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The effectiveness of combination filter cloth, Malimpung sand from South Sulawesi, and zeolite in improving drinking water quality

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Abstract

The quality of drinking water is very important for maintaining public health. This study aims to evaluate the effectiveness of the combination of filter cloth, sand, and zeolite filter media in improving clean drinking water. The experimental method involved designing a multi-level filtration system using these three media and testing it on water containing light contaminants. The parameters tested included turbidity, pH, and solute content before and after filtration. The results showed that the combination of filter cloth, sand, and zeolite could reduce turbidity levels by up to 85%, stabilize pH close to neutral, and significantly reduce solute content. These findings suggest that a simple filtration system with a combination of these media can be an efficient and economical solution to provide clean water, especially in areas with limited access to water treatment technology.

Keywords: Drinking water, Filter cloth, Filtration, Sand, Water treatment plant, Zeolite.

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1. Introduction

Clean water is a fundamental necessity for human life and other living organisms. Without water, life on Earth could not exist. Therefore, good drinking water must meet physical, chemical, and biological health standards to ensure the sustainability of life. Clean and safe water for consumption must not only be free of harmful substances such as heavy metals, toxic chemicals, and pathogenic microorganisms, but it must also have good taste, smell, and clarity [1, 2].

However, declining drinking water availability is a major challenge, especially in areas affected by industrial development, urbanization, and uncontrolled agricultural activities. Industrial activities that produce liquid waste, pollution from agriculture, as well as an increase in the population in need of clean water all have a significant impact on the quality of available water. In addition, climate change, which causes uncertainty in rainfall patterns, has further worsened this situation [3, 4].

Although clean water is the main need, many regions in Indonesia still have difficulty accessing clean water sources suitable for consumption. Drinking water in many areas often does not meet health standards, and in some areas, there is even water pollution caused by industrial and agricultural activities [5, 6]. Therefore, efforts are needed to provide safe and healthy clean water for the community, one of which is through effective water treatment technology.

One of the solutions that can be applied to improve drinking water is through the filtration process. Filtration is the process of separating solids from liquids by using a filtering medium. Filtration technology has been shown to be effective in removing solid particles, contaminants, and other harmful substances from water [3]. In recent years, various filtration media, such as textile fabrics, sand, zeolites, and filter cloths, have been widely used to treat water, both in households, industries, and for wastewater treatment [7, 8].

Filter cloth is one of the filtration media frequently used in the filtration process, particularly in multi-level filtration systems. It is made of monofilament yarn with a very small pore size, which makes it effective in filtering fine particles. The use of cloth filters in multi-level filtration can enhance filtration efficiency and reduce the load on preceding filters [1]. In addition, cloth filters can also be used in water treatment to reduce microplastics, as evidenced in research by Junardi Yudasti et al. [9], which demonstrated that the multi-stage filtration process using cloth filters effectively reduces microplastics in laundry waste.

In addition to fabric, sand media is also used as a filtration material. Sand has the ability to filter large particles and impurities from water. One example of the use of sand in filtration is a study that tested the effectiveness of Malimpung quartz sand from South Sulawesi as a filtering medium to reduce the level of manganese (Mn) in water. Malimpung sand has great potential in improving drinking water, especially in reducing turbidity and total suspended solids (TSS) [5, 9]. Research shows that Malimpung Sand can reduce turbidity by up to 72% and TSS by 84%, making it an effective and efficient choice for water treatment. This sand has a uniform grain size and a high SiO_2 content, which is about 97.07%, meeting the quality standards of filtration materials. In the research conducted by Bakri et al. [10], specific gravity testing indicated that the specific gravity value of Malimpung sand was 2.69 grams/cm³, and that of zeolite was 2.674 grams/cm³. The results of this test demonstrate that both Malimpung sand and zeolite meet the requirements and are suitable for use as filter media in water treatment, in accordance with the SNI 03-3981-2008 standard.

In addition to its efficiency in reducing turbidity and TSS, Pasir Malimpung also has a good uniformity coefficient, which is 2.19, indicating a relatively even distribution of grain size. This makes this sand effective in filtering out fine particles contained in water. The use of Malimpung Sand in water filtration provides a double benefit, namely, it can reduce the operational costs of the filtration system and utilize local natural resources, which are more affordable and environmentally friendly [10].

Zeolite, as a filtration medium, also has a high adsorption ability against various contaminants, such as heavy metals and ammonia. Zeolite can be used to treat household water, especially in areas with poor water quality [11]. The use of zeolite can improve the taste and clarity of water and reduce health risks due to consuming contaminated water. The combination of zeolite with other filter materials, such as sand and activated charcoal, can also improve filtration efficiency and reduce further contamination [4].

However, major challenges remain in providing affordable clean water, especially in areas with limited access to modern water treatment systems. Therefore, inexpensive and easy-to-apply filtration technology is an indispensable solution [6]. Filtration systems based on cloth, sand, zeolite, and filter cloth media can be accessed by the public independently and do not require high operational costs.

This study aims to examine the effectiveness of the combination of filter cloth, Malimpung Sand, and zeolite in improving clean drinking water, with a focus on reducing turbidity, total suspended solids, total dissolved solids, as well as heavy metal and ammonia contamination. It is hoped that this research can provide practical and sustainable solutions to overcome drinking water problems, especially in areas that have limited access to more sophisticated water treatment systems, and can improve the quality of life of the community by providing safe and healthy clean water.

Overall, filtration is one of the main solutions in addressing increasingly critical water quality problems. With the application of the appropriate filtration technology for clean water treatment, it is hoped that a more efficient, environmentally friendly, and accessible water treatment system can be realized by the wider community. This research is expected to make a significant contribution in providing better water treatment solutions in Indonesia, while helping to improve the quality of life for people exposed to drinking water issues.

2. Research Methods

This study employs an experimental method to evaluate the effectiveness of various types of filter cloths, as well as a combination of malimpung sand and zeolite, in improving drinking water quality. The independent variable is the type of cloth filter, while the dependent variables include the test results of Total Suspended Solids, Total Dissolved Solids, turbidity, pH, and water temperature after filtration, which are measured to assess the quality of drinking water and the filtration process's effectiveness. The research was conducted in a laboratory setting using descriptive and inferential analysis.

The following matrix of this research can be seen in the Table below:

Table 1.
Research Matrix.

Code of Conduct	Sampling		Filtration Media	Information
P1	Beginning	End	Malimpung Sand + Zeolite	Without a filter cloth
P2	Beginning	End	Malimpung Sand + Zeolite + Filter Cloth 13 µm	A combination of medium + fine filter cloth
P3	Beginning	End	Malimpung Sand + Zeolite + Filter Cloth 30 µm	Medium + filter combination
P4	Beginning	End	Malimpung Sand + Zeolite + Filter Cloth 50 µm	A combination of medium + coarse filter cloth

Note:
1. All treatments are done on the same water.
2. Parameters measured: turbidity (NTU), TSS (mg/L), TDS (mg/L), Temperature, and pH.
3. P1 is used as the main comparator to assess the effect of the addition of filter cloth.

The research was conducted by sampling at the water treatment plant of the Faculty of Engineering, Hasanuddin University, located in Gowa Regency, South Sulawesi Province, Indonesia. The specific location for sample collection is Jl. Malino No.Km.6, Romang Lompoa, Bontomarannu District, Gowa Regency. The research for the filtration reactor simulation was carried out at the Hydraulics Laboratory, Department of Civil Engineering, and the Aquatic Laboratory, Department of Environmental Engineering, Hasanuddin University, Gowa Regency, South Sulawesi Province.

This study examines the effectiveness of filter combinations in improving clean drinking water, with independent variables in the form of filter cloth pore sizes (50 µm, 30 µm, and 13 µm). The dependent variables are the test results of Total Suspended Solids, Total Dissolved Solids, turbidity, pH, and water temperature after filtration, which are measured to evaluate drinking water quality and the impact on filtration effectiveness, either separately or in combination. The control variable is the consistency of the use of the filter media. Filter cloth was chosen for its effectiveness in previous studies, while malimpung sand and zeolite were used as supporting media to improve the performance of the filtration system.

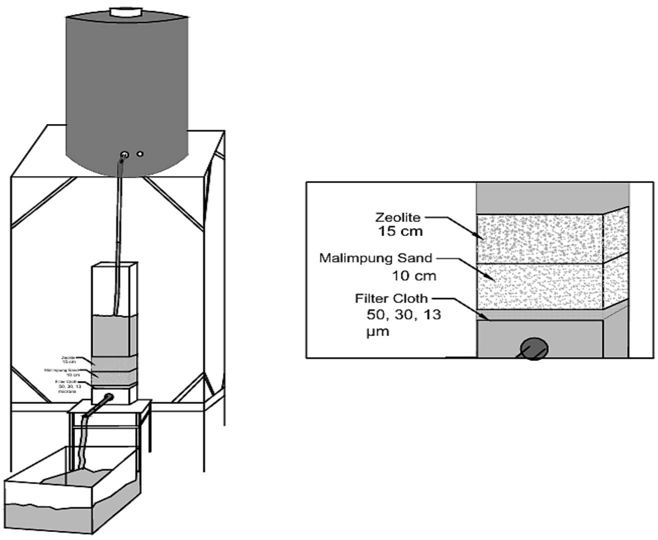

Figure 1.
Simple clean water treatment.

The experiment began by preparing a filtration system consisting of three filter cloth media (pore size 50 µm, 30 µm, and 13 µm), sand, and zeolite. The water in the reservoir flows separately through each medium, including a combination of the three, with the flow pressure kept stable to ensure accurate results. After filtration, the water sample is stored in a sterile container to prevent contamination. Each sample represents the results of each medium and will be analyzed to test *Total Suspended Solids, Total Dissolved Solids*, turbidity, pH, and temperature before and after filtration, to evaluate the overall effectiveness of the cloth filter.

Effectiveness analysis begins with conducting a water quality assessment before and after filtration using a combination of cloth filters, sand, and zeolite. Water samples are collected from the reservoir and filtered through a system with varying pore sizes of the filter cloth. Sampling occurs every 15 minutes, with a maximum filtration duration of 6 hours, measuring temperature, turbidity, total suspended solids, total dissolved solids, and pH. Subsequently, a descriptive statistical analysis is performed to summarize the data, including calculating average values, and to evaluate the efficiency of the filtration media in improving drinking water quality, providing an overview of its effectiveness. This analysis facilitates an objective comparison of each medium's performance.

3. Result and Discussion

3.1. Discharge Testing Analysis

Discharge testing aims to evaluate the ability of a combination of filtration media, such as Malimpung Sand, Zeolite, and Filter Cloth, to filter water with a certain capacity. This analysis provides an overview of the efficiency of the volume and rate of water flow, as well as the effectiveness of the filtration media in maintaining its performance during the filtration process.

Table 2.
Debit Testing.

Filter Variations			**Time**	**Volume**	**Debit**
Pasir	**Zeolite**	**Filter Cloth**	**minute**	**m3**	**m3/detik**
10 cm	15 cm	Without	273	0.34290	0.11430
		13 µm	378	0.25148	0.12574
		30 µm	360	0.27185	0.09062
		50 µm	234	0.32250	0.10750

This table shows the results of filtration with various combinations of sand malimpung, zeolite, and filter cloth with different μm sizes. The combination of 10 cm of malimpung sand and 15 cm zeolite without a cloth filter took 273 minutes, with a volume of 0.34290 m^3 and a discharge of 0.11430 m^3/second. The use of a 13 μm cloth filter increased the discharge to 0.12574 m^3/second despite a longer filtration time of 378 minutes. The 30 μm filter cloth lowers efficiency slightly with a discharge of 0.09062 m^3/sec and a volume of 0.27185 m^3. Meanwhile, the 50 μm filter cloth has the fastest filtration time of 234 minutes, with a volume of 0.32250 m^3 and a discharge of 0.10750 m^3/sec, but it is less efficient in filtering fine particles. Overall, the combination of 10 cm sand, 15 cm zeolite, and 13 filter cloth provides the best performance.

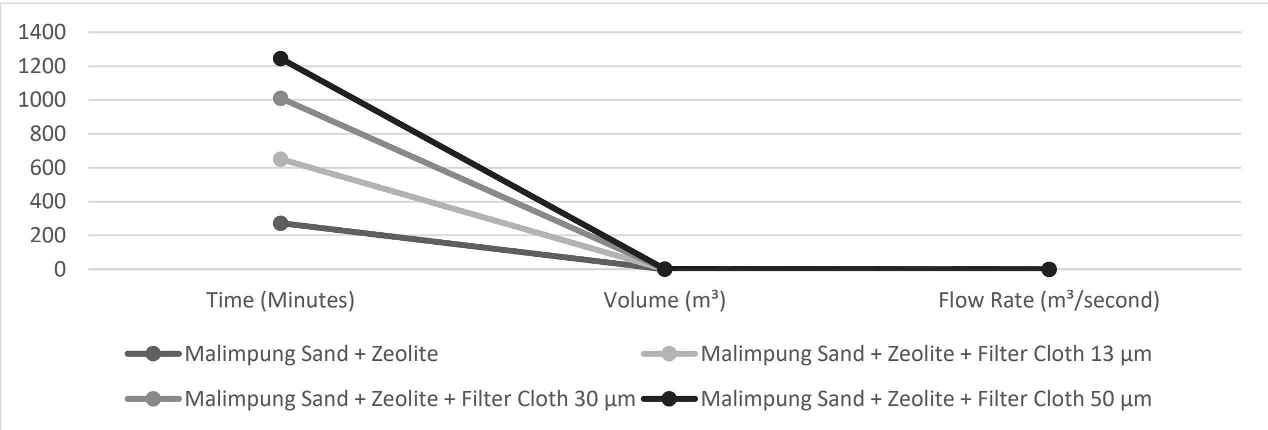

Figure 2.
Debit Testing Graph.

This graph displays the results of discharge testing using various combinations of filtration media, specifically Malimpung Sand, Zeolite, and filter cloths of 13 µm and 50 µm. The analysis focuses on two primary parameters: volume (m^3) and discharge (m^3/second). In terms of volume, the combination of Malimpung Sand and Zeolite showed a lower increase compared to other combinations, while the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth exhibited the most significant increase. Regarding discharge, the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth yielded the best results, followed by Malimpung Sand, Zeolite, and 13 µm Filter Cloth. The combination of Malimpung Sand and Zeolite had the lowest discharge. Overall, the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth offers the best performance in terms of both volume and discharge.

3.2. Analysis of Physical Characteristics of Raw Water Samples

3.2.1. Analysis of Raw Water Physical Characteristics Sample 1.

In the experiment with Malimpung Sand and Zeolite, several water parameters were measured at different intervals.

Table 3.
Physical Characteristics of Malimpung Sand and Zeolite Raw Water.

Malimpung Sand and Zeolite											
No	**Time**	**Temperature** °C		**Turbidity** NTU		**TSS** mg/L		**TDS** mg/L		**Ph**	
	Minute	Beginning	End	Beginning	End	Beginning	End	Beginning	End	Beginning	End
1	15	29.6	29.5	52.4	12	479	17.44	573	18	7.51	7.51
2	30		29.2		10		17.39		11		7.40
3	45		29.2		3		17.37		9		7.31
4	60		28.9		3		17.11		8		7.25

During the 60-minute experiment, turbidity decreased from 52.4 NTU to 3 NTU, and total suspended solids from 479 mg/L to 17.11 mg/L, indicating effective filtration. Total dissolved solids decreased from 573 mg/L to 8 mg/L by the 30th minute, while temperature decreased slightly from 29.6°C to 28.9°C, and pH from 7.51 to 7.25. Overall, this process effectively reduces suspended particles with minimal changes in temperature and pH.

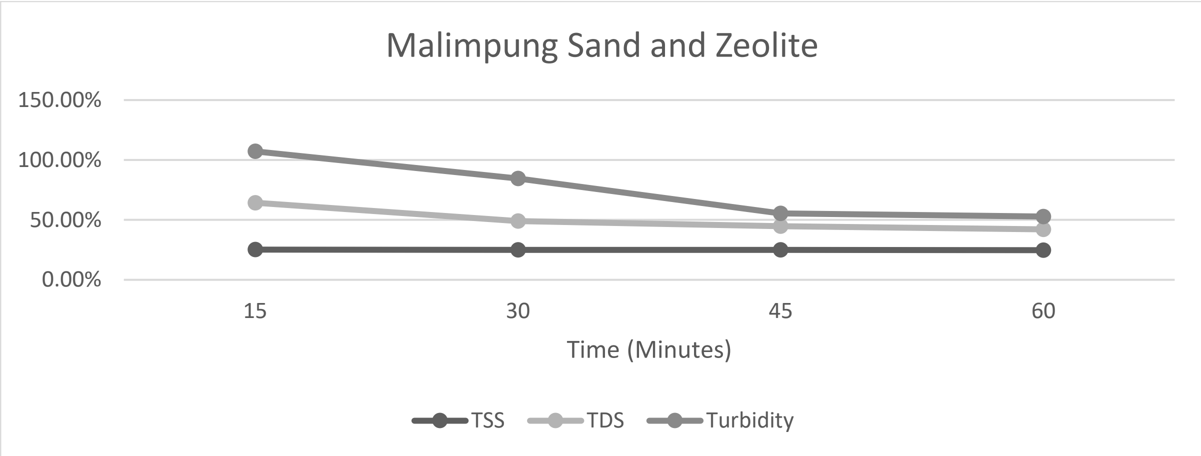

Figure 3.
Graph of the effectiveness analysis of Malimpung Sand and zeolite.

This graph illustrates the effectiveness of Malimpung Sand and Zeolite in reducing Total Suspended Solids, Total Dissolved Solids, and Turbidity. Total Suspended Solids decreased slightly over time, whereas Total Dissolved Solids showed a significant decrease from 39% at the 15th minute to 17% at the 60th minute. The turbidity decreased drastically, reaching nearly a 100% reduction at the 45th and 60th minutes. Overall, this filtration system is highly effective, with an increasing efficiency over time, achieving a filtration effectiveness of 96.10%.

3.2.2. Analysis of Physical Characteristics of Raw Water Sample 2

The filtration process using Malimpung Sand, Zeolite, and filter cloth 13 μm has been proven to be effective in improving drinking water.

Table 4.
Physical Characteristics of Malimmung Sand, Zeolite, and Filter Cloth Raw Water 13 µm.

Malimpung Sand. Zeolite And Filter Cloth 13 μm											
No	**Time**	**Temperature** °C		**Turbidity** NTU		**TSS** mg/L		**TDS** mg/L		**Ph**	
	Minute	Beginning	End	Beginning	End	Beginning	End	Beginning	End	Beginning	End
1	15	29.7	29.6	53.2	15	439	17.21	554	19	7.51	7.51
2	30		29.2		12		16.78		16		7.40
3	45		28.9		3		16.53		8		7.31
4	60		28.3		3		16.31		6		7.25
5	75		27.9		2		16.20		6		7.19

Filtration reduces the water temperature from 29.6°C to 27.9°C and turbidity from 53.2 NTU to 2 NTU. Total Suspended Solids decreased from 439 mg/L to 16.20 mg/L, TDS from 554 mg/L to 6 mg/L, and pH decreased slightly from 7.51 to 7.19. Overall, this process effectively improves the clarity and quality of the water.

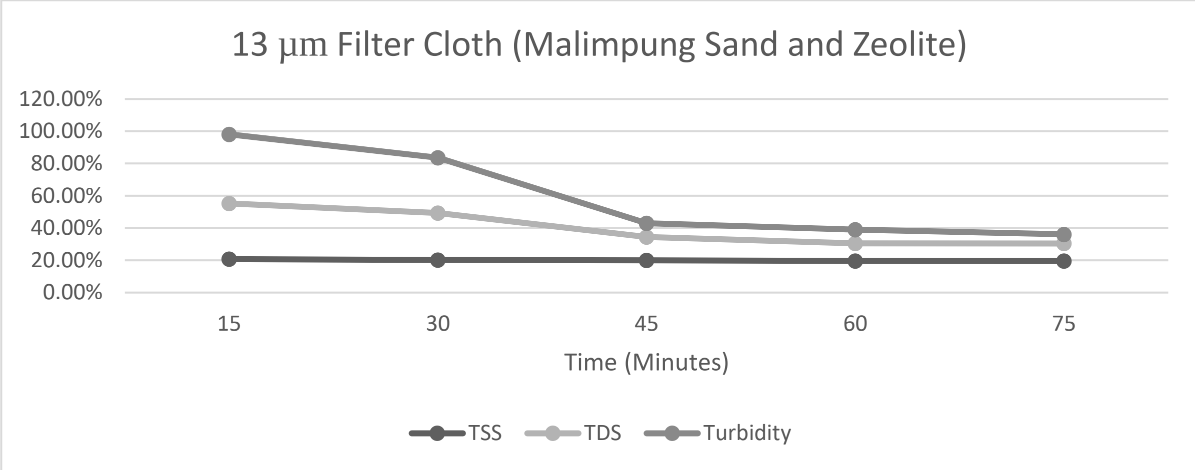

Figure 4.
Graph of the effectiveness analysis of 13 μm Filter Cloth, Malimpung Sand and zeolite.

The graph illustrates the effectiveness of the combination of 13 Filter Cloth, Malimpung Sand, and Zeolite in reducing Total Suspended Solids, Total Dissolved Solids, and Turbidity. Total Suspended Solids decreased from 20.73% to 19.51%, Total Dissolved Solids decreased from 34.55% to 10.91%, and Turbidity decreased from 42.86% to 5.71%. Overall, this combination effectively improves water quality, with a significant decrease in Total Dissolved Solids of 98.90% and Turbidity of 94.35%. The combination of Malimpung Sand, Zeolite, and 13 Filter Cloth demonstrated a filtration effectiveness of 96.51%, reflecting good performance in the filtration process.

3.2.3. Analysis of Physical Characteristics of Raw Water Sample 3.

The filtration process using Malimpung Sand, Zeolite, and filter cloth 30 μm showed effective results in improving drinking water.

Table 5.
Physical Characteristics of Malimmung Sand, Zeolite, and Filter Cloth 30 Raw Water μm

Malimpung Sand. Zeolite and Filter Cloth 30 μm											
No	**Time**	**Temperature** °C		**Turbidity** **NTU**		**TSS** **mg/L**		**TDS** **mg/L**		**Ph**	
	Minute	Beginning	End	Beginning	End	Beginning	End	Beginning	End	Beginning	End
1	15	29.2	29.5	43	6	399	19.57	583	27	7.19	7.21
2	30		29.2		6		19.06		21		7.19
3	45		28.9		3		19.01		19		7.10

During the 30 minutes of filtration, the water temperature decreased from 29.2°C to 28.9°C, turbidity from 43 NTU to 3 NTU, total suspended solids from 399 mg/Ls to 19.01 mg/L, and total dissolved solids from 583 mg/L to 19 mg/L. pH decreased slightly from 7.21 to 7.10, with no significant impact. Overall, filtration is effective in improving water clarity and quality for drinking purposes.

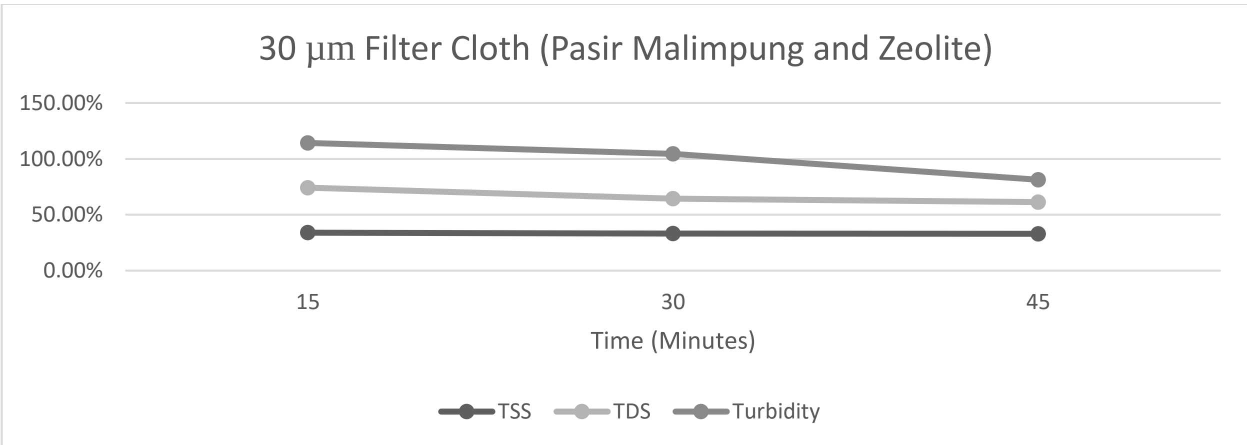

Figure 5.
Graph of the effectiveness analysis of 30 μm Filter Cloth, Malimpung Sand and zeolite.

This graph illustrates the effectiveness of a combination of 30 μm Filter Cloth, Malimmung Sand, and Zeolite in reducing water quality parameters, specifically Total Suspended Solids, Total Dissolved Solids, and Turbidity, over periods of 15, 30, and 45 minutes. Total Suspended Solids showed only a slight decline, decreasing from 33.95% at 15 minutes to 32.98% at 45 minutes. Both Total Suspended Solids and Total Dissolved Solids exhibited more significant reductions, from 40.30% at 15 minutes to 28.36% at 45 minutes. Turbidity remained stable at 40% up to 30 minutes but decreased sharply to 20% at 45 minutes. Overall, this combination is quite effective in improving water quality, with the most notable decreases observed in Turbidity, Total Suspended Solids, and Total Dissolved Solids. This filtration method has proven to be highly effective, achieving a filtration efficiency of 94.19%.

3.3.4. Analysis of Physical Characteristics of Raw Water Sample 4.

The filtration process using Malimpung Sand, Zeolite, and filter cloth 50 μm showed a significant decrease in several drinking water parameters.

Table 6.
Physical Characteristics of Malimpung Sand, Zeolite, and Raw Water Filter Cloth 50 µm.

Malimpung Sand. Zeolite and Filter Cloth 50 μm											
No	**Time**	**Temperature**		**Turbidity**		**TSS**		**TDS**		**Ph**	
		°C		**NTU**		**mg/L**		**mg/L**			
	Minute	Beginning	End	Beginning	End	Beginning	End	Beginning	End	Beginning	End
1	15	29.7	29.7	59.6	12	597	17.48	678	22	7.21	7.53
2	30		29.5		10		17.46		19		7.42
3	45		29.2		3		17.37		11		7.21

During the 30 minutes of filtration, the water temperature dropped from 29.7°C to 29.2°C. The turbidity dropped drastically from 59.6 NTU to 3 NTU, Total Suspended Solids decreased from 597 mg/L to 17.37 mg/L, and Total Dissolved Solids decreased from 678 mg/L to 11 mg/L. The pH level increased to 7.53 and then returned to 7.21. Overall, filtration has been shown to be effective in improving water clarity and drinking water.

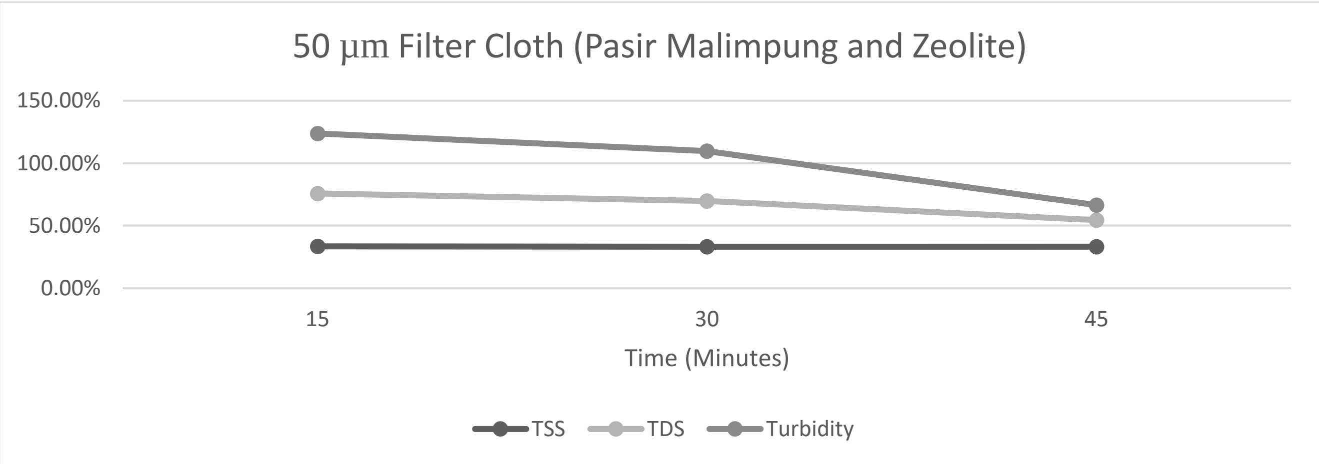

Figure 6.
Graph of the effectiveness analysis of Filter Cloth 50 µm, Malimpung Sand and zeolite.

This graph indicates that Filter Cloth 50, Malimpung Sand, and Zeolite are effective in reducing Total Suspended Solids, Total Dissolved Solids, and Turbidity. The reduction in Turbidity is significant, nearly reaching 100% after 30 minutes. Total Dissolved Solids also showed a consistent decline, while Total Suspended Solids remained relatively stable with a small decline, achieving an effectiveness of up to 100%. Overall, this filtration system provides excellent results, with a filtration effectiveness of 96.82%.

The relationship between time and turbidity, total suspended solids (TSS), and total dissolved solids (TDS) is recapitulation.

3.4. Turbidity

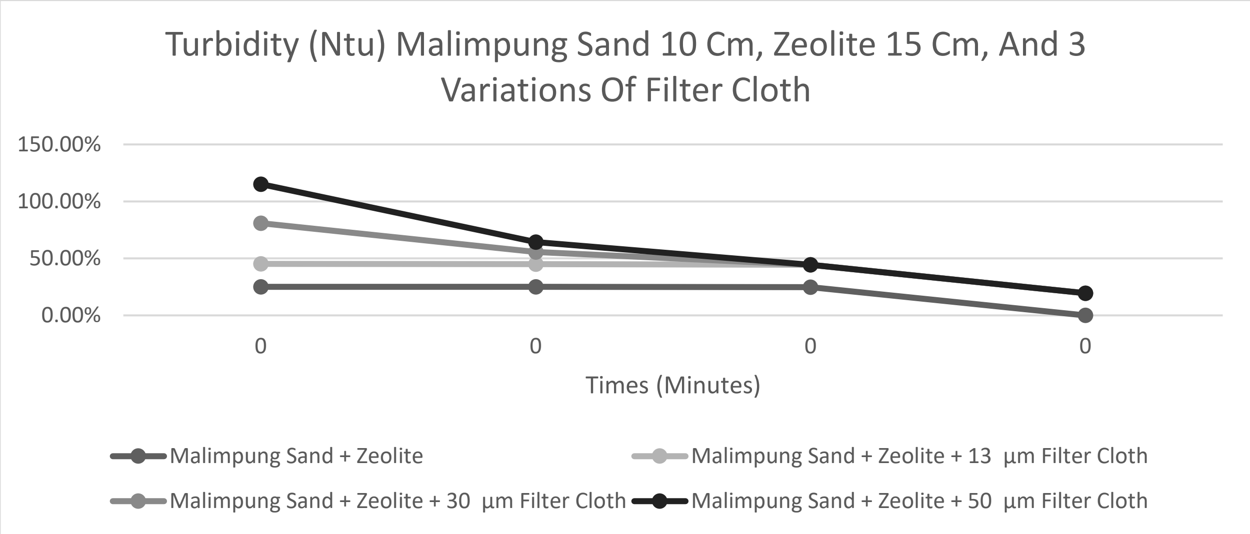

Figure 7.
Graph Relationship of time and NTU in 10 cm of malimpung sand, 15 cm zeolite, and filter cloth 3 variations.

From the graph, it can be concluded that filters with smaller pore sizes, such as 13 µm cloth filters, are more effective in lowering NTU (turbidity) compared to filters with larger pore sizes, such as 50 µm cloth filters. The 13 µm cloth filter shows a significant reduction in turbidity in a relatively short time, as it can filter out fine particles that cause turbidity. Conversely, a 50 µm cloth filter has a slower decline and is less effective because it can only capture larger particles. Although filter media such as sand and zeolite can help reduce turbidity, they are not as effective as filter cloth in lowering NTU. Overall, filter cloth with a small pore size (13 µm) provides the best results in reducing turbidity, while the combination with sand or zeolite is still less than optimal when compared to finer filter cloth.

3.5. Total Suspended Solids (TSS)

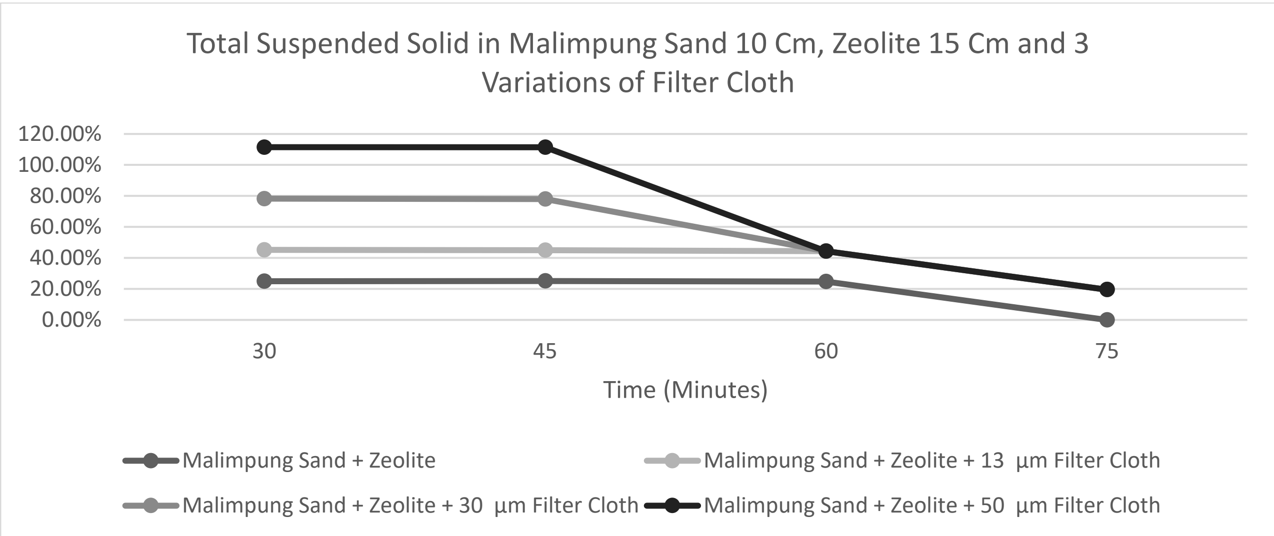

Figure 8.
Graph Relationship of time and TSS in 10 cm of malimpung sand, 15 cm zeolite, and 3 variations of filter cloth.

From the graph, it can be concluded that filters with smaller pore sizes, such as 13 µm cloth filters, are more effective in lowering TSS compared to filters with larger pore sizes, such as 50 µm filter cloth. This is because filters with small pores are able to capture finer and microscopic particles, resulting in more effective TSS removal. In contrast, a 50 µm cloth filter can only filter out larger particles, allowing smaller particles to escape, which makes it less effective in reducing overall TSS levels. Although the use of filter media such as sand and zeolite can help improve the filtration process, they are not as effective as cloth filters with small pore sizes. Sand and zeolite are indeed more effective at filtering out larger particles, but they cannot filter smaller fine particles as effectively. Therefore, although this combination of filter media improves filtration efficiency, cloth filters with a small pore size (13 µm) remain superior in lowering TSS.

3.6. Total Dissolved Solids (TDS)

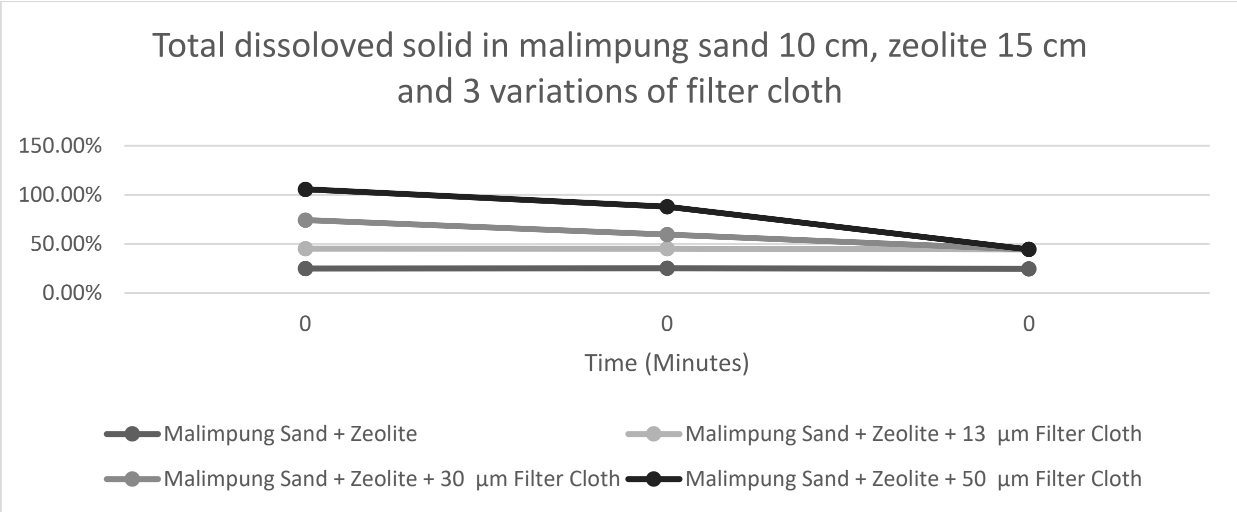

Figure 9.
Graph Relationship of time and TDS in 10 cm of malimpung sand, 15 cm zeolite, and filter cloth 3 variations.

From the graph, it can be concluded that filters with smaller pore sizes, such as 13 µm Filter Cloth, are more effective in lowering TDS (Total Dissolved Solids) compared to 30 µm Filter Cloth and 50 µm Filter Cloth. The 13 µm filter cloth shows a faster and significant decrease in TDS in a relatively short time, as the smaller pores are able to filter out finer dissolved particles. Meanwhile, the 30 µm Filter Cloth also demonstrated better TDS reduction compared to no filter, but it was not as effective as the 13 µm Filter Cloth. These filters are slower in lowering TDS because the larger pore size allows some small particles to pass through. The 50 µm filter cloth, with the largest pore size, has the slowest and least effective TDS reduction. These filters can only filter out larger particles, while smaller dissolved particles can still pass through, so the TDS decrease is not as good as filters with smaller pores. Although filter media such as sand and zeolite can assist the filtration process, they are not as effective as Filter Cloth in reducing TDS. Therefore, the use of a 13 µm Filter Cloth provides the best results in reducing TDS, while the combination with sand or zeolite results in less TDS reduction compared to the finer Filter Cloth.

3.7. Drinking Water Quality Analysis Based on Drinking Water Quality Standards

Table 7.
Testing on 1 Sample of Malimpung Sand and Zeolite.

Parameter	**Unit**	**Initial Test Results**	**Final Test Results**	∗ **Maximum Quality Standards**	**Information**
Temperature	°C	29.6	28.9	± 3°C from air temperature	Meet standards
Total Dissolved Solids (TDS)	mg/L	573	18	< 300 mg/L	Meet standards
Turbidity	NTU	52.4	3	< 3 NTU	Meet standards
TSS (Total Suspended Solids)	mg/L	479	17.11	Not specified	Effective in lowering TSS
pH	-	7.51	7.25	6.5 – 8.5	Meet standards

Note: ∗ Mandatory Drinking Water Parameters (PERMENKES NO. 2 YEAR 2023).

Overall, the test results show that the filtration system uses Malimpung Sand and Zeolite, which are effective in reducing turbidity, total suspended solids, and total dissolved solids, as well as maintaining pH and temperature within safe limits. All parameters tested meet the established clean water quality standards.

Table 8.
Testing on 2 samples of Malimpung sand, zeolite and Filter Cloth 13 µm.

Parameter	Unit	Initial Test Results	Final Test Results	∗ Maximum Quality Standards	Information
Temperature	°C	29.7	27.9	± 3°C from air temperature	Meet standards
Total Dissolved Solids (TDS)	mg/L	554	6	< 300 mg/L	Meet standards
Turbidity	NTU	53.2	2	< 3 NTU	Meet standards
TSS (Total Suspended Solids)	mg/L	439	16.20	Not specified	Effective in lowering TSS
pH	-	7.51	7.19	6.5 – 8.5	Meet standards

Note: ∗ Mandatory Drinking Water Parameters (PERMENKES NO. 2 YEAR 2023).

The test results indicated that the filtration system utilizing Malimpung Sand, Zeolite, and 13 µm Filter Cloth was effective in enhancing water quality. Water turbidity decreased significantly from 53.2 NTU to 3 NTU, meeting the quality standards (<3 NTU). Total Suspended Solids also decreased from 479 mg/L to 17.11 mg/L, indicating an effective system in lowering suspended solids. Total Suspended Solids, Total Dissolved Solids decreased from 573 mg/L to 18 mg/L, meeting the quality standard (<300 mg/L). pH remained within the permissible range, decreasing slightly from 7.51 to 7.25, while the temperature decreased from 29.6°C to 28.9°C, which is still within the permissible temperature variation limit. Overall, this filtration system effectively meets clean water quality standards.

Table 9.
Testing on 3 samples of Malimpung sand, zeolite and Filter Cloth 30 µm.

Parameter	Unit	Initial Test Results	Final Test Results	∗ Maximum Quality Standards	Information
Temperature	°C	29.2	28.9	± 3°C from air temperature	Meet standards
Total Dissolved Solids (TDS)	mg/L	17	21	< 300 mg/L	Meet standards
Turbidity	NTU	43	3	< 3 NTU	Meet standards
TSS (Total Suspended Solids)	mg/L	399	19.06	Not specified	Effective in lowering TSS
pH	-	7.19	7.10	6.5 – 8.5	Meet standards

Note: ∗ Mandatory Drinking Water Parameters (PERMENKES NO. 2 YEAR 2023).

In the test results, the turbidity of the water decreased significantly from 43 NTU to 3 NTU, which indicates that it still meets the water quality standards (<3 NTU). TSS (*Total Suspended Solids*) also decreased drastically from 399 mg/L to 19.06 mg/L, which means the filtration system is effective in reducing the amount of suspended solids. For TDS (*Total Dissolved Solids*), although slightly increased from 17 mg/L to 21 mg/L, it still met the permissible limit (<300 mg/L). The pH of the water remains within the safe range, although it has decreased slightly from 7.19 to 7.10, which still falls within the range of 6.5 - 8.5. Additionally, the water temperature has decreased slightly from 29.2°C to 28.9°C, remaining within the permissible temperature variation limit of ± 3°C relative to the air temperature.

Table 10.
Testing on 4 samples of Malimpung sand, zeolite and Filter Cloth 50 µm.

Parameter	Unit	Initial Test Results	Final Test Results	Maximum Quality Standards	Information
Temperature	°C	29.7	29.2	± 3°C from air temperature	Meet standards
Total Dissolved Solids (TDS)	mg/L	678	19	< 300 mg/L	Meet standards
Turbidity	NTU	59.6	3	< 3 NTU	Meet standards
TSS (Total Suspended Solids)	mg/L	597	17.3	Not specified	Effective in lowering TSS
pH	-	7.21	7.21	6.5 – 8.5	Meet standards

Note: ∗ Mandatory Drinking Water Parameters (PERMENKES NO. 2 YEAR 2023).

The test results indicated that the filtration system utilizing Malimpung Sand, Zeolite, and a 50 µm cloth filter was effective in enhancing water quality. Turbidity decreased from 59.6 NTU to 3 NTU, which meets the quality standards (<3

NTU). Total Suspended Solids, Total Dissolved Solids decreased from 597 mg/L to 17.3 mg/L, which means it is effective in lowering total suspended solids. Total Dissolved Solids decreased from 678 mg/L to 19 mg/L, which means it meets the quality standard (<300 mg/L). The pH remains stable at a range of 7.21, indicating it is within the quality standard range (6.5 – 8.5). The temperature decreased slightly from 29.7°C to 29.2°C, which is still within the permissible temperature variation limit (± 3°C of air temperature). Overall, the filtration system effectively meets clean drinking water standards.

3.8. Analysis of the Effectiveness of Clean Water Treatment Filters

A combination of Malimpung Sand, Zeolite, and Filter Cloth with various µm sizes. The overall effectiveness of different combinations of filtration media also showed significant variation. The combination of Malimpung Sand and Zeolite has a filtration effectiveness of 96.10%, while the combination of Malimpung Sand, Zeolite, and 13 µm Filter Cloth is slightly higher with an effectiveness of 96.51%. The combination of Malimpung Sand, Zeolite, and 30 µm Filter Cloth yielded 94.19% effectiveness, while the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth showed the best results with 96.82% effectiveness. Overall, the combination with the 50 µm Filter Cloth provides the best results in filtration, followed by other combinations that also demonstrate effective performance in lowering water quality parameters.

In the discharge test, the combination of Malimpung Sand and Zeolite showed a lower volume increase compared to other combinations, while the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth demonstrated the most significant volume increase. Regarding discharge parameters, the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth yielded the highest results, followed by Malimpung Sand, Zeolite, and 13 µm Filter Cloth, whereas Malimpung Sand and Zeolite had the lowest discharge. Overall, the combination of Malimpung Sand, Zeolite, and 50 µm Filter Cloth provides the best performance in terms of volume and discharge compared to other combinations.

4. Conclusion

Based on the results of the research that has been carried out, it can be concluded that the filtration process using a combination of sand malimpung, zeolite, and filter cloth with various µm sizes shows variation in effectiveness in reducing turbidity, total suspended solids, and total dissolved solids, as well as maintaining water pH stability.

- The effectiveness of simple, clean water treatment using malimpung sand and zeolite successfully reduced turbidity from 52.4 NTU to 3 NTU within 60 minutes, with a decrease in Total Suspended Solids from 479 mg/L to 17.11 mg/L and from 573 mg/L to 8 mg/L. The addition of a 13 µm cloth filter yielded the best results, reducing turbidity from 53.2 NTU to 2 NTU, Total Suspended Solids from 479 mg/L to 17.1 mg/L, and Total Dissolved Solids from 573 mg/L to 6 mg/L. Treatment with 30 µm and 50 µm filter cloth also showed significant reductions in turbidity, Total Suspended Solids, and Total Dissolved Solids, but the 13 µm filter cloth provided the most optimal results.
- The Cloth 50 filter demonstrates the highest effectiveness at 96.82% among all filtration media combinations, owing to its ability to handle water flow with improved filtration efficiency. Meanwhile, Filter Cloth 13 also performs well with a 96.51% effectiveness, although it may clog more quickly due to its smaller pore size. Conversely, Filter Cloth 30 shows a slightly lower yield of 94.19%, but remains effective in water filtration, especially when compared to Malimpung Sand and Zeolite, which have an effectiveness of 96.10$\mu m \mu m \mu m$%.

Based on the results of this study, it is recommended to optimize the use of 50 µm cloth filters, which have been proven to be the most effective in reducing turbidity, total suspended solids, and total dissolved solids. The filtration duration also needs to be extended to achieve better results, and the use of multistage filtration systems with different types of media can improve efficiency. Further research is suggested to explore variations of filtration and testing media on an industrial scale to ensure effectiveness in real applications.

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