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The Use of Granular Activated Carbon and Zeolite as an Adsorbent to Reduce the Concentration of Phosphate, Chemical Oxygen Demand and Total Suspended Solid in Laundry Wastewater

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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, 250 mg/L and 100 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 phosphate, COD and TSS levels 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 Scanning Electron Microscope test results and the percentage reduction in phosphate, COD and TSS levels 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%, a percentage reduction in COD levels of 63.11% and a percentage reduction in TSS levels of 53.11%. The phosphate, COD and TSS values of laundry liquid waste after processing with adsorbent mass, adsorbent composition and optimum contact time are 6.5 mg/L and 383.5 mg/L and 84.5 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, 2019). The laundry waste business produces liquid waste which is generally discharged directly into the drain and flows into water bodies without prior processing (Raissa, 2017). 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 chemical oxygen demand (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 dan Sooknanan, 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 (Chemical Oxygen Demand) values in laundry liquid waste will increase the toxic effect and will risk polluting the environment and the organisms in it (Esmiralda dan Zulkarnaini, 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, 2008). In the adsorption process, there are two phases involved, namely the adsorbing phase referred to as adsorbent and the adsorbed phase referred to as adsorbate (Lutfianingsih and Mulyani, 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 (Matsuo and Ishi, 2000). 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 Hisham, 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

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.

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. The materials used for COD parameter analysis were 1,0216 g $K_2Cr_2O_7$; 2,024 g $AgSO_4$; 250 mL concentrated H_2SO_4; 6,66 g $HgSO_4$; NH_2SO_3H and 425 mg $HOOCC_6H_4COOK$. The material used for TSS parameter analysis were filter paper No. 42 (Whatman), 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 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 work consisted of preparing experiments in 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 is carried out with liquid laundry waste samples put into three 1000 mL Erlenmeyer flasks each with an adsorbent composition, namely GAC: zeolite (50:50) (Yu et al., 2019) with each adsorbent mass variation of (2 : 2 g), (4 : 4 g) and (6 : 6 g) in 1 L of liquid laundry waste. 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 (Fasihah 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 experiments were conducted in duplo. The reactor uses a magnetic stirrer as in Figure 1.

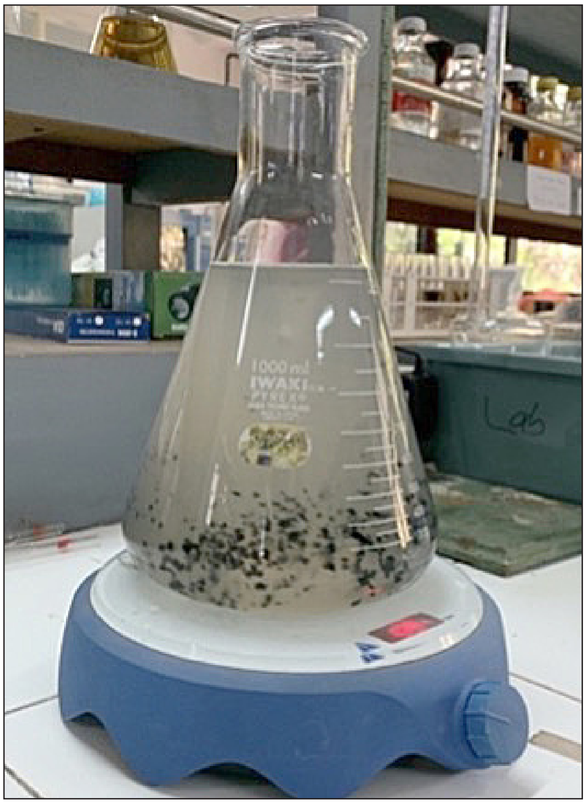

Figure 1. Process running on a batch system

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 GAC and zeolite adsorbents to reduce phosphate, COD and TSS 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.

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

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

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.

Phosphate removal

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 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 2.

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 g 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 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.

A graph of the relationship between adsorption capacity and time variations can be shown in Figure 3. It 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 12 g, namely 0.67 mg/g. This amount shows that every gram of GAC and zeolite adsorbent is capable of adsorbing 0.67 mg of phosphate, meaning that at a dosage of 12 g, it can adsorb 8.04 mg of phosphate.

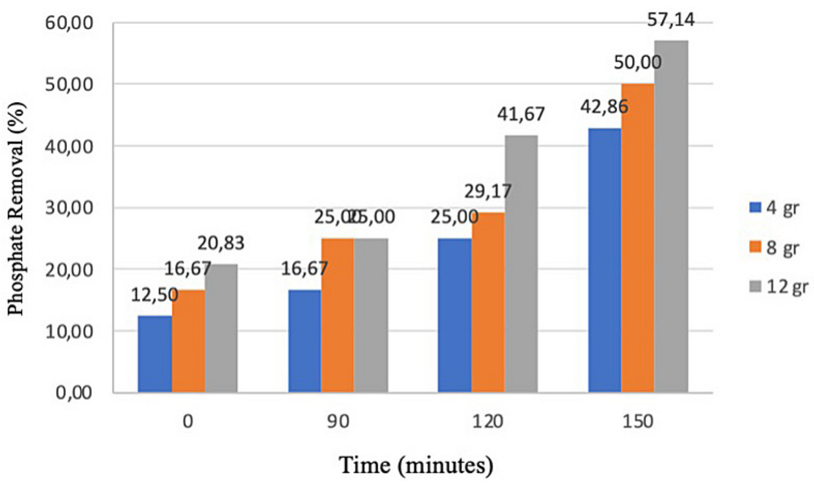

Figure 2. Average percentage reduction in phosphate levels

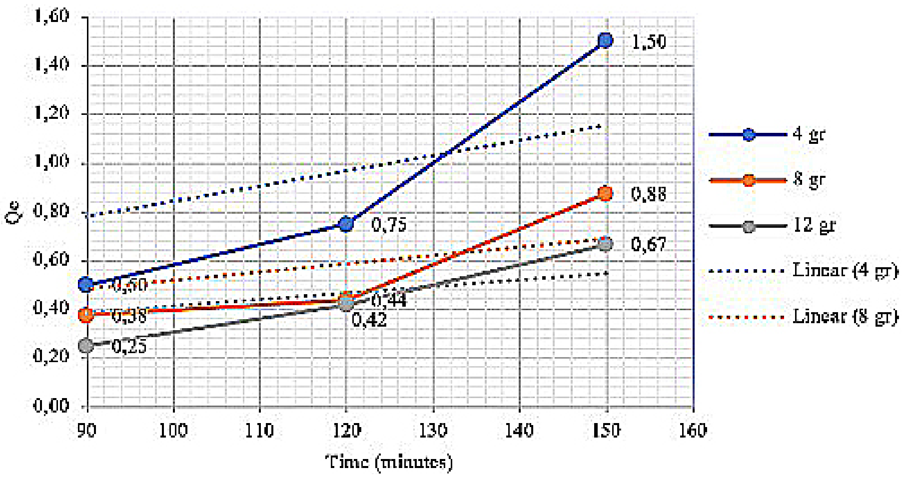

Figure 3. Adsorption capacity of phosphate levels on GAC and zeolite adsorbents

Chemical oxygen demand removal

The average percentage reduction in COD parameters was obtained based on the difference in initial and final concentration results for each variation. Based on this figure, the highest average COD reduction percentage was found at a contact time variation of 150 minutes and a dosage variation of 12 g with a percentage of 63.11%. This shows that the longer the contact time and the greater the dosage given, the higher the reduction in COD parameter concentrations obtained. The graph of the average percentage reduction in COD levels can be seen in Figure 4.

A graph of the relationship between adsorption capacity and time variation can be shown in Figure 5. Based on Figure 5, the adsorption capacity of GAC and zeolite adsorbents on COD parameters increases with increasing contact time. The adsorption capacity shows the number of parameters that are capable of being adsorbed by the adsorbent. 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 occurred under conditions of 150 minutes of contact time and a dosage of 12 g, namely 54.67 mg/g. According to this quantity, each gram of GAC and zeolite adsorbent can adsorb 54.67 mg of COD parameters, meaning that 12 g of GAC and zeolite adsorbent can adsorb 656.04 mg of COD parameters.

Total suspended solid removal

The average percentage reduction in TSS parameters was obtained based on the difference in initial and final concentration results for each

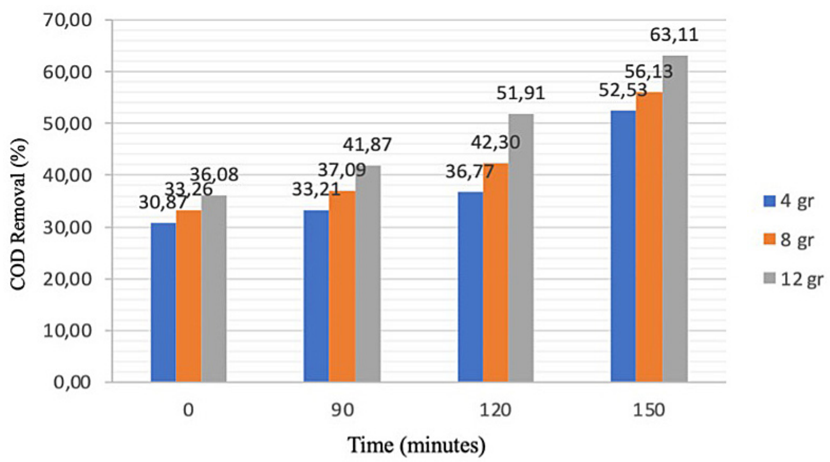

Figure 4. Average percentage reduction in COD levels

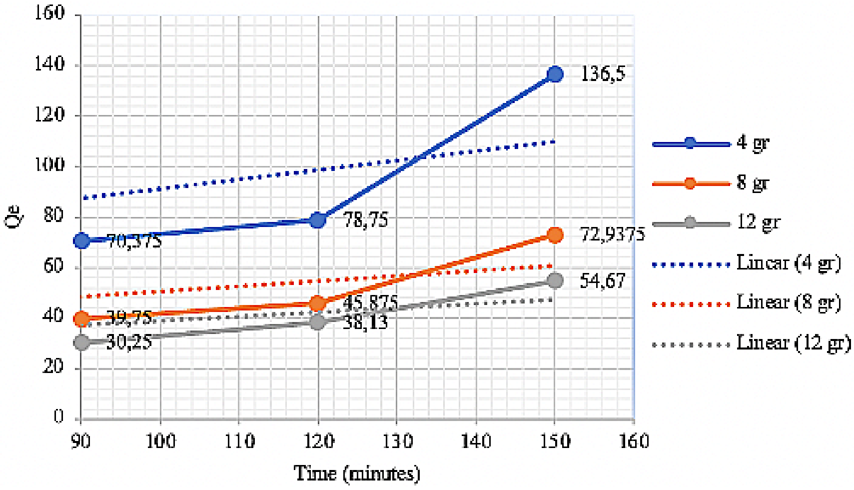

Figure 5. Adsorption capacity of COD levels on GAC and zeolite adsorbents

variation. Based on this table, the highest average percentage reduction in TSS was found at a contact time variation of 150 minutes and a dosage variation of 12 g with a percentage of 53.11%. This demonstrates that the decrease in TSS parameter concentrations obtained increases with longer contact times and higher dosages. The graph of the average percentage reduction in TSS levels can be seen in Figure 6.

A graph of the relationship between adsorption capacity and time variation can be shown in Figure 7. Based on Figure 7, the adsorption capacity of GAC and zeolite adsorbents on TSS parameters increases with increasing contact time. The adsorption capacity shows the number of parameters that are capable of being adsorbed by the adsorbent. 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 occurred under conditions of 150 minutes of contact time and a dosage of 12 g, namely 7.83 mg/g. This amount shows that every gram of GAC and zeolite adsorbent is capable of adsorbing TSS parameters of 7.83 mg.

Determination of the optimum dosage and contact time in reducing phosphate levels, COD, TSS in laundry wastewater

Determining the optimum type of adsorbent dosage and contact time in reducing phosphate, COD and TSS levels can be seen in the percentage efficiency values for reducing phosphate, COD and TSS levels and statistical results. In this study, the average variation in percentage reduction in phosphate levels in GAC and zeolite adsorbents was in the range of 12.50% to 57.14%. At a contact time of 0 minutes (control), the 4 g GAC and zeolite adsorbent dosage had the lowest

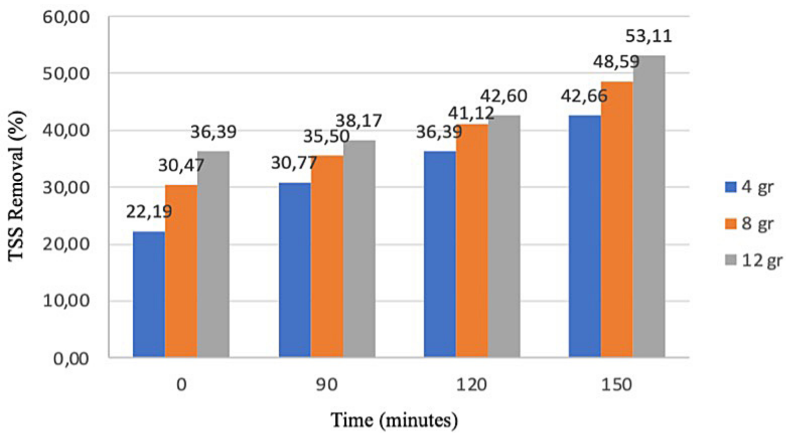

Figure 6. Average percentage reduction in TSS levels

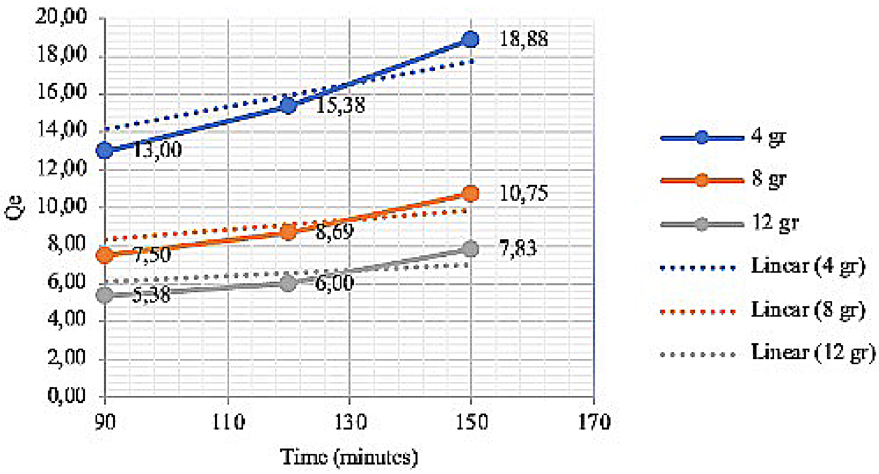

Figure 7. Adsorption capacity of TSS levels on GAC and zeolite adsorbents

percentage reduction in phosphate levels, namely 12.50% and the one with the highest percentage reduction in phosphate levels was the 12 g dosage of zeolite adsorbent at a contact time of 150 minutes. namely 57.14%. 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 (Ultama 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). Substances adsorbed on the surface of the adsorbent come from the detergent used and organic materials found in liquid laundry waste, namely organic compounds and pathogens originating from clothing (Howard et al., 2005).

In liquid laundry waste there are many organic compounds in surfactants and builders, this influences the increase in the values of BOD, COD and phosphate parameters in liquid laundry waste (Fardiaz, 1992; Effendi, 2003). Laundry liquid waste uses detergent that contains high levels of phosphate compounds derived from sodium tripolyphosphate (STPP) which functions as a builder. The purpose of the builder, which is the second most crucial component after surfactant, is to deactivate the hardness minerals in liquid waste so that detergent can function at its best (Hermansyah, 2010). This STPP will be hydrolyzed into PO_4 and P_2O_7 which will then also be hydrolyzed into PO_4 (Hera, 2003). In detergents, the phosphate content is in the form of polyphosphate. Polyphosphate which dissolves in water or during the washing process will form orthophosphate (Widyaningsih, 2011). Orthophosphates are monomeric compounds such as $H_2PO_4^-$, HPO_4^{2-} dan PO_4^{3-}, and polyphosphates are polymer compounds such as seperti $(PO_3)_6^{3-}$ (heksametafosfat), $P_3O_{10}^{5-}$ (tripolifosfat) dan $P_2O_7^{4-}$ (pirofosfat) (Alaerts dan Santika, 1984). The decrease in phosphate levels in liquid laundry waste is due to the positively charged surface on the adsorbent supporting phosphate adsorption due to electrostatic attraction or ion exchange with phosphate particles ($H_2PO_4^-$) (Jiang et al., 2013).

GAC adsorbent has adsorption power and a surface area that is very effective in adsorbing pollutants. This large surface area is because activated carbon has a pore structure. These pores are what cause activated carbon to have the ability to adsorb. Activated carbon's porous nature allows it to absorb impurities from liquid laundry waste, including phosphate, color, and odor, leaving the water odorless and clear (Sudibandriyo et al, 2003). Zeolite adsorbents in water have positive bonds so they are able to bind phosphate anions such as $H_2PO_4^-$, HPO_4^{2-}. Zeolites have a porous structure, are abundant, chemically and mechanically stable, and are low cost (Yang et al., 2014).

Based on Figure 2, the lowest percentage decrease in phosphate value was in the 4 g dosage variation with a contact time of 90 minutes, while the highest percentage decrease in phosphate value was in the 12 g dosage variation with 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 by adding adsorbent according to the required dosage, desorption does not occur. At the appropriate contact time, maximum adsorption capacity is produced (Syauqiah et al., 2011).

According to research by Sari (2021), the longer the contact time, the greater the percentage reduction in phosphate levels and achieving optimum concentration at the most optimum value at a weight of 15 g 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 similar to the study that used zeolite and GAC adsorbents, where the addition of adsorbents increased the percentage reduction in phosphate levels and according to research by Wardhana (2013) the highest phosphate removal efficiency in batch experiments was achieved using activated carbon derived from plastic waste, with a weight of 3 grams and a particle size of 100-200 mesh, amounting to 45.45%. This indicates that the phosphate removal efficiency in laundry wastewater is higher when employing GAC and zeolite as adsorbents.

Through the research results obtained, it can be determined with statistical results that the optimum dosage of GAC and zeolite adsorbent is 12 g 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 Duncan's test in Figure 8 and Figure 9. Different subsets or letters show significant differences in values.

At a dosage of 12 g and a contact time of 150 minutes it is in the highest subset. At dosages of 4 g and 8 g 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. Therefore, by using a coagulant dosage of 12 g, it is possible to reduce the highest phosphate content value, namely 6 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.

For each variation of dosage and variation of contact time, the average percentage reduction in COD value in liquid laundry waste was obtained from different results. The treatment was carried out using variations in adsorbent dosage and variations in contact time, which were the same as the previous treatment to reduce phosphate levels, which was used to determine the optimum dosage and contact time in reducing COD levels in laundry liquid waste.

The average variation in the percentage reduction in COD levels in the combined GAC and zeolite adsorbent was in the range of 30.87% to 63.11%. The highest percentage reduction in COD levels was 12 g of GAC and zeolite at a contact time of 150 minutes, namely 63.11%. The control in this study was with a contact time of 0 minutes and added variations in the adsorbent dosage. At a dosage of 4 g with a contact time of 0 minutes

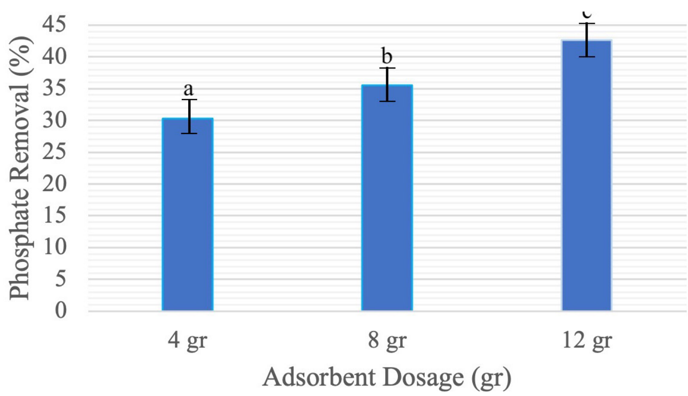

Figure 8. Percentage reduction in phosphate levels with variations in adsorbent dosage

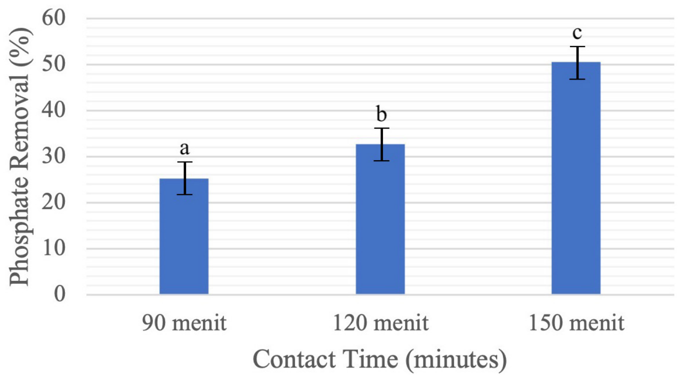

Figure 9. Percentage reduction in phosphate levels with variations in contact time

(control) there was a decrease in COD levels, this was due to the addition of adsorbent to the control sample. The presence of this adsorbent results in an adsorption process where there is mass transfer on the surface of the pores in the adsorbent granules. Adsorption can occur due to surface energy and surface attractive forces (Pungut et al., 2021).

The longer the contact time and the additional concentration of GAC and zeolite adsorbents, the percentage reduction in COD values was greater compared to the contact time of 0 minutes (control). The principle underlying the decrease in the COD value and the decrease in the phosphate value in laundry waste is the same: after adsorbents are added, adsorption activity takes place. In particular, this adsorption mechanism involves organic materials, some of which have already been adsorbed and bound by GAC. As a result, the amount of organic material in waste water automatically reduces the need for oxygen to chemically oxidize organic materials. The reduced oxygen demand results in the COD value in wastewater decreasing (Wiroesoedarmo et al., 2018).

In liquid laundry waste there are many organic compounds in surfactants and builders, this influences the increase in the values of BOD, COD and phosphate parameters in liquid laundry waste (Fardiaz, 1992; Effendi, 2003). COD is the amount of oxygen used to chemically oxidize organic materials (Sawyer et al., 2003). The surfactant content is a complex organic compound in laundry wastewater so it will increase the need for oxygen for microorganisms and oxidant compounds to decompose these organic materials so that the COD value will increase (Padmanabha et al., 2015).

Based on Figure 4, the lowest percentage reduction in COD value was at a dosage variation of 4 g and at a contact time of 90 minutes, while the highest percentage reduction in COD value was at a dosage variation of 12 g of GAC adsorbent and zeolite and at a contact time of 150 minutes, indicating that the more adsorbent added, the COD levels will decrease further. This is due to the decrease in COD levels in liquid laundry waste because activated carbon is a material in the form of amorphous carbon which mostly consists of free carbon and has good adsorption capacity. Adsorption by activated carbon by taking organic compounds from liquids that come into contact with activated carbon. In the adsorption process, organic molecules in the liquid phase will be attracted and bound to the surface of the active carbon pores when the liquid passes through the activated carbon. The organic molecules present in the liquid are referred to as adsorbate (substance that is adsorbed). Activated carbon as an adsorbent is called an adsorbent (Pungut et al., 2021). A decrease in organic material will cause a decrease in the oxygen needed to oxidize organic material, so that COD levels will decrease (Coniwanti et al., 2013).

Determination of the optimum dosage and contact time is based on statistical analysis using the Duncan test in Figure 10 and Figure 11, namely at a dosage of 12 g and a contact time of 150 minutes which is in the highest subset. The same is true for the phosphate parameter, namely based on the Duncan test, the COD parameter at dosages of 4 g and 8 g, subsets one and two, so it can be said that the two dosages have a significant difference. Through the results obtained, it can be determined that the optimum type and dosage of adsorbent is 12 g of GAC and zeolite and the optimum contact time is 150 minutes with the highest average percentage reduction in COD levels of 63.11% and is able to reduce the value of COD levels by 383.5 mg/L.

Determining the type of adsorbent, dosage and optimum contact time in reducing TSS levels can be seen from the variation in the average percentage reduction in TSS levels in GAC

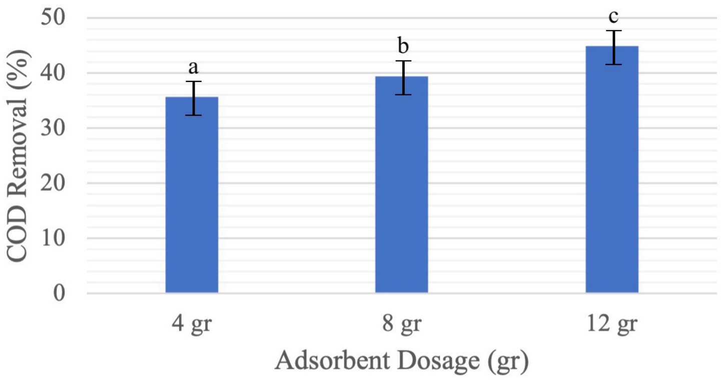

Figure 10. Percentage reduction in COD levels with variations in adsorbent dosage

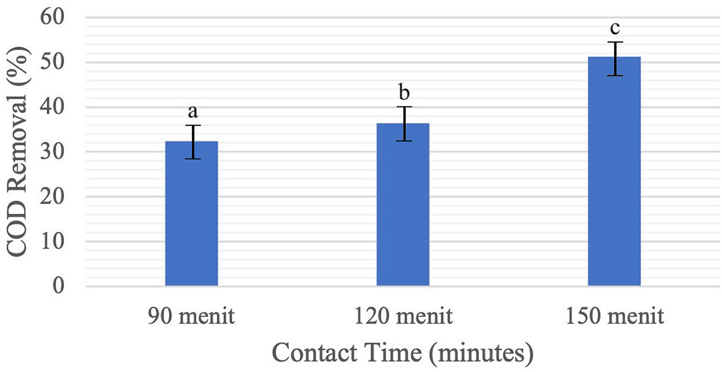

Figure 11. Percentage reduction in COD levels with variations in contact time

and zeolite adsorbents in the range of 22.19% to 53.11%. The highest percentage reduction in TSS levels was 12 g of GAC and zeolite adsorbents at a contact time of 150 minutes, namely 53.11%. Based on research conducted by Karamah et al. (2018) showed that as the adsorbent dosage increased, the percentage of efficiency obtained was effective in reducing TSS levels in tofu liquid waste by 88% using the GAC adsorbent.

High TSS content can increase turbidity which will further inhibit the penetration of sunlight into water bodies. The large amount of TSS in waters can reduce the availability of dissolved oxygen (Rinawati et al., 2016). The increasing concentration of GAC and zeolite adsorbents and the longer the contact time resulted in a greater percentage reduction in TSS values compared to the contact time of 0 minutes (control). The decrease in the TSS value has the same principle as the decrease in the phosphate value in laundry waste, namely that it is caused by adsorption activity carried out after the addition of adsorbents, especially through the adsorption mechanism by organic materials, some of which have been adsorbed and bound by GAC active carbon so that the amount of organic material is present in wastewater will decrease resulting in the TSS value in wastewater decreasing further (Wiroesoedarmo et al., 2018). The adsorption process uses a zeolite adsorbent, the concentration of Total Suspended Solid (TSS) can be reduced because zeolite has a molecular structure that forms pores which allow phosphate ions and other molecules to be trapped in the zeolite crystal structure. The longer the adsorption process takes, the more pollutants are adsorbed until the zeolite reaches its saturation capacity (Sisyanreswari et al. 2019).

Based on the results of the isotherm model analysis, the adsorption mechanism that occurs tends to follow the Freundlich model. According to Srivastava and Hasan (2011), the Freundlich adsorption isotherm model states that the adsorbed ions form a multilayer on the surface of the adsorbent because the pores in the adsorbent are heterogeneous. The results of the adsorption kinetics analysis were conducted to understand the adsorption mechanism of a adsorbent, and the obtained adsorption kinetics result is pseudo-second order.

Determination of the optimum dosage and contact time is based on statistical analysis using the Duncan test in Figure 12 and Figure 13, namely at a dosage of 12 g and a contact time of

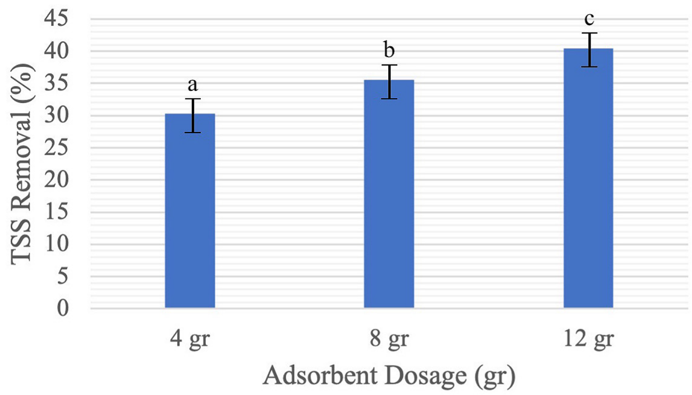

Figure 12. Percentage reduction in TSS levels with variations in adsorbent dosage

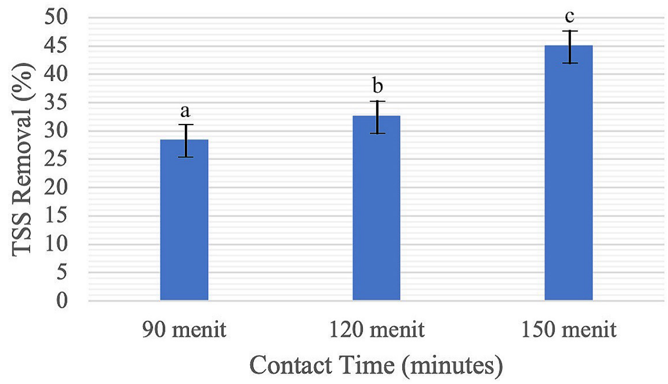

Figure 13. Percentage reduction in TSS levels with variations in contact time

150 minutes which is in the highest subset. Based on the Duncan test, the TSS parameters show that there is no significant difference between the two types of adsorbents because the TSS parameters for zeolite and GAC adsorbent types are in the same subset. Through the results obtained, it can be determined that the optimum adsorbent dosage is 12 g of GAC and zeolite and the optimum contact time is 150 minutes with the highest average percentage reduction in TSS levels of 53.11% and is able to reduce the TSS level value by 83 mg/L. 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.

Therefore, after looking at the results of the percentage reduction in phosphate, COD and TSS parameters and based on statistical results, it can be concluded that the adsorbent type GAC and zeolite (50:50) with an adsorbent dosage of 12 g at a contact time of 150 minutes is the optimum variation in batch system adsorption testing. Based on research by Yu et al. (2019), zeolite is effective in removing phosphate while activated carbon is effective in removing COD pollutants. For water treatment, a combination of activated carbon and zeolite is advised, as each kind of adsorbent has unique preferences for selective adsorption. (Eapen et al., 2016).

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.

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 14 and Figure 15 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.

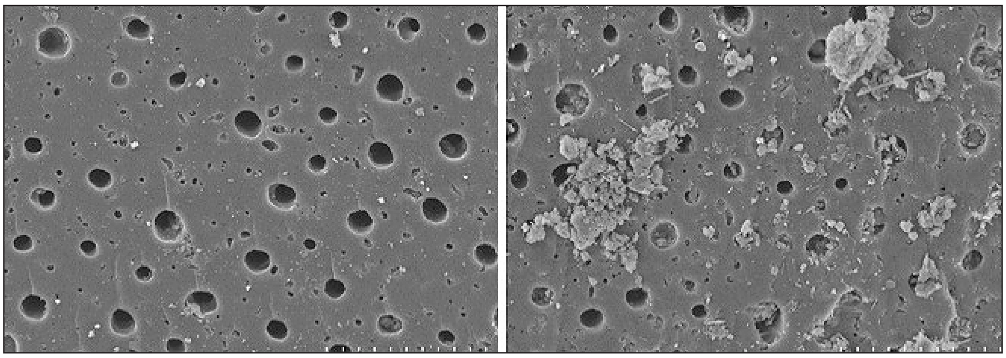

Figure 14. SEM GAC test results before and after adsorption with 2000 times magnification

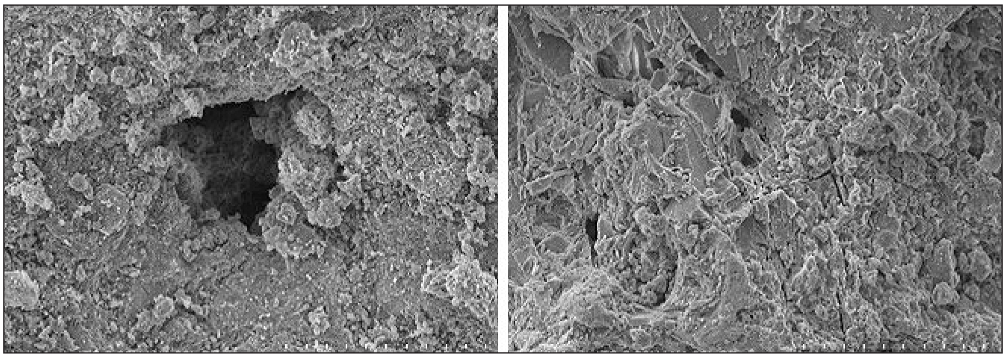

Figure 15. SEM zeolite test results before and after adsorption with 1000 times magnification

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 (Nasir, 2013).

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.

CONCLUSIONS

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 g of GAC and zeolite adsorbents. with a contact time of 150 minutes with a percentage reduction in phosphate levels of 57.14%, a percentage reduction in COD levels of 63.11% and a percentage reduction in TSS levels of 53.11%.

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