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THE USE OF GAC (GRANULAR ACTIVATED CARBON) AND ZEOLITE AS AN ADSORBENT TO REDUCE THE CONCENTRATION OF PHOSPHATE IN LAUNDRY WASTEWATER

Felicia Naila Nasir[1*], Harmin Sulistyaning Titah[2*]
[1,2]Department of Environmental Engineering, Faculty of Civil, Environmental and Geo-Engineering, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo, Surabaya, Indonesia
e-mail: felicianaila@gmail.com

ABSTRACT

The growth of the laundry business increases every year along with population growth, however the laundry waste produced is generally thrown straight into the drain and flows into water bodies without prior treatment. The threshold limits for laundry wastewater quality standards for phosphate content, Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS) are 10 mg/L respectively based on East Java Governor Regulation No. 72 of 2013. Disposing of laundry waste directly in large quantities into water bodies can have negative effects on the ecosystem in water bodies and water pollution problems. This research aims to determine the efficiency of using GAC and zeolite adsorbents in reducing phosphatelevels in laundry liquid waste. Based on the impact that can pollute water bodies, it is necessary to process laundry liquid waste. One of the processing methods used is the adsorption method, the adsorption process is carried out using Granular Activated Carbon (GAC) and zeolite with a batch system. This research uses liquid wastewater samples from laundry businesses. The variations used in this research are the adsorbent mass, and contact time. The results obtained from this research include SEM (Scanning Electron Microscopes) test results and the percentage reduction in phosphatelevels using GAC and zeolite adsorbents in batch systems. The research results show that the optimum adsorbent mass is 12 grams of adsorbent mixed with GAC and zeolite with a contact time of 150 minutes with a percentage reduction in phosphate levels of 57.14%. The phosphate values of laundry liquid waste after processing with adsorbent mass, adsorbent composition and optimum contact time are 6.5 mg/L.

Keywords: Adsorption, Batch, GAC, Laundry Wastewater, Zeolite

INTRODUCTION

The increased population growth each year creates opportunities for community laundry businesses to carry out daily activities, such as washing clothes. The Indonesian Laundry Association notes that laundry businesses experience an average annual growth of 20% (Siregar et al., 2019). The laundry waste business produces liquid waste which is generally discharged directly into the drain and flows into water bodies without prior processing (Siregar, 2019). The direct disposal of laundry waste in large quantities into water bodies can have negative effects on the ecosystem in water bodies and water pollution problems (Mohamed et al., 2018).

There are several pollutants contained in laundry liquid waste, including phosphate and COD. Laundry businesses use detergent and the main ingredients in detergent are surfactants, builders and bleach. Surfactants are the main ingredient in detergents. The most commonly used builder is sodium tripolyphosphate (a phosphate compound). The phosphate content in detergents is quite large, which can cause eutrophication effect which can cause algae blooms, a significant increase in the population of aquatic (Jagessar et al., 2011). The use of detergent in liquid laundry waste can affect the characteristics of liquid laundry waste, especially the COD value (Pratiwi et al., 2012). COD is the amount of oxygen in mg/L used to chemically decompose organic matter in water (Boyd, 1990). High concentrations of COD values in laundry liquid waste will increase the toxic effect and will risk polluting the environment and the organisms in it (Esmiralda et al., 2012).

In this research, processing will be carried out to reduce phosphate, COD and TSS levels using the adsorption method. Adsorption is the process of mass transfer on a porous surface from a liquid to a solid surface. This occurs due to physical processes or by chemical bonds (Artioli et al., 2008). In the adsorption process, there are two phases involved, namely the absorbing phase referred to as adsorbent and the absorbed phase referred to as adsorbate (Lutfianingsih et al., 2020).

Adsorption is a very common method because it has the advantage that the concept is simpler and also economical. In the adsorption process, the adsorbent plays an important role because it can influence the absorption efficiency of the compound to be removed (Tangio, 2013). The adsorbents that will be used in this research are GAC and zeolite adsorbents. The use of activated carbon in laundry waste has been shown to be able to remove dissolved organic compounds, especially surfactants surfactants (Akiyama et al., 2015). Activated carbon was chosen because it has a high absorption capacity, reaching 25-100% of organic or inorganic compounds (Utomo et al., 2018). Adsorption using zeolite can be used to reduce detergent contamination. Detergents, which are organic molecules, will be attracted by the zeolite and attached to the surface through a complex combination of physical forces and chemical reactions (Sisyanreswari et al., 2014). Activated carbon and zeolite are good materials as adsorbents because they have good adsorption capacity (Ali et al., 2020).

The content value of liquid laundry waste in the form of detergent waste water contains chemicals such as phosphate (70–80%), surfactant (20–30%), ammonia and nitrogen as well as dissolved solids, turbidity, BOD and COD (Ahmad and Dessouky, 2008). Based on these problems, further research is needed to reduce the levels of phosphate, COD, TSS in liquid laundry waste by using GAC and zeolite adsorbents to ensure the safe disposal of the liquid laundry waste directly into the environment.

METHOD

Research Tools and Materials

a) Research Tools

The tools used in this research were a 1000 mL IWAKI Pyrex Erlenmeyer, Ohaus Pioneer PX Analytical Balance, IKA big squid magnetic stirrer, stirrer rod, sample bottle, 10 L jerry can, 1000 mL measuring cup, 50 mL IWAKI beaker, 1000 mL DURAN beaker, Flex SEM 1000 Hitachi.

b) Research materials

The materials used for measuring phosphate parameters were 70 mL H_2SO_4; 1,3715 g SnCl; 20 g $(NH_4)6Mo_7O_{24}.4H_2O$; 2,195 g KH_2PO_4; 25 ml glycerol, phosphate stock solution, 500 mg P/L PP indicator solution and 3 L distilled water, 1 pack of tissue, 1 pack of latex, and label paper.

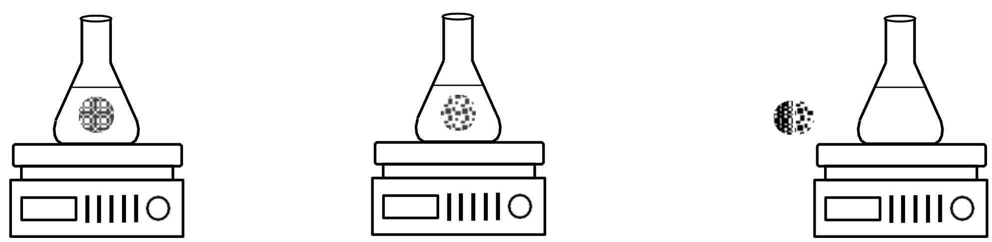
The Sampling of Laundry Liquid Waste

Sampling of liquid laundry waste using a method based on SNI 6989.59:2008 begins with preparing a waste sampling tool using a jerry can bottle made of High Density Polyethylene (HDPE). Before use, the jerry can is washed first using phosphate-free detergent and then rinsed with clean water. Then the jerry cans were washed with 10 mL of hydrochloric acid (HCl) and rinsed again with water three times and allowed to dry. Once dry, the jerry can is closed tightly.

Noah's laundry business uses 3 washing machines, 2 washing machines have a capacity of 7 kg and 1 washing machine has a capacity of 7.5 kg. In one wash, Noah's laundry can wash 2.5-4 kg and in one day it can wash 5-25 kg/day and produce liquid waste of 70-280 L/day. The sample of liquid laundry waste that will be taken is 100 L which comes from the exhaust channel of Noah's laundry waste washing machine. Liquid waste sampling is carried out using a composite sampling technique, namely taking water samples from the outlet channel before entering the waste water receiving waters. Waste water collection is carried out using a composite method from 3 washing machines and has 4 stages, namely washing with detergent, first rinsing, second rinsing, and deodorizing. 10 liters of homogenized laundry waste are taken from each washing machine and put into a 10 L jerry cans.

Preparation for Adsorption Treatment with a Batch System

The main research carried out was preparing experiments on a batch system. The reactor in the batch system adsorption uses an Erlenmeyer flask with a volume of 1000 mL. The batch system adsorption process was carried out with liquid laundry waste samples put into nine 1000 mL Erlenmeyer flasks each with variations in adsorbent composition, namely in the first reactor 100% GAC, in the second reactor 100% zeolite and in the third reactor GAC:zeolite (50:50) (Yu et al., 2019), with each adsorbent mass variation of 1, 2 and 3 gr GAC; 1, 2 and 3 grams of zeolite; GAC: Zeolite (0.5 gr:0.5 gr), (1 gr:1 gr) and (1.5 gr:1.5 gr). Then the mixture was stirred with a magnetic stirrer at a constant speed of 250 rpm (Sirajuddin and Irmawati, 2017). After stirring with a magnetic stirrer, samples were taken from each reactor for phosphate, COD, TSS tests with regular adsorption contact times, namely 0 minutes as a control, 90 minutes, 120 minutes and 150 minutes (Fasishah et al., 2022) and analysis carried out by PT. Unilab Perdana Surabaya and phosphate, COD and TSS concentration values were obtained after treatment to determine the percentage value of the efficiency of reducing phosphate and COD levels. The reactor uses a magnetic stirrer as in Figure 2.1.



(a) (b) (c)

Figure 1. Schematic of the composition variation batch system from the left image (a) GAC, (b) Zeolite, (c) GAC and zeolite

Data Analysis and Discussion

Data analysis and discussion on the data obtained from the research results were carried out. Data analysis in this study was carried out in two repetitions (duplo). Next, from the results of these repetitions, the average was taken and the adsorption efficiency was calculated for reducing phosphate, COD and TSS levels in liquid laundry waste.

Statistical data analysis was carried out after obtaining the percentage reduction value. The objective of statistical data analysis is to determine the effect of adsorbent composition and adsorbent contact time variations on the efficiency of phosphate concentration, COD and TSS using GAC and zeolite adsorbents. Statistical data analysis used a Two-Way ANOVA test with a Completely Randomized Design with a significance level of 5% and it could be seen that if the significance value was $p<0.05$, the effect of variations in adsorbent composition and contact time on the percentage would be known decrease in phosphate, COD and TSS levels and if data is obtained that has a significant difference value ($p>0.05$), the Duncan test is carried out to determine the location of the difference in efficiency values.

RESULTS AND DISCUSSIONS

Characteristics Laundry Wastewater

This research was conducted to determine the potential for using and zeolite adsorbents to reduce phosphate, COD and levels in liquid laundry waste based on time variations and adsorbent dosage variations. The initial characteristic values of liquid laundry waste were carried out to determine the initial content of phosphate, COD and TSS parameters before processing using GAC and TSS adsorbents. According to East Java Governor Regulation Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities, the limit value for phosphate content is 10 mg/L, COD content value is 250 mg/L and TSS content value is 100 mg/L. The following are the initial characteristic values for Noah's Laundry liquid waste which can be seen in Table 1.

Table 1. Initial characteristics of Noah Laundry liquid waste and compared with laundry waste quality standards according to East Java Governor Regulation Number 72 of 2013

No.	Parameter	Value	Quality standards	Unit	Annotation
1.	Fosfat	14	10	mg/L	above quality standards
2.	COD	1039,5	250	mg/L	above quality standards
3.	TSS	177	100	mg/L	above quality standards
4.	pH	8	6-9	-	meet quality standards

Based on the results of the initial characteristic values of Noah's Laundry waste in terms of phosphate, COD and TSS parameters, it exceeds the quality standards of East Java Governor Regulation Number 72 of 2013. The liquid laundry waste produced by Noah's Laundry has not undergone further processing, it is necessary to process the liquid laundry waste before discharge directly into water bodies.

Effect of GAC Adsorbent Type, Dosage and Adsorption Time on Phosphate Pollutant Levels in Laundry Waste

Adsorption test with varying dosages aims to see how the weight of the adsorbent influences the absorption of pollutants, while varying contact time aims to see how contact time influences the adsorption capacity parameters. Phosphate levels in laundry waste using GAC adsorbent with varying dosages and times resulted in different percentage reductions.

According to these results, the highest average percentage reduction in phosphate was found at a contact time variation of 150 minutes and a dosage variation of 12 grams with a percentage of 50%. This demonstrates that the reduction in phosphate parameter concentrations obtained is more significant the longer the contact time and the larger the dosage given. The graph of the average percentage reduction in phosphate levels can be seen in Figure 2.

Smaller particles have a larger surface area and therefore more room for pollutants to adhere, which results in a large removal of phosphate and a small final phosphate concentration. According to Hudaya & Wiratama (2016), one of the criteria that must be considered to determine an adsorbant is pores. Adsorbents with more pores have a greater ability to accumulate adsorbate on the surface of the adsorbant pores.

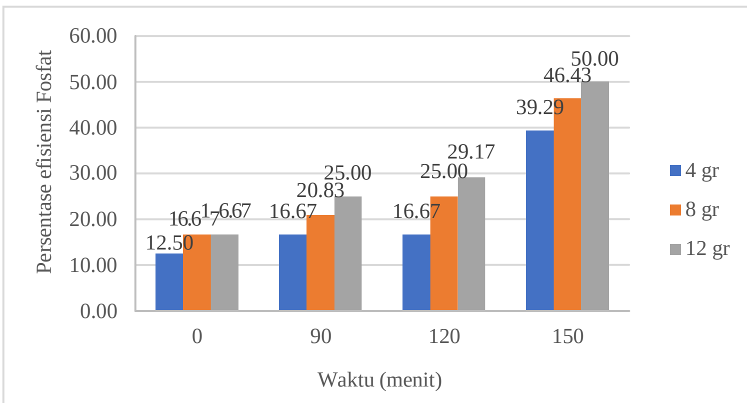


Figure 2. Average percentage reduction in phosphate levels

The adsorption capacity indicates the amount of adsorbate that can accumulate on the adsorbent's surface. A graph of the relationship between adsorption capacity and time variations can be shown in Figure 3. Based on Figure 3, the adsorption capacity of the GAC adsorbent on phosphate parameters increases with increasing contact time. Adsorption ability is determined by the structure of an adsorbent and other adsorption parameters. Adsorption capacity is also influenced by the adsorbent dosage. Based on the graph, it shows that the adsorption capacity decreases with increasing adsorbent dosage. The maximum adsorption capacity occurs under conditions of 150 minutes of contact time and a dosage of 4 grams, namely 1.13 mg/g. This amount shows that every gram of GAC adsorbent is capable of adsorbing 1.13 mg of phosphate.

The decrease in adsorption capacity accompanied by an increase in adsorbent mass is due to the large mass providing many active sites and during the adsorption process many active sites are unused. A large mass will cause a buildup of adsorbent particles, resulting in the total surface area of the adsorbent decreasing. The buildup of the adsorbent also results in blocking the active site of the adsorbent so that it cannot interact freely with the adsorbate ion.

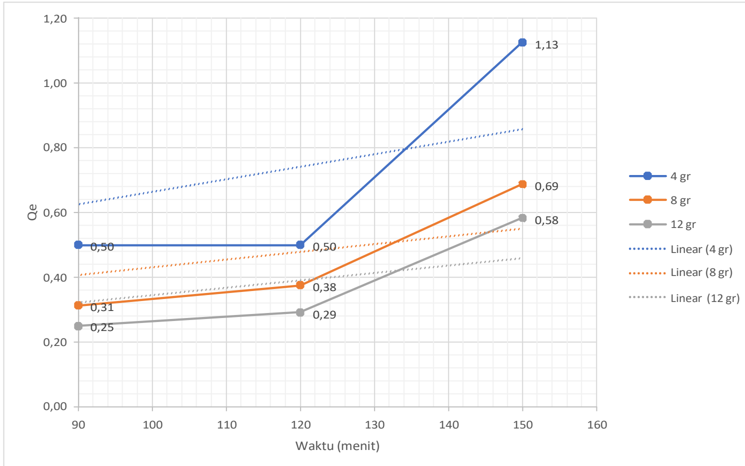


Figure 3. Adsorption capacity of phosphate content on GAC adsorbent

The adsorption mechanism in a treatment can be interpreted using the adsorption isotherm model. This model represents the equilibrium connection between the concentration of the adsorbate in the fluid and on the adsorbent's surface, while maintaining a constant temperature (Wiroesoedarmo et al., 2021). The equations used in this research to explain adsorption isotherms are Langmuir and Freundlich.

According to Shahbeig et al. (2013), the Langmuir adsorption isotherm model relies on a number of assumptions, including the following: there is no molecular interaction between the active sites; the adsorption process happens in a single layer (monolayer), only at particular homogeneous sites; the adsorbent has an adsorption capacity limit, which is reached at equilibrium; and all active sites can only adsorb one kind of atom or molecule. The Freundlich adsorption isotherm model, according to Srivastava and Hasan (2011), states that the adsorbed ions form a multilayer layer on the adsorbent's surface layer because the pores formed in the adsorbent are heterogeneous. Additionally, according to this model, different active sites have different adsorption energies, and the site with the highest adsorption energy will fill up completely first.

The results of plotting the Langmuir and Freundlich isotherm models of GAC adsorbent adsorption on phosphate parameters can be seen in Figure 4 and Figure 5. The adsorption process used is based on variations in adsorbent dosage. Based on the results of plotting the Langmuir isotherm model, the linear equation values obtained for each adsorbent dosage of 4 gr, 8 gr, and 12 gr were 0.9718, 0.9668, and 0.9271. The results of data analysis show that the adsorption of GAC adsorbent on phosphate parameters is more in line with the Freundlich isotherm model, this can be seen from the linear equation values obtained by each dosage variation of 4 gr, 8 gr, and 12 gr, namely 0.9999, 0.999, and 0.9986.

The results of plotting each graph then produce a linear equation to determine the constants of the Langmuir and Freundlich equations. The maximum amount of adsorbate that can be absorbed by the adsorbent, represented by Qm, and the Langmuir constant, represented by KL, make up the linear equation of the Langmuir model. Meanwhile, in the Freundlich model, the adsorption capacity is symbolized by Kf and the absorption intensity is symbolized by n. The linear equations resulting from the plotting results based on Figure 4 and Figure 5 are then analyzed to obtain the constants of each model, namely Langmuir and Freundlich. The analysis results of each model are displayed in Table 2.

Table 2. Results of isotherm model analysis of phosphate levels with GAC adsorbent

Dosage	Langmuir			Freundlich		
	K_L	Qm	R^2	K_F	n	R^2
4 gr	-0.126	0.098	0.9718	2.485	0.057	0.9999
8 gr	-0.148	0.086	0.9668	2.021	0.040	0.999
12 gr	-0.158	0.067	0.9271	1.867	0.028	0.9986

Based on the results of the isotherm model analysis, the adsorption mechanism that occurs tends to follow the Freundlich model. The Freundlich adsorption isotherm model, according to Srivastava and Hasan (2011), states that the adsorbed ions form a multilayer layer on the adsorbent's surface layer because the pores formed in the adsorbent are heterogeneous.

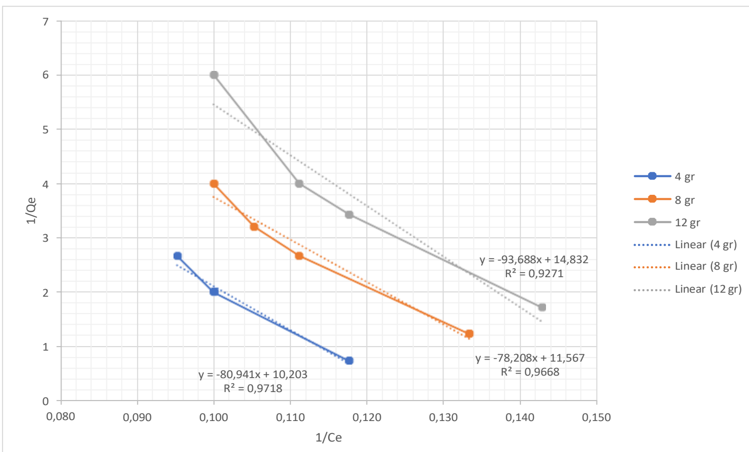


Figure 4. Langmuir isotherm of phosphate levels in GAC adsorbent

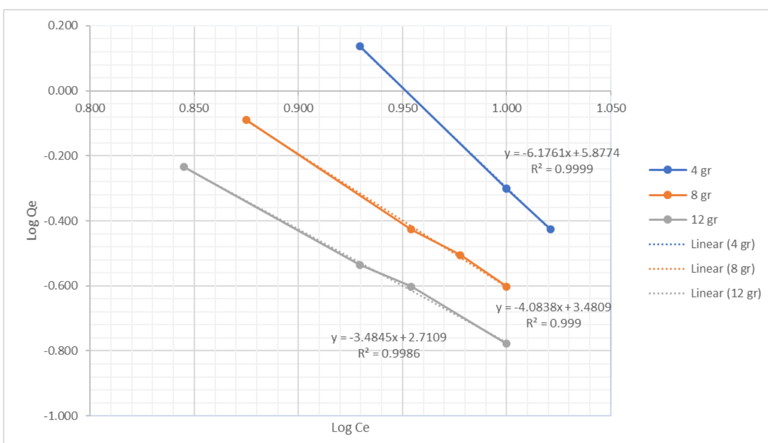


Figure 5. Freundlich isotherm of phosphate levels on GAC adsorbent

Effect of Zeolite Adsorbent Type, Dosage and Adsorption Time on Phosphate Contaminant Levels in Laundry Waste

Adsorption test with varying dosages aims to see how the weight of the adsorbent influences the absorption of pollutants, while varying contact time aims to see how contact time influences the adsorption capacity parameters. Phosphate levels in laundry waste using zeolite adsorbents with varying dosages and times resulted in different percentage reductions. The results of research using zeolite adsorbents to reduce phosphate parameters can be seen in Figure 6.

According to this figure, the highest average percentage reduction in phosphate was found at a contact time variation of 150 minutes and a dosage variation of 12 grams with a percentage of 60.71%. This indicates that a greater reduction in phosphate parameter concentrations can be achieved with longer contact times and higher dosages. This reduction can occur due to the ability of zeolites to reduce micro pollutants, for example organic substances and detergents found in water (Ronny, 2018). The graph of the average percentage reduction in phosphate levels can be seen in Figure 6.

According to Sisyanreswari et al. (2014) adsorption using zeolite can be used to reduce detergent contamination. The negative charge on the zeolite framework is neutralized by weakly bound cations. Detergents which are organic molecules will be attracted by the zeolite and attached to the surface by a combination of complex physical forces and chemical reactions.

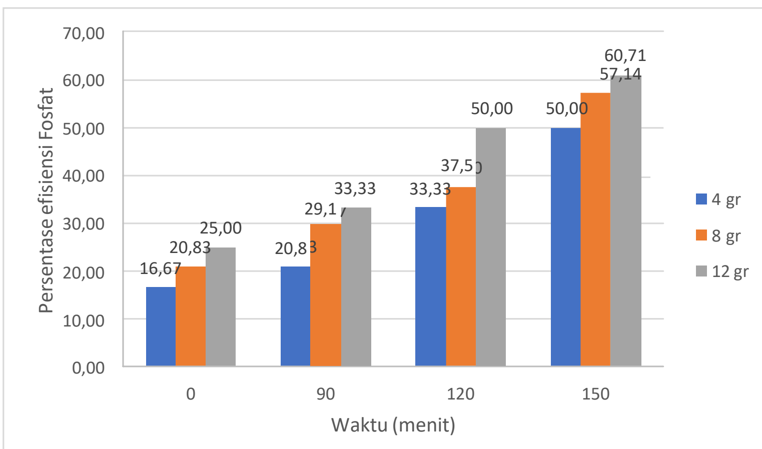


Figure 6. Average percentage reduction in phosphate levels

A graph of the relationship between adsorption capacity and time variations can be shown in Figure 7. Based on the graph, it shows that the adsorption capacity decreases with increasing adsorbent dosage. The maximum adsorption capacity occurs under conditions of 150 minutes of contact time and a dosage of 4 grams, namely 1.75 mg/g. This amount shows that every gram of zeolite adsorbent is capable of adsorbing 1.75 mg of phosphate.

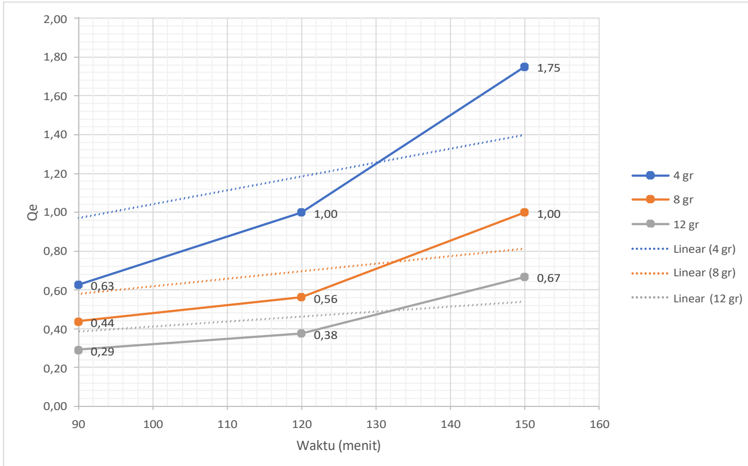


Figure 7. Adsorption capacity of phosphate levels on zeolite adsorbents

The results of plotting the Langmuir and Freundlich isotherm models of zeolite adsorbent adsorption on phosphate parameters can be seen in Figure 8 and Figure 9. The adsorption process used is based on variations in adsorbent dosage. Based on the results of plotting the Langmuir isotherm model, the linear equation values obtained for each adsorbent dosage of 4 gr, 8 gr, and 12 gr were 0.9691, 0.9271, and 0.9271. The results of data analysis show that the adsorption of zeolite adsorbents on phosphate parameters is more in line with the Freundlich isotherm model, this can be seen from the linear equation values obtained by each dosage variation of 4 gr, 8 gr, and 12 gr, namely 0.9912, 0 .9967, and .9967.

The results of plotting each graph then produce a linear equation to determine the constants of the Langmuir and Freundlich equations. The maximum amount of adsorbate that can be absorbed by the adsorbent, represented by Qm, and the Langmuir constant, represented by KL, make up the linear equation of the Langmuir model. Meanwhile, in the Freundlich model, the adsorption capacity is symbolized by Kf and the absorption intensity is symbolized by n. The linear equations resulting from the plotting results based on Figure 8 and Figure 9 are then analyzed to obtain the constants of each model, namely Langmuir and Freundlich. The analysis results of each model are displayed in Table 3.

Table 3. Results of isotherm model analysis of phosphate levels with zeolite adsorbent

Dosage	Langmuir			Freundlich		
	K_L	Qm	R^2	K_F	n	R^2
4 gr	-0.159	0.198	0.9691	1.839	-9.978	0.9912
8 gr	-0.193	0.155	0.9271	1.576	-2.373	0.9967
12 gr	-0.193	0.104	0.9271	1.576	-1.484	0.9967

According to the results of the isotherm model analysis, the adsorption mechanism that occurs tends to follow the Freundlich model.

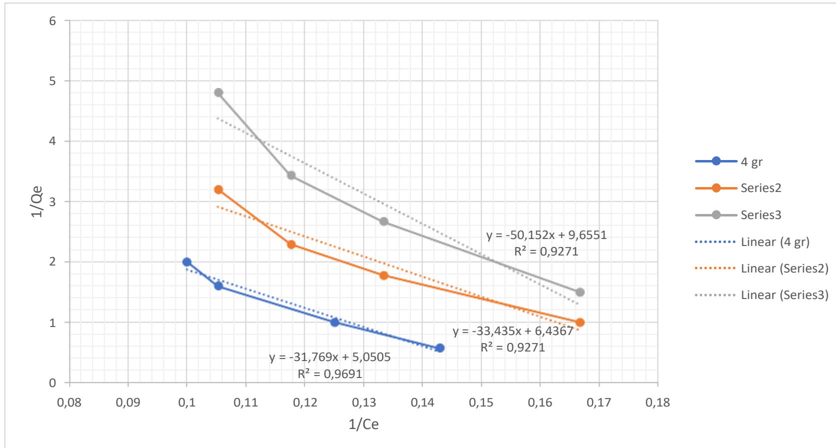


Figure 8. Langmuir isotherm of phosphate content in zeolite adsorbents

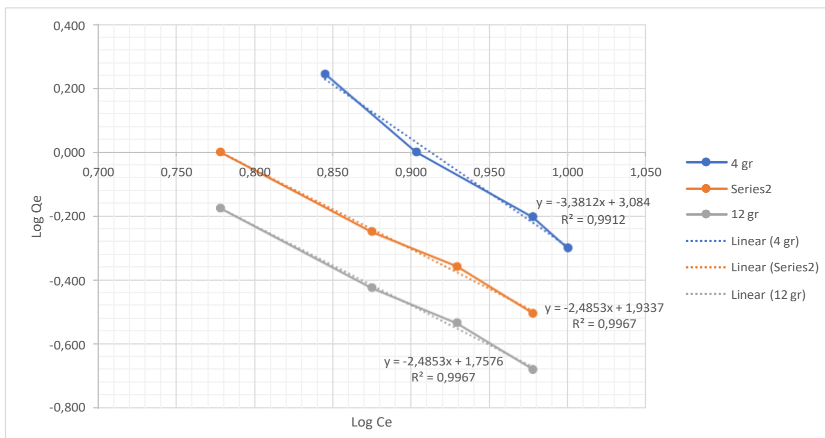


Figure 9. Freundlich isotherm of phosphate levels in zeolite adsorbent

Effect of GAC and Zeolite Adsorbent Type, Dosage and Adsorption Time on Phosphate Pollutant Levels in Laundry Waste

Adsorption testing with varying dosages aims to see how the weight of the adsorbent influences the absorption of pollutants, while varying contact time aims to see how contact time influences the adsorption capacity parameters. Phosphate levels in laundry waste using GAC and zeolite adsorbents with varying dosages and times resulted in different percentage reductions. The results of research using GAC and zeolite adsorbents to reduce phosphate parameters can be seen in Figure 10.

Based on this figure, the highest average percentage reduction in phosphate was found at a contact time variation of 150 minutes and a dosage variation of 12 grams with a percentage of 57.14%. This shows that the longer the contact time and the greater the dosage given, the greater the reduction in phosphate parameter concentrations obtained. The graph of the average percentage reduction in phosphate levels can be seen in Figure 10.

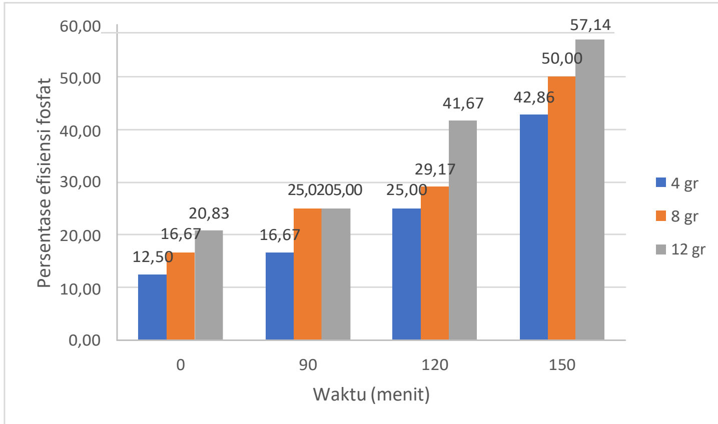


Figure 10. Average percentage reduction in Phosphate levels

A graph of the relationship between adsorption capacity and time variations can be shown in Figure 11. Figure 11 shows that as contact time increases, so does the adsorption capacity of GAC and zeolite adsorbents on phosphate parameters. Based on the graph, it shows that the adsorption capacity decreases with increasing adsorbent dosage. The maximum adsorption capacity occurs under conditions of 150 minutes of contact time and a dosage of 4 grams, namely 1.50 mg/g. This amount shows that every gram of GAC and zeolite adsorbent is capable of adsorbing 1.50 mg of phosphate.

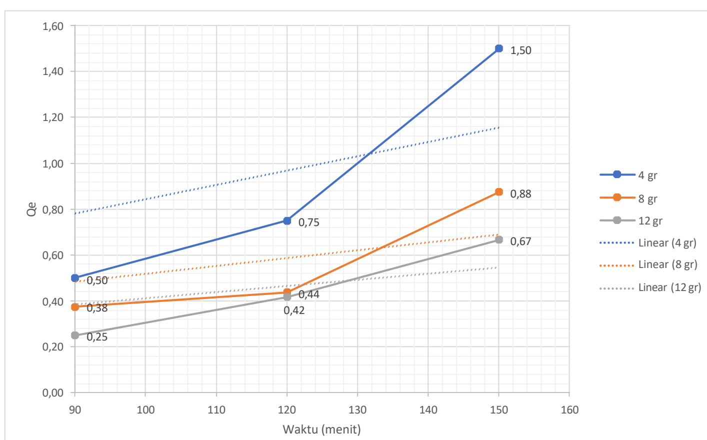


Figure 11. Adsorption capacity of phosphate levels on GAC and zeolite adsorbents

The results of plotting the Langmuir and Freundlich isotherm models of the adsorption of GAC and zeolite adsorbents against phosphate parameters can be seen in Figure 12 and Figure 13. The adsorption process used is based on variations in adsorbent dosage. Based on the results of plotting the Langmuir isotherm model, the linear equation values obtained for each adsorbent dosage of 4 gr, 8 gr, and 12 gr were 0.9592, 0.9271, and 0.9732. The results of data analysis show that the adsorption of GAC and zeolite adsorbents on phosphate parameters is more in line with the Freundlich isotherm model, this can be seen from the linear equation value obtained by each dosage variation of 4 gr, 8 gr, and 12 gr, namely 0.9921, 0.9986, and 0.9921.

The results of plotting each graph then produce a linear equation to determine the constants of the Langmuir and Freundlich equations. The maximum amount of adsorbate that can be absorbed by the adsorbent, represented by Qm, and the Langmuir constant, represented by KL, make up the linear equation of the Langmuir model. Meanwhile, in the Freundlich model, the adsorption capacity is symbolized by Kf and the absorption intensity is symbolized by n. The linear equation resulting from the plotting results based on Figure 12 and Figure 13 is then analyzed to obtain the constants of each model, namely Langmuir and Freundlich. The analysis results of each model are displayed in Table 4.

Table 4. Results of isotherm model analysis of phosphate levels with GAC and zeolite adsorbents

Dosage	Langmuir			Freundlich		
	K_L	Qm	R^2	K_F	n	R^2
4 gr	-0.134	0.117	0.9592	2.227	-4.889	0.9921
8 gr	-0.158	0.101	0.9271	1.867	-2.119	0.9986
12 gr	-0.193	0.101	0.9732	1.557	-1.459	0.9921

The adsorption mechanism that takes place tends to resemble the Freundlich model, according to the isotherm model analysis results.

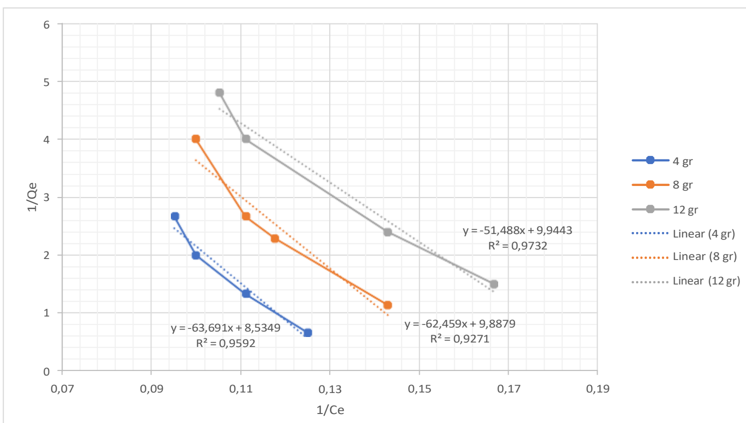


Figure 12. Langmuir isotherm of phosphate levels in GAC and zeolite adsorbents

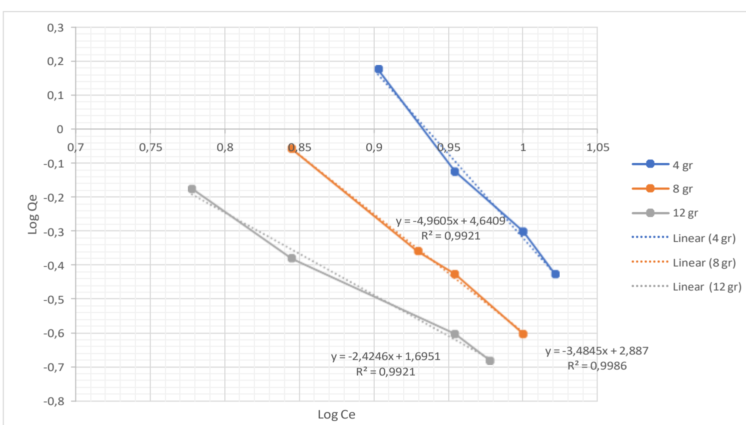


Figure 13. Freundlich isotherm of phosphate content in GAC and zeolite adsorbents

Determination of the Optimum Type of Adsorbent, Dosage and Contact Time in Reducing Phosphate Levels, Chemical Oxygen Demand (COD), Total Suspended Solid (TSS) in Laundry Waste

Determining the type of adsorbent, dosage and optimum contact time in reducing phosphate levels can be seen in the percentage value of the efficiency of reducing phosphate levels and statistical results. At a contact time of 0 minute (control), the 4 gr GAC adsorbent dosage had the lowest percentage reduction in phosphate levels, namely 12.5% and the one with the highest percentage reduction in phosphate levels was the 12gr dosage of zeolite adsorbent at a contact time of 150 minutes, namely 60.71%. The control in this study was with a contact time of 0 minutes by adding varying dosages of adsorbent. At a contact time of 0 minutes (control) there was a decrease in phosphate levels, this was due to the continued treatment by adding GAC coagulant to the liquid laundry waste sample. The decrease in percentage was due to the addition of variations in adsorbent dosage resulting in an adsorption process where there was an attractive force of atoms or molecules on the surface of the solid without seeping into the pores of the adsorbent (Utama et al., 2021).

The addition of GAC and zeolite adsorbent dosages with a contact time of 150 minutes had a greater percentage reduction in phosphate values compared to a contact time of 0 minutes (control). The decrease in phosphate value is caused by adsorption activity which is carried out mainly through the adsorption mechanism, where the process of mass transfer of a solution to the surface of the solid and the adsorption process on laundry waste is influenced by several factors including treatment during adsorption such as contact time, characteristics of the elements being adsorbed, type and amount of adsorbent (Wirosoedarmo et al., 2019).

Based on Figure 3.1, Figure 3.5 and Figure 3.9, the lowest percentage decrease in phosphate value was at a dosage variation of 4 gr and at a contact time of 90 minutes, while the percentage decrease in phosphate value was highest at a dosage variation of 12 gr and at a contact time of 150 minutes. This image shows that the more adsorbent added, the phosphate levels will decrease and as the contact time increases, the phosphate levels will decrease. This is because the addition of adsorbent according to the required dosage means no adsorption occurs. At the appropriate contact time, maximum adsorption capacity is produced (Syauqiah, 2011).

According to research by Sari (2021), the percentage reduction in phosphate levels increases with the duration of contact and achieving optimum concentration at the most optimum value at a weight of 15 grams with an absorption time of 40 minutes and is able to reduce the phosphate levels of laundry waste by 60.71% with using bottom ash as an adsorption medium. This is the same as in this research using GAC and zeolite adsorbents, where the percentage reduction in phosphate levels increases as the adsorbent is added.

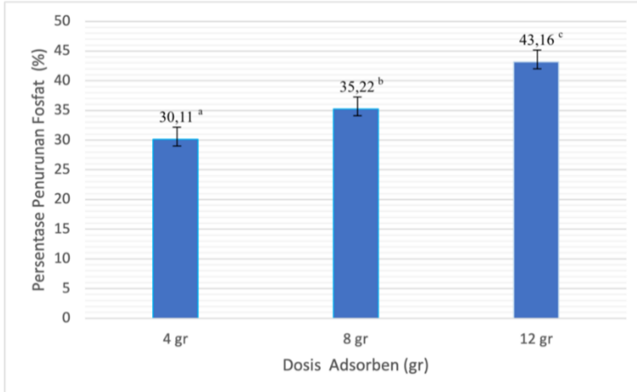


Figure 14. Percentage reduction in phosphate levels with variations in adsorbent dosage

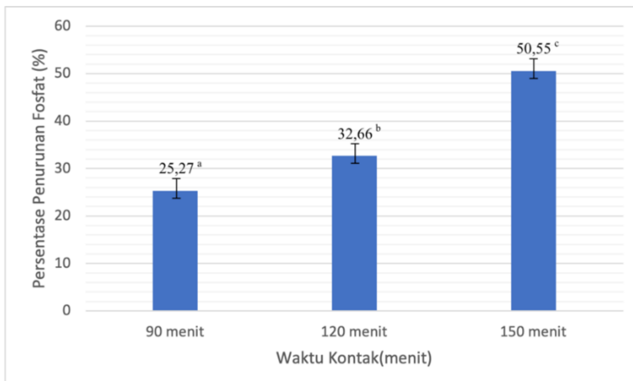


Figure 15. Percentage reduction in phosphate levels with variations in contact time

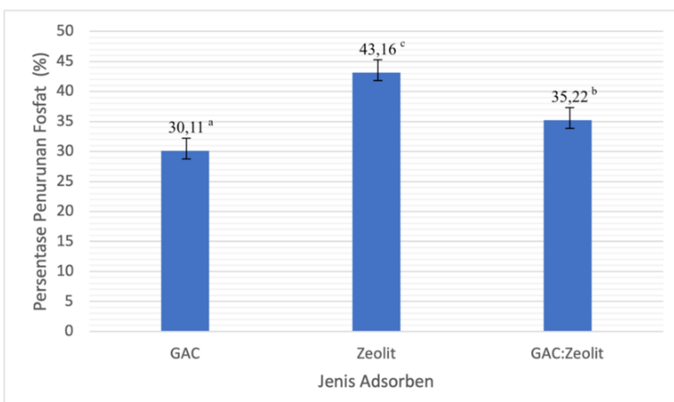


Figure 16. Percentage reduction in phosphate levels with variations in adsorbent type

Through the research results obtained, it can be determined with statistical results that the optimum dosage of zeolite adsorbent is 12 grams and the optimum contact time is 150 minutes with an average percentage reduction in phosphate levels of 60.71%. Determination of the optimum dosage and contact time is based on statistical analysis using the Duncan test in Figure 14, Figure 15 and Figure 16 in different subsets or letters, showing significant differences in values.

At a dosage of 12 grams and a contact time of 150 minutes it is in the highest subset. At dosages of 4 grams and 8 grams they are in subset 1 and subset 2 so it can be said that the two dosages have a significant difference in the percentage reduction in phosphate levels. By using a coagulant dosage of 12 grams, it is possible to reduce the highest phosphate content value, namely 6.5 mg/L, so that this value meets the quality standards based on East Java Governor Regulation Number 72 of 2013 concerning Quality Standards for Waste Water and/or Other Business Activities.

Morphological Analysis of GAC and Zeolite Adsorbents

Scanning Electron Microscopy is used to analyze the morphology of GAC and zeolite adsorbents. To ascertain the pores of the absorbent, SEM analysis was performed. The adsorbent utilized in the study for 150 minutes was also used for SEM analysis. In this study, the zeolite adsorbent was magnified 1000 times, and the GAC adsorbent was magnified 2000 times on average.

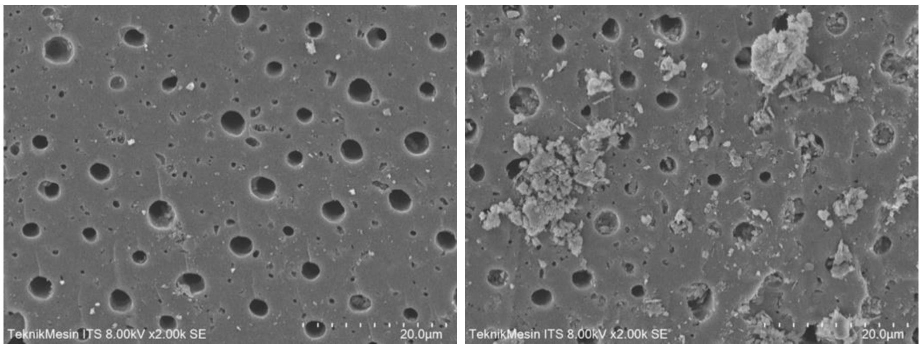


Figure 17. SEM EDX GAC test results before and after adsorption with 2000 times magnification

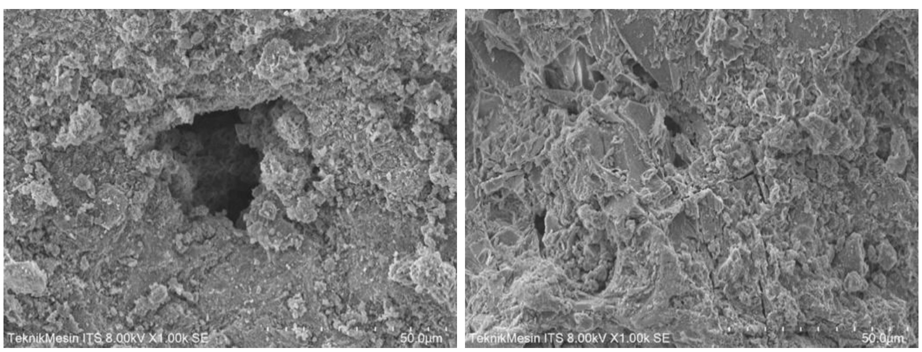


Figure 18. SEM EDX zeolite test results before and after adsorption with 1000 times magnification

The pores in the GAC and zeolite adsorbents were evidently visible prior to treatment, as demonstrated by the SEM analysis results. The adsorbent pores appear to be more filled following treatment in Figures 17 and Figure 18 compared to their pretreatment states. This is due to the buildup of material on the surface of the adsorbent. These particles are thought to be compounds in laundry wastewater which are absorbed by GAC and zeolite adsorbents.

The results of SEM analysis show the pores of the GAC and zeolite adsorbents clearly in Figure 17 and Figure 18. From this image, it can be seen that activated carbon has a hollow or pore structure. The pores contained in activated carbon can increase the ability to adsorb adsorbate because these pores are gaps that expand the surface of the activated carbon [10].

According to Sari and Damayanti's (2014) research, fouling causes the membrane to appear increasingly dense. Fouling occurs due to the accumulation of material on the membrane surface which leads to blockage of the pores in the membrane. In addition to the top surface or outer layer of the membrane that forms the cake, fouling on the membrane can also happen in the inner layer of the membrane. Because of the pressure that is applied during membrane operation, pollutants are able to penetrate the inner layer. Particle deposition on the membrane surface will be promoted by pressure.

CONCLUSION

Based on the research that has been carried out, the results and conclusions obtained are the type of adsorbent, adsorbent dosage and optimum contact time in reducing phosphate levels, COD and TSS in laundry wastewater, namely 12 grams of GAC and Zeolite adsorbents. with a contact time of 150 minutes with a percentage reduction in phosphate levels of 57.14%.

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