

Research Article

The Relationship Between Hygiene and Sanitation of Refill Drinking Water Depots with *Escherichia coli* and Total Coliform Bacteria Contamination in Drinking Water from Depots in Coblong District, Bandung City

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Abstract

Refill Drinking Water Depots (DAMIU) are popular in Coblong District, Bandung City, due to their lower cost compared to branded bottled water. However, poorly managed DAMIU can produce water that fails to meet health standards as stated in Peraturan Menteri Kesehatan Republik Indonesia No. 2 Tahun 2023, leading to adverse health effects from bacteria such as *Escherichia coli* and total coliforms. This study aims to analyze the relationship between DAMIU place and equipment sanitation as well as operator's hygiene with *E. coli* and total coliform bacteria contamination in DAM water located in Coblong District, Bandung City. There is a strong negative correlation relationship between place sanitation (with p -value=0.011 and ρ =-0.635) and equipment sanitation (p -value=0.017 and ρ =-0.606) with the presence of total coliform bacteria, while handler's hygiene condition (with p -value=0.068 and ρ =-0.483) shows no correlation with the presence of total coliform bacteria. There is no significant correlation found between place sanitation (p -value=0.607 and ρ =0.145), equipment sanitation (p -value=0.250 and ρ =0.317), and handler's hygiene condition (p -value=0.513 and ρ =0.183) with the presence of *E. coli*.

Keywords: drinking water depots (DAM) water, *E. coli*, hygiene, refill drinking water depots (DAMIU), sanitation, total coliform

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1. Introduction

Refill Drinking Water Depots (DAMIU) are popular in Coblong District, Bandung City, due to their lower cost compared to branded bottled water. However, poorly managed DAMIU can produce water that fails to meet health standards, leading to adverse health effects from bacteria such as *Escherichia coli* and total coliforms (Pracoyo, 2006). A 2017 study in Tembalang District showed that 76.6% of DAM water samples did not comply to total coliform standards, and 48.9% tested positive for *E. coli*, which should be which is 0 CFU/100 mL as stated in Peraturan Menteri Kesehatan Republik Indonesia No. 2 Tahun 2023, (Utami et. al., 2017). Another study in Kendari highlighted a strong relationship between sanitation hygiene of place, equipment, and operators with the presence of coliform and *E. coli* bacteria (Badun, 2021). Peraturan Menteri Kesehatan Republik Indonesia No. 43 Tahun 2014 requires hygiene sanitation certificates for drinking water depots to ensure water quality and safety. This study aims to analyze the relationship between DAMIU hygiene and

sanitation and *E. coli* and total coliform bacteria contamination in DAM water located in Coblong District, Bandung.

2. Methodology

The following figure shows the steps of the methodology for this research. Beginning from the data collection to the analysis and discussion.

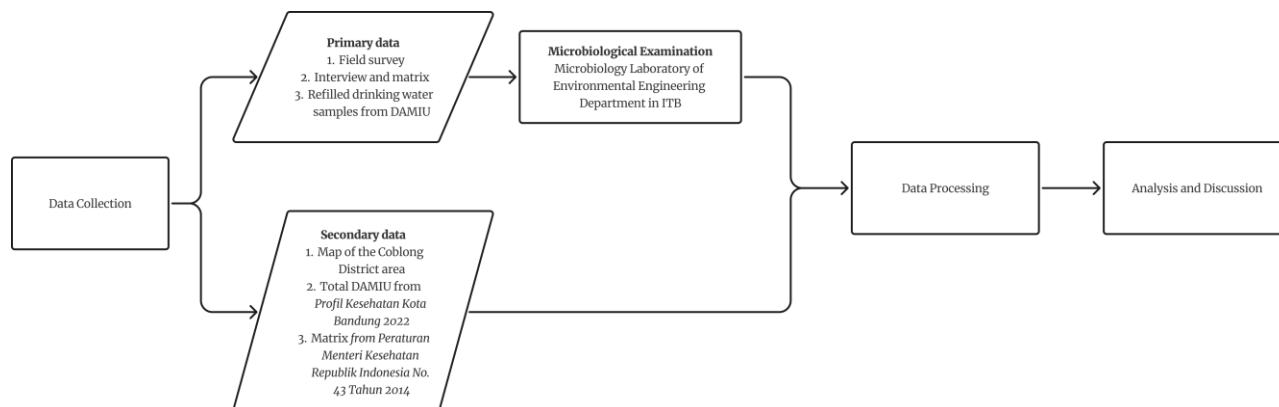


Figure 1. Research methodology flowchart

The sampling technique used in this research is total sampling where the sample size is equal to the population. The population in this study is all drinking water depot businesses in Coblong District. As listed in Profil Kesehatan Kota Bandung Tahun 2022, there are a total of 15 DAMIU. Hence, the number of samples is determined to be the whole population which is 15 DAMIU.

Data collection was done by sampling water, surveying and assessing each depot's place sanitation, equipment sanitation, and operator hygiene, categorized as unsatisfactory if the score is <70% of the total score and satisfactory if the score is $\geq 70\%$ of the total score, using an assessment form from Peraturan Menteri Kesehatan No. 43 tahun 2014 Tentang Higiene Sanitasi Depot Air Minum. Interview is done to obtain a comprehensive data about the equipment maintenance which might help in supporting the analysis part of this research.

Water samples were examined using the Colony Forming Unit (CFU) method membrane filtration technique, referring to APHA 9222 B and was done in Microbiology Laboratory of Environmental Engineering Department in ITB. This research conducted univariate and bivariate analyses using Spearman Rank correlation in SPSS to examine the relationship between place sanitation, equipment sanitation, and operator hygiene with the amount of total coliform bacteria as well as *E. coli* in DAM water. The duration of this research is approximately 6 months long from the month of January-June 2024 in Coblong District, Bandung City.

3. Result and Discussion

3.1 Univariate Analysis

Univariate analysis is the simplest form of statistical analysis, focusing on the examination of a single variable. It involves describing and summarizing the basic characteristics of the variable where the frequency distribution and percentage of each variable will be analyzed. Since the water samples will be taken in duplo from 15 DAMIU, there will be 30 data of microbiological quality but only 15 data for the place, equipment sanitation, and operator's hygiene variables. Only the highest total coliform and *E. coli* count data will be assessed its correlation with each aspect.

1. *Escherichia coli* and Total Coliform Presence

The frequency distribution of *E. coli* and total coliform testing in DAM water in Coblong District is as shown below.

Table 1. Frequency distribution of *E. coli* testing in DAM Water in Coblong District

Description	<i>Escherichia coli</i>		Total Coliform	
	Frequency (Depot)	Percentage (%)	Frequency (Depot)	Percentage (%)
Comply to Standard	11	73.3	0	0
Do Not Comply to Standard	4	26.7	15	100

Based on Table 1, among the 15 DAMIU in Coblong District, there are 11 (73%) depots that have met the standards for *E. coli* bacteria and only 4 (27%) depots that do not meet the standard for *E. coli* bacteria as stated in *Peraturan Menteri Kesehatan Republik Indonesia No. 2 Tahun 2023*, which is 0 CFU/100 mL. Meanwhile, there are 15 DAMIU (100%) that do not meet the standards for total coliform as stated in *Peraturan Menteri Kesehatan Republik Indonesia No. 2 Tahun 2023*, which is also 0 CFU/100 mL.

2. Place sanitation condition

Observations were conducted using visual method on DAMIU, referring to *Peraturan Menteri Kesehatan Republik Indonesia No. 43 Tahun 2014*, covering aspect of place, equipment, and operators. The results of the place sanitation condition observation are presented in the following tables. Visual method is conducted by taking documentations to prevent any conflicts with the DAMIU businesses.

Table 2. Frequency distribution of place sanitation observation results of DAMIU

No	Place aspect	Yes		No	
		f	%	f	%
1.	The location is free from pollution and disease transmission.	10	66.7	5	33.3
2.	The building is strong, safe, easy to clean, and easy to maintain.	12	80.0	3	20.0
3.	The floor is waterproof, has a flat, smooth surface, is non-slip, crack-free, does not absorb dust, and is easy to clean, with a gentle slope.	11	73.3	4	26.7
4.	The walls are waterproof, have a flat, smooth surface, are non-slip, crack-free, do not absorb dust, and are easy to clean, with bright colors.	8	53.3	7	46.7
5.	The roof and ceiling must be strong, rodent-proof, easy to clean, do not absorb dust, have a flat surface, and are brightly colored, with sufficient height.	7	46.7	8	53.3
6.	The layout consists of processing, storage, distribution/provision areas, and a waiting area for visitors/customers.	15	100.0	0	0.0
7.	The lighting is bright enough for working, not dazzling, and evenly distributed.	15	100.0	0	0.0
8.	The ventilation ensures good air circulation/exchange.	15	100.0	0	0.0
9.	The humidity level supports comfort during work/activities.	15	100.0	0	0.0
10.	There is access to bathrooms and toilets.	1	6.7	14	93.3
11.	There is a wastewater drainage system with smooth flow	15	100.0	0	0.0
12.	There is a closed trash bin.	3	20.0	12	80.0
13.	There is a sink equipped with running water and soap.	1	6.7	14	93.3
14.	Free from rats, flies, and cockroaches.	15	100.0	0	0.0

From Table 2, it can be observed that most of the sanitation conditions at the drinking water depots are adequate. However, there are still some deficiencies, such as the lack of access to bathrooms/toilets and a sink equipped with running water and soap in 14 depots (93.3%), as well as the absence of closed trash bin in 12 depots (80.0%).

Table 3. Frequency distribution of place sanitation condition category of DAMIU

Place sanitation	Frequency (Depot)	Percentage (%)
Satisfactory	8	53.3
Unsatisfactory	7	46.7

Table 3 shows that out of 15 DAMIU in Coblong District, the place sanitation at 8 DAMIU (53.3%) is considered satisfactory with a total score of >70% from the assessment form, while the other 7 (46.7%) shows an unsatisfactory result with a total score of <70%.

3. Equipment sanitation condition

The results of the equipment sanitation condition observation are presented in the following tables.

Table 4. Frequency distribution of equipment sanitation observation results of DAMIU

No	Equipment aspect	Yes		No	
		f	%	f	%
1.	The raw water storage tank must be covered and protected.	15	100.0	15	100.0
2.	The container/gallon bottle must be cleaned before filling.	15	100.0	15	100.0
3.	The containers/gallons filled with drinking water must be given directly to consumers and must not be stored at the distribution area for more than 24 hours.	15	100.0	15	100.0
4.	Periodically perform back washing and replace the macro filter cartridge.	8	53.3	8	53.3
5.	There are sterilization devices, such as ultraviolet and/or ozonization and/or other disinfection equipment, that are functional and used correctly.	15	100.0	15	100.0
6.	There are facilities for washing and rinsing bottles (gallons).	15	100.0	15	100.0
7.	There are facilities for filling bottles (gallons) in an enclosed room.	11	73.3	11	73.3
8.	New, clean bottle caps are available.	15	100.0	15	100.0

From the table above, by seeing the frequency of almost all descriptions from the equipment aspect having the number 15 of “Yes”, it can be concluded that almost all DAMIU have fulfilled the equipment sanitation condition. However, point 4 and 7 show that as much as 7 DAMIU (46.7%) do not periodically perform back washing and replace the macro filter cartridge, as well as 4 DAMIU (26.7%) not having an enclosed room for filling the bottles (gallons).

The fact of the DAMIU not performing backwash is confirmed since the operators were unsure when asked about when the filter should be cleaned, and backwash should be performed. Several of these operators seem to not comprehend the term backwash and were taken aback when questioned regarding the frequency of the filters cleaning process in their DAMIU.

Table 5. Frequency distribution of equipment sanitation condition category of DAMIU

Equipment sanitation	Frequency (Depot)	Percentage (%)
Satisfactory	15	100
Unsatisfactory	0	0

The table above shows that despite having 2 points not fulfilled by several DAMIU, all of them (100%) are classified as having a satisfactory results of equipment sanitation condition with total score of >70% from the assessment form.

4. Operator’s hygiene condition

The results of the operator’s hygiene condition observation are presented in the following tables.

Table 6. Frequency distribution of operator’s hygiene observation results of DAMIU

No.	Operators aspect	Yes		No	
		f	%	f	%
1.	Practicing hygiene and sanitation in every customer service interaction.	13	86.7	13	86.7
2	Always washing hands with soap and running water before serving customers.	0	0.0	0	0.0
3.	Wearing clean and neat work attire.	15	100.0	15	100.0
4	Undergoing regular health check-ups at least once a year.	0	0.0	0	0.0
5	The person in charge has a certificate from attending a hygiene and sanitation course for drinking water depots.	2	13.3	2	13.3

According to *Peraturan Menteri Kesehatan Republik Indonesia No. 43 Tahun 2014*, it is obliged for the operator to conduct regular check-ups as a screening for waterborne diseases and own a certificate of having attended a hygiene and sanitation course for drinking water depots as a requirement for applying for a DAM (*Depot Air Minum*) health certificate. From the table above, it can be concluded that the operator’s hygiene in most DAMIU is not in a very satisfying condition. It is seen that all DAMIU (100%) do not have their operators always sanitize their hands by washing them with soap and running water before serving customers and undergo regular health check-ups at least once a year.

Furthermore, out of 15 depots, there are only 2 (13.3%) DAMIU having a person in charge who owns a certificate from attending a hygiene and sanitation course for drinking water depots. These information were obtained by observing the staff’s behaviors when handling the gallons and serving to customers. Interview was also conducted to fill in point 4 and 5 of the assessment form.

Table 7. Frequency distribution of operator’s hygiene condition category of DAMIU

Operator’s hygiene	Frequency (Depot)	Percentage (%)
Satisfactory	0	0
Unsatisfactory	15	100

From Table 7, it is concluded that 15 out 15 (100%) DAMIU are considered unsatisfactory in terms of operator’s hygiene condition, meaning that all depots have a total score <70% on this aspect and the Table 8 is the recapitulation of assessment total score results of each DAMIU on each aspect and the total coliform as well as *E. coli* count.

Table 8. Assessment result total score and *E. coli* and total coliform count

Depots	Place aspect total score	Equipment aspect total score	Operators aspect total score	<i>E. coli</i> (CFU/100ml)	Total colifom (CFU/100ml)
A	86%	100%	33%	0	92
B	79%	90%	58%	0	63
C	57%	85%	33%	0	166
D	57%	75%	33%	6	300
E	93%	100%	33%	0	60
F	43%	85%	33%	0	300
G	79%	100%	33%	0	65
H	57%	75%	33%	0	119

Depots	Place aspect total score	Equipment aspect total score	Operators aspect total score	<i>E. coli</i> (CFU/100ml)	Total colifom (CFU/100ml)
I	71%	90%	33%	0	77
J	57%	100%	33%	0	127
K	79%	100%	42%	4	95
L	64%	85%	33%	0	98
M	50%	100%	33%	0	126
N	79%	85%	17%	9	300
O	71%	85%	33%	3	300

Table 9. Frequency of total coliform and aspects compliance

No.	Variable	Total coliform		Total
		Not comply to standard (f, %)	Comply to standard (f, %)	f, %
1.	Place aspect			
	Satisfactory	8 (53.3)	0 (0.0)	8 (53.3)
	Unsatisfactory	7 (46.7)	0 (0.0)	7 (46.7)
2.	Equipment aspect			
	Satisfactory	15 (100.0)	0 (0.0)	15 (100.0)
	Unsatisfactory	0 (0.0)	0 (0.0)	0 (0.0)
3.	Operators aspect			
	Satisfactory	0 (0.0)	0 (0.0)	0 (0.0)
	Unsatisfactory	15 (100.0)	0 (0.0)	15 (100.0)

The provided data in Table 9 presents an analysis of compliance with total coliform standards across three aspects: place, equipment, and operators. For the place aspect, 53.3% (8 out of 15) were deemed satisfactory and do not meet the standards for total coliform, while 46.7% (7 out of 15) were unsatisfactory also not complying to standards for total coliform. In the case of the equipment aspect, all observations (100%) were satisfactory but not meeting the standards for total coliform. Lastly, for the operators aspect, none of the observations were satisfactory, and all (100%) were unsatisfactory and do not comply to standards.

Table 10. Frequency of *E. coli* and aspects compliance

No.	Variable	<i>Escherichia coli</i>		Total
		Not comply to standard (f, %)	Comply to standard (f, %)	f, %
1.	Place aspect			
	Satisfactory	3 (20.0)	5 (33.3)	8 (53.3)
	Unsatisfactory	1 (6.7)	6 (40.0)	7 (46.7)
2.	Equipment aspect			
	Satisfactory	4 (26.7)	11 (73.3)	15 (100.0)
	Unsatisfactory	0 (0.0)	0 (0.0)	0 (0.0)
3.	Operators aspect			
	Satisfactory	0 (0.0)	0 (0.0)	0 (0.0)
	Unsatisfactory	4 (26.7)	11 (73.3)	15 (100.0)

The provided data in Table 10 presents an analysis of compliance with *E. coli* standards across three aspects: place, equipment, and operators. Out of all samples analyzed, 53.3% (8 out of 15) were classified

as having satisfactory place conditions. Among these, 33.3% (5 out of 15) complied with *Escherichia coli* standards, while 20.0% (3 out of 15) did not meet the compliance criteria. For samples with unsatisfactory place condition, 40.0% (6 out of 15) were compliant and 6.7% (1 out of 15) were not.

As for the equipment aspect, 100% (15 out of 15) were classified as having satisfactory equipment sanitation conditions. Among these, 73.3% (11 out of 15) complied with *Escherichia coli* standards, while 26.7% (4 out of 15) did not meet the compliance criteria. Lastly, for the operators aspect, 100% (15 out of 15) were classified as having unsatisfactory operator's hygiene conditions. Among these, 73.3% (11 out of 15) complied with *Escherichia coli* standards, while 26.7% (4 out of 15) did not meet the compliance criteria.

3.2 Bivariate Analysis

The bivariate analysis is done to know the correlation between place, equipment sanitation and operator's or operator's hygiene with the presence of total coliform and *E. coli* bacteria in DAM water. The analysis is done using the Spearman's Rank correlation test with IBM SPSS Statistics software. The results are as shown below.

Table 11. Bivariate analysis of total coliform and *E. coli* with place, equipment, operators aspect

Variable	Statistics	Place aspect	Equipment aspect	Operators aspect
Total Coliform	Correlation Coefficient (ρ)	-0.635	-0.606	-0.483
	Sig. (2-tailed)	0.011*	0.017*	0.068
	N	15	15	15
<i>E. coli</i>	Correlation Coefficient (ρ)	0.145	-0.317	-0.183
	Sig. (2-tailed)	0.607	0.250	0.513
	N	15	15	15

*: p-value (Sig. 2-tailed) <0.05, correlated

Table 12. Correlation Test results of filter backwash, raw water torrent cleaning, macro filter cartridge replacement frequency and *E.coli* and total coliform presence in DAM Water

Variable	Statistics	Total coliform	<i>E.coli</i>
Filter Backwash Frequency	Correlation Coefficient (ρ)	-0.007	0.328
	Sig. (2-tailed)	0.982	0.233
	N	15	15
Raw Water Torrent Cleaning Frequency	Correlation Coefficient (ρ)	0.140	0.258
	Sig. (2-tailed)	0.618	0.352
	N	15	15
Macro Filter Cartridge Replacement Frequency	Correlation Coefficient (ρ)	0.123	0.346
	Sig. (2-tailed)	0.663	0.206
	N	15	15

1. Place Sanitation and Total Coliform Presence Correlation

As it can be seen from the Table 11, the significance level for this variable is 0.011 ($p < 0.05$), with a correlation coefficient of -0.635, indicating a strong negative correlation between place aspect and compliance with total coliform standards and the number of total coliform in CFU/100ml. This suggests that unsatisfactory place conditions are strongly associated with non-compliance and a high count of total coliform. This result aligns with a previous research conducted by (Badun, 2021) in Kendari stating that there is a strong relationship between place sanitation with a result of significance level of 0.014 and a correlation coefficient of 0.822.

The strong negative correlation from SPSS implies that the higher value of total score of place sanitation condition, the lower the number of total coliform in CFU/100ml. This is proven, by for instance, DAMIU E having a total score for place sanitation condition of 93% and the total coliform count is 60 CFU/100ml while DAMIU F having a total score for place sanitation condition of 43% and the total coliform count from laboratory test is 300 CFU/100ml.

Several factors could explain why a depot with satisfactory place aspect, as seen in Table 10, might still fail to comply with standards for total coliform. These factors might include issues beyond the immediate environment's cleanliness and maintenance, such as operational practices, external contamination sources, and water treatment effectiveness. Contaminated raw water can compromise the quality of the final product regardless of place sanitation and even with good place sanitation, if the water treatment process is insufficient to remove coliform bacteria, the water can still be contaminated.

2. Equipment Sanitation and Total Coliform Presence Correlation

As it can be seen from Table 11, the significance level is 0.017 ($p < 0.05$), with a correlation coefficient of -0.606, indicating a strong negative correlation. This implies that poor equipment conditions will result in a higher number of total coliforms found in water indicating an incompliance to standards. This result is supported by previous research by (Librianti et. al., 2023) in Sukmajaya Sub-district, Depok City, revealing that there is a significant relationship between equipment sanitation conditions and the presence of coliform bacteria with a p-value of 0.001 ($p\text{-value} < 0.05$).

The strong negative correlation from SPSS implies that the higher value of total score of equipment sanitation condition, the lower the number of total coliform in CFU/100ml. This is proven, by for instance, DAMIU E having a total score for equipment sanitation condition of 100% and the total coliform count is 60 CFU/100ml while DAMIU D having a total score for equipment sanitation condition of 75% and the total coliform count from laboratory test is 300 CFU/100ml.

3. Operator's Hygiene and Total Coliform Presence Correlation

As it can be seen from Table 11, the significance level for this variable is 0.068 ($p > 0.05$), with a correlation coefficient of -0.483. Hence, it can be concluded that there is no correlation between the operator's hygiene condition to the incompliance and the number of total coliforms found in the DAM water.

The aforementioned results from this analysis do not reveal an association and is in contrast to a previous study by (Badun, 2021) in Kendari stating that there is a strong relationship between operator's hygiene condition with a result of significance level of 0.003 and a correlation coefficient of 1.000, indicating that there is a correlation between operator sanitation and total coliform levels.

The non-correlated result from SPSS, as illustrated in the output, implies that there is no significant linear relationship between the operator's hygiene condition scores and the total coliform counts in CFU/100ml. This means that changes in the hygiene scores do not consistently predict increases or decreases in coliform levels.

4. Place Sanitation and *E. coli* Presence Correlation

As seen from Table 11, the significance level for this variable is 0.607 ($p > 0.05$), with a correlation coefficient of 0.145. Hence, it can be concluded that there is no correlation between the place sanitation condition to the number of *E. coli* found in the DAM water. Comparing these findings with a study conducted by (Arumsari et. al., 2021) in Sragen Regency, which found no relationship between the sanitation conditions of the place and the presence of *E. coli*, the findings are consistent.

The non-correlated result from SPSS, as illustrated in the output, implies that there is no significant linear relationship between the place sanitation condition scores and the *E. coli* counts in CFU/100ml. This means that changes in the place aspect scores do not consistently predict increases or decreases in *E. coli* levels.

5. Equipment Sanitation and *E. coli* Presence Correlation

As seen from Table 11, the significance level for this variable is 0.250 ($p > 0.05$), with a correlation coefficient of -0.317. Hence, it can be concluded that there is no correlation between the equipment sanitation condition to the number of *E. coli* found in the DAM water. Comparing these findings with a study conducted by (Arumsari et. al., 2021), in Sragen Regency, which also found no relationship between equipment sanitation and *E. coli* presence, reveals consistency in the results.

The non-correlated result from SPSS, as illustrated in the output, implies that there is no significant linear relationship between the equipment sanitation condition scores and the *E. coli* counts in CFU/100ml. This

means that changes in the equipment aspect scores do not consistently predict increases or decreases in *E. coli* levels.

6. Operator's Hygiene and *E. coli* Presence Correlation

As seen from Table 11, the significance level for this variable is 0.513 ($p > 0.05$), with a correlation coefficient of -0.183. Hence, it can be concluded that there is no correlation between the operator's hygiene condition to the number of *E. coli* found in the DAM water. In contrast, a study conducted by (Arumsari et. al., 2021), in Sragen Regency found a significant relationship between the hygiene of depot operators and the presence of *E. coli* in refilled drinking water.

The observed discrepancy between the findings of this study and the Sragen Regency study may be due to additional confounding variables not accounted for in the research. Factors such as the quality of water sources can significantly influence *E. coli* presence. Differences in the quality of water sources, for instance, could result in varying baseline levels of contamination, thereby impacting the relationship between hygiene practices and bacterial presence. Additionally, inadequate water treatment processes, such as insufficient chlorination, filtration, or UV treatment, can result in the failure to eliminate *E. coli* from the water, leading to contamination. Contamination can also occur during the transport and handling of water from the source to the depot if proper sanitary measures are not followed.

7. Interview Results and *E.coli* and Total Coliform Correlation

The correlation analysis between the equipment maintenance frequency to the number of bacteria in DAM waters was done to prove and have potential further analysis as to why the DAMIU having satisfactory place and equipment sanitation condition results not complying to the total coliform and *E.coli* standards stated in *Peraturan Menteri Kesehatan Republik Indonesia No. 2 Tahun 2023*.

However, the results from Table 12 show that there are no correlation between the frequency of a DAMIU doing filter backwash, cleaning raw water torrent, and replacing macro filter cartridge to the number of *E.coli* as well as total coliform in the DAM water as the p-value (Sig. 2-tailed) are all above 0.05. This implies that whether these maintenance activities are conducted more frequently or less frequently, it does not have a significant impact on the presence or absence of these bacteria in the water. This suggests that there could be other factors at play which cause the *E.coli* and total coliform to be present in DAM waters and appear in a relatively high amount, such as the poor raw water quality and the inadequate process of disinfection.

4. Conclusion

The bivariate analysis showed a strong negative correlation relationship between place sanitation (p-value = 0.011 & $\rho = -0.635$) and equipment sanitation (p-value = 0.017 & $\rho = -0.606$) with the presence of total coliform bacteria but showing no correlation with operator's hygiene condition (p-value = 0.068 & $\rho = -0.483$).

For *E. coli*, no significant correlation was found between place sanitation (p-value = 0.607 & $\rho = 0.145$), equipment sanitation (p-value = 0.250 & $\rho = 0.317$), and operator's hygiene condition (p-value = 0.513 & $\rho = 0.183$), with the presence of *E. coli*.

In conclusion, there is a strong negative correlation between place and equipment sanitation with the presence of coliforms in DAM water, while operator hygiene does not. Furthermore, there is no correlation between all aspects with the presence *E. coli* in DAM water.

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