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The Effectiveness of PAC and Chitosan Usage in Jeneberang River Raw Water Treatment

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Abstract. Raw water treatment commonly uses effective coagulants with the purpose to reduce the concentration of particles causing turbidity. One of the most popular coagulants is poly aluminum chloride (PAC) with some advantages. It has low corrosiveness. Formed floccules are relatively easier to detach and pH result is in moderate level. Another alternative chemical substance as a coagulant is Chitosan, a high degradability, non-toxic substance, with high market availability. Chitosan usage produces small amount of sludge and no cationic residue. This research intended to analyze the comparison of effectiveness of PAC and chitosan as coagulants for raw water treatment in Jeneberang River. Samples were taken in two locations; at the long storage (first location) and at the ground sill (second location) in Jeneberang River. Samples were analysed at Water Quality Laboratory of Environmental Engineering Department, Engineering Faculty, Hasanuddin University. For first location, PAC has 94.57% effectiveness to reduce turbidity when compared to as for chitosan which gained 69.67% effectiveness in reducing turbidity. Therefore, the results show that PAC is more effective and efficient as a coagulant for raw water treatment in Jeneberang River when compared to Chitosan.

1. Introduction

In the processing raw water into clean water, several methods are carried out namely physical, chemical and biological processing. In physical processing, the methods include filtration and sedimentation. Biological processing is usually conducted to kill pathogenic microorganisms by introducing disinfectant. In chemical processing, the processing is carried out by adding a chemical compound called coagulant and flocculent to function as a water purifier [1-3]. In general, the most commonly used coagulant is aluminum sulphate or colloquially named as alum. However, Poly Aluminum Chloride (PAC) has been found to perform better than aluminum sulphate. In addition to PAC, an alternative material that can be used is chitosan. Chitosan is a chitin deacetylation product, which is a long chain polymer from glucosamine (2-amino-2-deoxyglucose). The molecular weight of chitosan depends on the degradation that occurs in the process of its production. Chitosan has free amino groups as polycationic, chelating and forming dispersions in acetic acid solutions [4]. This study aims to compare the effectiveness of raw water treatment using two alternative materials, which are Poly Aluminum Chloride (PAC) and Chitosan. Samples of water to be used are sourced from the Jeneberang River as one of the sources of raw water in Makassar City's clean water production. The



objectives of this research are to analyze the effectiveness of the results of processing using Poly Aluminum Chloride (PAC) and chitosan as coagulants for raw water treatment in Jeneberang River and to compare the effectiveness and efficiency of both materials.

2. Literature Review

If the solution is added with a solution with different charge in colloid system, the colloid system will pull the other to form a double layer. The first layer is a solid layer where the charge of the colloidal particle attracts ions with the opposite charge from the dispersing medium. The second layer is a diffusion layer where the charge from the dispersing medium diffuses into the colloidal particles. This multiple layer model is called the Stern double layer. The existence of this layer causes overall solution to be neutral. If the colloidal particles are neutral, there will be clotting and precipitation due to the influence of gravity. This process of clotting and precipitation is called coagulation [5]. PAC is a special aluminum chloride base salt designed to provide coagulation and flocculation that is stronger and better than ordinary aluminum and iron salts. Chitosan ($C_6H_{11}NO_4$) is a polymer with the chemical name 2-amino-2-deoxy-D-glucose, containing free amino groups in its carbon chain and positively charged. This free amine group has many functions for chitosan. Chitosan in an amorphous solid is one of the few natural polymers in the form of cationic polyelectrolytes in organic acid solutions [6].

3. Research Method

The type of research that will be carried out is an experimental development research conducted to prove the hypothesis in order to compile a generally accepted conclusion. This research was conducted in October 2017 at the Water Quality Laboratory of the Faculty of Engineering, Hasanuddin University which lasted in 3 days. Material collection was carried out in the Jeneberang River, namely Long Storage and Groundsill. The locations were chosen because it is a source of raw water for water treatment plant in its vicinity. Equipment in this research includes a set of jar test, turbidimeter, and pH meter. Raw water from the Jeneberang River was then mixed with 1% coagulant solution, and 10% PAC solution.

Testing the effectiveness of the coagulant solution is carried out in three stages. The first stage is the dissolution of the coagulant in the sample water, stirred in 150 rpm speed for 1 minute. The second stage is 50 rpm slow stirring to form floccules for 10 minutes. The third stage is the sedimentation process for 10 minutes. Determination of the dose of coagulant that will be used is determined based on the jar-test test where a dose of 10 ppm of coagulant solution can reduce turbidity in the sample water. To investigate the effectiveness of the two types of coagulants, the dosage was varied to 10 ppm, 20 ppm, and 30 ppm.

The turbidity measurement tool used is Lutron TU 2016 Turbidity Meter which has been calibrated to a standard of turbidity values in accordance with the standard of 0 NTU. Turbidity measurements used homogenised 10 mL of sample water (raw water and jar test water) which was put into the cleaned cuvette and then put into a turbidimeter. The results will be displayed after 10 seconds on the turbidimeter. The turbidity of water in jar-test was then measured for every 2 minutes to see a reduction in turbidity for a period of 10 minutes.

Electrodes were installed at pH-meter and dipped in a pH 4 buffer and then into a pH buffer 9 then the electrodes were transferred and dipped at pH 7. After the pH-meter was calibrated, the electrode was dipped in the sample solution of mixed raw water and jar test water and the pH indicated on the pH-meter device was recorded.

The effectiveness of the coagulant in reducing the turbidity value is expressed in percentage (%) and calculated using the following equation

$$ef (\%) = \left(\frac{\text{initial value} - \text{final value}}{\text{initial value}} \right) \times 100$$

where,
 ef (%) = effectiveness in percentages
 Initial value = turbidity value before processing
 Final value = turbidity value after processing

4. Results and Discussion

4.1. Relationship of sedimentation time and turbidity values

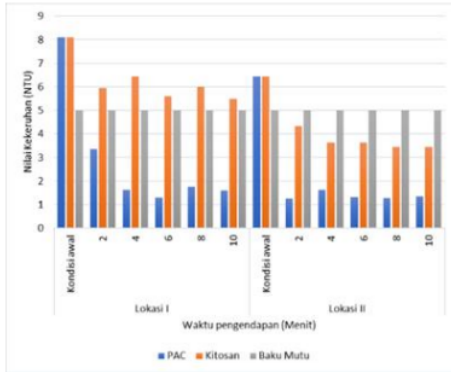


Figure 1. Results of 10 ppm measurements

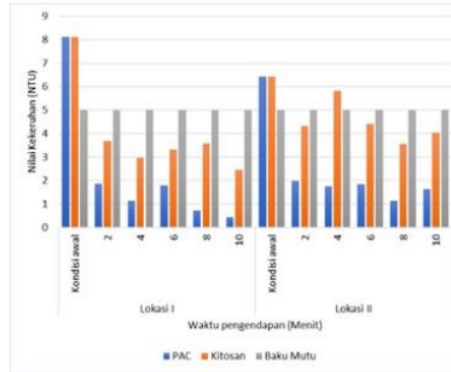


Figure 2. Results of 20 ppm measurements

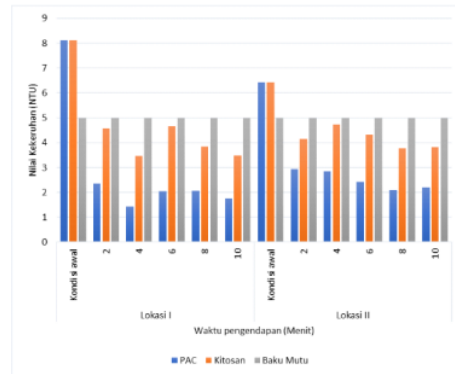


Figure 3. Results of 30 ppm measurements

Based on the graph above it can be seen that PAC coagulant is more effective in reducing turbidity values, and optimal precipitation occurs at a dose of 20 ppm. The highest effectiveness for location I is 94.575% using PAC coagulant as much as 20 ppm while the effectiveness for location II is 79.004% using PAC coagulant at a dose of 10 ppm.

4.2. Effectiveness of coagulants in reducing turbidity

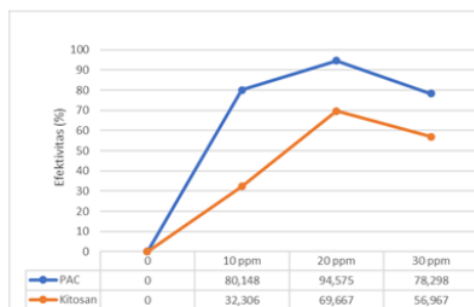


Figure 4. Effectiveness of coagulants in location I

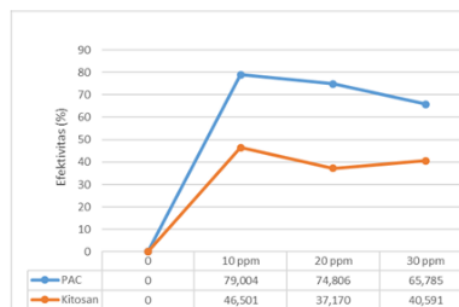


Figure 5. Effectiveness of coagulants in location II

4.3. Results of pH measurements

The pH value showed that the coagulation results with the addition of PAC coagulant were at the optimum concentration for 10 ppm, which are 6.8 at location I and 6.9 at location II. Whereas with the addition of chitosan, the pH value drops to 6.6 and has met the requirements of drinking water according to drinking water quality standards. The pH value decreases because both coagulants have acidic properties. In the sample using PAC, the pH will get more acid as the coagulant dose increases. This is because PAC contains free hydrogen ions produced from hydrolysis reactions. In general, the more coagulants used, the lower the pH will be higher [7].

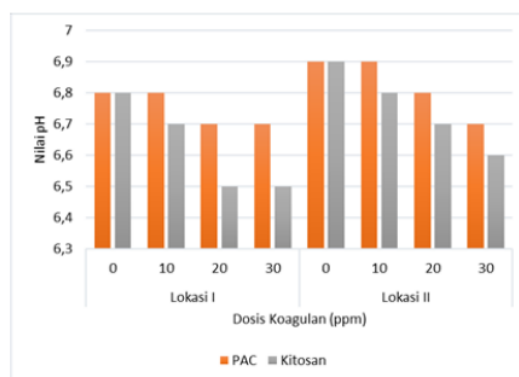


Figure 6. Results of pH measurements

4.4. Relationship of pH and the effectiveness of coagulants

In the graph below it can be seen that the highest effectiveness of PAC coagulant for location I uses a dose of 20 ppm with a pH value of 6.7. As for location II, a 10 ppm PAC dose provides the highest effectiveness with a pH value of 6.9. Based on this finding, it is known that PAC coagulants can reduce turbidity optimally at pH 6.7 - 6.9.

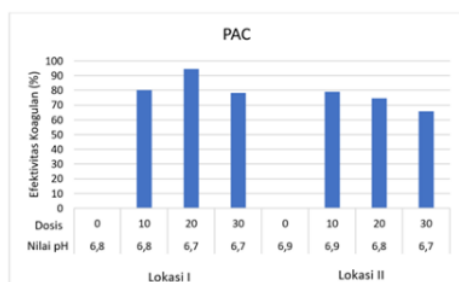


Figure 7. pH of PAC coagulant

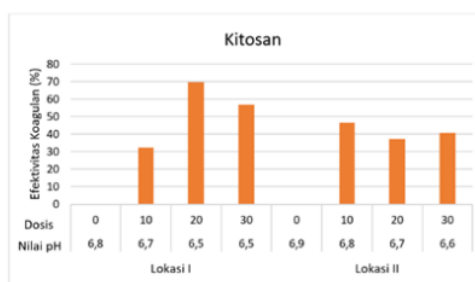


Figure 8. pH of Chitosan coagulant

The use of chitosan showed the highest effectiveness at a dose of 20 ppm at location I with a pH of 6.5 while at location II, the effectiveness of the highest coagulant occurred at a dose of 10 ppm with a pH value of 6.8. Based on this, it can be seen that chitosan coagulant can reduce turbidity optimally at pH 6.5 - 6.8. The initial pH value can affect the solubility of a coagulant. PAC has a large solubility in the pH range 5-9. While chitosan coagulant dissolves in acidic solutions with a pH range of around 4-6. The easier a coagulant to dissolve, the formation of aquometallic ions will be easier which eventually accelerate neutralized colloidal particles to form floccules. A higher pH gives smaller the solubility of the coagulant causing aquometallic ions to be increasingly difficult to form, which ultimately reduces the number of colloidal particles that can be neutralized to form floccules [8].

4.5. Production cost analysis

The calculation of production costs for both coagulants uses raw water discharge according to processing capacity in the treatment plant is as follows;

Table 1. Analysis of production costs

Coagulant	Usage (mg/L)	Hourly demand (kg/h)	Daily demand (kg/day)	Monthly demand (kg/mo.)	Price per kg	Production cost per month
PAC	20	3.6	86.4	2592	5,000	Rp 12,960,000
Chitosan	20	3.6	86.4	2592	54,000	Rp 1,399,680,000

A supporting factor causing PAC coagulant to more superior than chitosan coagulant is that PAC coagulant is in powder form which dissolved easily with water while chitosan can only dissolve with acidic solvents making its usage to be less efficient.

5. Conclusion

Based on the results of testing and data processing, it can be concluded that the PAC coagulant can reduce the turbidity of the Jeneberang River water with the highest effectiveness of 94.57%, at Location I with a dose of 20 ppm. For Location II the highest effectiveness was 79.01% at a dose of 10 ppm. Chitosan coagulant can reduce the turbidity of Jeneberang River water at Location I with the highest effectiveness of 69.67% at a dose of 20 ppm. For Location II the highest effectiveness is 46.5% with a dose of 10 ppm. The use of PAC coagulant is more effective than chitosan coagulant in reducing turbidity of Jeneberang River raw water in accordance with quality standards. In economic terms, the use of PAC coagulants is more efficient than chitosan coagulants.

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