OPTIMIZATION OF THE HARDNESS OF CLEAN WATER SOURCES WITH VARIOUS TREATMENT PRINCIPLES TO OBTAIN SOFT-CATEGORY DRINKING WATER IN KUPANG CITY IN 2022

[1]Ferry WF Waangsir, [2] I Gede Putu Arnawa, [2] Johanis JP Sadukh

[1,2,3] Poltekkes Kemenkes Kupang

[1] ferrykpg@gmail.com, [2] igdputuarnawa2812@gmail.com, [3] johankesling@gmail.com

Abstract

Purpose: The aim of this study are to identify the physical quality and hardness level of clean water in one of the water sources used by the people of Kupang City and also to analyze the level of hardness of borehole water before and after processing through the methods of filtration, coagulation, and the addition of quicklime.

Methodology: The research was conducted using experimental methods, and the research outputs were intellectual property rights, journal publications and simple modeling of water treatment methods in reducing hardness.

Findings: The results of the examination of the average hardness content of the raw water source from the Oenesu Spring were 365.33 mg/L. After being given treatment using Tohor Lime, Alum, Activated Charcoal, Silica Sand, Quartz Sand, and Zeolite media, the highest average decrease in hardness was obtained for Quartz Sand media with a reduction effectiveness of 53.41% and the lowest for Activated Charcoal media with a reduction effectiveness 0,79%.

Contribution: This research can contribute to the development of science, especially in the field of environmental health in improving the quality of clean water, especially the level of water hardness.

Keywords: *Hardness; Processing; Kupang City*

1. Introduction

The purpose of health development is to improve public health fairly and equitably, one of which is the program for providing drinking water for residents. Water used for consumption should meet several requirements including colorless, normal temperature, tasteless, odorless, clear or not cloudy, and not contain solids (1). Good water is water that meets the physical, microbiological and chemical requirements. Physical requirements that must be met are odorless, colorless, and tasteless. Water that meets microbiological requirements is that it does not contain Escherichia coli and coliform bacteria. Chemically, the water must meet the requirements that there are no chemicals in the form of arsenic (As), iron (Fe), chloride (Cl-), and hardness in the form of $CaCO_3$ (2).

The problem that is often faced in groundwater management is hardness. This can happen because in the process of taking it from the soil it passes through various layers of soil including

limestone soil containing Ca and Mg so that the water becomes hard. Hard water is often found in areas with thick topsoil and limestone formation (3).

The city of Kupang has a limestone topography so that during the rainy season, rainwater contacts through the calcareous soil layer so that the raw water becomes hard and even very hard. Various efforts have been made by residents or drinking water providers to reduce total hardness or calcareous water, among others, by heating water, processing refillable water depots, and processing various drinking water products. According to Sanropie, drinking water consumed by the body is categorized as soft, which has a total hardness range of 60-120 mg/lt (4).

Hard impact or lime content of drinking water above 60-120 mg/lt can cause health problems in the form of kidney stones and below 60-120, mg/lt causes mineral and calcium deficiency in the body

2. Literature review and hypotheses development

A. The Role of Water

Clean water in Indonesia is used for drinking water raw materials, and other purposes such as washing clothes, cooking, bathing, and other sanitation hygiene needs. All living things need water because water is a basic need for life. For humans, water is a very absolute necessity because the substances that make up the human body consist mostly of water, amounting to about 73% of body parts without fat tissue. The use of water for the human body, among others, for the process of digestion, metabolism, lifting of food substances in the body, regulating body temperature balance, and keeping the body from drying out. The water needed by humans for a healthy life must meet the quality requirements and quantity (amount) is also met. Water needs cover many things and are very broad, for example, water needs for irrigation (plants), livestock and fisheries, industry, and water needs for households (6).

B. Water Resources

Clean water data was obtained from various water sources. Sources of raw water data come from surface water and subsurface water. In Indonesia, the use of raw water sources from rivers, lakes, or other sources has been widely practiced. The choice of each region depends on the availability of water sources. Water from the sea or swamp is currently an option that, although still relatively expensive, can be processed into drinking water. Here are some examples of raw water sources that can be used as drinking water (6):

1) Rainwater. This type of rainwater source is widely used with simple direct storage. Rainwater is generally harvested or stored and used in areas where water is scarce during the dry season. The direct use of rainwater for household needs is not significant. Rainwater storage for reserves in meeting water needs during the dry season can be placed on the ground or in the ground.
2) Water springs. These water sources generally qualify as drinking water or close to drinking water. Springs are usually available in mountainous areas. This is because

the elevation of the water table in the soil, both as a compressed aquiver and a free aquiver, is still higher than the area below it. Thus, spring water occurs, which is when water comes out of the ground.

3) River water. There are quite a lot of river water sources in Indonesia. The quality of river water varies greatly depending on the location, the load of sediment and pollutants it carries, and so on. River water can be raised in elevation using damming. With bending, river water can be flowed to a higher place to be treated, then flowed to the community by gravity or using a pump.
4) Reservoir or Artificial Lake. Raw water extraction from the reservoir can be carried out using a pump or using a siphon pipe that was previously planned at the time of the reservoir construction.
5) Shallow well. The use of this water source has been widely used. The quality of shallow well water is better than that of surface water sources. The ability of shallow wells to guarantee the family's water volume needs is generally more than adequate.
6) Deep well. Deep wells penetrate groundwater and look for aquifer areas that have better quality and capacity in both dry and rainy seasons.

C. Water Treatment Principles

Water treatment is defined as a technical operation carried out on raw water so that it becomes clean water which becomes clean water that meets the quality requirements of clean water or drinking water by combining several processing processes. Water treatment aims to reduce the concentration of each pollutant in the water so that it is safe to use (7), (8). The operating units and process units used in clean water treatment are as follows:

1) Physical Processing

There are several physical processing processes, namely:

a) Pre-sedimentation is a simple gravity deposition process without the addition of any chemical coagulant. Its use is to protect moving mechanical equipment, one of which is aeration. Multiple tray aerator is a reactor that is commonly used as one of the aeration processes because it does not cost much and has a simple design so that people can operate it.
b) Sedimentation, this process uses the principle of specific gravity, which aims to precipitate colloidal particles that have been destabilized by the previous process, namely flocculation. At present, the processes of coagulation, flocculation, and sedimentation in a Water Treatment Plant (WTP) are combined into a process called an accelerator.
c) Filtration, the filtration process aims to filter out the suspensions in the water. The filtration process can be carried out with membrane technology, besides that it can also use other media such as sand, gravel, and others (9). In membrane technology, this filtration process uses several types, namely Multi Media Filter, UF (Ultrafiltration) System, NF (Nanofiltration) System, MF (Microfiltration) System, and RO (Reverse Osmosis) System.

2) Chemical processing

a) Coagulation is the process of changing a liquid or solution into soft lumps, either in whole or in part. Because basically, the water source is usually in the form of a colloid

with various contents contained therein. The purpose of this process is to separate water from dissolved impurities. This destabilization process can be done physically with rapid missing, hydraulically, or mechanically.

b) Flocculation, is a collection of small particles and colloids that form like the filtrate on a filter that passes (floc). Flocculations begin to form immediately after destabilization in the mixing zone or aftershocks. Aims to enlarge the floc and do slow stirring also the water conditions must be calm.

c) Disinfection carried out after the coagulation and flocculation process, there are still impurities that remain, possibly bacteria and germs. So it is necessary to add chemical compounds to kill these germs. Chlor, ozonation, UV, heating, and others are commonly used for addition before entering the reservoir

D. Hardness Reduction Principles

The principle of decreasing the temporary hardness can be reduced by heating the water. The reaction is as follows Ca(HCO3)2 CaCO3+ H2CO3. The precipitated CaCO3 is separated by filtering. Temporary hardness can also be reduced by adding quicklime, namely CH(OH2x), while the permanent hardness can be reduced by adding quicklime, namely Ca(OH2x,) and adding soda, namely Na2CO3, then the precipitate that occurs is filtered. Using an ion exchanger and the chemicals used are Ziolite or Resin chemicals that can bind calcium and magnesium hardness ions.

3. Research methodology

This type of research is an actual experiment where the purpose of this research is to investigate the relationship of an effect by exposing an experimental group or more to one or more conditions and comparing the results with a control group or more that did not receive treatment (11). The variable of this study are the spatial is one of the water sources used by the community in Kupang City; filtration using activated charcoal media, silica sand, quartz sand, and zeolite; Coagulation using alum with various doses of 0.1 mg/L, 0.5 mg/L, 1 mg/L, 1.5 mg/L and 2 mg/L; Affixing with quicklime with various doses of 0.2 mg/L, 0.5 mg/L, 1 mg/L, 1.5 mg/L and
2 mg/L; and total hardness level before and after treatment.

4. Results and discussions

A. Overview of Oenesu Clean Water Source

The source of clean water used by the community in Kupang City generally comes from springs, drilled wells, or dug wells One of the water sources used by the community in

Kupang City is the one sourced from Oenesu Spring which is managed by Perusahaan Daerah Air Minum Kupang Regency. This water source is located in Oenesu Village, West Kupang District, Kupang Regency with an altitude from sea level ranging from ± 288 meters above sea level (BPS Kabupaten Kupang, 2020). The location of the water source in question is seen in the following figure.

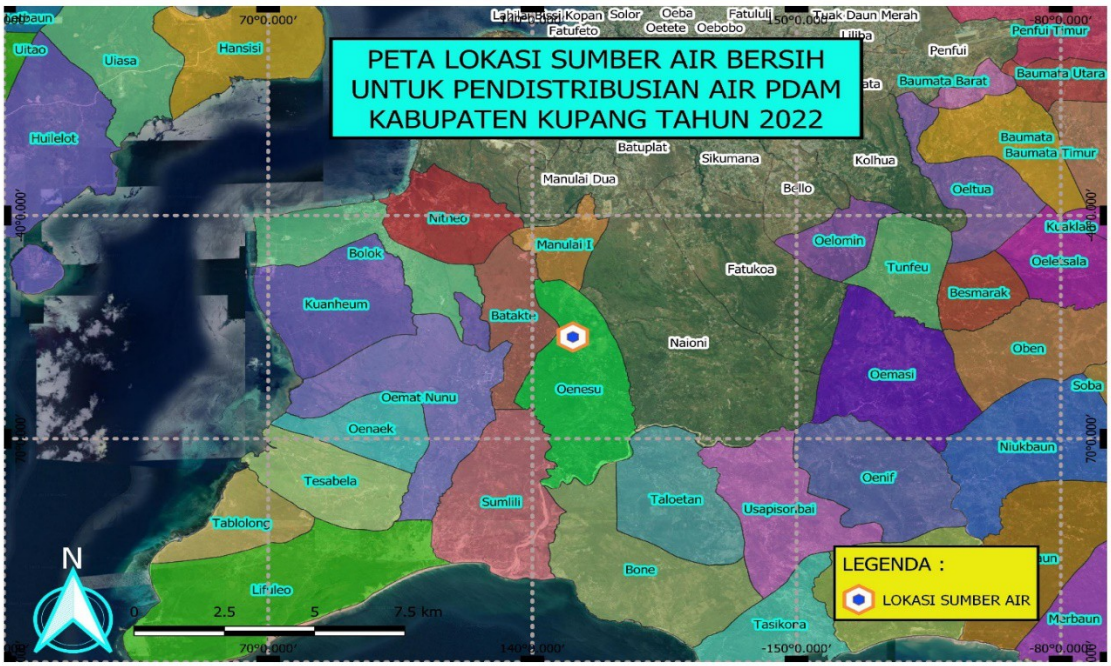

Figure 1. Water Source Location Map

Kupang City has a limestone soil topography, so that conditions during the rainy season, rainwater contacts through the calcareous soil layer so that the raw water will become hard and even very hard. The results of a study conducted by Theodolfi (2014), showed that water resources that are commonly used for the need for clean water services for the needs of Kupang City are taken from springs that come out in several areas, flowed at a certain height, and then distributed by gravity. Another source that is still potential and is used as one of the main sources of water needs for Kupang City is to use drilled wells (13). The quality of clean water consumed by the people of Kupang City has generally not been polluted by heavy metals or other chemical contamination. Research conducted by Arnawa (2021) shows that one of the surface water sources in Kupang City is still found to contain E Colli bacteria in addition to the type of contamination others (14).

Various efforts have been made by the community or drinking water providers to reduce the rate of total hardness or calcareous water, including heating water and treatment at refill drinking water depots. People generally heat the water before consumption as one of the efforts made to reduce hardness (15). According to Sanropie, drinking water consumed for the soft category body has a total hardness rate range of 60-120 mg / lt.

Hardness in principle is contaminated with water with cation elements such as Na, Ca, and Mg. the most common hardness is seawater. In surface fresh water, the content of

Ca and Mg is generally high in high levels (>200 ppm) of CaCO3. So that the water flowing in the limestone area will have a high level of hardness. High hardness and starting to accumulate in household appliances if the amount is above 100 ml / L. A hardness above 300 mg / L in the long term will affect humans with weak kidneys so they experience kidney disorders (16).

The results of the examination of the average hardness content in the Oenesu raw water source were 365.33 mg / L. The level of hardness in the Oenesu water source in this study was still high when compared to The level of hardness in the water source used by PDAM Wainitu Ambon City ranges from 84.07 - 98.09 mg / L at several different sampling locations (17).

B. Reduction of Hardness Level using the Filtration Process

The results of the examination of the level of hardness in water sourced from Oenesu Springs before and after processing using filtration media are shown in the following table.

Table 1

Average Results of Examination of Hardness Level Before and After the Filtration Process Using Various Filtration Media

No	Filtration Media	Hardness Level (Mg/L)		
		Before Treatment	After Treatment	Decreased Effectiveness (%)
1	Activated Charcoal Media	365,33	362,85	0,79
2	Silica Sand Media		236,53	35,50
3	Quartz Sand Media		239,01	53,41
4	Zeolite Media		296,59	28,76

Source: Processed Primary Data, 2022

From the table above, it can be seen that quartz sand media is more effective in reducing the level of hardness of raw water with a decreased effectiveness of 53.41% and the lowest is activated charcoal media, which is 0.79%.

The use of filtration media such as activated charcoal, sand, and zeolite in reducing hardness has been tested to be effective. For this reason, it is necessary to analyze further related to the mixing of the filtration media (*mixed media*) with a longer residence time to increase the effectiveness of reducing the level of hardness in raw water. The longer the contact in the filtration and adsorption process, the more effective it will be in reducing the level of well water hardness (7).

C. Decreased Hardness Levels using the Coagulation Process

1. Use of Alum

   Alum is a coagulant material that is generally used in binding dissolved particles present in water. The results of the examination of the use of alum in reducing hardness with various doses are shown in table 2 below.

Table 2

Average Results of Examination of Hardness Levels Before and After Coagulation Process Using Alum with Dose Variations

No	Alum Dosage Variations	Hardness Level (Mg/L)		
		Before Treatment	After Treatment	Decreased Effectiveness (%)
1	0.2 mg/L	365,33	326,93	11,88
2	0.5 mg/l		324,45	12,50
3	1 mg/l		321,98	13,36
4	1.5 mg/L		325,69	12,31
5	2 mg/L		313,31	15,97

Source: Processed Primary Data, 2022

From the table above, it can be seen that beware with d osis 2 mg / L is more effective in reducing the level of hardness of raw water with a decreased effectiveness of 15.97% and the lowest is at a dose of 0.2 mg / L which is 11.88%.

This research is inversely proportional to research conducted by Trimaly, et al (2017) which shows that the use of alum in water in peatlands tends to increase hardness levels ($CaCO_3$) (Trimaily et al., 2017). In terms of physique, the treated water with this treatment does not feel slippery and is effective with the use of soap. As it is known that a high level of hardness will cause the water to feel slippery and the soap work does not become effective (does not cause foam).

2. Use of Quicklime

Quicklime, also known as calcium oxide (CaO), is the result of burning raw lime (calcium carbonate or $CaCO_3$) at a temperature of approximately 90 degrees Celsius. If it is doused with water, then quicklime will generate heat and turn into extinguished lime (calcium hydroxide, CaOH).

The results of the examination of the use of the Kapur tour in reducing hardness with various doses are shown in table 3 below.

Table 3

Average Results of Examination of Hardness Levels Before and After Coagulation Process Using Quicklime with Dose Variations

No	Variations in the dosage of quicklime	Hardness Level (Mg/L)		
		Before Treatment	After Treatment	Decreased Effectiveness (%)
1	0.2 mg/L	365,33	346,75	5,09
2	0.5 mg/l		331,89	9,64
3	1 mg/l		333,13	9,70
4	1.5 mg/L		326,93	11,53
5	2 mg/L		323,22	12,88

Sumber: Processed Primary Data, 2022

From the table above, it can be seen that lime with a dose of 2 mg / L is more effective in reducing the level of hardness from raw water with a decreased effectiveness of 12.88% and the lowest is at a dose of 0.2 Mg / L which is 5.09%.

Research conducted by Jannah (2015) showed an increase in the pH value of water from

3.07 to an average pH of 7.14 in a span of 40 minutes (19).

The high CaO content in quicklime is what is said to be able to bind hardness particles to make the level of hardness drop or lower in raw water.

5. Conclusion

From the results of the study, some can be concluded several things as follows:

a. The level of raw water hardness sourced from Oenesu clean water source is 365.33 mg / L;
b. The level of hardness of treated water in the filtration process using quartz sand media is more effective in reducing the hardness level of raw water with a decreased effectiveness of

   53.41% and the lowest is activated charcoal media, which is 0.79%;
c. The level of hardness of treated water in the coagulation process using alum at a dose of 2 Mg / L is more effective in reducing the level of hardness of raw water with a decreased effectiveness of 15.97% and the lowest is at a dose of 0.2 Mg / L which is 11.88%;
d. The level of hardness of treated water in the coagulation process using quicklime with a dose of 2 Mg / L is more effective in reducing the level of hardness from raw water with a decreased effectiveness of 12.88% and the lowest is at a dose of 0.2 Mg / L which is 5.09%.

Limitation and study forward

-.

Acknowledgement

-.

References

Arnawa, I. G. P., Waangsir, F. W. F., Maran, A. A., & Susilawati, N. M. (2022). Studi Aktivitas Pencemaran, Kuantitas, Kualitas Perairan (Indeks Biotik), Kualitas Air Limbah, Air Kali Dendeng Sebagai Air Baku Pada Daerah Hilir, Tengah dan Hulu di Kota Kupang Tahun 2021. *Syntax Literate; Jurnal Ilmiah Indonesia*, *7*(5), 5821–5836.

Astuti, D. W., Fatimah, S., & Anie, S. (2016). Analisis Kadar Kesadahan Total Pada Air Sumur Di Padukuhan Bandung Playen Gunung Kidul Yogyakarta. *Analit: Analytical and Environmental Chemistry*, *1*(1), 69–73. http://jurnal.fmipa.unila.ac.id/analit/article/view/1239/982

BPS Kabupaten Kupang. (2020). *Kecamatan Kupang Barat Dalam Angka Tahun 2020*.

Husaini, A., Yenni, M., & Wuni, C. (2020). Efektivitas Metode Filtrasi Dan Adsorpsi Dalam Menurunkan Kesadahan Air Sumur Di Kecamatan Kota Baru Kota Jambi. *Jurnal Formil (Forum Ilmiah) Kesmas Respati*, *5*(2), 91. https://doi.org/10.35842/formil.v5i2.323

Jannah, N. W. (2015). *Pada Netralisasi Air Skala Laboratorium*. *5*(1), 1–4.

Latupeirissa, A. N., & Manuhutu, J. B. (2020). Analisis Parameter Fisika Dan Kesadahan Air Pdam Wainitu Ambon. *Molluca Journal of Chemistry Education (MJoCE)*, *10*(1), 1–7. https://doi.org/10.30598/mjocevol10iss1pp1-7

Theodolfi, R., & Waangsir, F. W. F. (2014). Analisis Kebutuhan Air Bersih Kota Kupang Menurut Ketersediaan Sumber Air Bersih dan Zona Pelayanan. *Media Kesehatan Masyarakat Indonesia*, *10*(2), 90–95.

Triatmadja, R. (2019). *Teknik Penyediaan Air Minum Perpipaan*. Gadjah Mada University Press.

Trimaily, D., Nofrizal, N., & Maryanti, E. (2017). Efektivitas Penggunaan Tawas dan Tanah Lempung pada Pengolahan Air Gambut Menjadi Air Bersih. *Dinamika Lingkungan Indonesia*, *4*(1), 39. https://doi.org/10.31258/dli.4.1.p.39-52

Waangsir, F. W. F., Maran, A. A., & Banoet, D. M. (2018). Survey On Provision Of Clean Water And Household Water in Kampung Amanuban Oebufu Village Oebobo Sub District in 2017. *Proceeding 1st. International Conference Health Polytechnic of Kupang*, 361–372.

Arnawa, I. G. P., Waangsir, F. W. F., Maran, A. A., & Susilawati, N. M. (2022). Studi Aktivitas Pencemaran, Kuantitas, Kualitas Perairan (Indeks Biotik), Kualitas Air Limbah, Air Kali Dendeng Sebagai Air Baku Pada Daerah Hilir, Tengah dan Hulu di Kota Kupang Tahun 2021. *Syntax Literate; Jurnal Ilmiah Indonesia*, *7*(5), 5821–5836.

Astuti, D. W., Fatimah, S., & Anie, S. (2016). Analisis Kadar Kesadahan Total Pada Air Sumur Di Padukuhan Bandung Playen Gunung Kidul Yogyakarta. *Analit: Analytical and Environmental Chemistry*, *1*(1), 69–73. http://jurnal.fmipa.unila.ac.id/analit/article/view/1239/982

BPS Kabupaten Kupang. (2020). *Kecamatan Kupang Barat Dalam Angka Tahun 2020*.

Husaini, A., Yenni, M., & Wuni, C. (2020). Efektivitas Metode Filtrasi Dan Adsorpsi Dalam Menurunkan Kesadahan Air Sumur Di Kecamatan Kota Baru Kota Jambi. *Jurnal Formil (Forum Ilmiah) Kesmas Respati*, *5*(2), 91. https://doi.org/10.35842/formil.v5i2.323

Jannah, N. W. (2015). *Pada Netralisasi Air Skala Laboratorium*. *5*(1), 1–4.

Latupeirissa, A. N., & Manuhutu, J. B. (2020). Analisis Parameter Fisika Dan Kesadahan Air Pdam Wainitu Ambon. *Molluca Journal of Chemistry Education (MJoCE)*, *10*(1), 1–7. https://doi.org/10.30598/mjocevol10iss1pp1-7

Theodolfi, R., & Waangsir, F. W. F. (2014). Analisis Kebutuhan Air Bersih Kota Kupang Menurut Ketersediaan Sumber Air Bersih dan Zona Pelayanan. *Media Kesehatan Masyarakat Indonesia*, *10*(2), 90–95.

Triatmadja, R. (2019). *Teknik Penyediaan Air Minum Perpipaan*. Gadjah Mada University Press.

Trimaily, D., Nofrizal, N., & Maryanti, E. (2017). Efektivitas Penggunaan Tawas dan Tanah Lempung pada Pengolahan Air Gambut Menjadi Air Bersih. *Dinamika Lingkungan Indonesia*, *4*(1), 39. https://doi.org/10.31258/dli.4.1.p.39-52

Waangsir, F. W. F., Maran, A. A., & Banoet, D. M. (2018). Survey On Provision Of Clean Water And Household Water in Kampung Amanuban Oebufu Village Oebobo Sub District in 2017. *Proceeding 1st. International Conference Health Polytechnic of Kupang*, 361–372.