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Effect of Characteristics on the Treatment Refill Drinking Water Depots (DAMIU) in Kendari, Southeast Sulawesi

Nani Yuniar*, Asnia Zainuddin, Yusuf Sabilu, Nurmaladewi, Yasnani, Jafriati, Suhadi, Agnes Mersatika

Department of Public Health, Faculty of Public Health, Universitas Halu Oleo, Southeast Sulawesi, Indonesia

Abstract: Southeast Sulawesi is a province where most of its residents get drinking water from refilled drinking water depots with an average of 32.7%. The data from the Health Department of Southeast Sulawesi recorded in 2018, there were 670 water depots and significantly increased to 833 depots in 2019. Meanwhile, in 2019, based on the bacteriological tests made in 587 refilled water depots in Southeast Sulawesi, 24 depots did not meet the health requirements. The present study aimed to understand the process of water treatment in DAMIU, raw water storage cleaning in DAMIU, and the quality assessment of refill tools in DAMIU. This study was a descriptive study with an observational approach. As many as 88 depots were selected in this study. Regarding the water treatment standard, as many as 51 (58%) drinking water depots in Kendari had already met the requirements, and the other 37 (42%) depots did not. Meanwhile, regarding the raw water storage cleaning in DAMIU, 34 (39%) depots already met the standard and the other 54 depots did not. Besides, in regards to the quality assessment of refill tools, there were 63 (72%) depots that met the standard, and the other 25 depots failed to meet the standard. The age (year), education, year of managing depots affected the treatment Process of DAMIU Production. The age (year), education, year of managing depots affected the raw Water Storage Tank Cleaning in DAMIU. All typical indicators affected the Quality Assessment of Refill Tool of DAMIU. The government and related parties should monitor and examine the raw water and processed drinking waters periodically and sustainably. They should be more selective in granting a business license according to the standard of drinking water depots.

Keywords: refill drinking water depots, treatment process, raw water storage cleaning, refill tool treatment.

特征对东南苏拉威西省肯达里处理补给饮用水库 (达米乌) 的影响

摘要:

东南苏拉威西省是一个省，该省的大多数居民从重新填充的饮用水库中获得饮用水，平均比例为
32.7%。东南苏拉威西省卫生厅2018年数据显示，2018年共有670个水库，2019年显着增加至833个。同时，2019年，根据对东南苏拉威西587个回灌水库的细菌学检测，24个水库没有不符合卫生要求。本研究旨在了解达缪的水处理过程，达缪的原水储存清洁以及达缪的补水工具的质量评估。本研究是一项采用观察性方法的描述性研究。在这项研究中选择了多达88
个仓库。在水处理标准方面，肯达里多达51个（58%）饮用水库已经达到要求，其他37个（42%）库没有达到要求。同时，在大牛原水库清洗方面，已有34个（39%）库位达标，其余54个库位未达标。此外，在填充工具的质量评估方面，63个（72%）仓库达标，其他25个仓库不达标。年龄（年）、受教育程度、管理仓库的年份影响了大米生产的处理过程。年龄（年）、受教育程度、管理库的年份影响了大牛原水储罐清洗。各项典型指标均影响了达米乌

Received: April 10, 2021 / Revised: May 11, 2021 / Accepted: June 9, 2021 / Published: July 31, 2021

About the authors: Dr. Nani Yuniar, M.Kes., Dr. Asnia Zainuddin, M.Kes., Yusuf Sabilu, Nurmaladewi, SKM. MPH., Yasnani, S.Si, M.Kes., Jafriati, Suhadi, Agnes Mersatika, SKM.M.Kes., Department of Public Health, Faculty of Public Health, Universitas Halu Oleo, Southeast Sulawesi, Indonesia

Corresponding Author Nani Yuniar, naniyuniar0509@gmail.com

笔芯工具的质量评估。政府及相关方应定期、可持续地对原水和加工后的饮用水进行监测和检查。应当更加有选择性地按照饮用水库标准颁发营业执照。

关键词：补充饮用水库，处理过程，原水储存清洁，补充工具处理。

1. Introduction

Refill drinking water has emerged as an option to fulfill the needs of daily water in society. Refill drinking water is ready-to-drink water without boiling because it has undergone a purification process either by ultraviolet irradiation, ozonation, or both. Nowadays, public awareness to access healthy drinking water is rising. The World Health Organization (WHO) mentions that the volume of clean water needs for the average population in the world is different. In developed countries, the water needed is approximately 500 liters/day, while in Indonesia (big cities) is about 400 liters/day. The quality of drinking water in big cities in Indonesia remains a concern. The population density, incorrect spatial planning, and increasing need for clean water have become rare in cities. The source of clean water is polluted, either by organic pollutants, domestic pollutants, or toxic pollutants from industrial residues. Moreover, the well water is not safe for drinking due to biological contamination either from a septic tank or surface water [1].

The Basic Health Survey in 2018 showed that 46.5% of households in Indonesia consumed water for more than 100 liters/day/person. Otherwise, approximately 53.5% of households had no optimal access to clean [2]. Clean water is used for drinking, washing, bathing, and other hygiene activities [3].

Southeast Sulawesi is a province where most people get drinking water from refilled drinking water depots with a percentage of 17.2%, following protected dug well and tap water, namely 22.1% and 20.8%, respectively. In Southeast Sulawesi, people get drinking water from refilled drinking water depots with an average of 32.7%. The data from the Health Department of Southeast Sulawesi recorded in 2018, there were 670 water depots and significantly increased to 833 depots in 2019. Meanwhile, in 2019, based on the bacteriological tests made in 587 refilled water depots in Southeast Sulawesi, 24 depots did not meet health requirements [4].

In the Regulation of the Minister of Health of the Republic of Indonesia concerning the requirements and supervision of drinking water quality, it is stated that drinking water is water that has gone through a treatment process or without a treatment process that meets health requirements and is ready-to-drink. Moreover, it must also meet the drinking water quality requirements that have been determined both in terms of bacteriological, chemical, radioactive, and physical qualities [5]. The bacteriological test of water samples from several refill drinking water depots in Kendari showed a total coliform bacteria of 96–240 for each 100 ml/liter and consequently did not meet health requirements. The water sources are from drilled wells, dug wells, and tap water (PDAM) in a container, processed through several stages, namely pH adjustment, purification, and disinfection. Disinfection can function as an oxidizing agent to eliminate odors, tastes and oxidize as a disinfectant to kill pathogenic bacteria that spread through water.

However, a preliminary survey showed that people complain about the quality of drinking water from water depots in Kendari. It has bad taste, and it cannot last for more than four days; otherwise, the color, taste, and smell will be degraded. The bad quality of drinking water can lead to several acute infections, including diarrhea, kidney disease, hepatitis, and cholera.

Hence, further study is required for a novel insight to stakeholders in overcoming refill drinking water depot problems.

2. Method

2.1. Ethical Approval

Our research was conducted with the permission of the ethical committee research, Institution of Research and Community Service of the University Halu Oleo (No. 1184a/UN29.20/PPM/2019). All research procedures in this study were performed according to guidelines for planning research and Regulation of the Minister of Health of the Republic of Indonesia No. 492/Menkes/Per/IV/2010.

2.2. Research Design

The present study was an observational study with a cross-sectional study design by observing and measuring characteristics (age, education, sex, year of managing depots, treatment process of DAMIU production, raw water storage cleaning in DAMIU, and the quality assessment of refill tools in DAMIU) at the same point of time.

2.3. Place, Study Population and Sample

This study was established in Kendari with a population of 274 depots. Eighty-eight refill water depots were then selected as samples through a purposive sampling method.

2.4. Data Analysis

Data were analyzed descriptively to describe the

whole variables and analytically. Later, an ordinal regression analysis was employed to determine the effect of the treatment process of DAMIU production, storage tank cleaning, and the quality assessment of refill tools.

2.5. Research Hypothesis

A hypothesis is a statement of expectation or prediction that will be tested by **a** study.

Ha: There is an effect of characteristics (age, education, sex, year of managing depots) on the treatment process of DAMIU production.

Ha: There is an effect of characteristics (age, education, sex, year of managing depots) on the raw water storage cleaning in DAMIU.

Ha: There is an effect of characteristics (age, education, sex, year of managing depots) on the quality assessment of refill tools in DAMIU.

3. Results

3.1. The Characteristic Managers of Depot Air Refill Drinking Water Depots

Table 1 shows that most depot managers were 30 years old, 15 respondents were females, 51 respondents were high school graduates, and managed the depot for 31 years.

Table 1 The characteristics of the respondents (Primary data, 2020)

Characteristics	n=88	%
Age (Year)		
15-20	7	8,69
21-25	14	15,21
26-30	17	20,66
31-35	30	32,61
36-40	12	13,04
≥ 40	8	9,79
Education		
Elementary School	3	3.26
Junior High	12	14.13
Senior High	51	56.52
Diploma	5	5.43
Graduate	17	20.66
Year of managing depots		
1	12	13.04
2	16	16.30
3	31	34.79
4	21	23.92
≥ 5	11	11.95
Sex		
Male	73	81.53
Female	15	18.47

3.2. The Treatment Process of DAMIU Production

Table 2 shows that, on average, 51 depots (57.35%) already met the treatment requirements, and the other 37 depots (42.65%) did not.

Table 2 The treatment process of DAMIU production (Primary data, 2020)

The treatment process of DAMIU production	Met requirements	Did not meet requirements
	n=88(%)	**n=88(%)**
Undergo a trial of the quality of the water source to be treated	49(55.68)	39(44.32)
Performing raw water filtration in the DAMIU treatment process	64(72.73)	24(27.27)
Raw water sources are from groundwaters, springs, and PDAM	55(62.50)	33(37.50)
Disinfect microorganisms on the raw materials before processing	33(37.50)	55(62.50)
Adding chemicals (excellence and neutralizing pH) as well as stirring and settling	36(40.90)	52(50.09
Trying to control the DAMIU processing factors	42(47.73)	46(52.27)
Using clean water in the production process	76(86.36)	12(13.63)
Using sterile equipment in the processing	56(63.63)	32(36.36)
Using more than one microfilter	73(82.95)	15(17.04)
The existence of guidance or supervision by the health office to ensure the quality of the water	29(32.95)	59(67.05)
Keep the environment surrounding DAMIU clean	43(48.86)	45(51.14)
Always carry out inspections at every stage of DAMIU processing	55(62.50)	33(37.50)
Using unharmful equipment in the DAMIU processing	11(12.50)	77(87.50)
Always wash the tools and materials before DAMIU processing	79(89.77)	9(10.27)
workers do not smoke during the DAMIU processing	56(63.64)	32(36.36)

3.3. Raw Water Storage Tank Cleaning in DAMIU

Table 3 shows that the raw water storage tank cleaning was not maximal yet since only 54 depots met the standards and the other 34 depots did not. As a result, there are still many depots that do not clean their storage properly.

Table 3 Raw water storage tank cleaning in DAMIU (Primary data, 2020)

Raw Water Storage Tank Cleaning in DAMIU	Met requirements	Did not meet requirements

	n=88(%)	n=88(%)
Regular cleaning of the raw water tank 3-4 times a month	58(65.91)	30(34.09)
Use a clean cloth, sponge, chamois/mop to clean the inside walls of the tank	73(82.95)	15(17.05)
Tank cleaning does not use copper or brush	59(67.05)	29(32.95)
After cleaning, the raw water tank is sprayed with clean water using a hose	43(48.86)	45(51.14)
The water reservoir is made of materials that cannot pollute the water (free from pollution)	43(48.86)	45(51.14)
Clean the raw water tank regularly	36(40,91)	52(59.09)
Raw water tank maintenance using sterile tools	57(64.77)	31(35.23)
The feasibility of using a raw water tank container	76(86.36)	12(13.64)
Tank cleaning equipment from non-hazardous materials	62(70.46)	26(29.54)
Always try to keep the raw water tank clean	70(79.54)	18(20.45)
Regularly check all components of the water tank before cleaning	65(73.86)	23(26.14)
Draining the raw water tank regularly	32(36.36)	56(63.64)
Drying the inside of the tank using a rag after draining	36(40.91)	52(59.09)
Daily sterilization of raw water tank	48(54.55)	40(45.45)
Procurement of appropriate cleaning materials or means	53(60.23)	35(39.77)

3.4. The Quality Assessment of Refill Tool of DAMIU

Table 4 shows that the quality of refill tool processing of DAMIU was not maximal yet. There were still 25 depots that failed to meet the requirements for refill tool processing and thus may affect the quality of refill drinking water in Kendari.

Table 4 The quality of refill tool processing (Primary data, 2020)

The quality of refill tool processing	Met requirements	Did not meet requirements
	n=88(%)	n=88(%)
The depot filling equipment must be protected from chemical reactions	59(67.05)	29(32.95
Tools and equipment must be corroded (rubber)	72(81.81)	16(18.19)
Processing of filling equipment is protected from microbes	59(67.05)	29(32.95)
Depot filling equipment must be kept away from materials that are easily soluble in water	63(71.59)	25(28.41)
Processing equipment must be cleaned regularly	63(71.59)	25(28.41)
Need training on processing depot filling tools	79(89.77)	9(10.23)
The depot filling equipment is checked 1-2 times a week	55(62.50)	33(37.50)
Filling the depot is done by people who understand the cleanliness of the equipment	36(40.91)	52(59.09)
Cleaning the depot processing equipment so that the water is fit for consumption	62(70.45)	26(29.55)
Provide tools and equipment that are not rusty	68(77.27)	20(22.73)
Prepare a filling device that does not react with chemicals	83(94.39)	5(5.69)
Avoid tools or materials that are easily soluble in water	77(87.50)	11(12.50)
Wear clean and neat clothes		
Always perform optimal cleaning of processing equipment	43(48.86)	45(39.14)

3.5. Effect of Characteristics on the Treatment Process of DAMIU Production

The results of ordinal regression analysis separately showed that age (year), education, and year of managing depots affected the treatment Process of DAMIU Production. However, sex did not affect the treatment Process of DAMIU Production.

Table 5 Effect of characteristic on the treatment process of DAMIU production (Analysis results, 2020)

Variable Characteristics	(β)	S.E.	Wald	df	Sig (P)	95% C.I	
						Lower Bound	Upper Bound
Age (Year)	2.143	0.832	6.566	1	0.009	0.879	4.423
Education	1.477	0.579	5.306	1	0.019	0.205	2.546
Year of managing Depots	1.789	0.686	6.720	1	0.021	0.434	3.123
Sex	0.796	0.505	2.422	1	0.110	-.204	1.776

3.6. Effect of Characteristics on the Raw Water Storage Tank Cleaning in DAMIU

The results of ordinal regression analysis separately showed that age (year), education, and year of managing depots affected the raw water storage cleaning in DAMIU. However, education and sex did not affect the raw water storage cleaning in DAMIU.

Table 6 Effect of characteristics on the raw water storage tank cleaning in DAMIU (Analysis results, 2020)

Variable Characteristics	(β)	S.E.	Wald	df	Sig (P)	95% C.I	
						Lower Bound	Upper Bound
Age (Year)	3.147	0.944	11.103	1	0.001	1.296	4.998
Education	2.157	0.714	10.093	1	0.012	1.850	3.164
Year of managing Depots	3.147	0.944	11.103	1	0.001	1.296	4.998
Sex	0.339	0.938	0.413	1	0.520	-.716	1.285

3.7. Effect of Characteristics on the Quality Assessment of Refill Tool of DAMIU

The results of ordinal regression analysis separately showed that age (year), education, and year of managing depots affected the Quality Assessment of Refill Tool of DAMIU. However, sex did not affect the Quality Assessment of Refill Tool of DAMIU.

Table 7 Effect of characteristic on the quality assessment of refill tool of DAMIU (Analysis results, 2020)

Variable Characteristics	(β)	S.E.	Wald	df	Sig (P)	95% C.I	
						Lower Bound	Upper Bound
Age (Year)	1.689	0.746	5.119	1	0.024	1.226	3.152
Education	2.075	0.739	7.876	1	0.005	3.626	3.525
Year of managing Depots	1.931	0.732	6.956	1	0.008	2.496	3.367
Sex	3.317	0.496	8.374	1	0.003	1.103	5.585

4. Discussion

4.1. Effect of Characteristics on the Treatment Process of DAMIU Production

The result of regression analysis showed that characteristics (age, education, and year of managing depots) affected the treatment process in DAMIU production. And thus, these characteristics significantly affected the treatment process in DAMIU production. In contrast, sex did not affect the treatment process in DAMIU production.

The characteristics of the depot manager should be maintained. Hence, the age, education of managers, and year of managing depots should be considered to develop knowledge and insight of managers to impact a good way of processing DAMIU production.

Direct observation in drinking water depots in Kendari showed that, on average, the treatment process of DAMIU had met the requirements. However, some depots failed to meet the standard by the Regulation of the Health Minister in 2010. The depots that met the standard are relatively new, about 1 to 3 years. In contrast, older depots of more than four years tend to ignore the standard. This is because, at the beginning of their business, they still maintain the quality of their water production to find many consumers. However, after maintaining regular customers, most of them pay less attention to the hygiene standards of DAMIU processing.

Our findings are in line with a study conducted in Bandung showing that depot owners have managed the depots for about 4 – 14 years, yet the hygiene standard of water treatment remained neglected. This is due to the lack of both knowledge and awareness about the hygiene standard in the water treatment process as well as the personal hygiene of handlers [6], [7], [8]. Furthermore, they become less motivated to follow the hygiene standard such as regularly cleaning tools and storage tanks since they already maintained regular consumers.

Furthermore, another study reported that 98.15% of the handlers at refill drinking water depots in Banyumas had hygienic behavior that did not meet the requirements. Inadequate personal hygiene is potential for contamination risk, especially microbiological contamination that can threaten public health, especially DAMIU consumers [9].

In contrast, other research found that all drinking water depots (DAM) in Kediri already have complete equipment that met the regulations' requirements. The equipment used to produce drinking water is made of food-grade materials, non-toxic, does not absorb odors and tastes, rust-proof, wash-resistant, and resistant to re-disinfection. In terms of completeness, DAM has raw water filling pipes, raw water reservoirs, suction pumps, filters, microfilters, drinking water filling faucets, gallon washing or flushing faucets, connecting faucets, and disinfection equipment. The microfilter used is tiered, starting from the largest to the smallest diameter. There are 40.9% of DAMs who replace their microfilter tubes regularly. Replacement is done when the tube has begun to reduce its performance in treating drinking water. All DAMs use microfilters and disinfection equipment that are still in use [10].

Generally, the treatment process of DAMIU in Kendari has already met the requirements. However, there are still some concerns regarding the water treatment, especially the source of raw water, mostly from drilled wells where the quality of water and contaminations remain unknown. The drilled wells must be away from feces disposal sites, cattle pens, and garbage dumps. The quality of drinking water at DAMIU should meet drinking water requirements, including physical, chemical, microbiological, and radioactive requirements. As regulated in Permenkes No. 492/Menkes/Per/IV/2010.

Our study found that the water treatment process in refill water depots in Kendari is done without heating. The raw water is filtrated and disinfected. To maintain the product quality, they use tap water (PDAM) as a raw water source regularly collected from mountain springs or drilled wells. Several processes and tools are used to maintain the water quality of the Refill Drinking Water Depot in Kendari. Raw water taken from the source is transported using water tanks and then stored in tendon tanks. The tendon tanks are made of food-grade materials and free from materials that can contaminate the water, in addition to the raw water drainage, where the hoses and pumps used for loading and unloading raw water are properly covered, stored safely, and protected from possible contamination. Tanks, hoses, pumps, and connections are made of food-grade material resistant to corrosion and chemicals that can contaminate water. The pump uses a type of semi-jet pump made of stainless.

4.2. Effect of Characteristics on the Raw Water Storage Tank Cleaning in DAMIU

The result of regression analysis showed that characteristics (education and year of managing depots) affected the raw Water Storage Tank Cleaning in DAMIU. And thus, the better the education and the longer the effort, the more qualified it will be in cleaning the DAMIU raw water tank.

Drinking water comes from processed raw water used for consumption and can even provide health benefits for human survival. If raw water is treated properly, it can produce drinking water that is truly guaranteed and safe for consumers. The raw water needs to meet the quality standard as regulated by the health ministry. Accordingly, the source of raw water must be monitored as well. The raw water storage tank cleaning must be monitored regularly and continuously to maintain the quality of water. The monitoring is related to cleaning raw water tanks, including periodic laboratory inspections from physical, bacteriological, and chemical aspects.

Our study highlighted that the water storage cleaning of DAMIU in Kendari is not optimal yet as only 54 water depots met the requirements and the other 34 depots did not. The raw water used is from tap water (PDAM) and drilled wells. In contrast, other sources like springs have met the standard. There are still some depots that do not clean their raw water storage properly [11].

The sources of raw water can affect the quality of drinking water. They are susceptible to contaminants and thus cannot be processed due to virus or bacteria contaminations. Similarly, the quality of water can also affect health status. When the water has good quality, then the public health quality is also guaranteed. In contrast, bad water quality can lead to health problems [12], [13], [20].

Table 3 shows that 54 depots have met the requirement in cleaning their water storage tanks. They regularly clean the tanks 3–4 times per week. Treatment of raw water tanks using sterile tools from food-grade materials such as stainless steel and polyvinyl carbonate. Equipment used in cleaning the raw water tank includes cloth, sponge, chamois/clean mop to clean the tank's inner walls. In addition, the raw water tank containers used are still suitable for use, do not use hazardous materials such as copper, always check all components of the water tank before cleaning, and the point is that almost all DAMIUs use appropriate cleaning materials or tools.

4.3. Effect of Characteristics on the Quality Assessment of Refill Tool of DAMIU

The result of regression analysis showed that characteristics (age, education, year of managing depots, sex) affected the Quality Assessment of Refill Tool of DAMIU. Thus, the better of characteristics, the better of quality of the DAMIU filling tool.

As shown in Table 4, of 88 water depots in Kendari, 63 depots have good quality refill tools, while the other 25 depots do not. The filling equipment is cleaned regularly and optimally, checked for its suitability 1-2 times a week, tools and materials are avoided and do not react with chemicals, from corroded materials (rubber) and not using tools and equipment that are not suitable and rusty. Moreover, tools or materials used are not easily soluble in water. One of the factors that affect the quality of drinking water produced by a drinking water depot is the place/location of the drinking water depot and its parts [14].

Nevertheless, many depot handlers pay less attention to the condition of filter tubes. All equipment used in processing drinking water should be checked regularly for its condition and functions to avoid contaminations [15]. We found only some filter tubes that have met the standard as per the Minister of Health Regulation No.492/MENKES/Per/IV/2015. Our finding is relevant to a study conducted in 9 refill water depots that applied a backwashing system in Campalagian District, Polewali Mandar, where only five depots met the standard. This can be assessed from the personal hygiene of the handlers and the availability of basic sanitation facilities [16].

Some aspects required in maintaining production

facilities and sanitation programs include machine maintenance and cleaning as tools, maintenance and cleaning of buildings, and prevention of rodents and insects. Machine maintenance, such as replacing filter equipment, checking ultraviolet lamps, checking worn machine tools and equipment should be carried out at least less than once a month. Engine cleaning is carried out at least once a week by cleaning various filters and engine equipment. The hose/pipe where the drinking water comes out of the processed product is a vital piece of equipment that must be cleaned every day and even every time because it is very easy to get mossy and dirty by dust so that it can affect the quality of drinking water. Equipment plays an important role in processing raw water into drinking water. Good condition of equipment and drinking water treatment processes that meet the requirements will produce good drinking water [17]. On the contrary, if the treatment process is less optimal, it can be susceptible to bacterial contamination [18].

Based on the study results, it can be explained that for operators or handlers who still have low scores at the time of observation, namely the lack of awareness of handlers to wear neat and clean work clothes, 6 (6.82%) DAMIU do not qualify [19]. Operators must wear clean work clothes, uniforms, hair caps, and these clothes are only worn when on duty. In addition, they must be equipped with identification. This must also be supported by a clean and healthy lifestyle. Hand washing, for instance, is crucial to prevent the spread of germs [12]. Therefore, training about how to increase the knowledge and attention of the workers about personal hygiene is mandatory.

Good DAMIU's tool maintenance should be done regularly and sustainably since it can affect the quality of drinking water produced. Despite the quality of the machines and equipment used in drinking water treatment, if maintenance and cleaning are not carried out regularly and continuously, the drinking water produced will affect the health and safety of consumers.

By keeping the quality of DAMIU equipment properly, the quality of drinking water production will be maintained. Therefore, continuous supervision is needed by the relevant parties, especially the government, which has permitted the establishment and processing of DAMIU. In addition, it is also necessary to periodically supervise by the Health Office to avoid bacterial contamination due to the quality of processing that does not meet the requirements.

Good monitoring will help maintain good management so that sanitation is maintained. Giving penalties on DAMIUs that do not manage according to the specified conditions will have a very good effect on the sustainability of DAMIU's production and for the community as the main consumers.

5. Conclusion

The owners of drinking water depot should monitor any aspect regarding the production of drinking water itself, employ healthy workers and do a routine medical check-up, regularly do laboratory assays to the raw water and its production, carry out routine maintenance and cleaning of machines and all depot equipment, take precautions against the presence of rodents/insects in the depot.

As a consumer, society should be more selective in choosing drinking water depots. They should look at the business license, workers' health, the condition of the machinery, equipment, building, and surroundings of the depot. Moreover, they should see the processing, starting from washing gallon bottles to filling drinking water, and buy drinking water by coming directly to the drinking water depot.

The government and related parties should regularly monitor and test the quality of raw water and its products and be more selective in granting business licenses according to the terms of establishing a drinking water depot.

Acknowledgment

Thanks to Halu Oleo University through the Institute for Research and Community Service, who have funded this research stated in the work contract number 411/UN29.20/PPM/2018. Thanks are also conveyed to the Kendari City Health Office, Southeast Sulawesi Province, for providing support, information, and completing the data needed by researchers.

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