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The Relationship Between Aluminium Sulfate and Poly Aluminium Chloride on Ph and Total Dissolved Solid (Study Case Water Treatment Plant in Terbanggi Besar Pematang Panggang Kayuagung Tollroad)

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Abstract

This research will discuss the relationship between coagulant aluminium sulfate and poly aluminium chloride (PAC) on pH and total dissolved solid parameter : study case of water treatment plant in terbanggi besar – pematang panggang – kayuagung tollroad. The study will describe the impact on water treatment especially on coagulation process with coagulant aluminium sulfate and poly aluminium chloride will affect pH and total dissolved solid in the final product. It was found that the use of aluminium sulfate coagulant resulted in average deviation of 9.8 % in total dissolved solid and 14.6% in pH compared to poly aluminium chloride coagulant. It happens due the characteristic of aluminium sulfate, which has density of 2.672 g/cm^3 and pH range of 4.5 – 6.5. The dosage of aluminium sulfate required is higher than poly aluminium chloride to achieve the same result for adequate Indonesia regulation, increasing operational cost, particulary for aluminium sulfate coagulant needs. Therefore, poly aluminium chloride is the appropriate coagulant and can meet the quality standards according to Minister of Health Regulation Number 2 of 2023 by considering pH and total dissolved solid parameters in the water treatment plant at rest area 306 B on the terbanggi besar – pematang panggang – kayuagung tollroad. Monitoring these two parameter will affect other parameter, particularly iron (Fe) and manganese (Mn). This study will help operator at rest area 306 B to achieve the best dosage with jar test method for poly aluminium chloride coagulant and reduce operational and maintenance cost form previously using aluminium sulfate as coagulant.

Keywords: Alumnium Sulfate, Clean Water, Coagulant, Poly Aluminium Chloride, Rest Area, Water Treatment Plant

1. Introduction

The water treatment plant (WTP) at rest area 306 B on the terbanggi besar – pematang panggang – kayuagung tollroad is a water treatment unit that aimed at meeting need of rest area visitors as well usaha kecil dan menengah (UMKM). The regulation about standard water quality is based on Minister of Health Regulation Number 2 of 2023 concerning the implementation of government regulation number 66 of

2014 on environmental health. The raw water comes from a well drilled to a depth of approximately 100 meters. Based on the raw water test conducted by PT. Sucofindo as independent consultan on June 2023. It was found that the iron (Fe) content exceeded the quality standard at 1.3 mg/l. Therefore, the well water can be categorized as contaminated. Iron ions are natural ions that can be found in soil, rocks, and minerals. When water passes through these sources, it will contain iron and will oxidize with air, resulting in a reduction-oxidation process. When organic matters is found in groundwater, the biochemical oxygen demand (BOD) requirement will be higher, and the dissolved oxygen in the water will decrease.

Table 1: Raw Water Analysis At Rest Area 306 B

Parameters	**Result (mg/l)**	**Threshold (Minister Of Health Regulation Number 2 of 2023)**
Total Dissolved Solid (TDS)	109	300
pH	6.42	6.5 – 8.5
Iron	1.6	1
Mangan	<0.01	0.5
Total Coliform	160	50

The water treatment plant at rest area 306 B has a treatment configuration system with coagulation – flocculation process. In general, coagulation functions to destabilize colloidal or dissolved particles in the water, followed by the flocculation process to form larger floc particles that can be settled. The separation of floc can be done by sedimentation, flotation, or filtration methods. The use of coagulant in the coagulation – flocculation process affects the pH and total dissolved solid parameters in the water. These parameters need to be closely monitored and must comply with the Minister of Health Regulation Number 2 of 2023. Controlling pH and total dissolved solid will influence other parameters.

2. Objective

The objectives of this research are as follow :

1. To identify the relationship between aluminium sulfate and poly alumnium chloride coagulant on pH and total dissolved solid at water treatment plant of rest area 306 B terbanggi besar – pematang panggang – kayuagung tollroad.
2. To provide recommendation for the best coagulant option for coagulation process according to pH and total dissolved solid monitoring.
3. To identify coagulant that meet with minister of health regulation number 2 of 2023

3. Review Literature

1. Clean water quality standards
   According to Minister of Health Regulation Number 2 of 2023 that concerned about clean water quality standard. It has been arranged that each parameter has own threshold to define the water it's safe to use and not contamined.
2. Water treatment plant research According to implementation report of STP – WTP combined 20 ft research product that hold by system division at PT. Hutama Karya (Persero). It's been reported the

daily monitoring of pH and total dissolved solid with each coagulant poly aluminium chloride and aluminium sulfate

4. Methodology

This research was conducted using quantitative methods, obtained through data collection with daily monitoring each coagulant that affect on pH and total dissolved solid, literature such as journal, previous research, government policies or regulation, and book relevant to the study. The analysis method in this study using simple liner regression with independent and dependent variables. There are 2 independent variables and 2 dependent variables, which are input to Microsoft excel that will determine the relationship between the poly aluminium choride and aluminium sulfate on pH and total dissolved solid parameter. There are limitation area of study : (1) This study hold in water treatment plant of terbanggi besar – pematang panggang – kayuagung tollroad ; (2) Coagulant that will be observed are aluminium sulfate and poly aluminium chloride ; (3) Tools to detect pH and total dissolved solid using water quality tester ; (4) The coagulant dosage uses is the result of a jar test conducted by the field implementation team for both poly aluminium chloride and aluminium sulfate coagulants.

5. Analysis and Discussion

5.1 Coagulation Process On Water Treatment Plant At Rest Area 306 b Terbanggi Besar – Pematang Panggang – Kayuagung Tollroad

The use of the coagulation – flocculation system at the water treatment plant in rest area 306 B employs a reaction tank with a size of 1 m^3 for a flow rate of 25 m^3/day. In practices, the optimal coagulant dosage is first determined using a jar test. The jar tes is an experiment to obtain the optimum dosage using coagulant chemicals in the water treatment process. The jar test has three stages in it's testing. Stage 1 involves rapid mixing (flashmixing) and the addition of coagulant to destabilize colloida or inorganic particles. Then, stage 2 slow mixing is carried out, and auxiliary material in the form of ionic polymer flocculants can be added. And the last stage for sedimentation type II, which functions to settle floc particles by forming larger aggregates. The separation process is carried out in a clarifier tank with a tube settler to increase the sedimentation rate with size of the clarifier tank is 3.4 m^3.

Table 2: Coagulant Dosage On Jar Test Experimental

No	Chemical	Dosage (ppm)
1	Poly Aluminium Chloride	20
2	pH Adjuster	-
3	Floculant	2
4	Chlorine	20

In this study will be using poly aluminium chloride as the result that has been investigate as effective and efisient coagulant on coagulation – flocculation process.

5.2 Experimental Result

The test result were conducted during the period for 18 October 2023 to 22 November 2023. There were times when the water treatment plant could not be used to due to repairs on the pipe from the reaction tank to the second sedimentation tank. Below are the summarized result of pH and total dissolved solid using poly aluminium chloride and aluminium sulfate coagulant.

Figure 1: Experimental Result On Total Dissolved Solid Parameters

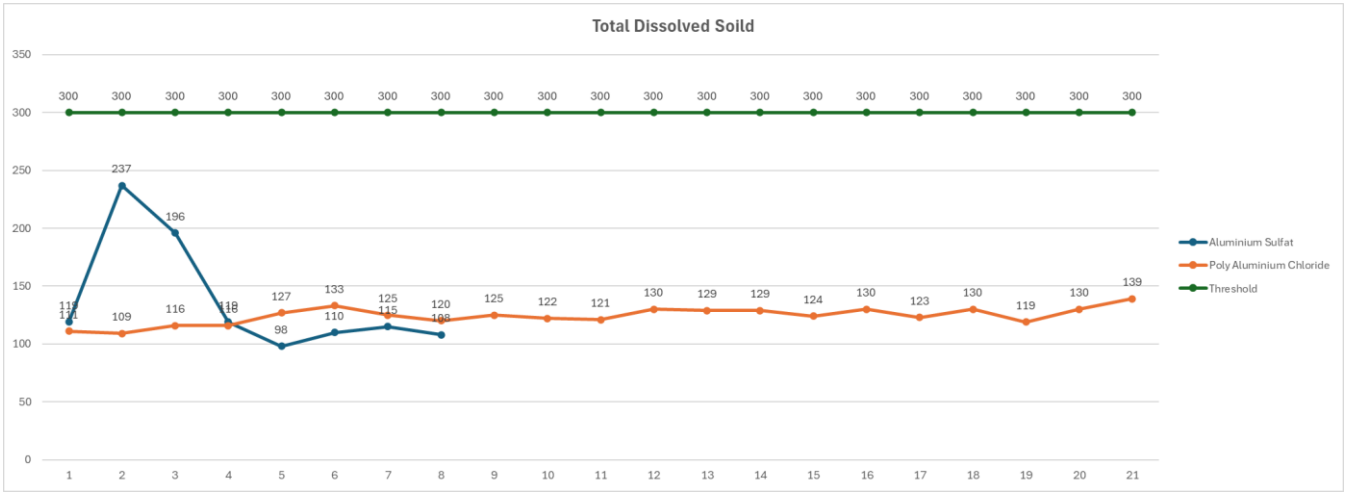


Figure 2: Experimental Result On pH Parameter

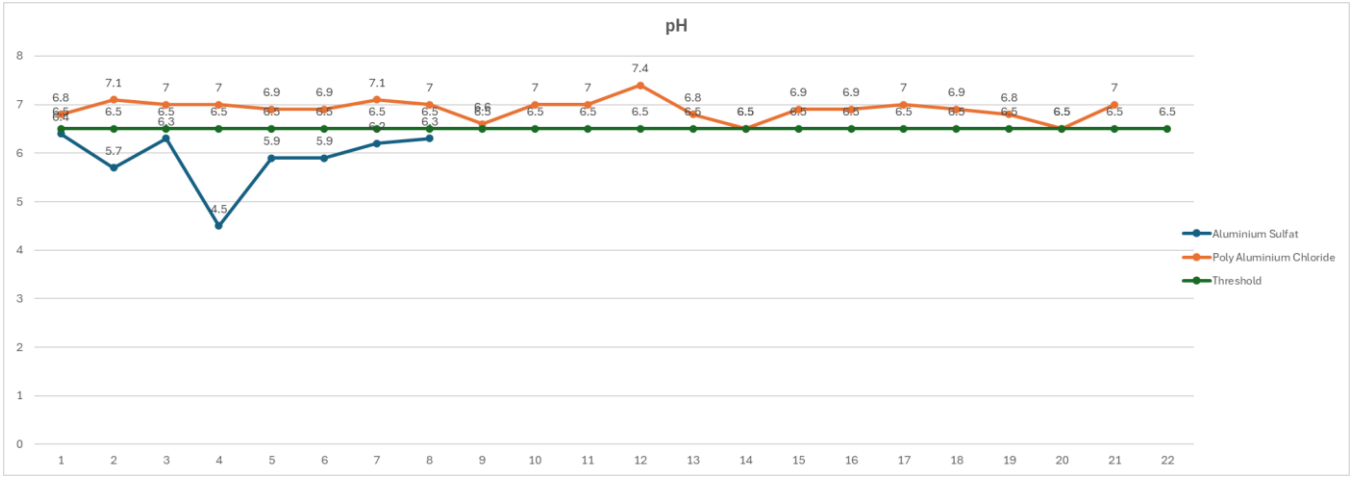


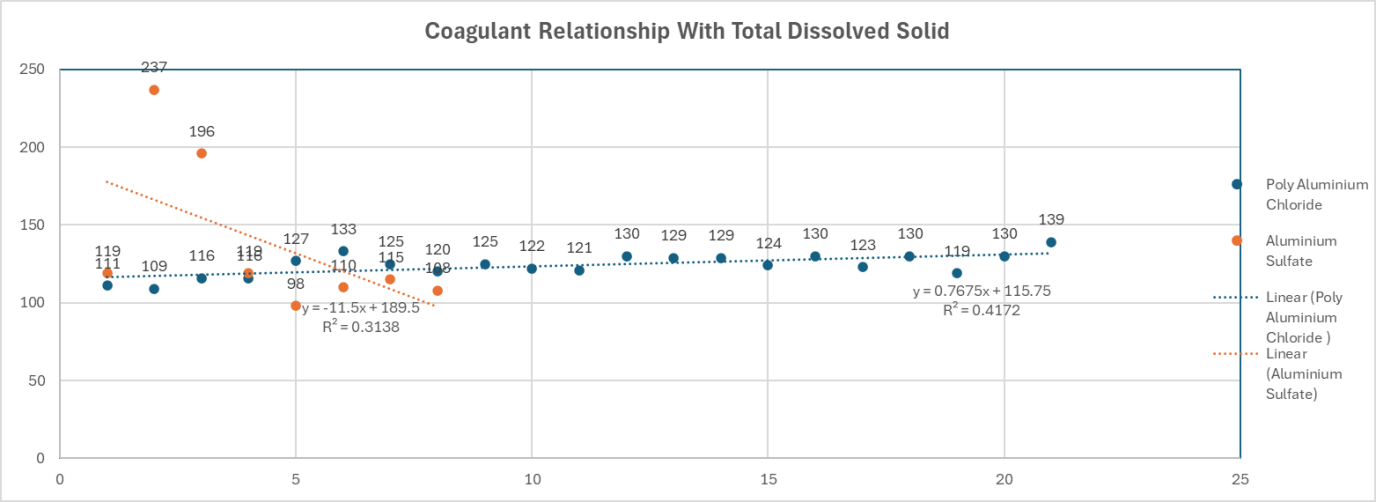
Table 3: Summary Poly Aluminium Chloride and Aluminium Sulfate Experiment

No	Coagulant	Parameter	
		Total Dissolved Solid	pH
		Average	Average
1	Poly Aluminium Chloride	124.2	6.9
2	Aluminium Sulfate	137.8	5.9
3	Deviation Percentage (%)	9.8%	14.6%

Based on Figure 1, it can be seen that the total dissolved solid (TDS) value for poly aluminium chloride is 139 mg/l, while for aluminium sulfate is 237 mg/l. The average total dissolved solid deviation for these two coagulant is 9.8 %, with aluminium sulfate having a higher total dissolved solid. The data range for poly aluminium chloride with the total dissolved solids parameter is 109 mg/l – 139 mg/l and pH 6.5 – 7.4, compared to the data range for alumnium sulfate coagulant with the total dissolved solid parameter being 98 mg/l – 237 mg/l and pH 4.5 – 6.4. The data distribution is used to find the relationship or correlation between the coagulant data and the total dissolved solid and pH parameter. Below is the data

distribution for aluminium sulfate and poly aluminium chloride with respect to total dissolved solid parameter.

Figure 3: Coagulant Relationship With Total Dissolved Solid



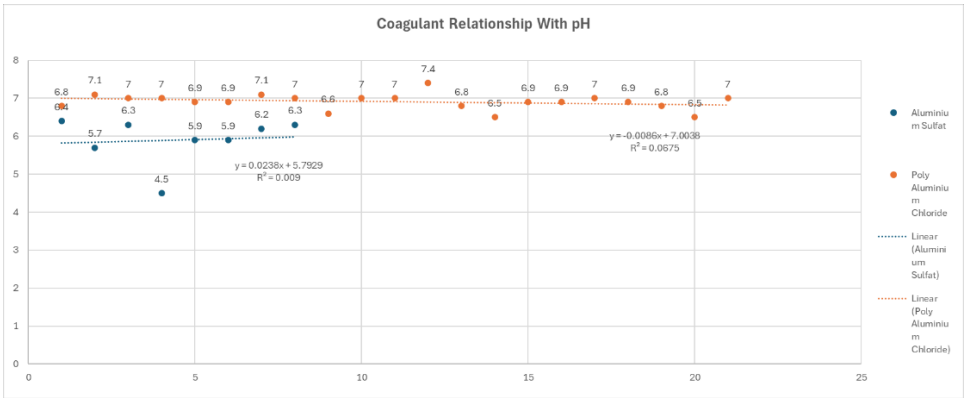
The determination of the correlation between coagulant and the total dissolved solid and pH parameter can be seen in **Figure 3** and interpreted using the linear regression method. This method is a statistical analysis technique used to predict the relationship between two or more variables. Based on the linear regression data, the equation for poly aluminium chloride coagulant with total dissolved solid parameter is as follow.

$$y = 0.7675x + 115.75 \quad (1)$$

$$R^2 = 0.4172 \quad (2)$$

The R Square obtained between the relationship of aluminium sulfate coagulant to total dissolved soliid parameter reached 31.38 % and for poly aluminium chloride it reached 41.72 %. Thus, the independent variable explains the dependent variable to a relatively small extent. The significant range of total dissolved solid is due to the ineffective dosage of the coagulant in achieving the same quality standards as the use of poly aluminium chloride coagulant. Additionally, there is and indication that the coagulant is not fully dispersed in the water and form flocs, resulting in high total dissolved solid values.

Figure 4: Coagulant Relationship With pH



The determination of the correlation between aluminium sulfate and poly aluminium chloride on pH can be seen ini **Figure 4**. The relationship was determined using the linear regression method and the equation for the poly aluminium chloride coagulant with respect to the pH parameter is as follow.

$$y = 0.0086x + 7.0038 \quad (3)$$

$$R^2 = 0.0675 \quad (4)$$

The low R Square percentage of 0.9 % for aluminiums sulfate and 6.75 % for poly aluminium chloride indicates that the independent variables cannot explain the relationship with dependent variables. Based on the test data, pH and total dissolved solid have varying characteristics depending on the coagulant used, For the pH parameter, aluminium sulfate has more acidic with pH between 4.6 – 6.5. This cause the raw water pH to drop. Therefore, a buffering process with H^+ ions (hydroxide) is needed during implementation. On the other hand, poly aluminium chloride is an organic polymer aluminium salt that easy to implementation. It was also found that the pH and total dissolved solid still meet the quality standard according to Minister Health Regulation Number 2 of 2023 are the poly aluminium chloride. Therefore, an evaluation can be carried out on parameters iron. The water test result showed that the iron value exceeded the quality standard, which is 1.6 mg/l. After the water treatment process using the coagulation – flocculation unit with poly aluminium coagulan, a removat efficiency of 98.13 % was obtained with iron parameter reduce to 0.03 mg/l.

Table 3: Iron Efficiency Removal

	Iron (Fe) Mg/L	**Removal**
Raw Water	1.6	98.13 %
Treatment Result	0.03	

6. Conclusion

From the evaluation result the relationship between poly aluminium chloride and aluminium sulfate on pH and total dissolved solid. It was found, the average values of these parameter meet the quality standards according to Minister Health Regulation Number 2 of 2023. Furthermore, the use of poly aluminium chloride can provide removal of 98.13 % iron parameter.

Reference

1. Ministry of Health of The Republic Indonesia. (2023). Ministerial Regulation No. 2 of 2023. Jakarta : Ministry of Health of the Republic Indonesia.
2. M. Akbari Zadeh, A. Daghbandan, and B. Abbasi Sourakki. (2022). Removal of Iron and Manganese From Groundwater Sources Using Nano-biosobernts. Chemical and Biological Technologies in Agriculture Volume 9 Number 1 P 3 2022. doi: 10.1186/s40538-021-00268-x.
3. M.E. Sutharsan, S. P. S. Meegahakumbura, and N.S. (2023). Removal of Manganese and Iron From Groundwater by Using Chlorination and Rapid Sand Filtration : A Case Study. Engineer : Journal of the Insitutiton of Engineers. Sri Lanka Volume 56 Number 2 PP 13 – 21 May 2023. doi: 10.4038/engineer.v56i2.7529.
4. M. Pivokonsky, K.Novotna, R, Petricek, L. Cermakova,M. Prokopova. And J. Naceradska. (2024).

Fundamental Chemical Aspect of Coagulation in Dringking Water Treatment – Bact to Basics. Journal of Water Process Engineering Volume 57 Januari 2024. doi: 10.1016/j.jwpe.2023.104660.

5. R. Mayasari. (2018). Optimalisasi Dosis Koagulan Aluminium Sulfat dan Poli Aluminium Klorida (PAC) (Studi Kasus PDAM Tirta Musi Palembang)
6. R.Masarari, M. Hastarina, and E. Apriyani. (2019). Analisis Turbidity Terhadap Dosis Koagulan Dengan Metode Regresi Linier (Studi Kasus di PDAM Tirta Musi Palembang). JISI : Jurnal Integrasi Sistem Industri Volume 6 Number 2 2019. doi: 10.24853/jisi.6.2.117-125.
7. SIT Division og PT. Hutama Karya (Persero). (2023). Laporan Implementasi Produk Hasil Riset STP – WTP Kombinasi 20 Ft. 2023
8. Z.Liu et al. (2019). Impact of Ai – Based Coagulant on The Formation of Aerobic Granutes : Comparison Between Poly Aluminium Chloride (PAC) and Aluminium Sulfate. Science of The Total Environment Volume 685 October 2019. doi: 10.1016/j.scitotenv.2019.05.306.