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SPATIAL ANALYSIS OF BACTERIOLOGICAL AND CHEMICAL QUALITY OF REFILL DRINKING WATER IN PALEMBANG

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ABSTRACT

Research by Trisnaini (2013) in Ogan Ilir Regency found that there were 13 depot refill drinking water which water samples were positive for Coliform. Data by the Environmental Health Engineering Center of Palembang on 136 depot found that not all depot were not suitable with the requirements of Ministry of Health Regulations RI Number492/2010. The impact is low drinking water quality that potentially cause diseases. The purpose of this study was to analyze the quality of depot refill drinking water in the city of Palembang based on the parameters of Coliform, Escherecia Coli, and pH. This research used a quantitative design, with a survey method. The research was conducted in the city of Palembang. The research population was 136 depot refill drinking water in the city of Palembang. Sampling was using proportionate stratified random sampling. Based on the results of laboratory tests, it was found that from 36 depot refill drinking water *there were 2 (5.8%) which showed positive results of water samples containing Coliform, 2 (5.8%) which were positive for Escherecia Coli, and most of (91%) water samples examined did not suitable the health requirements on the parameter of pH. It is concluded that most of the water samples from the* depot *refill drinking water studied had met the health requirements based on the parameters of Coliform and Escherecia Coli, but most did not suitable the health requirements for the pH parameter based on the Ministry of Health Regulations RI Number 492/2010.The need for increased supervision of refill drinking water depots*

Keywords: *spatial analysis, water quality, refill drinking water, sanitation hygiene*

ABSTRAK

Penelitian oleh Trisnaini (2013) di Kabupaten Ogan Ilir menemukan bahwa terdapat 13 depot air minum isi ulang (32,5%) yang sampel airnya positif mengandung bakteri *Coliform*. Data hasil uji oleh Balai Teknik Kesehatan Lingkungan Kota Palembang pada 136 unit depot menemukan bahwa tidak semua depot air minum dikelola dengan baik sesuai dengan persyaratan Permenkes Number492/Menkes/Per/IV/2010. Dampaknya adalah rendahnya jaminan kualitas air minum yang berpotensi menimbulkan kerugian bagi kesehatan. Tujuan dari penelitian ini ialah untuk menganalisis kualitas air minum isi ulang yang ada di Kota Palembang berdasarkan parameter kandungan bakteri koliform dan *Escherecia Coli*, serta berdasarkan parameter pH. Penelitian ini merupakan penelitian dengan desain kuantitatif, dengan metode survey. Penelitian dilakukan di Kota Palembang. Populasi penelitian adalah seluruh Depot Air Minum Isi Ulang di Kota Palembang yaitu sebanyak 136. Pengambilan sampel dilakukan menggunakan teknik *proportionate stratified random sampling*. Berdasarkan hasil uji laboratorium, didapatkan bahwa dari 36 depot air minum isi ulang terdapat 2 (5,8%) yang menunjukkan hasil sampel airnya positif mengandung bakteri *Coliform*, 2 (5,8%) yang positif mengandung bakteri *Eschericia Coli*, serta sebagian besar (91%) depot yang diteliti sampel airnya tidak memenuhi syarat kesehatan pada parameter derajat keasaman (pH). Sebagian besar sampel air dari depot air minum isi ulang yang diteliti sudah memenuhi syarat kesehatan berdasarkan parameter kandungan bakteri *Coliform* dan *Escherecia Coli*, namun sebaliknya sebagian besar belum memenuhi syarat kesehatan untuk parameter pH berdasarkan Permenkes Number492/menkes/per/IV/2010. Perlunya peningkatan pengawasan kepada depot air minum isi ulang.

Kata kunci: analisis spasial, kualitas air, air minum isi ulang, higiene sanitasi

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Introduction

Water is a very crucial component for life, especially living things. Daily water needs are different for every future life. Usually, the higher the standard of living of living things, the higher the amount of water needs. Humans need water especially for drinking. Meanwhile, the availability of water, especially fresh water in the world is only about 3% and the other 97% is sea water. Water that can be used to meet human needs is only about 0.3%.[1] Refill drinking water is an alternative option to meet people's need for drinking water.[2] This drinking water can be drunk directly without boiling it first, because it has undergone a purification process either by ultraviolet irradiation, ozonation, or both. In recent years, technological advances in the refill drinking water business have developed rapidly in several cities in Indonesia, including the city of Palembang. Along with this, nowadays refill drinking water depots that provide ready-to-drink water are mushrooming. The community's need for drinking water continues to increase along with population growth, not matched by the availability of clean water. This refill drinking water is one of the answers to meet the needs of the Indonesian people for drinking water that is cheap and practical.[3] However, the fact that there are still drinking water depots that does not meet health quality, it shows that more attention is still needed on the high consumption of refill drinking water, as an example of a study conducted by Khoeriyah. It was showed the result that 75% of drinking water depots those examined did not meet the health requirements, containing Coliform of 3 MPN/100.[1]

The selection of refill drinking water depots as an alternative to meeting drinking water needs is a risk that can endanger health if the quality of refill drinking water is still in doubt, especially if consumers do not pay attention to its safety and hygiene. The quality of water produced by refill drinking water depots has recently been declining with problems in general, including drinking water depot equipment that is not equipped with a sterilizer, has low killing power against bacteria, or employers and employees who do not know the quality of the raw water used, types of good drinking water depot equipment and how to maintain it and handle processed water.[4] The results of Trisnaini's research in Ogan Ilir Regency, South Sumatra in 2018 found that based on laboratory examinations it was found that 13 Refill Drinking Water Depots (32.5%) had positive water samples containing Coliform bacteria.[5] Data from the test results from BTKL Palembang City had 136 Refill Drinking Water Depots units with 10 working areas of health center, but not all drinking water depots were managed properly according to the requirements of Ministry of Health Regulations RI Number 492/menkes/per/IV/2010. Based on Ministry of Health Regulations RI Number 416/1990 concerning the requirements and supervision of the quality of clean water states that the content of Total Coliform bacteria in clean water is 50/100 ml for well

water and 10/100 ml for piped water.[6] Based on *Permenkes* Number 492 of 2010 concerning requirements for the quality of drinking water states that the content of Escherecia Coli bacteria in drinking water is 0/100ml.[7] Various studies have shown that Escherecia Coli bacteria are still found in refill drinking water samples, such as research by Sampulawa who found a water depot containing a total Coliform content of 979/100ml.[3]

Based on the Regulation of Health Ministry Number 492 of 2010 concerning Drinking Water Quality Requirements Article 1 paragraph (1) and (2), paragraph (1) drinking water is water that goes through a processing process or without a processing process that meets health requirements and can be drunk directly, paragraph (2) the organizers of drinking water are state/regional-owned business entities, cooperatives, private business entities, individual businesses, community groups and/or individuals who carry out the organization of drinking water supply. In Article 3 Paragraph 1 also states that: "paragraph (1) drinking is safe for health if it meets the physical, microbiological, chemical and radioactive requirements contained in the mandatory parameters and additional parameters.[8] Therefore, clean water and drinking water must not exceed the specified requirements. The impact was the low-quality assurance of drinking water which has the potential to cause harm to health, for example if drinking water and clean water were contaminated with Escherecia Coli and Total Coliform bacteria which exceed the requirements it will cause diarrhea disease. As an effort to overcome this problem, the first step was to find out the distribution of drinking water quality from refill drinking water depots, one of which was by using a Geographic Information System (GIS) as a system capable of collecting, storing, transforming, displaying, and correlating data. spatial and geographical phenomena, can be used to obtain distribution.[7] The purpose of this study was to determine the distribution of drinking water quality based on bacteriological parameters (Coliform and Escherecia Coli) and chemical parameters (pH) originating from refill drinking water depots using a Geographic Information System (GIS).

Methods

A quantitative design in the terms of survey method was used in this research. The research was conducted in Palembang City. The research population was all Refill Drinking Water Depots (in Indonesia: *Depot Air Minum Isi Ulang* or *DAMIU*) spread across 10 Districts in Palembang City, 136 *DAMIU*.

$$n = \frac{z^2_{1-\alpha/2} P(1-P) N}{d^2 (N-1) + z^2_{1-\alpha/2} P(1-P)}$$

Using the estimation formula, a sample of 32 *DAMIU* was obtained. Selection of the sample using the proportion of random sampling technique. The initial number of stratified sample

members was determined by means of proportionate stratified random sampling by using the proportionate formula:

$$ni = \frac{Ni}{N} \times n$$

DAMIU samples were taken from 10 subdistricts in Palembang City, 3 Reffilable Drinking Water Depots in Alang-Alang Lebar District, 5 *DAMIU* in Basuki Rahmat District, 4 *DAMIU* in Boom Baru District, 2 *DAMIU* in Bukit Sangkal District, 2 *DAMIU* in Dempo District, 3 *DAMIU* in Nagaswidak District, 3 *DAMIU* in OPI District, 3 *DAMIU* in Sekip District, 4 *DAMIU* in Sukarami District, 3 *DAMIU* in Talang Betutu District. Besides, microbiology laboratory tests (Coliform and Escherecia Coli) and chemical tests (pH) were also carried out on water samples from each *DAMIU*. The analytical method for refill drinking water samples for parameters of Coliform and Escherecia Coli content was using the Most Probable Number (MPN) method with reference to SNI 1-3554-2006. As for the chemical parameters, the degree of acidity (pH) using the inspection method based on SNI 6989.11:2019. Then, it was compared based on Ministry of Health Regulations RI Number 429/2010 concerning Quality of Drinking Water. The maximum level allowed for Coliform and Escherecia Coli content was 0/100 ml and the pH level was 6.5-8.5. Furthermore, the results of laboratory test data carried out spatial analysis. The activities carried out at this stage are the map overlay method or map overlay through the Arc program's Geographic Information System (GIS).[7] Some of the overlays that were carried out in this study were maps of the research area with survey data to produce a map of the characteristics of drinking water quality from refill drinking water depots from 32 depots spread across 10 sub-districts in Palembang City. This research had been declared ethical by the Ethics Committee of Health Research Public Health Faculty of Sriwijaya University based on certificate No: 306/UN9.1.10/KKE/2022.

Results

The results of mapping using GIS based on laboratory test data on the parameters of Coliform and Escherecia Coli content and the degree of acidity (pH) of 10 villages in Palembang City; Alang-Alang Lebar, Basuki Rahmat, Boom Baru, Bukit Sangkal, Dempo, Nagaswidak, OPI, Sekip, Sukarami, Talang Betutu. The laboratory test results were then compared with the Regulation of the Minister of Health of the Republic of Indonesia Number 429 of 2010 concerning Drinking Water Quality. The maximum level of Coliform and Escherecia Coli content that is allowed is 0/100 ml and a pH level of 6.5-8.5. Overall the results obtained were that the majority of the water samples examined contained Coliform and Escherecia Coli and the degree of acidity was still below the maximum limit based on the Regulation of the Minister of Health of the Republic of Indonesia Number 429 of 2010. the results obtained as follows:

Table 1. Microbiology (Coliform and Escherecia Coli) and Chemistry (pH) Laboratory Test Results for Water Samples from Refill Drinking Water Depots in Palembang City in 2021.

Parameters	Frequency	Percent (%)
Coliform content		
Not eligible	2	5,8
Eligible	34	94.2
Escherecia Coli content		
Not eligible	2	5,8
Eligible	34	94,2
pH level		
Not eligible	33	91
Eligible	3	9
Total	36	100

Based on the results of laboratory tests, as shown in Table 1, out of 36 *DAMIU*, most of the *DAMIU* (94.2%) of the water samples met the health requirements for the content of Coliform and Escherecia Coli. Meanwhile, the degree of acidity (pH) showed that the majority (91%) of the water samples did not meet health requirements.

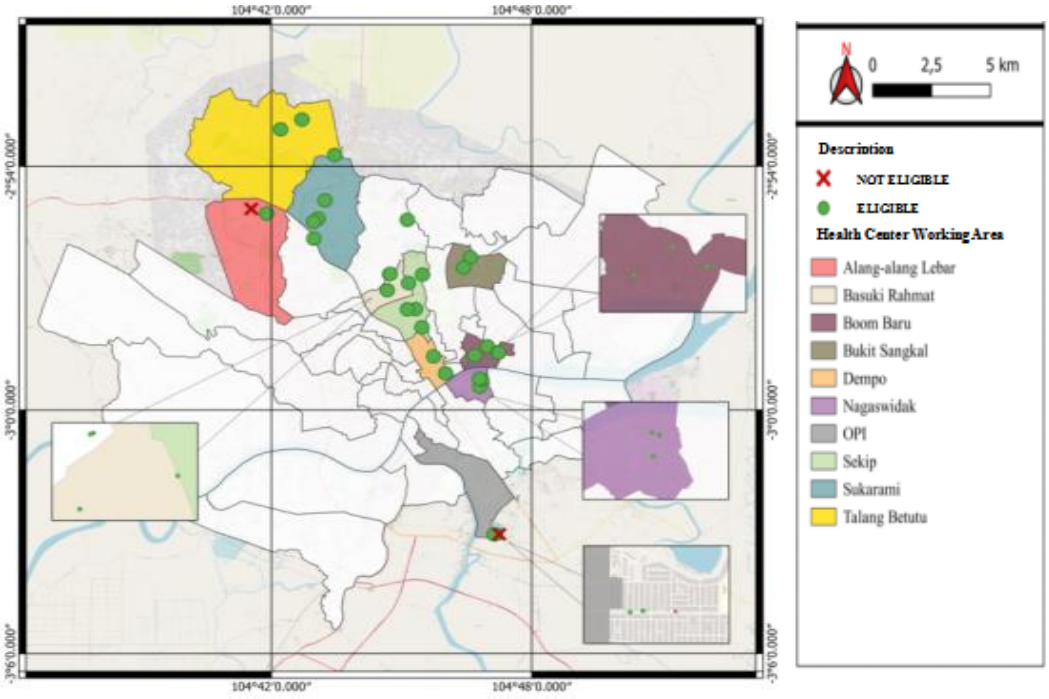

Figure 1. Map of Water Microbiological (Coliform) Quality Distribution at Refill Drinking Water Depots (*DAMIU*) in Palembang City in 2021

In Figure 1 it is presented that the distribution of 36 *DAMIU* in 10 Subdistricts in Palembang City shows that most of the water samples taken from the *DAMIU* met the health requirements based on the Ministry of Health Regulations RI Number 492/2010 concerning the quality of drinking water, 0/100 ml of water, except *DAMIU* was located in Alang-ALang Lebar District and OPI District that did not meet health requirements

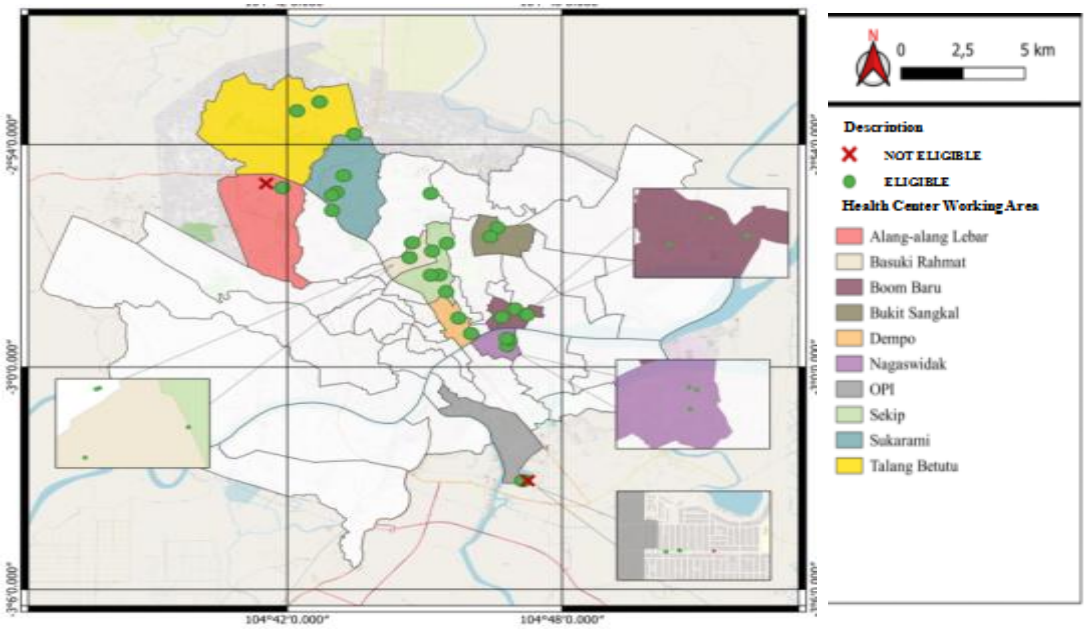

Figure 2. Map of Distribution of Water Microbiological Quality (Escherecia Coli) at Refill Drinking Water Depots (*DAMIU*) in Palembang City in 2021.

In the distribution map shown in Figure 2, that of the 36 *DAMIU* in 10 sub-districts in Palembang City shows that most of the water samples taken from the *DAMIU* have met the health requirements based on the Ministry of Health Regulations RI Number 492/2010 concerning the quality of drinking water 0/100 ml of water. However, there were *DAMIU* water samples that did not meet health requirements, *DAMIU* located in Alang-Alang Lebar District and OPI District.

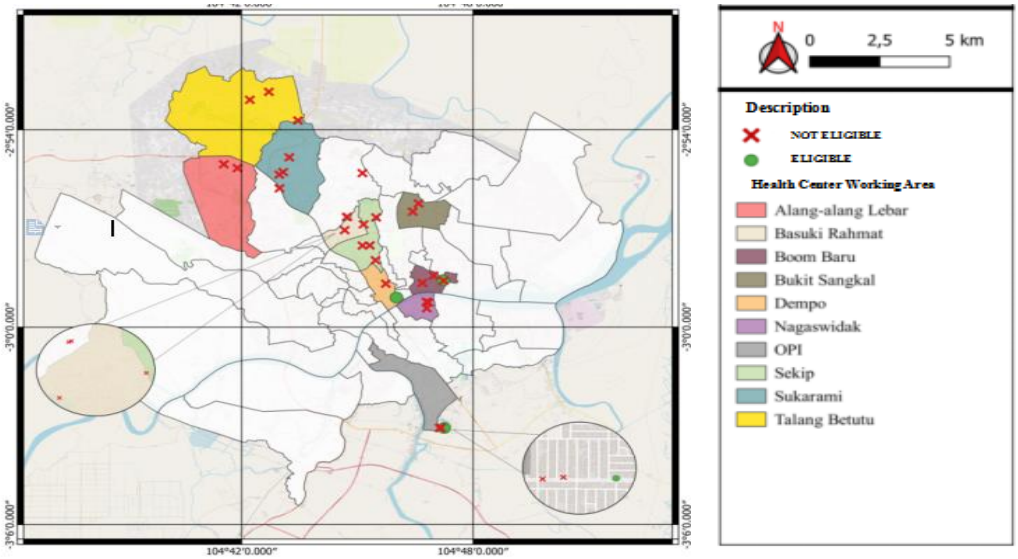

Figure 3. Map of Distribution of Water Chemical Quality (pH) at Refill Drinking Water Depots (*DAMIU*) in Palembang City in 2021.

The distribution map shown in Figure 3, there were 36 *DAMIU* in 10 Districts in Palembang City, it reported that most of the water samples taken from the *DAMIU* did not meet the health requirements based on the Ministry of Health Regulations RI Number 492/2010 concerning the Quality of Drinking Water, 0/100 ml of water. There were only a few samples of *DAMIU* water that met health requirements, *DAMIU* located in Dempo District, Boom Baru District and OPI District.

Discussion

Laboratory test results showed that out of 36 *DAMIU*, there were 2 *DAMIU* (5.8%) showed that the results of the water sample did not meet the health requirements for Coliform content, while the majority (94.2%) of the water samples met the health requirements. Various other studies in several regions have also shown the presence of Coliform bacteria in refill drinking water.[9-13] Among them, research conducted by Fitri Mairizki in Riau, that the entire Drinking Water Depot around the Riau Islamic University Campus which became a research analysis unit found that all the samples studied were positively contaminated with Coliform bacteria and did not meet drinking water quality requirements based on biological parameters.[2] The presence of Coliform in raw water indicated that the water has been contaminated with feces of humans/warm-blooded animals/other feces. Coliforms could survive in shallow groundwater for more than 2 months. Coliforms were bacteria that lived in the human intestine, so if drinking water contained Coliforms it was an indicator that the drinking water has been contaminated with feces. This situation may be caused by the poor health of the handlers, the physical quality of the *DAMIU*, poor raw water sources or inadequate sanitary hygiene and sanitation facilities, all of which were interrelated and cannot be separated. Coliform was not a disease-causing bacteria, but could be used as an indicator for the presence of pathogenic bacteria that can cause various diseases.[1] Many factors can influence the occurrence of Coliform bacteria contamination in refill drinking water, one of which is cross contamination by the depot operator.

So, to minimize the occurrence of this contamination, operators must wear clean work clothes, uniforms, wear hair caps and wear them specifically when on duty, and wear identification so that only official workers work. Operators must carry out clean and healthy living behavior practices, do not smoke while working, don't spit or sneeze carelessly, how to hold a clean gallon and always make it a habit to wash your hands when serving consumers. Then, *DAMIU* operators should have a hygiene course certificate.[14] In addition, research conducted by Rido reported factors that could affect the quality of the water products produced were raw materials, handling of the buyer's container, operator cleanliness, and depot conditions.[15] Improving employee hygiene and depot sanitation was very important given the high consumption of refill drinking water by the community. Various factors have led to an increase in the community's need for refill drinking

water, such as research by Abu Yazid et al in 2018, that the use of refill drinking water by the community is increasing, one of the causes was groundwater contamination which was getting worse to date which may be because of industrial waste. Refill drinking water was one of the answers to fulfilling the people's need for cheap and practical drinking water. This was the reason why people chose refill drinking water for consumption.[16]

The results of laboratory tests for Escherecia Coli content showed that out of 36 *DAMIU* there were 2 *DAMIU* (5.8%) did not meet health requirements for Escherecia Coli content, while the majority (94.2%) of the water samples met health requirements. The Study data presents that most of the water samples taken from these *DAMIU* have met the health requirements based on the Ministry of Health Regulations RI Number 492/2010 concerning the quality of drinking water, 0/100 ml of water. However, there were *DAMIU* water samples that do not meet health requirements, *DAMIU* located in Alang-ALang Lebar District and OPI District.

Various other studies in several regions have also shown the presence of E.coli bacteria in refill drinking water.[17-22] Among them, there was a research by Nita Rostita in South Tangerang, which showed that only one refill drinking water depot out of twelve refill drinking water depots (*DAMIU*) in South Tangerang, especially around the UIN Syarif Hidayatullah Jakarta campus, was suitable for consumption in accordance with Ministry of Health Regulations RI Number 492/2010 concerning the quality of drinking water both in terms of biology, the content of E.coli, the rest did not meet the requirements for drinking water consumption.[9] Diarrheal disease could occur through water contaminated by bacteria such as Coliform bacteria. Coliform bacteria were a group of intestinal bacteria, which lived in the human digestive tract which could cause various diseases for humans, for example diarrhea by Escherichia coli bacteria.[23] The presence of E. coli in drinking water indicated that fecal contamination has occurred from humans and warm-blooded mammals, which could be interpreted as the presence of other pathogenic micro-organisms in the drinking water in the form of viruses, bacteria and protozoa. Many strains of E. Coli, some of which were harmless, it was found in the gastrointestinal tract in humans or warm-blooded animals, but there w

ere several categories of Escherichia coli that were toxic and could cause diarrhea. For example E. Colienterotoxigenic (ETEC) which was present in water at around 2% -8% could cause stomach inflammation and severe diarrhea accompanied by stomach cramps and vomiting.[24]

Personal hygiene/hygiene for depot workers was essentially a condition that fulfills the physical health requirements individually or individually. Personal hygiene was very influential in the occurrence of infectious diseases. To avoid various infectious diseases requires awareness from individuals to fulfill their need for cleanliness. This could be realized by having clean living habits.[25] The spread of Escherecia Coli bacteria, from humans to other humans, these bacteria were spread by flies through dirty hands, food or drink contaminated with feces. In addition, the occurrence of contamination could be caused by the condition of the equipment, especially those

used for disinfection (ultraviolet), which were not replaced regularly. In addition, cleaning equipment and filters that were not routinely carried out could cause contamination.[26]

Monitoring activities were one of the important elements in maintaining the safety of refill drinking water. Drinking water quality monitoring activities themselves were regulated in Permenkes number 736 of 2010 concerning Procedures for Supervision of Drinking Water Quality. supervision for the quality of drinking water for commercial purposes shall carry out regular internal and external monitoring and indications of pollution. Sanitary inspections were also carried out as surveillance efforts. The minimum frequency of sanitation inspections for drinking water depots was the place of origin of raw water 4 times per year, raw water transport equipment (tank cars) 4 times per year, water reservoirs 4 times per year, washing gallons and filling gallons 4 times per year.[27]

The results of laboratory tests showed that out of 36 *DAMIU*, there were only 3 *DAMIUs* (9%) met the health requirements at the degree of acidity (pH), while the majority (91%) of the water samples did not meet the health requirements. The distribution map illustrated that from 36 *DAMIU* in 10 sub-districts in Palembang City did not meet the health requirements based on the Ministry of Health Regulations RI Number 492/2010 concerning the Quality of Drinking Water, 0/100 ml of water. There were only a few samples of *DAMIU* water that met health requirements, *DAMIU* located in Dempo District, Boom Baru District and OPI District.

According to Ministry of Health Regulations RI Number 492/2010, Drinking water that has gone through a processing process or without a processing process that met health requirements and could be drunk directly. But now there has been a decline in water quality. One of the causes of the decline in water quality and supply was due to contamination by industrial waste, household waste, and other wastes.[28] Inspection of the quality of water products was carried out so that the water produced meets the requirements for drinking water quality according to the Regulation of the Ministry of Health Regulations RI Number 492/MENKES/PER/IV/2010, which includes physical, chemical, bacteriological and radioactive parameters. According to chemical parameters, drinking water must not contain inorganic and organic substances that exceeded the set standards and have a pH between 6.5-8.5.[29]

The pH value was influenced by several parameters, including biological activity, temperature, oxygen content and ions. The pH < 6.5 will cause corrosion on metal (eg. drinking water pipes) which dissolved lead, copper, cadmium, etc. and is toxic. Likewise, if the pH is > 8.5, it could form deposits (scale) on metal water pipes which then produced trihalo methane which is toxic.[30] In addition, acidic water could cause aesthetic problems such as metallic or acidic water and could cause health problems such as acidosis. A pH value higher than 8.5 means the water was alkaline for human consumption. Alkaline drinking water did not directly cause health problems but causes aesthetic problems such as an alkaline taste, makes coffee taste bitter, and reduces the

efficiency of the water heater.[31] Decreasing the quality of existing water would cause disease outbreaks, where water was the easiest medium for the spread of disease. In Indonesia, cases of poisoning or waterborne disease were not yet complete, therefore cases of poisoning could be described as an iceberg phenomenon. Every year there was an increase in cases of poisoning and the cause is rarely known.[32]

Operator cleanliness was one of the most important things to reduce contamination in drinking water, but not all depot operators were aware of this. There were still several depot operators who did not wash their hands when refilling drinking water, then there were also those who did it while smoking and all depot operators do not drain the gallons until they were dry after washing so that the gallons still had washing water left which could be there were bacteria. Therefore, monitoring the quality of drinking water, especially monitoring bacterial contamination, must be routinely carried out by the owner of the *DAMIU* and the local Health Service to ensure that the drinking water consumed by the public meets the specified requirements, because water was not safe for human consumption when it was contaminated.[33] Based on RI Law Number 7/2004 article 40 paragraph 2 stated that the development of a drinking water supply system was the responsibility of the government and regional governments, therefore a Regional Drinking Water Company was established.[34] However, the next task was how to improve and maintain the quality of water produced by the regional company.

This study had limitations regarding the collection of bacteriological (Escherecia Coli and Coliform) and chemical (pH) data which still used secondary data from the Center for Disease Control Environmental Health Engineering (BTKLPP) Palembang City where data collection was not at the same time. Therefore, researchers could not know the process of taking laboratory test samples.

Conclusion

Based on the results of laboratory tests, it was found that out of 36 *DAMIU*, there were 2 *DAMIU* (5.8%) had positive results containing Coliform bacteria, 2 *DAMIU* (5.8%) were positive for Escherecia Coli bacteria, and the majority (91%) of the *DAMIU* examined did not meet the health requirements in terms of the degree of acidity (pH). As for the distribution map, it was presented that out of 36 *DAMIU* in 10 Districts in Palembang City Alang-Alang Lebar District and OPI District were found The *DAMIU* which positive Coliform bacteria. This study found that most of the water samples taken from the DAMIU did not meet the health requirements, especially for the parameter of degree of acidity (pH), especially the *DAMIU* that located in Dempo District, Boom Baru District and OPI District. This condition indicated that there was a health risk to consumers of refill drinking water in Palembang City. So, to overcome the conditions that existed

at this time, it was necessary to increase supervision of the application of sanitary hygiene refill drinking water depots by authorized officers.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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