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Effectiveness of Peanut Shell Activated Charcoal as Adsorbent of Chromium and Lead Metal Ions Using Continuous System

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ABSTRACT

This study aims to determine the characteristics of peanut shell adsorbents based on SNI 03-3730-1995, the optimum conditions, efficiency and adsorption capacity of Cr and Pb metals in textile industry waste (simulated waste), and the morphology of the adsorbents. Peanut shells were converted into activated carbon by carbonization in a furnace at 450 °C for 5 minutes, then ground and sieved to a 60 mesh particle size. The carbon was chemically activated using a 0.5 M NaOH solution for 24 hours. Adsorption experiments employed a continuous system with variations in adsorbent mass (0.3, 0.6, and 0.9 grams), flow rate (slow and fast), and simulated Pb:Cr ratios (1:1, 1:2, and 1:3 (v/v)). The characterization results of activated carbon include moisture content of 3.99%, ash content of 7.46%, volatile matter content of 53.88%, iodine adsorption of 355.32 mg/g, and carbon content of 74.497%. Surface morphology showed porous structure with a pore diameter of 919.34 nm. The optimal conditions for the adsorption of Pb and Cr metals were an adsorbent mass of 0.9 g, slow flow rate, and a simulated waste ratio of 1:2. Adsorption efficiency for Cr and Pb metals was 73.33% and 100%, respectively, with adsorption capacities of 14.2902 mg/g and 2.0286 mg/g.

Keyword: Adsorption, Peanut shell, Continuous system

1. INTRODUCTION

Textiles are one of the basic necessities for society. The development of the textile industry in Indonesia is influenced by the factor of continuous population growth (Faradilla *et al*., 2022). In addition to producing clothing products, the textile industry also produces by-products in the form of waste. According to research conducted at the BBT Laboratory, water in textile waste contains 225 mg/L of reactive dyes (Enrico, 2019).

Heavy metals are one of the hazardous contaminants present in textile industry waste. In the dyeing process, dyes contain heavy metals such as chromium (Cr), lead (Pb), copper (Cu), cadmium (Cd), arsenic (As), zinc (Zn), iron (Fe), mercury (Hg), and sulfur (S) (Panigrahi & Santhoskumar, 2020). Heavy metals cannot be broken naturally, so they can accumulate in the body and cause disease (Dang *et al*., 2022). If this waste is not properly treated, it can pollute the environment and be harmful to human health.

Chromium is one of the heavy metals found in textile waste. Chromium is highly toxic. Chromium (VI) ions are more toxic than chromium (II) and (III) ions (Dina *et al*., 2022). High exposure to chromium in fish can cause kidney, liver, and lung damage, while exposure in humans can lead to cancer, hyperemia, bronchitis, and asthma (Badriyah *et al*., 2017; Pratiwi, 2020). Lead is also one of the heavy metals found in textile waste. Lead that contaminates water bodies can enter aquatic organisms through their gills, where it accumulates in the gills, kidneys, liver, and flesh (Ahmed *et al*., 2014). Other effects that can occur if it accumulates in the human body include tooth decay and osteoporosis (Moelyaningrum, 2016).

Adsorption is chosen as a method for treating textile industry waste to reduce heavy metal content such as Cr and Pb. Adsorption is based on the interaction of functional groups on the adsorbent surface, such as -OH, -NH, -SH, and -COOH, with heavy metal ions. The adsorption process can be carried out using batch and continuous methods (Foroughi-dahr, 2016). The continuous method is considered more effective due to its ease of continuous application, making it suitable for large-scale waste treatment. Adsorption is a simple method that can utilize natural materials (Purwitasari, 2022). Peanuts are one of the bioadsorbents that can be used for the adsorption of heavy metals such as chromium and lead in liquid waste. According to data from the Center for Agricultural Data and Information Systems (2020), peanut production in Indonesia reached 484,786 tons in 2020. Peanut shells contain 62% cellulose and 15% lignin (Handono & Kusmartono, 2017). Peanut shells can be used as heavy metal adsorbents due to their high cellulose content, which allows them to be converted into activated carbon, thereby increasing the economic value of peanut shell waste.

Adsorption activation is one of the factors that influence metal removal efficiency, with chemically activated adsorbents showing higher metal removal efficiency. According to Oktasari's research (2018), peanut shell adsorbents activated with base exhibit higher adsorption affinity compared to non-activated adsorbents and adsorbents activated with acid. This is supported by Putri *et al*. (2024), who stated that base-activated sorghum bagasse adsorbents are also effective for Cr metal adsorption.

This study aims to determine the ability of peanut shell adsorbents to reduce Cr and Pb metals in textile industrial wastewater. The method used involves a column system with variations in flow rate and adsorbent mass to determine optimal conditions. Additionally, variations in simulated Cr and Pb wastewater were conducted to assess the effects of ion competition. SEM-EDX analysis was performed to examine the morphology of the adsorbent before and after the adsorption process, and the concentrations of Cr and Pb metals were tested using SSA.

2. RESEARCH METHOD

2.1. Production of Peanut Shell Adsorbent

The peanut shells are washed with water until clean. Once clean, the peanut shells are dried in direct sunlight for 2-3 days. Next, they are roasted for approximately 30 minutes or until the peanut shells turn blackish brown. The dried peanut shells are then carbonized by placing them in a furnace at 450°C for 5 minutes until carbon is formed. The peanut shell carbon is then ground and sieved using a 60-mesh sieve to obtain uniform carbon particle size.

2.2. Activation of Peanut Shell Carbon

As much as 60 g of peanut shell carbon powder is placed in a 500 mL beaker, then 300 mL of 0.5 M NaOH solution is added. It is then soaked for 24 hours. The filtrate and peanut shell carbon powder are separated by filtering using filter paper and a vacuum pump. The peanut shell carbon powder is washed with distilled water until a neutral pH is achieved. The activated carbon is then dried in an oven at 105°C for 3 hours. If the activated carbon forms clumps, it is ground again and sieved using a 60-mesh sieve.

2.3. Characterization

2.3.1. Moisture Content

A porcelain crucible containing 1 g of activated carbon is placed in an oven at 115˚C for 3 hours, then placed in a desiccator for 15 minutes and weighed with an analytical balance after cooling until a constant weight is obtained. The mass obtained is recorded. The moisture content of peanut shell activated carbon can be determined through calculation.

2.3.2. Ash Content

A crucible containing 2 g of activated carbon was placed in a furnace at 800°C for 2 hours, then placed in a desiccator and weighed after cooling until a constant weight was obtained. The mass obtained was recorded. The ash content of activated carbon from peanut shells can be determined through calculation.

2.3.3. Volatile Matter Content

A crucible containing 2 g of activated carbon is placed in a furnace at 950°C for 6 minutes, then transferred to a desiccator. After cooling, it is weighed until a constant weight is obtained. The mass obtained is recorded. The volatile matter content of activated carbon from peanut shells can be determined through calculation.

2.3.4. Adsorption Capacity for Iodine

Peanut shell activated carbon was oven-dried at 115°C for 1 hour. 0.5 g of peanut shell activated carbon was weighed, placed in an Erlenmeyer flask, and 50 mL of 0.1 N iodine solution was added. The mixture was homogenized by shaking for 15 minutes. The precipitate and filtrate were separated by filtration. Take 10 mL of the filtrate, place it in an Erlenmeyer flask, and titrate with 0.1 N $Na_2S_2O_3$ solution until the solution turns light yellow, then add 1% kanji indicator solution, which will turn blue. Continue the titration until the solution is colorless. Record the total titration volume for calculating the adsorption capacity for iodine.

2.4. Determination of Optimal Conditions

2.4.1. Preparation of Simulated Waste

Simulated waste was prepared from a 1000 ppm Cr and Pb stock solution. First, 0.7692 g of $Cr(NO_3)_3.9H_2O$ and 0.160 g of $Pb(NO_3)_2$ were weighed. Each was dissolved in distilled water to a volume of 100 mL. Next, the two solutions were mixed to a total volume of 300 mL with Pb:Cr ratios of 1:1, 1:2, and 1:3, respectively.

2.4.2. Application of Adsorbent to Simulated Waste

The glass column was rinsed with water until clean, then 0.5 g of glass wool was added and pressed slightly to compact it. The peanut shell adsorbent is added to the column with varying masses of 0.3, 0.6, and 0.9 g. Distilled water is flowed through to remove trapped air. Next, the simulated waste solution with varying volume ratios of 1:1, 1:2, and 1:3 is added to the separator funnel and slowly flowed into the column. The valve on the column was operated by fully opening it for fast flow rate variations and half-opening it for slow flow rate variations. The simulated wastewater flowed continuously downward. The adsorption filtrate was collected in sample bottles, and the Cr and Pb metal content was analyzed using AAS. The optimal results were used for application in textile industry wastewater.

3. RESULTS AND DISCUSSION

3.1. Peanut shell adsorbent

The production of peanut shell adsorbent begins with the preparation of raw materials. The peanut shells are washed thoroughly to remove impurities. Then, a dehydration process is carried out, which involves removing the water content from the raw materials before carbonization to achieve perfect carbon formation (Monarita, *et al*., 2022). The dehydration process is carried out by sun-drying the peanut shells under direct sunlight for 2–3 days and roasting them until they turn dark brown. The dried peanut shells are then carbonized in a furnace at 450°C for 5 minutes. Carbonization is the process of decomposing organic matter (cellulose) into charcoal through heating without oxygen (Soofiyah & Zhendika, 2023). During the carbonization stage, elements other than carbon, such as hydrogen and oxygen, are removed, resulting in the formation of bound carbon and pore structure (Tani & Lumingkewas, 2022). The result is black peanut shell charcoal.

The carbonized peanut shells are then ground using a mortar and pestle and sieved with a 60-mesh sieve. The purpose of this stage is to reduce the size of the adsorbent to increase its surface area. The activated carbon powder from peanut shells is then subjected to chemical activation. The purpose of activating peanut shell carbon is to remove impurities and enlarge the pore size to enhance adsorption efficiency (Baunsele *et al*., 2023). In this study, the peanut shell adsorbent was activated using a 0.5 M NaOH solution for 24 hours, then filtered and washed with distilled water until the pH was neutral.

In this activation process, the NaOH solution acts to break the lignocellulose bonds into lignin and cellulose, allowing the lignin to dissolve easily. The mechanism of NaOH in breaking lignocellulose bonds involves OH- ions from NaOH attacking carbon atoms in lignocellulose carbonyl groups, causing bond breakage, followed by Na+ ions binding with lignin to form water-soluble sodium phenolate salts. The formation of phenolate salts is indicated by the black color of the washing solution (Novia *et al*., 2015). The activated peanut shell adsorbent is then dried in an oven at 105°C for 2 hours to remove water molecules.

3.2. Characterization

The characterization of activated carbon aims to determine the quality and characteristics of activated carbon and to ascertain its compliance with the activated carbon standards in SNI 06-3730-1995. The testing of peanut shell adsorbent characteristics includes moisture content, ash content, volatile matter content, adsorption capacity toward iodine, carbon content, and surface morphology of activated carbon. To determine the effect of using a 0.5 M NaOH activator, activated carbon characteristics were tested before and after activation. The results of the peanut shell adsorbent characteristics testing can be seen in Table 1.

Table 1. Characterization of Peanut Shell Adsorbents

Parameter	Characterization of Peanut Shell Adsorbents		SNI 06-3730-1995
	Before activation	After activation	
Moisture Content (%)	3,11	3,99	Maks. 15
Ash Content (%)	5,54	7,46	Maks. 10
Volatile Matter Content (%)	64,01	53,88	Maks. 25
Adsorption Capacity for Iodine (mg/g)	261,68	355,32	Min. 750
Carbon content (%)	85,43	74,497	Min. 65

3.2.1. Moisture Content

The determination of moisture content aims to determine the hygroscopic properties (water absorption capacity) of activated carbon (Ischak *et al*., 2021). Based on the data in Table 1, it is known that the moisture content before activation was 3.11% and after activation was 3.99%. These results are in line with the quality standards for activated carbon specified in SNI 06-3730-1995, which states that the maximum moisture content should not exceed 15%. The increase in moisture content after activation is attributed to the hygroscopic nature of activated carbon, which can adsorb water molecules during the rinsing, cooling, or weighing processes (Zulkania *et al*., 2018). The concentration of NaOH as an activator can also influence the increase in moisture content. According to research by Primastiyaningayu *et al*. (2024), higher activator concentrations and longer activation times cause the carbon to become basic, prolonging the washing and neutralization processes. This results in water particles becoming trapped in the pores.

3.2.2. Ash Content

Ash content testing aims to determine the amount of mineral residue after the carbonization process because activated charcoal contains not only carbon but also minerals or metal oxides (Ganing *et al*., 2023). The ash content test results before activation were 5.54%, and after activation, they increased to 7.46%. This ash content is in accordance with the SNI 06-3730-1995 standard for activated carbon quality. The increase in ash content may be influenced by the concentration of the NaOH activator used. This is supported by research by Priambudi & Susanti (2024), which shows that a high activator concentration will expand the surface area of the activated carbon and result in more pores. During the pore formation process, crystallization combustion occurs, producing ash. Thus, the number of pores produced is directly proportional to the ash content produced.

3.2.3. Volatile Matter Content

The volatile matter content is defined as the amount of non-carbon substances, usually hydrocarbon compounds, that do not evaporate during the carbonization process but can evaporate at temperatures above carbonization (Sa'bandi *et al*., 2021). The results of this study show that the volatile matter content of activated carbon before activation was 64.01% and after activation was 53.88%. The results obtained exceeded SNI 06-3730-1995, which states that the maximum volatile matter content is 15%. High volatile matter content may be caused by the breaking of atomic bonds, such as hydrogen, nitrogen, and oxygen, in the formed groups, which can undergo evaporation due to heating (Anwar *et al*., 2022).

3.2.4. Adsorption Capacity for Iodine

Adsorption capacity toward iodine is a parameter of activated carbon to determine the iodine number. The iodine number is defined as the number of milligrams of iodine that can be adsorbed by 1 g of carbon under test conditions (Dwityaningsih *et al*., 2023). The research results obtained show that the adsorption capacity of peanut shell adsorbent before activation was 261.68 mg/g and after activation was 355.32 mg/g. The results obtained are still below the SNI 06-3730-1995 standard, which requires a minimum of 750 mg/g. This is due to the high moisture and ash content, which can result in suboptimal iodine adsorption.

3.2.5. Carbon Content

The bound carbon content is the carbon content in peanut shell adsorbents that does not evaporate during the carbonization process (Imani *et al*., 2021). The analysis of bound carbon content in peanut shell adsorbent in this study was conducted using SEM-EDX instrumentation. The results obtained in this study showed that the carbon content in the adsorbent before activation was 85.43%, and after activation, it decreased to 74.497%. These results meet the SNI 06-3703-1995 standard with a minimum carbon content of 65%.

3.2.6. Surface morphology of adsorbents

Morphological analysis needs to be done to figure out the microstructure (including porosity and cavity shape) of peanut shell adsorbents. The results of the morphological analysis of the surface of peanut shell adsorbents before and after activation can be seen in Figure 1. Based on the results of SEM analysis of peanut shell adsorbents, it can be seen that before activation, pores had already formed on the surface of the adsorbent as a result of the carbonization process, but they were not yet fully open (Asuquo *et al*., 2017). After activation, there was a difference in that the number of pores increased and became more regular. This was due to the NaOH activation process, which could break lignocellulose bonds and dissolve non-carbon compounds (Puspitasari *et al*., 2021). Additionally, the study found that the pore diameter before activation ranged from 194.2 nm to 1,102 µm, and after activation, it increased to 674.6 nm to 1,347 µm, indicating that the use of 0.5 M NaOH activator has the ability to enlarge pore size, thereby allowing more adsorbed heavy metals.

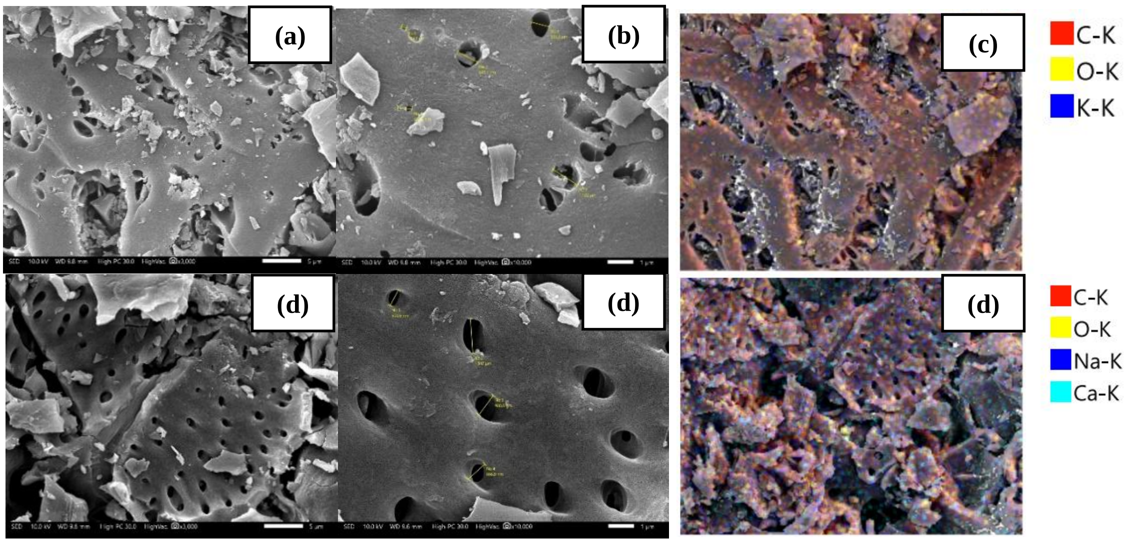

Figure 1. Surface morphology of the adsorbent (a) before activation at 3000x magnification (b) at 10,000x magnification (c) element distribution (d) after activation at 3000x magnification (e) at 10,000x magnification.

3.3. Determination of optimume conditions

Determining the optimum conditions is the stage of applying the adsorbent to simulated waste under various conditions, namely variations in mass, flow rate, and simulated waste ratio. This aims to determine the adsorption conditions that yield optimal results for Cr and Pb metals. This study uses a continuous adsorption system, where the adsorbent is placed in a column with a diameter of 1.5 cm and a height of 40 cm, and the waste is continuously flowed through, resulting in direct contact between the adsorbent and the waste. There are two stages in determining the optimal conditions: preparing the simulated waste and applying the adsorbent to the simulated waste with variations in mass (0.3 g, 0.6 g, and 0.9 g) and flow rate (full-open valve and partially-open valve).

The simulated waste was prepared by mixing Cr and Pb 1000 ppm stock solutions in volume ratios of 1:1, 1:2, and 1:3 in 300 mL. The purpose of varying the volume ratio was to determine the adsorption competition between the two metals in the waste on the adsorbent. The simulated waste was analyzed for Cr and Pb content before adsorption using an AAS instrument. The next step was the adsorption process of the simulated waste by flowing it into a column containing activated peanut shell adsorbent with 0.5 M NaOH. The adsorption apparatus setup is shown in Figure 2.

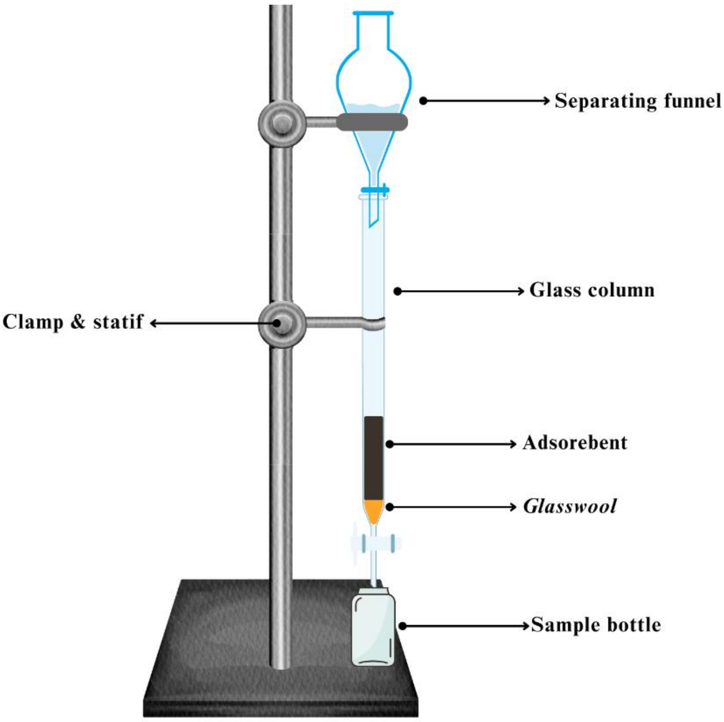

Figure 2. Adsorption Apparatus Setup

During the adsorption process, chemical bonding occurs between the active groups of the adsorbent and the Pb and Cr metals. There are several possible interaction mechanisms that may occur. The mechanisms that may occur during adsorption are shown in Figure 3.

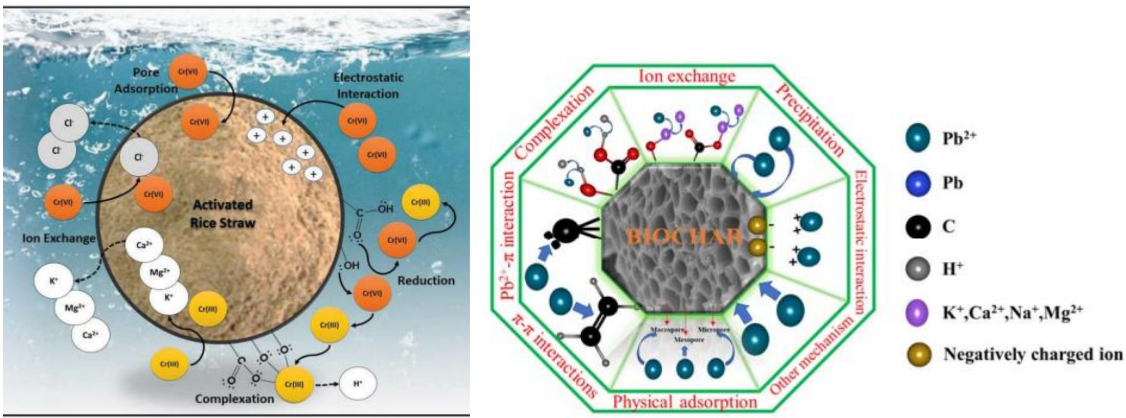

Figure 3. Mechanisms adsorption of Pb and Cr metal (Source: Putra *et al.,* 2022; Wang *et al.,* 2022)

The simulated waste filtrate that has undergone the adsorption process is then collected in a sample container and analyzed for Cr and Pb metal content using AAS. Once the final concentrations of Cr and Pb metals (after adsorption) are known, the adsorption efficiency and adsorption capacity can be calculated. The results of the calculations for the adsorption efficiency and adsorption capacity of Cr and Pb metals can be seen in Table 2.

Table 2. Adsorption Efficiency and Adsorption Capacity Data of Peanut Shell Adsorbent for Pb and Cr

FR	Mass (g)	Volume Variation (v/v)	Pb				Cr			
			Concentration (mg/L)		AE (%)	AC (mg/g)	Concentration (mg/L)		AE (%)	AC (mg/g)
			Initial	Final			Initial	Final		
Fast	0,3	1:1	82,8497	72,2486	12,80	1,0601	467,483	440,965	5,67	2,6518
		1:2	66,2282	48,6576	26,53	1,7571	584,604	551,456	5,67	3,3147
		1:3	54,4429	31,6836	41,80	2,2759	628,800	562,505	10,54	6,6295
	0,6	1:1	82,8497	18,3842	77,81	3,2233	467,483	312,794	33,09	7,7344
		1:2	66,2282	8,0023	87,92	2,9113	584,604	385,719	34,02	9,9442
		1:3	54,4429	2,6802	95,08	2,5881	628,800	485,161	22,84	7,1820
	0,9	1:1	82,8497	-0,7831	100	2,7878	467,483	134,903	71,14	11,0860
		1:2	66,2282	-1,0373	100	2,2422	584,604	240,975	58,78	11,4543
		1:3	54,4429	-1,0316	100	1,8492	628,800	278,542	55,70	11,6753
Slow	0,3	1:1	82,8497	21,2881	74,31	6,1562	467,483	382,404	18,20	8,5078
		1:2	66,2282	21,2881	67,86	4,4940	584,604	469,692	19,66	11,4911
		1:3	54,4429	17,1073	68,58	3,7336	628,800	594,548	5,45	3,4252
	0,6	1:1	82,8497	13,1299	84,15	3,4860	467,483	299,535	35,93	8,3974
		1:2	66,2282	1,7706	97,33	3,2229	584,604	404,502	30,81	9,0051
		1:3	54,4429	9,9345	81,75	2,2254	628,800	455,328	27,59	8,6736
	0,9	1:1	82,8497	4,4881	94,58	2,6121	467,483	143,742	69,25	10,7913
		1:2	66,2282	-0,5345	100	2,2254	584,604	155,896	73,33	14,2902
		1:3	54,4429	-0,5119	100	1,8318	628,800	246,499	60,80	12,7434

Notes : FR = Flow rate; AE = Adsorption efficiency; AC = Adsorption capacity

Based on the data in Tables 10 and 11, it can be seen that the highest adsorption efficiency for Pb and Cr metals is 100% and 73.33%, respectively, while the lowest adsorption efficiency is 12.80% and 5.67%. The data indicates that the adsorption efficiency of Pb is higher than that of Cr. The adsorption capacity of Pb ranges from 1.0601 to 6.1562 mg/g, while the adsorption capacity of Cr ranges from 2.6518 to 14.2902 mg/g. This means that the adsorption capacity of Cr is higher than that of Pb. The graph showing the relationship between adsorption efficiency and mass, flow rate, and simulated waste volume can be seen in Figure 4.

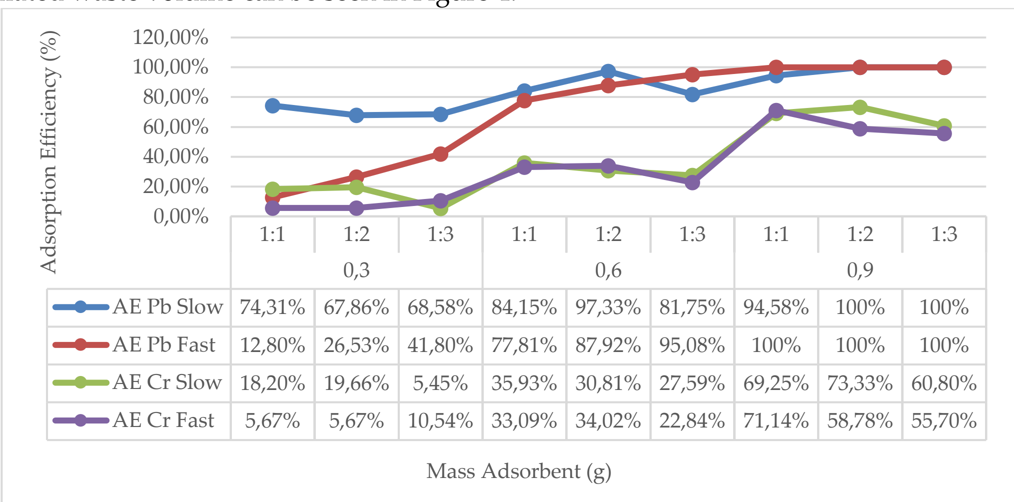

Figure 4. Graph showing the relationship between adsorbent mass, flow rate, and simulated waste variation on adsorption efficiency

3.3.1. Mass Adsorbent

The difference in the mass of activated peanut shell adsorbent with 0.5 M NaOH can affect the adsorption efficiency value for Cr and Pb metal ions. Based on the data in Table X, it is known that the optimal adsorbent mass for Pb metal adsorption is 0.9 g with 100% adsorption efficiency, and the lowest adsorption efficiency is 12.80% at a mass of 0.3 g. For Cr metal adsorption, the highest efficiency is achieved at a mass of 0.9 g with an adsorption efficiency of 73.33%, while the lowest efficiency is 5.67% at a mass of 0.3 g. The research results indicate that as the mass of the adsorbent increases, the adsorption efficiency also increases. The optimal mass of activated NaOH 0.5 M peanut shell adsorbent was 0.9 g. This aligns with the research by Zaini & Sami (2017), who stated that the more adsorbent used, the greater the number of pores and surface area of the adsorbent, thereby increasing the active sites involved in binding Cr and Pb metals.

3.3.2. Flow Rate

In determining the optimum conditions, slow and fast flow rates were used. The flow rate is related to factors that influence adsorption, namely the contact time between the active side of the adsorbent and the adsorbate. The data obtained showed that a slow flow rate resulted in higher adsorption efficiency compared to a fast flow rate. The highest adsorption efficiency for Cr metal was 73.33% at a flow rate of 0.02 mL/sec (slow flow rate), while the lowest adsorption efficiency was 5.67% at a flow rate of 0.59 mL/sec. At a slow flow rate, the contact time between the adsorbent and the adsorbate is longer, increasing the likelihood of interaction between the metal and the active groups on the adsorbent surface, and vice versa. This is supported by the research of Ayu *et al.* (2024), which states that a faster flow rate causes the adsorbent to reach saturation point more quickly, thereby reducing adsorption efficiency.

At a fast flow rate of 0.04–0.05 mL/s and a slow flow rate of 0.02 mL/s with a mass of 0.9 g, the adsorption efficiency of Pb metal was the same, reaching 100%. However, at a mass of 0.6 g, the adsorption efficiency of Pb metal is higher at a slow flow rate of 97.33% compared to a fast flow rate of 95.08%. This is because at a mass of 0.9 g, both slow and fast flow rates have reached equilibrium. An increase in adsorption efficiency occurs at the onset of contact between the adsorbent and the adsorbate. As adsorption proceeds, the adsorbate continues to be adsorbed into the pores of the adsorbent and reaches equilibrium, i.e., when the adsorbent can no longer bind the adsorbate, resulting in constant or decreasing adsorption efficiency (Kristianingrum *et al.*, 2020).

3.3.3. Waste Variation Simulation

In a waste stream, such as textile industry waste, there is not only one type of metal present, but also other metals and various pollutants. Therefore, different volumes of simulated waste were used to determine the competition between Cr and Pb metals in a waste stream. The results of the study showed that there was adsorption competition between Pb and Cr metals in the simulated waste. Based on the graph, the adsorption efficiency of peanut shell adsorbent toward Pb metal is higher than that toward Cr metal. The results obtained indicate that the highest adsorption efficiency for Pb metal reaches 100%, while for Cr metal it is 73.33%. This can be influenced by several factors, such as ion radius, electronegativity properties, and metal hydration energy. The hydration energy of Pb is lower than that of Cr, making it easier for Pb to break the bonds with surrounding water molecules and form bonds with the active groups on the adsorbent surface. Metals with lower hydration energy are more easily adsorbed by the adsorbent (Xia *et al.*, 2022). The electronegativity of metals also influences their adsorption onto the adsorbent. Pb ions have an electronegativity of 2.33, while Cr has an electronegativity of 1.66. The electronegativity of Pb ions is higher than that of Cr. This indicates that the higher the electronegativity of a metal, the easier it is to bond with the active groups on the adsorbent surface, resulting in higher adsorption efficiency.

This study used NaOH solution as an activator. The results showed that NaOH activator on peanut shell adsorbent was more efficient in reducing Pb metal. This is supported by Sihotang's (2021) research, which stated that adsorbents activated using NaOH can increase Pb metal absorption compared to using HCl activator. The results of the study indicate that the optimal adsorbent mass is 0.9 g and the flow rate is slow with the tap open halfway. The adsorption efficiency values of peanut shell adsorbent for reducing Cr and Pb metals under optimal conditions were 73.33% and 100%, respectively, while the adsorption capacities obtained were 14.2902 mg/g and 1.8–2.6 mg/g.

4. CONCLUSION

Based on the research conducted, it can be concluded that activated peanut shell adsorbent treated with 0.5 M NaOH meets the SNI 06-3730-1995 standards for moisture content, ash content, and carbon content, while the volatile matter content and adsorption capacity for iodine do not meet the SNI 06-3730-1995 standards. The surface morphology of the activated peanut shell adsorbent after activation with 0.5 M NaOH shows an increase in the number and regularity of pores compared to before activation. The pore diameter of the adsorbent before activation ranged from 194.2 nm to 1.102 μm, and after activation, it increased to 674.6 nm to 1.347 μm. The optimal conditions for NaOH-activated peanut shell adsorbent for the removal of Cr and Pb metals were obtained with an adsorbent mass of 0.9 g, a slow flow rate (half-open tap), and a simulated waste ratio of 1:2 (v/v). Activated peanut shell charcoal is effective for the adsorption of Cr and Pb metals, with adsorption efficiencies of 73.33% and 100%, respectively, for Cr and Pb reduction in simulated wastewater, while the adsorption capacities obtained were 14.2902 mg/g and 2.0286 mg/g, respectively.

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