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Effect of Aluminium Chlorohidrate (ACH) and Polydadmac Comparison on Coagulation and Floculation Processes in Cengkareng Drain River Water Treatment

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Abstract:
This study was conducted to determine the effect of the concentration ratio of Aluminium Chlorohidrate (ACH) and Polydadmac coagulants on the coagulation and flocculation process in river water treatment. The raw water used was raw water that is processed by PT XYZ Taman Kota WTP, namely Cengkareng Drain river water. Cengkareng Drain River has unstable water quality due to pollution from factory and household discharges that interfere with the water purification process, the floc formed becomes light and does not settle. One way to overcome this problem is the use of additional coagulants. This research used descriptive methods by conducting various measurements and experiments, both in the field and in the laboratory. The experiment conducted was Jar test, with floc testers. The variables used were variations in the concentration of ACH and polydadmac. The resulting jar test water was tested for turbidity and pH. This research began with sampling raw water, then 1000 mL was entered into each glass of the floc testers tool. The flocculation process was carried out with a stirring speed of 200 rpm for 2 minutes. It was followed by the coagulation process with a stirring speed of 40 rpm for 18 minutes. The process continued with sedimentation for 10 minutes. The optimum dose obtained was the combination of ACH 11 ppm and polydadmac 0.6 ppm with a turbidity value of 1,49 NTU or with a removal efficiency value of 93,66 % and a pH value of 7,19.

Keywords: *Aluminium Chlorohidrate (ACH), Polydadmac, Jar Test, Coagulation, Optimum Dose*

INTRODUCTION

Clean water is one of the basic needs of the community in West Jakarta which is unlimited and sustainable. The use of clean water is crucial for household consumption, industrial needs, and public places in this region, so it is only natural that the clean water sector in West Jakarta gets top priority handling because it involves the lives of many people. Population growth, development, and rising living standards in West Jakarta have led to an increasing demand for clean water. However, the decline in environmental quality in this region has also increased along with the increasing activities of the people of West Jakarta, both domestic and non-domestic, which pollute water bodies, such as garbage, household waste, and chemicals. This has led to a decline in water quality in the region.

Many areas in West Jakarta have naturally contaminated groundwater that is unfit for use as clean water for daily domestic requirements, therefore even under normal conditions, many residents in this area rely on clean water suppliers to meet their daily clean water demands. Sea water intrusion due to the construction of tall buildings has also caused water conditions in several areas in West Jakarta to become salty. Not only that, the dirty groundwater in West Jakarta is more caused by industries that do the blessing, which is disposing of waste without passing through the wastewater treatment plant first. Thus, the waste that is discharged directly into the sewer causes the water to become polluted. Therefore, it is necessary to process raw water into drinking water that is not only maintained in quantity but also in quality.

Taman Kota Water Treatment Plant (WTP) is one of the water treatment plants located in West Jakarta and was established in 1982 to meet drinking water needs, especially Cengkareng and surrounding areas. In the process of processing Taman Kota WTP uses raw water from the Cengkareng Drain River.

In general, the most commonly utilized coagulant in the water treatment process is Aluminum Sulfate, also known as alum. The coagulation and flocculation method for water treatment is quite popular in Indonesia since aluminum sulfate and PAC coagulants are readily available on the market. When compared to the usage of aluminum sulfate coagulants, PAC has various advantages, including reduced corrosivity, a more easily separated floc, and a pH that is not too low. But now Aluminium Chlorohidrate (ACH) is also starting to be widely used, which is a development of PAC.

Cengkareng Drain river has unstable water quality due to pollution from factory and household discharges that interfere with the water purification process, the floc formed becomes light and does not settle. One way to overcome this problem is the use of additional coagulants.

A coagulant auxiliary (additional) is needed to produce flocs quickly, settle, and optimize the work of coagulants. This process will become more effective with the addition of this additional material for the formation of larger flocs, in addition to reducing the dose of coagulant material and removing organic matter that often gives color to water (Amal, 2006).

Polydadmac is an additional coagulant that has been widely used in recent years. Therefore, polydadmac will be tested for its effectiveness in water treatment. This study aimed to determine the optimum concentration ratio of coagulants and additional coagulants to the coagulation and flocculation process in the water treatment process by looking at the quality of the final result of turbidity and pH of the resulting clean water.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

River water

The river is one of the containers where water gathers from an area. Surface water or runoff water flows by gravity to a lower place (Yogafanny, 2015). The quality of river water in an area is strongly influenced by human activities, especially those around the river (Yogafanny, 2015).

River water is one of the sources of raw water for the community. River water is good quality because it comes directly from springs in the mountains. However, the farther from the source the greater the level of pollution in river water, due to the accumulation of waste from upstream to downstream (Mayasari & Hastarina, 2018).

Water treatment

Water treatment or purification is a method used to remove contaminants dissolved in water, so that water is produced that can be used for human life, for example for drinking water, and for cooking (Budiman et al., 2017).

In general, three methods are commonly utilized in water treatment:

1. Physical water treatment is a water treatment that is primarily accomplished through the use of filtration and sedimentation processes.
2. Chemical water treatment is defined as a water treatment procedure that uses chemicals or chemical processes to remove pollutants from water.
3. Biological water treatment is carried out to remove harmful organisms contained in water. In general, biological water treatment is divided into 2 categories, namely: aerobic treatment and anaerobic treatment (Budiman et al., 2017).

Aluminium Chlorohidrate (ACH)

Coagulants commonly used in water treatment include: Aluminum Sulfate ($Al_2(SO_4)3.xH_2O$), Sodium Aluminate ($NaAlO_2$ or $Na_2Al_2O_4$), Polyaluminium Chloride (PAC), ferric sulfate ($Fe_2(SO_4)_3.9H_2O$), Ferric Chloride ($FeCl_3.6H_2O$), and Ferrous Sulfate ($FeSO_4.7H_2O$) (Mayasari & Hastarina, 2018). Apart from that, there is also Aluminum Chlorohydrate (ACH) with the chemical formula ($Al_2ClH_6O_7$), which is a coagulant with a high alkalinity level that is highly polymerized, which has little impact on alkalinity and pH. Apart from that, ACH is a development of PAC which is capable of working in the high pH range (Sandora et al., 2022).

Polydadmac

Difficulties during the coagulation process sometimes occur due to long settling times and soft flocs that form, which complicates the separation process. Additional coagulants benefit the coagulation process by shortening the settling time and hardening the flocs formed, so the definition of an additional coagulant is a secondary coagulant added after the primary or main coagulant aims to accelerate precipitation, formation, and hardening of flocs (Afdal & Fadhilah, 2020). One of the widely used additional coagulants is Polydiallyl dimethyl ammonium chloride or Polydadmac which is a polyelectrolyte with a positive charge type (cation). Polydadmac is a polymer that has a high charge density, so it can combine suspended particles to be effective in the flocculation process, remove color, kill algae, and remove organics such as humus (Anggarani et al., 2015).

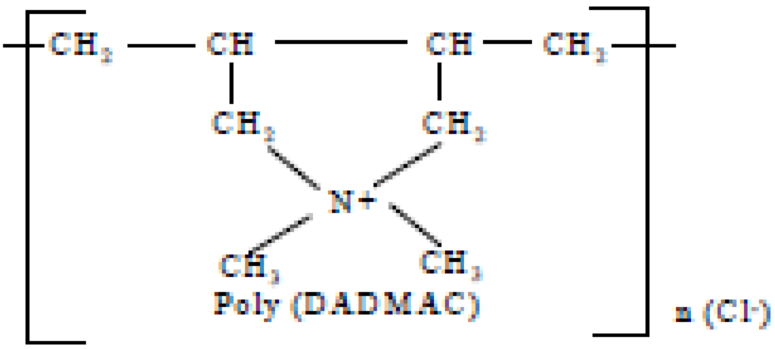

Figure 1. Polydadmac structure *(Leopold, 2009)*

Coagulation and Flocculation

Coagulation and flocculation are a purification method that works by using chemicals. Coagulation is a chemical process that aims to reduce turbidity and materials in water which are mostly colloidal particles (1-200 millimicrons in size) such as algae, bacteria, inorganic organic substances, and clay particles (Mayasari & Hastarina, 2018). While flocculation is an advanced process and coagulation. The formation of good flocs is usually preceded by an efficient coagulation process. The quality of the flocs affects how quickly or slowly the particles settle in the sedimentation basin. In the flocculation process, unstable particles are combined to form larger and faster flocs that can be separated (Sutapa, 2014).

Floc formation in the coagulation process is influenced by physical and chemical factors such as stirring conditions, pH, alkalinity, turbidity, and water temperature. As alum if used outside its optimum pH range (5.8 - 7.4), the floc formed will be imperfect and will dissolve again. However, the optimum dose of coagulant material added must be determined based on laboratory experiments with Jar tests (Indriyati, 2018).

METHODS

The method used in this research was a descriptive method by conducting various measurements and experiments, both in the field and in the laboratory. The experiment conducted was a Jar test, which is a way to determine the optimum dose of coagulant and additional coagulant in the water treatment process. Coagulation and flocculation optimization were carried out based on variations in the concentration of coagulants and additional coagulants. The tools used are floc testers.

Clean water from the treatment process was tested for turbidity and pH with a turbidimeter and pH meter. Determination of the optimum coagulant is a combination of the lowest coagulant dose and the highest turbidity reduction efficiency (removal efficiency). The percentage removal calculation is presented as follows:

$$Removal = \frac{Raw\ water\ turbidity - Clean\ water\ turbidity}{Raw\ water\ turbidity}\ x\ 100\%$$

Research Materials

The raw material used in this research was Cengkareng Drain river water. The materials used for the process and analysis were ACH, Polydadmac, distilled water, tissue, and 3M KCl.

Research Instruments

The equipment used in this study were floc testers, 1000 mL beaker glass, 100 mL beaker glass, 1000 mL volumetric flask, 500 mL volumetric flask, Digital balance, dropper pipette, turbidimeter, pH meter, and bucket.

Sample Preparation

In this preparation process, the Cengkareng Drain river water was taken as much as 6000 mL for each experiment with a bucket from the sample point located at Taman Kota WTP.

Jar Test Experiment

Before the jar test, a water quality study was conducted. The parameters observed were pH and turbidity. The jar test work began with preparing a jar test tool and 6 1000 mL beaker glass. Then put 1000 mL of water samples into each beaker. After that, ACH coagulant and additional coagulant polydadmac were added with variations in ACH concentration of 9, 10, 11, 12, 13, and 14 ppm and variations in polydadmac dosage of 0.4, 0.6, 0.8 ppm. After the coagulant addition, fast stirring with a stirring speed of 200 rpm for 2 minutes, followed by slow stirring with a stirring speed of 40 rpm for 18 minutes. It was followed by the settling stage for 10 minutes. Then the supernatant (parts that did not settle) was taken for analysis. Analysis was carried out with a turbidimeter to determine the turbidity value and a pH meter for pH analysis.

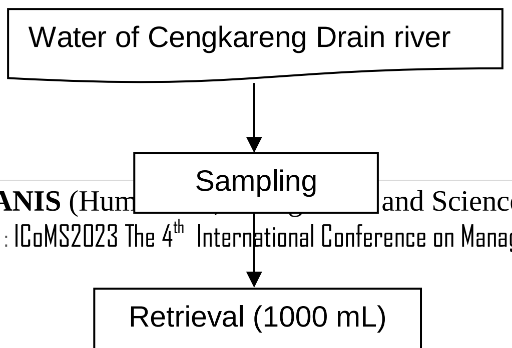

Figure 2. Flow chart of water treatment process with jar test

RESULT AND DISCUSSION

Effect of Coagulant Concentration on Turbidity

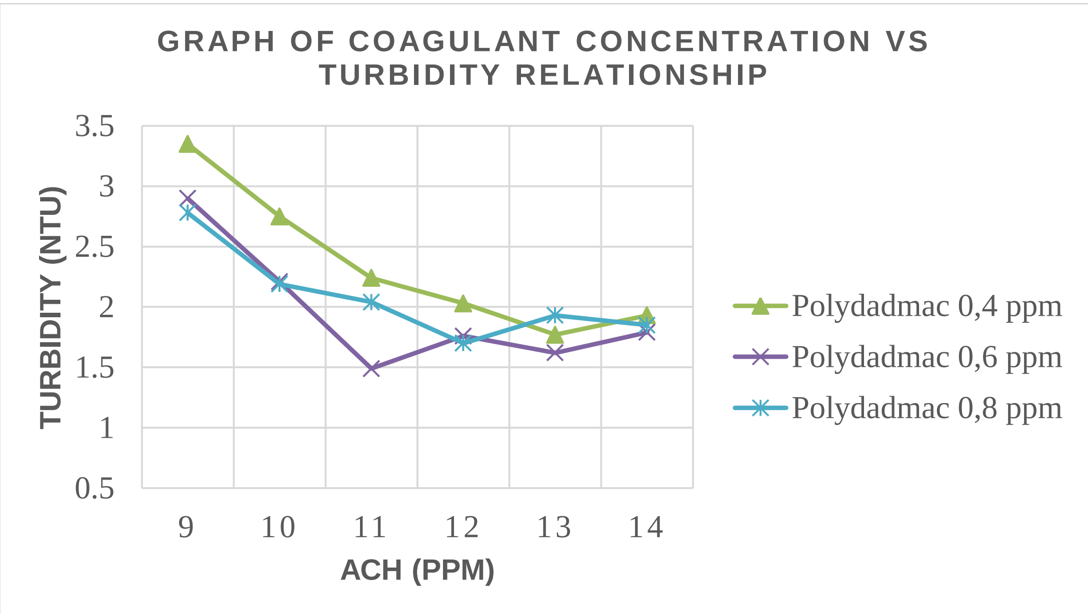

Figure 3. Graph of the effect of the comparison of the addition of ACH and Polydadmac on the turbidity of the water from the Jar test.

In previous studies to determine the optimum dose in the water treatment process with jar tests using alum and ACH coagulants, the removal efficiency values were obtained below 70%. While in the combination of alum with polydadmac the removal efficiency results were above 90%. Therefore, in this study, the authors chose to use a combination of ACH coagulant with polydadmac. Experiments were conducted with variations in ACH concentrations of 9, 10, 11, 12, 13, and 14 ppm, while for polydadmac concentrations of 0.4, 0.6, and 0.8 ppm. Polydadmac was used in small concentrations because according to Anggarani (2015) Polydadmac poses a health risk if it reacts with chlorine to produce water with carcinogenic content, therefore the dose used is very low, which is less than 1 mg/L.

This study used Cengkareng Drain River raw water with a turbidity of 23.5 NTU. The optimum dose of coagulant was obtained in the combination of ACH 11 ppm with polydadmac 0.6 ppm with a turbidity value of 1.49 NTU or with a removal efficiency value of 94.40%. These results showed an increase in the removal efficiency value compared to previous studies using ACH without additional coagulants.

In water treatment with this jar test, there was a decrease in turbidity from raw water to clean water. This happened because the coagulant affix caused the process of coagulation and flocculation in the water. Coagulation is where the coagulant releases positive charges, and then reacts with the negative charges of the colloids contained in the water. The reaction produces clumps or flocs. These small flocs then bind together to form larger flocs, this process is called flocculation. In the next water treatment process, the sedimentation process was carried out, which is the process of precipitating the large flocs, so that water with lower turbidity is produced.

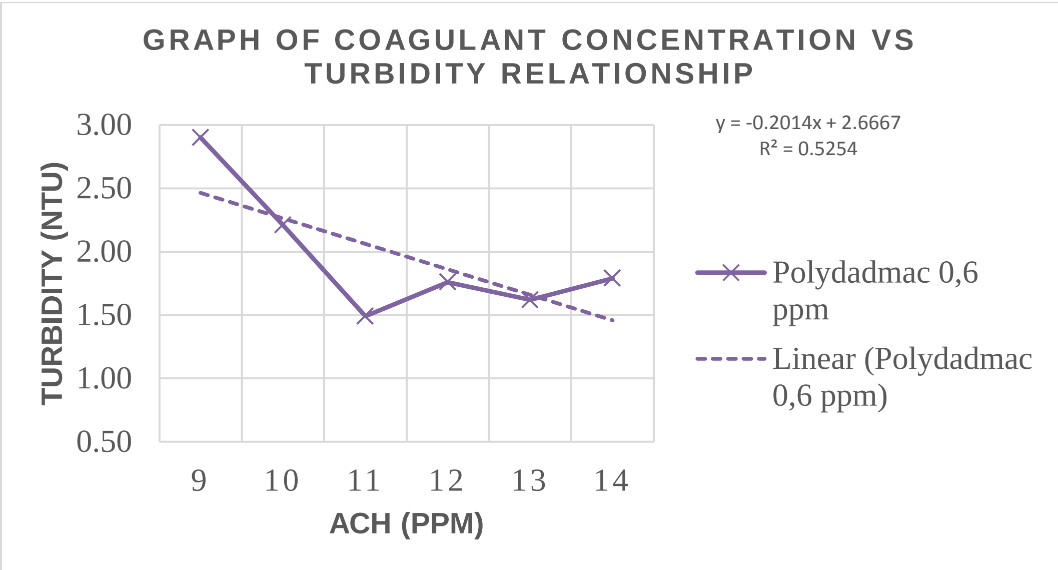

Figure 4. Graph of correlation of the relationship between the ratio of the addition of ACH and Polydadmac to the turbidity of water from Jar test results

From the results of the study, it can also be seen that the graph drops and then rises again after the optimum dose point. This showed that the more coagulant used, the higher the reduction in raw water turbidity, but this did not apply after passing the optimum dose point. The turbidity value becomes fluctuating and unstable. This instability occurred because after the optimum dose was reached there was excess coagulant in the water, this excess causes saturation and increases the turbidity of the water. Excess coagulant then binds again with colloidal remains in the water, some do not bind, and this happens continuously with colloidal remains in a non-linear manner. Figure 4 shows this correlation relationship. The equation obtained was

$y=-0,2014x+2,6667$

$R^2 = 0,5254$

Effect of Coagulant Concentration on pH

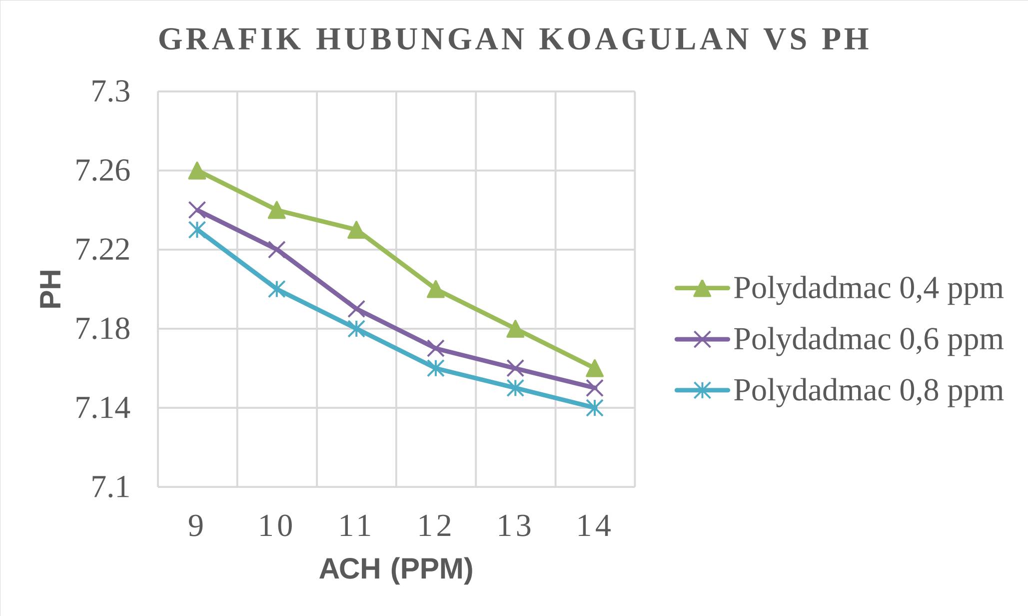

Figure 5. Graph of the comparative effect of adding ACH and Polydadmac on the pH of the resulting water Jar test

The pH measurement results shown in Figure 5 that the more ACH and Polydadmac are used, the more the pH of the water will decrease. However, the decrease in pH was not too drastic and not too different between all coagulant comparisons. The pH of the raw water used was 7.29 and the pH at the optimum dose obtained, the pH value of the water was 7.19. This is because the ACH and polydadmac used are small doses.

CONCLUSIONS

Conclusion

The use of polydadmac as an additional coagulant could reduce the use of ACH in the water purification process to reduce raw water turbidity. The more polydadmac that is added, the less ACH is used. However, when the coagulant is excessive in water, it will make the water saturated and the turbidity value will increase.

The results of the study obtained the optimum dose in the ratio of 11 ppm ACH and 0.6 ppm polydadmac with a turbidity value of 1.49 NTU or with a removal value of 93,66% and a pH value of 7.19.

Suggestions

1. This research can be developed by researching using other variables such as speed and stirring time at the optimum dose obtained.
2. Conducted research using different raw water turbidity.

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