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Analysis of the Content of *Escherichia Coli* in Public Bathing Pools Before and After Using Visitors

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Abstract

BACKGROUND: *Escherichia coli* is a bacterium that commonly causes diarrhea almost all over the world. *E. coli* can grow well on almost all media commonly used to isolate enteric bacteria. *E. coli* bacteria are organisms that generally live in the human digestive tract. *E. coli* bacteria are commonly found in polluted swimming pools, causing its users.

AIM: The aim of this study was to determine the difference in *E. coli* content in swimming pool water in public baths.

METHODS: The method in this study uses a descriptive survey method. The research location is at the Poltekkes Laboratory of the Ministry of Health, Aceh, October to December 2021. Sampling is at one of the natural attractions used for public baths in the Aceh Besar area. The subject of this research is swimming pool water in public baths for children as much as 5 points of 5 L/point, and adults 5 points of 5 L/point; all water taken is 50 L.

RESULTS: The results showed that before visitors bathed in the swimming pool, the number of *E. coli* colonies had a minimal average (12.1) with a deviation of 4.977. The distribution of the number of *E. coli* colonies after 9 h was used by visitors, which had an average *E. coli* colony of 190.9 with a deviation of 30.490 MPN, who received that the intervention also showed that the number of *E. coli* colonies after 9 h was very high, with an average of 159.4 and a deviation of 32.898 MPN.

CONCLUSION: There is a difference in the average content of *E. coli* before and after using public baths by visitors. The number of users of public baths affects the number of microorganisms in the water, such as *E. coli* and Enterococci.

Introduction

Bacterial infection is one of the most important factors causing morbidity and mortality among infectious diseases, including *Escherichia coli*, a Gram-negative bacterium. The economic burden of this bacterial disease due to medical costs and mortality and lost productivity is estimated at $405 million per year [1], [2]. *E. coli* bacteremia is a threat to the global population's health. *E. coli* is a frequent cause of urinary tract infections and has disrupted the health of most of the world's population [3], [4]. *E. coli* is a bacterium that generally causes diarrhea almost all over the world. *E. coli* can grow well on almost all media commonly used to isolate enteric bacteria. Most *E. coli* grow as colonies capable of fermenting lactose and are microaerophilic [4].

E. coli is a Gram-negative bacterium belonging to the Enterobacteriaceae group and is a pathogenic agent in 50% of nosocomial infections. These bacteria are the main cause of UTIs and can cause acute meningitis, pneumonia, intra-abdominal infections, and enteric infections [5]. The cause of UTI by *E. coli* bacteria in Indonesia is 29.8% in men and 70.2% in women with an age range of 18–60 years, 34.3% in children aged 0–12 years, and 50–60% of 10% postmenopausal women experience a UTI at least once every year [6], [7], [8]. In recent years, a strain called *E. coli* O157 has gained prominence for causing foodborne infections, which can have severe health consequences, especially in young children [9]. when found outside the intestinal tract, *E. coli* can cause, among other things, urinary tract infections (UTIs), pneumonia, bacteremia, and peritonitis [10], [11], [12]. *E. coli* bacteria are commonly found in polluted swimming pools, causing illness to its users. The most common disease caused by contamination of polluted ponds is diarrhea, caused by *E. coli* and Giardia bacteria. These bacteria can be serious or even fatal. Pregnant women and children are very susceptible to germs from polluted water. Other dangers of undisinfected pool water include causing wounds, skin infections, ear, and eye infections. One of the swimming pools suspected to be contaminated with *E. coli* bacteria is the MA public swimming pool located in Aceh Besar.

This MA pond water treatment is done manually without using the water treatment method and the recirculating polls type. Based on information from the MA swimming pool visitors in Aceh Besar, Aceh Besar, it is known that the average number of visitors is 162 children and 116 adult visitors. Excess

user capacity can contaminate microorganisms, because there are visitors who urinate and defecate in the pool. Meanwhile, water treatment does not use the water treatment method. *E. coli* bacteria that normally live in the human digestive system will form feces into swimming pool water. Hence, this study aims to determine the difference in the content of *E. coli* in swimming pool water before and after visitors at the MA public baths in Aceh Besar?

Methods

The method in this study used a descriptive survey method. This research design is descriptive, namely, research conducted on a set of objects that aim to see a picture of the phenomena that occurs in a specific population. The survey is descriptive-analytic, namely, to describe and find out the difference in *E. coli* content in the public bathing pool water before and after visitors in one of the areas of Aceh Besar. Research location in Ministry of Health Health Polytechnic Laboratory in Aceh October 2021. A sampling at one of the natural attractions used for public baths in the Aceh Besar area. The subject of this research is swimming pool water in public baths for children as much as 5 points of 5 L/point and 5 points for adults of 5 L/point, all water taken is 50 L.

The sample in this study had several criteria: first, the public bathing pool water was 600 ml before being used by visitors. Second, the public bathing pool water is 600 ml after being used by visitors and has not been processed using Effluent Osmosis. Third, the public bathing pool water is 600 ml after being used by visitors and processed using Effluent Osmosis. The data obtained from the results of research in the laboratory are processed manually through Editing, Coding, and Tabulating. Descriptive data analysis comparing the results with the MPN table to determine the difference in the content of *E. coli* in the public bathing pool water before and after there were visitors and continued with the Dependent Test (intervention).

Results

The number of E. coli in the swimming pool

Based on the results of research on measurements of *E. coli* in swimming pools from 1000 ml of samples taken at ten sampling points statistically shows, the number of MPN *E. coli* is presented in the following table.

Table 1 shows that, before visitors bathed in the swimming pool, the number of *E. coli* colonies had an average of very few (12.1) with a deviation of 4.977 based on the *Most Probable Number* (MPN) measurement. Furthermore, after observing the swimming pool for 9 h, and the swimming pool was filled with visitors who swim, a re-examination of the distribution of *E. coli* colonies was carried out. These results indicate that the distribution of the number of *E. coli* colonies after 9 h of use (visitors swimming) has an average *E. coli* colony of 190.9 with a deviation of 30,490 MPN. Meanwhile, the sample that received the intervention also showed that the number of *E. coli* colonies after 9 h was huge, with an average of 159.4 and a deviation of 32.898 MPN.

Table 1: Distribution of *E. coli* based on observational data in swimming pools

Observation	Minimum	Maximum	Average	Deviation
Before visiting	5	20	12.1	4,977
After 9 h of use by visitors	156	242	190.9	30,490
After 9 h and unique tool intervention	102	218	159.4	32,898

Based on observations, after 9 h of use by visitors, the minimum value is 165 and the maximum is 245. After 9 h and special tools are intervened, the minimum value is 102 and the maximum is 218. Thus, descriptively, the number of colonies can increase to a considerable number after the swimming pool is used by visitors for 9 h. However, the distribution of the number of *E. coli* colonies, on average, can be derived through the Effluent Osmosis model that has been carried out in this study.

Distribution of research data and variables

The data distribution aims to see, whether the data in this study have a good distribution (regular and symmetrical); then, a statistical test was carried out using the *Shapiro–Wilk test*. The test results are presented in Table 2.

Table 2: *E. coli* normality test results based on observational data in swimming pools

Observation data	Average	Deviation	Lower-Upper	p value
Before visiting	12.1	4,977	8.54–15.66	0.794*
After 9 h of use by visitors	190.9	30,490	168.09–212.71	0.352*
After 9 h and unique tool intervention	159.4	32,898	135.87–182.93	0.993*

*Data are normally distributed (p>0.05) at 95% significance level.

Based on the statistical test results of the *Shapiro–Wilk test* (at the 95% significance level, it shows that all observational data have $p > 0.05$. For example, the data on the number of *E. coli* before being visited had $p = 0.794$ ($p > 0.05$), the data after 9 h the swimming pool was used, which also had $p = 0.352$ ($p > 0.05$), and the data after 9 h the swimming pool was used that Effluent Osmosis also had $p = 0.993$ ($p > 0.05$). It was concluded that all the data and observation variables in this study had a fairly good data distribution or were normally distributed and symmetrically well ($p > 0.05$); thus, the assumptions or requirements for the parametric statistical test could be fulfilled.

Table 3: The difference in the number of colonies between before and after visitors use the swimming pool for bathing

Observation of the Number of *E. coli*	Mean ± deviation	Mean difference ± deviation	95%CI lower–upper	p-value
Observation 1				
Amount of *E. coli* before use (8 h) *	12.1 ± 4.977	178.8 ± 26,890	159.6–198.0	0.000
The number of *E. coli* after visitors use (17h)	190.9 ± 30,490			
Observation 2				
Amount of *E. coli* before use (8 h) *	12.1 ± 4.977	147.3 ± 31.990	124.4–170,2	0.000
The number of *E. coli* after visitors use (17 h), and the Effluent Osmosis Model is carried out	159.4 ± 32.898			

The difference in the number of E. coli colonies between before and after visitors use the swimming pool for bathing

In this section, researchers measure the average difference in the content of *E. coli bacteria* in swimming pool water at Taman Rusa Aceh Besar, between before and after visitors use the swimming pool for bathing. The results of the data normality test showed that all the data in this research variable were normally distributed (p > 0.05). Thus, the *Dependent t-test* was able to meet the requirements for testing in answering the research objectives and proving the proposed hypothesis. The results of the statistical analysis are presented in Table 3.

Based on the study results above (Table 3), it is related to the difference in the number of *E. coli* colonies between before and after visitors use the swimming pool. The results showed that there was a difference in the number of *E. coli* colonies between before use (8 h) and after visitors used (17 h) for bathing with the difference in the average *E. coli* colony being 178.8 MPN, with statistical test results obtained p = 0.000 (p < 0.01)). At the 99% significance level, there was a difference in the number of *E. coli* colonies in the swimming pool after visitors used it for bathing. Furthermore, at the 10 sample points used in the Effluent Osmosis Model, there was an average difference in the number of colonies before and after visitors used the swimming pool for bathing. The difference in the average number of *E. coli* colonies reached 147.3 with a deviation of 31.990 MPN, and the results of statistical tests obtained p = 0.000 (p < 0.01). These results show a significant difference in the number of *E. coli* colonies before and after visitors use the swimming pool for bathing.

The effectiveness of the intervention model in reducing the number of E. coli colonies in swimming pools (using TCCA Chlorine)

In general, swimming pools use *TCCA Chlorine* to purify the pool water to keep it healthy and stable. *TCCA Chlorine* is a water purification drug commonly used to keep the chlorine content in water stable. This drug is used to purify swimming pool water so that the pH level is balanced at 7.00–7.60 with a temperature of 250°C. As is known, pH levels in the water that are too low will be acidic and then make metal rust and be harmful to humans. Conversely, pH levels that are too high will foster the development of microorganisms such as algae, algae, and mosses. This study used an Effluent Osmosis Model in reducing the number of *E. coli* colonies. The intervention model is Effluent Osmosis. A comparative test was conducted to measure the effectiveness in reducing the number of *E. coli* colonies in swimming pools that visitors have used for bathing. The results of the data analysis are presented in Table 4.

Table 4: The effectiveness of the intervention model in reducing the number of *E. coli* colonies in swimming pools (using TCCA Chlorine)

Observation of the number of colonies of *E. coli*	Average	Standard deviation	Average difference	95% CI lower–Upper	p-value
The number of *E. coli* after visitors use (17 h), without Intervention	190.9	30,490	31.5	1.69–61.31	0.040
The number of *E. coli* after visitors use (17 h), and the Effluent Osmosis Model is carried out	159.4	32,898			

Based on the results of the study above (Table 4), it can be seen descriptively that the average number of *E. coli* in the swimming pool after 9 h of use by visitors to bathe is greater (190.9 MPN) in the group without intervention, compared to the number of *E. coli* who received an intervention that is only 159.4 MPN. The measurement results showed an average difference in the number of *E. coli* colonies, 31.5 MPN. The results of the *T-Independent* statistical test obtained p-value = 0.040 (p < 0.05). The intervention model that has been carried out has better effectiveness in reducing the number of *E. coli* colonies in swimming pools than using water cleaners such as *TCC Chlorine*.

Discussion

The results showed that before visitors bathed in the swimming pool, the number of *E. coli* colonies had an average of very few (12.1) with a deviation of 4,977. These results indicate that the distribution of the number of *E. coli* colonies after 9 h of use by visitors has an average *E. coli* colony of 190.9 with a deviation of 30.490 MPN. The number of users in public baths can affect the number of microorganisms in the water, such as *E. coli* and Enterococci. The study results that received the intervention also showed that the number of *E. coli* colonies after 9 h was huge, with an average of 159.4 and a deviation of 32.898 MPN. One of the microbiological contamination of swimming pool water can come from dirt contamination from swimmers,

where the presence of dirt contamination will cause high microbiological content in swimming pool water [12].

The use of swimming pools by many visitors causes an increase in the number of germs, MPN coliform, and MPN *E. coli* due to the excretion of feces by visitors for swimming such as urine, saliva, and sweat as well as disturbances to humans, especially diseases related to water, including diarrhea, filariasis, dysentery, and others [13]. The increased rates of resistance to uropathogenic *E. coli* isolates reported worldwide [14], [15] require evaluation of other treatments such as fosfomycin [16]. From the results of this study, it is also known that there are differences before and after visitors use the swimming pool for bathing. The number of *E. coli* colonies between before use (at 8) and after visitors use (17 h) for bathing with an average difference of *E. coli* colonies which are 178.8 MPN, with statistical test results obtained $p = 0.000$ ($p < 0.01$)).

Another factor that affects the absence of *E. coli* bacteria is cleaning the area and swimming pool facilities and the process of draining swimming pool water, which is carried out regularly by pool owners, because a clean environment can help prevent the transmission of infectious diseases through vectors. Other factors that affect the number and ability of bacteriophages are the presence of organic matter, ultraviolet radiation, temperature, pH, salinity, and metabolic activity of non-host bacteria [17], [18], [19]. Several studies have proven this, which state that the activity of bacteriophages in closed areas (septic tanks) has a higher density of bacteriophages than river water but does not reduce the virulence levels of bacteriophages [20]. In addition to fecal contamination by users, another thing that can be a source of contaminants is animal waste around the bathing area. An open bathing area can increase the risk of contamination by bird droppings. Bird droppings can contaminate either directly or carry away by rainwater, increasing the number of bathing water microorganisms, especially *E. coli* and Enterococci [21].

Conclusion

Before visitors bathe in the swimming pool, the number of *E. coli* colonies has an average of very few (12.1) with a deviation of 4.977. The distribution of the number of *E. coli* colonies after 9 h was used by visitors, which had an average *E. coli* colony of 190.9 with a deviation of 30.490 MPN, who received the intervention also showed that the number of *E. coli* colonies after 9 h was very high, with an average of 159.4 and a deviation of 32.898 MPN. The number of users of public baths affects the number of microorganisms in the water, such as *E. coli* and Enterococci.

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