RESEARCH ARTICLE **Open Access**

Gema Lingkungan Kesehatan
Vol. 23, No. 3 (2025), pp 357-369
e-ISSN 2407-8948 p-ISSN 16933761
Doi: https://doi.org/10.36568/gelinkes.v23i3.314 *Journal Hompage: https://gelinkes.poltekkesdepkes-sby.ac.id/*

Effectiveness of Banana Peel Ash, Zeolite and Clam Shells in Reducing Waterturbidity and Iron (Fe) Contentration

Selviana Selviana[1]*, Kamaran[1], Linda Suwarni[1], Suharno[2)]

[1] Faculty of Health Sciences and Psychology, Muhammadiyah University, Pontianak, Indonesia
[2] Department of Environmental Health, Poltekkes Kemenkes Pontianak, Pontianak, Indonesia

*Correspondence: selviana@unmuhpnk.ac.id

ABSTRACT

One method to reduce iron content and water turbidity is to use banana peel coagulants and zeolite and clam shell filtration. The biochemical components in banana peels are believed to be effective in reducing turbidity and heavy metals, while zeolites and clam shells function to reduce iron levels in water. This study aims to determine the effectiveness of kepok banana peel ash coagulant (Musa acuminate balbisiana C.) and zeolite and clam shell filtration in reducing turbidity and iron (Fe) content in river water in Punggur Kecil Village, Sungai Kakap District, Kubu Raya Regency. The research method used was a quasi-experiment with a one-group pretest-posttest design, taking river water samples in Punggur Kecil Village, as many as 27 samples from 9 repetitions. Data were analyzed descriptively with the paired sample t-test statistical test. The results of the analysis showed that river water treatment using banana peel ash coagulant and clam shell filtration and zeolite decreased the average iron (Fe) content from 2.21 mg/l to 0.25 mg/l, with an effectiveness of 88.18%, but there was no significant change. While the average decrease in turbidity levels was from 57.67 NTU to 17.6 NTU, with an effectiveness of 65.56%, the results were also not significant. The results of the paired t-test showed a significant difference before and after treatment in iron content with a value of 0.000 ($p < 0.05$) and turbidity content with a value of 0.003 ($p < 0.05$). The conclusion of this study shows a significant difference in iron (Fe) and turbidity levels, but this treatment method has not been effective in reducing the level of turbidity of river water. The conclusion of this study shows a significant difference in iron (Fe) and turbidity levels, but this treatment method has not been effective in reducing the level of turbidity of river water.

Keywords: Banana peel ash, Clam shell, Zeolite, Iron (Fe)

INTRODUCTION

The coverage of clean water services in Indonesia is still low, with PAM or PDAM only able to meet the needs in cities with small quantities. Most unreached communities use ground or surface water, which often does not meet quality standards (Regulation of the Indonesian Minister of Health, 1990) and (Regulation of the Indonesian Minister of Health, 2010) Groundwater is one of the water with high Fe content, if consumed too much can cause diseases such as arthritis, birth defects, cancer, hepatitis, hypertension, infections, insomnia, and liver. The presence of contaminants such as heavy metals and microbiology in water can have adverse health effects. Among the diseases that arise from consuming polluted water is diarrhea.

As the population in Indonesia continues to increase, the demand for water is highly dependent on raw water sources from nature, such as rain, rivers, and groundwater. The sustainability of raw water sources is very important for the continuity of water supply. In West Kalimantan in 2017, the percentage of households that have access to proper drinking water source services by district / city only reached 68.77% (Central Bureau of Statistics of West Kalimantan Province, 2017) so it is necessary to increase the coverage of clean water use.

The human need for clean water requires the availability of sufficient water in quantity, quality, and continuity. condition of water containing iron (Fe) has different physical characteristics such as fishy smell, brownish color, turbidity, and leaves stains on the walls around the water (Pratiwi et al., 2022). In addition, turbidity in water has an impact on fish mortality due to damage to respiratory organs and damage to breeding areas for aquatic organisms. Based on a preliminary survey conducted in Punggur Kecil Village, the iron (Fe) content and turbidity of river water exceeded the NAB, with iron levels of 4.98 mg/L and turbidity of 214 NTU. Based on (Regulation of the Indonesian Minister of Health, 1990), the iron standard is 1.0 mg/L and turbidity is 25 NTU. In addition, other sources state that the maximum quality standard for iron levels for drinking

water quality is 0.3 Mg / L (Regulation of the Indonesian Minister of Health, 2010) clean water 1.0 mg/l. The quality standard for water turbidity for sanitary hygiene purposes is 25 NTU (Permenkes Ri No 32, 2017) so the sample clearly exceeds the set limit. Unqualified raw water must be treated, Water treatment using filters with activated carbon media, Manganese green sand, silica sand, activated sand and zeolite has proven effective in improving water quality according to quality standards (Putra et al., 2025). often with chemicals such as alum and PAC (Prianti et al., 2022; Sisnayanti et al., 2021) However, these methods can have side effects. A more environmentally friendly alternative is to use ash from kepok banana peels to purify water. One way to reduce iron (Fe) content and turbidity in water is by using banana peel media and zeolite filtration and active coral.

The effectiveness of pisang kepok peel in the adsorption process is much better than carbon and silica (Hanifah et al., 2021). The carboxyl group and cellulose hydroxyl content will directly affect the absorption of Cu and Pb metals (Castro et al., 2011). According to Rahman, 2004 zeolite filter media reduced Fe by 55% but only 40% of Mn in groundwater containing 3.6 mg/l Fe and 0.7 mg/l Mn, the optimum conditions for removing Fe and Mn were 30 minutes for contact time and 2 ml/minute for filtration rate. Zeolite is a hollow mineral that has many uses in filtration. Its prominent properties include the ability to release water molecules, which enhances the interaction with adsorbed molecules, as well as the ability to separate molecules based on size and polarity. In, zeolites can perform ion exchange influenced by size and charge, and serve as efficient catalysts thanks to their large pores and maximum surface (Dongoran et al., 2021). Zeolites are effective in removing metal ions such as Fe and Mn from water. In addition, zeolites can also remove ammonia and other organic impurities and can also be used as a color absorbent material (Al Kholif et al., 2024). Clamshell is a mineral source material that generally comes from marine animals in the form of shells that have undergone grinding and have high carbonates. The calcium content in clam shells is 38%. Chemical Content of Clam Shell Powder Component Content (weight %) CaO 66.70 SiO_2 7.88 Fe^2O_3 0.03 MgO 22.28 Al2O3 1.25 (Siregar, 2009). So that from some of the substances contained in the clam shells it is effective in reducing iron levels in water, in accordance with research that found that the average decrease in iron (Fe) in the 30 cm clam shell reactor was 88.64%, the 20 cm clam shell reactor was 78.45%, and the 10 cm clam shell reactor was 68.82%, it can be concluded that clam shells have an effect on reducing iron levels in water with a certain thickness concentration (Safitri & Purnomo, 2023).

Based on the above background all three materials analyzed have significant drawbacks. The kepok banana peel, although showing effectiveness as a bioadsorbent, can be affected by environmental variables such as pH and metal concentration, which can limit its adsorption capacity. Zeolite, although efficient in reducing Fe and Mn levels, requires a regeneration process after use, which can increase operational costs as well as the complexity of the filtration system. On the other hand, clam shells are effective in reducing iron concentrations, but the availability of raw material sources and potential contamination from marine organisms are important considerations in their application. Therefore, it is necessary to know how the effectiveness of kepok banana peel ash (Musa acuminate balbisiana C.) as a coagulant material with zeolite filtration and clam shells to reduce iron (Fe) levels and turbidity in river water in Punggur Kecil Village, Sungai Kakap District, Kubu Raya Regency. So that the right water treatment method is obtained and can be applied by the community.

METHODS

This type of research is a quasi-experiment with a one group pretet posttest design with the aim of knowing the effectiveness of kepok banana peel ash coagulant (Musa acuminate balbisiana C.) and zeolite filtration and clam shells in reducing turbidity content and iron (Fe) content in river water in Punggur Kecil Village, Sungai Kakap District, Kubu Raya Regency which was conducted from July-September 2024. The population in this study is river water in Punggur Kecil Village, Sungai Kakap District, Kubu Raya Regency, where there is no PDAM access. Sampling will be carried out at one point of the river with 9 repetitions and consecutively so that 27 total samples are obtained. River water sampling is done by rinsing the jerry can thoroughly using river water three times to avoid contamination. Next, the jerry cans were put into the river at a depth of 10 cm from the water surface to ensure representative sampling. Once the jerry can was fully filled, the jerry can head was to prevent changes in the sample composition. Determination of the dose of kepok banana peel ash as a coagulant was carried out through a jar test using a flocculator equipped with a glass and stirrer. The process began by preparing five 1000 ml beaker glasses, each filled with 1 liter of sample water. Next, coagulant was added to each beaker with varying doses, namely 1.2 g, 1.3 g, .4 g, 1.5 g, and 1.6 . The coagulation process was carried out with a stirring speed of 1.5°C. The coagulation process was carried out at a stirring speed of 100 rpm for some time, followed by settling for 120 minutes to allow the particles to settle. The tools and materials used during the study include a catch basin, coagulant basin, settling basin, kepok banana peel ash and clam shell and zeolite filtration pipes. The following is a visualization of the design of the filtration equipment used:

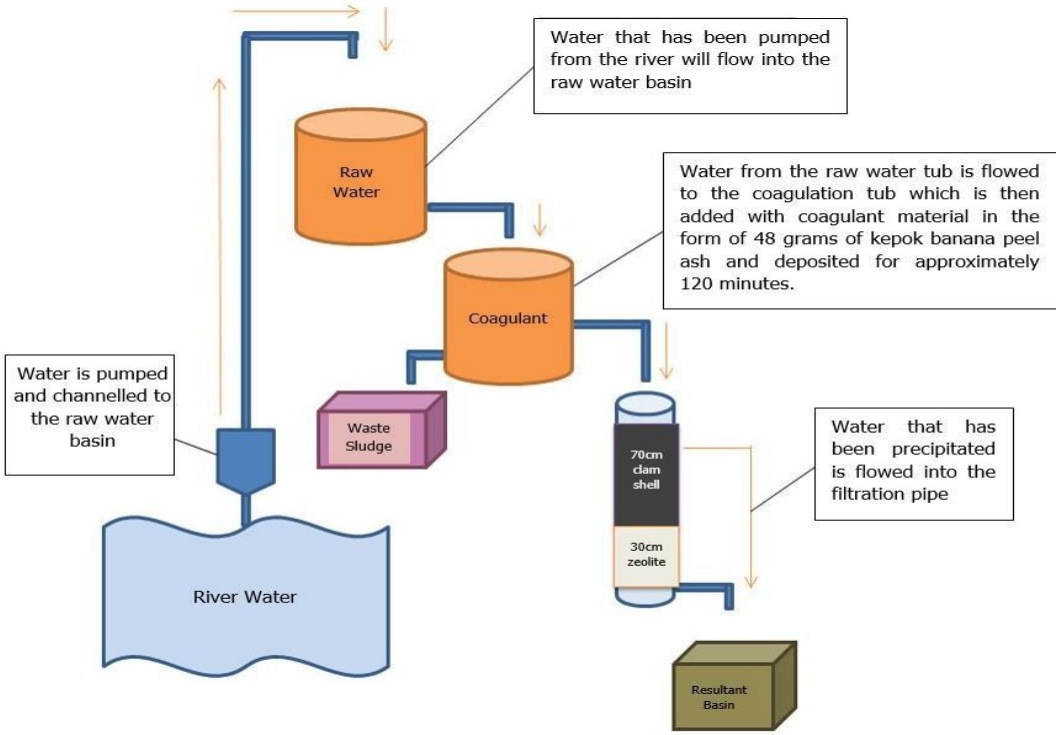

Figure 1. Filtration Device Design

The water samples taken were then sent to the laboratory for analysis of iron (Fe) content and turbidity. Water samples were then taken to the Industrial Research and Development Agency, Pontianak Industrial Research and Standardization Center Testing Laboratory, with repetitions carried out 9 times for 9 days. Data were analyzed using a computerized system descriptively with the Paired Sample T-Test statistical test while the effectiveness test of the complete processing tool with iron (Fe) content and turbidity in river water using the following formula:

$$\text{Effectiveness} = \frac{(A-B)}{A} \times 100\%$$

Description:

A = Intensity of content Turbidity/iron content intensity before treatment.

B = Intensity of content Turbidity/iron content intensity after treatment.

This experiment has passed the ethical review at the Faculty of Health Sciences and Psychology, Universitas Muhammadiyah Pontianak Number 007/KEPK-FIKES/ UM PONTIANAK/ 2024.

RESULTS AND DISCUSSION

Tests were carried out on river water from Punggur Kecil Village in a tub with a capacity of 40 liters of water mixed with 48 grams of kepok banana peel ash and stirred manually for 15 minutes, the mixed water flowed into the settling basin for 60-120 minutes. Next, the precipitated water flowed into a filtration pipe containing clam shells and zeolite, then collected in a tightly closed bottle to be taken to the laboratory.

Table 1
Average Iron (Fe) Content and Turbidity Before and After Using Coagulants of Kapok Banana Peel Ash and Filtration of Shells and Zeolite in Punggur Kecil Village

No	Control		Kepok Banana Peel Ash Coagulant		Kepok Banana Peel Ash Coagulant and Clam shell Filtration and Zeolite	
	Iron (Fe) (Mg/L)	Turbidity (NTU)	Iron (Fe) (Mg/L)	Turbidity (NTU)	Iron (Fe) (Mg/L)	Turbidity (NTU)
1	2.83	51.6	0.343	66.2	0.303	77.6
2	2.41	69.8	0.351	99.8	0.275	72.2
3	2.9	67.4	0.221	54.4	0.258	16.1
4	2.17	59.3	0.361	93	0.154	83.2
5	2.33	54.4	0.155	65.6	0.189	15.6
6	2.08	49.4	0.3	55.5	0.125	19

No	Control		Kepok Banana Peel Ash Coagulant		Kepok Banana Peel Ash Coagulant and Clam shell Filtration and Zeolite	
	Iron (Fe) (Mg/L)	Turbidity (NTU)	Iron (Fe) (Mg/L)	Turbidity (NTU)	Iron (Fe) (Mg/L)	Turbidity (NTU)
7	2.19	84.4	0.271	88.6	0.408	18.4
8	1.87	52.6	0.532	86.4	0.32	19.2
9	1.11	30.2	0.328	27.6	0.204	17.3
Aver-age	2.21	57.67	0.32	76.19	0.25	17.6

Description:
: Extreme value
: calculated value

Based on table 1 above, it is found that the average iron (Fe) content and turbidity before and after the treatment of Banana Peel Ash Coagulant and Shell Filtration and Zeolite in Punggur Kecil Village, Sungai Kakap Subdistrict, Kubu Raya Regency from the first repetition to the ninth repetition of the raw water value of iron (Fe) 2.21 mg/l and turbidity 57.67 NTU. Meanwhile, the average iron (Fe) content after treatment using Banana Peel Ash Coagulant Kepok is 0.32 mg/l and turbidity 76.19 NTU. While the average iron (Fe) after treatment using Banana Peel Ash Coagulant Kepok 0.32 mg/l and turbidity 76.19 NTU in the turbidity value data there are extreme values that are colored yellow and not calculated in the average value. And the average iron (Fe) after treatment using Kepok Banana Peel Ash Coagulant and Clam Shell Filtration and Zeolite 0.25 mg/l and turbidity 17.6 NTU.

River water in Punggur Kecil Village has characteristics of turbid, rust-smelling, and yellow-colored water, indicating high levels of iron (Fe) in water. Where the average iron (Fe) level is 2.21 mg/l which means >1.0 mg/l which exceeds the value. Iron (Fe) is one of the chemical elements that can be found in almost every place on earth, in all geological layers and all water bodies. The presence of iron (Fe) in groundwater is usually related to the dissolution of rocks and minerals, especially oxides, carbonate sulfides, and silicates containing these metals. In surface water the presence of iron (Fe) can be in the form of suspended particles or dissolved particles in water. The element iron (Fe) enters with metal industry waste or due to coal mining operations. Iron (Fe) is a chemical element that can affect water quality (Kurniawan et al., 2020).

Iron (Fe) levels that are too high in water can cause water to change color, and smell. Although iron (Fe) is needed by the body, if absorbed in excessive doses in the human body it can cause damage to the intestinal wall, damage to the brain to poisoning and can even cause death if iron (Fe) is continuously absorbed excessively (Sappewali et al., 2024). Therefore, efforts to reduce iron (Fe) levels in river water in Punggur Kecil Village can be done with a simple method, namely coagulation of kepok banana peel ash and filtration of clam shells and zeolite which can reduce iron (Fe) levels dissolved in river water.

Before the treatment, the results of laboratory measurements showed that the results of iron (Fe) levels dissolved in river water in Punggur Kecil Village were an average of 2.21 mg/l. After water treatment using the coagulation process of kepok banana peel ash and clam shell filtration and zeolite in river water, the iron (Fe) content in the river water decreased with an average result of 0.25 mg/l, this shows decrease in iron (Fe) content in the coagulation process of kepok banana peel ash and clam shell filtration and zeolite, and has met the threshold value allowed according to PERMENKES 492 of 2010 which is 1.0 mg/l. Based on the results of laboratory tests on the river water, it can be seen that there is no significant change in the decrease in iron (Fe) levels between before the application of banana peel ash and after the application of banana peel ash.

While water treatment using the coagulation process of kepok banana peel ash and filtration of clam shells and zeolite in river water, the turbidity level of river water has decreased with an average result before the application of kepok banana peel ash and filtration of clam shells and zeolite of 56.4 NTU, and the average decrease after the application of kepok banana peel ash and filtration of kepok banana peel ash was 17.6 NTU, this shows that the decrease in turbidity levels in the coagulation process of kepok banana peel ash and filtration of clam shells and zeolite has met the threshold value allowed according to PERMENKES 492 of 2010 which is 25 NTU. Based on the results of laboratory tests on river water, it can be seen that there is a significant change in the decrease in turbidity levels between before and after the application of banana peel ash and clam shell filtration.

Previous test results showed an average decrease in the level of turbidity of dug well water consecutively, namely, Po (control) 57 NTU, P1 (40 g dose of banana peel) average decrease is 34.97 NTU, P2 50 g dose of banana peel) average decrease is 28.87 NTU and P3 (60 g dose of banana peel) average decrease is 26.1 NTU (Maliandra et al., 2016). And the decrease in Iron (Fe) levels, Po (control) 0.09 mg/L, P1 (40 g banana peel dose) average decrease is 0.026 mg/L, P2 (50 g banana

peel dose) average decrease is 0.063 mg/L and P3 (60 g banana peel dose) average decrease is 0.02 mg/L. The conclusion of this study is that there is an effect of various doses of kepok banana peel (Musa acuminate balbisiana C) in reducing turbidity and iron (Fe) levels in dug well water.

There is an extreme value in the turbidity content when filtration of clam shells and zeolite is carried out, the extreme value is in repetitions 1, 2 and 4. This can occur due to the deposition of banana kepok peel ash that is not optimal and the dose given at repetitions 1, 2 and 4 exceeds the predetermined dose, so that when filtrating the turbidity content does not decrease.

Table 2
Results of Statistical Analysis Using Paired Sample T-Test Paired Decrease in iron (Fe) content and turbidity before and after using Kepok Banana Peel Ash Coagulant and Shell Filtration and Zeolite in river water in Punggur Kecil Village, Sungai Kakap District, Kubu Raya Regency in 2024.

Treatment	Sig	Description
Iron raw water - kepok banana peel ash coagulant and clam shell and zeollite filtration	0.000	There is a difference.
Raw water turbidity - kepok banana peel ash coagulant and clam shell and zeollite filtration	0.003	There is a difference.

Based on table 2 above the results of the Paired Sample T-Test, it can be concluded that there is a difference in the decrease in iron (Fe) levels before and after being combined with kepok banana peel ash coagulant and clam shell filtration and zeolite obtained a significance number of 0.000 because p < 0.05 which indicates a difference in iron (Fe) levels, and in turbidity content before and after being combined with kepok banana peel ash and clam shell filtration and zeolite obtained a significance number of 0.000 because p < 0.05 which indicates a difference in iron (Fe) levels. 0.05 which indicates a difference in iron (Fe) levels, and in the turbidity content before and after being combined with kepok banana peel ash and mussel shell filtration and zeolite obtained a significance value of 0.003 because p < 0.05 which indicates a difference in turbidity content.

The results of the statistical analysis using regression showed a p-value of 0.010 for the turbidity variable (p < 0.05), indicating a significant effect of turbidity reduction in dug well water before and after treatment with three different doses of banana peel: 40g, 50g, and 60g (Maliandra et al., 2016). The results of statistical test analysis using regression obtained p value for variable iron content (Fe) (0.276 > 0.05), meaning that there is an effect of decreasing turbidity in dug well water before and after treatment with 3 doses of banana peel 40g, 50g, 60g but still less significant. In line with the research that found that the use of activated charcoal ash filter media from banana peels has an effect on reducing Fe and Turbidity parameters, the ash content of milk banana peel activated charcoal is 8.7%. This ash content indicates the amount of metal oxides and minerals in the material, where the presence of excessive ash can result in blockage of activated carbon pores, thus reducing its surface area and effectiveness in absorption. The desired ash content is as low as possible to support the reduction of iron (Fe) and turbidity levels in well water (Humaira, 2023).

Effectiveness of reducing iron (Fe) content before and after coagulant treatment of Kepok Banana Peel Ash in river water

Table 3
Coagulant Effectiveness of iron (Fe) content reduction before and after coagulant treatment of Banana Peel Ash

Repetition	Iron (Fe) Result		Difference in Decrease (Mg/l)	Effectiveness (%)	Clean Water Quality Standards (Fe = 1 Mg/L)
	Raw Water Before Treatment (mg/l)	After Coagulant Kepok Banana Peel Ash (mg/l)			
1	2.83	0.343	2.48	87.88	<NAB
2	2.41	0.351	2.05	85.43	<NAB
3	2.9	0.221	2.67	92.38	<NAB
4	2.17	0.361	1.8	83.36	<NAB
5	2.33	0.155	2.17	93.35	<NAB
6	2.08	0.3	1.78	85.58	<NAB
7	2.19	0.271	1.91	87.62	<NAB
8	1.87	0.532	1.33	71.55	<NAB

Repetition	Iron (Fe) Result		Difference in Decrease (Mg/l)	Effectiveness (%)	Clean Water Quality Standards (Fe = 1 Mg/L)
	Raw Water Before Treatment (mg/l)	After Coagulant Kepok Banana Peel Ash (mg/l)			
9	1.11	0.328	0.78	70.45	<NAB
Average	2.21	0.32	1.89	84.18	

Based on table 3 above, it is known that iron (Fe) levels after treatment have decreased. The average iron (Fe) level before treatment was 2.21 mg/l and the average after coagulant Kepok Banana Peel Ash with an average of 0.32 mg/l, and this value has met the quality standard requirements of PERMENKES 492 of 2010 for iron (Fe) quality standards of 1.0 mg/l. From the table above, the average effectiveness is 84.18%. In line with research that found that activated carbon of banana peel can reduce iron (Fe) levels in river water from 0.450 mg/L to 0.00 mg/L, this is because the composition of activated carbon in banana peel kepok is appropriate, namely with a weight of 60 grams, it is able to reduce iron (Fe) levels in river water (Poniman, 2022). Laboratory test results show that the 4.76 mm size of kepok banana peel charcoal media effectively reduces the iron content of the Cinnamon Housing lake water from 0.569 mg/liter to 0.229 mg/liter (59.75% efficiency), reaching a value below the quality standard. Smaller sized charcoal media (2.38 mm and 2 mm) experienced clogging and could not be tested. These findings confirm the potential of kepok banana peel charcoal as an effective natural adsorbent for iron reduction in water treatment (Erwinsyah et al., 2018).

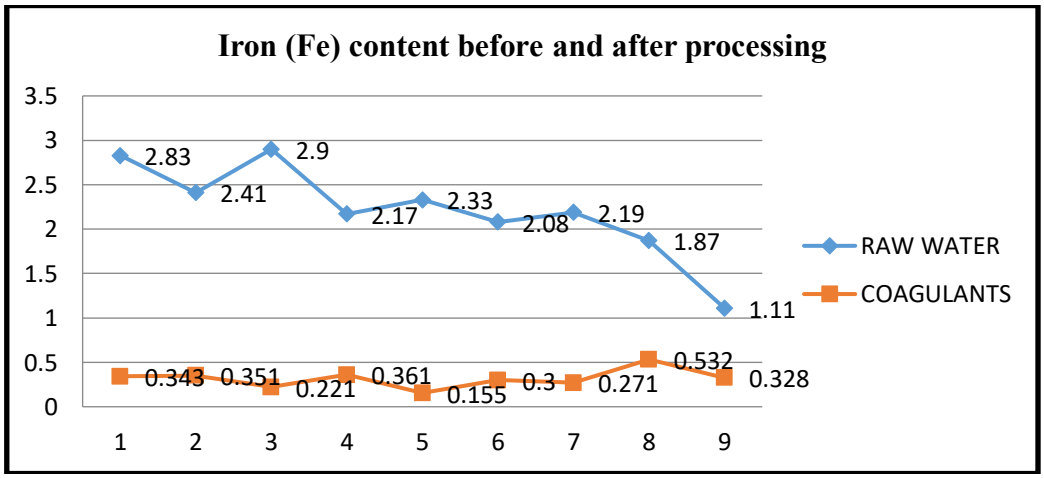

Figure 2. Graph of Reduction of Iron (Fe) Content in Raw Water and Coagulant

Based on Figure 2 above, it is known that raw water with varying Fe concentrations (1.11-2.9 mg/L), with a decreasing pattern from period 3 to 9. After the coagulation process, the Fe content dropped dramatically to 0.155-0.532 mg/L in all measurement periods. The highest reduction efficiency reached 92% in period 3 (from 2.9 to 0.221 mg/L). Despite a slight increase in Fe content in the coagulation results in period 8 (0.532 mg/L), the system remained consistent in keeping the Fe content below 0.6 mg/L. This data proves that the coagulation process is very effective in precipitating and removing iron contaminants from raw water.

The effectiveness of reducing turbidity content before and after the treatment of Kepok Banana Peel Ash Coagulant in river water

Table 4
Effectiveness of reducing turbidity content before and after coagulant treatment of Kepok Banana Peel Ash

Repetition	Turbidity Results		Difference in Decrease (NTU)	Effectiveness (%)	Clean Water Quality Standard (Turbidity = 25 NTU)
	Raw Water (NTU)	After Coagulant Kepok Banana Peel Ash (NTU)			
1	51.6	66.2	-14.6	-28.29	>NAB
2	69.8	99.8	-30	-42.97	>NAB
3	67.4	54.4	13	19.28	>NAB
4	59.3	93	-33.7	-56.82	>NAB

5	54.4	65.6	11-2	-20.58	>NAB
6	49.4	55.5	-6.1	-12.34	>NAB
7	84.4	88.6	-4-2	-4.97	>NAB
8	52.6	86.4	-34	-64.25	>NAB
9	30.2	27.6	2.6	8.6	>NAB
Rata-rata	57.67	76.19	-12.3	-26.36	

: Extreme value
: Calculated value

Based on table 4 above, it is known that the turbidity content after treatment has increased. The average turbidity level before treatment was 57.67 NTU and the average after coagulant kepok banana peel ash was 76.19 NTU, there are extreme values that are colored yellow which are not calculated into the average value, and these values do not meet the quality standards of PERMENKES 492 of 2010 for turbidity levels of 25 NTU. From the results obtained, the average effectiveness is -26.37%.

Turbidity increases when adding banana peel ash coagulant, this can occur because the banana peel ash particles are lighter than the raw water mass, this causes the banana peel ash particles to float so that the raw water experiences an increase in turbidity levels, making the average value of effectiveness -26.36 (mines). In line with research stating that the results of the characterization of kepok banana peel waste activated carbon obtained ash content and iodine absorption did not meet the SNI requirements for technical activated charcoal so that this affected the coagulant's ability to adsorb water (Abdi et al., 2015). Increasing the coagulant dose can increase the formation of larger flocs, helping to precipitate particles that cause turbidity. However, too high a dose can lead to increased turbidity if the coagulant particles do not function properly. Therefore, it is important to optimally adjust the coagulant dose to reduce groundwater turbidity Wardani in (Hanifah et al., 2020).

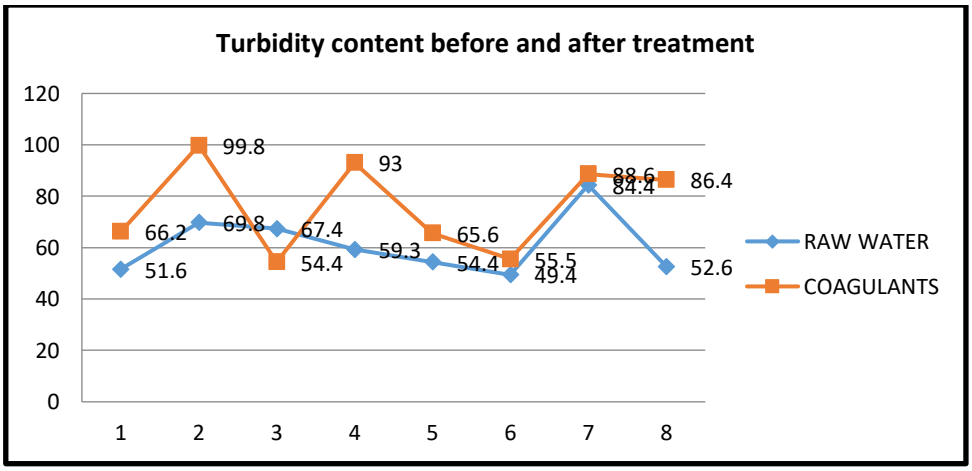

Figure 3. Graph of Turbidity Content Reduction in Raw Water and Coagulant

Based on Figure 3 above, is known that an interesting phenomenon in water treatment, where the coagulation process actually increases the level of turbidity. The raw water had a relatively stable turbidity (49.4-69.8 NTU), while after the addition of coagulant, the water turbidity increased significantly in some periods (reaching 99.8 NTU in period 3). This pattern indicates that the coagulant caused floc formation (particle agglomeration) which initially increased the turbidity. In periods 7-8, the two values almost coincide, indicating that the coagulation process is in the adjustment stage. This phenomenon is normal in the early stages of a complete treatment process, where coagulation is only a preparatory stage before the settling and filtration processes that will remove the formed flocs.

The effectiveness of reducing iron (Fe) content before and after coagulant treatment of Kepok Banana Peel Ash and Clam Shell Filtration and Zeolite in river water

Based on table 5 above, it is known that iron (Fe) levels after coagulant of kepok banana peel ash and filtration of clam shells and zeolite have decreased. The average iron (Fe) level after coagulant of kepok banana peel ash is 0.32 mg/l and the average after filtration of clam shells and zeolite is 0.25 mg/l, this value has met the quality standard requirements of PERMENKES 492 of 2010 for iron (Fe) quality standards of 1.0 mg/l. From the table above, the average effectiveness is 15.32%.

Table 5
Percentage reduction in Iron (Fe) content before and after
Coagulant treatment of Kepok Banana Peel Ash and Filtration of Clam Shell and Zeolite

Repetition	Iron (Fe) Result		Difference in Reduction (Mg/l)	Effectiveness (%)	Clean Water Quality Standard (Fe=1 mg/l)
	Kepok Banana Peel Ash Coagulant (mg/l)	Clam Shell and Zeolite Filtration (mg/l)			
1	0.343	0.303	0.04	11.66	<NAB
2	0.351	0.275	0.08	22.16	<NAB
3	0.221	0.258	-0.04	-16.74	<NAB
4	0.361	0.154	0.21	57.34	<NAB
5	0.155	0.189	-0.03	-21.94	<NAB
6	0.3	0.125	0.17	58.33	<NAB
7	0.271	0.408	-0.14	-50.55	<NAB
8	0.532	0.32	0.21	39.8	<NAB
9	0.328	0.204	0.12	37.80	<NAB
Average	0.32	0.25	0.07	15.32	

In line with research that found that kepok banana peel waste (Musa acuminate) is effective as an iron (Fe) biofilter and ineffective as a lime (CaCO3) biofilter (Budiman et al., 2018). The iron (Fe) content in well water before going through the filtration process with clam shell media from 2.01 mg/l to 0.49 mg/l. addition, the most effective clam shell powder size in reducing iron levels is at a size of 100 mesh (Auliah et al., 2019). Similarly, in zeolite media, water with iron levels in raw water fell from 5 mg/l to 1 mg/l after being passed through a zeolite column (Ismawati et al., 2018).

The three filtration media showed effectiveness in reducing iron levels through different adsorption mechanisms. Kepok banana peel contains lignin and cellulose with active groups that have a high affinity for iron (Fe) ions. Clam shells with a size of 100 mesh provide the optimal surface area for iron ion sorption. While zeolite, with its hollow aluminosilicate structure, offers good cation exchange capacity. Differences in the reduction efficiency of each media were influenced by the chemical composition and physical characteristics of each adsorbent.

Table 6
Effectiveness of Iron (Fe) content reduction before and after
Coagulant treatment of Kepok Banana Peel Ash and Filtration of Clam Shell and Zeolite

Repetition	Iron (Fe) Result		Difference in Decrease (Mg/l)	Effectiveness (%)	Clean Water Quality Standards (Fe=1 mg/l)
	Raw Water (mg/l)	Clam Shell and Zeolite Filtration (mg/l)			
1	2.83	0.303	2.53	89.29	<NAB
2	2.41	0.275	2.14	88.59	<NAB
3	2.9	0.258	2.64	91.10	<NAB
4	2.17	0.154	2.02	92.9	<NAB
5	2.33	0.189	2.14	91.89	<NAB
6	2.08	0.125	1.95	93.99	<NAB
7	2.19	0.408	1.78	81.37	<NAB
8	1.87	0.32	1.55	82.89	<NAB
9	1.11	0.204	0.91	81.62	<NAB
Average	2.21	0.25	1.96	88.18	

Based on table 6 above, it is known that iron (Fe) levels after treatment have decreased. The average iron (Fe) level before treatment was 2.21 mg/l and the average after filtration of shells and zeolite was 0.25 mg/l, this value has met the quality standards of PERMENKES 492 of 2010 for iron (Fe) quality standards of 1.0 mg/l. From the table above, the average effectiveness is 88.18%.

Based on the results of the effectiveness test after the treatment of small Punggur river water using kepok banana peel ash coagulant and shell filtration and zeolite, iron (Fe) levels in the river water decreased significantly with an average value of 0.25 mg/l, with an average effectiveness of 88.18%. Laboratory test results show a very significant change in the decrease in iron (Fe) levels between before and after treatment. This proves

that the combination of water treatment with kepok banana peel ash coagulant and clam shell filtration and zeolite is very effective in reducing iron (Fe) levels in small Punggur river water. This high effectiveness is due to the combined action of the kepok banana peel ash coagulant which contains active compounds to precipitate iron (Fe), as well as the clam shell and zeolite filter media which work synergistically. Clam shells with $CaCO_3$ content and zeolites with aluminosilicate structure provide optimal adsorption sites to adsorb iron ions through cation exchange mechanism.

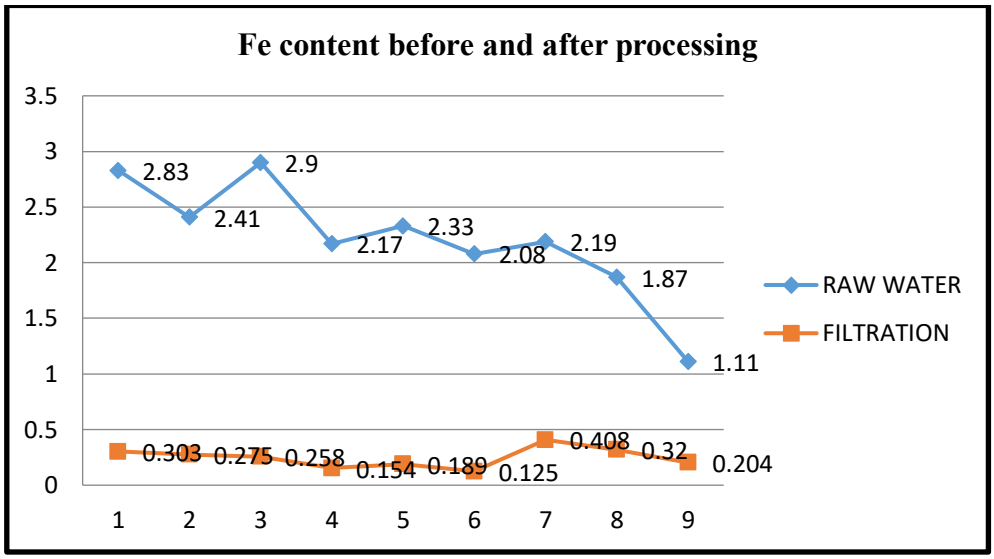

Figure 3. Graph of Reduction of Iron (Fe) Content in Raw Water and Filtration

Based on Figure 3 above, is known that the filtration process proved to be very effective in reducing Fe (iron) content in water. The graph shows that the raw water had varying Fe concentrations (1.11-2.9 mg/L), with a decreasing trend from period 3 to 9. After going through the filtration process, the Fe content was significantly reduced to 0.125-0.408 mg/L. The highest reduction efficiency reached 93% in period 3 (from 2.9 to 0.258 mg/L). Despite small fluctuations in the filtration results, the system consistently reduced the Fe content to below 0.5 mg/L throughout the measurement period. This proves the reliability of the filtration system in removing iron contaminants from raw water, resulting in safer water for use.

The effectiveness of reducing turbidity content before and after the treatment of Clam Shell Filtration and Zeolite in river water

Table 7
Percentage reduction in Turbidity content before and after
Coagulant treatment of Kepok Banana Peel Ash and Filtration of Clam Shell and Zeolite

Repetition	Turbidity Results		Difference in decline (NTU)	Effectiveness (%)	Clean Water Quality Standards (Turbidity = 25 NTU)
	Kepok Banana Peel Ash Coagulant (NTU)	Clam Shell and Zeolite Filtration (NTU)			
1	66.2	77.6	-11.4	-17.22	>NAB
2	99.8	72.2	27.6	27.65	>NAB
3	54.4	16.1	38.3	70.40	<NAB
4	93	83.2	9.8	10.54	>NAB
5	65.6	15.6	50	76.21	<NAB
6	55.5	19	36.5	65.77	<NAB
7	88.6	18.4	70.2	79.23	<NAB
8	86.4	19.2	67.2	77.78	<NAB
9	27.6	17.3	10.3	37.32	<NAB
Average	76,19	32,62	38,74	55,61	

: Extreme values
: Calculated value

Based on table 7 above, it is known that the turbidity level after coagulant of kepok banana peel ash and filtration of clam shells and zeolite has decreased. With an average turbidity level after coagulant of kepok

banana peel ash is 76.19 NTU and the average after filtration of clam shells and zeolite is 32.62 NTU, in the data above there are extreme values that are colored yellow which are not calculated into the average value, and these values do not meet the quality standards of PERMENKES 492 of 2010 for turbidity quality standards of 25 NTU. From the table above, the average effectiveness is 55.61%.

In line with research that found that the ability of clam shells as a filter media was able to reduce turbidity levels by 91.07%, at a filter media thickness of 8 cm there was an optimum turbidity reduction of 1.81 NTU (Jalaly & Hamidil, 2020). In zeolite media has the ability to reduce water turbidity greater with the help of 1000 mg zeolite composition produced water with turbidity, Cu, Cd, Pb and Al ion content is below the maximum allowable price in drinking water and permanganate number (30.51 ppm), still above the allowable limit (10 ppm) (Saryati et al., 2019). The results of this study showed a less than optimal reduction in turbidity compared to other studies, the effectiveness of 55.61% in reducing turbidity has not reached the established quality standards.

Table 8
Effectiveness of reducing Turbidity content before and after
Coagulant treatment of Kepok Banana Peel Ash and Filtration of Clam Shell and Zeolite

Repetition	Turbidity Results		Difference in decline (NTU)	Effectiveness (%)	Clean Water Quality Standards (Turbidity = 25 NTU)
	Raw Water (NTU)	After Filtration of Shells and Zeolite (NTU)			
1	51.6	77.6	-26	-50.39	>NAB
2	69.8	72.2	-2.4	-3.44	>NAB
3	67.4	16.1	51.3	76.11	<NAB
4	59.3	83.2	-23.9	-40.3	>NAB
5	54.4	15.6	38.8	71.32	<NAB
6	49.4	19	30.4	61.54	<NAB
7	84.4	18.4	66	78.19	<NAB
8	52.6	19.2	33.4	63.49	<NAB
9	30.2	17.3	12.9	42.71	<NAB
Average	56,4	17,6	38,8	65,56	

: Extreme values
: Calculated value

Based on table 8 above, it is known that the turbidity level after treatment has decreased. The average turbidity level before treatment is 56.4 NTU and the average after coagulant filtration of clam shells and zeolite is 17.6 NTU, there are extreme values that are colored yellow which are not calculated into the average value, and this value meets the quality standards of PERMENKES 492 of 2010 for turbidity levels of 25 NTU. From the table above, the average effectiveness is 65.56%.

The results of laboratory tests can be seen that there is no significant change in the decrease in turbidity levels between before and after water treatment with kepok banana peel ash coagulant and shell filtration and zeolite. This shows that water treatment with kepok banana peel ash coagulant is not effective in reducing turbidity levels in river water. Turbidity increases when adding banana peel ash coagulant, this can occur because banana peel ash particles are lighter than the mass of raw water, this causes the banana peel ash particles to float so that the raw water experiences an increase in turbidity levels. This is in line with the percentage results in the table above which show a less than optimal reduction in turbidity levels so that to increase the effectiveness of turbidity reduction, it is necessary to optimize the thickness of the filter media, media composition, and contact time between water and filtration media. In , the stirring and settling process in the coagulation stage with kepok banana peel ash also needs to be considered to avoid increasing turbidity at the initial stage of treatment

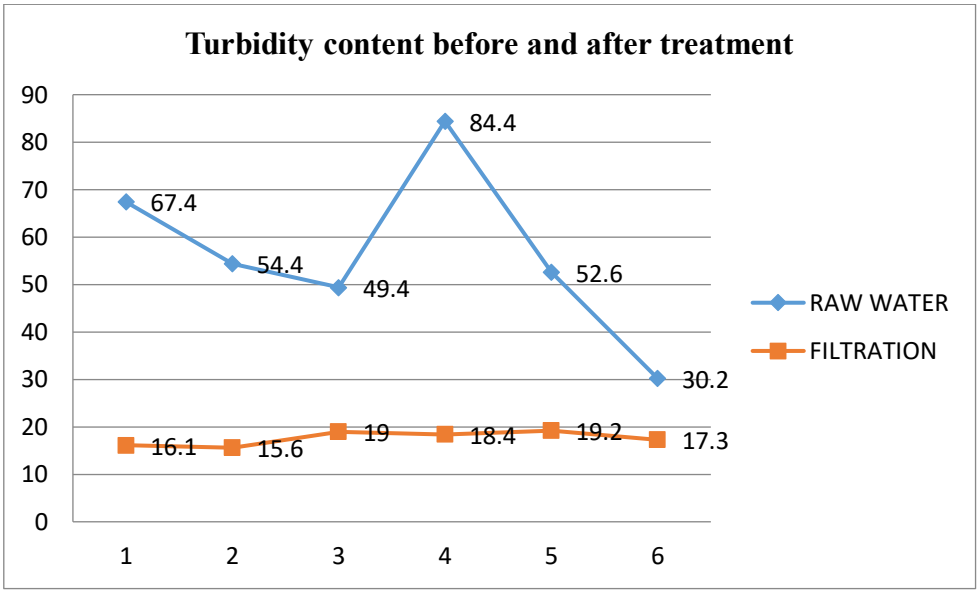

Figure 4. Graph of Reduction of Iron (Fe) Content in Raw Water and Filtration

Based on Figure 4 above, is known that the filtration process shows significant results in reducing turbidity levels. The graph shows that the raw water has a very fluctuating turbidity level (30.2-84.4), with the highest peak in the 4th period. After filtration, the turbidity was reduced to a relatively stable level (15.6-19.2) throughout the measurement period. The effectiveness of filtration was most evident during the worst raw water quality (4th period), with a reduction of up to 78%. Overall, the filtration system proved capable of producing water with consistent turbidity despite extreme variations in raw water quality, demonstrating the reliability of the treatment process in maintaining water quality.

Punggur Kecil river water treatment using kepok banana peel ash coagulant and clam shell filtration and zeolite showed a decrease in iron (Fe) levels by an average of 0.25 mg/l with an effectiveness of 88.18%, but there was no significant change. In addition, turbidity levels also decreased by an average of 17.6 NTU with an effectiveness of 65.56%, the results of laboratory tests showed that there was no significant change in the decrease in iron (Fe) and turbidity levels so this indicates that the processing method is not effective in reducing iron and turbidity levels of river water. In line with the research that found rice husk activated carbon to be better than banana peel activated carbon in reducing river water pollution levels, this is indicated by the optimum dose for rice husk activated carbon being 15 grams, while for banana peel it is 20 grams.The effectiveness of rice husk activated carbon reached 98.13% and banana peel 94.39% (Legiso et al., 2019). From the results conducted (Wulandari, 2013) it is known that the percentage of the ability of kepok banana peel on the response to reduce the level of turbidity in river water is 57.85%. This is better than the purification without using kepok banana peel which shows a response of only 19.85%. Meanwhile, the percentage of kepok banana peel's ability to reduce Fe metal content in river water is 65.02%. This is better than the purification without using kepok banana peel which showed a response of only 28.11%.

Stated that zeolite filter media reduced Fe by 55% but only 40% of Mn in groundwater containing 3.6 mg/l Fe and 0.7 mg/l Mn, the optimum conditions for removing Fe and Mn were 30 minutes for contact time and 2 ml/minute for filtration rate (Hartono, 2004). While this research is about the effectiveness of the combination of zeolite filter media and activated carbon in reducing iron (Fe) and manganese (Mn) levels in well water at Perum Griya Fajar Gentan Baki Sukoharjo. From the research conducted using the coagulant of kepok banana peel ash, there was an increase in the content of turbidity substances when adding kepok banana peel ash to raw water. This can occur because the mass of water is heavier than the mass of kepok banana peel ash which makes the ash float on water which causes the water to become cloudier than before, but when filtration is carried out using clam shells and zeolites, the turbidity content decreases. In line with research that found that carbon size, mass and contact time of kepok banana peel activated carbon nanoparticles affect the effectiveness and capacity of adsorption (Elvida, 2021).

The coagulation of kepok banana peel ash has been effective in reducing Fe iron content but not turbidity, therefore the use of banana peel ash coagulation cannot be done without filtration, filtration can help to reduce turbidity content and filtration used is not only my clam shell and zeolite but can also use charcoal, sand and so on. Varied filter media and innovative methods can enhance filter performance effectiveness, as demonstrated by experiments testing the effectiveness of sand filter methods, which were proven to reduce turbidity levels by up to 100%. This is influenced by the distance between filter particles, elution

volume, water flow rate, different filter media, gravity, and pressure (Mangallo et al., 2023). The use of filtration is quite effective in reducing turbidity and organic substances. This occurs because of the ability of multi-media filters combined with the performance of microfiltration in rejecting molecules larger than the pore diameter of the membrane, while molecules with a diameter smaller than the membrane can pass through (Kaslum et al., 2019).

CONCLUSIONS

Based on the analysis of river water treatment using banana peel ash coagulant and shell filtration and zeolite to reduce the average iron (Fe) content from 2.21 mg/l to 0.25 mg/l, with 88.18% effectiveness. While the average decrease in turbidity levels from 57.67 NTU to 17.6 NTU, with an effectiveness of 65.56%. The results of the analysis found that there was a significant difference in iron (Fe) and turbidity levels in river water in Punggur Kecil Village before and after adding coagulant material of kepok banana peel ash and filtration of clam shells and zeolite, but this processing method was not effective in reducing the turbidity level of river water. Therefore, the findings suggested can be used as evaluation material in developing media and methods that are more appropriate for use in river water in Punggur Kecil Village.

SUGGESTION

Suggestions that can be given to the community of Punggur Kecil Village are expected to maintain the quality of river water by maintaining the filtering equipment so that it functions optimally to reduce iron (Fe) and turbidity levels. For future researchers to conduct further research by exploring combinations of coagulants or additional filtration methods that are more effective. In addition, regular water quality monitoring and collaboration with the local community can increase awareness and sustainability of water treatment.

REFERENCES

Abdi, C., Khair, R. M., & Saputra, D. M. W. (2015). Pemanfaatan Limbah Kulit Pisang Kepok (Musa acuminate L.) Sebagai Karbon Aktif Untuk Pengolahan Air Sumur Kota Banjabaru : Fedan Mn. *Jukung Jurnal Teknik Lingkungan*, *1*(1), 8–15. [Crossref], [Publisher]

Rahman, A., & Hartono, B. (2004). Penyaringan Air Tanah Dengan Zeolit Alami Untuk Menurunkan Kadar Besi dan Mangan. *MAKARA of Health Series* , *8*(1), 1-6. [Publisher]

Badan Pusat Statistik Provinsi Kalimantan Barat. (2017). *Persentase Rumah Tangga yang Memiliki Akses Terhadap Layanan Sumber Air Minum Layak menurut Kabupaten/ Kota (Persen)*. [Publisher]

Mangallo, B., Alfontus, R., & Lestari, A. D. N. (2023). Efektifitas Metode Sand Filter Dalam Menurunkan Tingkat Kekeruhan dan Kadar E.Coliform Pada Air Sumur. *Jurnal Natural*, *19*(1), 89–93. [Publisher]

Budiman, Hamidah, & Hasria. (2018). Limbah Kulit Pisang Kepok (Musa acuminate) Sebagai Biofilter Zat Besi (Fe) dan Zat Kapur (CaCO3). *PROMOTIF: Jurnal Kesehatan Masyarakat*, *8*(2), 152–158. [Crossref], [Publisher]

Castro, R. S. D., Caetano, L., Ferreira, G., Padilha, P. M., Saeki, M. J., Zara, L. F., Martines, M. A. U., & Castro, G. R. (2011). Banana Peel applied to the solid phase extraction of copper and lead from river water: Preconcentration of metal ions with a fruit waste. *Industrial and Engineering Chemistry Research*, *50*(6), 3446–3451. [Crossref], [Publisher]

Pratiwi, C. M., Kriswandana, F., & Wardoyo, I. R. E. (2022). Efektivitas Pistia Stratiotes L. Dan Echinodorus palaefoloius Dalam Penyerapan Ferrum (FE) Dalam Air Sumur Menggunakan Metode Fitoremediasi. *Gema Lingkungan Kesehatan*, *20*(2), 124–132. [Crossref], [Publisher]

Elvida, D. (2021). *Uji Efektivitas Nanopartikel Karbon Aktif Dari Kulit Pisang Kepok (Musa acuminata) Untuk Pengolahan Air Bersih*. (Skripsi Sajana Universitas Islam Negeri Ar-Raniry). [Publisher]

Prianti, D., C., Hadiantoro, S., & Prastijono. (2022). Pengaruh Penambahan PAC Terhadap Tingkat Kekeruhan Pada Proses Penjernihan Air Sungai di Perumda Delta Tirta-Sidoarjo. *Jurnal Polinema*, *2022*(3), 526–531. [Crossref], [Publisher]

Erwinsyah, Waryati, & Meicahayanti, I. (2018). Pemanfaatan Filter Dengan Media Arang Kulit Pisang Kepok Unruk Penuruanan Kadar Besi (Fe) dan Mangan (Mn) Air Danau Perumahan Kayu Manis. *Jurnal Ilmu Pengetahuan Dan Teknologi Sipil*. [Crossref], [Publisher]

Hanifah H.N., Hadisoebroto, G., Reswari, l.A., & Jenia A.V. do R.M. Neves. (2021). Perbandingan Efektivitas Pektin Kulit Durian (Durio zibethinus L.) dan Pektin Kulit Pisang Kepok (Musa acuminata X balbisiana ABB Group) Sebagai Bioadsorben Logam Timbal. *Chimica et Natura Acta*, *9*(2), 81–89. [Crossref], [Publisher]

Hanifah H.N., Hadisoebroto, G., Turyati, T., & Anggraeni, I.S. (2020). Efektivitas Biokoagulan Cangkang Telur Ayam Ras dan Kulit Pisang Kepok (Musa Balbisiana ABB) dalam Menurunkan Turbiditas, TDS, dan TSS dari Limbah Cair Industri Farmasi. *Al Kimiya: Jurnal Ilmu Kimia Dan Terapan*, *7*(1), 47–54. [Crossref], [Publisher]

Auliah I,N, Khambali, & Ernita Sari. (2019). Efektivitas Penurunan Kadar Besi (Fe) pada Air Sumur dengan Filtrasi Serbuk Cangkang Kerang Variasi Diameter Serbuk. *Jurnal Penelitian Kesehatan Suara Forikes*, *10*(1), 25–33. [Crossref], [Publisher]

Ismawati, R., Ngirfani, M. N., & Rinarni, A. (2018). Penurunan Kadar Besi Air Sumur Gali dengan Menggunakan Mn-Zeolit. *EduChemia (Jurnal Kimia Dan Pendidikan)*, *3*(2), 135. [Crossref], [Publisher]

Jalaly, & M Jauhari Hamidil. (2020). Eco Filter Air dengan Memanfaatkan Cangkang Kerang Darah (Anadara granosa) sebagai Media Filtrasi untuk Menurunkan Kekeruhan dan Kadar TSS (Total Suspended Solid). *Skripsi Sarjana Universitas Islam Indonesia*. [Publisher]

Dongoran J, Putri Sulistiawati, Sri Yulandari Simangunsong, Pandu Gizta Rapi Paksi, & Marvin Horale Pasaribu. (2021). Perkembangan Zeolit Sebagai Katalis Alam Potensial. *Jurnal Jejaring Matematika Dan Sains*, *3*(2), 28–39. [Publisher]

Kaslum, L., Anerasari, Ahmad Zikri, Yesi Tanjung, Yaya Oktaviana, Aulia A, Lismayani, & Arnida. (2019). Kinerja Sistem Filtrasi Dalam Menurunkan Kandungan TDS, Fe dan Organik Dalam Pengolahan Air Minum. *Jurnal Kinetika*, *10*(01), 46–49. [Publisher]

Kurniawan, P., Kasmiyatun, M., & Soebiyono. (2020). Reduksi Kandungan Logan Berat Fe Pada Air Sungai Jetis Salatiga Secara Adsrobsi Menggunakan Karbon Aktif. *Journal of Chemical Engineering*, *1*(1), 12-17. [Crossref], [Publisher]

Legiso, Heni Juniar, & Utari Maya Sari. (2019). Perbandingan Efektivitas Karbon Aktif Sekam Padi Dan Kulit Pisang Kepok Sebagai Adsorben Pada Pengolahan Air Sungai Enim. *Prosiding Semnastek*. [Publisher]

Safitri M, & Purnomo Y,S. (2023). Efektivitas Media Cangkang Kerang dalam Menurunkan Kadar Besi (Fe) dengan Metode Slow Sand Filter (SSF). *INSOLOGI: Jurnal Sains Dan Teknologi*, *2*(6), 1147–1154. [Crossref], [Publisher]

Al Kholif M., Putra, M.U.D., Sutrisno J, Sugito, Majid D, & Nurhayati I. (2024). Peningkatan Kualitas Air Bersih Gali Menggunakan Teknologi Filtrasi. *Jurnal Sains Dan Teknologi Lingkungan*, *16*(2), 38–53. [Crossref], [Publisher]

Humaira N. (2023). *Penurunan Parameter Logam Besi (Fe) dan Turbiditas pada Air Sumur Menggunakan Filter Bermedia Arang Aktif Sekam Padi dan Kulit Pisang Susu*. (Doctoral dissertation, UIN Ar-raniry). [Publisher]

Peraturan Menteri Kesehatan RI. (1990). *Peraturan Menteri Kesehatan RI Nomor 416/Menkes/Per/IX/1990 Tentang Syarat-syarat Dan Pengawasan Kualitas Air*. [Publisher]

Peraturan Menteri Kesehatan RI. (2010). *Peraturan Menteri Kesehatan Republik Indonesia Nomor 492/MENKES/Per/IV/2010 Tentang Persyaratan Kualitas Air Minum*. [Publisher]

Permenkes Ri No 32 Tahun 2017. (2017). Standar Baku Mutu Kesehatan Lingkungan dan Persyaratan Kesehatan Air Untuk Keperluan Higiene Sanitasi, Kolam Renang, Solus Per Aqua dan Permandian Umum. *Peraturan Menteri Kesehatan Republik Indonesia*. [Publisher]

Poniman, L. (2022). Analisis Adsorben Pengolahan Air Sungai Muara Lebung Menggunakan Karbon Aktif Sekam Padi dan Kulit Pisang Kepok. *Jurnal Redoks*, *7*(2), 1–7. [Crossref], [Publisher]

Putra, D. A., Suwarni, L., & Selviana, S. (2025). Pengolahan Air Bersih Sistem Filtrasi Menggunakan Tabung Filter FRP di Desa Tambatan. *Jurnal Ilmiah Manusia Dan Kesehatan*, *8*(1), 185–192. [Crossref], [Publisher]

Maliandra, M. R., Shatriadi, H., & Zairinayati, Z. (2016). Efektivitas Kulit Pisang Dalam Menurunkan Kekeruhan dan Kadaer Besi (Fe) Pada Air Sumur Gali. Masker Medika, *4*(2), 371-381. [Publisher]

Sappewali, S., Muke, C. M., Armus, R., & Aminah, S. (2024). Pengaruh Variasi Ketebalan Media Filtrasi Terhadap Penurunan Kadar Besi (Fe) Air Sumur Gali. *Jurnal Ilmu Alam Dan Lingkungan*, *15*, 33–42. [Crossref], [Publisher]

Saryati, Sutisna, Sumarjo, Wildan ZL, Wahyudianingsih, & Siti Suprapti. (2019). Komposit Tawas Arang Aktif Zeolit Untuk Memperbaiki Kualitas Air. *Indonesian Journal of Materials Science*, *4*, 9–15. [Crossref], [Publisher]

Siregar, S.M. (2009). Pemanfaatan Kulit Kerang Dan Resin Epoksi Terhadap Karakteristik Beton Polimer. *Medan: Tesis Universitas Sumatera Utara.* [Publisher]

Sisnayanti, Winoto, E., Yhopie, & Aprilyanti, S. (2021). Perbandingan Penggunaan Tawas dan PAC Terhadap kekeruhan dan PH Air Baku PDAM Tirta Musi Palembang. *Distilat Jurnal Teknologi Separasi*, *6*(2). [Crossref], [Publisher]

Wulandari. (2013). Pemanfaatan Kulit Pisang Kepok (Musa acuiminate balbisiana C) sebagai Media Penjernihan Air. *Skripsi Sarjana Politeknik Pertanian Negeri Samarinda.* [Crossref], [Publisher]