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Differences in the reduction of coliform bacteria and escherichia coli with the chlorine diffuser method combined with silica sand in clean water

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ABSTRACT

For all living things, including humans, water is a very important need. Problems that are often found include groundwater or rivers owned by the community that do not meet the criteria to provide clean and safe drinking water. The objective was to determine the difference in the decrease of Coliform and Escherichia coli bacteria by the Chlorine Diffuser method combined with silica sand in clean water for 30, 45, 60 minutes. The method used was a quasi-experiment with a pretest-postest with control design. Samples were taken in one of the wells in the Golilan area. The analysis uses One Way Annova with a sig of 95%. The results showed that there was a difference in the number of Coliform bacteria with a treatment time with a sig value of 0.000, but there was no difference in the number of Escherichia coli bacteria with a treatment time with a sig value of 0.659

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INTRODUCTION

Water is an important necessity of all forms of life, especially humans(Westall & Brack, 2018). Water is also the most important natural resource on earth, accounting for about 70% of the entire world(Dwivedi & Sonawane, 2024)(SAKET, 2022). Regulation of the Minister of Health Number 32 of 2017 regulates water quality norms for sanitation and hygiene. The provision stipulates that the maximum amount of Total Coliform allowed is 50 CFU/100 ml, while the minimum amount of Escherichia coli allowed is 0 CFU/100 ml. There are specific criteria for water used for sanitation and hygiene, and the quality standards for this type of water differ from the drinking water quality standards. Water contaminated by harmful organisms can cause disease or other health problems(Widyawati et al., 2020).

Water pollution both anthropogenic and natural causes including microorganisms such as viruses, protozoa, and bacteria; inorganics such as salts and metals; organic chemical emissions from industrial processes and agricultural use; pesticides and herbicides; and other contaminants(Singh et al., 2020). The problem that exists is that the quality level of groundwater or

rivers when used by the community has not reached the standard like clean water or safe to consume as healthy drinking water(Suryani, 2020)(Djana, 2023)(Hasanah et al., 2023). Drinking water has standard requirements, namely physical, chemical, and bacteriology. Drinking water that is not in accordance with quality standards can cause health problems, dissensification is microorganisms that can cause protozoan and bacterial diseases(Patmawati & Sukmawati, 2019).

In Central Java Province, 75.88% of households already have standard water and drinking water sources, but 24.2% of the population still lacks a decent source of drinking water, referring to the Indonesia Health Profile in 2016. Meanwhile, 44.86% of people in Central Java still choose to use drilled wells or dug wells as the main source of water for household purposes(Jumaida et al., 2020)(Rosiani et al., 2020)(Oktaviarini et al., 2019). Based on the above facts, it is concluded that most of the residents of Central Java still get their daily clean water needs through dug wells. However, due to the population density and the distance between the dug well and the septic tank nearby, the quality of the well water is also affected by population growth in terms of both quantity and density(Kinasih et al., 2023).

According to data from the World Health Organization(Organization, 2022), Diarrhoeal diseases caused by inadequate drinking water quality and poor sanitation are expected to kill 829,000 people annually in 2018 (Word Health Organization, 2019). In Indonesia, the percentage of diarrhoea sufferers who received treatment at all ages was 4,504,513 people in 2018, 62.93%; 4,485,513 in 2019, 61.7%; and 3,252,277 in 2020, 44.4%. Although the number of illnesses due to diarrhea is still relatively high, the data above shows a decrease in the number of diarrhea sufferers who seek treatment at health facilities in 2020(Pratiwi et al., 2022).

Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 states that public baths, swimming pools, aqua solutions, sanitary hygiene requirements, and water health requirements are all covered by this regulation. Water used for activity needs has a different quality for drinking water, therefore it is used for sanitation and hygiene purposes. Water used for daily activities that are of different quality from drinking water is called water for sanitation and hygiene reasons(AQUA, 2017).

Coliform bacteria is a type of bacteria that is used as an indicator of water quality, its presence in the water shows whether the water is clean or not. Escherichia coli bacteria are a type of Coliform bacteria found in the digestive organs of humans and animals(Katon et al., 2020). Escherichia coli and Coliform bacteria are parameters of microorganisms that are usually present in clean water and their presence must be reduced. One way to reduce microorganism contamination by using the Chlorine Diffuser method is with silica sand.

A mineral called silica sand (SiO2) consists of silica crystals and impurities that are transported during the deposition process. These impurity components are often clay, magnesium oxide, and organic matter that remains when animal and plant debris is washed away during the precipitation process(Vegatama et al., 2020). Meanwhile, a chemical called chlorine functions to prevent the growth of pathogenic microbes in the water. These chemicals can be solid, liquid, or gaseous in various forms. Chlorine is used as a powerful oxidant that is good for human health and to remove microorganisms from water as part of the disinfection process(Behzadi et al., 2021).

The Chlorine Diffuser technique uses chlorine and silica sand to prevent and reduce the degree of contamination of Coliform bacteria and Escherichia coli. It is used for water treatment to destroy harmful germs and bacteria. The use of chlorine diffusers has several advantages, such as improving water quality, lowering the risk of contracting waterborne diseases, inexpensive, easy to make and maintain, and replaceable (Patmawati, 2018).

The results of a study on Chlorine Diffuser stated that there was no significant difference in chlorine residue from the various types of Chlorine Diffuser filler materials used, using the longest effective period was ten days, namely the results obtained from Chlorine Diffuser with sand filling materials. The findings of this study are the basis for research on the use of chlorine and sand in the manufacture of the Chlorine Diffuser used(Nurhidayah et al., 2022).

RESEARCH METHOD

The research method used was an experiment with a quasi-experimental design which aimed to determine the difference in the precipitation of Escherichia coli and Coliform bacteria with the Chlorine Diffuser method with treatment for 30 minutes, 45 minutes, and 60 minutes.

The time in this study is 3 stages, namely the first preparation process on March 20-22, 2024, the implementation stage on March 25-27, 2024, and the completion stage on March 28-29, 2024. The subject of the study was dug well water used in boarding house X in the Gonilan area, Kartasura District, Sukoharjo Regency, with a sample of 20 liters. This research was conducted with pretest and postest with control in the laboratory of the University of Muhammadiyah Surakarta.

Tools used are solder, ruler, 3/4inch small pipe, 2inch large pipe, shock, 2inch cap, 3/4inch cap, 3/4 inch drat cap for the manufacture of chlorine diffuser. The materials used are silica sand as much as 870 grams, chlorine 0.2 grams, pipe glue.

The first way to make a tool is to cut a large pipe with a size of 30, the second cut a small pipe with a size of 20 cm, the third cap the end of the pipe using a headpipe and glue as well as a small pipe, to the fourth mix the crushed chlorine with the sand that has been provided, to the fifth input of sand that has been mixed with chlorine in a small pipe, The sixth after that the small pipe is put into the big pipe, to the seven remaining sand is put into the big pipe until the small pipe is closed, the eighth then the big pipe is closed with a lid of drat, to the ninth tool who is used.

RESULTS AND DISCUSSIONS

Result

Univariate Analysis

The results of the analysis carried out on the study of the content of *Coliform* bacteria and *Escherichia coli* throughout the application monitoring period of thirty, forty, and sixty minutes, both before and after treatment with a chlorine dose of 2.5 mg/l are presented in Figure 1. are as follows:

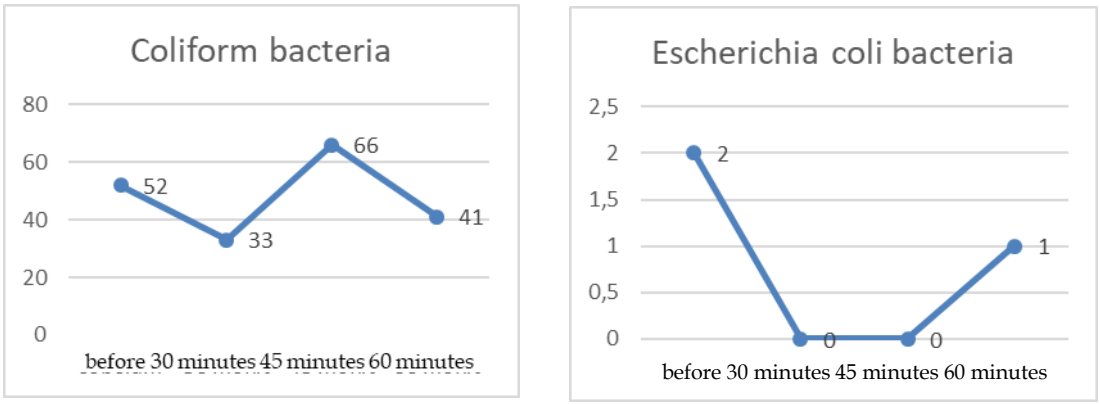

Figure 1. Results of pre-treatment and post-treatment analysis

If *the water coliform* bacteria is above the quality guideline limit, it should not be used for drinking, washing dishes, or maintaining personal hygiene. Based on the Regulation of the Minister of Health 32 of 2017, a sample of 50/100 ml has a maximum total Coliform limit for water used for sanitation and hygiene purposes. The implementation of the study for the use of the first sample dose was in the form of an assessment of the content *of Coliform* bacteria according to the results of the analysis of the number of bacteria in kos x in the control group and after being

treated in the application of the monitoring time before, 30, 45 and 60 minutes with a chlorine dose of 0.2 grams/L, On the contrary, Escherichia coli bacteria are mostly found in soil and water affected by surface water as well as human and animal waste. Based on the results of the examination, a study was carried out on the application of the initial sample dose in the form of analysis of the bacterial content (Escherichia coli) of the number of bacteria in kost x in the control group and after being treated on the application of the monitoring time before, 30, 45 and 60 minutes with a chlorine dose of 0.2 grams/L.

Bivariate Analysis

The results of the analysis of the oneway annova test with a sig of 95% can be seen in the Table. 1 namely:

Table 1. One way annova test

		Sum of Squares	df	Mean Square	F	Sig.
Bakteri *Coliform*	Between Groups	1598.917	3	532.972	20.304	.000
	Within Groups	210.000	8	26.250		
	Total	1808.917	11			
Bakteri *Escherichia coli*	Between Groups	1.667	3	.556	20.304	.659
	Within Groups	8.000	8	1.000		
	Total	9.667	11			

Based on the results of the study, there was a difference in the number of *Coliform bacteria* with a treatment time with a sig value of 0.000, but there was no difference in the number of *Escherichia coli bacteria* with a treatment time with a sig value of 0.659.

Discussion

Life depends on water for survival, therefore all humans need access to a sufficient amount of this essential element (appropriate, safe, and accessible) (Khairudin et al., 2018). The need for clean water in Indonesia continues to increase because along with the increasing growth of the community in meeting the daily needs of (Prayoga & Wulandari, 2024). The availability of clean water is a form of basic need in all countries in the world (Asyfiradayati et al., 2023). Physical, biological and chemical criteria must be met in the form of additional conditions and are necessary for sanitary hygiene. In contrast to optional parameters, which can only be verified if there are indications of pollution, mandatory parameters need to be checked regularly in accordance with relevant laws (Inayatus et al., 2018), as stated in the Regulation of the Minister of Health Number 32 of 2017 related to Water Requirements for Sanitation and Hygiene, Swimming Pools, Aqua Solutions, and Public Baths, as well as Environmental Quality Criteria (Permenkes, 2017).

Humans have always had to deal with pollution, especially water contamination. Water pollution has the potential to pose a health risk to humans with the entry of harmful bacteria, viruses, and other diseases. Although it is difficult to identify bacteria in water, from investigation and detection it can be concluded that fecal contamination is a source of Coliform bacteria and Escherichia coli, which are capable of causing a number of disorders related to water pollution, including diarrhea, dysentery. , and typhoid fever (Nurhidayah et al., 2022).

Diarrhea is often caused by water contaminated with bacteria. Water is essential to human life and is necessary for a high standard of living. An estimated 20 million people die from drinking contaminated water, and 80% of those deaths are children under the age of five. Bacteria and viruses that cause disease easily multiply in dirty water. Diarrhea is one of the infectious diseases that is able to spread through water. Escherichia coli is one of the coliform bacteria that causes most diarrheal diseases. One type of fecal coliform bacteria that is usually found in the human intestine is Escherichia coli. Water contaminated with human and animal feces, known as Escherichia coli, can cause diarrhea, a digestive disease. If there is Escherichia coli in the water, it means that the water is not safe to drink (Sari et al, 2019).

Referring to the results of the research obtained that the results of the analysis **of Figure 1** show the results of *Coliform bacteria* before and after the action. It can be seen that before the treatment of the number of bacteria is 52, while after the treatment with the application time of 30 minutes shows a decrease with the number of bacteria 33, at the application time of 45 minutes there is an increase in the number of bacteria with the number of 66, then at 60 minutes there is a decrease again with the number of bacteria 41. The results of the analysis **in Figure 2** show the results of *Escherichia coli* bacteria before and after treatment. It can be seen before the treatment of the number of bacteria 2, while after the treatment with the application time of 30 minutes shows a significant decrease with the number of bacteria 0 as well as the time of 40 minutes, then at the application time of 60 minutes the bacteria appear with the number of bacteria 1.

The time used in this study includes 0 minutes, 30 minutes, 45 minutes, and 60 minutes. In the test results of Table. 1 shows the results of the OneWay Annova test with a sig of 95% with the result that there is a difference in the number of *Coliform bacteria* with a treatment time with a sig value of 0.000, but there is no difference in the number of *Escherichia coli bacteria* with a treatment time with a sig value of 0.659.

Based on this research, it is shown that 30 minutes of application is an effective time to reduce the number of *Coliform* and *Escherichia coli* (*E. coli*) bacteria in water. *Coliform* bacteria and *Escherichia coli* are often used as indicators of water quality, as their presence can indicate fecal contamination and potential health risks. Then the *Coliform* bacteria before the treatment amounted to 52 CFU/100 ml and after 30 minutes of treatment, the number of *Coliform* bacteria decreased to 33 CFU/100 ml. The decrease from 52 CFU/100 ml to 33 CFU/100 ml after 30 minutes of treatment showed a decrease of 19 CFU/100 ml. It can be interpreted that there is a decrease of about 36.5% in the number of *Coliform* bacteria after 30 minutes of treatment. Likewise, *Escherichia coli* bacteria before treatment amounted to 2 CFU/100 ml and after treatment for 30 minutes, the number of *Escherichia coli* bacteria decreased by 0 CFU/100 ml. This shows that after 30 minutes of treatment, there was a 100% reduction in the number of *Escherichia coli* bacteria, which means that all previously existing *Escherichia coli* bacteria have been eliminated by the treatment. This study refers to the clean water quality standards set by the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017. According to the regulation, the maximum allowable level for the amount of Total *Coliform* is 50 CFU/100 ml, while *Escherichia coli* must be 0 CFU/100 ml in clean water. The results obtained from this study showed that after 30 minutes of treatment, the number of *Coliform* and *Escherichia coli (E. coli*) bacteria was in accordance with the standards set by the Regulation of the Indonesian Minister of Health No. 32 of 2017 (Permenkes, 2017).

In this study, the dose of chlorine used in the treatment was 0.2 grams/L. This dose of chlorine was proven to be effective in reducing the number of *Coliform* bacteria and *Escherichia coli* in clean water within 30 minutes. Chlorine is one of the most commonly used disinfectants in water treatment (EPA, 2019). The use of chlorine to remove bacteria in water is part of the disinfection process and its properties as a powerful oxidizer that is very beneficial for human health (Prasadini et al., 2019). Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 stipulates that clean water suitable for consumption must have a Total *Coliform level* of not more than 50 CFU/100 ml and the level *of Escherichia coli* must be 0 CFU/100 ml. This standard aims to protect public health from the risk of diseases caused by pathogenic bacteria in water. By following these standards, clean water service providers can ensure that the water supplied to the community is safe for consumption. The results of this study showed that after being treated for 30 minutes with a chlorine dose of 0.2 grams/L and combined with silica sand, the amount of *Coliform* bacteria and *Escherichia coli* in clean water was in accordance with the standards set by the Regulation of the Minister of Health. This means that the treated water is safe to consume and free from the risk of contamination by pathogenic bacteria.

Therefore, the use of water management technology is expected to be able to adjust to the condition of local water sources as well as social, cultural, economic, and human resource

conditions. Chlorination is one of the techniques often used in well water treatment to remove Escherichia coli germs and total coliforms. This takes into account the fact that Escherichia coli and total Coliform bacteria can be disinfected quickly and easily using chlorine, making it suitable for treating large amounts of surface water on an ongoing basis. Chlorine is also affordable and widely available in the market. The advantage of adding chlorine gradually using a chlorine diffuser is that the general public can apply it easily, and the chlorine level will gradually decompose and not cause any odor. Silica sand is used as an additional filtration medium, where the combination of chlorine with silica sand provides a dual effect: chlorine acts as a chemical disinfectant, while silica sand provides physical filtration that helps remove particles and bacteria from the water. Silica sand can also help to extend the contact time between chlorine and microorganisms, improving the effectiveness of disinfection (WHO, 2017). The Chlorine Diffuser *method* is one of the effective technologies in clean water treatment, namely chlorination in preventing and overcoming bacterial pollution with total indicators *of Coliform* and *Escherichia coli*. The impact of water pollution caused by bacteria such as *Coliform* and *Escherichia coli* can cause indigestion, especially diarrhea, so *the Chlorine Diffuser* method is effective in reducing the number of these bacteria significantly and is able to improve water quality standards by reducing these contaminations (Patmawati, 2019).

CONCLUSION

Based on the results of the above research, the use of *the Chlorine Diffuser method* with a combination of silica sand and chlorine with an application time of 30 minutes is able to reduce *Coliform* and *Escherichia coli bacteria*. The use of Chlorine Diffuser in clean water treatment can be an effective solution that can be applied in the community. In the results of *the OneWay Annova test* with a sig of 95% with the result there was a difference in the number of *Coliform bacteria* with a treatment time with a sig value of 0.000, but there was no difference in the number of *Escherichia coli bacteria* with a treatment time with a sig value of 0.659. This study refers to the Regulation of the Minister of Health Number 32 of 2017 concerning water health requirements for sanitation and hygiene needs, swimming pools, aqua solutions, and public baths, as well as environmental health quality criteria. For the public, it is recommended to use *the Chlorine Diffuser* as a means of disinfecting bacteria, especially *Coliform* bacteria and *Escherechia coli,* in water storage basins. In order for the research findings to be applied more widely, it is recommended that future researchers who are interested in conducting research choose two or more research locations with different environmental characteristics. In addition, research that seeks to make the design of the Chlorine Diffuser can be carried out to improve its function and appearance.

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