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Submission date: 13-Dec-2024 09:55AM (UTC+0700)
Submission ID: 2550856931
File name: ita_merin-020159_1_5.0122454.pdf (1.17M)
Word count: 2900
Character count: 14934

RESEARCH ARTICLE | MAY 08 2023

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AIP Conference Proceedings 2706, 020159 (2023)
https://doi.org/10.1063/5.0122454

The Utilization of *Kepok* Banana (*Musa Parasidiaca L*) Peel as Adsorption Material in Removal of Cadmium Metal (Cd) in Radiological Wastewater

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Abstract. Manual X-ray Film washing wastewater produced from radiology installation categorized as hazardous waste can be a severe problem for the environment. One of the contents of radiological wastewater is Cd metal. Furthermore, the adsorption method was a promising alternative, and the adsorbent used from *kepok* banana (*Musa parasidiaca L*) peel waste. Making *kepok* banana peel adsorbent was by drying in the sun, carbonization with a furnace at high temperature. Then, it was sieved with a size of 100 meshes, activated with H2SO4, and soaked for 24 hours. Moreover, the experiment was on a batch scale with a jar test tool for the moving process. Variations in mixing speed (rpm) of 100 and 150 with variations in contact time of 15, 30, 45, 60, 75, and 90 minutes, and adsorbent mass of 10 grams. The optimum conditions of mixing variation obtain at a contact time of 60 minutes and a mixing speed of 150 rpm getting 97.51% removal efficiency. The concentration of Cd metal was 3.294 mg/L. Meanwhile, after the adsorption process, the effluent concentration reached 0.08 mg/L, which met the effluent standard of 0.1 mg/L for Cadmium (Cd) from The Decree of Environmental Minister Number 05 Year 2014.

INTRODUCTION

The role of radiology in the medical world, especially during the Covid-19 pandemic, is quite important for examinations/diagnoses. In addition to the increase in wastewater, wastewater due to radiology installation activities also increased with the patient's number seeking treatment at the hospital. Hazardous waste, which includes developer, fixer, cleaner, and lead, and hazardous waste including heavy metals, such as mercury (Hg), nickel (Ni), chromium (Cr), cadmium (Cd), Cu (copper), and lead, are both formed when X-ray films are washed (Pb). These are heavy metals that can be discovered in a polluted aquatic environment [1].

The wastewater is toxic, irritating, and, if discharged directly into the environment, can disrupt the balance of the number of bacteria in the environment [2]. Heavy metal ions can be removed using a variety of methods. Chemical precipitation, lime, coagulation, ion exchange, reverse osmosis, solvent extraction, and adsorption are all common methods for removing heavy metal ions from wastewater [3]. Unfortunately, these technologies have limits, owing to secondary waste creation, a considerable amount of slug formation, and high running expenses [4]. The hospital radiology waste treatment process uses the adsorption process since adsorption is the most widely used method because it has a simpler concept; besides, it is relatively more affordable.

The adsorbent used in this study was the adsorbent from the peel of the *kepok* banana (*Musa paradisiaca L*). According to data from the Central Statistics Agency (BPS) in 2015-2019, banana production in Indonesia averaged 28.851.420 tons. Thus, the consumption of many bananas will produce waste in the form of banana peels. One of the ways to reduce the waste of banana peels is by making them into an adsorbent. Therefore, the activated carbon from the banana peels reduces metal levels in toxic and hazardous waste. *Kepok* banana (*Musa paradisiaca L*) peel contains pectin, which has functions as a sugar group. In addition, galacturonic acid compounds can adsorb heavy metals [5].

According to [6], *kepok* banana (*Musa parasidiaca L*) peel is a biomaterial that can absorb metal ions. One of the compounds contained in the banana peel is cellulose. The presence of cellulose enables the banana peel to absorb

3rd Borobudur International Symposium on Science and Technology 2021
AIP Conf. Proc. 2706, 020159-1–020159-6; https://doi.org/10.1063/5.0122454
Published by AIP Publishing. 978-0-7354-4447-8/$30.00

metals ion. According to [7], using leather as activated carbon, the yield rate of carbonization reaches 96.56% in removing heavy metals.

METHODS

Preparation of adsorbent material

The samples of *kepok* banana peels were processed into adsorbent in this study. The peels are first collected from kitchen garbage. The banana peels were then washed with tap water before being sliced into small pieces and dried in the sun for five days to minimize the moisture content linked to the banana peel. After that, it was combined for 3 hours in a furnace at 400°C to make charcoal. The *kepok* banana peels were mashed uniformly and sieved using a 100 mesh sieve after drying. Place the refined charcoal in the desiccator after that. The banana peels, which have carbonized, are subsequently activated with a 20% solution. The adsorbates to adsorbents ratio was 2 mL to 1 gram. By soaking the banana peel in a solution for 24 hours, the adsorbents become active. The activated carbon was also cleaned with distilled water before being dried in an oven at 110°C for two hours. After that, 100 mesh charcoals were chemically activated. Its goal is to open the pores that close when carbonized by combustion residues, increasing the adsorption power [8]. The purpose of activation is to remove hydrocarbons and water trapped in carbon pores [9]. The number of pores will increase as a result of activation. The activator will bind contaminants in the form of tar compounds, which are a byproduct of the carbonization process and will be washed away during the process [10]. These sorbents are commonly referred to as activated sorbents.

Preparation of radiology wastewater sample

Hospital radiology wastewater samples were taken 50 mL and put into a 250 mL Erlenmeyer and 5 mL of HNO_3. After blending, the solution heat used a heater until the sample shrunk to ± 10-15 mL. Furthermore, heavy metals levels were analysed using Atomic Absorption Spectrophotometer (AAS) with a wavelength of 228.8 nm.

Determination of mixing speed

Variations of 100 and 150 rpm are used to establish the mixing speed. The banana peel adsorbent was introduced to beaker glasses filled with 250 mL radiological wastewater, with the weight of the adsorbent being 10 g. During the previously acquired 10, 30, 45, 60, 75, and 90 minutes, the mixture was stirred using jar test with a speed variation of 100, 150 rpm. To separate residues from the filtrate, the solution was filtered with Whatman filter paper No 42. With a wavelength of 228.8 nm, the filtrate was measured using an Atomic Absorption Spectrophotometer. The best removal result was an indicator to estimate the optimum mixing speed, as demonstrated in Atomic Absorption Spectrophotometer (AAS) measurements.

Removal efficiency and adsorption capacity analysis

The adsorption capacity or amount of cadmium ions that the adsorbent can absorb calculate uses the following equation 1:

$$q = [(C_O\text{-}C).V] / W \tag{1}$$

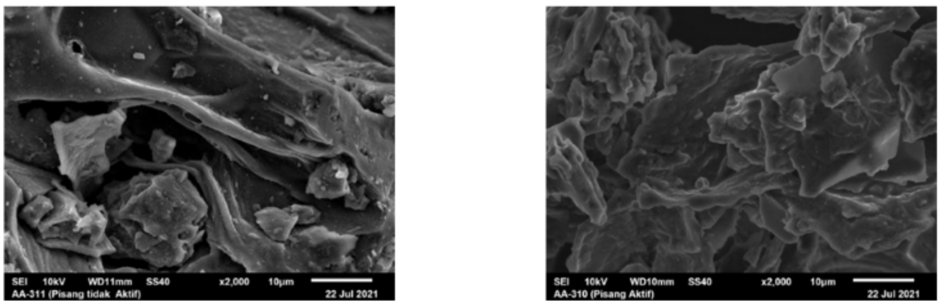
q is the number of cadmium ions absorbed by the adsorbent (mg/g). The initial waste of Co contains cadmium ion concentration (mg/L), while the final waste of C has cadmium ion concentration after adsorption (mg/L). In addition, V is the initial volume of waste containing cadmium ion solution (L), while W is the weight of the adsorbent (gr) [11]. Allowance efficiency can also be determined using the following equation 2:

$$RE = [(C_O\text{-}C) / C_O] \times 100\% \tag{2}$$

RESULTS AND DISCUSSION

Characterization of banana peel

Figure 1 (a) shows the results of banana peels before activation, where the surfaces of the cavities are more closed and denser. Since the skin's surface of banana peel is cover with impurities, the pores and cavities formed are very little open. This possibility is because it is not evaporated optimally in the carbonization process, and it can interfere with the adsorption process. (b) Based on the results of the SEM tool, it shows that there are morphological differences in the skin pores. Impurities still cover the activated carbon of the banana peel after 20% H_2SO_4 becomes open, and a cavity form. It is supposed since the H_2SO_4 solution has the nature of a dehydrating agent. Furthermore, the surface of the activated banana peel looks more regular and curved than the inactivated banana peel. This curved and regular surface will later use as an adsorption medium. It shows that the activation process has been successful and active as a heavy metal absorbing medium.



(a) (b)

FIGURE 1. banana peel before activation (a) banana peel after activation (b)

Effect of mixing speed and contact time

This study uses a mixing speed of 100, 150 rpm with a contact time throughout dispersing particles' movement at 10, 30, 45, 60, 75, 90 minutes. The following results of the mixing speed analysis in contacted time can show in Figure 2.

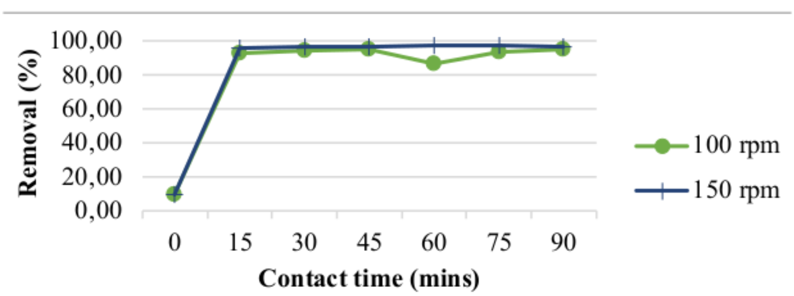


FIGURE 2. Effect of Stirring Speed and Time in Heavy Metal Cd

Figure 2 shows that a stirring speed of 150 rpm with a contact time of 60 minutes has the highest removal value of 97.51%, while at a stirring speed of 100 rpm the highest value is 95.05%, with a contact time of 45 minutes. If seen from the graph above, several different stirring speeds with variations in contact time are obtained from the optimum stirring at a stirring speed of 150 rpm within 60 minutes with a yield of 97.51% from the initial concentration of 3,294 mg/L. Due to the long stirring contact time and between the adsorbent and the adsorbate, it spread evenly to reduce Cd metal. The greater the stirring rotation speed, the greater the adsorption rate constant value since stirring will affect the thickness of the film layer that coats the surface of the adsorbent. Moreover, at a speed of 100 rpm with a contact time of 15 minutes has been able to reduce Cd metal. However, the results are still not optimal compared to a contact time of 60 minutes and a speed of 150 rpm. The adsorbent and adsorbate do not have enough time since there are still many active sides of the adsorbent that have not been able to bind Cd metal evenly. The longer the contact time, the more metal adsorb since, the more opportunities for activated carbon particles to contact the metal.

Adsorption isotherm

Freundlich and Langmuir's graphic methods were utilized to determine the adsorption capacity. The equilibrium relationships between the adsorbent and the adsorbate are described by adsorption isotherms.

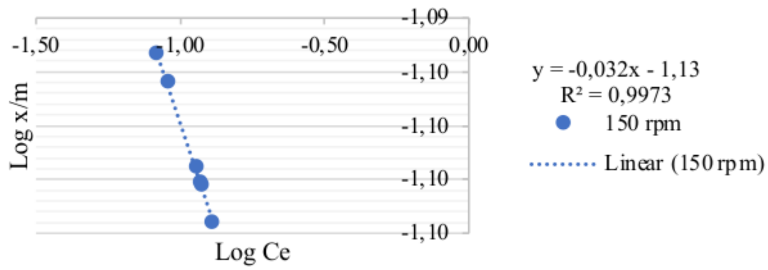


FIGURE 3. Freundlich isotherm for cadmium adsorption onto banana peel

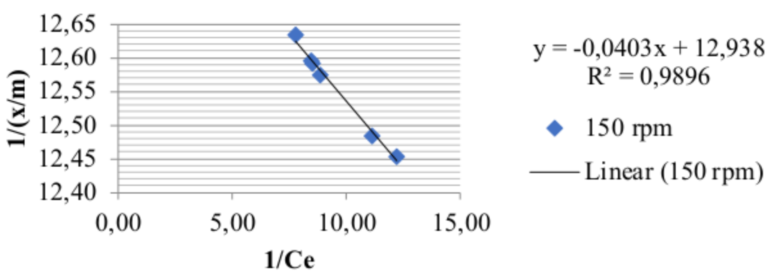


FIGURE 4. Langmuir isotherm for cadmium adsorption onto a banana peel

Figures 3 and 4 indicate that when (R2) is near to 1, the Freundlich isotherm model with a regression value of 0.9973 is followed. Meanwhile, Kf has a value of 0.074 and n has a value of -31.250. Freundlich states that the isotherm process follows the Freundlich isotherm model if the value of 1/n is between 0 and 1. Multilayers form in the Freundlich isotherm. As a result, the layer generated will be thicker due to the high concentration of contaminants. Furthermore, the value of Kf indicates an adsorbent's relative capacity to absorb adsorbate. The higher the value of Kf, the better an adsorbent's ability to adsorb. The value of 1/n indicates the strength of the interaction between the adsorbent and the adsorbate. The greater the contact between adsorbent and adsorbate, the smaller the value of 1/n..

Adsorption kinetics

Adsorption kinetics describes not only the metal adsorption mechanism on adsorbents, but also the metal adsorption rate, which affects the metal contact time at the solid-liquid interface [12]. Different kinetics equations, such as First Order and Second Order, fit the data.

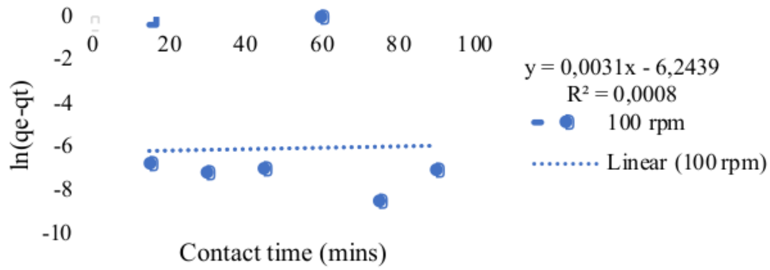


FIGURE 5. Linear plot of pseudo-first-order equations for cadmium adsorption

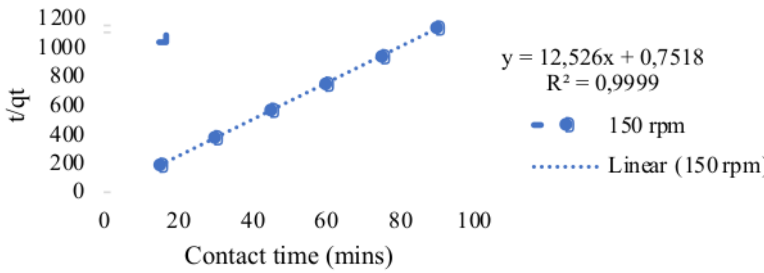


FIGURE 6. Linear plot of pseudo-first-order equations for cadmium adsorption

Figure 5 and Figure 6 show that with a stirring speed of 150 rpm and a contact time of 60 minutes following the order, the time is more optimal than other times. The obtained regression value of 0.9999 for heavy metal Cd shows that the second-order adsorption kinetics according to the adsorbent of *kepok* banana peel. The greater the value, the more representative the results and show the curve's linearity level.

CONCLUSION

With a contact duration of 60 minutes and a reduction efficiency of 97.51 percent and a final concentration of 0.08 mg/L, the optimum stirring speed is 150 rpm with a contact period of 60 minutes. The isotherm kinetic of removing Cd metal employs activated banana peel in accordance with the Freundlich isotherm, although the adsorption kinetic is second order. Finally, banana peels can be used as a media adsorbent for extracting heavy metals from wastewater.

ACKNOWLEDGMENTS

The authors would like to thank the Research Institute of Trisakti University for the Grant of Lecturer Research Year 2020-2021. The funding for this project was from Trisakti University to encourage the faculty members to carry out research.

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