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INNOVATIVE GRAVITY-FED FILTRATION SYSTEM TO IMPROVE COASTAL COMMUNITY WATER QUALITY

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ABSTRACT

Efforts to meet clean water needs, especially for drinking water, depend on the condition of groundwater that is healthy and sufficiently available. Filtration is the process of separating particles from a liquid by passing the liquid through a permeable material. This study examines the Gravity-Fed Filtering System with innovative Imhoff technology, combined with a Primary Treatment stage, to produce clearer and higher-quality water. The objective of this research is to assess the effectiveness of this system in reducing contamination levels in groundwater, including iron (Fe), manganese (Mn), total hardness (Ca and Mg), and organic compounds. The study employed an experimental method with a quantitative approach and used a One Group Pretest-Posttest design. The research was conducted in two locations: Barombong Village in Makassar and Pauwo Village in Gorontalo. Fifteen samples were randomly selected for analysis. The study began with preliminary observations and initial testing in March 2022, followed by the main research and prototype evaluation in 2023-2024. The results show that the system effectively reduced Fe, Mn, organic compounds, and total hardness levels. In Makassar, the highest reduction in Fe is 87.3% in sample 8, while in Gorontalo, the highest reduction is 93.3% in sample 8. The highest reduction in manganese (Mn) in Makassar is 63.3% in sample 1, and in Gorontalo, it is 62.1% in sample 1. The highest reduction in organic compounds in Makassar is 81.6% in sample 3, while the lowest reduction in total hardness in Makassar is 77.1% in samples 4, 5, 6, and 10. In Gorontalo, the highest reduction in total hardness is 90.3% in samples 1, 2, and 3. Recommendations for the community, The use of gravity-fed filtering system technology as one of the media used to reduce iron and manganese concentrations is considered quite good, but for similar research to be carried out, modifications should be made to the media specifically starting with the size, shape and other variables that support it so that it is more effective in reducing pollutant concentrations.

Kata Kunci:

Air Tanah; Masyarakat Pesisir; Teknologi Filtrasi.

ABSTRAK

Upaya pemenuhan kebutuhan air bersih, khususnya untuk air minum, bergantung pada kondisi air tanah yang sehat dan cukup tersedia. Penyaringan adalah proses memisahkan partikel dari cairan dengan melewatkan cairan melalui bahan penyaring. Penelitian ini menguji sistem penyaringan Gravity-Fed Filtering System dengan inovasi teknologi Imhoff yang digabungkan dengan tahap Primary Treatment, untuk menghasilkan air yang lebih jernih dan berkualitas. Tujuan penelitian adalah untuk mengetahui efektivitas sistem ini dalam menurunkan kadar pencemaran air tanah, seperti besi (Fe), mangan (Mn), kesadahan total (Ca dan Mg), dan zat organik. Penelitian ini menggunakan metode eksperimen dengan pendekatan kuantitatif, dengan desain One Group Pretest-Posttest. Penelitian dilakukan di dua lokasi: Kelurahan Barombong, Makassar, dan Kelurahan Pauwo, Gorontalo. Sampel diambil secara acak dengan 15 sampel untuk dianalisis. Penelitian dimulai dengan observasi dan uji awal pada Maret 2022, dilanjutkan dengan penelitian dan evaluasi prototipe pada 2023-2024. Hasil penelitian menunjukkan bahwa sistem ini efektif mengurangi kadar Fe, Mn, zat organik, dan kesadahan total. Di Makassar, penurunan tertinggi Fe tercatat 87,3% pada sampel 8, sementara di Gorontalo, penurunan Fe tertinggi mencapai 93,3%. Penurunan mangan tertinggi di Makassar adalah 63,3% pada sampel 1, dan di Gorontalo, 62,1% pada sampel 1. Penurunan zat organik terbesar di Makassar adalah 81,6% pada sampel 3, sementara kesadahan total terendah di Makassar mencapai 77,1% pada sampel 4, 5, 6, dan 10. Di Gorontalo, penurunan kesadahan total tertinggi mencapai 90,3% pada sampel 1, 2, dan 3. Rekomendasi bagi masyarakat, Penggunaan teknologi gravity-fed fitering system sebagai salah satu media yang digunakan untuk menurunkan konsentrasi besi dan mangan dianggap cukup baik namun untuk penelitian sejenis yang akan dilakukan sebaiknya dilakukan modifikasi terhadap media tersebut secara khusus di mulai dengan ukuran, bentuk dan variabel lain yang mendukung agar lebih efektif dalam menurunkan konsentrasi pencemar

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INTRODUCTION

Coastal communities often face serious problems related to water quality. The main source of water for many coastal areas is groundwater or well water taken from a certain depth. However, the water is often polluted by various contaminants, such as iron (Fe), manganese (Mn), organic substances, and high total hardness (consisting of calcium and magnesium) (Pitojo Tri Juwono, 2019). In some areas, groundwater also contains high levels of salt, due to seawater intrusion, which makes it unfit for consumption without further treatment. In addition, low public awareness of the importance of water treatment and limited access to effective filtration technology make the quality of water consumed by coastal communities often not meet health standards.

Water quality in coastal areas, especially in Makassar and Gorontalo, faces a number of problems that have an impact on public health and the environment. In Makassar, one of the main issues is the high levels of iron (Fe) and manganese (Mn) in groundwater, which can pollute water sources and affect their quality. Research conducted in Makassar shows that around 40% of wells in the coastal area of Makassar have iron levels that exceed the WHO quality standard threshold, which is 0.3 mg/L. In addition, manganese levels found in some areas also exceed 0.1 mg/L, which can have an impact on skin and respiratory health. In Gorontalo, a similar problem was also found, with high levels of calcium and magnesium, causing water with a high level of hardness that affects the quality of water for household consumption. The Gorontalo Environment Agency reported that almost 30% of water sources in coastal areas have a level of hardness that exceeds safe limits, as well as a fairly high content of organic substances and heavy metals (Navia et al., 2018).

In Makassar, several previous studies have shown high levels of iron in groundwater, which not only affects the taste and color of the water but also has the potential to cause health problems if consumed in the long term (Misbah, 2020). Likewise in Gorontalo, where high levels of iron and manganese are often found in several groundwater sources, disrupting the quality of water for household consumption.

In addition to the problem of contamination of water quality in these two areas, it is also affected by high levels of organic matter and total hardness, which often contaminate groundwater and increase the risk of water-based diseases, such as diarrhea and cholera. These factors demonstrate the importance of efficient and environmentally friendly technological solutions to address water quality problems in coastal areas. However, despite efforts to treat water, many communities still rely on simple and less effective filtration methods to tackle pollution, especially against heavy metals and organic contaminants.

Water filtration technology is very important for coastal communities because of natural conditions that often limit the availability of clean water. In coastal areas, in addition to contamination from industrial and domestic pollution, the quality of groundwater is often affected by geographical and weather conditions, such as saltwater due to seawater intrusion. Therefore, filtration technology that can address pollution issues and ensure water quality remains up to health standards is essential. The use of efficient, cost-effective, and environmentally friendly technology can help ensure the availability of sufficient and quality clean water for coastal communities.

The Gravity-Fed Filtering System is an innovation in water filtration technology that utilizes the force of gravity to pass water through various layers of the filter. In contrast to filtration systems that require pumps or external energy sources, this system relies quite a bit on the difference in height between the water source and its outlet point. This technological innovation lies in the merger of various stages of filtration that are more efficient, namely by utilizing Imhoff technology which can reduce contamination more optimally in the early stages of water purification (Primary Treatment). With this treatment, this system is able to significantly reduce the level of contaminants such as iron, manganese, organic substances, and water hardness, so that the water produced becomes cleaner, clearer, and more suitable for consumption.

This research introduces the Gravity-Fed Filtering System, an innovative solution that combines Fast Sand Filtration (SPC) and Slow Sand Filtration (SPL) technologies. Fast Sand Filtration (SPC) is a filtration method that uses a layer of sand with a high water flow rate. While effective at removing large particles and more visible contaminants, these systems require periodic filter replacement or cleaning and typically use an external energy source to maintain the flow of water. Slow Sand Filtration (SPL) is a technology that uses a layer of sand with a slow water flow rate, which can remove microorganism contaminants, such as bacteria, and produce cleaner water. However, the process is more time-consuming and requires more space. So by combining these two technologies into a Gravity-Fed Filtering System by utilizing the force of gravity to flow water through various filter layers, without the need for an external energy source. The system is designed to work efficiently by integrating Imhoff technology in the early stages of purification, which is able to reduce contamination faster and more effectively. Compared to SPC and SPL, the Gravity-Fed Filtering System has advantages in terms of energy efficiency, process speed, and the ability to reduce various types of contaminants more comprehensively.

Imhoff's technology in the Gravity-Fed Filtering System functions to optimize the deposition and separation process of organic matter and large particulate matter in the early stages of filtration. By combining this primary treatment process, the system can separate solid materials more efficiently before the water proceeds to the next filtration stage. As a result, the system is faster at reducing the content of iron, manganese, and other contaminants, compared to traditional filtration technologies. In addition, this integration also increases the resistance of the filtration system to damage and extends the life of the filters, thereby reducing the high cost of maintenance and filter replacement. Thus, the use of Imhoff technology in this system increases efficiency and effectiveness in producing cleaner and higher-quality water.

The research was conducted in Barombong Village, Makassar City, and Pauwo Village, Gorontalo, involving 15 groundwater samples obtained through simple random sampling. It uses an experimental design with a One-Group Pretest-Posttest approach to evaluate the effectiveness of the system. The research lasted for three years, starting with prototype design and field observations in 2022, followed by prototype evaluation and performance testing in 2023 and 2024.

This research aims to provide measurable and sustainable water treatment solutions for underserved communities. The stages involve refining the prototype, registering intellectual property, and disseminating the findings in leading international journals. The Gravity-Fed Filtration System is a significant step towards achieving Technology Readiness Level (TRL) 6, marking its readiness for wider implementation in improving public access to clean water.

METHOD

Type of Research

This study adopts an experimental quantitative approach with a One-Group Pretest-Posttest design to evaluate the effectiveness of the Gravity-Fed Filtering System in improving water quality. The focus of this study is on specific parameters: iron (Fe), manganese (Mn), total hardness (Ca & Mg), and organic matter, which have been measured before and after the filtration process. This design allows for objective and statistically valid results, providing a clear understanding of the impact of filtration systems on water quality.

Place and Time of Research

This research was conducted in Barombong Village, Makassar City, South Sulawesi Province, and Pauwo Village, Kabila District, Gorontalo Province. The research began with initial observations in May 2023 and then continued at the implementation stage, which included research activities and planning of water treatment equipment.

Population and Sample

A total of 15 samples were taken through a simple random sampling technique from dug wells used by local communities in both locations. This number of samples was chosen because it was in the range of 10-20 samples, which is a commonly used sample size in experimental research.

Data Collection

Data collection is carried out in structured steps to ensure accuracy and reliability. Groundwater sources were identified, and water samples were taken from wells in Barombong and Pauwo. Initial measurements for iron, manganese, total hardness, and organic matter were recorded in a certified laboratory. Once the Gravity-Fed Filtration system had been installed at each location, water samples after treatment were collected and tested using the same method to ensure consistency.

To analyze the data, a paired t-test was used to compare water quality parameters before and after treatment. This statistical test was suitable for the interval and ratio scale data used in this study. Data processing was carried out using SPSS for Windows, ensuring accurate and reliable results. The results of the study will be presented in tables and graphs to facilitate the interpretation of the impact of the filtration system on water quality.

RESULT

The measurement data of Iron (Fe), Manganese (Mn), Organic Substance (KMnO4), and Total Hardness levels in Makassar City and Gorontalo have been obtained in the laboratory in mg/l, as shown in the following table:

Table 1 Measurement Results of Iron (Fe) Level, Manganese (Mn) Level, Organic Substance Level (KMnO4), Total Hardness in Makassar City

Sample	Iron (Fe)		Manganese (Mn)		Organic Substance Level (KMnO4)		Total Hardness	
	Before	After	Before	After	Before	After	Before	After
1	21,16	4,78	11,48	4,21	242,14	80,15	600	125,8
2	19,19	2,65	8,35	3,23	246,18	85,33	600	125,8
3	17,21	3,42	8,46	3,35	227,62	41,87	500	86,5
4	17,15	2,68	8,52	3,62	284,15	98,71	700	160,5
5	16,54	2,92	10,25	4,30	260,22	103,45	700	160,5
6	16,67	2,42	10,40	4,32	272,23	89,57	700	160,5
7	14,52	2,10	8,44	3,67	342,13	196,58	600	125,8
8	16,88	2,15	9,35	3,82	327,42	174,65	600	125,8
9	14,18	2,43	9,42	3,61	316,72	163,84	600	125,8
10	14,42	2,58	9,41	3,65	342,43	187,77	700	160,5
average	**16,79**	**2,81**	**9,41**	**3,78**	**286,12**	**122,19**	**630**	**135,75**

Table 1 shows the measurement results of iron (Fe), manganese (Mn), organic matter (KMnO4), and total hardness levels in Makassar City before and after treatment. For iron levels, the highest before treatment is found in sample number 1 with 21.16 mg/l, and the lowest in sample number 9 with 14.18 mg/l, with an average of 16.79 mg/l. After treatment, the highest iron level is in sample number 1 with 4.78 mg/l, and the lowest in sample number 7 with 2.10 mg/l, with an average of 2.81 mg/l.

For manganese levels, the highest before treatment is in sample number 1 with 11.48 mg/l, and the lowest in sample number 2 with 8.35 mg/l, with an average of 9.31 mg/l. After treatment, the highest manganese level is in sample number 6 with 4.32 mg/l, and the lowest in sample number 2 with 3.23 mg/l, with an average of 3.78 mg/l.

For organic matter (KMnO4) levels, the highest before treatment is found in sample number 10 with 342.43 mg/l, and the lowest in sample number 1 with 242.14 mg/l, with an average of 286.12 mg/l. After treatment, the highest organic matter level is in sample number 7 with 196.58 mg/l, and the lowest in sample number 3 with 41.87 mg/l, with an average of 122.19 mg/l.

For total hardness, the highest before treatment is in samples 4, 5, 6, and 10 with 700 mg/l, and the lowest in sample number 3 with 500 mg/l, with an average of 630 mg/l. After treatment, the highest total hardness is in samples 4, 5, 6, and 10 with 160.5 mg/l, and the lowest in sample number 3 with 86.5 mg/l, with an average of 135.75 mg/l.

Table 2. Measurement Results of Iron (Fe) Level, Manganese (Mn) Level, Organic Substance Level (KMnO4), Total Hardness in Gorontalo

Sample	Iron (Fe)		Manganese (Mn)		Organic Substance Level (KMnO4)		Total Hardness	
	Before	After	Before	After	Before	After	Before	After
1	28,16	8,78	8,48	3,21	261,11	70,14	600	58,5
2	21,15	4,65	8,35	3,22	256,10	70,35	600	58,5
3	21,17	4,42	8,46	3,32	237,60	60,82	600	58,5
4	19,14	3,68	8,52	3,60	294,10	70,73	700	158,5
5	19,17	3,92	10,25	4,20	270,21	99,40	700	158,5
6	19,17	3,42	10,40	4,20	282,22	70,56	700	158,5
7	19,14	3,10	8,44	3,52	362,11	165,55	700	158,5
8	17,26	1,15	8,35	3,52	367,41	162,63	700	158,5
9	17,26	1,43	8,42	3,61	366,71	161,82	700	158,5
10	17,42	1,21	8,41	3,65	362,47	170,75	700	158,5
Average	**19,90**	**3,58**	**8,81**	**3,61**	**306,00**	**110,28**	**670**	**128,50**

Table 2 shows the measurement results of iron (Fe) levels, manganese (Mn) levels, organic matter (KMnO4) levels, and total hardness in Gorontalo City before and after treatment. For iron levels, the highest before treatment is found in sample number 1 with 28.16 mg/l, and the lowest in sample number 10 with 17.42 mg/l, with an average of 19.90 mg/l. After treatment, the highest iron level remained in sample number 1 at 28.16 mg/l, while the lowest is recorded in sample number 10 at 1.21 mg/l, with an average of 3.38 mg/l.

For manganese levels, the highest before treatment is found in sample number 6 with 10.4 mg/l, and the lowest in sample number 2 with 8.35 mg/l, with an average of 8.81 mg/l. After treatment, the highest manganese levels are found in sample numbers 6 and 7 with 4.20 mg/l, and the lowest in sample number 1 with 3.21 mg/l, with an average of 3.61 mg/l.

For organic matter (KMnO4) levels, the highest before treatment is in sample number 8 with 367.41 mg/l, and the lowest in sample number 1 with 230.60 mg/l, with an average of 306.00 mg/l. After treatment, the highest organic matter level is recorded in sample number 10 at 170.75 mg/l, and the lowest in sample number 3 at 60.82 mg/l, with an average of 110.28 mg/l.

For total hardness, the highest before treatment is found in samples number 4, 5, 6, 7, 8, 9, and 10 with 700 mg/l, and the lowest in samples number 1, 2, and 3 with 600 mg/l, with an average of 670 mg/l. After treatment, the highest total hardness is recorded in samples number 4, 5, 6, 7, 8, 9, and 10 with 158.5 mg/l, and the lowest in samples number 1, 2, and 3 with 58.5 mg/l.

DISCUSSION

Water is an essential necessity required by all forms of life on Earth. It occupies around 71% of the Earth's total surface area. Hydrology is the examination of the distribution, availability, utilization, and flow of groundwater. Water exists in all three states: solid (ice), liquid, and gas (steam), underscoring the need to comprehend the science and structure of water. It is a colorless, transparent chemical compound consisting of one oxygen atom covalently linked to two hydrogen atoms (P.R. Yaashikaa, 2019). The fulfillment of the need for water must meet two conditions, namely quantity and quality (Sakila, 2023).

Water provides several benefits for the survival of living organisms. However, water that exists in nature does not all meet the requirements for sanitary hygiene purposes, but rather water that contains various substances with levels higher than the maximum reference. The substances in question are high levels of iron (Fe), manganese (Mn), $KMnO_4$, and total hardness. One of the efforts to overcome this problem is the innovation of gravity-fed filtering system technology.

The gravity-fed filtering system technology is one of the water purification technologies that combines the fast sand filter (SPC) and slow sand filter (SPL) models (Navia et al., 2018). This filtration system, which uses gravity to remove impurities from water, has the potential to significantly improve the health and quality of life of coastal communities.

Innovation of gravity-fed filtering system technology to reduce iron (Fe) levels

The results have shown iron (Fe) levels for Makassar and Gorontalo before the gravity-fed filtering system at 16.79 & 19.90, respectively, after the gravity-fed filtering system become 2.81 & 3.58. According to iron (Fe) levels that meet the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes are a maximum of 1 mg/l. These results show that iron (Fe) levels after gravity-fed filtering systems have decreased significantly but have not met the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes.

The use of aeration media in particular does have a tendency to be less effective in reducing the concentration of iron (Fe) levels in the research sample. A large decrease occurs in the filtration process which shows a significant decrease in manganese levels in the sample. The process of reducing iron levels through aeration and filtration processes generally shows a fairly good percentage reduction rate even though the reduction does not reach the standard value recommended by national and international health institutions. The use of aeration media in particular has a tendency to be less effective in reducing iron levels in research samples. A large decrease occurs in the filtration process which shows a significant decrease in iron in the sample.

Iron content in groundwater, especially in well water, is common. Groundwater that generally has a high concentration of carbon dioxide can cause anaerobic conditions. This condition causes the concentration of iron in the form of insoluble minerals (Fe^{3+}) to be reduced to soluble iron in the form of two-variable ions (Fe^{2+} (Febrina & Ayuna, 2019). Iron concentrations in groundwater vary from 0.01 mg/l - 25 mg/l. In surface water it is rare to find Fe concentrations exceeding 1 mg/l, but in groundwater. High concentrations of Fe can be felt and can stain fabrics and kitchen utensils.

The high concentration of iron in the well could be due to the higher mineral content of the rocks around this well location compared to other well locations because it is located on relatively higher ground. In addition, the pH of the well water is the lowest or acidic compared to other wells as explained in the theory above, the more acidic the pH, the more it will dissolve metals, including iron. This can be caused by the low dissolved oxygen content in the well as described in the theory above, dissolved oxygen at neutral pH conditions will oxidize ferrous to ferric and then will form deposits, the lower. The concentration of dissolved oxygen will increase the concentration of dissolved iron, while in other wells, the low dissolved iron content can be due to high enough. Dissolved oxygen concentration in well water (Boyd et al., 2018). Along with the rapid development of cities and industrial progress, it turns out that it can adversely affect the environment, especially the marine environment which many people consider the final disposal site for various types of waste, both industrial waste and household waste. The waste that enters the sea contains various kinds of pollutants including heavy metals such as lead (Pb), iron (Fe), chromium (Cr), cadmium (Cd), and others. These metals are initially in small concentrations but if the incoming waste is increasing, then slowly these metals will cause pollution to the environment (Navia et al., 2018). Many problems that occur when utilizing groundwater are mineral content The type of mineral content of groundwater is quite diverse, including mercury, iron, manganese, sodium, copper, and zinc (Daniel Hillel, 2012) Iron (Fe) is one of the elements that can be found almost everywhere on earth, in all geological layers and all water bodies In general, iron in water can be dissolve (Murphy et al., 2010). The Fe ion content in borehole water can range from 5 - 7 mg/L while the standard of clean water iron content is based on a maximum of 1.0 mg/L. The high-low content of Fe in water is strongly influenced by the condition of the soil structure. The content of chemical elements in water is highly dependent on the geological formation where the water is located and the geological formation through which the water passes. For example, if during its journey water passes through a rock that contains iron, the water will automatically contain iron, as well as other elements. The amount of dissolved material depends on the length of time the water is in contact with the rock. The longer the water is in contact with the rock, the higher the dissolved elements in it.

Innovation of gravity-fed filtering system technology to reduce Manganese (Mn) levels

The results have shown Manganese (Mn) levels for Makassar and Gorontalo before the gravity-fed filtering system at 9.41 & 8.81, respectively, and after the gravity-fed filtering system at 3.78 & 3.61. According to Permenkes (2017) Manganese (Mn) which meets the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes is a maximum of 0.5 mg/l. These results show that Manganese (Mn) levels after the gravity-fed filtering system have decreased significantly but have not met the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes.

The use of aeration media in particular does have a tendency to be less effective in reducing the concentration of iron (Fe) levels in the research sample. The big decrease occurs in the filtration process which shows a significant decrease in manganese levels in the sample. The process of reducing manganese levels through aeration and filtration processes generally shows a fairly good percentage reduction rate even though the decline does not reach the standard value recommended by national and international health institutions (Muntu & Mahawira, 2021). The use of aeration media in particular does have a tendency to be less effective in reducing manganese levels in research samples. The big decrease occurred in the filtration process which showed a significant decrease in manganese in the sample. (Isma, 2022).

The Mn content on earth is about 1060 ppm, in soil about 61 - 1010 ppm, in rivers about 7 mg/l, in the sea about 10 ppm, and in groundwater about < 01 mg/ (Irawan & Irvan, 2022). Manganese is present in complex form with bicarbonate, minerals, and organic manganese elements in surface water in the form of four-valent ions in complex organic form. Manganese is widely present in pyrolusite (MnO2), braunite, (Mn2 + Mn3 + 6) (SiO12), psilomelane (Ba, H2O) 2Mn5O10 and rhodochrosite (MnCO3). The concentration of manganese in natural water systems is generally less than 01 mg/l, if the concentration exceeds 1 mg/l then by ordinary means of treatment it is very difficult to reduce the concentration to the degree permitted as drinking water (Hartini, 2012). In 2022 Considerations for new manganese analytical techniques for drinking water quality management set the maximum concentration of manganese in drinking water in Europe at 01 mg/l, but was later updated to 005 mg/l In the United States (US EPA) since the beginning set the maximum concentration of manganese in drinking water 005 mg/l Japan set a total concentration of iron and manganese in drinking water maximum 03 mg/l (Yu Pei, n.d.).

Indonesia based on the sets the concentration of iron in drinking water at a maximum of 0,3 and manganese at a maximum of 0,1 mg. Both iron and manganese, in water, are usually dissolved in the form of compounds or bicarbonate salts, sulfate salts, hydroxides, and in colloidal form or in a state of joining organic compounds. Therefore, the treatment method must be adjusted to the form of iron and manganese compounds in the water to be treated. In the process of removing iron and manganese, the principle is the oxidation process, which is to increase the oxidation level by an oxidizer with the aim of changing the dissolved iron form into a non-dissolved iron form (precipitate). The precipitate formed is removed by sedimentation and filtration processes (Lawrence K Wang, 2021).

In general, the methods used to remove iron and manganese are physical, chemical, biological, or a combination of each of these methods. Physical methods can be done by filtration, aeration, precipitation, electrolyte, ion exchange (ion exchange), adsorption, and so on. Chemical methods can be done by affixing chlorine compounds, permanganate, lime-soda, ozone, polypHospHat, coagulants, flocculants, and so on. Biological methods can be done by using certain autotrophic microorganisms such as iron bacteria that are able to oxidize iron and manganese compounds (Ehsan et al., 2022) From the results of the analysis described above related to the depth of the well with the content of iron (Fe) concentration in water, it can be seen that the depth of the well does not contribute significantly to the content of iron (Fe) concentration in well water.

Innovation of gravity-fed filtering system technology to reduce organic matter (KMnO4)

The results have shown organic matter (KMnO4) for Makassar and Gorontalo before the gravity-fed filtering system at 286.12 & 306.00 respectively after the gravity-fed filtering system has become 122.19 & 110.28. According to organic matter (KMNO4) that meets the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes is a maximum of 500 mg/l. These results show that organic matter (KMnO4) after the gravity-fed filtering system has decreased significantly and meets the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes (Sabor, 2017).

KMnO4 is a water-soluble chemical compound, and in a gravity filtration system, if you try to filter a solution containing KMnO4, KMnO4 will remain soluble in water and will pass through the filter media. Therefore, this chemical will not "degrade" in the gravity filtration process due to the nature of the solution (Pasaribu et al., 2023).

Innovation of gravity-fed filtering system technology to reduce total hardness

The results have shown total hardness for Makassar and Gorontalo before the gravity-fed filtering system at 630 & 670, respectively after the gravity-fed filtering system at 135, 75 & 128.50. With total hardness levels that meet the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes is a maximum of 500 mg/l. These results show that hardness after a gravity-fed filtering system has decreased significantly and meets the chemical parameters in the environmental health quality standards for water media for sanitary hygiene purposes (Awliahasanah et al., 2021).

Gravity filtration systems do not have the capacity to reduce water hardness, as there is no ion exchange process or chemical reaction involved in removing calcium and magnesium ions from water. This research is in line with the research of (Sakila, 2023) which states that the gravity-fed filtering system method is able to reduce the hardness of well water. To increase the effectiveness of the Gravity-Fed Filtering System in improving water quality for coastal communities, several technological innovations can be applied. First, integration with coagulation and flocculation methods can be carried out in the early stages of water purification. The coagulation process binds fine particles and colloids in water that are difficult to filter by ordinary filters, while flocculation helps form large flocs to facilitate sedimentation. The use of natural coagulants, such as neem leaves or chitosan, can be a more affordable environmentally friendly alternative for coastal communities.

In addition, the use of special filter media can improve the performance of the system. Activated carbon filters are effective for removing odors, organic substances, and chemical contaminants, while zeolites can be used to lower levels of ammonia and heavy metals in water. The combination of several types of filter media (such as sand, charcoal, and zeolite) will help to deal with a wide range of contaminants more thoroughly, making the resulting water cleaner and safer for consumption (Cai et al., 2023).

Flexible system design is also very important, given that water quality in coastal areas often fluctuates, for example, due to increased salinity or seasonal contamination. Filtration systems that can adapt to varying water conditions will ensure their effectiveness remains high in a variety of environmental conditions. For example, filters that can adjust to salinity levels or filtration methods that can handle specific contaminants according to the season (Clasen et al., 2009).

CONCLUSION AND SUGGESTION

The application of the Gravity-Fed Filtration System significantly reduces the levels of Iron (Fe), Manganese (Mn), Organic Compounds (KMnO4), and Total Hardness in water samples. This system has proven to be very effective in improving water quality parameters. The decrease in Iron (Fe) levels in Makassar ranges from 77.4% to 87.3%. Meanwhile, in Gorontalo, it ranges from 68.8% to 93.3%. For Manganese (Mn) levels in Makassar and Gorontalo, the decrease ranges from 56.5% to 63.3%, and 56.6% to 62.1%, similarly the decrease in organic matter (KMnO4) in Makassar ranges from 42.5% to 81.6% while in Gorontalo ranges from 52.9% to 76.0%, and the decrease in total hardness in Makassar ranges from 77.1% to 82.7% while Gorontalo ranges from 77.4% to 90.3%. From the results of water treatment with the parameters of Iron (Fe), Manganese (Mn), Organic Compounds (KMnO4), and total hardness that meets the requirements in accordance with the Minister of Health Regulation No. 32 of 2017 is the total hardness parameters in Makassar and Gorontalo, namely the standard quality standard for total hardness for water for sanitary hygiene purposes <500 mg/l.

Gravity Filtration Systems are effective in reducing Iron (Fe) and Manganese (Mn) levels. However, future research should explore modifications in media size, shape, and additional variables to further improve its efficiency, including varying the thickness and size of the materials used, such as sand, activated carbon, gravel, and other absorbent materials, to optimize filtration capacity. In addition, suggestions for further research can be carried out tests with heavy metal parameters such as Pb and Cd. The conclusion is presented here. It should not be numbered. If necessary, suggestions or recommendations may be added in this section.

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