples did not meet bacteriological standards due to E. coli contamination. Nevertheless, more than 90% of respondents practiced good sanitation habits, including handwashing with soap, boiling drinking water, cleaning water containers, and ensuring proper storage. The presence of E. coli in some samples indicates potential weaknesses in water treatment processes at the household or refilling station level. These findings emphasize the need for routine water quality monitoring and improved community education on water safety practices, particularly in water handling, treatment, and storage, to reduce health risks and support public health outcomes.

1 Introduction

Clean and safe drinking water is a basic necessity essential for maintaining public health. In many developing countries, including Indonesia, the issue of drinking water quality remains a major concern due to contamination by pathogenic bacteria such as Escherichia coli (E. coli). E. coli is a common indicator of fecal contamination, signaling serious health risks for communities consuming such water. Drinking water contaminated with E. coli causes gastrointestinal diseases in humans, such as diarrhea. In general, drinking water treatment is an approach related to Community-Led Total Sanitation (CLTS). Community participation, such as community behavior, water treatment, and sanitation, is a crucial factor in providing drinking water that meets health standards. The basic water consumption required for a healthy urban lifestyle is 92 liters per person per day [1]. In 2019, the Indonesian Ministry of Health reported that 33.4 million people across Indondewanataesia were experiencing clean water scarcity, while another 99.7 million people continued to face difficulties in accessing clean water[2]. Alongside the growing demand for safe drinking water due to population growth, new alternatives have emerged, such as bottled drinking water and refillable drinking water. Indonesia initially produced bottled drinking water through an automated process that

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underwent testing before being distributed to the public. As the price of bottled drinking water increased, another alternative emerged: refillable drinking water produced by Refillable Drinking Water Depots (DAMIU) [3].

Water is one of the basic necessities of life on earth. Therefore, the provision of water is one of the most essential needs for humans to survive, and serves as a determining factor in human health and well-being. Human dependence on water makes it extremely important. Drinking water refers to water that can be consumed directly, while DAMIU may be classified as clean water or raw water that requires treatment before being suitable for consumption. DAMIU is considered unsuitable for consumption if its water source is contaminated, its storage facility does not meet hygiene and sanitation standards, or its filtration and disinfection processes rely on outdated technology. Refillable Drinking Water Depots provide a very practical and efficient alternative solution, particularly in urban areas. People prefer to refill their drinking water through refillable drinking water depots, as it is instant and relatively affordable. DAMIU has become the choice of people across major islands in Indonesia. Refillable drinking water depots are businesses engaged in the industrial sector that process raw water into drinking water and then sell it directly to consumers. However, such businesses must be subject to strict supervision to ensure that the drinking water produced meets quality standards and is safe for the community [4].

Water and health are closely linked. While water provides numerous benefits, it can also pose adverse impacts on public health. This occurs when the water used does not meet health standards, thereby becoming a medium for disease transmission. Despite the increasing number of DAMIUs in Indonesia, some still lack proper hygiene and sanitation practices, thus require regular testing for cleanliness and safety. In addition to water quality, the hygiene of food handlers is also a crucial issue in ensuring safe and healthy food and beverage processing. Poor hygiene can act as a vector for disease transmission within communities if not properly monitored.

E. coli bacteria naturally inhabit the large intestine. Their presence can sometimes be beneficial, such as aiding digestion, but they can also be harmful by causing various diseases including urinary tract infections, meningitis, septicemia, diarrhea, and other illnesses [5]. In the Samarinda region, particularly in Lempake, some communities still reside near the river. This area has limited access to clean water, and the quality of the water consumed does not meet the standards for clean water or drinking water. The water quality of the Karang Mumus River in the upstream segment of Lempake meets bacteriological standards at some points, but exceeds the standards at others, particularly in areas with high population density [6]. The community also uses river water for daily needs, resulting in poor environmental hygiene and sanitation.

The limited access to drinking water from the Regional Drinking Water Company has led many people to shift to DAMIU, while some still rely on dug wells to meet their water needs. The total coliform levels in water require monitoring and bacteriological testing, as water quality does not always meet the standards at all times [7]. Based on this, it is necessary to conduct research on the E. coli content in the community drinking water sources of the Lempake area, Samarinda City, to determine whether the available drinking water quality is suitable for consumption and meets health standards.

2 Methods

This research was a quantitative-descriptive research, with samples examined at the Provincial Health Laboratory of East Kalimantan. The laboratory analysis results were adjusted to drinking water quality standards that meet health requirements in the Minister of Health Regulation No. 2 of 2023. Drinking water sampling was carried out using purposive sampling, taking into account drinking water sources that had been treated and were ready

for consumption and widely used in densely populated settlements. A total of 8 drinking water samples were collected, consisting of 3 samples from the Regional Drinking Water Company, 4 samples from DAMIU, and 1 sample from a dug well. The parameter tested was E. coli bacteria. The water sampling procedure involved placing the water samples in sterilized glass bottles.

The role of community sanitation involved 185 respondents. The sample size was determined from a total population of 344 households using the Slovin formula. Respondents were selected using stratified random sampling.

$$n = \frac{N}{1+N \times e2} \qquad (1)$$

Description:

n = sample size

N = population

e = margin of error (5%)

This research was conducted in Lempake Subdistrict, Samarinda, East Kalimantan, specifically in RT (neighborhood unit) 12, 10, 32, 43, 15, and 16, which have relatively large populations, as shown in Figure 1. In several RTs within the Lempake area, the population distribution is uneven.

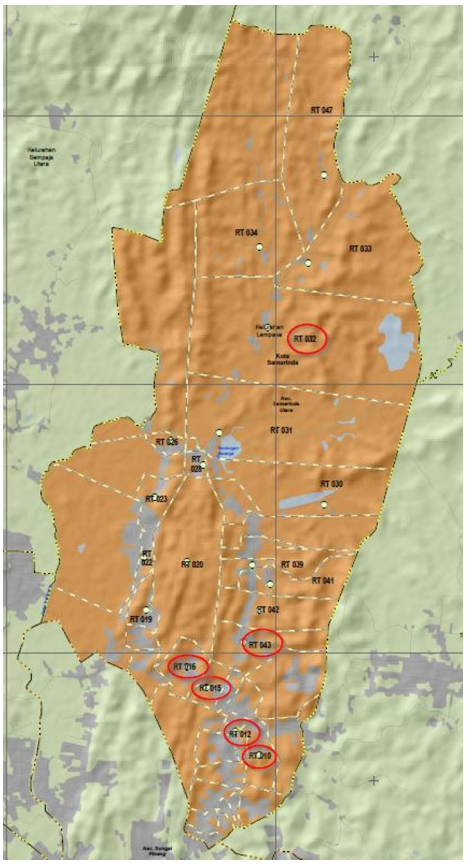

Fig. 1. Sampling Locations in Lempake Subdistrict

3 Results And Discussion

3.1 Drinking Water Quality

The Indonesian government has established drinking water quality standards that comply with health requirements. The microbiological parameter quality standard is the Escherichia Coli bacteria content of 0 CFU/100mL based on the Ministry of Health Regulation No. 2 of 2023 concerning Environmental Health. Escherichia coli bacteria belong to the coliform group, which consist of intestinal bacteria capable of surviving in the human digestive tract. These bacteria are used as an indicator of water quality. The higher the coliform content, the less suitable the water is for consumption. The presence of E. coli bacteria in water sources such as dug wells may also indicate that the well water has been contaminated by feces containing microorganisms that cause diseases related to soil quality. The most common disease resulting from consuming contaminated water is diarrhea. The results of laboratory testing of microbiological parameters in drinking water in the Lempake area, Samarinda, are presented in Table 1.

Table 1. E. Coli Test Results

No	Drinking Water Sample	E-Coli Result	Quality Standards	Remarks
1	RT 12 (Regional Drinking Water Company)	<1.1 MPN/100mL	0 MPN /100 mL	Qualified
2	RT 10 (DAMIU B)	<1.1 MPN/100mL	0 MPN /100 mL	Qualified
3	RT 32 (DAMIU SA)	<1.1 MPN/100mL	0 MPN /100 mL	Qualified
4	RT 43 (Regional Drinking Water Company)	<1.1 MPN/100mL	0 MPN /100 mL	Qualified
5	RT 15 (DAMIU AZ)	3.6 MPN/ 100mL	0 MPN /100 mL	Not Qualified
6	RT 16 (Regional Drinking Water Company)	1.1 MPN/100mL	0 MPN /100 mL	Not Qualified
7	RT 16 (Dug Well)	23 MPN/100mL	0 MPN /100 mL	Not Qualified
8	RT 16 (DAMIU FL)	1.1 MPN/100mL	0 MPN /100 mL	Not Qualified

Based on field data collection and drinking water sample testing from several drinking water sources in the Lempake area of Samarinda, four drinking water sources were found not to meet the required standards. These sources included two Refillable Drinking Water Depots in RT 15 with a test result of 3.6 MPN/100mL and RT 16 with 1.1 MPN/100mL, 1 Regional Drinking Water Company in RT 16 with a test result of 1.1 MPN/100mL, and 1 dug well in RT 16 with a result of 23 MPN/100mL. Based on laboratory test results, it was found that 4 out of all the tested drinking water samples contained E. coli bacteria. Microbiological parameters should not be detected in drinking water, especially in refillable drinking water depots, according to the Ministry of Health Regulation No. 2 of 2023. The water treatment

plant at the Regional Drinking Water Company uses disinfection in the final stage to eliminate bacteria before distribution to consumers. There are several factors that affect the water quality of the Regional Drinking Water Company for bacteriology, especially E. Coli. This indicates possible problems in the treatment process or contamination within the distribution pipelines. To improve water quality, the Regional Drinking Water Company needs to optimize disinfection, regularly monitor chlorine residuals, maintain pipeline infrastructure, and conduct routine microbial testing. By strengthening these efforts, the Regional Drinking Water Company can ensure that the water distributed is not only sufficient in quantity but also safe in quality, thereby reducing the risk of waterborne diseases in the community.

3.2 Sanitation Conditions

Based on the examination results, it was found that samples 1 to 4, originating from the Regional Drinking Water Company and DAMIU water sources, met drinking water quality standards. The water was stored in closed, easy-to-clean containers, with an average cleaning frequency of once a week. Physically, the water appeared clear and odorless. The water treatment process of the Regional Drinking Water Company typically involves a sedimentation stage to remove impurities. Although the water quality is already good, the community is still advised to boil the water until it reaches a rolling boil before consumption to reduce the number of bacteria that may still be present in the water.

In samples 5 to 8, it was found that the water sources used in the Lempake area, originating from several DAMIUs, the Regional Drinking Water Company, and wells, did not meet drinking water standards based on laboratory results for microbiological parameters. Several of these water sources were still unclean, with no designated storage facilities, leading to bacterial contamination, especially E. coli. The biological quality of dug wells is influenced by well construction, sanitation, and the cleanliness of the surrounding environment, as well as the distance between the E. coli contamination source and the well location. The closer the distance, the higher the likelihood of E. coli contamination. A study highlighted how different water treatment processes affect microbial contamination in rural areas and emphasized the importance of effective infrastructure in ensuring safe drinking water [8]. The coliform content in DAMIU in rural areas, such as Sungai Danau Village, showed that out of 5 DAMIU samples, all tested positive. This may be influenced by several factors, including community knowledge and sanitation practices.

The sanitation conditions and community practices in Lempake related to household drinking water provision are presented in Table 2.

Table 2. Community Sanitation Conditions

No.	Sanitation Conditions	Yes		No	
		N	%	N	%
1	Availability of Adequate Handwashing Facilities with Soap	185	100	0	0
2	Always washes hands before eating and after defecating	182	98.38	3	1.62
3	Always treats water before consumption	169	91.35	16	8.65
4	Treated drinking water is stored in tightly closed containers	179	96.76	6	3.24

5	Drinking water containers are cleaned regularly (at least once a week)	185	100	0	0

Based on Table 2, 185 respondents (100%) reported having adequate handwashing facilities with soap. This indicates a very high level of awareness regarding the importance of hand hygiene as a preventive measure against infectious diseases. Adequate and well-maintained handwashing facilities are essential to prevent the spread of germs, particularly in rural communities. In the context of acute airborne epidemics, hand hygiene is an efficient infection prevention and control strategy in the community. Encouraging the people to practice better hand hygiene and expanding access to soap and clean water [9]. A total of 182 respondents (98.38%) reported that they always wash their hands before eating and after defecating. This habit is crucial for maintaining personal hygiene and preventing bacterial contamination of food and hands. Understand the behaviors and norms related to hand hygiene within their communities before implementing handwashing facility interventions very important [10]. Handwashing with soap is recognized as a primary step in reducing the risk of infectious diseases, especially in areas with limited water sources [9]. Following the COVID-19 pandemic, the Lempake community has become accustomed to consistently washing their hands after daily activities and before eating. Furthermore, a total of 169 respondents (91.35%) treated their drinking water before consumption, most commonly by boiling it, regardless of whether it comes from the Regional Drinking Water Company, wells, or DAMIU. Treating water before consumption is an essential step in reducing exposure to pathogenic bacteria and hazardous chemicals. According to a study [11], household-level water treatment is a critical solution in reducing the disease burden associated with poor water quality, particularly in areas lacking access to safe water. The majority of the Lempake community obtain drinking water from DAMIU, while clean water sources include the Regional Drinking Water Company, wells, and in part, rivers. A total of 179 respondents (96.76%) stored their treated drinking water in tightly sealed containers. Storing drinking water in sealed containers helps prevent recontamination from dust, dirt, or insects. Proper water storage is crucial to prevent secondary contamination after treatment [12]. Finally, a total of 185 respondents (100%) reported that they clean their drinking water containers regularly, at least once a week. This practice is important to ensure that no biofilm or dirt adheres to the containers, which may serve as a source of contamination. Regular cleaning of containers is an effective preventive measure to maintain water quality and ensure that it remains safe for consumption [13].

Overall, the community has implemented good sanitation practices in providing and storing food and beverages within households. Improving knowledge, behavior, and hygiene is essential to achieve environmental sanitation, water cleanliness, and healthy living practices in the community [14]. Access to clean water, sanitation, and improving water quality by reducing pollution are among the key targets of Sustainable Development Goals (SDGs) [15]. Community drinking water sources in Lempake are shown in Table 3. The majority of the community (81.52%) obtain their drinking water from DAMIU. Based on this finding, special attention must be given to sanitation and water quality monitoring of DAMIU in the Lempake area to ensure it meets health standards, especially bacteriological standards.

Table 3. Community Drinking Water Sources

No.	Drinking Water Sources	Yes	Percentage (%)
1	DAMIU	150	81.52
2	Regional Drinking Water Company	10	5.43

3	Spring	11	5.98
4	Drilled Well	6	2.72
5	Dug Well	8	4.35
Total		**185**	**100**

The types of illnesses suffered by the Lempake community are seasonal coughs and colds influenced by weather and seasonal changes. The percentage of disease incidence is presented in Figure 2.

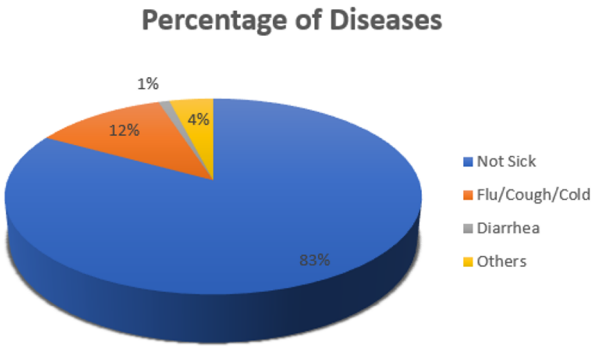

Fig. 2. Percentage of Diseases in Lempake Subdistrict

Most respondents (83%) were in good health or did not experience any illness. This percentage indicates that the majority of respondents have good health conditions, influenced by proper community sanitation practices including handwashing with soap, as well as the provision and safe storage of drinking water. Access to safe drinking water, sanitation, and good hygiene can significantly reduce the burden of infectious diseases in the community [13]. The majority of the community obtain drinking water from DAMIU. Hence, it is necessary for health authorities to monitor DAMIU in terms of water quality, location, equipment, and handlers to protect the community from potential harm or disease resulting from consuming drinking water from refillable water depots. In this context, depot owners play a key role in ensuring safety through proper disinfection processes such as UV or ozone treatment, supported by regular filter replacement, tank cleaning, and periodic water quality testing.

4 Conclusion

Based on the evaluation of sanitation conditions and the laboratory test results for E. coli content in drinking water from Refillable Drinking Water Depots (DAMIU), the Regional Drinking Water Company, and wells, it can be concluded that proper sanitation plays a crucial role in ensuring safe drinking water quality for the community. Of the eight drinking water samples examined, four did not meet health standards. However, the community's sanitation conditions related to the provision and storage of drinking water showed positive results, with more than 90% of respondents having implemented practices in accordance with standards. Nevertheless, compliance with sanitation practices still needs to be continuously improved, thus becoming a sustainable habit, in order to create a clean environment free from disease risks.

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