EFECTIVENESS OF USING COCONUT SHELL CHARCOAL AND RICE HUSK ASH IN REDUCING THE LEVELS OF Fe (IRON) AND Mn (MANGANESE) IN CLEAN WATER FROM DRILLED WELLS

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ABSTRACT

Clean water is a vital basic need for human life. However, in several areas such as Makassar City, well water is often contaminated by heavy metals such as iron (Fe) and manganese (Mn) which exceed quality standard limits. This study aims to determine the effectiveness of using coconut shell charcoal and rice husk ash as filtration media in reducing Fe and Mn levels in clean water from well sources.

This research is an experimental study using a vertical filtration design made of PVC pipes. Well water samples were taken from the Banta-Bantaeng area, Makassar City, and tested for Fe and Mn levels before and after treatment using both media.

The research results showed that the use of coconut shell charcoal was more effective than rice husk ash. Coconut shell charcoal reduced Fe levels by an average of 61.11% and Mn levels by 88.17%, while rice husk ash reduced Fe levels by an average of 35.19% and Mn levels by 52.25%.

It can be concluded that coconut shell charcoal and rice husk ash can be alternative natural filtration media for community-based clean water treatment. However, coconut shell charcoal showed a higher reduction compared to rice husk ash. The community is advised to use coconut shell charcoal as a filtration medium for well water, as it has been proven effective in reducing Fe and Mn levels. The production of this media can be done independently at low cost and in large quantities. Future research is recommended to further explore the potential of natural filtration media in improving water quality.

Keywords : Bore Well Water; Fe Level; Mn Level ; Coconut Shell Charcoal, Rice Husk Ash

INTRODUCTION

Water is the most vital element in life after air. Approximately 75% of the human body is water, and a person cannot survive more than four to five days without water. From a public health perspective, the availability of clean water must be sufficient to meet community needs, as limited clean water supplies can increase the risk of disease transmission. On average, each person requires approximately 150 to 200 liters of water per day, equivalent to 34 to 40 gallons. This requirement can vary depending on climate conditions, level of prosperity, and community habits (Riskawati & Amir, 2019).

Globally, 2 billion people need access to clean water with well-managed services, and only around 1.2 billion of them receive basic services. 282 million people have inadequate access to services. Furthermore, 367 million people depend on unsafe water sources, and 122 million people need water treatment plants (IPA) in the Barombong area and the northern part of the city. In addition, the Regional Water Company (PDAM) also provides ready-to-drink water services in several locations, such as the Barombong and Losari Beach areas, and collaborates with USAID IUWASH Tangguh to improve the provision of safe drinking water and sanitation (Riadi et al., 2024).

Makassar City is a densely populated city with high levels of pollution. The demand for clean water is very high, but availability is low due to pollution. The lack of clean water meeting quality standards in Makassar City is caused by the high levels of groundwater contamination, such as heavy metals, particularly high levels of iron (Fe) and manganese (Mn), with an average Fe content of 0.8 mg/L and an average manganese content of 1.7 mg/L. The water source most contaminated by iron (Fe) and manganese (Mn) is borehole water due to the high industrial activity and urbanization in Makassar City, which cause environmental pollution. Improperly managed industrial and household waste can seep into the soil and contaminate it with heavy metals such as Fe and Mn (Hoesin, 2022).

According to Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Environmental Health, the Water Quality Standard for Hygiene and Sanitation Purposes is water used for personal and/or household hygiene purposes with an Iron (Fe) parameter of 0.2 mg/l and a Manganese (Mn) parameter of 0.1 mg/l (Minister of Health Regulation, 2023).

One simple solution to address high levels of iron (Fe) in well water is to use coconut shell charcoal and rice husk ash as adsorbents to reduce iron (Fe) and manganese (Mn) levels. Both of these materials are abundantly available in Indonesia, particularly in Makassar City, and are readily available to the public. By utilizing the potential of these local resources, communities can independently address water quality issues in their communities.

One method that can be applied to reduce Fe and Mn levels is through filtration. This method uses a filter to separate solids from liquids or gases. In this filtration process, the liquid passes through the filter, while the solid particles are retained, resulting in a cleaner liquid. Activated carbon, also known as charcoal, is a porous material with a very large surface area that can be used as an adsorbent to reduce pollutants in water (Rasid et al., 2024).

Coconut shells are usually used only as fuel, but they can also be used as activated charcoal to purify liquids. In the structure of a coconut, the fiber serves as a protective layer, the shell as a framework, the flesh as a food reserve, and the coconut water as a nutrient-rich endosperm fluid. Coconut shells are approximately 3–5 mm thick, account for 15–19% of the total weight of the coconut, and contain chemical compounds such as cellulose, lignin, and pentosans (Amira et al., 2022).

Based on research conducted by Syarifuddin (2019), turbidity reduction using rice husk ash filtration media. The effectiveness of turbidity reduction in treatment one (13 cm thickness) was 91.7%, treatment two (26 cm thickness) was 96.7%, while treatment three (39 cm thickness) was 97.3%, meeting drinking water quality requirements.

Based on research by Rasid et al. (2024), the results of well water testing at TPS 3R Mugirejo, Mugirejo Village, Sungai Pinang District, Samarinda, which was tested at the Samarinda City Regional Health Laboratory, parameters tested included Iron (Fe), Manganese (Mn), and pH. The control filtration results showed that the iron content before treatment was 3.06 mg/L and the manganese content was 0.9 mg/L, with

MATERIALS AND METHODS

This quasi-experimental study assessed the effectiveness of coconut shell charcoal and rice husk ash filter media in reducing iron (Fe) and manganese (Mn) levels in clean water. The samples tested were before and after treatment.

HASIL

Based on research conducted at the sampling point of the H. Bahar Princess Boarding House in Banta-bantaeng, Rappocini District, Makassar City, where the condition of the yellowish drilled well was visible from its physical appearance before processing, the following results were obtained :

Table 1. Reduction of Fe and Mn Levels Using Coconut Shell Charcoal Media on Day 1

Jumlah Replikasi	Fe (Besi) Mg/l	Penurunan Fe (%)	Mn (Mangan) Mg/l	Penurunan Mn (%)
Air Baku	0,21	-	0,98	-
Kontrol	0,19	9,52%	0,95	3,06%
Replikasi 1	0,17	10,53%	0,27	71,58%
Replikasi 2	0,13	31,58%	0,23	75,79%
Replikasi 3	0,09	52,63%	0,11	88,42%
Rata-rata	0,13	31,58%	0,20	78,60%

Based on table 1, it can be seen that the examination of drilled well water in terms of iron (Fe) and manganese (Mn) reduction using a simple filtration tool with coconut shell charcoal media on the first day with an average reduction in iron (Fe) parameters of 31.58% and manganese (Mn) of 78.60%.

Table 2. Reduction of Fe and Mn Levels Using Coconut Shell Charcoal Media on Day 2

Jumlah Replikasi	Fe (Besi) Mg/l	Penurunan Fe (%)	Mn (Mangan) Mg/l	Penurunan Mn (%)
Air Baku	0,21	-	0,95	-
Kontrol	0,19	9,52%	0,92	3,16%
Replikasi 1	0,15	21,05%	0,23	75,00%
Replikasi 2	0,11	42,11%	0,18	80,43%
Replikasi 3	0,03	84,21%	0,07	92,39%
Rata-rata	0,10	49,12%	0,16	82,61%

Based on table 2, it can be seen that the examination of drilled well water in the reduction of iron (Fe) and manganese (Mn) using a simple filtration tool with coconut shell charcoal media on the second day with an average reduction in iron (Fe) parameters of 49.12% and manganese (Mn) 82.61% so that it can be seen that the reduction increased on the second day.

Table 3. Reduction of Fe and Mn Levels Using Coconut Shell Charcoal Media on Day 3

Jumlah Replikasi	Fe (Besi) Mg/l	Penurunan Fe (%)	Mn (Mangan) Mg/l	Penurunan Mn (%)
Air Baku	0,20	-	0,95	-
Kontrol	0,18	10%	0,93	2,11%
Replikasi 1	0,12	33,33%	0,17	81,72%
Replikasi 2	0,07	61,11%	0,11	88,17%
Replikasi 3	0,02	88,89%	0,05	94,62%
Rata-rata	0,07	61,11%	0,11	88,17%

Based on table 3, it can be seen that the examination of drilled well water in the decrease of iron (Fe) and manganese (Mn) using a simple filtration tool with coconut shell charcoal media on the third day with the highest decrease in Fe (iron) levels occurred in Replication 3, namely 88.89%, while the highest decrease in Mn (manganese) also occurred in replication 3, namely 94.62%. The average decrease in iron (Fe) parameters was 61.11% and manganese (Mn) 88.17% so it can be seen that the highest decrease was on the third day.

Table 4. Reduction in Fe and Mn Levels Using Rice Husk Ash Media on Day 1

Jumlah Replikasi	Fe (Besi) Mg/l	Penurunan Fe (%)	Mn (Mangan) Mg/l	Penurunan Mn (%)
Air Baku	0,21	-	0,98	-
Kontrol	0,19	9,52%	0,95	3,06%
Replikasi 1	0,19	0%	0,83	12,63%
Replikasi 2	0,17	10,53%	0,44	53,68%
Replikasi 3	0,14	26,32%	0,32	66,32%
Rata-rata	0,17	12,95%	0,53	44,21%

Based on table 4, it can be seen that the examination of drilled well water in the reduction of iron (Fe) and manganese (Mn) using a simple filtration tool with rice husk ash media on the first day with the effectiveness of Fe reduction on the first day was relatively low, with an average of only 12.95%, and the highest reduction in replication 3, namely 26.32%. The average reduction in iron (Fe) parameters was 12.95% and manganese (Mn) was 44.21%. This shows that rice husk ash media is more effective in absorbing Mn than Fe on the first day of use.

Table 5. Reduction in Fe and Mn Levels Using Rice Husk Ash Media on Day 2

Jumlah Replikasi	Fe (Besi)	Penurunan Fe (%)	Mn (Mangan)	Penurunan Mn (%)
Air Baku	0,21	-	0,95	-
Kontrol	0,19	9,52%	0,92	3,16%
Replikasi 1	0,18	5,26%	0,51	44,57%
Replikasi 2	0,15	21,05%	0,32	62,22%
Replikasi 3	0,09	52,63%	0,21	77,17%
Rata-rata	0,14	26,31%	0,35	46,32%

Based on table 5, the examination of drilled well water for iron (Fe) and manganese (Mn) reduction using a simple filtration tool with rice husk ash media on the 2nd day showed an increase in the average reduction in iron (Fe) parameters of 26.31% and manganese (Mn) of 46.32%.

Table 6. Reduction in Fe and Mn Levels Using Rice Husk Ash Media on Day 3

JUMLAH REPLIKASI	Fe (Besi)	Penurunan Fe (%)	Mn (Mangan)	Penurunan Mn (%)
Air Baku	0,20	-	0,95	-
Kontrol	0,18	10%	0,93	2,11%
Replikasi 1	0,15	16,67%	0,42	54,84%
Replikasi 2	0,13	27,78%	0,22	76,34%
Replikasi 3	0,07	61,11%	0,19	79,57%
Rata-rata	0,12	35,19%	0,28	52,25%

Based on table 6, it can be seen that the examination of drilled well water in the reduction of iron (Fe) and manganese (Mn) using a simple filtration tool with rice husk ash media on the third day experienced a greater reduction compared to the replication of the first and second days with an average reduction in the parameters of iron (Fe) 35.19% and manganese (Mn) 52.25%.

Table 7. Paired t-Test Results for Metal Content Fe and Mn

Pasangan Perlakuan	Rata-rata Selisih (Mean)	P	r
Kontrol Arang Tempurung Kelapa Fe - Arang Tempurung Kelapa Fe	8.778	0.001	0.422
Kontrol Arang Tempurung Kelapa Mn - Arang Tempurung Kelapa Mn	77.556	0.000	0.327
Kontrol Abu Sekam Padi Fe - Abu Sekam Padi Fe	4.556	0.007	0.460
Kontrol Abu Sekam Padi Mn - Abu Sekam Padi Mn	54.889	0.000	0.465

Table 7 shows the results of a paired t-test to determine whether there was a significant difference between the control and treatment groups in Fe and Mn metal levels using two types of adsorbent materials: coconut shell charcoal and rice husk. The mean is the average difference between the control and treatment. A p-value <0.05 indicates a significant difference. Pairs 1 and 2 (Coconut Shell Fe & Mn) showed a highly significant difference (p <0.01), indicating high effectiveness in reducing metal levels. Pair 3 (Rice Husk Fe) also showed a significant difference (p = 0.007), although not as significant as coconut shell. Pair 4 (Rice Husk Mn): Very significant (p = 0.000), indicating the effectiveness of rice husk in absorbing Mn. These results indicate that treatment with natural adsorbents can significantly reduce Fe and Mn heavy metal levels in the samples, especially coconut shell charcoal.

Correlation analysis was conducted to determine the linear relationship between the two groups. The correlation coefficient (r) measures the strength and direction of a linear relationship (values close to 1 or -1 indicate a strong correlation). All pairs had positive correlation values (between 0.32 and 0.46), but they were not statistically significant (p > 0.05). This indicates that while there is a positive relationship between the control and treatment scores, the relationship is not strong or consistent enough to be considered significant. In other words, the difference between the control and treatment is not simply linear and may be influenced by other factors

DISCUSSION

Based on the table showing the effectiveness of coconut shell charcoal in reducing Fe (Iron) and Mn (Manganese) levels on days 1, 2 and 3, where the reduction in coconut shell charcoal on the first day (Table 1), it can be seen that Fe levels decreased by an average of 31.58% and Mn by 78.60%. The largest decrease for Fe occurred in replication 3 with a value of 52.63%, while Mn was also reduced the most in replication 3, namely 88.42%. This shows that filtration began to have a positive impact from the first day, especially in reducing Mn levels. On the second day (Table 2), the effectiveness of filtration increased. The average reduction in Fe levels reached 49.12% and Mn by 82.61%. The highest decrease occurred in replication 3, namely 84.21% for Fe and 92.39% for Mn. This indicates that the duration of contact between the water and the coconut shell charcoal media also influences the filtration effectiveness. On the third day (Table 3), the filtration process showed the most optimal results. The average reduction in Fe levels reached 61.11%, while Mn levels decreased by 88.89% and Mn by 94.62%. This confirms that the longer the filtration media is used, the greater the reduction in heavy metal content in the water. Therefore, the effectiveness of coconut shell charcoal in reducing Fe and Mn levels can be seen increasing day by day. Therefore, the use of coconut shell charcoal has great potential as a simple filtration solution to reduce heavy metal content in water, especially in areas dependent on well water.

Rice husk ash was used as a comparison to determine the effectiveness of the two simple filtration media. On the first day (Table 4), filtration using rice husk ash media showed an average decrease in Fe content of 12.95% and Mn of 44.21%. The highest decrease in Fe content occurred in replication 3 at 26.32%, while the highest decrease in Mn was also in replication 3 at 66.32%. This

indicates effectiveness, although still limited. On the second day (Table 5), filtration effectiveness increased. The average decrease in Fe content rose to 26.31% and Mn to 46.32%. Replication 3 again showed the highest results, namely a decrease in Fe content of 52.63% and Mn of 77.17%. This increase indicates that the duration of contact between water and the filtration media has a positive effect on the effectiveness of reducing metal content. On the third day (Table 6), there was a further increase in filtration effectiveness. The average decrease in Fe content reached 35.19% and Mn by 52.25%. Replication 3 remained the most effective, with a 61.11% reduction in Fe and 79.57% in Mn. This reinforces the finding that the effectiveness of rice husk ash also increases over time. Filtration using rice husk ash showed increasing effectiveness over time in reducing Fe and Mn levels, although the reduction was not as optimal as using coconut shell charcoal. Nevertheless, rice husk ash remains a potential and environmentally friendly alternative media for filtering heavy metals from well water.

Based on the results of the paired samples statistical test (paired t-test) conducted to determine the effectiveness of coconut shell charcoal and rice husk ash filter materials in reducing Fe (Iron) and Mn (Manganese) levels in well water, the first table (Paired Samples Test) shows that all pairs (Pair 1 to Pair 4) have a significance value (2-tailed Sig.) <0.05, namely 0.001; 0.000; 0.007; and 0.000, respectively. This indicates that the difference between the control and post-treatment conditions is statistically significant. This means that both coconut shell charcoal and rice husk ash significantly reduced Fe and Mn levels in the water.

The second table (Paired Samples Statistics) shows the mean and standard deviation for each group before and after treatment. For example, in Pair 1 (Fe with coconut shell charcoal), Fe levels decreased from an average of 18.67 to 9.89. A more drastic decrease was seen in Mn, which decreased from 93.33 to 15.78 in Pair 2 (Mn with coconut shell charcoal). A similar trend was observed in the rice husk treatment: Fe decreased from 18.67 to 14.11 (Pair 3), and Mn from 93.33 to 38.44 (Pair 4). This indicates that both materials are effective, although coconut shell charcoal showed a greater reduction, particularly for Mn.

Meanwhile, the third table (Paired Samples Correlations) shows the correlation between pre- and post-treatment data. The correlation values ranged from 0.327 to 0.465, but were not statistically significant (Sig. value > 0.05). This indicates that the relationship between metal levels before and after treatment was not strong enough, but still provides an indication of the direction of change due to the filtration treatment.

CONCLUSIONS AND SUGGESTIONS

Coconut shell charcoal was less effective in reducing iron (Fe) levels, with an average reduction of 61.11%. Because the reduction was less than 80% and the statistical test results were significant, this charcoal was categorized as an effective filtration medium.

Coconut shell charcoal was effective in reducing manganese (Mn) levels, with an average reduction of 88.89%. Because the reduction exceeded 80% and the statistical test results were significant, this charcoal was categorized as an effective filtration medium.

Rice husk ash was less effective in reducing iron (Fe) levels, with an average reduction of only 35.19%. Because the reduction was less than 80%. Although the results were statistically significant, the reduction did not meet the effectiveness criteria of ≥ 80%.

Rice husk ash was less effective in reducing manganese (Mn) levels, with an average reduction of 52.25%. Although the results were statistically significant, the reduction did not meet the effectiveness criteria of ≥ 80%. However, it still has potential as an alternative, inexpensive and environmentally friendly filtration medium. Recommendations for the Community

The community is advised to use coconut shell charcoal as a filtration medium for drilled well water, as it has been proven effective in reducing Fe and Mn levels. Simple filtration devices can be built independently at low cost. Furthermore, it is important to regularly check water quality and raise awareness of the dangers of heavy metals in water.

Further research is recommended to explore combinations of filtration media, variations in thickness and contact time, and to examine other water quality parameters such as pH and other heavy metals. Trials at different locations and cost analyses are also needed to determine the effectiveness and sustainability of this method on a large scale.

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