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Analysis of Coliform Bacteria Contamination in Drinking Water Sources in Malang City

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Abstract

This study aims to determine the contamination of coliform bacteria in drinking water sources of residents in Malang City. Type of this research is explorative descriptive research. The study population was all drinking water sources of residents throughout Malang City, while the research sample was 15 residents wells in five subdistricts of Malang City with each sample taken three sample points. The samples were tested using 3M petrifilm E. coli/coliform count plate. The results showed that all the samples studied were contaminated with coliform bacteria with the highest percentage of 23.01% for E. coli bacteria contamination and 15.41% for total coliform bacterial contamination with an average of bacterial colonies > 200 colonies.

1. INTRODUCTION

Water is a very important material in a plant, animal, and human life. The need for clean water, especially consumption water, is increasingly increasing along with the needs and standard of living of the population. Water is a natural resource needed for the lives of many people. One of the water sources that is used by the community is well water that is in a residential neighborhood. Dug wells provide water from soil layers that are relatively close to the soil surface that is susceptible to contamination through seepage from the feces of human, animal, or household waste.

Water quality can be seen through the characteristics of water in accordance with the needs and use of water, for example, drinking water, fisheries, irrigation, industry, recreation, and so on. Water pollution has become a problem in various countries and has the attention of researchers regarding water pollution around the world. scarcity or

difficulty in obtaining clean water that is suitable for use makes problems that arise in various regions. Fulfillment of clean water for residents of a region is a challenge for the government, especially since the presence of clean water is currently a rare item to obtain (Minister of Health, 2010).

Water is very susceptible to bacterial contamination and causes disease (Reed & Rasnake, 2016; Ehrhardt, 2017, et al). Europe, mainly in Germany, Intestinal bacterium was recently recognized as the main cause of incidents of serious illness and human deaths. Intestinal bacteria are primarily transmitted to the environment via feces, and therefore it is of immense importance to monitor the potential fecal contamination of food and water in order to protect human and environmental health. Defining an appropriate fecal indicator among the intestinal bacteria, in particular, coliforms would assist in this process (Paruch & Maehlum, 2012). Diarrheal diseases induced by pathogens are responsible for about 3.4 million deaths worldwide through direct or indirect consumption of contaminated water (WHO, 2012).

In Malang, the number of people using protected excavation wells reached 148,143 people. While residents who use protected excavation wells and meet the requirements reach 63,343 people (Public Office Health of Malang, 2015). We can imagine a lot of dug wells that have not fulfilled the requirements as drinking water sources for the residents of Malang City.

Coliform bacteria are found in aquatic environments, soil, vegetation, and fecal matter. These bacteria inhabit the intestinal tract of both humans and animals. A typical coliform bacterium is characterized as rod-shaped, a gram-negative, nonspore forming lactose fermenter, and includes *Escherichia* sp, *Klebsiella* sp, *Enterobacter* sp, and *Citrobacter* sp (Johnson, 2011). Coliform bacteria are significant because they are fecal indicator bacteria. Environmental Protection Agency and other organizations are often monitored levels of coliforms in the drinking water supply to detect sewage contamination that could be accompanied by fecal pathogens. It is very necessary to do Tempo-spatial controls of total coliform and E. *coli* contamination to maintain the drinking water quality of the residents (Xue, et al., 2018).

Based on government regulation No. 82 of 2001 concerning "Management of Water Quality and Water Pollution Control", Indonesia sets water quality standards. Safe water used for households has a threshold of Coliform 0 MPN/100 ml and E. *coli* 0 MPN/100 ml. To find out whether or not the water is contaminated with coliform bacteria, identification of laboratory microbiology testing needs to be done. Testing Total Plate Number (ALT) or the number of microorganisms contained in water usually uses the MPN test, but over time there are easier and faster methods using Petrifilm Aerobic Count Plate (PACP) (Organization Method 3M, 2000). Using this latest method can increase the time and make it easier to get coliform test results. The purpose of this research is to analysis the contamination of coliform bacteria in drinking water sources in Malang city.

2. MATERIALS AND METHODS

Research Design

This type of research is explorative description research. The study was conducted in November 2017 at the Laboratory of Microbiology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang.

Tools and Materials

The tools used are pipettes, glass bottles, spirits, LAF. The materials used are drinking water samples and 3M Petrifilm E. *coli*/coliform count plate.

Population and Sample

The population in this study is all drinking water sources of residents in Malang City. The sample is the source of drinking water taken from the wells of residents in five subdistricts

of Malang (Kedungkandang, Lowokwaru, Klojen, Blimbing, and Sukun). From each subdistrict, 3 points were taken, so that a total of 15 samples were taken. Control samples are taken from PDAM water and branded mineral water. The sample is then taken to the laboratory for testing.

Coliform Bacteria Testing

Coliform bacteria testing is carried out aseptically at LAF. Taken 1 ml of drinking water sample and then poured it in petrifilm. Incubated at an incubator at 35°C for 24-48 hours. After that, the results are said to be negative if the petrifilm is clean, there is no bubble with red color on the edges or no blue spots. The results are said to be positively polluted if there are coliform bacteria. If there is a bubble accompanied by red on the edges, then the sample is contaminated with total coliform. However, if there are blue spots with bubbles (gas) then the sample is contaminated with *E. Coli* (Interpretation Guide, 2014).

Data Analysis

Data were analyzed using ANOVA to determine differences between samples contaminated with *E. coli* and total coliform. Then the data descriptive analysis was carried out about the content of *E. coli* and total coliform in the samples that had been observed.

3. RESULTS

Observation Result

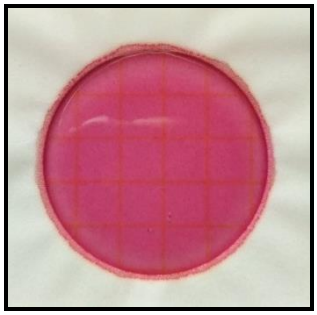

Figure 1 - PDAM Water (Without Coliform)

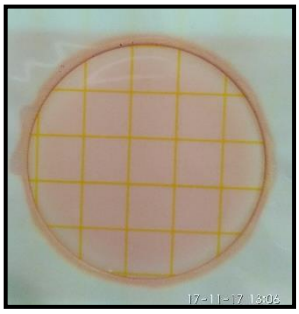

Figure 2 - Mineral Water (Without Coliform)

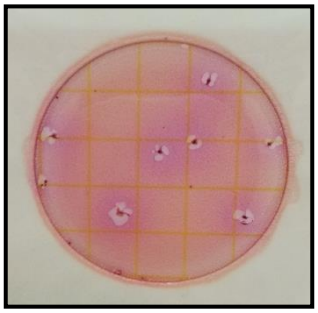

Figure 3 - Well Water (Contaminated with E. coli)

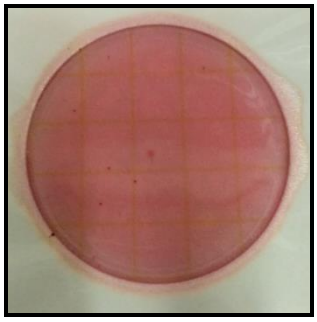

Figure 4 - Well Water (Contaminated with Non Fecal Coliform)

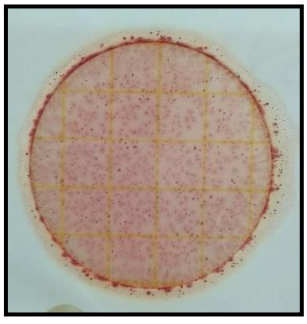

Figure 5 - Well Water (Total Coliforr Contaminated)

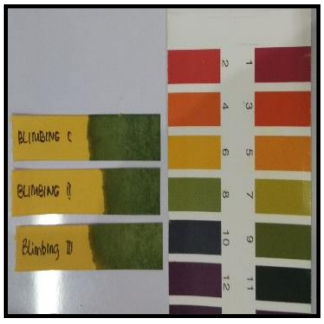

Figure 6 - Measuring pH

Based on the data above (figure 1-6), it can be seen that water contaminated with E. *coli* has the characteristics of a blue colony and is bubbly, while contaminated with coliform is

red and bubbly. Total Coliform is a combination of fecal coliform (E. *coli*) and nonfecal. For the pH value, it can be seen that all water samples have a pH of 8, only one water sample has a pH of 7 is Dinoyo sample.

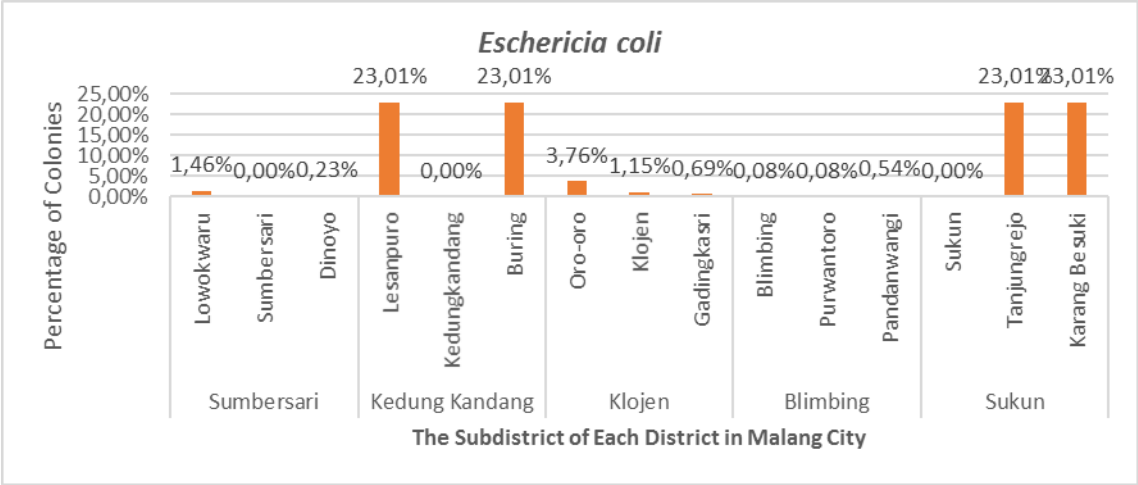

Figure 7 - Graph of Percentage of Escherichia coli Colonies in Each Subdistrict

Based on the data at figure 7 above it can be seen that the well water from Lesanpuro, Buring, Tanjung Rejo, and Karang Besuki has the highest percentage in Malang City with a percentage of 23.01% with a number of colonies ≥ 300. This shows that the subdistrict is heavily contaminated with E. *coli* bacteria. Whereas the lowest percentage is found in Sumbersari, Kedungkandang, and Sukun where no bacterial colonies were observed.

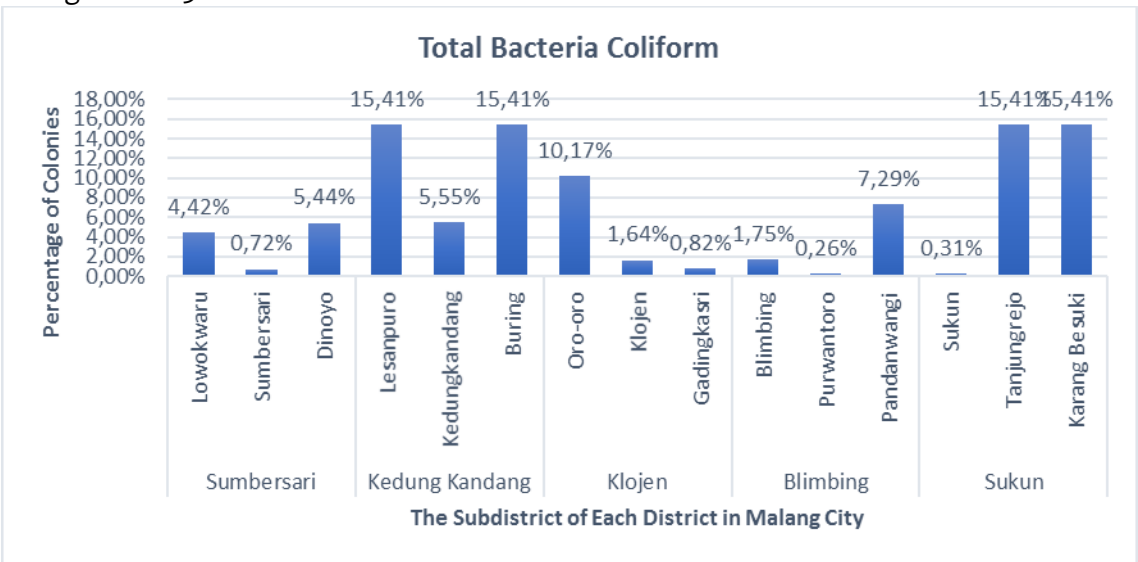

Figure 8 - Graph of Percentage of Total Coliform Colonies for Each Subdistrict

Based on the above data at figure 8, it can be seen that the highest percentage of Total Coliform bacteria is found in Lesanpuro, Buring, Tanjung Rejo, and Karang Besuki with a percentage of 15.41% with the number of bacterial colonies ≥ 300. This shows that the four subdistricts were highly contaminated with total bacteria coliform. While the lowest percentage is found in Purwantoro sample with a percentage of 0.26%

Results of Research Data Analysis

Table 1 - Calculation of *E. coli* colonies

Groups	*Count*	*Sum*	*Average*	*Variance*
Sumbersari	*3*	*22*	*7,333*	*104,333*
Kedungkandang	*3*	*600*	*200*	*30000*
Klojen	*3*	*73*	*24,333*	*465,333*
Blimbing	*3*	*9*	*3*	*12*
Sukun	*3*	*600*	*200*	*30000*

Based on the data above (Table 1), it can be seen that the average number of E. *coli* colonies is highest in the sample water of Kedungkandang and Sukun subdistricts which is 200 colonies. While the sample with the lowest number of colonies is from Blimbing subdistrict with an average number of colonies is 3.

Table 2 - ANOVA Summary Table

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	*128603,6*	*4*	*32150,9*	*2,653*	*0,096*	*3,478*
Within Groups	*121163,33*	*10*	*12116,33*			
Total	*249766,93*	*14*				

Based on the Table 2 above analysis that has been done using ANOVA, it can be seen that $F_{count} < F_{table}$, where 2.653<3.478, so it can be said that there is no difference between the number of E. *coli* colonies found in the observation sample based on differences in sampling locations in 15 subdistricts throughout Malang City.

Table 3 - Calculation of Coliform Bacterial Colonies

Groups	*Count*	*Sum*	*Average*	*Variance*
Sumbersari	*3*	*206*	*68,666*	*2341,333*
Kedungkandang	*3*	*708*	*236*	*12288*
Klojen	*3*	*246*	*82*	*10156*
Blimbing	*3*	*181*	*60,333*	*5212,333*
Sukun	*3*	*606*	*202*	*28812*

Based on the data above (Table 3) it can be seen that the average sample with the total number of coliform bacteria is found in Kedungkandang District with an average of 236 colonies. Whereas for the smallest average sample is in Blimbing District with an average of 60.33 colonies.

Table 4 – ANOVA Summary Table

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	*82017,067*	*4*	*20504,267*	*1,743*	*0,217*	*3,478*
Within Groups	*117619,33*	*10*	*11761,933*			
Total	*199636,4*	*14*				

Based on the analysis that has been done using ANOVA, it can be seen that $F_{count} < F_{table}$, where 1,743 <3,478, so it can be said that there is no difference between the total coliform

number of colonies found in the observation sample based on the different sampling locations in 15 subdistricts in Malang

4. DISCUSSION

The analysis showed that of the 15 water samples there were 13 positive samples containing E. *coli*, which consisted of Lowokwaru, Dinoyo, Lesanpuro, Buring, Oro-oro, Klojen, Gadingkasri, Blimbing, Purwantoro, Pandanwangi, Tanjungrejo, and Karang Besuki. While water samples that do not contain E. *coli* are Sumbersari, Kedungkandang, and Sukun. The highest percentage is in Lesanpuro, Buring, Tanjungrejo, and Karang Besuki villages with a percentage of 23.01%. This same percentage was due to the number of bacterial colonies ≥ 300 colonies in the observation sample. This shows that the water sample is highly contaminated by E. *coli* bacteria in the drinking water of residents. Based on observations made, the factors that cause it are because the residents drinking water sources are very close to a septic tank with a distance of <10 meters. This greatly affects the quality of the drinking water sources of residents in the region. This is consistent with research conducted by Dewi (2015) and Huwaidha (2014), where the distance has a significant relationship to the quality of water sources, the closer the water source to the septic tank, the higher the bacteria content in the water source. Whereas in Sumbersari, Kedungkandang, and Sukun it is known that there is no content of E. *coli* in the observation sample, based on observations made this is because the resident's water source is quite far from the septic tank, and the well used is a borehole with a depth of ≥ 20 meters.

In observing coliform bacteria, it can be seen that water samples in the study sample are Total Coliform bacteria. A Total Coliform is a group of bacteria that is used as an indicator of dirt pollution and conditions that are not good for water, milk and dairy products. The presence of Coliform bacteria in food and drinks. Shows the presence of enteropathogenic or toxigenic microbes that are harmful to health (Suriawiria, 1996). Coliform bacteria can be divided into 2 groups: 1) Fecal coliform, for example, E. *coli*, is a bacteria derived from animal and human feces. The presence of E. *coli* in drinking water, this indicates that drinking water consumed has been contaminated by human feces. 2) Coliform non-fecal example, Enterobacter aerogenes For man drinking water is one of the major needs in view of water as a major factor in the spread of disease, especially in a society, it is the main purpose of clean water or drinking water is to prevent disease carried by water (Suriawira, 1996). In the Total Coliform observation, the intended total coliform is both coliform fecal and nonfecal. And based on observations it can be seen that the highest percentages are in Lesanpuro, Buring, Tanjungrejo, and Karang Besuki with a percentage of 15.4%. Based on observations made, the factors that cause it are because the residents' drinking water sources are very close to a septic tank with a distance of <10 meters. While the lowest subdistrict contains coliform bacteria is Purwantoro sample with a percentage of 0.26%. Based on observations made this is because the residents' water sources are quite far from the septic tank, and the wells used are bore wells with a depth of ≥ 20 meters.

Based on statistical tests using ANOVA (Table 4) it can be seen that in the E. *coli* observation sample, $F_{count} < F_{table}$, where 2.654 <3.478, so there was no difference between the number of E. *coli* colonies found in the observation sample based on differences in sampling locations in 15 subdistricts in Malang. Whereas in the total coliform observation that $F_{count} < F_{table}$, where 1,743 <3,478 with interpretation there is no difference between the number of coliform bacterial colonies found in the observation sample based on differences in sampling locations in 15 subdistricts throughout Malang City. Both analyses show that the conditions of the location are relatively similar to contamination

and there is no difference in bacterial content in the drinking water of the residents.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the results of the study, conclusions among others:

a. Lesanpuro, Buring, Tanjung Rejo and Karang Besuki subdistrict have the highest percentage of *E. coli* bacteria contamination of 23.01%, and 15.41% for the total percentage of coliform bacteria contamination with an average of bacterial colonies ≥ 200.
b. There is no difference between the number of *E. coli* colonies found in the observation sample based on differences in sampling locations in 15 subdistricts in Malang.
c. There is no difference between the total number of coliform bacteria colonies found in the observation sample based on differences in sampling locations in 15 subdistricts in Malang.
d. All subdistrict in Malang are contaminated with total coliform bacteria in the drinking water of residents.

Recommendations

a. It is necessary to conduct counseling for residents to ensure the quality of drinking water used by the community.
b. The community must be more selective in choosing the drinking water to be consumed in order to avoid various diseases
c. Need supervision from relevant agencies on microbial contamination in drinking water by conducting regular checks

6. ACKNOWLEDGMENT

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