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Treatment for Landfill Leachate Utilize Coagulation-Flocculation Combined with Biofilter

Pengolahan Air Lindi Menggunakan Koagulasi-Flokulasi Terpadukan Biofilter

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ABSTRAK

Air lindi yang dihasilkan dari Tempat Pemrosesan Akhir (TPA) Sampah mengandung bahan organik dan nutrient yang tinggi. Metode koagulasi-flokulasi terpadukan biofilter aerobik-anaerobik merupakan salah satu alternatif teknologi untuk pengolahan air lindi. Penelitian bertujuan untuk mengkaji efisiensi kombinasi koagulan $Al_2(SO_4)_3$ *dan* $FeCl_3$ *pada proses koagulasi-flokulasi terpadukan biofilter dalam penurunan kadar* Biological Oxygen Demand *(BOD) dan* Total Suspended Solid *(TSS) pada pengolahan air lindi TPA. Metode pengumpulan data dilakukan dengan cara metode eksperimen air lindi dengan dua langkah pengolahan, yaitu koagulasi-flokulasi dan dilanjutkan dengan biofilter secara aerobik dan aerobik. Koagulan yang digunakan yaitu aluminium sulfat dan ferri klorida dengan variasi komposisi 12 g/L:3 g/L (R.K1), 12 g/L:7 g/L (R.K2), 16 g/L:3 g/L (R.K3), dan 16 g/L:7 g/L (R.K4). Hasil penelitian didapatkan bahwa komposisi koagulan pada R4 mampu menurunkan konsentrasi BOD dengan efisiensi sebesar 87,99% dari konsentrasi 2.331 mg/L menjadi 280 mg/L dan konsentrasi TSS dengan efisiensi 81,48% dari konsentrasi 108 mg/L menjadi 20 mg/L. Manfaat dari penelitian ini yaitu menjadi alternatif yang mudah diterapkan untuk menurunkan tingkat polutan pada air lindi agar tidak mencemari lingkungan. Kedepan, masih perlu diupayakan inovasi teknik untuk dapat menurunkan BOD sesuai ketentuan baku mutu.*

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ABSTRACT

Landfill leachate contains high organic matter and nutrients. The coagulation-flocculation method integrated aerobic-anaerobic biofilter is one of the technological alternatives for leachate treatment. The research aimed to examine the effect of the combination of $Al_2(SO_4)_3$ and $FeCl_3$ coagulants on the coagulation-flocculation process integrated with biofilters. The data were collected from two-stage leachate experiments (coagulation-flocculation), followed by aerobic and anaerobic biofilter. The coagulants used are aluminum sulfate and ferric chloride with composition variations of 12 g/L:3 g/L (R.K1), 12 g/L:7 g/L (R.K2), 16 g/L:3 g/L (R.K3), and 16 g/L:7 g/L (R.K4). The results showed that the coagulant composition in R4 was able to reduce BOD concentration with an efficiency of 87.99% from a concentration of 2,331 mg/L to 280 mg/L and TSS concentration with an efficiency of 81.48% from a concentration of 108 mg/L to 20 mg/L. The benefit of this research is that it is an alternative that is easily applied to reduce the level of pollutants in leachate water so as not to pollute the environment. In the future, it is still necessary to seek technical innovations to be able to reduce BOD according to quality standards.

1. INTRODUCTION

1.1 Background

Blandongan Landfill, which is located in Bugulkidul District, Pasuruan City, East Java, with an area of ± 7.19 Ha, has been of concern for its surrounding environment. This landfill potentially receives of waste generated by Pasuruan City, an average volume of 81,284 kg/day. Currently, the leachate treatment process in the Blandongan Landfill consists of aerobic and anaerobic processes. However, the Blandongan Landfill leachate effluent test still does not meet the quality standards required by the (Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59 About Leachate Landfill Quality Standard and/or Activities of Landfill, 2016). Therefore, the current situation of leachate treatment process in the Blandongan Landfill may cause water, soil, and air pollution, which thus concerned with the improvement of its treatment process.

It has been known that Leachate has the characteristics of containing dissolved organic matter, inorganic macro components, and heavy metals (Sugito & Ratnawati, 2020). Organic compounds include aromatic hydrocarbon and phenols in groundwater, with very high concentrations of ammonium, heavy metals, and organic contaminants. In general, the main parameters used to describe the concentration of contaminants in leachate are levels of Chemical Oxygen Demand (COD) concentration, ammonia (NH_4-N), Suspended Solid (SS), Dissolved Solids (DS), heavy metals, and salts (Mojiri et al., 2021) which thus as target parameters for leachate treatment.

Alternative technologies for leachate treatment are quite diverse, including physical, chemical, and biological treatment. Physical-chemical treatment is considered more effective. It can be completed in a shorter time than biological treatment. The most commonly used leachate treatment methods are coagulation-flocculation, adsorption, membrane processes, and oxidation methods (Rasool et al., 2016). Treatment by the coagulation-flocculation process is a method that can be used to treat leachate. The process is simple, reliable, low cost, and commonly used with low energy consumption. Coagulation involves the addition of a coagulant for conditioning suspensions, colloids, and solutes for further processing by flocculation. Flocculation is the aggregation of stable particles and precipitate products formed by the addition of coagulant into larger particles known as flocculant particles or more commonly called floc. Furthermore, an aggregated floc can be removed by gravity sedimentation and/or filtration (Reddy et al., 2022).

A coagulant is the most popular material because they are economical, easily available in the market, and easy to store are aluminum sulfate and ferric chloride. Research conducted by Reddy et al. (2022) showed leachate treatment using ferric chloride coagulant with a dose of 0.25% can reduce the COD and TSS values by 59% and 57%, respectively. Rezagama et al. (2016) conducted leachate processing at the Jatibarang Landfill Semarang City, Central Java, Indonesia, with coagulation-flocculation and ozonation. The results showed that the optimum dose of aluminum sulfate coagulant for leachate treatment was 16 g/L of which the removal efficiency of BOD, COD, and TSS parameters were 68%, 74%, and 48%, respectively. Sayuti et al. (2015) stated that the effective dose of ferric chloride coagulant in reducing COD levels of batik wastewater was 4.5 g/L, where the efficiency of reducing COD levels was 70.96%.

On the other hand, the use of zeolite as a biofilter media is also possible because of the potential for zeolite to be quite common as an adsorbent and from its fairly rough (Ratnawati & Sugito, 2021). Besides, irregular rock structure can be used as a biofilter medium. Thus, to overcome the problem of leachate in the Blandongan landfill, integration of processing is probably needed so that the treated leachate can approach the specified quality standard. The use of various combinations of coagulants reduces BOD and TSS parameters in leachate. Research on leachate treatment physically-chemically combined with biology still need to be completed. Therefore, this research aims to examine the effect of the combination of $Al_2(SO_4)_3$ and $FeCl_3$ coagulants on the coagulation-flocculation process integrated with biofilters.

1.2 Objective

This research aims to examine the effect of the combination of $Al_2(SO_4)_3$ and $FeCl_3$ coagulants on the coagulation-flocculation process integrated with biofilters.

2. METHODS

This study is experimental research with a continuous system where, in principle, leachate is flowed into the reactor in two stages, namely the coagulation-flocculation process, then followed by an aerobic-anaerobic biofilter process using zeolite media.

Data collection was carried out utilizing the leachate experimental method with coagulation and biofilter processing based on variations in the concentration of the coagulant used, namely ($Al_2(SO_4)_3$) and $FeCl_3$. The combination variations used in this study consisted of: R.K1 (12 g/L ($Al_2(SO_4)_3$) and 3 g/L $FeCl_3$), R.K2 (12 g/L ($Al_2(SO_4)_3$) and 7 g/L $FeCl_3$), R.K3 (16 g/L ($Al_2(SO_4)_3$) dan 3 g/L $FeCl_3$), and R.K4 (16 g/L ($Al_2(SO_4)_3$) dan 7 g/L $FeCl_3$). The detailed combination of these variations is shown in Table 1.

Table 1. Experiment condition

Reactor Code	Doses of $Al_2(SO_4)_3$) g/L	Doses of ($FeCl_3$) g/L
R.K1	12	3
R.K2	12	7
R.K3	16	3
R.K4	16	7

The design of the research reactor for the treatment of leachate at the Blandongan Landfill by coagulation-flocculation and biofilter aerobic-anaerobic is presented in Figure 1. The reactor used 4 glass tanks with detailed coagulation (Figure 1-a), flocculation (Figure 1-b), biofilter aerobic (Figure 1-c), and biofilter anaerobic (Figure 1-d), which were combined into one process with total dimensions of 80 cm x 20 cm x 25 cm. The coagulation reactor in tanks with dimensions of 20 cm x 20 cm x 25 cm was carried out with a stirring speed of 100 rpm for 2 minutes. In tanks-a, coagulant aluminum sulfate ($Al_2(SO_4)_3$) and ferric chloride ($FeCl_3$) were added according to the variation of doses. The flocculation reactor in tanks-b with dimensions of 20 cm x 20 cm x 25 cm was carried out at 30 rpm for 15 minutes, with the aim of maximizing the settling process. The combination of aerobic and anaerobic biofilter reactors in tanks-c and d each has dimensions of 20 cm x 20 cm x 25 cm. The biofilter media used was 15 cm high zeolite in both aerobic and anaerobic biofilter reactors. In the aerobic biofilter reactor, the air flow applied is 1 L/minute. The reactor operated for 5 days with a continuous system where the source of leachate flowed into the reactor, was then mixed with coagulant, and went through a biofilter process within 8 hours.

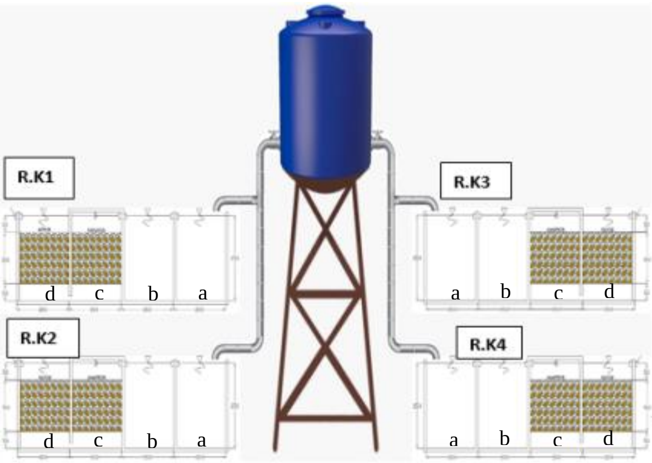

Figure 1. Schematic diagram of coagulation-flocculation and biofilter

The research was conducted at the Blandongan Landfill, Pasuruan City. The sample used for this study was leachate from the Blandongan Landfill, Pasuruan City area. The sample used was 96 liters for each reactor every day. The leachate samples in the study were diluted 20 times. Before the processing, seeding and acclimatization were carried out on the zeolite media used for seven days. Seeding was a breeding process carried out to grow and revive microorganisms. The process of adapting microorganisms that had grown to the conditions of the new reactor and the leachate to be treated was also called the acclimatization process (Nurhayati et al., 2019). The leachate flowed continuously into the aerobic-anaerobic biofilter reactor for eight hours.

After the growth of microorganisms had been physically stable, then the sample was tested for the concentration of permanganate for five days. A permanganate test was carried out to determine the condition of microorganisms in the biofilter reactor. The leachate sample was taken directly from the sedimentation tank, which was treated with a coagulation process and a biofilter. Parameters measured levels were BOD, TSS, pH, and temperature carried out at the Pasuruan Environmental Agency Laboratory. The BOD and TSS parameters of Blandongan Landfill leachate were tested using equipment and procedures according to the 2017 SM APHA Method (Section 5219 B). The measurement results were compared with the Landfill Leachate Water Quality Standard according to the Minister of Environment and Forestry of the Republic of Indonesia, 2016. The analysis method used in this study used One-Way ANOVA (5% significant percentage) with SPSS software and continued with post hoc analysis.

3. RESULT AND DISCUSSION

3.1 Characteristics of Leachate from WTP Blandongan Landfill

The characteristics of leachate obtained from the sedimentation basin of the Wastewater Treatment Plant at Blandongan Landfill are presented in Table 2.

Table 2. Initial characteristics of leachate from WTP Blandongan Landfill

Parameter	Grade	Quality Standards*	Unit
BOD	2,331.0	150	mg/L
TSS	108.0	100	mg/L
pH	8.2	6-9	-
Temperature	28.7	-	^{0}C

*) Minister of Environment and Forestry of the Republic of Indonesia, 2016

The leachate from the Blandongan Landfill is more than 10 years old (Mojiri et al., 2021; Teng et al., 2021). Thus, it is included in the old leachate category. The BOD and TSS parameters of Blandongan Landfill leachate during Maret until June 2022 were still above permissible leachate quality standards. For instance, the test results of the leachate BOD parameter were 2,331 mg/L, and the TSS parameter was 108 mg/L, above the leachate quality standard by the Minister of Environment and Forestry of the Republic of Indonesia, 2016 of 150 mg/L and 100 mg/L for BOD and TSS levels in the leachate, respectively. According to Setiawan et al. (2022), the high BOD is affected by the composition of the pollutant and the age characteristics of the waste. Fresh leachate has a relatively higher concentration of BOD because it has a lot of organic content (Teng et al., 2021). Meanwhile, BOD levels in old leachate have decreased due to a good degradation process by microbes. The microbes are able to degrade organic materials, and naturally, the soil is able to become a filter and adsorbent to absorb harmful substances in leachate water.

3.2 Permanganate Test

The results of the permanganate test are shown in the graph of Figure 2.

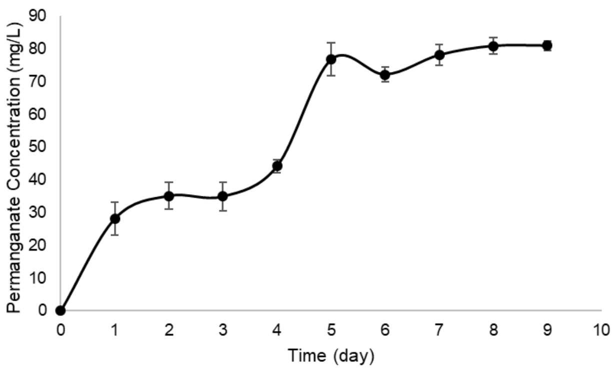

Figure 2. Permanganate test

Based on Figure 2, day 3 to 5 permanganate test values began to obtain stable results so that the leachate water could be treated with the prepared reactor. Measurement of the pH of the treated leachate samples was carried out every day during observation before the samples were tested at the Pasuruan Environmental Agency Laboratory.

3.3 Permanganate Test

Measurement of leachate BOD concentration efficiency is presented in Table 3 and Figure 3. Based on Figure 3, the value of BOD reduction efficiency was better at the optimum dose of R.K3 combination, namely the combination of coagulant with the concentration of 16 g/L $Al_2(SO_4)_3$ and 3 g/L $FeCl_3$ with an average decrease in efficiency of 62.93%. The value of the reduction efficiency in R.K1 is the combination of coagulant with a concentration of $Al_2(SO_4)_3$ 12 g/L and $FeCl_3$ 3 g/L experienced a decrease in efficiency with an average of 57.96%, the average value of the efficiency of decreasing BOD in R.K4 was in the combination of coagulant with a concentration of $Al_2(SO_4)_3$ 16 g/L dan $FeCl_3$ 7 g/L had a decrease in efficiency with an average of 55.21%. In comparison, the lowest average value of BOD reduction efficiency occurred in R.K2 was the combination of coagulant with a concentration of $Al_2(SO_4)_3$ 12 g/L and $FeCl_3$ 7 g/L or 51,78%. The decrease in BOD levels in R.K1, R.K2, R.K3, and R.K4 does not meet the quality standards (Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59 About Leachate Landfill Quality Standard and/or Activities of Landfill, 2016) which requires a maximum BOD level of 150 mg/l in the leachate. The results of the efficiency of BOD reduction that was tested for 5 days showed a fluctuating value. This was affected by the condition of the Blandongan Landfill, which had not fully used the sanitary landfill system, so the leachate produced every day had different contents. The quantity of leachate produced is also influenced by the conditions of the rainy season at the time of this research. Thus, the leachate produced fluctuated and varied.

Table 3. BOD concentration on the samples

Reactor Code	BOD Concentration (mg/L)					Quality Standards (mg/L)*
	Day 1	Day 2	Day 3	Day 4	Day 5	
R.K1	1,820	1,740	260	520	560	150
R.K2	1,780	1,620	1,340	400	480	
R.K3	1,540	1,620	280	360	520	
R.K4	1,460	1,540	1,260	560	400	

*) Minister of Environment and Forestry of the Republic of Indonesia, 2016

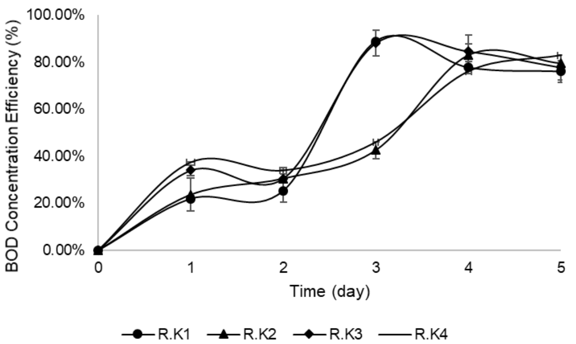

Figure 3. BOD concentration efficiency

The decrease in BOD levels in leachate using the coagulation-flocculation process is due to the addition of an effective aluminum sulfate coagulant solution. There is a bond between aluminum sulfate and colloidal particles that form flocs so that it becomes more apparent, and flocs of colloidal leachate particles in the form of small particles become large clumps that easily settle (Teguh et al., 2022).

The coagulation-flocculation process in leachate with stirring and adding variations in the concentration of aluminum sulfate ($Al_2(SO_4)_3$) and ferric chloride ($FeCl_3$) coagulant produces a uniform dispersion. It causes contact and collision between colloidal particles, organic matter, and suspended solids in the leachate. The collision that occurs results in a chemical reaction, where the negative charges of the colloidal particles repel each other in the leachate and are neutralized by positively charged ions contained in the coagulant solution, which attract each other and then agglomerate to form flocs (Ratnawati & Ulfah, 2020).

The previous research has the results that the application of coagulation and flocculation leachate treatment in the efficiency removal of COD by 55.3% and BOD by 83.9% (De et al., 2019). However, this research is mostly applied to developed countries with conditions for Final Processing Sites that have implemented sanitary landfill well. The condition of the leachate treatment in the Blandongan Landfill has different characteristics because the system used has yet to use the sanitary landfill fully. This results in a larger organic pollutant load that appears, and the resulting discharge fluctuates.

In the research conducted by Fajri et al. (2017), the addition of aluminum sulfate coagulant $Al_2(SO_4)_3$ concentration increased the percentage of removal of BOD levels to 38.36%, with an effective concentration of aluminum sulfate coagulant solution at a concentration of 60 ppm accompanied by stirring. The use of variations in the dose of $FeCl_3$ coagulant of 4 g/L, 8 g/L, 12 g/L, and 16 g/L in the removal of BOD with a dose of 16 g/L has a better percentage value than other doses in the removal of BOD levels, namely by 50% (Wirandani et al., 2017).

Other research by Rezagama et al. (2016) showed the optimum dose of addition of ferric chloride and aluminum sulfate coagulant was 16 g/L for the treatment of leachate at the Jatibarang Landfill in Semarang, Central Java, Indonesia, with an efficiency of removing BOD levels of 50% and TSS of 52%. At a dose of 18 g/L aluminum sulfate which was added as a coagulant in the removal of BOD, COD, and TSS parameters, the percentage of removal was better than the other doses tested. Still, the pH value with the addition of a dose of 18 g/L decreased to below the quality standard.

Research conducted by Wahyuni & Sugito (2016) indicated the percentage decrease in BOD levels for the variation without coagulant that occurred was 86.5%. In the second variation with the addition of a coagulant dose of 200 ppm into the reservoir, the highest BOD reduction efficiency value was 48%. In the third variation, with a coagulant dose of 300 ppm added to the reservoir, the highest percentage of BOD reduction was 72%. The results of the One-Way ANOVA analysis (5% significant) can be seen in Table 4.

Table 4. One-way ANOVA analysis of BOD concentration and coagulant variation

Summary

Groups	Count	Sum	Average	Variance
Column 1	4	330	82.5	78.33333
Column 2	4	326	81.5	17
Column 3	4	210	52.5	697
Column 4	4	94	23.5	17
Column 5	4	96	24	10.66667

Anova

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	13575.2	4	3393.8	20.6939	5.76E-06	3.055568
Within Groups	2460	15	164			

When comparing the effect of the combination of coagulants on the decrease in BOD levels at the significance level (α) of 5%, the F table obtained was 3.056 from the F distribution table. The calculated F value for the coagulant combination output was 20.69. The probability value for the coagulant combination was 0.00000575. The decision that can be taken for the variation of the combination of taking is to accept the alternative hypothesis (H_1) and reject the initial hypothesis (H_0) because the calculated F value > F table and P value < 0.05. This means that the combination of $Al_2(SO_4)_3$ and $FeCl_3$ has a significant effect on reducing BOD levels in Blandongan leachate.

3.4 Decreasing of TSS Concentration in Landfill Leachate

The efficiency of reducing TSS levels is presented in Table 4 and Figure 4. The decrease in TSS levels in all combinations of coagulants R.K1, R.K2, R.K3, and R.K4 has met the quality standards (Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.59 About Leachate Landfill Quality Standard and/or Activities of Landfill, 2016) that require a maximum TSS content of 100 mg/L in leachate. Coagulation-flocculation processing in this research was carried out by adding a combination of coagulant solutions in the form of $Al_2(SO_4)_3$ and F_eCl_3. $Al_2(SO_4)_3$ and $FeCl_3$ solutions, when stirred with leachate in the reactor, cause ions with positive electrical charges contained in them to be able to bind and attract negative charges on the colloidal surface. The addition of $Al_2(SO_4)_3$ and $FeCl_3$ solutions can reduce TSS levels. Thus, they are below the required quality standard of 100 mg/l.

Table 5. TSS concentration on the samples

Reactor Code	TSS Concentration (mg/L) Day 1	Day 2	Day 3	Day 4	Day 5	Quality Standards (mg/L)*
R.K1	16	40	40	20	60	100
R.K2	20	20	20	20	40	
R.K3	8	40	40	40	20	
R.K4	20	20	20	20	40	

*) Minister of Environment and Forestry of the Republic of Indonesia, 2016

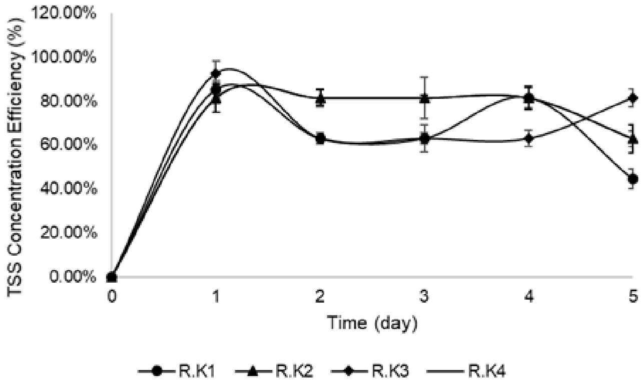

Figure 4. TSS concentration efficiency

Based on the research by Lindu et al. (2015), COD and TSS reduction efficiency is affected by the chemical composition and age of leachate. Leachate that is less than 5 years (young) requires a higher dose of coagulant than leachate aged over 10 years (old), which comes from landfills that have old stockpiles. Blandongan Landfill is over 10 years old, so the potential for TSS parameters is not too high as in the initial condition test. The TSS level in Blandongan Landfill leachate is 108 mg/l. Thus, the dose of coagulant needed is not too much to reduce TSS levels in the water leachate.

According to research by Sukwika & Muhammad (2021), the decrease in TSS levels in leachate using the coagulation-flocculation process was due to the leachate forming aggregated floc particles. When the floc growth was maximal, the flocs settled to the bottom of the coagulation-flocculator cup. Thus, two layers are formed, namely, on the top layer, there is clear wastewater, and on the bottom layer, there is a mud-like floc deposit that will be separated. This is what makes the levels of BOD, COD, and TSS of leachate after the coagulation-flocculation process smaller than before the coagulation-flocculation process.

The decrease in TSS levels that occurred was caused by the process of adding a combination of $Al_2(SO_4)_3$ and $FeCl_3$ solutions as a coagulant in the coagulation-flocculation process, which was thought to exceed the optimum limit. The combined dose of $Al_2(SO_4)_3$ and $FeCl_3$ solution given was not optimal. Thus, the role of the initial dose as a decrease in TSS levels shifted to the impurity of the tested sample. The process of stabilization of suspended substances occurs because the dose of coagulant given exceeds the optimum dose. In the research by Rezagama et al. (2016) doses of $Al_2(SO_4)_3$ and $FeCl_3$ of 16 g/L have a TSS removal efficiency value of 24% and 21%, respectively.

The decrease in TSS levels that occurred in leachate the Blandongan Landfill in the combination of R.K1, R.K2, and R.K4 on the 5^{th} day of observation found that the percentage of efficiency decreased. This was due to the clumping of the floc that occurred on the previous days, which settled at the bottom of the reactor, resulting in a smaller percentage of efficiency. The use of a combination of aluminum sulfate ($Al_2(SO_4)_3$) and ferric chloride ($FeCl_3$) solution as a coagulant can affect the decrease in TSS levels. The use of coagulant solution can be used to precipitate colloidal particles, organic substances and suspended solids dissolved in the leachate and can be used as a water purifier. The coagulant solution of aluminum sulfate ($Al_2(SO_4)_3$) and ferric chloride ($FeCl_3$) has a positive electron charge, while solids suspended in leachate have a negative electron charge. When these two substances act, with a long residence time, the suspended solids in the leachate will be bound by a combination of a solution of aluminum sulfate ($Al_2(SO_4)_3$) and ferric chloride ($FeCl_3$). The final result will form flocs in the leachate. The floc will settle by itself by gravity during the sedimentation process (Sugito et al., 2021). The results of the One-Way ANOVA analysis (5% significant) can be seen in Table 6.

Table 6. One-way ANOVA analysis of TSS concentration and coagulant variation

Summary

Groups	Count	Sum	Average	Variance
Column 1	4	3.2	0.8	0.08
Column 2	4	6	1.5	0.333333
Column 3	4	6	1.5	0.333333
Column 4	4	5	1.25	0.25
Column 5	4	8	2	0.666667

Anova

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	3.048	4	0.762	2.290581	0.107628	3.055568
Within Groups	4.99	15	0.332667			
Total	8.038	19				

When they are compared, the effect of the combination of coagulants on the decrease in TSS levels. At the significance level (α) of 5%, the F table obtained was 3.056 from the F distribution table. The calculated F value for the coagulant combination output was 2.29. The probability value for the coagulant combination was 0.0107. The decision that could be taken for the variation of the combination of taking was to reject the alternative hypothesis (H_1) and accept the initial hypothesis (H_0) because the calculated F value < F Table and P value > 0.05. This means that the administration of a combination of $Al_2(SO_4)_3$ and $FeCl_3$ coagulants has no significant effect on reducing TSS levels in leachate.

3.5 pH Value Measurement

The pH values of leachate treatment using coagulation-flocculation with aerobic-anaerobic biofilter are presented in Table 5. According to Sugito et al. (2021), pH values in the range of 7.9-8.6 indicated that the leachate was wet. In landfills with old stockpiles (more than 10 years), the pH value will be greater than 7.5. This pH condition, which tends to be alkaline, is actually beneficial because the pH value is still in the pH range suitable for biological processing, which is in the range of six until nine (Renou et al., 2008). Yet, the biological processes that had been carried out previously were not optimal in treating the leachate at the Blandongan Landfill. Based on the results of pH measurements from each given coagulant combination, the pH value measured every day had a value below 5, so it did not meet the quality standards, which require the pH value in leachate in the range of six until nine.

Table 7. pH measurement on the samples

Reactor Code	pH Measurement				
	Day 1	Day 2	Day 3	Day 4	Day 5
R.K1	5.0	4.1	4.1	3.8	4.2
R.K2	4.2	4.1	3.9	3.9	3.9
R.K3	5.0	3.9	4.1	4.0	4.1
R.K4	4.1	4.1	3.7	3.9	3.9

According to Sugito et al. (2021), the addition of aluminum sulfate coagulant solution in leachate will produce aqua metallic ions $Al(OH)_3$ or, by another name, floc. Aquometallic ions or flocs are not always $Al(OH)_3$ but can also be $Al(OH)^{2+}$ and $Al(OH)^{4-}$. If the feed pH is in the optimum pH range, floc will be formed in the form of $Al(OH)_3$, and if it is outside the optimum pH, floc will be formed in the form of $Al(OH)^{2+}$ and $Al(OH)^{4-}$. The floc in the form of $Al(OH)_3$ has insoluble properties. Thus, it is not easily broken, on the other hand, the floc in the form of $Al(OH)^{2+}$ and $Al(OH)^{4-}$ has partially soluble properties so that it is easily broken.

This drastic change in pH was due to the addition of an acidic $FeCl_3$ coagulant until the pH decreased drastically. The more coagulant used, the more acidic the pH. This drastic change in pH was due to the addition of an acidic $FeCl_3$ coagulant until the pH decreased drastically (Norjannah, 2015). $FeCl_3$ is a salt derived from a strong acid, and a weak base, when dissolved in water, will produce an acidic solution (Teguh et al., 2022). The decrease in pH value is influenced by the hydrolysis reaction of $FeCl_3$ as follows: $Fe^{3+}+3H_2O$ $Fe(OH)_3+H^+$.

The addition of $Al_2(SO_4)_3$ also reduces the pH value of acid because when dissolved in water, it will produce H_2SO_4 compounds. This is due to the greater the dose of coagulant given in a solution, the greater the content of H^+ ions in the solution due to the hydrolysis process.

3.6 Measurement of Temperature Value

Temperature measurements were carried out every day before the samples were brought to the Pasuruan Environmental Agency Laboratory. It is presented in Table 8.

Table 8. Temperature measurement on the samples

Reactor Code	Temperature Measurement (°C)				
	Day 1	Day 2	Day 3	Day 4	Day 5
R.K1	27.5	27.7	27.9	28.2	28.5
R.K2	28.8	28.9	28.2	28.2	28.0
R.K3	27.3	27.5	28.1	28.0	28.3
R.K4	28.4	28.6	27.8	27.8	27.7

The results of the measurement of the leachate temperature of the Blandongan Landfill after the addition of coagulant and the biofilter process were in the range of 27.3–28.9°C. The addition of a coagulant combination carried out in this research was not significant in affecting the leachate temperature of the Blandongan Landfill. If the coagulant $FeCl_3$ (ferric chloride) is dissolved in a liquid, it will undergo a hydrolysis process in the form of an exothermic reaction. An increase in temperature characterizes it (Wirandani et al., 2017). However, in some observations, the temperature decreased after receiving treatment with the addition of a coagulant solution, which was considered to occur due to the release of heat by CO_2.

4. CONCLUSION

Leachate water treatment using a combination of coagulation-flocculation and aerobic-anaerobic biofilter showed a difference in results between the initial characteristics and the final results of the study. The BOD parameter showed that of the 4 reactors, the highest efficiency was in reactor 3 at 87.99% from a concentration of 2,331 mg/L to 280 mg/L on day 3. At the same time, the TSS parameter shows the best results in reactor 3, with an efficiency of 81.48% from a concentration of 108 mg/L to 20 mg/L on day 5. Both parameters show the best results in reactor 3 with a coagulant composition of aluminum sulfate and ferric chloride 16:3. However, these results have not met the quality standards set in the Minister of Environment and Forestry Regulation Number 59 of 2016 concerning Leachate Quality Standards for Businesses and/or Waste Final Processing Site Activities, so further processing is needed so that the processed leachate water can be flowed into water bodies without polluting the environment. Further research that can be done is by adding a combination of coagulants with other concentration ratios to make it more varied and the research reactor needs to add mud circulation so that the resulting floc does not interfere with the research process.

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