

Comparison of Coagulant Dose (Poly Aluminum Chloride) Use in The Water Treatments Process of Kalimalang River

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Abstract

River has a vital role to fulfill the water needs of the community. In the water bodies, the small suspended particles, also known as colloids, with the small weight and stability in the water bodies they have, they cannot be settled or eliminated naturally. There are some concerns regarding colloid removal in Kalimalang river, such as increase in water turbidity resulting the decrease in the river water quality as a water source and disruption of the ecosystem in the river. The experiment used poly-aluminum chloride (PAC) as the coagulant and jar test method which contains coagulation-flocculation process. This aims to determine optimal dosage of PAC to reduce the turbidity and pH value of water sample that relate to the regulation of water quality standard for sanitary hygiene, which is regulated by law No 32 Year 2017. The optimum dose for this experiment is 2 mg/L PAC 0.5 percent as the sample achieved the lowest average of turbidity that is 0.02 NTU with the average of pH is 7, indicating that the sample meets the quality standards of Environmental Health Quality Standards for sanitary hygiene purposes.

Keywords: Poly-Aluminum Chloride, coagulation, flocculation, pH, turbidity

Abstrak

Sungai sebagai peran vital dalam memenuhi kebutuhan air masyarakat. Di dalam badan air, partikel-partikel kecil tersuspensi yang disebut juga koloid, yang karena bobotnya yang kecil dan stabilitasnya di badan air, tidak dapat mengendap atau dihilangkan secara alami. Ada beberapa kekhawatiran mengenai pembuangan koloid di sungai Kalimalang, seperti air semakin keruh yang mengakibatkan penurunan kualitas air sungai sebagai sumber air dan terganggunya ekosistem sungai. Penelitian ini menggunakan poli-aluminium klorida (PAC) sebagai koagulan dan metode jar test yang mengandung proses koagulasi-flokulasi untuk menentukan dosis PAC yang optimal untuk mengurangi kekeruhan dan nilai pH sampel air yang berhubungan dengan pengaturan kualitas air. standar higiene sanitasi diatur dalam undang-undang No 32 Tahun 2017. Dosis optimum untuk percobaan ini adalah 2 mg/L PAC 0,5 persen karena sampel mencapai rata-rata kekeruhan terendah 0,02 NTU dan rata-rata pH 7, menunjukkan sampel memenuhi baku mutu dari regulasi Baku Mutu Kesehatan Lingkungan untuk keperluan higiene sanitasi.

Kata Kunci: Poli-Aluminium Klorida, koagulasi, flokulasi, pH, kekeruhan

1. Introduction

In the water bodies, the small suspended particles, also known as colloids, with the small weight and stability in water bodies they have, they cannot be settled or eliminated naturally. These particles are stable and contribute to water turbidity [1]. In this study, Kalimalang River in Bekasi regency has a vital role for community. Thus, it is important to keep the river to have a good condition and to treat the river water as clean water source before it is used by the community

On the water treatment, there are several processes to reduce suspended solid (colloid) from water by using the application of chemical coagulants. The chemical coagulation process is regarded as a legitimate method, as determined by the hydrolyzed species of inorganic coagulants under various raw water and coagulation circumstances. Adsorption, complexation, and coprecipitation are the major methods for heavy metal elimination [2]. In this study, the chemical coagulant used organic coagulants which is Poly Aluminum Chloride (PAC) that has benefit in some applications, in which the Floc generated is denser and settles faster than alum [3]. Poly Aluminum Chloride (PAC) which comes from chemical material and categorized as cationic polymer coagulant [4], on coagulation-flocculation. PAC is defined as a long chain complex polymer $Al_m(OH)_n(Cl)_{3m-n}$ [5]. Polymers have a higher molecular weight and greater density than monomers, yet the size is smaller than monomer's [6]. As a result, PAC chemicals react more readily with

water-borne particles, and the coagulation-flocculation process with PAC does not necessitate huge concentrations.

Coagulation – flocculation is a turbidity – reduction technique in which colloids in water are destabilized so that they can agglomerate and be physically removed [7]. The coagulation and flocculation process removes TSS by adding a coagulant and rapidly stirring it to neutralize (destabilize) suspended particles and colloids in water that have a negative charge and are less than 1 μm in size, forming micro-flocs that are not visible to the naked eye and range in size from 1 to 100 μm . Brownian force causes micro-flocs to collide, and subsequently they bind together to form larger aggregates (peri-kinetic flocculation) [8].

The effected suspension or solution needs coagulation process with the purpose to destabilization or address the factors which increase the stability of a particular system. After the coagulation process, flocculation process is needed to aggregate the destabilized particles from coagulation process to have contacts into settle able flocs. Temperature, pH, effluent quality, dose, and coagulant type are all elements that impact coagulation – flocculation [9].

In Indonesia, the regulation of water quality standard for sanitary hygiene is regulated by law No 32 Year 2017 regarding “Environmental Health Quality Standards And Water Health Requirements For Sanitation Hygiene Purposes, Swimming Pools, Per Aqua Solutions, And Public Bathings”. In the Article 1, Water for Sanitary Hygiene Purposes is water of a certain quality used for daily purposes in which the quality is different from the quality of drinking water [10]. Physical, biological, and chemical parameters in the form of mandatory and optional parameters are included in Environmental Health Quality Standards for sanitary hygiene reasons. Additional parameters are only required to be checked if the geohydrological conditions indicate a potential pollution associated with additional parameters. Mandatory parameters must be checked on a regular basis in compliance with the requirements of laws and regulations, whereas additional parameters are only necessary to be checked if the geohydrological conditions indicate a potential pollution associated with additional parameters.

Table 1. Mandatory physical parameter

No.	Mandatory Parameter	Unit	Quality Standards (Maximum)
1.	Turbidity	NTU	25
2.	Color	TCU	50
3.	Total dissolved solids	mg/l	1000
4.	Temperature	$^{\circ}\text{C}$	Air temperature ± 3
5.	Taste		No taste
6.	Odor		No odor

Source : Menteri Kesehatan Republik Indonesia [10]

Table 2. Mandatory biology parameter

No.	Mandatory Parameter	Unit	Quality Standards (Maximum)
1.	Total coliform	CFU/100 ml	50
2.	<i>E. coli</i>	CFU/100 ml	0

Source: Menteri Kesehatan Republik Indonesia [10]

Table 3. Mandatory and additional chemical parameter

No.	Parameter	Unit	Quality Standards (Maximum)
Mandatory			
1.	pH	mg/L	6.5 - 8.5
2.	Iron	mg/L	1
3.	Fluoride	mg/L	1.5
4.	CaCO_3	mg/L	500
5.	Manganese	mg/L	0.5
6.	Nitrate	mg/L	10
7.	Nitrite	mg/L	1
8.	Cyanide	mg/L	0.1
9.	Detergent	mg/L	0.05
10.	Total pesticide	mg/L	0.1
Additional			
1.	Mercury	mg/L	0.001
2.	Arsenic	mg/L	0.05
3.	Cadmium	mg/L	0.005

4.	Chromium (Valence 6)	mg/L	0.05
5.	Selenium	mg/L	0.01
6.	Zinc	mg/L	15
7.	Sulfate	mg/L	400
8.	Lead	mg/L	0.05

Source: Menteri Kesehatan Republik Indonesia [10]

In this study, the objective of experiment is to determine the optimum coagulant (PAC) dose for water sample through turbidity and pH measurement.

2. Material and Method

The method used in this paper refers to the literature review from published article employing quantitative method to analyze the data comparison. The data collected from the laboratory practicum "Jar Test of Coagulation and Flocculation" have been done previously.

2.1 Water Sample Collection

The source of water sample collected from two-point location of Kalimalang River performs different level of turbidity. To assure that the water sample was homogeneous before the test, both of the water sample were mixed using agitator mixer in different bucket until the sample blended well. The turbidity and pH level are listed in the **Table 4**.

Table 4. Initial value of sample

Sample	Turbidity	pH
I	323	7.42
II	293	7

Source: Research data, 2021

2.2 Coagulation - Flocculation

Coagulation is the process to aggregate the colloid particle and small-suspended matters. It can be done by reducing the zeta potential in the system until the value getting lower than it and it will merge in low stirring. The zeta potential offers information about the charge neutralization status when Zeta potential is zero. Hence, the particle is not mobile, and the particle will be settled [11]. While flocculation is the process by which small flocs generated during the coagulation process combine to form bigger flocs that settle. Distinct types and dosage of coagulants will create different mechanisms of action under different water quality conditions [12]. There are three types of coagulation effects that coagulants and have on colloidal particles in water, for this practicum, we used Poly Aluminum Chloride (PAC) 10%. PAC knowingly can perform high ability to remove suspended solid (faster kinetic). However, adding the dose requires several parameters to consider [13].

Experimental Procedure

Dose of Coagulant

In this laboratory experiment, the coagulant used was Poly Aluminum Chloride or PAC with the concentration of 0.5%. Since the original PAC is 10%, then we needed to dilute by 20 times using distilled water. The calculation:

$$0.5\% \rightarrow 5 \text{ mL} \rightarrow 100 \text{ mL} = 5000 \text{ mL}$$

$$(20\times) \quad 20\times$$

$$\text{mL Sample} = 500 \text{ mL}$$

$$V_1 C_1 = V_2 C_2 \quad (1)$$

$$500 \times 5 = V_2 \times 5000$$

$$V_2 = \frac{2500}{5000} = 0.5 \text{ ml}$$

From this the PAC 5% is requiring 0.5 mL in 500 ml of sample volume

Mechanism

The Jar Test experiment aims to simulate the wastewater treatment plants to remove suspended particles and pollutants in water by coagulation and flocculation to determine and test the right dose of coagulant [14]. From the experiment that had been proceeded, we took 5L of water sample from a few rivers in some area and mixing it using the agitators. Then the mixed sample were poured into six different

beaker glasses with a volume of 500 mL. Moreover, 0.5% of Poly aluminum chloride (PAC) added with a different volume in each jar (**Table 5**) and mixed in the mechanical mixer with the speed of 100 rpm for 1 minute (coagulation process) (**Fig. 1**) and reduced the speed to 40 rpm for 15 minutes (flocculation process) (**Fig. 2**). It can be identified that all the impurities are trapped and forming flocs. After that, slow the mixer to 0 rpm for 15 minutes, then wait until all the flocs go down into the bottom of the beaker glass. Next, separate 50 mL from each jar to Erlenmeyer glass and add 1 Erlenmeyer glass consisting of original water to test the turbidity using turbidimeter and pH using pH meter. There was also 50 mL of pure sample which turbidity and pH were checked as well as the rest of the six samples.



Fig. 1. Coagulation process
Source: Research data, 2021



Fig. 2. Flocculation process
Source: Research data, 2021

Table 5. PAC dose of sample

Beaker glass	1	2	3	4	5	6
ppm (mL/L)	5	10	15	20	25	30
ppm (mg/L)	6	12	18	24	30	36
PAC dose 0.5% (mL)	0.5	1	1.5	2	2.5	3

Source: Research data, 2021

3. Results and Discussion

In water treatment Coagulation-flocculation is one of the important processes in water treatment where it will affect the upstream treatment (sedimentation, biological process, oxidation process etc.) [15]. In large scale of water treatment, the water quality could be different every time, to add the dose of the coagulant, it is achieved with jar test experiment using the water sample to know what the optimum dose of coagulant is. This jar test experiment employs Poly Aluminum Chloride (PAC) 0.5% as the coagulant.

3.1 Effect of Coagulant Dose on Turbidity

Turbidity is the presence of contaminants in water in the form of colloidal particles or suspensions created by domestic or industrial waste [16]. The contents of the cloudiness of water can contains chemical precipitation or heavy metal such as manganese and iron, or organic particles such as plant waste and organisms [17]. **Fig. 3** depicts the influence of the coagulant dosage on the turbidity value of the water sample. The figure shows when the concentration of coagulant is higher or reach the optimum level in which the turbidity 0 NTU on sample I and 0,04 on sample II with the optimum dose is 2 mg/L PAC 0.5%. Increasing the dose above the optimum level causes a repulsive force between positively charged particles, resulting in a floc deflocculation process which causes the solution to become increasingly cloudy [16], [18].

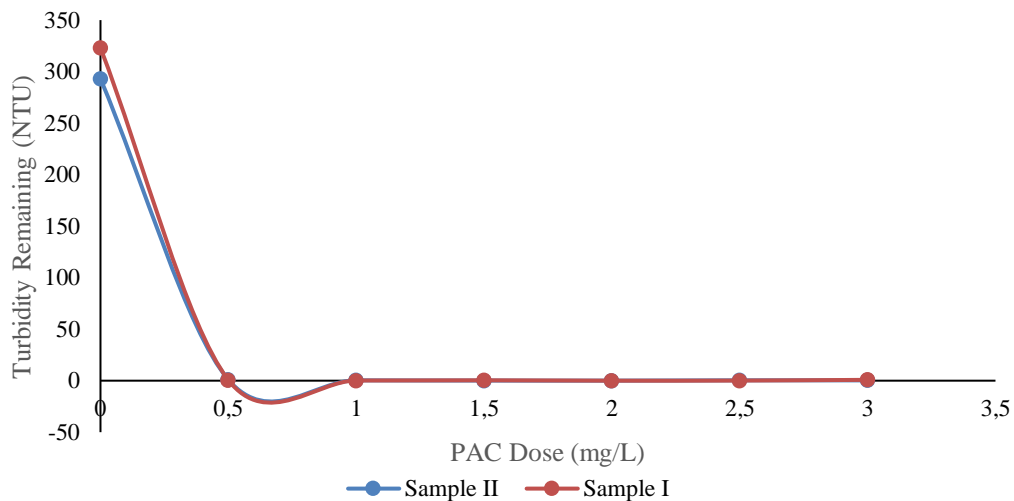


Fig. 3. Turbidity of each PAC dose in water sample
Source: Research data, 2021

3.2 Effect of Coagulant Dose on pH

A pH meter is used to determine the acidity or alkalinity of a solution. The most effective use of PAC is between the pH range of 6-9. Based on **Fig. 4**, the optimum dose is 2 mg/L PAC 0.5% with value of pH is 7.05 on sample I and 6.94 on sample II or fulfill the require of standard of pH (6.5 - 8.5 mg/L). The pH of solution keeps decrease if the PAC dose increases because the H⁺ ion is getting higher in the solution due to continued adsorption of mono- and the polynuclear hydrolysis process. Thus, the rise in H⁺ ions, the solution has a low (acidic) pH [18], [16], [19].

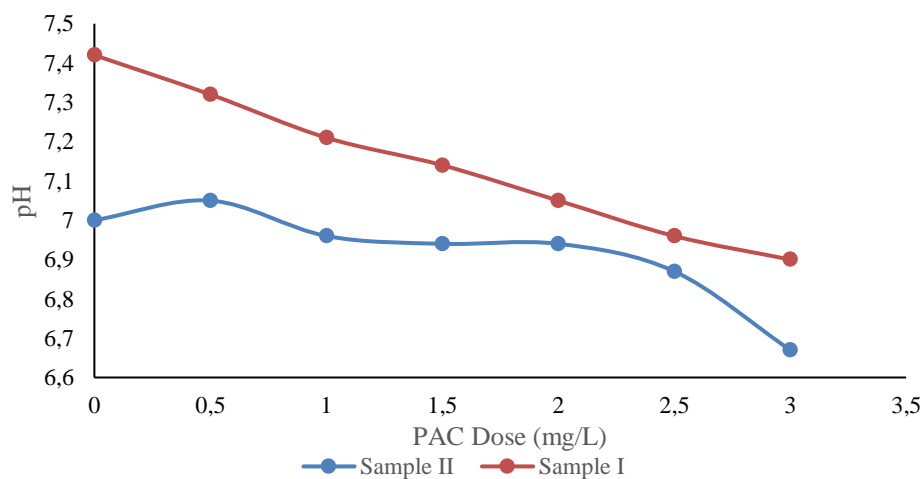


Fig. 4. Turbidity of each PAC dose in water sample
Source: Research data, 2021

4. Conclusion

Based on the results of the experiment, it can be stated that the experiment was effective in reducing high turbidity and pH with the optimal dose of Poly aluminum chloride (PAC) as the coagulant. The optimum dose for this experiment is 2 mg/L PAC 0.5 percent as the sample achieved the lowest average of turbidity as 0.02 NTU and the average of pH is 7, indicating the sample meets the quality standards of Environmental Health Quality Standards for sanitary hygiene purposes.

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