Ceramic Industry Wastewater Treatment by Chemical Coagulation Process

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Abstract
Ceramic industrial waste contains organic compounds and several heavy metals that exceed the quality standards of ceramic industrial wastewater, therefore the wastewater is treated using the coagulation method. This study uses a coagulant Poly Aluminium Chloride (PAC) with the aim to determine the effect of coagulant mass and stirring time on reducing the content of COD, TSS, lead metal (Pb), and colour. Starting with the waste mixed with PAC has been diluted with a concentration of 1%. Then stirred using a flocculator with a speed of 100 rpm and time (2, 4, 6, 8, and 10 minutes) to form floc. Then it is deposited and separated between the filtrate and the solids. Then the filtrate was analysed. With this analysis, it can be seen that the highest reduction efficiency of TSS levels was 99.9% with a coagulant volume of 12.5 ml at 6 minutes. The highest efficiency of COD levels was obtained at 98.23% with a coagulant volume of 15 ml at 6 minutes. The highest efficiency of waste colour reduction was 99.85% with a coagulant volume of 15 ml at 10 minutes and the efficiency of reducing Pb levels was 99.10% with a coagulant volume of 5ml at 2 minutes, all of which were below the quality standard ceramic industry.

***Keywords*:** *Coagulation, Poly Aluminium Chloride, Wastewater.*

Abstrak
Limbah industri keramik mengandung senyawa organik dan beberapa logam berat yang melebihi baku mutu air limbah industri keramik oleh karena itu air limbah tersebut diolah menggunakan metode koagulasi. Penelitian ini menggunakan koagulan Poly Aluminium Chlorida (PAC) dengan tujun untuk mengetahui pengaruh massa koagulan dan waktu pengadukan terhadap penurunan kandungan COD, TSS, logam timbal (Pb), dan warna. Diawali dengan limbah dicampurkan dengan PAC telah diencerkan dengan konsentrasi 1% lalu diaduk menggunakan flokulator dengan kecepatan 100 rpm dan waktu (2, 4, 6, 8, dan 10 menit) hingga terbentuk flok. Kemudian diendapkan dan di pisahkan antara filtrat dan padatannya. Kemudian dilakukan analissi filtrat. Dengan

analisa tersebut dapat diketahui efisiensi penurunan kadar TSS tertinggi sebesar 99,9% dengan volume koagulan sebesar 12,5 ml pada waktu 6 menit. Efisiensi kadar COD tertinggi didapatkan sebesar 98,23% dengan volume koagulan sebesar 15 ml pada waktu 6 menit. Serta efisiensi penurunan warna limbah tertinggi didapatkan sebesar 99,85% dengan volume koagulan sebesar 15 ml pada waktu 10 menit dan efisiensi penurunan kadar Pb didapatkan sebesar 99,10% dengan volume koagulan sebesar 5ml pada waktu 2 menit yang seluruhnya sudah sesuai di bawah baku mutu industri keramik.

Kata Kunci: *Koagulasi, Poly Aluminium Chlorida, Limbah Cair.*

1. Introduction

As technology advances in Indonesia, waste is a problem that needs special attention, Disposal of industrial waste is a problem that needs to be tackled appropriately and quickly, especially if the waste containing certain chemical compounds is a hazardous Au7nd toxic material. (Ichtiakhiri, 2015). This is because waste can have a negative impact on the surrounding environment. Inappropriate waste processing can cause environmental pollution which in turn will be harmful to human health, especially waste classified as hazardous and toxic materials. Like the waste in the ceramic industry (Sariadi, 2015).

Based on the results of the analysis of ceramic industrial liquid waste containing heavy metals namely Cadmium (Cd), Chromium total (Cr), and Lead (Pb). Industrial liquid waste is usually acidic or alkaline, old color with a high content of organic matter and contains synthetic materials that are difficult to decompose by microbes, so it has a high COD value. Some previous research on liquid waste treatment was conducted by coagulation-flocculation method and using several types of coagulants.

Research conducted by Pertiwi and Haryanto (2019), concluded that the method of coagulation flocculation with coagulant PAC was able to lower COD levels by a percentage of 46.80%-90.18%. In laundry liquid waste, after treatment obtained the result of a decrease in COD levels by 77.19%. This study used coagulation-flocculation method with rapid stirring of 100 rpm for 1 minute and slow stirring flocculation of 40 rpm with time variations of 5, 10, 15, 20, 25 minutes and determination of optimum mass of coagulants with variations of 0.25, 0.5, 0.75, 1, and 1.25 grams in 1 liter of detergent waste water synthesis. Pac coagulant dosage and stirring time were effective in lowering cod levels of detergent synthesis wastewater in this study was 1.25 grams in 15 minutes with a decrease of 90.18% because at that time and mass caused the formation of a perfect floc so that particles are easy to separate. (Pertiwi and Haryanto, 2019).

The development of the ceramic industry in Indonesia is increasing. The need for ceramics has greatly increased both for decoration, tiles and others. The main raw materials used for ceramic products are felspard, ballclay and sand, in addition to that also used a variety of other minerals such as salts and oxides (Amuda, 2006). One of the additives used to lower

the melting temperature and reaction temperature is lead oxide. The ceramic industry toousedye containing chromium. In addition to the process of producing ceramics, Glaze waste contains heavy metals that come from the coloring process, glaze coloring materials can be obtained from additional ingredients in ceramics (Samosir, 2017). It is also necessary to understand the process of processing ceramic waste, this is because every production process must be accompanied by the release of manufactured waste. (Austin, 1996).

Based on the analysis results of ceramic industrial wastewater containing heavy metals, namely Cadmium (Cd), total chromium (Cr), and lead (Pb). This industrial liquid waste is usually acidic or alkaline, dark in color with high organic matter content and contains synthetic materials that are difficult to decompose by microbes, so it has a high COD value. There are several kinds of processes for treating liquid waste, including Physical wastewater treatment processes include adsorption, screening, sedimentation and filtration processes. The process of treating wastewater chemically uses coagulation, flocculation, and neutralization processes. It should be noted that the large amount of hazardous waste contains waste management which is necessary and does not cause new waste, so a research on the ceramic industrial wastewater treatment is carried out using the coagulation method using the chemical coagulant Poly Aluminum Chloride (PAC) which is expected to reduce the levels of COD, TSS and the content of lead metal (Pb) is in accordance with the quality standards of ceramic industrial wastewater.

Coagulation is the process of changing a liquid or solution into soft or hard lumps such as a whole or only part of a gel. The coagulation process, coagulant and waste water will be mixed in a container or place and then stirred quickly in order to obtain an even mixture so that the clot formation process can occur evenly (Yuanita, 2015). The function of coagulation is to reduce turbidity due to the presence of inorganic and organic colloid particles in the water, reduce the color caused by colloid particles in water, reduce pathogenic bacteria in colloidal particles, and reduce the taste and smell caused by colloidal particles in water (Nuryani, 2016).

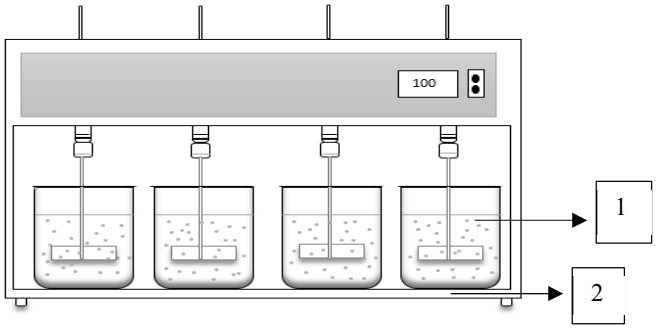
As the reaction is shown in the following equation:

$$Al_2(OH_5)\,Cl + H_2O \rightarrow 2Al(OH)_3 + H^+ + Cl^- \quad (1)$$

$$Pb^{2+} + 2Cl^- \rightarrow PbCl_2 \downarrow \text{ (White Sediment)} \quad (2)$$

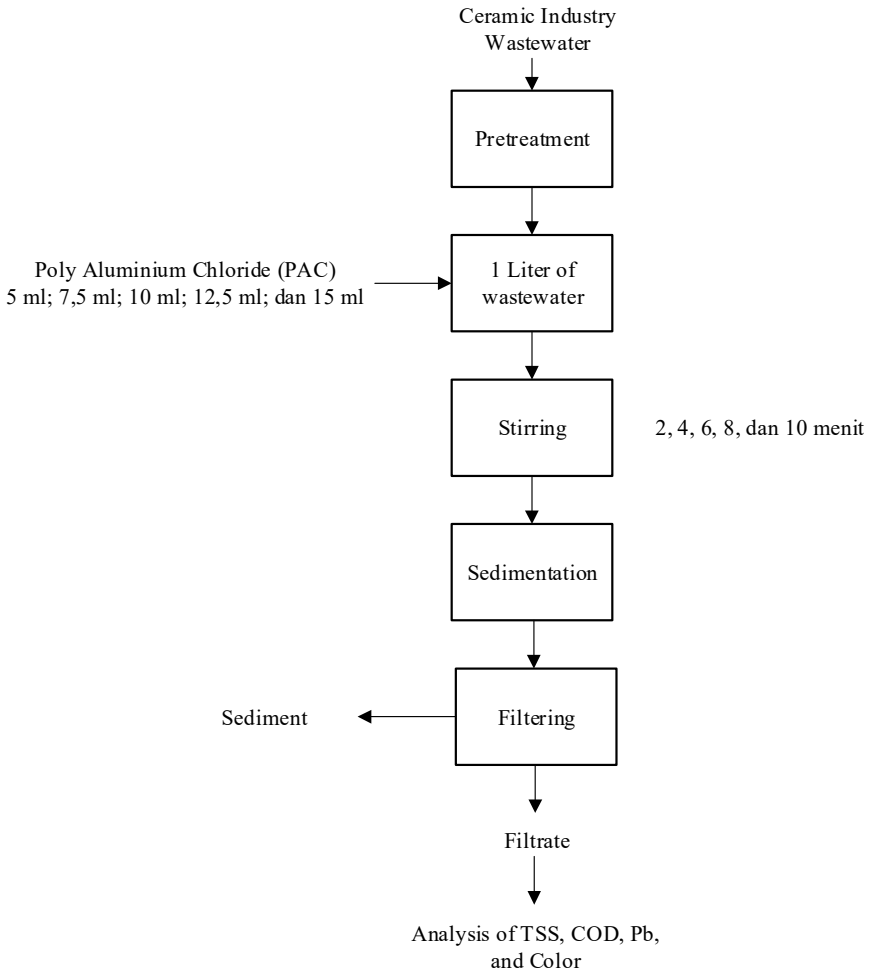
In the PAC coagulant, lead pollutants will be trapped in Cl- anion and lead cations will be absorbed in the lead chloride, a decrease in the metal content of Pb in waste occurs with the formation of white deposits that are insoluble in water, where lead (II) chloride or $PbCl_2$ is an inorganic compound. which is a white solid compound. This compound has a poor solubility level in water so it is insoluble. The solubility product constant (Ksp) is 1.7 × 10-4. This compound is one of the four insoluble chlorides, and other compounds. (Sari, 2019). Metal or Lead will precipitate and result in the binding of heavy metal Pb the metal concentration is getting smaller. So that the Pb content in the waste will decrease. (Cahyono, 2016).

2. Methodology



Where:
1. Beaker glass 2000 ml
2. Flocculator

Picture 1. Processing Tools



Picture 2. Research Flowchart.

In this research, the main material used is ceramic industrial wastewater. The coagulant used is Poly Aluminium Chloride (PAC). First, the preparation of raw materials (pre-treatment). The material to be tested is ceramic industrial wastewater in this pre-treatment to separate the sludge, then the waste is deposited for 1 day then its characteristics are analysed. The deposited filtrate is then used for chemical

waste treatment. Waste treatment uses the Poly Aluminium Chloride (PAC) coagulant. The coagulant was put into a beaker glass containing 1000 ml of liquid waste with a coagulant volume of (5 ml, 7.5 ml, 10 ml, 12.5 ml, and 15 ml). Furthermore, the stirring of the mixture was carried out at a speed of 100 rpm and the time varied for (2, 4, 6, 8, and 10 minutes) which was calculated since the addition of the coagulant. The mixture formed was then left to stand for 30 minutes then filtered using filter paper to separate the precipitate from the filtrate. Then the filtrate is taken for analysis TSS, COD, Pb, and Color.

3. Result and Discussion

Table 1 based on the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Waste Water Quality Standards, Waste Water Quality Standards or Ceramic Industry Activities are as follows:

Table 1. Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014

Parameter	Unit	Highest Rate
pH		6-9
COD	mg/l	300
TSS	mg/l	100
Cobalt (Co)	mg/l	0,6
Timbal (Pb)	mg/l	1,0
Kadmium (Cd)	mg/l	0,1
Krom Total (Cr)	mg/l	1,0
Highest Wastewater Quantity	m^3/ton materials	1,5

Source: Kusumaatmadja, 2014

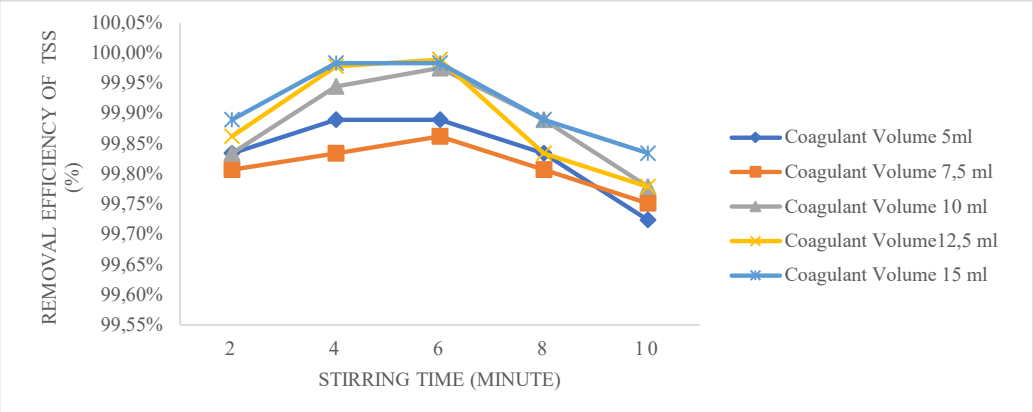
In research on chemical industrial wastewater treatment, we first conducted a test on ceramic industrial wastewater before processing with the following results:

Table 2. Results of Analysis of Ceramic Industry Liquid Waste Before Processing

Test Parameters	Unit	Test results	Test Method
COD	mg / liter	503.8	SNI 6989.2: 2009
Suspended Solids (TSS)	mg / liter	3620	SNI 06-6989.3: 2004
Lead (Pb)	mg / liter	1,775	SNI 6989.8: 2009
Color	PtCo unit	3418	SNI 6989.80: 2011

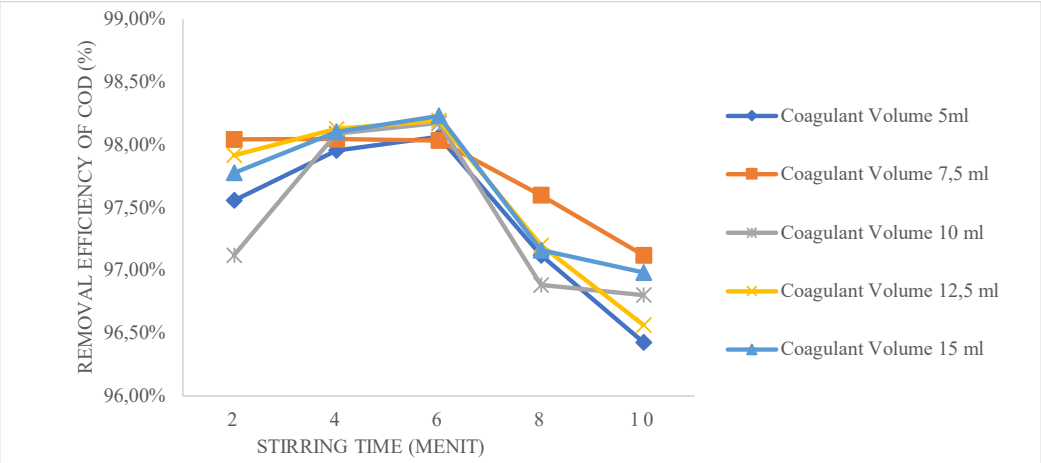
Source: Surabaya Industrial Research and Standardization Center, 2020

Based on the Table 2, it can be seen that from the results of the analysis, the liquid waste content of the ceramic industry has not met the quality standard of ceramic industrial waste water, so waste treatment must be carried out.



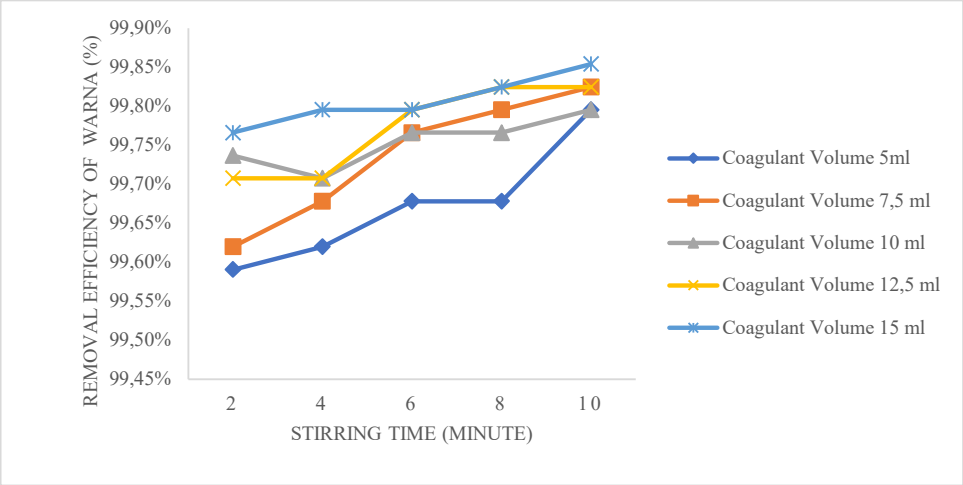
Picture 3. Removal Efficiency Of TSS (%) and Stirring Time (Minute) at Various Coagulant Volume

Based on Picture 3 shows that after processing the ceramic industrial wastewater with the addition of the PAC coagulant, TSS levels decreased. The highest result of the efficiency of reducing TSS levels was 99.9% at the coagulant volume of 12.5 ml and the stirring time of 6 minutes. This is because the greater the volume of the PAC coagulant added, the more positive charge is generated, the more floc is formed, so that the efficiency of reducing TSS levels will increase. The optimum stirring time was obtained to reduce TSS levels, namely the stirring time of 6 minutes. At 8 minutes and 10 minutes of stirring time, the efficiency of reducing TSS levels decreased due to the stirring speed of 100 rpm at the stirring time of 8 minutes and 10 minutes. refuse to reject between the positive charges of the particles so that the efficiency of reducing TSS levels even decreases because the floc that has been formed will split. The decrease in the efficiency of TSS levels is also influenced by the particle size and the shape of a particle. So the larger the particle size, the smaller the density between the PAC particles and the ceramic industrial wastewater causes TSS to not be removed optimally so that the efficiency of reducing TSS levels drops again.



Picture 4. Removal Efficiency Of COD (%) and Stirring Time (Minute) at Various Coagulant Volume

Based on Picture 4 shows that after processing the ceramic industrial wastewater with the addition of the PAC coagulant there was an increase in the efficiency of decreasing COD levels. Coagulation with PAC can reduce the COD value because some of the particles in the waste water have been bound and settled together with the coagulant, thereby reducing the number of particles in the wastewater. This decrease in COD is due to the floc formed by the ions of organic compounds associated with positive coagulant ions. By decreasing the number of particles, the oxygen needed to oxidize organic compounds also decreases, so that the COD value after coagulation is also low (Pertiwi and Haryanto, 2019). The highest reduction efficiency in COD levels was 98.23% at 6 minutes with a volume of 15ml PAC coagulant. In the results of previous research, COD decreased efficiency was 90.18% can be concluded with the dose and processing of this research get greater removal efficiency. The efficiency of COD levels fluctuates in value, that is, it increases and decreases again. The decrease in efficiency of COD levels occurred after the stirring time was more than 6 minutes, this was because the coagulant had a saturation point, where the volume and time of stirring could no longer break down the contaminants contained in the wastewater.



Picture 5. Removal Efficiency Of Warna (%) and Stirring Time (Minute) at Various Coagulant Volume

Based on Picture 5 shows that after processing the ceramic industrial wastewater with the addition of the PAC coagulant , The efficiency of color content decreases increasingly along with the increase in stirring time and coagulant volume. This decrease is due to the formation of larger floc-flok and many consequences of the gravitational force exerted by greater coagulants. In addition to the volume of coagulants 15 ml and stirring time 15 minutes obtained efficiently decreased color content by 99.85%, at the volume of coagulants and stirring time obtained the highest efficiency of color content reduction. This is because at the time of stirring and the volume of coagulants produces a lot of large floks so it is very easy to settle and the filtrate obtained is very clear.

Table 3. Effect of Stirring Time and Coagulant Volume on Pb Levels

Time (minutes)	Initial levels of Pb (mg / L)	Removal Efficiency of Pb (%)				
		Coagulant volume 5 ml	Coagulant volume 7.5 ml	Coagulant volume 10 ml	Coagulant volume 12.5 ml	Coagulant volume 15 ml
2	1,775	99.10%	99.10%	99.10%	99.10%	99.10%
4	1,775	99.10%	99.10%	99.10%	99.10%	99.10%
6	1,775	99.10%	99.10%	99.10%	99.10%	99.10%
8	1,775	99.10%	99.10%	99.10%	99.10%	99.10%
10	1,775	99.10%	99.10%	99.10%	99.10%	99.10%

Based on Table 3, the addition of the volume of 5ml PAC coagulant and 2 minutes of stirring time can reduce the initial Pb level before the addition of the coagulant by 1.775 Mg/ Litre to <0.016 Mg/Litre when the addition of PAC coagulant. Pb levels <0.016 Mg/Litre, which means that the efficiency of reducing Pb levels was 99.10%. This result is the best result in Pb testing and is in accordance with the Pb quality standard for lead. This means that the PAC coagulant can reduce the Pb level in the liquid waste. The reduced Pb content in the ceramic industrial wastewater is caused by because the Cl^- and OH^- groups in PAC cause these two ions to be able to bind Pb in the waste.

4. Conclusion

Based on the research results, it can be concluded that the volume of PAC coagulant and stirring time which is effective in reducing TSS, COD, Color, and Pb levels of ceramic industrial wastewater in this study is 10 ml and the stirring time is 6 minutes. This is because in these conditions the levels of TSS, COD, Color, and Pb can be reduced according to the wastewater quality standards.

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