Horn banana peel powder biocoagulants in lowering the turbidity of water

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Abstract
Purpose: In response to contemporary global issues like pollution, global warming, and the loss of natural resources, the circular bioeconomy has been proposed. Using organic waste as a bioagulant facilitates the shift to a circular and sustainable bioeconomy. For homes that use well water that has been excavated, the concentration of chemical coagulants must be taken into consideration. The purpose of this study is to use banana peel powder as a biocoagulant to lower the turbidity level of water from a dug well.
Research methodology: The Paired Sample T-Test and the ANOVA test with Welsh correction were used to examine the average change in turbidity 0.000 <0.05 was the ρ value obtained.
Results: The Post Hoc Games-Howell test findings revealed a noteworthy distinction between the treatment groups. This study concludes that the biocoagulant made of powdered banana horn can lower turbidity to a level that satisfies health standards.
Keywords: *turbidity, biocoagulant, horn banana peel*
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1. Introduction

Circular bioeconomy solutions are being implemented in response to contemporary world concerns such as environmental degradation, global warming, and depletion of natural resources (Lizundia et al., 2022). One resource that is thought to be able to aid in the shift to a circular and sustainable bioeconomy is organic waste (Mahjoub & Domscheit, 2020). It is anticipated that global organic waste production will decrease between 2015 and 2050, from 47% to 39% (Chen et al., 2020). Between 44% and 75% of all garbage produced in Indonesian cities comes from households, making them the primary source of waste (Qonitan et al., 2021). Only 20% of waste is recycled in poor nations, when waste is deposited in open spaces for certain target products (Ashokkumar et al., 2022). Currently available methods for handling organic waste are landfilling, burning, composting, and feeding animals. Even though there are many trash disposal facilities spread out, they only account for 26% to 46% of organic waste, with the majority still being disposed of in landfills (Coma et al., 2017). Since it concentrates more on facilities than on resources consumed, it is uncommon to estimate the percentage of households that use groundwater relative to other water sources (Carrard et al., 2019). The amounts of chemical coagulants, such as alum or aluminum sulfate, must be closely watched in water treatment facilities because they have numerous drawbacks and pose a health risk to people (Krupińska, 2020; Zaidi et al., 2019).

A number of extensively used conventional techniques, including coagulation, flocculation, reverse osmosis, and activated carbon adsorption, have been used to remove pollutants from wastewater (Peck & Kian, 2017). Managing organic waste can be aided by treating wastewater with activated carbon derived from nearby organic waste (Shukla et al., 2020). Carbonized trash can potentially be utilized as a substitute fuel to generate energy (Kacprzak & Włodarczyk, 2023). Because organic coagulants do not harm the environment and produce less sludge than chemical coagulants, their use in wastewater treatment plants (WTPs) increases the usage of renewable energy sources (Diver et al., 2023). Renewable resources are promoted by the use of organic coagulants in wastewater treatment plants (IPAL) (Czerwionka et al., 2020). Chemical coagulants have a considerable impact on the pH of treated water; thus, it is advised to substitute coagulants composed of natural substances (Zaidi, 2019). In many underdeveloped nations, natural coagulants have shown to be successful in eliminating the color and turbidity of water. They can be utilized for environmentally responsible and sustainable water treatment (Halder, 2021). At the moment, organic waste can be used in low- and middle-income countries to create 39.6 The mixture is then agitated at 200 rpm for three minutes and at 40 rpm for twenty minutes, Next, a 60-minute observation contact period was completed, and Whatman No. filter paper was used for filtering. 42 x 110 mm, Measuring the water samples' turbidity at each dosage is the next stage (AP1 et al., 2018)million cubic meters of biogas or 135.000 tons of solid fuel annually; only a small portion of organic waste is converted into goods containing enzymes. (Ddiba et al., 2022; Pandyaswargo et al., 2019).

2. Literature Review

So far, limited organic waste is used in wastewater experiments as a biocoagulant. There are some biocoagulant studies of organic matter. The highest. Loss of ruggedness of 97.3% of the 90 mg/L sugarcane bagasse tested as a coagulant (Zaidi et al., 2019). Extracts such as those of fenugreek can achieve turbidity removal efficiencies as high as 98% as compared to 85% for alum (Diver et al., 2023). The results revealed that banana peels demonstrated the most effective turbidity removal at 70.78 % in relative to other fruit wastes, without optimization processes. Interestingly, after the bioflocculation treatment using banana peels, residual pH of the treated water was 6.73, which was very close to neutral pH at 7.0 and fall within the WHO recommended pH value for drinking water quality (6.5 – 8.5) (Peck & Kian, 2017). The use of organic coagulants contributed to 14–81% increase of pollutant removal efficiency (Czerwionka et al., 2020). The three screened natural products (Moringa oleifera seeds, Cactus opuntia and Carica papaya seeds) towards the treatment of raw water. Among them, Moringa oliefera seeds could be employed at industrial scale because of its efficacy in water treatment (Halder, 2021). Testing is done by soaking the adsorbent in waste liquid of batik for 80 minutes. Based on the test results, Chitosan adsorbent and banana peels can adsorb metal Cr as much as 69.8%. Comparison of optimum weight fraction for adsorbing metal Cr is 6:6. Chitosan and banana peels can adsorb metal Cr because they contain functional group of amino and carboxylic that are reactive to the metal ions (AP1 et al., 2018). The use of bio-coagulant Moringa oleifera seeds has shown a significant reduction in turbidity with a yield of 99.9% under optimal conditions: coagulant dose 2.5 ml, coagulation time 5 min, the coagulation speed 210.5 rpm, flocculation time 12.5 min and a flocculation speed 30 rpm (Madjene et al., 2023).

The treatment of synthetic wastewater using banana peel coagulant was found to be the most effective at pH 1 and dosage of 100 mg/l whereas the most effective solvent to extract this type of fruit waste is sodium hydroxide (NaOH) (Mokhtar et al., 2019). banana peel powder had an average particle size and diameter of 978 ± 37 nm and 602 ± 13 nm, respectively, while the modified powder possessed 571 ± 41 nm and 360 ± 19 nm particle size and diameter, respectively. The coagulation performance was investigated at different pH levels, doses, sedimentation times, and NaCl quantities. The optimum dose was found to be 0.4 g/L for modified banana peel with turbidity removal of up to 90%. NaCl slightly enhanced the coagulation performance at low quantities of less than 0.4 g/L, but the activity was reduced at higher concentrations even in the modified powder (Azamzam et al., 2022). Maximum turbidity reduction was found for highly turbid waters. After dosing, water-soluble extract of banana peel and lemon peel reduced turbidity from 38 to 5.2 NTU after dosing and filtration (Subashree et al., 2018). A mixture of organic coagulant doses of Moringa Oleifera doses 15 mg/L at pH 6 provides the best reduction efficiency for major physico-chemical parameters followed by Aloe Vera and Cactus in identical conditions (Muruganandam et al., 2017). Found that the hydroxyl, carboxyl, and amine groups and protein that exist in both biocoagulants and bioflocculants have played important roles in the coagulation and flocculation processes (Kurniawan et al., 2022).

In this study, a powder biocoagulant made of organic waste from banana horn skins was employed to lessen the roughness of well water. Strong bases and strong acids were used in several investigations to perform activation; nevertheless, these studies simply involved heating. The objective of this investigation was to employ basic biocoagulants at concentrations of 6 g/l, 7 g/l, and 8 g/L in order to enhance the physical quality of well water utilized by the general public in order to fulfill health regulations.

3. Research Methodology

3.1 Regional Studies

Digged wells at Sukodadi Village (-2.911243,104.672154),Sukarami District, Palembang City, provided the raw water for the research sample. The organic waste from horned banana peels, dug well water, a test jar (Lovibond Jar Tester Flocculator ET730), a turbidity meter Hach 2100Q, Whatman filter paper No. 42 Ø 110 mm, and an oven (Memmert Oven Laboratory Un 55 53L) were the materials and instruments utilized in the investigation (Putri, Mazni, & Suharto, 2021; Syarif, Rumengan, & Gunawan, 2021; Yahya & Yani, 2023).

3.2 Execution

After collecting samples of the well water to determine its turbidity level prior to treatment and samples of the well water that will be treated, small pieces of banana peels are used to prepare the organic waste, which is then dried for two hours at 250 ºC in an oven before being formed into ten mesh size (Murakonda & Dwivedi, 2021). The prepared dug well water sample is mixed with horn banana peel powder in doses of 6g, 7g, and 8g. The mixture is then agitated at 200 rpm for three minutes and at 40 rpm for twenty minutes, Next, a 60-minute observation contact period was completed, and Whatman No 42X110 mm filter paper was used for filtering. Measuring the water samples' turbidity at each dosage is the next stage (AP1 et al., 2018)**.**

3.3 Information Analysis

Using a pre-test and post-test control group research design, this kind of study is truly experimental. (Albay & Eisma, 2021; Madjene et al., 2023). The independent and dependent variables are the variables employed in this study. With a total sample size of 24 samples, the dependent variable is the degree of turbidity, and the independent variable is the fluctuation in the mass of hornet banana peel biocoagulant. One way ANOVA and paired sample t-test were employed in the data analysis. (Delacre et al., 2019; Manfei et al., 2017).

4. Results and Discussions

4.1 Reduced degree of turbidity

Turbidity is one of the physical characteristics that is frequently employed as a groundwater quality indicator (Liu et al., 2023). There has been extensive research on groundwater turbidity levels that are higher than the maximum allowable limit for drinking water. (Agyemang, 2023; Din et al., 2023). An optical property of water called turbidity gauges the water's relative clarity. Turbidity in water is typically related to suspended particles. (Bright et al., 2020; Karangoda & Nanayakkara, 2023). The average outcomes indicated in Table 1 were obtained after six repetitions of testing the turbidity levels in water samples treated with 6 g, 7 g, and 8 g of horn banana peel powder biocoagulant. Table 1 demonstrates that the average turbidity following treatment with banana peel powder biocoagulant was 21.17 NTU at a dose of 6 g, 10.68 NTU at a dose of 7 g, and 2.42 NTU at a dose of 8 g, compared to 159 NTU in the control. The highest level of reduction was observed in the percentage of turbidity level reduction for the 6 g dose (91.50%), 7 g dose (95.71%), and 8 g dose (99.03%). In conclusion, the degree of efficacy of horn banana peel powder as a biocoagulant in decreasing the turbidity of water from a dug well by 99.03%, specifically at a dose of 8 g. Turbidity is one of the physical characteristics that is frequently employed as a groundwater quality indicator (Liu et al., 2023). There has been extensive research on groundwater turbidity levels that are higher than the maximum allowable limit for drinking water. (Agyemang, 2023; Din et al., 2023). An optical property of water called turbidity gauges the water's relative clarity. Turbidity in water is typically related to suspended particles. (Bright et al., 2020; Karangoda & Nanayakkara, 2023).

Table 1. Using horn banana peel biocoagulant to lower turbidity levels in well water

Recurrence	Turbidity Prior to Intervention (NTU)	Turbidity After Intervention (NTU)							
		Dosage 6 g	Diminished (%)	Dosage 7 g	Diminished (%)	Dosage 8 g	Diminished (%)	Control	Diminished (%)
1	249	22.20	91.08	10.97	95.59	2.67	98.93	168	32.53
2		22.20	91.08	10.85	95.64	2.65	98.94	162	34.94
3		21.00	91.57	10.75	95.68	2.46	99.01	160	35.74
4		20.80	91.65	10.65	95.72	2.46	99.01	158	36.55
5		20.60	91.73	10.45	95.80	2.33	99.06	157	36.95
6		20.20	91.89	10.40	95.82	1.92	99.23	148	40.56
Average		21.17	91.50	10.68	95.71	2.42	99.03	159	36.21

Source: Primary research data

4.2 Test for Turbidity Level Statistically

Following that, statistical tests were conducted using the research data to ascertain the impact of each dosage of banana horn powder biocoagulant on variations in the turbidity level of dug well water. The test findings for each treatment dose's average turbidity level will be shown in the Paired Sample T-Test results, as indicated in table 2.

Table 2. Paired Sample T-Test Results

No.	Treatment Dosage (g)	t	Sig. (2 tailed)
1.	6	379	0.000
2.	7	983	0.000
3.	8	503	0.000
4.	Control	32	0.000

Source: Processed data by SPSS

Table 2 displays the sig (2-tailed) value for each treatment and control dose; the ρ value is 0.000 < 0.05, indicating that Ho is rejected and Ha is accepted. This indicates that the average change in turbidity in the water samples from the drilled well before and after delivery differs significantly biocoagulant powder made from banana peels Three weights: six, seven, and eight grams. The data test results were normally distributed, but the data was not homogenous, thus an ANOVA with Welsh correction was performed. This was followed by a dose comparison analysis test. The outcomes are displayed in table 3 and 4 below.

Tabel 3. *One Way Anova* Results

Uji Statistik	Sig
Anova	0,000

Source: Processed data by SPSS

Table 4. Results *Welch* analysis

Uji Statistik	Statistic^a	df1	df2	Sig
Welch	2342,388	3	10.081	0,000

Source: Processed data by SPSS

Given the biocoagulant dose of 6 g, 7 g, and 8 g of horn banana peel powder, and the ANOVA test and Welsh correction, the p-value = 0.000 < 0.05 indicating that Ho is rejected and Ha is accepted, it can be concluded that there is a difference in the average change in turbidity in the dug well water samples. The post hoc games-Howell test was then used to continue the testing in order to identify any significant changes between treatment groups. The Games-Howell test was employed as an additional post hoc analysis because the homogeneity test results indicated that the variances were not the same. Table 5 below displays the test results:

Table 5. *Post Hoc Games-Howell* Results additional tests

Treatment Dosage (g)	**Average Difference**	**95% Confidence Interval**		**Sig.**
		Min	**Max**	
6 vs 7	10,49	9,24	11,74	0,000
6 vs 8	18,75	17,50	20,00	0,000
7 vs 8	8,26	7,82	8,71	0,000

Source: Processed data by SPSS

Table 5 demonstrates that, as demonstrated by a ρ value of 0.000 < α 0.05, there is a significant difference in the average change in turbidity in excavated well water samples given a biocoagulant dose of 6 g of horn banana peel powder and 7 g of biocoagulant. A ρ value of 0.000 < α 0.05 indicates a significant difference between the doses of 6 g and 8 g, while a ρ value of 0.000 < α 0.05 indicates a significant difference between the doses of 7 g and 8 g.

There are notable variations between the treatment groups, according to the Post Hoc Games-Howell additional test results.

4.3 Discussion

Turbidity is one of the physical characteristics that is frequently employed as a groundwater quality indicator (Liu et al., 2023). There has been extensive research on groundwater turbidity levels that are higher than the maximum allowable limit for drinking water. (Agyemang, 2023; Din et al., 2023). An optical property of water called turbidity gauges the water's relative clarity. Turbidity in water is typically related to suspended particles. (Bright et al., 2020; Karangoda & Nanayakkara, 2023). There is a noteworthy positive association ($p < 0.05$) between turbidity and various heavy metal types, including Fe, Mn, and Cr. As a result, management techniques are required to reduce the amount of groundwater that is used in areas with high turbidity concentrations. These tactics may include educating the public about accessible, low-cost technologies and/or taking into account the availability of pipe network services for clean water (Fahimah et al., 2023). A number of things, including poorly constructed buildings, their proximity to pollution sources, and marsh embankments, can contribute to the turbidity of the water from the dug well sampled. Prior to treatment, laboratory testing revealed that the turbidity level of the water from the excavated well in Sukodadi Village, Sukarami District, Palembang City, was 249 NTU. This turbidity surpasses the established water quality requirement for sanitation and hygiene, which is < 3 NTU based on the Republic of Indonesia Number 2 of 2023's Minister of Health (Indonesia, 2023).

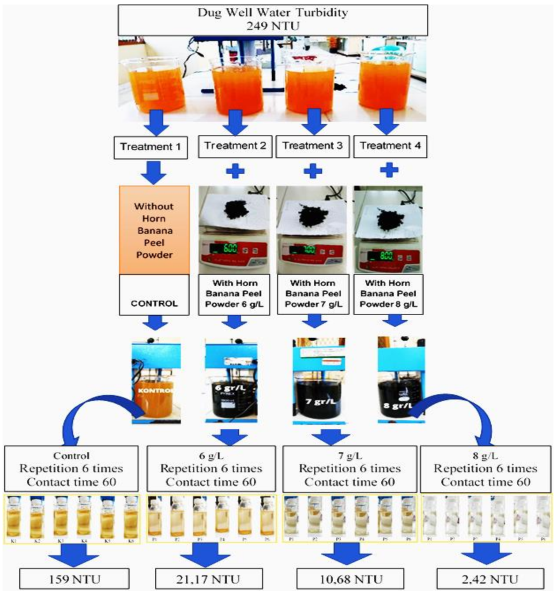

Figure 1: Outcomes of treatment with per-dose and control biocoagulants

The organic waste from horn banana peels was utilized in this study as an alternate source of natural biocoagulant materials for residual activities in the homes, markets, and merchants (MSMEs) that produce horn bananas, a popular snack item. Six grams, seven grams, and eight grams of horn banana peel powder are used to lower the turbidity of well water that has been excavated. The value (ρ value 0.000 < 0.05) indicates that there is a substantial influence and difference in each dose in lowering the turbidity level of excavated well water before and after processing, according to the research findings. The average turbidity was able to be reduced by 91.50% with an average turbidity of 21.17 NTU when horn banana peel powder biocoagulant was used at a dose of 6 g/L, 95.71% with an average turbidity of 10.68 NTU when a dose of 7 g/L was used, and 99.03% with an average reduction in turbidity of 2.42 NTU when a dose of 8 g/L was used. It satisfies the clean water quality standards for hygiene and sanitation purposes, which are < 3 NTU based on the Minister of Health of the Republic of Indonesia Regulation Number 2 of 2023, and has the maximum reduction in turbidity when compared to other treatment doses at 8 g/L (Indonesia, 2023). This study supports a number of investigations on biocoagulants made from different organic materials that are chemically activated (NaCl) to reduce water turbidity by 78.5% to 99.74% (Halder, 2021). Research has shown that using biocoagulants made from banana peels activated with other chemicals (NaCl), wastewater turbidity can be reduced by up to 88% (Mokhtar et al., 2019). Similar studies have shown that coagulation performance can reduce turbidity by up to 90% at various pH levels, dosages, sedimentation periods, and NaCl amounts. The ideal dose for banana peels activated with NaCl is 0.4 g/L. At low concentrations of less than 0.4 g/L, NaCl somewhat enhanced the coagulation performance; however, even in the modified powder, the activity decreased at larger concentrations. In river water, banana peel powder has lower capacities of 76 and 84% for unmodified and modified powder, respectively. It also significantly reduces total soluble solids, BOD, and COD (Azamzam et al., 2022). According to other studies, turbidity and BOD in water can be considerably decreased from 38 to 5.2 NTU by using naturally occurring coagulants that are readily available locally, such as extracts from lemon and banana peels (Subashree et al., 2018). In river water, banana peel powder dramatically lowers the chemical and biochemical oxygen demand, total dissolved solids, and water color, but only significantly lowers For the unmodified and modeled powders, the turbidity was 75% and 83%, respectively. SEM and FT-IR spectroscopy were used to study and validate the coagulation process. This modified banana peel powder is safe for the environment and has a lot of potential as an affordable bio-coagulant that can help cut down on waste (Dharsana & Jose, 2023). It is more cost-effective and less environmentally harmful to employ natural materials than synthetic organic polymers and inorganic chemical goods. One thing that can be done is to utilize "green" chemicals in place of the chemicals that are used in the procedure.

Water can be coagulated using a variety of plant- or organic-based natural coagulants, including Carica papaya, Cactus Opuntia, and Moringa Oleifera seeds. Numerous well-reviewed research have demonstrated the efficacy of this plant-based natural coagulant in a range of water treatment procedures (Muruganandam et al., 2017). Coagulation is the process that modifies colloids in water to make them adhere to one another. Positive ions are given to the water during coagulation to lower the charge until the colloids no longer oppose one another. Chemicals known as coagulants are added to water in order to cause coagulation. Coagulants have these three primary characteristics:1. Because water molecules have a negative charge, cations are required to balance this charge. The most effective cations are trivalent ones. 2. The coagulants used in the manufacturing of safe water must not be poisonous. 3. In order to prevent large ion concentrations from remaining in the water, the additional coagulant needs to settle insoluble in neutral pH. (Halder, 2021). Unique properties of biocoagulants and bioflocculants aid in the coagulation and flocculation processes. The active ingredients of biocoagulants and bioflocculants differ depending on how they function, such as charge neutralization, adsorption, bridging, sweep coagulation, and patch flocculation (Kurniawan et al., 2022). The process of flocculation, which turns microscopic particles into giant floc particles that settle in sediment, is how coagulant is effectively dosed to lower sample turbidity. This is measured using a jar test (Bodlund, 2013).

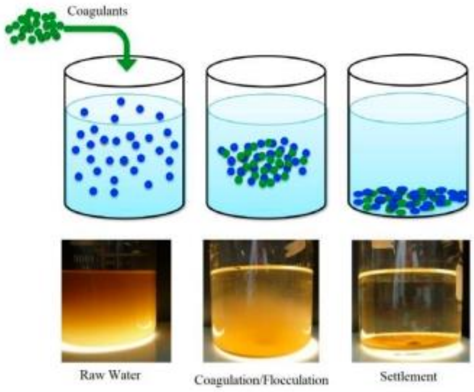

Figure 2: Mechanism of Coagulation and Flocculation (Bodlund, 2013)

The protein content of fruit waste is the primary factor contributing to the effectiveness of banana peel coagulants. This is due to the fact that a polymer's chain lengthens with increasing molecular weight. As a result, the particles will experience a greater coagulation process, revealing the adsorption mechanism. The attraction of positive charges on amino acids in protein molecules is enhanced in acidic wastewater conditions. Its capacity to enhance and affect the functionality of molecules that serve as effective coagulant agents [28]. Depending on the pH level, the charge on the protein itself causes varying reductions in turbidity, particularly as the pH rises. It is thought that when the positive and negative charges of various amino acids in the protein rise, the coagulant's net cationic potential for the coagulation process diminishes. Thus, this phenomena has a major impact on the decrease in water turbidity. (Zurina et al., 2014). This study has the advantage of offering scientific evidence for the use of horn banana peels, an organic waste or material, as a biocoagulant. This biocoagulant can lower the turbidity of well water that has been dug, and it is simple to make because it doesn't require a lot of chemical activation (strong bases and acids). via oven drying.

5. Conclusion

This study find that the biocoagulant of banana horn skin powder is able to reduce the roughness of well water by up to 99.03% (average 2.42 NTU from previous 249 NTUs) by adding 8 g/L ensuring that well water meets health standards. This biocoagulant is beneficial to people who use well water because it's easy to make and the material is easy to obtain. This research forms the basis for replacing the use of chemical coagulants in water treatment processes to support bioeconomics and circulation.

5.1 Limitation/s and study forward

The unstudied aspect is how the use of this biocoagulant affects changes in the pH of water and other physical parameters. This requires further research on groundwater sources that have high hardness and acidity by analysing not only changes in turbidity or pH but also other parameters such as TSS, TDS and BOD.

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