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The Effectiveness of Reducing Hardness in the Filtration Process Using Mixed Media with Detention Time Variations

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Abstract: The problem that is often faced in groundwater management, especially deep groundwater such as boreholes is hardness. This can happen because in the process of taking it from the soil through various layers of soil including limestone soil containing Ca and Mg, so that the water becomes hard. Hard water is found in areas where the top soil layer is thick and there is limestone formation. This study aims to identify the physical quality and hardness level of clean water sourced from dug wells and drilled wells, after treatment through filtration methods. Filtration is carried out using mixed media with variations in residence time in the filtration media, namely 30 minutes, 60 minutes and 90 minutes. The results showed that the effectiveness of reducing hardness in dug wells and drilled wells was highest for a variation in 90 minutes, For dug wells, the effectiveness of 90 minutes of residence time reached 9.18% and for drilled wells, the effectiveness reached 16.36%.

Keywords: Detention time; Filtration; Mixed media; Reducing hardness

Introduction

Water is a necessity for the survival of humans and all living things. Therefore, the need for water that meets the requirements for consumption becomes an obligation that must be fulfilled for the entire community (Dewi et al., 2018; Mishra, 2023). The Drinking Water Supply Program for residents organized by the government guarantees that the availability of water must be the main need for services supported by qualified quantity and quality (Juwono et al., 2022; Prihatin et al., 2015). Water used for consumption should meet several requirements including colourless, normal temperature, tasteless, odourless, clear or not cloudy and not contain solids (Azteria & Rosya, 2023; Kusneidi, 2010). Water that is suitable for consumption is water that meets physical, microbiological and chemical requirements (Organization, 2022; Richards et al., 2021). The physics 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 (Wen et al., 2020). Chemically water must meet the requirements of no chemicals in the form of arsenic (As), iron (Fe), chloride (Cl-) and hardness in the form of $CaCO_3$ (Peraturan Menteri Kesehatan Republik Indonesia Nomor 32 Tahun 2017, 2017).

A problem that is often faced in groundwater management is hardness. This can happen because in the process of taking it from the soil through various layers of soil including limestone soil containing Ca and Mg, so that the water becomes hard. Soil with a thick layer and formed from calcareous rocks is found a lot of water with a high hardness level (Sutrisno, 2006; Wang et al., 2021). Kupang City has limestone topography, so that conditions during the rainy season, rainwater contacts through the calcareous soil layer so that raw water will become hard even very hard.

Hardness levels can be lowered by filtration using activated charcoal media, quartz sand and zeolite (Rivai & Rayani, 2019; Waangsir et al., 2023). According to Sanropie, drinking water consumed for the body is soft category which has a total hardness range of 60-120mg/lt (Sanropie, 1984). The World Health Organization (WHO) states that water hardness can cause health problems such as heart blood clots and

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kidney stone disease, where consuming water with high levels of hardness can cause kidney failure, as well as causing scale on cooking utensils and waste in the use of soap because the foam produced is small (Rivai & Rayani, 2019). The purpose of this study is to identify the physical quality and hardness level of clean water sourced from dug wells and drilled wells, after treatment through filtration methods using mixed media with variations in residence time.

Method

This research is a type of experimental research. Raw water samples were taken from a dug well owned by one of the residents in Kupang City and a drill well which is often used as a water filling place on tank cars. The filtration media used is mixed media placed in several filtration containers with successive layers as follows: zeolite, activated charcoal, silica sand, quartz sand with residence time variations of 30 minutes, 60 minutes and 90 minutes, respectively. Raw water and treated water from the filtration process are checked for field parameters tested for hardness.

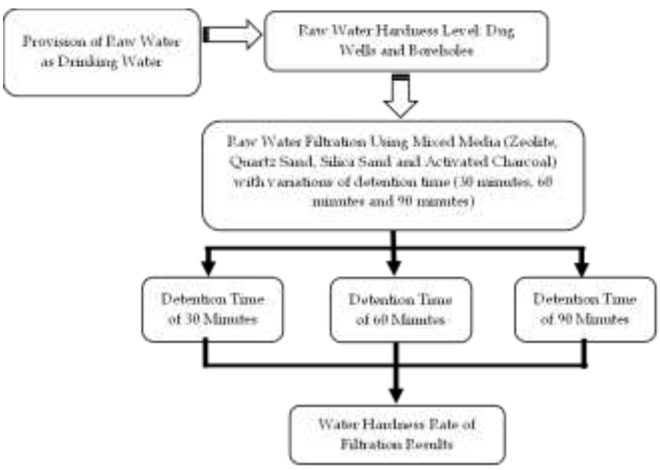

Figure 1. Stages of the research process

The results of laboratory tests are presented in the form of tables for further descriptive analysis to obtain the effectiveness of reducing hardness due to the filtration process using mixed media with variations in residence time.

Result and Discussion

Springs, Boreholes or Dug Wells Digging wells and boreholes are sources of groundwater that are very helpful in providing clean water for the community, especially people in Kupang City. Dug wells can only be used in areas that have sufficient access to groundwater. In areas with shallow or polluted groundwater, dug wells may not be effective. In Kupang City itself, the community uses dug wells, especially after the post-rainy season and entering the dry season, some of the community's dug wells have begun to dry up and switch to water sources derived from boreholes. Boreholes are a solution that is often used in providing access to clean water in various regions, especially in areas that have deep enough groundwater and adequate resources (Carrard et al., 2019; Martín-Loeches et al., 2020).

Water quality from dug wells and boreholes can vary depending on several factors, including geographic location, surrounding environment, and construction and maintenance practices used (Gemeda et al., 2021; Murei et al., 2023). Kupang has limestone topography, so that conditions during the rainy season, rainwater contacts through calcareous soil layers so that raw water will become hard and even very hard. Water with a high level of lime content can have an unusual taste and smell. In addition, this water can precipitate lime inside household appliances and pipes, resulting in the formation of lime deposits called lime crust. The results of examination of field parameters and hardness in raw water are shown in Figure 2 and Table 1.

Figure 2. Sample examination process

Table 1 shows the results of physical parameter examination and hardness level before the Filtration Process where all field parameters tested are still qualified, while for hardness there is a difference in test results between water sources derived from dug wells and drilled wells.

Table 1. Results of Examination of Physical Parameters and Water Hardness Level before the Filtration Process

Parameters	Raw Water	
	Dug Well	Boreholes
Color	Colorless	Colorless
Taste	Tasteless	Tasteless
Odour	Odourless	Odourless
pH	7.54	7.47
Water Temperature	28.50	28.80
Hardness	548.8	616

The results of the above research, when compared with Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Purposes, Swimming Pools, Solus per Aqua and Public Baths according to Permenkes Number 32 of 2017, are categorized as still meeting the specified requirements, except for the Hardness parameter that has exceeded the quality standard (Peraturan Menteri Kesehatan Republik Indonesia Nomor 32 Tahun 2017, 2017).

The physical quality of raw water sourced from dug wells and boreholes depends on the soil layer and the material content contained in the soil in addition to other polluting factors that affect the quality of the water (Abanyie et al., 2023). Water hardness includes calcium and magnesium hardness; Carbonate hardness is very sensitive to heat and easily settles to high temperatures. Groundwater, such as dug well water, is usually more impermeable than surface water. The ability of water to form foam is affected by water hardness. The higher the water hardness, the more difficult it is for soap to form foam due to precipitation (Bozorg-Haddad et al., 2021; Das, 2023). The results of hardness effectiveness tests on dug wells and drilled wells are seen in Table 2.

Table 2. The Effectiveness of Hardness of the Filtration Process Using Mixed Media with Variations of Contact Time

Raw Water	t	Analysis Result		
		X0	X1	Effectiveness
Dug Well	30 ʹ		532	3.06 %
	60 ʹ	548.8	526.4	4.08 %
	90 ʹ		498.4	9.18 %
Bore Well	30 ʹ		554.4	10.00 %
	60 ʹ	616	520.8	15.45 %
	90 ʹ		515.2	16.36 %

Note:
t : detention time (minute)
X0 : hardness level before filtration (mg $CaCO_3$)
X1 : hardness level after filtration (mg $CaCO_3$)

Table 2 shows the effectiveness of hardness before and after the filtration process using mixed media with variations in contact time. The highest effectiveness with a contact time of 90 minutes for both water sources with an effectiveness value of 9.18% for dug wells and 16.36% for drilled wells. Judging from the filtration process with mixed media with variations in residence time when compared to hardness standards according to Permenkes 32 of 2017, those who meet the requirements are treated water sourced from dug wells with a stay time of 90 minutes (quality standard: 500 mg/L).

The results of this study show that the longer the contact time between the media and water, the more effective it will be in reducing the level of water hardness. The results of this study are in line with research conducted by Dewi et al. (2018) which showed that activated charcoal media was able to reduce hardness most effectively at a contact time of 30 minutes when compared to contact times of 10 minutes and 20 minutes (Dewi et al., 2018).

Filtration is a preliminary treatment in the water purification process that aims to remove particles in water. The filtration process is the process of separating solids from solutions to remove very fine suspended particles, where the solution is passed through a porous medium or porous material (Husaini et al., 2020). Decreased hardness, also known as water softening, is the process of removing minerals dissolved in water (Tang et al., 2021), including hardness-causing minerals such as Ca2+ and Mg2+. In this study, the hardness reduction process was carried out through precipitation during the filtration process (Setyobudiarso et al., 2022).

The difference in contact time has an impact on decreasing hardness levels. This is due to the adsorbs process. Adsorption is the process by which molecular substances leave a solution and join on a solid surface through physical and chemical bonds. This process usually uses activated carbon, which sets aside aromatic compounds and dissolved compounds (Franke et al., 2021; Hidayah et al., 2023). The process by which molecules leave a solution and stick to the surface of a substance due to chemical and physical bonds is called adsorption. The presence of Van Der Walls forces causes physical adsorption. If the attraction force of the solute molecules with the adsorbent is greater than the attraction force of the molecules with the solvent, the solute will be adsorbed. This very weak bond of solutes makes them easily broken when the concentration of adsorbed solutes changes. In the chemical adsorption process, the bond between the adsorbed solute and the adsorbent is very strong, making it difficult to remove and almost impossible to reverse the process. Due to the duration of the adsorption process, the decrease in hardness increases during contact. This is due to the amount of hardness-causing substance bound by carbon (Vaddi et al., 2019). The use of zeolite media in this method also affects the quality of the hardness produced. Due to the alkali and alkaline earth metal cations present in zeolite, zeolite has ion-exchange properties, which allows it to lower water hardness. These cations can move freely within the cavity and are interchangeable with cations of other metals of the same amount. Anions or molecules smaller or equal in size to the cavity can enter and get trapped due to the hollow structure of the zeolite (Nurhayati, 2010; Rahmawati & Nurhayati, 2016).

Conclusion

In the filtration process using mixed media shows that at 90 minutes contact time is more effective in reducing the hardness level in water sources coming from dug wells and drilled wells. Further research is recommended to compare mixed media, dual media and single media filtration in reducing hardness.

Author Contributions

The first author, Suliono, contributed to the entire research from planning, implementation, article writing, and dissemination. The second author, Eny Enawaty, contributed as the first supervisor in research and article writing. The third author Indri Astuti contributed as the second supervisor in research and article writing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Abanyie, S. K., Apea, O. B., Abagale, S. A., Amuah, E. E. Y., & Sunkari, E. D. (2023). Sources and factors influencing groundwater quality and associated health implications: A review. *Emerging Contaminants*, 100207. https://doi.org/10.1016/j.emcon.2023.100207

Azteria, V., & Rosya, E. (2023). Drinking Water Quality of Water Refill Station in Gebang Raya Tanggerang. *Journal of Environmental Health*, *15*(2). Retrieved from https://e-journal.unair.ac.id/JKL/article/download/42203/24469

Bozorg-Haddad, O., Delpasand, M., & Loáiciga, H. A. (2021). Water quality, hygiene, and health. In *Economical, Political, and Social Issues in Water Resources* (pp. 217–257). Elsevier. https://doi.org/10.1016/B978-0-323-90567-1.00008-5

Carrard, N., Foster, T., & Willetts, J. (2019). Groundwater as a source of drinking water in southeast Asia and the Pacific: A multi-country review of current reliance and resource concerns. *Water*, *11*(8), 1605. https://doi.org/10.3390/w11081605

Das, S. (2023). Basic Physicochemical Properties of Water. In *An Introduction to Water Quality Science: Significance and Measurement Protocols* (pp. 39–69). Springer. https://doi.org/10.1007/978-3-031-42137-2_3

Dewi, R. S., Kusuma, M. I., & Kurniawati, E. (2018). Pengaruh Lama Kontak Arang Kayu Terhadap Penurunan Kadar Kesadahan Air Sumur Gali Di Paal Merah II Kota Jambi. *Riset Informasi Kesehatan*, *7*(1), 46–54. https://doi.org/10.30644/rik.v7i1.125

Franke, V., Ullberg, M., McCleaf, P., Wålinder, M., Köhler, S. J., & Ahrens, L. (2021). The price of really clean water: Combining nanofiltration with granular activated carbon and anion exchange resins for the removal of per-and polyfluoralkyl substances (PFASs) in drinking water production. *ACS ES&T Water*, *1*(4), 782–795. https://doi.org/10.1021/acsestwater.0c00141

Gemeda, S. T., Springer, E., Gari, S. R., Birhan, S. M., & Bedane, H. T. (2021). The importance of water quality in classifying basic water services: the case of Ethiopia, SDG6. 1, and safe drinking water. *Plos One*, *16*(8), e0248944. https://doi.org/10.1371/journal.pone.0248944

Hidayah, E. N., Cahyonugroho, O. H., & Fauziyah, N. A. (2023). Performance of Alum Coagulation and Adsorption on Removing Organic Matter and E. coli. *Nature Environment and Pollution Technology*, *22*(1), 497–502. https://doi.org/10.46488/NEPT.2023.v22i01.048

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), 91–102. https://doi.org/10.35842/formil.v5i2.323

Juwono, P. T., Subagiyo, A., & Winarta, B. (2022). *Neraca Sumber Daya Air dan Ruang Kota Berkelanjutan*. Universitas Brawijaya Press.

Peraturan Menteri Kesehatan Republik Indonesia (2017) Nomor 32 Tahun 2017, Pub. L. No. Permenkes RI Nomor 32 Tahun 2017, Peraturan Menteri Kesehatan Republik Indonesia 1.

Kusneidi. (2010). *Mengolah Air Kotor Untuk Air Minum*. Jakarta Pusat: Penebar Swadaya.

Martín-Loeches, M., Martín-Loeches, M., Díaz-Alcaide, S., & Danert, K. (2020). Manual borehole drilling as a cost-effective solution for drinking water access in low-income contexts. *Water*, *12*(7), 1981. https://doi.org/10.3390/w12071981

Mishra, R. K. (2023). Fresh water availability and its global challenge. *British Journal of Multidisciplinary and Advanced Studies*, *4*(3), 1–78. https://doi.org/10.37745/bjmas.2022.0208

Murei, A., Kamika, I., & Momba, M. N. B. (2023). Selection of a diagnostic tool for microbial water quality monitoring and management of faecal contamination of water sources in rural communities. *Science of The Total Environment*, *906*, 167484. https://doi.org/10.1016/j.scitotenv.2023.167484

Nurhayati, I. (2010). Inasi Media Filtrasi Untuk Penurunan Kesadahan Dan Besi. *Jurnal Teknik UNIPA*, *08*(Januari), 108. Retrieved from https://jurnal.unipasby.ac.id/index.php/waktu/article/download/882/726

Organization, W. H. (2022). *Guidelines for drinking-water quality: incorporating the first and second addenda*. World Health Organization.

Prihatin, R. B., Suryani, A. S., Qodriyatun, S. N., Prasetiawan, T., Winurini, S., & Prayitno, U. S. (2015). *Penyediaan Air Bersih di Indonesia: Peran Pemerintah, Pemerintah Daerah, Swasta, dan Masyarakat*. P3DI Setjen DPR RI dan Azza Grafika.

Rahmawati, J. O., & Nurhayati, I. (2016). Pengaruh Jenis Media Filtrasi Kualitas Air Sumur Gali. *WAKTU: Jurnal Teknik UNIPA*, *14*(2), 32–38. https://doi.org/10.36456/waktu.v14i2.131

Richards, S., Rao, L., Connelly, S., Raj, A., Raveendran, L., Shirin, S., Jamwal, P., & Helliwell, R. (2021). Sustainable water resources through harvesting rainwater and the effectiveness of a low-cost water treatment. *Journal of Environmental Management*, *286*, 112223. https://doi.org/10.1016/j.jenvman.2021.112223

Rivai, A., & Rayani, E. M. (2019). Efektivitas Arang Tempurung Kelapa (Cocus nucifera) Dalam Menurunkan Kesaddahan Total Pada Air. *Sulolipu: Media Komunikasi Sivitas Akademika Dan Masyarakat*, *18*(2), 224–229. https://doi.org/10.32382/sulolipu.v18i2.1162

Sanropie, D. (1984). *Pedoman Bidang Studi Penyedian Air Bersih*. Jakarta: pusat Pendidikan dan Latihan Depkes RI.

Setyobudiarso, H., Sudiro, S., & Agnes, A. T. (2022). Uji Banding Efektifitas Roughing Filter Aliran Horizontal Dan Aliran Upflow Dalam Reduksi Kadar Kekeruhan Dan Kesadahan Air Sungai Brantas. *Prosiding SEMSINA*, *3*(2), 317–323. https://doi.org/10.36040/semsina.v3i2.5114

Sutrisno, T. (2006). *Teknologi Penyediaan Air Bersih*. Jakarta: Rineka Cipta.

Tang, C., Rygaard, M., Rosshaug, P. S., Kristensen, J. B., & Albrechtsen, H.-J. (2021). Evaluation and comparison of centralized drinking water softening technologies: Effects on water quality indicators. *Water Research*, *203*, 117439. https://doi.org/10.1016/j.watres.2021.117439

Vaddi, D., Subbarao, M. V., & Muralikrishna, M. P. S. (2019). Removal of calcium (Ca2+) ion from aqueous solution by chemically activated thuja occidentalis leaves carbon (CATLC)-application for softening the groundwater samples. *Physical Chemistry Research*, *7*(3), 449–466. https://doi.org/10.22036/PCR.2019.170974.1590

Waangsir, F. W., Arnawa, G. P., Sadukh, J. J., & Suluh, D. G. (2023). Use of Various Filtaritaion Media in Lowering the Level of Water Hardness. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1182–1186. https://doi.org/10.29303/jppipa.v9i3.3086

Wang, X., Cui, J., Wu, Y., Zhu, C., & Wang, X. (2021). Mechanical properties of calcareous silts in a hydraulic fill island-reef. *Marine Georesources & Geotechnology*, *39*(1), 1–14. https://doi.org/10.1080/1064119X.2020.1748775

Wen, X., Chen, F., Lin, Y., Zhu, H., Yuan, F., Kuang, D., Jia, Z., & Yuan, Z. (2020). Microbial indicators and their use for monitoring drinking water quality—A review. *Sustainability*, *12*(6), 2249. https://doi.org/10.3390/su12062249