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Analysis of Sanitation Hygiene and Coliform Bacteria Content in Drinking Water Depots: A Cross-Sectional Study in Jember Regency

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ABSTRACT

Effective Water, Sanitation, and Hygiene (WaSH) management is critical in emergency settings to prevent outbreaks of diarrheal diseases and reduce the total disease burden. Sanitary hygiene of drinking water depots is an effort to control risk factors for contamination from raw water, places, equipment and drinking water depot handlers so that drinking water depot products are safe for consumption. The study aimed to analyze the relationship between sanitary hygiene of drinking water depots to the content of coliform bacteria in drinking water depot products. Research used was the cross-sectional method is analytical descriptive. The sample calculation formula used was Lemeshow, obtaining 80 samples from a population of 432 drinking water depots. Sampling was done using proportional sampling techniques. The variables studied were raw water sanitation hygiene, place, equipment, drinking water depot handlers and total coliform bacteria. The statistical test uses the Rank Spearmen test to test whether there is a relationship between variables. The results showed that among the 80 drinking water depots, there were 67 (83.4%) drinking water depots that met the requirements for the total amount of coliform and 13 (16.6%) did not meet the requirements for the total amount of coliform. The results of the statistical test showed the significance value of raw water (p=0.000), equipment (p=0.000), handler (p=0.000) and place (p=0.885). The study showed that there was a significant relationship between raw water, equipment and handling of drinking water depots sanitation hygiene with the content of coliform bacteria in drinking water depot products, there was no significant relationship between drinking water depot places sanitation hygiene and coliform bacteria content in drinking water depot products. Further research can add other variables that affect the quality of drinking water depot products.

Keywords: Sanitary Hygiene, Drinking water depot, Coliform, Cross-sectional study

INTRODUCTION

Worldwide, there are 780 million individuals who do not have access to clean water, and nearly 2.5 billion people in developing countries live without adequate sanitation (Agingu, 2020). The availability of sufficient, safe, and accessible drinking water supplies, along with adequate sanitation, are key elements in achieving guaranteed health status (Szálkai, 2019). Drinking water is water that undergoes treatment or, without treatment, meets health standards and can be consumed directly. The most commonly used water source for drinking purposes in households in Indonesia is refillable drinking water (31.1%), followed by protected dug wells (15.9%), drilled wells/pumps (14.1%), piped water (13%), and branded bottled water (10.7%) (Irianto et al., 2020).

As technology advances and societal activities become more intense, people increasingly choose more convenient and economical solutions to meet their drinking water needs by consuming refillable bottled water (Sudiana & Sudirgayasa, 2020). Despite its more economical price, not all drinking water depots can guarantee the quality of their products. Research by Ummah & Adriyani (2019) found that only 27.3% of drinking water depots (DAM) in Ngasem District, Kediri, East Java, met hygiene standards for employees, while 63.6% met sanitation requirements for the surrounding environment. All DAMs had adequate sanitation conditions and equipment. Mila et al. (2020) found that 28 out of 30 refillable drinking water depots in Banyuwangi District, or 93.33%, met cleanliness and sanitation requirements. In contrast, only 2 depots, or 6.67%, did not meet the same standards. Mairizki (2017) found that the quality of refillable drinking water around the University of Islam Riau campus did not meet the requirements for total coliform in all samples. One of the coliform bacteria that poses a potential health risk is Escherichia coli (E. coli), which can cause diarrhea (Zikra et al., 2018). The presence of bacteria in DAMs can be influenced by several factors, including unsanitary equipment, inadequate processing, and the presence of microbes as pollutants in the water source used by refillable water depots (Askrening & Yunus, 2017). Contaminated drinking water, when used in food preparation, can be a source of waterborne diseases by transmitting microorganisms.

Most waterborne diseases are characterized by diarrhea symptoms, involving excessive bowel movements, which often lead to dehydration and can be fatal (Manetu & Karanja, 2021).

Professor John E. Gordon of Harvard University proposed a theory on the onset of diseases in society caused by three main factors: the environment, agents, and hosts (Islam et al., 2021). According to this theory, the community (host) that consumes water from a drinking water depot with varying levels of sanitation hygiene (environment) may experience symptoms of diarrhea, likely due to water contamination, as indicated by the presence of coliform bacteria (agent). Hygiene sanitation in drinking water depots involves efforts to control risk factors for contamination from raw water, the depot location, equipment, and depot handlers (Ministry of Health of the Republic of Indonesia, 2014). Safe drinking water for health must meet environmental health quality standards for drinking water, including microbiological, physical, and chemical parameters (Ministry of Health of the Republic of Indonesia, 2023). Microbiological parameters include total coliform, which is an indicator of water pollution, as the presence of coliform bacteria signals contamination.

In Jember Regency, there are 432 drinking water depots, 84% of which meet hygiene sanitation requirements, while 16% do not meet total coliform microbiological standards. The total number of diarrhea cases in all age groups is 21,699, and there is no certification for hygiene sanitation in drinking water depots (Jember District Health Office, 2023). This study aims to analyze the relationship between the hygiene sanitation of drinking water depots, including raw water, location, equipment, and handlers, and the coliform bacteria content in drinking water depot products.

RESEARCH METHODS

This study uses a quantitative research approach with an analytical observational type and employs a cross-sectional research design (Royanulloh, 2022). The research was conducted at drinking water depots in the Puskesmas (Community Health Centers) across Jember Regency, covering 50 Puskesmas in 2024. The sample criteria used were drinking water depots that were actively serving customers. The sample collection was conducted by environmental sanitation officers from each Puskesmas, with samples sent to the laboratory for examination by the Jember District Health Laboratory. Sampling was carried out using proportional sampling technique, where samples were taken from each designated region/Puskesmas, ensuring the number of samples from each area/Puskesmas was proportional to the total samples taken (Sugiyono, 2017). The sample size calculation used the Lemeshow formula to determine the sample size when the total population could not be precisely determined (Riyanto & Hatmawan, 2020). The sample size calculation resulted in 78.72, which was rounded to 80 drinking water depots.

Data collection was carried out through observation using an observation sheet for the hygiene sanitation of drinking water depots (Ministry of Health of the Republic of Indonesia, 2014). The independent variables studied were the hygiene sanitation of raw water, location, equipment, and depot handlers, while the dependent variable was the total coliform bacteria content. The total coliform bacteria examination was conducted using the fermentation tube method with the unit MPN/100 ml according to SNI 06-4158-1996. Data analysis was performed using univariate and bivariate analysis techniques. Univariate analysis was carried out on each variable used in the study, based on the data obtained from the research results. Bivariate analysis was conducted by correlating the independent variables with the dependent variable used in the study. The results of the observations, which were recorded and analyzed statistically, included normality testing using the Kolmogorov-Smirnov test, followed by the Spearman Rank test to analyze whether the relationship between the variables was significant or not (Amruddin et al., 2022). The study received ethical approval from the Health Research Ethics Committee (KEPK) of the Faculty of Dentistry, University of Jember, under No. 2540/UN25.8/KEPK/DL/2024.

RESULTS AND DISCUSSION

Based on the results of observations and laboratory examinations in Table 1, it was found that the sanitation of raw water in 6 drinking water depots was categorized as poor, 2 depots were categorized as adequate, and 5 depots were categorized as good, with coliform bacteria content not meeting the required standards. Meanwhile, 2 drinking water depots were categorized as poor, and 65 depots were categorized as good, with coliform bacteria content meeting the required standards.

Table 1
Relationship Between Raw Water Sanitation and Coliform Bacteria Content

Raw Water Sanitation	Total Coliform Bacteria Content				Total		*p value*
	Does Not Meet Requirements		Meets Requirements				
	n	%	n	%	n	%	
Poor	6	46.1	2	3.0	8	10.0	0.000
Fair	2	15.4	0	0	2	2.5	
Good	5	38.5	65	97.0	70	87.5	
Total	13	100	67	100	80	100	

The data analysis results indicate a significant relationship between the sanitation of raw water at drinking water depots and the coliform bacteria content in the drinking water depot products, with a p-value of 0.000 < 0.01. In this study, many drinking water depots lacked written proof or certification of the water source. The raw water used by drinking water depots should be sourced from locations with guaranteed quality. If the water source

is of poor quality, it can become contaminated with coliform bacteria, resulting in the presence of coliform bacteria in the drinking water if the production process at the depot is not properly managed.

This study is consistent with Darlan et al. (2022), which found a correlation between the water source and the bacteriological quality in Lombok Tengah Regency. This is further supported by research by Atari et al. (2021), where statistical testing showed a P-value of 0.001, indicating a relationship between the water source at Refillable Drinking Water Depots (DAMIU) and the number of coliform bacteria in refillable drinking water in Pontianak City.

The raw water used by drinking water depots in Jember Regency comes from mountain springs and drilled wells, many of which lack written proof of quality certification. Raw water used in drinking water depots should come from sources with guaranteed quality, meaning it must be protected from chemical and microbiological contamination that can harm health. It must also be regularly tested for physical, chemical, and microbiological parameters. The local government should establish firm policies to ensure compliance with the quality assurance of raw water used by drinking water depots to protect public health.

Based on the observations and laboratory examinations in Table 2, it was found that sanitation at the depot location was categorized as adequate for 1 drinking water depot, and good for 12 depots, with coliform bacteria content not meeting the required standards. Meanwhile, 6 depots were categorized as adequate, and 61 depots were categorized as good, with coliform bacteria content meeting the required standards.

Table 2
Relationship Between Place Sanitation and Coliform Bacteria Content

Place Sanitation	Total Coliform Bacteria Content				Total		*p value*
	Does Not Meet Requirements		Meets Requirements				
	n	%	n	%	n	%	
Fair	1	7.7	6	9.0	7	8.7	0.885
Good	12	92.3	61	91.0	73	91.3	
Total	13	100	67	100	80	100	

The data analysis results show that there is no significant relationship between the sanitation of the depot location and the coliform bacteria content in the drinking water depot products, with a p-value of 0.885 > 0.01. In this study, most of the drinking water depots were found to be in good condition. The coliform bacteria contamination in the drinking water depot products could be caused by other factors such as the condition of the equipment and the hygiene of the handlers, as these factors have direct contact with the drinking water.

Previous research by Virdha Amartya et al. (2023) also found that the relationship between the sanitation of the depot location and coliform bacteria contamination in refillable drinking water depots yielded a p-value of 0.537 > 0.05, indicating no significant relationship between the sanitation of the location and the presence of coliform bacteria in the refillable drinking water. This is further supported by Atari et al. (2021), where no relationship was found between the sanitation hygiene of the depot location and the number of coliform bacteria in refillable drinking water in Pontianak City.

Some drinking water depots in Jember Regency are still located alongside other businesses, such as grocery stores. Although the sanitation of the location is not significantly related to coliform bacteria content, one requirement for depot location sanitation is that it must be free from rats, flies, and cockroaches to prevent contamination of the drinking water. The local government should enforce strict regulations regarding the location requirements for drinking water depots in their operations.

Based on the observations and laboratory examinations in Table 3, it was found that sanitation of equipment in 5 drinking water depots was categorized as adequate, 8 depots as good, with coliform bacteria content not meeting the required standards, while 67 depots were categorized as good, with coliform bacteria content meeting the required standards.

Table 3
Relationship Between Equipment Sanitation and Coliform Bacteria Content

Equipment Sanitation	Total Coliform Bacteria Content				Total		*p value*
	Does Not Meet Requirements		Meets Requirements				
	N	%	N	%	n	%	
Fair	5	38.5	0	0	5	6.2	0.000
Good	8	61.5	67	100	75	93.8	
Total	13	100	67	100	80	100	

The data analysis results show a significant relationship between the sanitation of the equipment at drinking water depots and the coliform bacteria content in the drinking water depot products, with a p-value of 0.000 < 0.01. Observations revealed that many drinking water depots did not carry out a regular reverse washing (back washing) system, did not replace the macro filter tubes, and did not use microfilters, while disinfection equipment was either still in use or past its expiration date. This is consistent with the study by Virdha Amartya et al. (2023), which found a meaningful relationship between equipment sanitation and the presence of coliform bacteria in refillable drinking water. This is due to the fact that sterilization and disinfection equipment at many drinking water depots is not functioning properly or is unfit for use, which means that bacteria in the water source are not killed optimally.

This finding is further supported by Badun (2021), who found a relationship between sanitation of equipment at drinking water depots and the number of coliform and Escherichia coli bacteria in the drinking water at refillable

drinking water depots in Kendari District, with a p-value of 0.014 (p-value < 0.05). This is due to the fact that most depot equipment is not functioning properly according to standards, such as using expired microfilters.

In Jember Regency, some drinking water depots were found to have coliform bacteria levels that did not meet the required standards because they did not replace the macro filter tubes, did not use microfilters, and had disinfection equipment that was past its service life. The equipment at drinking water depots is used to treat raw water and turn it into safe drinking water. Drinking water depots must ensure that their equipment remains functional and meets the required standards, including components for collecting raw water, filtration, disinfection, and filling consumer containers. The local government should enact strict policies to regulate depot compliance with the use of proper equipment.

Based on the observations and laboratory examinations in Table 4, it was found that the hygiene of depot handlers was categorized as poor for 1 drinking water depot, adequate for 9 depots, and good for 3 depots, with coliform bacteria content not meeting the required standards. Meanwhile, 6 depots were categorized as adequate, and 61 depots were categorized as good, with coliform bacteria content meeting the required standards.

Table 4
Relationship Between Attendant Hygiene and Coliform Bacteria Content

Attendant Hygiene	Total Coliform Bacteria Content				Total		*p value*
	Does Not Meet Requirements		Meets Requirements				
	n	%	n	%	n	%	
Poor	1	7.7	0	0	1	1.2	0.00
Fair	9	69.2	6	9.0	15	18.8	
Good	3	23.1	61	91.0	64	80.0	
Total	13	100	67	100	80	100	

The data analysis results show a significant relationship between the hygiene of the handlers at drinking water depots and the coliform bacteria content in the depot's drinking water products, with a p-value of 0.000 < 0.01. Many handlers at drinking water depots do not undergo regular health checks at least once a year, nor do they hold certification for completing hygiene and sanitation courses for drinking water depots. This is in line with the findings of Virdha Amartya et al. (2023), which highlighted a meaningful relationship between the hygiene of the handlers and the presence of coliform bacteria in refillable drinking water.

To improve hygiene, practices such as handwashing before starting work should be implemented. This practice has proven to be effective in reducing bacterial contamination, as suggested by Arumsari et al. (2021). This is further supported by research from Atari et al. (2021), which found a relationship between the hygiene of handlers at refillable drinking water depots and the number of coliform bacteria in drinking water in Pontianak City. A significant number of handlers still lack certification for hygiene and sanitation courses, leading to improper handling of equipment in accordance with Indonesian Ministry of Health Regulation No. 43 of 2014.

Observations revealed that there was direct contact during the process of refilling the water into gallon containers, which involved interaction between the worker and the refillable drinking water. A drinking water depot handler must work in a healthy condition, free from infectious diseases, maintain personal cleanliness, always serve customers with washed hands, and refrain from smoking when interacting with customers. In light of this, it is necessary for the District Health Office, in collaboration with the Puskesmas (health centers), to enhance training for handlers and apply stricter hygiene standards for depot workers.

CONCLUSION

Based on the research findings, it can be concluded that some drinking water depots in Jember Regency still do not comply with hygiene and sanitation efforts, and some of their products still contain coliform bacteria. Sanitation of raw water, equipment, and handler hygiene have a significant relationship with the coliform bacteria content in the drinking water depot products. This study will be presented to the Health Department, drinking water depot owners, and the community for follow-up actions, including free hygiene and sanitation training, subsidized laboratory examinations, and regular monitoring by the government, the community, and the depot owners.

SUGGESTIONS

For owners/handlers of drinking water depots, it is recommended that they actively participate in hygiene and sanitation training at the health centers or the local Health Department, and implement hygiene and sanitation measures from the aspects of raw water, premises, equipment, and handlers to maintain product quality, consumer safety, and business continuity.

The local government, through the Health Department, relevant agencies, and health centers, should actively conduct regular inspections, organize free training for depot owners and handlers, provide subsidized laboratory examinations, issue certifications for drinking water depots, and enforce stricter regulations supported by strong local legal foundations in monitoring drinking water depots to safeguard public health.

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