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Research Paper

The Effect of pH Variations and Aluminum Sulfate Coagulant Dosage on Reducing Turbidity in Salupangkang Tua River Water

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Abstract: This research was carried out using coagulation and flocculation methods. By using a varying pH series, namely 1 - 14 and also varying coagulant doses, namely 10 ppm, 20 ppm, 30 ppm and 40 ppm. The solution whose pH has been adjusted is then stirred using a flocculator with the addition of a coagulant for fast stirring at 100 rpm for 3 minutes, then a flocculant is added for slow stirring at 30 rpm for 3 minutes. After stirring, the turbidity of the solution was measured using a turbidimeter. The research show that pH and coagulant dosage parameters significantly influence the coagulation and flocculation process in water treatment at palm oil mills. The results indicated that the optimal pH for coagulation using aluminum sulfate ($Al_2(SO_4)_3$) is 7, with an effective coagulant dosage ranging from 30 ppm.

Keywords: coagulation, flocculation, jar test, pH variation, turbidity.

1. Introduction

Water is a universal need. Most living creatures need water to support their life. The need for clean water increases along with population growth. The condition of clean water is greatly influenced by human activities both on a household and industrial scale. Water sources commonly used by Clean Water Treatment Plants to process raw water into clean water are springs, river water, shallow wells and deep wells. Conventional physicochemical methods commonly used for clean water treatment are coagulation/flocculation and sedimentation [1].

The water around us is very useful for life. In the industrial world, most of the materials needed are water. Water is vitally needed because the properties and characteristics of water are very supportive for chemical processes. Clean water is a type of water-based resource that is of good quality and can be used by humans. To consume water you need a health agency and also water requirements as a reference. Because there is a risk of Escherichia coli bacteria contamination even if cooked to a temperature of 100 °C. Many dangerous substances, especially metals, are found in this quality. Various requirements and standards form a single unit that must be fulfilled as a whole. So if one condition is not met, a decision can be made that the water is not suitable for consumption. Based on Minister of Health Regulation number 32 of 2017, environmental health quality standards for sanitation hygiene needs include physical, biological and chemical parameters. Physical parameters include turbidity, TDS, temperature, taste and odor. Meanwhile, chemical parameters include pH, Fe and Mn metal levels [2].

The coagulation process is the process of collecting turbidity-forming particles that cannot be deposited by gravity, into larger particles that can be deposited by administering coagulant chemicals. This is then followed by the flocculation process, where the floc particles form larger particles through a stirring process so that floc binding is more optimal. The purpose of flocculation is to form particles of larger size and heavier mass so that the solid can be separated from the liquid by settling. The merging of small flocs into large flocs occurs due to collisions between flocs. This collision occurs due to slow stirring [3].

There are many types of coagulants that can be used, one of which is aluminum sulfate ($Al_2(SO_4)_3$). Aluminum sulfate can be obtained in solid or liquid form. The process of processing river water by adding alum coagulant is based on the ability of alum to form floc nuclei which can bind metal ions in river water in an alkaline environment [3]. Aluminum sulfate ($Al_2(SO_4)_3$) showed limited effectiveness in reducing pollutants, particularly in removing organic compounds and heavy metals, compared to other aluminum-based coagulants. Its treatment effect was weaker than that of modified polyaluminium chloride ($PAX_{19}XL$) in wastewater treatment [4-5].

Based on research conducted by Widya [6], the maximum coagulant dose is found in concentration 55 ppm using aluminum sulfate, 40 ppm using lime, and 50 ppm using 50 ppm chlorine. This dosage showed the best quality at pH 6.83 with a decrease in turbidity from 73.30 NTU to 2.1 NTU. Using variations in the aluminum sulfate coagulant dosage of 65 ppm, 50 ppm using lime, and 50 ppm using chlorine can reduce the turbidity value to 0.9 NTU. This shows that increasing the coagulant dose can increase the value of reducing turbidity. This also happened in research conducted by Hidayati [5] which stated that increasing the coagulant dose could increase the efficiency of reducing turbidity. Excessive coagulant doses can increase the turbidity value again due to restabilization.

Aluminum sulfate coagulant has high efficiency in reducing pollutants. While aluminum sulfate is effective, its performance can be enhanced when used in combination with other coagulants or polymers, suggesting that further research into composite coagulants may yield even better results in pollutant reduction. Aluminum sulfate (ALS) achieves 95-99% removal of particles, turbidity, and phosphates when combined with high molecular weight organic polymers, significantly enhancing treatment efficiency while reducing ALS usage by 40%, thus demonstrating high efficiency in reducing pollutants [7].

The study demonstrated that aluminum sulfate (Al2(SO4)3) treatment effectively eliminated various pollutants from a highly polluted water source, showing significant reductions in most physicochemical parameters after treatment, thus confirming its high efficiency in reducing pollutants. Research conducted by Rachmawati [6] Coagulation with alum at high turbidity, where an optimum pH of 6 occurred at a coagulant dose of 2 mg/L alum, while with a dose of 15 mg/L a wider optimum pH was obtained, namely between 6-7. This also occurs with ferric chloride coagulants, increasing the coagulant dose appears to widen the operating pH range [8]. The effectiveness of Al2(SO4)3 is sensitive to pH variations, particularly between pH 7 to 10, affecting floc properties and settling performance [7]. Optimal pH levels enhance the coagulation mechanism, primarily through charge neutralization [8].

Research carried out by increasing the dose of coagulant can cause an increase in precipitates which is followed by an increase in the frequency of collisions between particles so that larger flocs can be formed. This research was conducted to analyze the effect of pH and Aluminum Sulphate coagulant $Al_2(SO_4)_3$ on the turbidity value in Salupangkang Tua river water using coagulation-flocculation [9]. While increasing coagulant dosage generally improves floc formation and turbidity reduction, it is essential to balance this with pH control to avoid adverse effects on floc stability and performance [10].

2. Research and Methodology

2.1 Materials

The materials used in this research were samples of Salupangkang Tua river water, Aluminum Sulphate $Al_2(SO_4)_3$, Superflock, HCL 37%, NaOH 0.1 N, and Aquadest as well as other auxiliary materials commonly used in the laboratory concerned. The main tools used are a flocculator used to stir the sample and coagulant mixture until floc is formed, a 600 mL beaker, a pH meter and a turbidimeter.

2.2 Experiments

Prepare the necessary ingredients such as: Aluminum Sulphate, distilled water, and old Salupangkang river water samples then make a stock solution with a concentration of 5000 ppm. After that, the coagulant dose was varied by 10 ppm; 20ppm; 30ppm; and 40 ppm in a 500 mL sample of old Salupangkang river water. After that, a flocculant solution was made at a concentration of 500 ppm using superflock and aquadset materials.

The standard solution that has been made is then measured and adjusted to the pH to be used. The pH variation for each solution is 1 to 14. To adjust the acidic pH (1-7), hydrochloric acid (HCl) is added to the solution, while to adjust the alkaline pH (7-14), sodium hydroxide (NaOH) is added until the desired pH is reached.

The solution with a concentration that has been adjusted to the pH is then stirred using a flocculator as a jar test tool. The flocculator was then turned on and the stirrer was lowered and the stirring speed was set to 100 rpm for 3 minutes while the flocculant mother liquor was added little by little. Then set the stirring speed again to 30 rpm for 3 minutes. Turn off the tool and leave it for 15 minutes to see the flocs form and settle. Turbidity testing is used using a turbidimeter. The solution that has been given a dose of coagulant and flocculant is pipetted into a glass turbidimeter bottle. The glass bottle is then inserted into a calibrated turbidimeter to test the turbidity value. The percent reduction in turbidity is then calculated based on the difference in initial and final turbidity values. Then, analysis of turbidity values was carried out using a turbidimeter.

3. Result and Discussion

3.1 Determination of Turbidity Test for Salupangkan Tua River Water Samples

The turbidity test result for Salupangkan Tua River Water Samples can be seen in Figure 1.

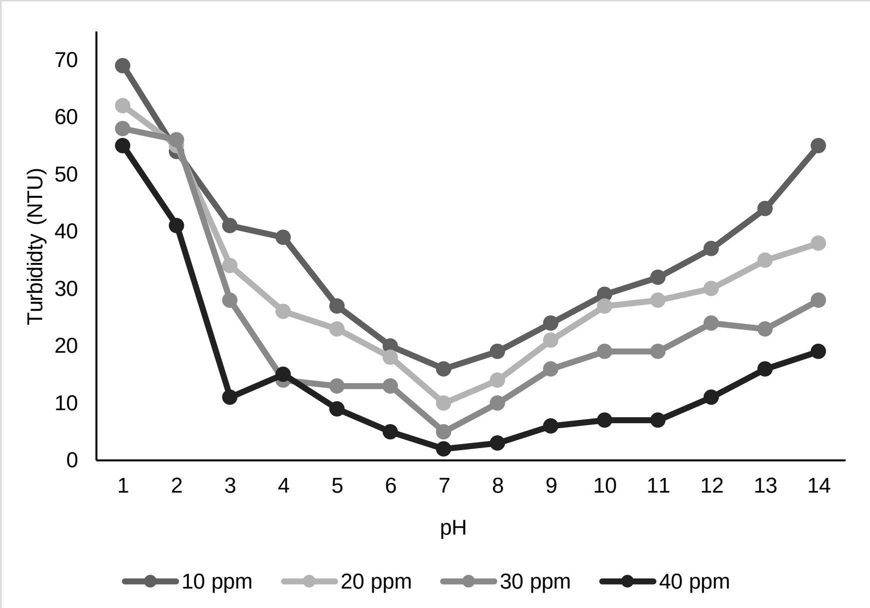

Figure 1. Comparison of Turbidity and Coagulant Dosage

Based on the graph in Figure 1, the turbidity value decreases as the pH decreases to pH 7. At coagulant doses of 10 ppm, 20 ppm, 30 ppm and 40 ppm, the lowest turbidity occurs at pH 7. Based on Rachmawati's statement [6] that at pH <4.5 and >8.0, most of the aluminum is in the form of dissolved species [11]. This shows that in this pH range the coagulant is not effective in forming precipitates. In the optimum pH range, the decrease in turbidity is influenced by the dominance of $Al(OH)_3$ precipitates, which activate the sweep coagulation or trapping mechanism in the precipitates. This process produces large flocs that settle easily, so the efficiency of reducing turbidity is higher compared to the charge neutralization mechanism [12].

At pH conditions below the optimum pH, the amount of metal precipitate formed competes with the presence of dissolved species, and in amounts that are not as large as at the optimum pH (lowest solubility). The mechanism that works in this situation is charge neutralization, where positively charged precipitates will be adsorbed onto the surface of negatively charged colloidal particles, and this will cause changes in the surface characteristics of the particles, which is followed by reducing the repulsive force which can trigger coagulation [6, 13].

Under pH conditions above the optimum pH, the amount of $Al(OH)_3$ precipitate in the sample decreases, thereby reducing the efficiency of reducing water turbidity. The efficiency of Al(OH)3 precipitate in reducing water turbidity is significantly influenced by pH levels. Research indicates that as pH rises above the optimal range, the precipitation of Al(OH)3 diminishes, leading to reduced turbidity removal efficiency. This phenomenon is critical in water treatment processes. This is caused by the start of the formation of dissolved aluminum species, namely aluminate ions. This aluminate ion also does not react with colloidal particles but rather dissolves in water so that the reduction in turbidity is less than optimal [14].

3.2 Determination of Optimum Coagulant Dosage

Determining the optimum coagulant dose is seen from the use of the lowest coagulant dose and the highest turbidity reduction efficiency. The efficiency of using Aluminum Sulfate coagulant in the Salupangkang Tua river can be seen in Figure 2.

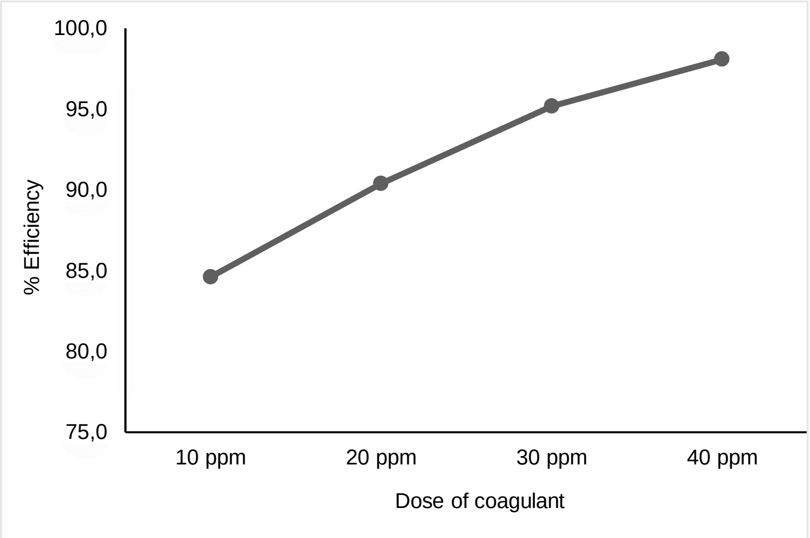

Figure 2. Comparison graph of efficiency and coagulant dose at pH 7

Based on Figure 2, the efficiency of using Aluminum Sulfate coagulant in Salupangkang Tua river water samples has a higher efficiency after increasing the coagulant concentration. The highest coagulant efficiency was found at a concentration of 30 ppm at 95.2% and 40 ppm at 98.1% [15-16]. The lowest dose used to reach the efficiency value is at a coagulant concentration of 30 ppm which is the optimum coagulant dose for the Salupangkang Dua river sample. Increasing the aluminum dose results in the formation of more aluminum polymer, resulting in $Al(OH)_3$ precipitation. Increasing the amount of these precipitates increases the collision frequency thereby accelerating the reduction of turbidity and expanding the operating pH range [17].

Overall, the decrease in turbidity level also shows a directly proportional relationship with increasing coagulant dosage over a range of pH variations. For example, at a coagulant dose of 30 ppm the turbidity is accepted to improve water quality to class 1 based on PP No. 82/2001, namely ≤ 5 NTU found at pH 7. Meanwhile for the 40 ppm coagulant variation, results showing turbidity ≤ 5 NTU were found in the pH range 6-8 [18].

4. Conclusion

Based on the research that has been carried out, it can be concluded that the optimum pH to obtain an efficient level of use of Aluminum Sulfate coagulant is pH 7 with a turbidity value of around 5-2 NTU. The efficient coagulant dose to reduce the turbidity of the Salupangkang Tua river water is 30 ppm. Increasing the coagulant dose provides a wider range of pH variations.

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