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DECREASING THE LEVEL OF WATER TURBIDITY OF THE BENGAWAN SOLO RIVER USING THE JAR TEST METHOD WITH COAGULANTS AL2(SO4)3 AND CA(OH)2

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Abstract

Water is a compound composed of hydrogen (H_2) and oxygen (O_2), with turbidity caused by suspended particles such as clay and sewage. This study aims to reduce the turbidity of the Bengawan Solo River using the jar test method with pre-sedimentation and no pre-sedimentation treatment. The conclusions obtained show that the turbidity of the water of the Bengawan Solo River can be significantly reduced through the pre-sedimentation method with the use of the main coagulant $Al_2(SO_4)_3$ at a concentration of 10,000 ppm. The best results were achieved under sample conditions with a concentration of 60 ppm, where the initial turbidity of 30.3 NTU was successfully suppressed to only 0.1 NTU. In addition, the relatively small change in pH from 6.10 to 6.07 indicates that this process does not significantly affect the acidity level of the water. This method is effective in reducing turbidity and has the potential to be applied in large-scale water treatment.

Keywords: Water, Turbidity, Pre-sedimentation

Introduction

Water is a natural resource that is very important for human life and environmental sustainability. The need for clean and usable water continues to increase in line with population growth and human activities. However, the availability of clean water is increasingly threatened by pollution, especially in watersheds that are the center of domestic, agricultural, and industrial activities (Kodoatie & Sjarief, 2017). The Bengawan Solo River, the longest river on the island of Java, has an important role in supplying water for various community needs. Unfortunately, the quality of this river water continues to decline due to the high level of pollution from domestic, agricultural, and industrial wastewater (Surya, Purwanto, Yanuar, Sapei, & Widiatmaka, 2015), (Wardhana, 2020).

One of the biggest problems faced by Bengawan Solo is the high level of turbidity. Turbidity is caused by suspended particles such as sediment, organic matter, and other micro-pollutants. This condition not only affects water quality but also poses serious problems in treating water to make it suitable for consumption (Kaslum et al., 2021). High levels of turbidity can reduce the potential ability of river ecosystems to support biodiversity (Andini, R., Setiawan, T., & Kurniawan, 2020). This decline in water quality can directly have an impact on public health and the performance of the industrial sector that uses water from rivers (Marselina, Wibowo, & Mushfiroh, 2022). In addition, poor water quality also has an impact on the economy, which can lead to an increase in the cost of water treatment to become clean water that must be borne by clean water providers (Susanto, 2021).

To overcome this problem, efficient water treatment technology is needed. One of the widely used methods is the coagulation-flocculation process. This process uses chemical coagulants to separate the suspended particles, so that the water becomes cleaner. Aluminum sulfate (Al2(SO4)3) and calcium hydroxide (Ca(OH)2) are effective coagulants to reduce water turbidity at a relatively low cost (Armus et al., 2022). The jar test method is used to determine the optimal dose of coagulant so that the water treatment process is effective (Lestari, 2019) (Simbolon et al., 2021).

This study focuses on the use of a combination of Al2(SO4)3 and Ca(OH)2 to reduce water turbidity in the Bengawan Solo River (Solin, 2022). This approach is expected to provide practical and applicable solutions for river water quality management and become a benchmark for the development of water treatment technology in Indonesia (Absori, Hernanda, Azhari, Wardiono, & Budiono, 2023). In addition, this study also aims to support efforts to improve environmental management in line with the Sustainable Development Goals (SDGs), including Goal 6 on safe access to drinking water and sanitation (WHO, 2020 The role of the community in maintaining river sustainability through household waste management and participation in conservation activities is also very important to support long-term sustainability (Yunus, Therefore, this research not only contributes to the development of technology but also raises awareness of the importance of maintaining water quality for a sustainable future (Rahmawati, T., Haryono, P., & Kusuma, 2023).

Research Methods

Lowering the level of water tubidity can be done by chemical water treatment methods that involve the help of coagulants. Chemically, this water treatment is carried out in three stages, namely coagulation, flocculation, and sedimentation. Coagulation is the stage of adding a certain volume of coagulant needed to a water sample and then stirring it using a test jar of 100 rpm for 1 minute. Flocculation is the next stage of stirring using a jar test of 30 rpm for 15 minutes. Sedimentation is the deposition of impurity particles in a water sample for 1 hour. To determine the parameters of test success, pH and turbidity testing of water samples was carried out between before and after treatment. pH testing is carried out using a pH meter and turbidity testing using a turbidity meter as shown in figure 1.

Figure 1 Turbidity Meter

The type of coagulant used is $Al2(SO4)_3$ (Mr 666 grams/mol) with a concentration of 10,000 ppm (ppm p) as the main coagulant. $Ca(OH)_2$ (Mr 74 grams/mol) with a concentration of 5,000 ppm (ppm r) as an auxiliary coagulant. In addition, there is an additional treatment in the form of pre-sedimentation for 30 minutes. To determine the effect of the main coagulant dose, variations were carried out in the form of concentrations. In this case, the sample used was the water of the Bengawan Solo River which was taken on October 15, 2022. The following is equation (1) to determine the dose of the main coagulant while equation (2) is used to determine the dose of the auxiliary coagulant against the variation in concentration.

$$V_p = \frac{V_q \times ppm_q}{ppm_p} \quad (1)$$

$$V_r = \frac{V_q \times ppm_q \times 3 \times Mr\ Al_2(SO_4)_3}{ppm_r \times Mr\ Ca(OH)_2} \quad (2)$$

Results and Discussion

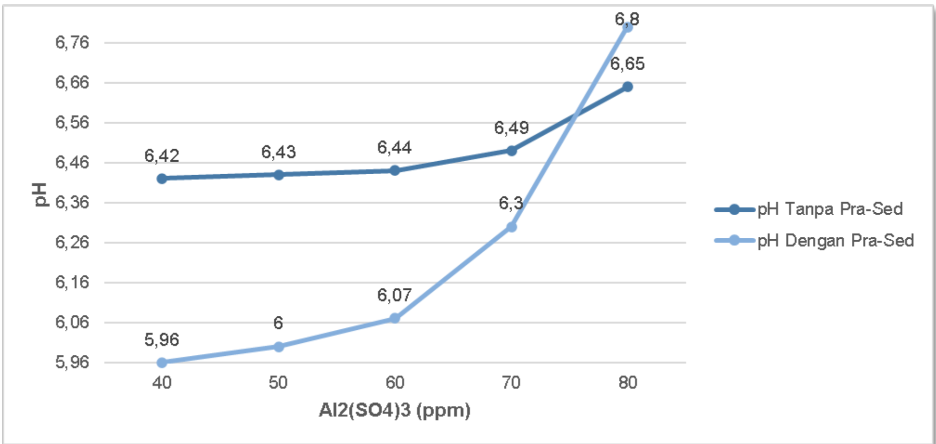
Table 1: Main Coagulant Test Results $Al2(SO4)_3$ 10,000 ppm

Treatment	It	$Al2(SO4)_3$ (ppm)	Ph		Turbidity (NTU)	
			Beginning	End	Beginning	End
No Pre-Sedimentation	1	40	6,11	6,42	55,8	1,2
	2	50	6,13	6,43	56,4	1,8
	3	60	6,10	6,44	54,9	1,7
	4	70	6,16	6,49	53,6	0,9
	5	80	6,09	6,65	54,7	0,4
With Pre-Sedimentation	1	40	6,08	5,96	30,7	0,1
	2	50	6,11	6,00	29,9	1,9
	3	60	6,10	6,07	30,3	0,1
	4	70	6,14	6,30	28,5	1,1
	5	80	6,17	6,80	31,4	0,6

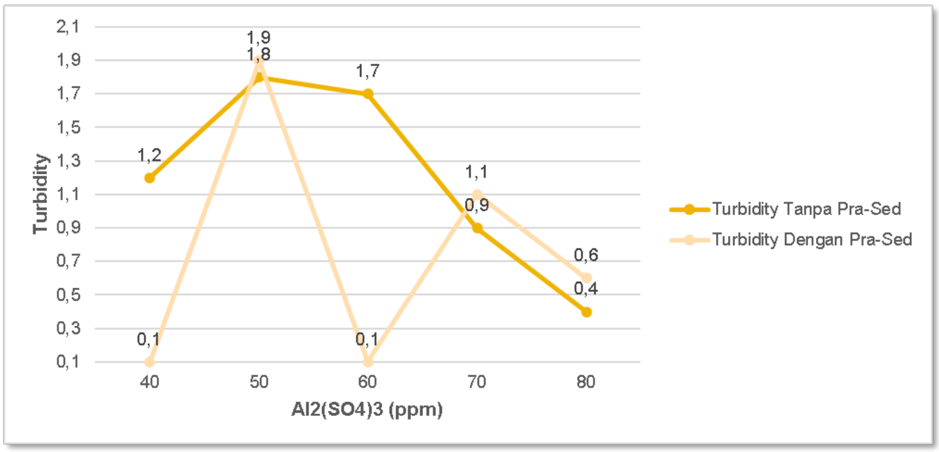
Table 2: Test Results of Al2(SO4)3 Main Coagulant 10,000 ppm and Ca(OH)2 Auxiliary Coagulant 5,000 ppm

Treatment	It	$Al_2(SO_4)_3$ (ppm)	Ph Beginning	Ph End	Turbidity (NTU) Beginning	Turbidity (NTU) End
No Pre-Sedimentation	1	40	6,11	7,80	55,8	9,0
	2	50	6,13	8,06	56,4	7,0
	3	60	6,10	8,13	54,9	6,9
	4	70	6,16	8,17	53,6	4,7
	5	80	6,09	8,21	54,7	6,0
With Pre-Sedimentation	1	40	6,08	7,78	30,7	6,0
	2	50	6,11	8,02	29,9	5,7
	3	60	6,10	8,18	30,3	5,5
	4	70	6,14	8,21	28,5	4,9
	5	80	6,17	8,24	31,4	4,5

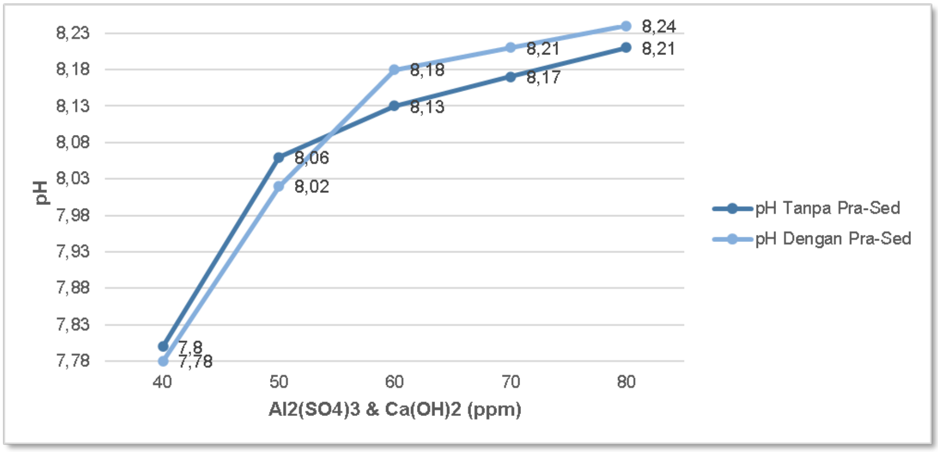
Graph 1: Final pH of Al2(SO4)3 Main Coagulant Test Results 10,000 ppm



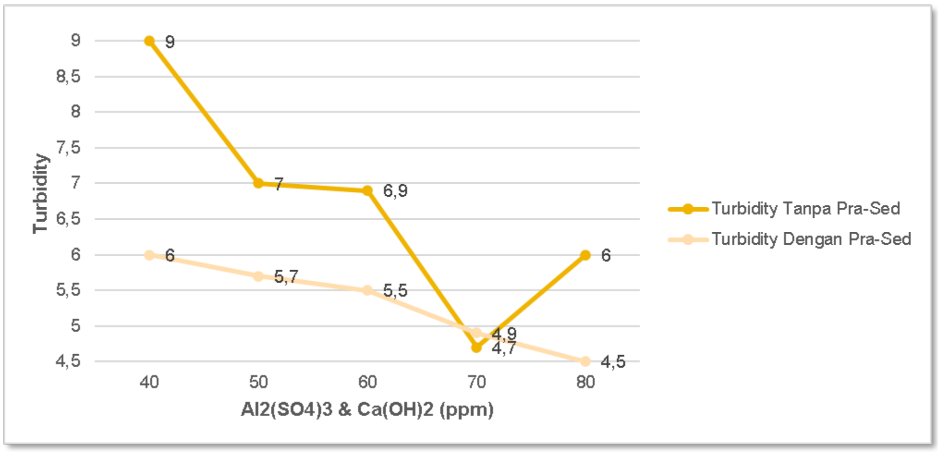
Graph 2: Final Turbidity of Al2(SO4)3 Main Coagulant Test Results 10,000 ppm



Graph 3: Final pH of Al2(SO4)3 Primary Coagulant Test Results 10,000 ppm and Ca(OH)2 Auxiliary Coagulant 5,000 ppm



Graph 4: Final Turbidity of Al2(SO4)3 Primary Coagulant Test Results 10,000 ppm and Ca(OH)2 Auxiliary Coagulant 5,000 ppm



Discussion

Water can be interpreted as a compound composed of two elements, namely the element H2 with the element O2 which then produces water compounds. Water is said to be cloudy if it contains a lot of suspended substance particles so that it gives a cloudy, dirty, and smelly color/appearance. Substances that cause turbidity include clay, waste, and organic matter dispersed from small suspended particles. Water treatment is necessary to obtain water that is free from suspended solids and meets water quality standards. Coagulation is a water treatment process in which suspended solids and very small colloids combine and form flocs by adding chemicals called coagulants. Coagulants are needed to aid in the coagulation and sedimentation process of small particles that cannot be resolved by gravity.

The test to reduce the water turbidity of the Bengawan Solo River was carried out using the jar test method. The jar test in figure 2 is a test method to determine the ability of a coagulant and determine the optimal operating conditions in the water and wastewater purification process. This test can be used to determine the exact type and dosage of coagulant in the water treatment being tested. The first test was carried out by treating two treatments, namely with pre-sedimentation and without pre-sedimentation. Pre-sedimentation is a preliminary deposition that serves to separate suspended objects consisting of coarse sand, fine sand and very fine mud from the sample water. The difference in treatment resulted in a difference in the turbidity value of the sample water tested, namely without pre-sedimentation the average turbidity value was found to be 55.08 NTU and with pre-sedimentation the average turbidity value was found to be 30.16 NTU. This is because pre-sedimentation can precipitate the suspension in the sample water so that the turbidity is reduced. Then the value of the degree of acidity in each treatment was measured. It was found that the average pH value obtained in the treatment without pre-sedimentation was 6.12 and the average pH value obtained in the treatment with pre-sedimentation was 6.12. The results obtained were relatively close or more or less the same because the two test samples had not been given any coagulants.

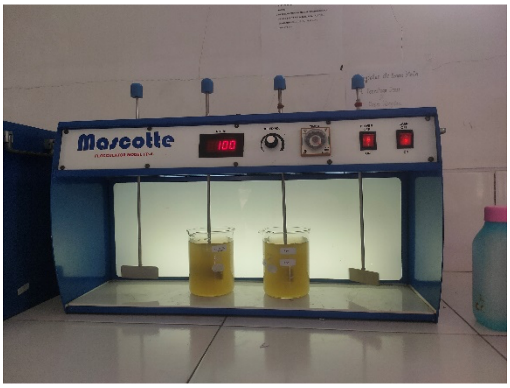


Figure 2 Coagulation and Flocculation Test Suit Method

The water sample of the Bengawan Solo River used for each treatment was as much as 500 mL with a variation in concentration. By using equation (1), the dosage of the main coagulant can be determined into the sample. For samples to which the helper coagulant is added, the amount of dose required can be calculated through equation (2). In the coagulation process, there is a clumping of colloidal particles due to the addition of the main coagulant so that the particles are neutral. The purpose of slow stirring is to produce slow water movement so that there is contact between particles to form a combination of larger particles. Then the speed is slowly lowered to produce a good floc and not break again and has the opportunity to combine with others to form a larger fusion through the flocculation process. The water sample is left for 1 hour to go through the sedimentation process as shown in figure 4. This process can be observed with particles moving down to form a deposit at the bottom of the glass due to the influence of Earth's gravity. Then the turbidity value and pH value are measured again using a turbidity meter and pH meter as shown in figure 3.

Figure 3 pH Testing Using a pH Meter

The test results are classified based on the type of coagulant used, namely only the main coagulant shown in table 1 and the main and auxiliary coagulants shown in table 2. The results obtained in graph 1 show that the higher the concentration of the water sample, the pH of the water sample will increase. This should cause the pH to drop further because SO42 sulfate ions from the ionized primary coagulant can cause the atmosphere of the water sample to become more acidic. However, this increase is quite low so it can be assumed that the pH meter device varies in reading water samples or it can be ignored. As for the results obtained in graph 2, it shows that with a higher sample concentration, the pH of the water sample will also increase, the presence of SO42 sulfate ions - from the main ionized coagulant. In addition, it is accompanied by an increase in OH- ions due to the addition of auxiliary coagulant doses. Therefore, the addition of primary coagulants and auxiliary coagulants can affect the pH value of water samples.

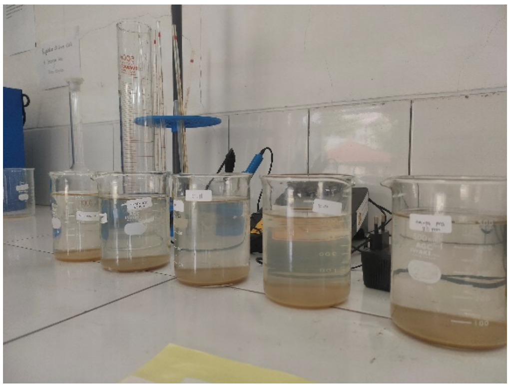


Figure 4 Sedimentation Process

In the turbidity aspect generated for all experiments, there are fluctuating changes as shown in Graphs 3 and 4. This is because the auxiliary coagulant $Ca(OH)_2$ is ionized into Ca2+ and OH^-. Then the Ca2+ cation reflected in the solution turns into a precipitate which causes the water sample to become more cloudy or the turbidity value increases. Meanwhile, the OH- anion will affect the increase in the similarity value or pH. For the effect of the main coagulant Al2(SO4)$_3$ is ionized into Al3+ and SO42-. Then the Al3+ cation reflected in the solution also turns into a precipitate which causes the water sample to become more cloudy or the turbidity value increases. Meanwhile, the SO42- anion will also affect the increase in the similarity value or pH. Therefore, the addition of primary coagulants and auxiliary coagulants can affect the turbidity value of water samples.

From the overall test carried out, it is interpreted that when more types of coagulants are used in water samples, more deposits will be shown. This is because more and more cations will react with the impurity micron particles in the water sample. That will cause the water sample to become dirtier and cloudy, which will lead to an increase in the value of the tubidity. As shown in the final results, table 2 has a higher tubidity value than table 1. From table 1, it was found that the water samples with the lowest tubidity values were samples with pre-sedimentation treatment of 40 ppm and 60 ppm. Compared to this treatment without pre-sedimentation, it shows that the initial precipitation on the sample affects the final tubidity value of the water sample. This is because the impurity particles in the water sample have initially been precipitated compared to the treatment without pre-sedimentation so that the same dose and type of coagulant have a lower final turbidity value. Based on the pH value from the test of table 1 which is closest to the safe limit of water for the environment (pH=7.0) was found in a water sample with a concentration of 60 ppm, which is 6.07. When compared to water samples with a concentration of 40 ppm, which is 5.96, it is more acidic.

Conclusion

The conclusions obtained show that the turbidity of the water of the Bengawan Solo River can be significantly reduced through the pre-sedimentation method with the use of the main coagulant $Al_2(SO_4)_3$ at a concentration of 10,000 ppm. The best results were achieved under sample conditions with a concentration of 60 ppm, where the initial turbidity of 30.3 NTU was successfully suppressed to only 0.1 NTU. In addition, the relatively small change in pH from 6.10 to 6.07 indicates that this process does not significantly affect the acidity level of the water. This indicates that this method is very effective in lowering water turbidity while maintaining pH stability, so that it has the potential to be applied in the water treatment of the Bengawan Solo River practically and efficiently.

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