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Optimization of the coagulation flocculation process of Benowo Landfill using poly aluminum chloride and chitosan

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ABSTRACT

The content of organic material which is not easily degraded in Benowo landfill leachate is quite high and it makes microorganisms difficult to degrade waste. One of the methods that can be used to reduce organic load is by optimizing the processing of coagulation flocculation using PAC coagulant and chitosan flocculant. This study aims to reduce the concentration of COD (Chemical Oxygen Demand), TSS (Total Suspended Solid) and turbidity in the leachate. The variations that used in this study are the concentration of PAC (Poly Aluminum Chloride) coagulant and concentration of chitosan flocculant. The advantages of using coagulation flocculation is to reduce the organic load of leachate as well as removing suspended solids to make further processing is easier. The coagulation process operate on 260 rpm for 1 minute and 50 rpm for 20 minutes using PAC and chitosan because coagulants and flocculants are faster in floc formation and can reduce organic particles in leachate. The results showed the highest efficiency of COD, TSS and turbidity at dose of PAC coagulant 2400 mg / L with 350 mg / L chitosan flocculants are 71%, 45%, and 94%.

Key words : *Benowo landfill, Coagulation, Flocculation, Chitosan, PAC coagulant.*

Introduction

Leachate of Benowo sanitary landfill has a very complex content due to the diverse composition of waste that enters the landfill. The concentration of organic matter in the leachate shows a high value, as a result of waste decomposition and also comes from the infiltration process of runoff water (Susanto *et al.,* 2004). Leachate treatment at the Benowo landfill currently uses AOP (Advanced Oxidation Process) and NF (Nano Filter), this AOP-NF creates strong oxidation with great energy for the help of electric power with certain voltage and frequency. AOP in the Benowo landfill uses peroxide, ozone and UV oxidizers where the cost of the chemicals compounds are expensive and the efficiency will be reduced if there are carbonates and bicarbonates in the leachate. When turbidity is high, the efficiency will be reduced when using UV as an oxidizer. And if TDS value is high the use of NF can be interrupted resulting in blocking.

The salinity content of the leachate's Benowo landfill is in the category of brackish water, which can affect the activity of microorganisms, so there is an imbalance of fluid concentration in the microorganism cells due to the collapse of the cell wall

(Kargi and Dincer, 1996). These factors can be bad for the environment if the levels exceed the quality standards. The Benowo landfill which accommodates various types of waste every day can produce a large amount of leachate. High organic content can interfere with the activity of microorganisms in degrading waste which cause the biological process will be not effective to apply. In general, leachate has a very low BOD5/COD ratio (<0.4). Benowo landfill has a BOD5/COD ratio between 0.2-0.4 (Maghriba, 2010). Low BOD5/COD values make biological processing will be difficult to process (Rezagama *et al.,* 2016). So in this study, it will be done with physical-chemical processing.

Materials and Methods

Sampling method

The sampling method of Benowo landfill leachate uses the grab sampling method, in the collecting pool before the leachate undergoes processing and goes to the next processing site. Sampling is taken in the rainy season. During the rainy and dry season, there is temperature differences which can cause microorganisms in leachate degrading having different optimum growth temperatures (Wall and Zeis, 1995). This will affect the quality of the leachate characteristics.

Experimental set up

The experiment begins by determining the initial characteristics of the leachate. Leachate samples used were 1000 mL. The coagulation speed used was 260 rpm for 1 minute. The flocculation coagulation process uses a jar. In the coagulation process, PAC coagulant is applied in various doses when flocculation chitosan is added at a speed of 50 rpm for 20 minutes. The next process through the sedimentation stage. In this process, the flocs that have formed will settle completely after 30 minutes. Supernatants that have been separated from the sediments will be analyzed to determine the reduction in COD, TSS concentrations and turbidity. In this study the analytical method used was COD with closed reflux using macherey-nageldegester, TSS with gravimetry using a binder oven, turbidity with the H1887703 hanna turbidimeter, salinity with salinometer, and pH with potentiometry using eutech expert pH.

Results and Discussion

Leachate concentration produced from the Benowo landfill is between 500-3000 mg/L and above the quality standard (Iraya, 2015). Leachate characteristics measured included several parameters (Table 1). BOD/COD ratio value = 0.2, indicates that organic matter in leachate is difficult to be degraded by microorganisms. COD, TSS, and turbidity values are above the quality standard. Physical characteristics of leachate is blackish brown. While the pH is still in the range of 8.4 that still fulfil the quality standards. Leachate treatment can simply use the coagulation flocculation process. Coagulation flocculation process is included in the physical chemical processing using coagulants / flocculants to destabilize particles and increase floc formation. In this experiment, determining the optimum dose of parameter removal using PAC coagulants. Treatments carried out in 500 mL leachate varied with PAC doses of 1000-2600 mg/L.

Table 1. Leachate Characteristic

Parameter	Value	Standard*	Unit
pH	8,4	6-9	
BOD	773	150	mg/L
COD	3680	300	mg/L
TSS	212	100	mg/L
Turbidity	165	-	NTU
Salinity	6,46		ppt

*) Per Men LH No 59, 2016 about Leachate Standar Quality

The optimum dose of PAC obtained when added PAC at a dose of 2400 mg/L and can remove 63% COD, 57% TSS and 93% turbidity that shown in Figure 1. The higher COD value, the higher the level of pollutants in the waste. Elimination using PAC can remove COD concentration to 1360 mg/L with 63% removal efficiency. When in that conditions, organic ions have binded with coagulant ions to form floc which finally settles well (Harwiyanti, 2015). Efficiency that has not reached maximum condition, is caused by fewer PAC cations than colloidal particles, whereas PAC adsorption by colloidal particles is greater. In condition Leachate solution is saturated, there is destabilization of particles where the coagulant can no longer bind to the colloids in the leachate. This resulted causes decrease in COD efficiency and COD concentration raise again.

The highest allowance is achieved when affixing a PAC dose of 2400 mg/L. The characteristics of the leachate after the coagulation-flocculation process showed the yellowish clear color of the blackish brown leachate. Colloidal particles that have formed flocs can settle completely after the process of sedimentation for 20 minutes. So the efficiency of the resulting TSS is higher. The efficiency of TSS at a dose of 2600 mg/L decreased due to absorption of more cations by colloidal particles resulting in particle restabilization or deflaculation. Particles are in stable condition again. So that not all particles can bind and settle properly. There are still particles that cannot be deposited by the force of gravity, resulting in some particles being held back by the filter medium

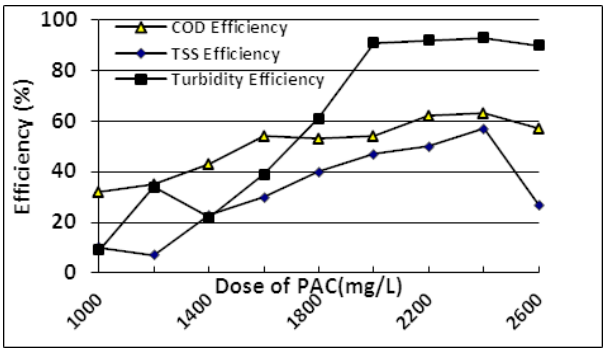

Fig. 1. Removal Efficiency of COD Parameter, TSS and Turbidity after Added PAC Coagulant

PAC is effective in reducing turbidity and hydrolysis reaction occurs to form dissolved aluminum compounds and can neutralize the surface of negatively charged colloidal particles so the coagulation process occurs (Wityasari, 2015). The optimum turbidity efficiency at a dose of PAC 2400 mg / L can produce removal until 93%. Turbidity can be caused by organic or inorganic matter which is suspended in the waste (Reynolds and Richards, 1996). If the turbidity efficiency decreases due to excessive absorption of cations by colloidal particles there will be repulsive forces between particles resulting in the floc not forming into a turbid solution (Rachmah, 2013). The addition of PAC at doses of 1000 to 2600 mg/L increase of salinity value from 7.04 to 7.9 ppt as the dose increases.

The concentration of leachate salinity before the flocculation coagulation process is included in the brackish water category. This is because, the condition of the Benowo landfill surrounded by ponds. it causes seawater instruction in the leachate. Based on the results of the leachate salinity test,sanility value after the flocculation coagulation process has increased. This increase can be caused by the addition of PAC coagulants. PAC is a special chloride base salt to provide stronger and better coagulation and flocculation power than ordinary aluminum and iron salts. The presence of chlorides in PAC compounds increases the salt content in the leachate. Increased salinity concentration is from 6.46 ppt to 7.93 at a dose of PAC 2400 mg/L. The coagulation process of flocculation with PAC coagulants cannot reduce salinity concentration, so another coagulant is needed in order to reduce salinity concentration in the leachate.The coagulation flocculation process is influenced by several factors of turbidity, suspended solids, coagulant dosage, composition and concentration of the ratio and anion, temperature and pH (Masduqi, 2012).

pH (Power of Hydrogen) is the degree of acidity to determine the levels of acid or base in a solution. Leachate condition after the addition of PAC coagulant to pH tends to be neutral (7.6). PAC coagulant does not make the pH conditions drop dramatically like other coagulants. PAC in the hydrolysis reaction only releases one H^+ ion. So, the leachate is not acidic like aluminum sulfate which releases $6H^+$ which can cause it to be more acidic (Budiman *et al.*, 2008).

Alkalinity affects the pH present in a solution. Alkalinity affect the capacity of water to maintain pH, the higher the alkalinity, the lower the pH of the liquid. The pH condition is influenced by alkalinity because alkalinity is an indicator of pH buffering capacity. The concentration of alkalinity along with the high pH in the leachate. PAC coagulants can take alkalinity, where aluminum chloride salts will release hydrogen ions which can neutralize alkalinity so that it can reduce the pH of treated water (Gebbie, 2005). The organism will survive when the alkalinity is between 30-500 mg/L $CaCO_3$ (Putra *et al.*, 2014).

The coagulation flocculation process in this experiment is also carried out by coagulation-flocculation with the addition of chitosan flocculants after the coagulation process with PAC. The function of coagulants is as positive charge donors to destabilize negative charge particles. While the function of flocculants is as a binder to the clots formed due to the addition of flocculants, so the clots (flocks) are larger. Addition of chitosan flocculant is as an addi-

tion of cations in leachate which will later add positive ions to bind more colloids to the leachate. Chitosan can reduce suspended inorganic and organic particles and dissolved organics in wastewater (Renault *et al.*, 2009). Chitosan has amine and hydroxyl groups which are useful as electron donors, therefore chitosan is reactive and cationic polyelectrolytes and includes long-chain polymers (Sinardi, 2013). After obtaining the optimum dose of the flocculation coagulation process with PAC, variations in chitosan flocculants are carried out.

PAC coagulant was applied as much as 2400 mg / L with variations of chitosan from doses of 200-450 mg/L in 1000 mL leachate. Based on Figure 2, the greatest efficiency is when the chitosan dose is 350 mg/L. PAC coagulant with chitosan flocculant produces efficiency for COD parameters and increases turbidity rather than just the addition of PAC coagulant. The removal efficiency of using PAC and chitosan can remove 71% of COD and 94% of turbidity. The increase in efficiency is caused by polycationic chitosan which has hydroxyl groups and amines along the polymer chain (Shapira *et al.*, 2017) Chitosan dose of 350 mg/L makes the repulsive force between particles weakness. The particles will be close together and join the flocculants to form floc until they reach optimum conditions (Saputra, 2015). However, if the addition of excessive chitosan it will occur the particle restabilization

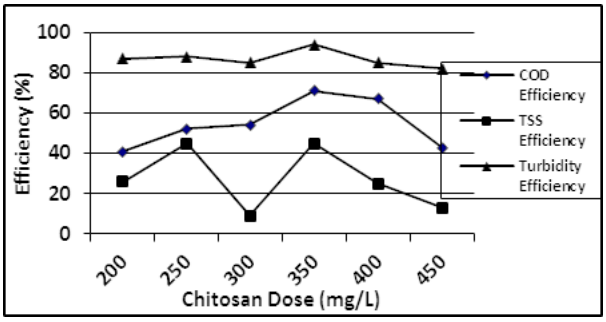

Fig. 2. Removal eficiency of PAC coagulant and Chitosan flocculant against COD, TSS and Turbidity Parameters

process. Chitosan overdose can cause reversal of the charge so the particles will be stable again.

TSS removal efficiency reaches 45% when the optimum dose of chitosan. The efficiency of TSS resulting from the use of PAC coagulants has greater results than the addition of PAC coagulants and chitosan. This can occur, when the application of chitosan is not in optimum condition, the pH of chitosan makes the flocculant not completely dissolved in the leachate. Colloid particles are not entirely bound and form an aggregate that can settle perfectly. The pH condition after the addition of chitosan is dropped again to 7.2. This decrease in pH is due to the presence of cationic protein in chitosan (Hendrawati, 2007). The following is a salinity chart after adding PAC coagulants and chitosan flocculants.

The salinity concentration after the addition of PAC and chitosan at the addition dose of PAC coagulant in 2400 mg/L and chitosan flocculant 350 mg/L is 7.89 ppt (Table 2). Salinity conditions with these values are classified as brackish water salinity (Purwanti, 2006). It can be seen that the leachate supernatant from the flocculation coagulation process is included in the category of leachate with low salt content or can be called a low concentration of brackish leachate. And, leachate condition after the addition of PAC coagulant and chitosan flocculant to pH tends to be neutral (7.4). PAC coagulant and chitosan flocculant are not effective in reducing salinity concentration in the leachate.

Table 2. Salinity and pH Concentration after added PAC and Chitosan

No	PAC Dosage (mg/L)	Chitosan Dosage (mg/L)	Salinity (mg/L)	pH
1	2400	200	7,88	7.4
2	2400	250	7,55	7.3
3	2400	300	7,72	7.4
4	2400	350	7,82	7.2
5	2400	400	7,89	7.4
6	2400	450	7,92	7.4

Conclusion

The results showed the highest efficiency of COD, TSS and turbidity at dose of PAC coagulant 2400 mg /L with 350 mg/L chitosan flocculants are 71%, 45%, and 94%.

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