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Water Treatment Process using Manganese Zeolite Filter, Activated Carbon Filter, and Silica Sand Filter

Abdul Rahman[1]*, Aulia Salman[2], Ardianta[3], Ansharuddin[4], Rufinus Nainggolan[5], Sarmedi Agus Siregar[6], Ts. Wan Zuhari bin Wan Ismail[7], Ts. Mohd Azri bin Abdul Ghani[8],

[1,2,3,4,5,6] *Politeknik Negeri Medan, Indonesia*
[7] *Agroteknologi & Bioindustri Department, Polytechnic Jeli Kelantan, Malaysia*

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ABSTRACT

Clean water is basic for daily human needs, such as bathing, washing, and drinking water consumption. Until now, the community is still facing several complex problems related to the availability of clean water that has not been fully resolved by the local government. One of the problems is how to treat existing water sources using a simple system so that water containing chemicals that exceed the quality standards, cloudy and polluted can be processed into clean water suitable for public consumption. The purpose of this research is to treat unwarranted polluted water that contain chemicals such as iron (Fe), manganese (Mn), and the like which into clean water. The method used is filtering using Manganese Zeolite Filter, Activated Carbon Filter, and Silica Sand Filter. Laboratory results showed water parameters related to health, namely Total Coliform showed results of n<2 (standard 0.0) while the physical parameters for TDS (Total Dissolve Solid) are 263 mg/l (standard 1000 mg/l) and chemical properties pH 8.0 mg/l (standard 8.00-8.50), iron (Fe) 0.02 mg/l (standard 0.03), mercury (Hg) < 0.0008 mg/l (quality standard 0.001), cadmium (Cd) < 0.005 mg/l (standard 0.05), lead (Pb) 0.03 mg/l (standard 0.05), and organic matter (KmnO4) 7.13 mg/l (standard 10.00). The laboratory tests result showed that the water treated utilizing this method is suitable for daily consumption, but not readily to be drunk like mineral water in the market. This treated water still need to be boiled to kill the bacteria contained in the water.

1. Introduction

Water is the main need to improve public health, an absolute substance for every creature which is the main requirement for ensuring health, because water is one of the media for disease transmission, such as diarrheal disease (Dwijosaputro, 1981). All creatures are very dependent on water to survive. Water used for daily consumption must meet clean water quality standards. The condition of water can be tested in terms of physical or chemical, microbiologically, and radioactively. However, the quality of clean water that is suitable for consumption is not always available in nature. So that the water needed by living things, whether in the form of drinks or food, does not cause disease, it must be treated such as filtering first.

Human life is desperately in need of water. When consumption of water is not fulfilled, it may have a big impact on health and social vulnerabilities. The provision of clean water in Indonesia, especially on a large scale, is still carried out in urban and is managed by the city's drinking water company (PAM). Clean water scarcity is an event where, reducing the depletion, or drying up of the volume of clean water from existing water sources (wells, groundwater, PAM, rivers, springs, etc.), consumption of clean house water at a certain time is limited or scarce. Climate change has an impact on clean water sources in terms of supply, demand, and air quality.

Based on Indonesian Statistic since 2019, the concept used refers to the SDGs (Sustainable Development Goals) metadata where households are said to have access to improved drinking water, namely if the main drinking water sources used are piped water, protected water, and rainwater. Protected water includes drilled/pump wells, protected wells, and protected springs. For households that use a source of drinking water in the form of bottled water, the household is categorized as having access to proper drinking water if the source of water for bathing/washing comes from pipes, drilled wells/pumps, protected wells, protected springs, and rainwater.

The problem arises often found that the quality of groundwater and river water used by the community does not meet the requirements of healthy drinking water, and in some places, the water is below standard of . Water that is fit for drinking has certain standard requirements, namely physical, chemical and bacteriological requirements, and these requirements are an integral part. So if one of the parameters does not meet the requirements according to the specified quality standard, then the water is not fit for drinking.

Percentage of Households by Province, Type of Region, and Source of Adequate Drinking Water (Percent), 2019-2021

Province	Percentage of Households by Province, Type of Region, and Source of Adequate Drinking Water (Percent)								
	Urban			Rural			Urban+Rural		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
North Sumatra	96,00	95,75	96,12	83,51	82,57	84,48	90,22	89,68	90,89

Source: BPS-RI, Susenas 2019-2021

Standard quality drinking water based on Regulation of the Minister of Health of the Republic of Indonesia Number: No. 492/MENKES/PER/IV/2010, water that is used for daily purposes and can be drunk after cooking. The use of drinking water that does not meet these quality standards can cause health problems, both directly and quickly or indirectly and slowly. Groundwater often contains quite large amounts of iron (Fe) and Manganese (Mn). The presence of Fe and Mn in the water causes the color of the water to turn yellow-brown after some time in contact with air. Besides being able to interfere with health, it also causes an unpleasant odor and causes a yellow color on the tub wall, and yellow spots on clothes. Therefore, according to PP No. 20 of 1990, the maximum permissible level of (Fe) in drinking water is 0.3 mg/lt, and the level of Manganese (Mn) in drinking water that is allowed is 0.1 mg/lt. In developed countries such as America and Japan, the regulations for drinking water quality standards are even more stringent. The total content of iron and manganese in drinking water is the maximum allowed is 0.3 mg/lt (http://www.kelair.bppt.go.id). To overcome this problem, it is necessary to make efforts to provide a household-scale water treatment system that can eliminate or reduce the iron and manganese content contained in wells or groundwater. One way to improve groundwater quality is by using a filter with manganese zeolite and activated carbon media (http://www.kelair.bppt.go.id) In many developing countries the problem of providing clean water is not new in rural areas. The water system used is irregular and many have problems using well water and river water as the main source of clean water, which is not sufficient for such high demand.

2. Literature Review

2.1 Definition of Water

According to Kodoatie (2003), clean water is water that is used daily for washing, bathing, and cooking, and can be drunk after cooking. Meanwhile, according to Suripin (2002), what is meant by clean water is safe water (healthy) and good for drinking, colorless, odorless, a good taste fresh. While the definition of clean water according to the Minister of Health of the Republic of Indonesia No. 492/MENKES/PER/IV/2010 is used for daily

purposes and may be drunk after cooking. Clean water is a type of resource in the form of good quality water and is used by humans for daily life, including sanitation. According to WHO, domestic water is clean water used for domestic purposes such as consumption, drinking water, and food preparation.

Clean water is healthy water that is used for human needs and must be free from germs that cause disease, free from chemicals that can pollute water. In Indonesia, most people in rural areas use groundwater to gain the availability of clean water. To get water, the community uses dug wells. Dug wells are the simplest clean water facilities and have been known to the public for a long time. As the name implies, other water sources are made by digging the soil to the depth of the first impermeable soil layer (WHO, 2020).

Based on the Regulation of the Minister of Health Republic of Indonesia No. 492/MENKES/PER/IV/2010 concerning Conditions and Monitoring of Water Quality, Drinking water is safe for health if it meets the physical, microbiological, chemical, and radioactive requirements contained in mandatory and additional parameters.

2.2 Clean Water Treatment

Clean water treatment is a system used to treat water of poor quality to get the desired water quality/determined for further use according to the desired results. The clean water treatment system used is highly dependent on the quality of the available raw water. The quality of groundwater as raw water is very different from one area to another, and it all depends on the topology of each area. (Elfiana, Nahar and Nurdin, 2016).

Improving the quality of drinking water is carried out by managing water, especially water from surface water. The water management in question starts from the simplest way to complete management. (C. Totok Sutrisno, 2010).

There are various ways to solve this problem, one of them is the application of appropriate technology which can produce water of good quality, economical, and easy to use. The technology used includes physical processing (filtration), chemical processing (adsorption) and disinfection using chemical Ca(ClO)2 (chlorine oxidation) with the main media being manganese, activated carbon, and silica sand.

Inadequate management of urban, industrial, and agricultural wastewater means the drinking water of hundreds of millions of people is contaminated or contaminated with hazardous chemicals. The natural presence of chemicals, particularly in groundwater, can also be of health significance, including arsenic and fluoride, while other chemicals, such as lead, may increase in drinking water as a result of leaching from components of the water supply that come into contact with drinking water (https://www.who.int/news-room/fact-sheets/detail/drinking-water).

2.3. Water Treatment Method

Water treatment is an effort to get clean and healthy water with water quality standards that meet health requirements. The water treatment process is a way of changing physical, chemical, and biological raw water. The purposes of water treatment are:

(i) Improve the degree of acidity
(ii) Reduce odour
(iii) Reduce and kill microorganisms
(iv) Reducing the levels of dissolved materials

The water installation system can treat raw water containing chemical elements such as iron (Fe), manganese (Mn), cadmium (Cd), nickel (Ni), lead (Pb), mercury (Hg), and other elements. physical properties, such as smell, taste, color, turbidity, and total dissolved solids (TDS) which exceed the quality standard into clean water suitable for consumption based on the water quality standard (https://aquariontechnologies.weebly.com).

2.3.1 Physical Water Treatment

Physical water treatment that has been carried out is filtration, sedimentation, absorption, and adsorption.

1. Filtration

Filtration is the separation process between solids or colloids in a liquid. Filter wastewater with other media such as sand, silica gravel, and other media that are much more complicated. The process of assessing water through flowing water on granular media. Naturally, water filtration occurs on the surface that has permeated the soil layer. Bacteria can be effectively removed by the process as well as color, turbidity, and iron.

In a sufficient process, large particles will be filtered in the sand media, while bacteria and smaller colloidal materials are not filtered as a whole. The space between the grains serves as sediment where the dissolved grains settle. The dissolved colloidal materials are likely to be captured due to the electrokinetic forces.

Many dissolved materials can form flocs and do not block the clumps from entering the filter and being filtered out. Types of sand filters that are often used ((https://aquariontechnologies.weebly.com).

a. Slow Sand Filter

A natural sand filter is a sand filter that has the work of treating raw water by gravity through a layer of sand as a filtering medium. The filtering speed ranges from 0.1-0.4 m^3/hour. The filtering process can run well if the filter sand height is at least 70 cm because the activity of microorganisms occurs in layers up to 30-40 cm below the surface. These organisms function to eat by destroying organic matter as water flows through the sand. The thickness of micro sand underneath again functions as a chemical filter, because chemical processes occur here. The diameter of the sand ranges from 0.2-0.3 mm, it can filter worm eggs, amoebic cysts, worm larvae, and bacteria. (https://aquariontechnologies.weebly.com).

b. Quick Sand Filter

The fast sand filter also works based on the gravity through the sand with a diameter of 0.2-2.0 mm, and gravel with a diameter of 25-50 mm, with a filtration rate of 100-125 m/day. Effective sand thickness is about 80-120 cm. This fast sand filter can filter worm eggs, amoeba cysts, and worm larvae. Quicksand can also be used to reduce Fe and Mn.

2. Sedimentation

Sedimentation is a process of deposition of solid particles suspended in a liquid or liquid under the influence of gravity or natural gravity. The use of sedimentation is to assuage materials suspended in water and the content of certain organisms in the water.

There are two types of deposition, namely Discrete Settling and Flocelent Settling. Discrete Settling occurs when the process of deposition of a particle is not fulfilled by grouping the particles, thence the deposition rate will be constant. Flocculent Settling is influenced by the grouping of particles so that the depositional speed that is owned changes to a greater extent.

The sedimentation process is influenced by several factors, namely:

(i) Diameter of granules
(ii) Density of granules
(iii) Density of liquid
(iv) Liquid turbidity
(v) Flow speed

2.3.2 Chemical Water Treatment

1. Coagulation or flocculation is the process of collecting particles that cannot be precipitated by adding coagulation. The commonly used metal coagulants fall into two general categories: those based on aluminum and those based on iron. The aluminum coagulants include aluminum sulfate, aluminum chloride, and sodium aluminate. The iron coagulants include ferric sulfate, ferrous sulfate, ferric chloride, and ferric chloride sulfate. Other chemicals used as coagulants include hydrated lime and magnesium carbonate (https://www.iwapublishing.com). The method of coagulation or flocculation in water treatment with chemicals is useful for water-containing chemicals, and color but not too concentrated. In principle, if the water is hard to settle, it means that chemicals need to be added. (https://aquariontechnologies.weebly.com).

2. Aeration is a water treatment process by mixing water with air which aims to increase oxygen and reduce carbon dioxide, and manganese so that they can be precipitated. This process also removes odors from the water (Sanropie, 1984)

2.3.3 Microbiological Water Treatment

The most conventional attempt to improve water microbiology is to kill microorganisms in water. The process of killing microorganisms that are broadly applied and the simplest is to boil water until it reaches a temperature of 100ºC.

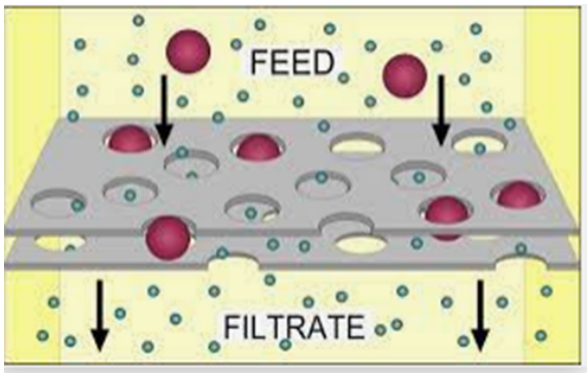


Figure 1. Microbiology filter (https://tuttnauer.com)

Filtration is the first and only sterilization method that eliminates bacteria by separating the microorganisms from the sterilized medium, but unlike other sterilization methods, it doesn't kill or stop the bacteria's ability to reproduce. Filtration uses membranous filters that have tiny pores that let the liquid pass through but prevent bigger particles such as bacteria to pass through the filter. Therefore, the smaller the pore, the more likely the filter is to stop more things from going through it. If the pores of a filter, which is designed to remove a microbe, which is a microscopic organism, are small enough, they should be able to stop all living things from passing through (https://tuttnauer.com). During chemical and microbial treatment, chemicals and microbes decompose into ions and also microbial metabolism generates lots of ions that increase the conductivity.

3. Methodology

The method used in this study is a descriptive method by doing various measurements and experiments, both on the field and in the laboratory.

The water installation system (Figure 2) can treat raw water containing chemical elements such as iron (Fe), manganese (Mn), cadmium (Cd), nickel (Ni), lead (Pb), mercury (Hg), and other physical elements. properties such as smell, taste, color, turbidity, and total dissolved solids (TDS) which exceed the quality standard into clean water suitable for consumption according to the water quality standard.

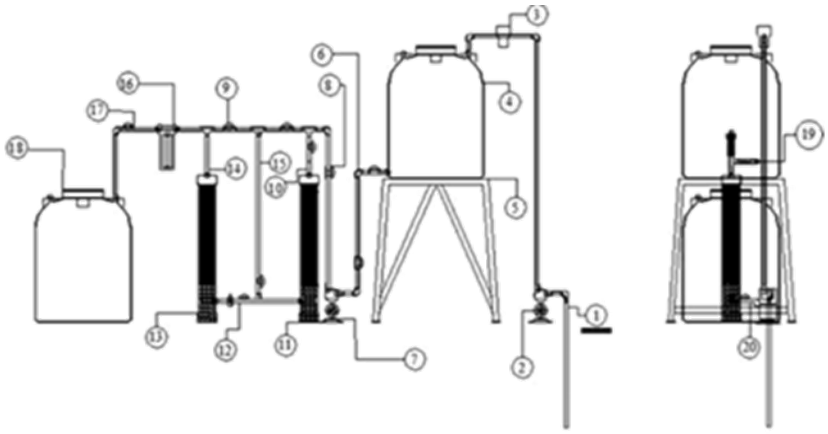


Figure 2. Water Installation System

Name of Parts:

1. Suction pipe
2. Suction pump
3. Chlorine tube1
4. Raw water tank
5. Tank stand
6. Distribution pipe 1
7. Distribution pump
8. Pipe distribution 2
9. Pipe distribution 3
10. Inlet filter 1
11. Filter 1
12. Inlet filter 2
13. Filter 2
14. Clean water outlet
15. Washing line
16. Cartridge
17. Clean Water Channels
18. Clean Water Tank
19. Washing outlet 1
20. Washing outlet 2

4. Finding and Analysis

4.1 Water Treatment and Filter Installation System

The result achieved is one unit of water treatment equipment installation system with a capacity of up to 500 liters/hour.

4.2 Laboratory Test Results

The treated and filtered water was laboratory tested for several parameters as shown in Table 1.

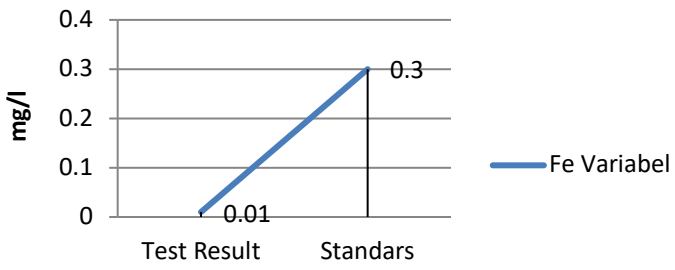
Table 1. Laboratory Test Results

No.	Parameter	Unit	Test result	Standards	Method
1	Total Coliform	mg/l	<2	0	SNI 19-2897-1992
2	Fecal Coliform	CPU/100ml	Negatif	0	MPN
	Physical Parameter				
1	Test		Tasteless	Tasteless	Standard Methode
2	Color	TCU	15	15	Standard Methode
3	Turbidity	NUT	1,12	5	SNI 06-2413-1991
4	TDS	mg/l	263	1000	SNI 06-6989.27 -2005
	Chemical Parameter				
1	Fe++	mg/l	0.01	0.3	SNI 6989.4-2009
2	pH++		8,03	6,5-8,5	SNI 06-6989.73 -2009
3	Organic Substances (KMnO4)	mg/l	7,13	10	SNI 06-6989.22-2004-1991
4	Mercury (Hg)	mg/l	<0,0008	0,001	SNI 06-2462-1991
5	Cadmium (Cd)	mg/l	<0,003	0,005	SNI 6989.16-2009
6	Plumbum (Pb)	mg/l	<0,005	0,05	SNI 6989.8-2009
7	Chromium (Cr)	mg/l	0,03	-	SNI 6989.17-2009
8	Nickel (Ni)	mg/l	<0,008	-	SNI 6989.18-2009

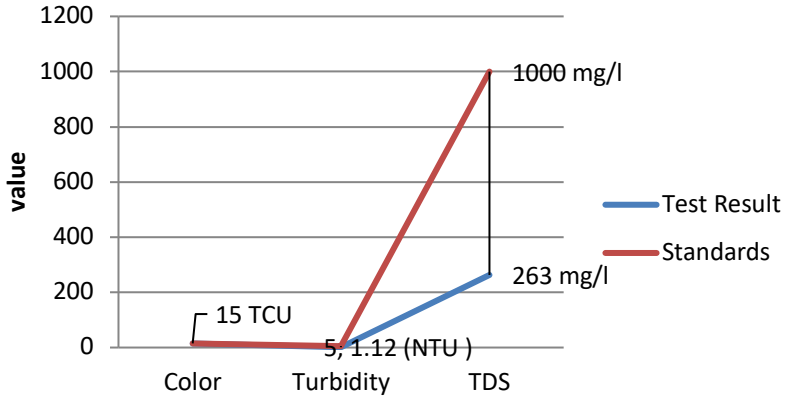
After taking water samples, then testing the iron content contained in the sample water. The results of the initial analysis showed that the groundwater sources found metal elements or organic substances, namely iron (Fe) which exceeded the required quality standards. This indicates that the water source is polluted and does not meet the requirements for clean water quality based on Minister of Health Regulation No. 492/Menkes/PER/IV/2010.

From Table 1, the results of the laboratory tests for 14 parameters indicate that the treated, and filtered water is suitable for consumption but is not ready yet to be drunk immediately because it must go through a boiling process first. Meanwhile, for daily necessities, especially for washing clothes and the like, it is feasible to use because the results of laboratory tests for several parameters related to physical parameters meet the required water quality standards.

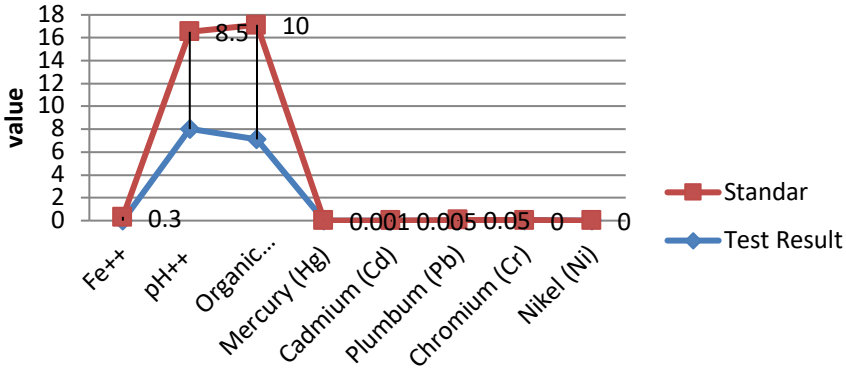
Based on Table 1, data obtained that the value of iron content before filtering was 0.69 mg/liter. This iron content value is above the allowable quality standard of 0.3 mg/liter.and the value of iron content after filtering was 0.01 mg/liter The results of the iron content research that were carried out after using a sieve, turned out to have a large effect, where the removal value was around 43.48%. The value of this reduction in iron content was included in the permitted clean water quality standard. The value of several physical and chemical parameters of the filtered water is shown in the graph below



Graph 1. Parameter iron (Fe) after filtering process



Graph 2. Physical Parameter



Graph 2. Chemical Parameter

4.3 Manual Test Results

Manual testing is done by taking a test sample of unfiltered water (sample 1) dipped in tea powder, it looks like the water shows a blackish-brown color, and the filtered water sample (sample 2) is dipped in tea powder, it looks like the water shows a clear brown color as original tea color. This indicates that filtered water is suitable for consumption as drinking water.

Figure 3. Water Sample

5. Conclusion

The results of laboratory testing showed that the filtered water for health-related parameters, namely F. Coliform and T.Coliform, showed results <2 mg/l and is suitable for consumption for drinking water. While the physical parameter for TDS of 263 mg/l has met the quality standard requirements (1000 mg/l), and the chemical parameter for pH of 8.0 meets the water quality standard requirements (6,5-8,5). The results of laboratory testing and manual filtering of water samples show that the water is suitable for consumption as drinking water but is not ready to drink as well as mineral water on the market.

Meanwhile, for daily needs such as bathing and washing water, it is feasible to use because of the 14 water

parameters filtered, 12 parameters meet the specified quality standard requirements. The results obtained from processed water are according to the Minister of Health, Republic of Indonesia Regulation No. 492/Menkes/PER/IV/2010.

The results of manual testing, namely by giving tea powder to raw water and processed water, have shown differences, namely the color of the raw water looks dark brown while the filtered water is brownish-red. This shows that the content of metal elements is according to the quality standards of water suitable for consumption.

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References

Agency for the Assessment and Application of Technology, 1999; Public Health and Water Quality Improvement Technology, Directorate of Environmental Technology Deputy for Technology.

Central Bureau of Statistics, 2018, Amount of Clean Water Distributed by Clean Water Companies (thousand m3), 2018-2020, https://www.bps.go.id/indicator/7/115/1/sum-air-net-yang-distributed-corporate-air-net.html

C. Totok Sutrisno, 2010, Clean Water Supply Technology, Rineka Cipta, Cet 7, Jakarta

Darsono, et al, 2002, Effect of Sand Diameter and Thickness in Slow Sand Filters.

Dwijosaputro, D. 1981, Clean Water Treatment Technology, *Publisher, Graha*, Jakarta.

Elfiana, Nahar, Nurdinn, 2016, Groundwater Filtering into Clean Water in Modern Dayah Ihyaaussunnah in Lhokseumawe, *Journal of Community Service,* Volume 22 No. April 4-June 2016 (82–87), Lhokseumawe . State Polytechnic

Kusnaedi. (2004). Treating Peat Water and Dirty Water for Clean Water, *Self-Help Disseminator*, Jakarta.

Kodoatie, J. Robert. 2003, Management of Water Resources in Regional Autonomy. *Association of Indonesian Hydraulic Engineers*. Jakarta.

Minister of Health, 2010 List of Water Quality Requirements. *Regulation of the Minister of Health of the Republic of Indonesia*. No. 492/Menkes/PER/IV/2010

Nusa Idaman Said, 2012, Manufacturing of Filters to Remove Iron and Manganese in Water, Directorate of Environmental Technology Deputy for Information Technology, Energy and Materials, *Agency for the Assessment of Application of Technology*, Jakarta

Nuraini et all, 2015, Profile of Indonesian Population Result of SUPAS 2015, Central Bureau of Statistics, Indonesia.

Sanropie, 1984, Handbook for the Provision of Clean Water, *Academy of Health Inspectors, Sanitation Technology, Jakarta.*

Suripin, 2002. Preservation of Groundwater Resources. *Jakarta: PT*. Gramedia Pustaka Utama.

Tuttnaver Team, 2017, How Does Filtration of Liquids in the Lab Work, Laboratory Autoclave,

WHO (2020) Water safety and quality. Av*ailable at: https://www.who.int/water_sanitation_health/water-quality/en/*

http://www.kelair.bppt.go.id/Sitpa/Artikel/Filter/filter.html
https://tuttnauer.com/blog/liquids-sterilization-by-filtration Accessed 21.02.2022
https://jurnalsda.pusair-pu.go.id/index.php/JSDA/article/view/412/309 Accessed 21.02.2022
https://media.neliti.com/media/publications/48298-ID-profil-penduduk-indonesia-hasil-supas-2015.pdf