Effect of particles size adsorbent of sugarcane bagasse and contact time on removal Pb(II) ions in wastewater by using vertical series column method

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Abstract. Amounts of heavy metals in wastewater can cause problems for living things and the environment. Handling efforts have been done with various methods. A relatively effective and efficient method is the adsorption. This study aims at removing Pb (II) in water using adsorbent of sugarcane bagasse with column system. The experimental design as a fixed variable consisted of 50 g of adsorbent, and 10 litres adsorbate volume, flow rate of 7 litres / minute. The independent variables consist of particle sizes with variations of 10; 20; 30 mesh and contact time with variation 0;5;10;15;20;30;60;90;120;150;180;210;240 minutes and the dependent variable of Pb(II) concentration (ppm). The results showed that the removal of Pb (II) was influenced by particle size factor of adsorbent and contact time. Universally the best removal power occurs on the size of 20 mesh adsorbent particles and with a contact time of 30 minutes. The fastest and highest removal percentage based on parameters of Pb(II) concentration for 10 mesh particles: 53.34% at contact time 180 minutes, 20 mesh particles: 54.84% at contact time 30 minutes, and 30 mesh particles: 65.67% at contact time 210 minutes.

1. Introduction
Effective removal of heavy metal ions from wastewater is important to protect the environment and improve the quality of public health. Heavy metals such as mercury, lead and cadmium cannot be biodegradable and are known to accumulate bio in the food chain and are very toxic to living things [1]. Lead is a metal that is very dangerous for human health which lasts a lifetime because lead accumulates in the human body. Even in the case of exposure to lead pollution in low doses, it turns out it can cause interference to the body without showing clinical symptoms [2]. Therefore, the study of lead ion removal in wastewater is very important both in terms of health and the separation technology.

On the other hand, around 50% of bagasse produced in each sugar factory is used as boiler fuel and the rest is stockpiled as waste with low economic value. The accumulation of bagasse at a certain time will cause problems, because this material is flammable, pollutes the surrounding environment, and confiscates large areas of storage [3]. In this case the bagasse can be used as an alternative raw material for making activated carbon, which can then be used as a heavy metal adsorbent [4]. A number of low cost agricultural wastes that are used as adsorbents for remediation of heavy metals from waste water, include banana peel, coconut shell, orange peel, rice husk, pecan shells, jackfruit, maize cob, sawdust, sugarcane bagasse, peanut hull, apple waste [5].
Physical and chemical methods have been employed in the removal of trace metals from contaminated water through processes such as chemical precipitation, membrane filtration, ion exchange, and adsorption [6]. As mentioned above there are many choices of heavy metal separation processes. However, the adsorption process with the fixed bed column method is still very minimal and most do not use biomass as an adsorbent in terms of the system is practical, more effective and efficient [7]. Proses adsorpsi seperti penyisihan ion Pb(II) tergantung pada ukuran partikel adsorbent [8]. Bed height, contact time, flow rate and activation process affect the percent absorption of lead metal ions [9].

In this study, the absorbed material is in the form of adsorbate used from waste water containing Fe, Mn, Ca and Pb. On the other hand, agricultural wastes such as bagasse can be made as absorbent which the material was low cost for sequestration of heavy metal ions and synthetic dyes [10] and absorbent can be made from modification bagasse by acrylic acid and acrylamide for adsorbed heavy metal ions such Pb(II) ions [11].

The adsorption process can take place physically and chemically depending on the conditions and characteristics of the adsorbent. In the adsorption process using adsorbents derived from biomass depend on the functional group. The component that plays a role in the adsorption process between heavy metals and adsorbents from agricultural waste is the presence of active groups hydroxyl (–OH), carbonyl (C=O), carboxyl (-COOH), amine (-NH2), amide (-CONH2) and thiol (-SH) [12].

Sorption is the process of absorbing ions by absorbent particles. The sorption process is divided into two, namely adsorption and absorption. The adsorption process if the ion is retained on the surface of the absorbent particle (adsorban), while absorption if the binding process takes place inside the absorbent particle [13].

The removal or separation of heavy metals from the water there are several methods including the adsorption method. One solution to handling metal Pb waste with relatively low cost is by using bagasse as an adsorbent. In this study, Pb (II) metal as adsorbate was derived from the wastewater reservoir of the Lhokseumawe State Polytechnic chemical laboratory.

Removal of Pb (II) ions from the effective solution using the adsorption method [14]. Factors that influence the decrease in heavy metal content: contact time, particle size of adsorbent, type of activator, adsorbate flow rate. And the other literature the adsorption factor in the bath process are adsorbent dose, pH, contact time and agitation speed [15].

For some of the considerations above, such as the danger of Pb metal, bagasse waste and lack of research with the column method, then the study of removal of lead ions in wastewater is essential. The study mainly aimed to study the effect of particle size on adsorbents and contact time of adsorption.

2. Materials and methods

2.1. Materials

The instrument used consists of a tool for making adsorbents consisting of size shrinkers, cutting tools: scissors, crushers, sieves, oven drying tools, balance sheets, beakers using beaker. The main tool is a water demineralization unit with a column system using bagasse as an adsorbent.

Adsorbate derived from chemical laboratory liquid waste includes metals Fe, Mn, Ca and Pb. Chemicals in the form of HCl 0.5 N, H2SO4 0.5 N, NaOH 0.5 N.

2.1.1. Adsorbents. The adsorban is made from bagasse derived from sugarcane water waste that is around the Lhokseumawe State Polytechnic campus. The adsorbent material is then cleaned, dried and reduced in size using scissors, crusher and sieve with the particle size of 10 mesh, 20 mesh, 30 mesh. Each adsorbent used without activation treatment.

2.1.2. Adsorbate. Adsorbate comes from inorganic waste from chemical laboratory waste water sources from waste residues of anion cation analysis labs which include metals Fe (II), Mn (II), Ca (II) and Pb (II). The content of metal ions such as Pb (II) ions was analyzed using an atomic absorption
spectrophotometer. (AAS). The results of this analysis are then processed data about the percentage absorption from adsorbent to Pb metal which is separated from adsorbate.

2.2. Methods
The adsorption process takes place in 2 columns arranged in a vertical series with a column diameter of 6.35 cm and an empty column height between 25 cm. The adsorbent is inserted into the adsorption column with a period 50 g of the adsorbent without activation treatment inserted into the column, each column containing 25 g of adsorbent. The research was carried out in the Lhokseumawe State Polytechnic Chemical Engineering laboratory. The experimental design consists of a variable flow rate 7 litres / minute, volume (V) adsorbate 10 liters, operation on room temperature 30 °C.

2.2.1. Sample analysis. Analysis of Pb (II) metal content in the sample from the results of data collection was analyzed using instrumentation method with an Atomic Absorption Spectrophotometer (AAS) based on the light source of a certain length of Pb cathode lamp. Other analyzes are related to pH analysis, turbidity, dissolved solids and total solids.

2.2.2. Removal efficiency. The ability to separate adsorbents from lead metal using a simple formula. The metal removal efficiency equation for Pb (II) during the process is calculated based on the equation of adsorption capacity as follows:

\[ R = \left( \frac{(C_0 - C_t)}{C_0} \right) \times 100\% \]  \hspace{1cm} (1)

3. Results and discussion
The separation and purification of the stirring system (batch), is very complicated, including the need for stirrer, stirrer motor, pump, filtering, space consuming, less effective and less efficient and less economical compared to column systems. The fundamental difference in these methods lies in the size of the adsorbent particles used. Stirring system particle size can be smaller while the system depends on the size of the filter column and feed flow rate. But this can be overcome by the feed system (recycle) or system column series.

This research uses a 2 column vertical series column method, using bagasse pulp bioadsorbent without carbonization. This selection is to produce efficient and effective separation efficiency by adsorbents. Adsorbents after the absorption process can be recycled into useful materials such as raw materials for brick, brick, paint, solid fertilizer, liquid fertilizer. Handling problems without creating new problems or precisely environmentally friendly technology.

3.1. Concentration \((C_t)\) Pb at time \(t\) (minutes) in adsorbate

| Table 1. Analysis results Pb (ppm). |
|------------------------------------|
| t min | Adsorbent Particle Size | 10 mesh | 20 mesh | 30 mesh |
|-------|-------------------------|---------|---------|---------|
| 0     | 9,46                    | 10,13   | 11,16   |
| 30    | 6,27                    | 4,58    | 9,92    |
| 60    | 7,95                    | 6,21    | 8,14    |
| 90    | 6,32                    | 6,88    | 9,06    |
| 120   | 7,63                    | 7,97    | 9,54    |
| 150   | 5,34                    | 5,87    | 5,98    |
| 180   | 4,59                    | 5,09    | 5,77    |
| 210   | 5,05                    | 6,12    | 4,39    |
| 240   | 4,42                    | 5,09    | 3,83    |
Characteristics of adsorbent, particle size of 10 mesh, 20 mesh, 30 mesh with dry water content of about 10%. The results of the analysis of the characteristics of the wastewater used by the content Fe(II) ± 10 ppm, Mn(II) ± 5 ppm Mn, Ca(II) ± 60 ppm Ca, Pb(II) ± 10 ppm Pb and pH 3-6, TDS 24-25 ppm, conductivity 57-58 μS/cm.

3.2. Metal removal of Pb (II) from adsorbate

The removal of metal Pb concentration from adsorbate (table 1) on contact time shows the effect or effect. At the initial stage of adsorption, it is clear that the difference in Pb removal ability by bioadsorbents is that a sharp decrease occurs in the first 30 minutes. The highest decrease was sequentially for 20 mesh bioadsorbent, 10 medium and lowest decrease mesh at 30 mesh particle size.

This difference is due to the surface of the adsorbent with a particle size of 30 mesh, its pores are still covered by impurities. In addition the interaction between particles from the adsorbent is still relatively strong compared to the adsorbent which has a particle size of 10 mesh and 20 mesh so that the metal contained in the adsorbate still faces obstacles to enter the pores of the adsorbent.

As the contact time of 30 mesh biosorbent pores increased gradually the removal capability continued to increase, while for 20 mesh and 10 mesh adsorbents towards the stability of Pb metal removal. However, at 120 minutes there was a barrier to removal, this was due to the condition of the adsorbent experiencing density so that the Pb metal removal ability was reduced.

At the contact time above 120 minutes, the adsorbent conditions which initially form the solids are again decomposed so that the separation capacity of the bioadsorbent increases to the three particle size of the adsorbent until it reaches equilibrium.

3.3. Concentration (Ct) Pb is absorbed in time t

In figure 1 shows the absorption of Pb (II) metal by sugarcane bagasse adsorbent increased sharply at 30 minutes contact time, while at 120 minutes there was a very sharp decrease. This decrease was caused by the adsorbent compaction so that the adsorption process was inhibited. After the adsorbent has undergone decomposition, the adsorption process is increased, thus increasing the absorption of metal. At 30 minutes contact time, the best absorption occurred at a particle size of 20 mesh, followed by particles with a size of 10 mesh and the lowest occurred in the adsorbent with a particle size of 30 mesh.

On the other hand, at the contact time above 150 minutes the best absorption occurred in the adsorbent with a particle size of 30 mesh. This proves that the smallest particle size has better absorption capability compared to 10 mesh and 20 mesh particle sizes. That smaller particle of adsorbent imply more effective and optimal when compared with other particle sizes.
3.4. Removal efficiency

Data in table in the percentage of Pb (II) metal which is removed into the adsorbent shows that the longer contact time, the excluded Pb (II) heavy metal increases except for contact time of about 120 minutes. At this time there is a temporary compaction of the adsorbent, so the removal ability is reduced. After solidification of the adsorbate becomes uncovered, then the allowance increases again. Removal efficiency for each particle size was 10 mesh: 53.34% at 240 minutes, particle 20 mesh: 54.84% at 30 minutes and particle 30 mesh: 65.65% at 240 minutes.

| t min | 10 mesh | 20 mesh | 30 mesh |
|-------|---------|---------|---------|
| 0     | 0.00    | 0.00    | 0.00    |
| 30    | 33.73   | 54.84   | 11.13   |
| 60    | 15.95   | 38.69   | 27.11   |
| 90    | 33.23   | 32.10   | 18.79   |
| 120   | 19.33   | 21.36   | 14.54   |
| 150   | 43.61   | 42.05   | 46.42   |
| 180   | 51.51   | 49.76   | 48.27   |
| 210   | 46.64   | 39.61   | 60.67   |
| 240   | 53.34   | 49.71   | 65.67   |

Previous research Zaini H and Sami of adsorption of Cu (II) metal in artificial waste using adsorbent of peanut shells activated by \( H_2SO_4 \) 1N and \( NaOH \) 1N the removal efficiency of 70-80\%, while the adsorbent which was not activated was 50-60\% [16]. Likewise Zaini H and Sami, the ability of Pb (II) removal by adsorbent activated with 1N \( H_2SO_4 \) was 86.02\% and activated with 1N \( NaOH \) was greater than Pb (II) metal adsorption which was 96.57\%, while the adsorbent without activation results is 65.67\% on 30 mesh [17].

Adsorption of Cu (II) metal using bagasse particle size of 100 μm (0.5 mesh) without activation showed removal efficiency of 52.22\% and activation of adsorbent with 0.1 M oxalic acid, sludge efficiency of 73.8\% [18].

Based on the above study for adsorption of Pb (II) metal using bagasse asbestos without activity with 30 mesh particle size giving more effective and efficient results that is equal to 65.67\%. The acquisition rate is slightly higher than with the adsorption of Pb (II) using adsorbent without activation of peanut shells. With the same particle size of the adsorbent and the same adsorbent more efficient and effective than Cu (II) metal removal.

According Chen et al. by Cross-linked metal-imprinted chitosan microparticles were prepared from chitosan, using four metals (Cu(II), Zn(II), Ni(II), and Pb(II)) as templates, and epichlorohydrin as the cross-linker. The results showed that the sorption capacities of Pb(II) on the templated microparticles increased from 12 to 43\% [19]. The adsorption results are small compared to the adsorption of Pb (II) using adsorbent from sugarcane bagasse. Macropungus biomass for removal Pb(II) ion from the aqueous solution which activated by using 1 M HCl and 1 M HNO\(_3\). The recovery for Pb(II) ions was found to be higher than 90\% [20]. IR spectrum analysis Manzoor suggested amido or hydroxy, C=O and C–O could combine intensively with Pb(II) and the efficiency of removing Pb (II) ions by fungal biomass is 92\% and better than sugarcane bagasse [21].

4. Conclusion

Based on the results of the study, data processing and discussion can be concluded: The adsorption of Pb (II) metal in chemical laboratory wastewater using bagasse bioadsorbent is influenced by the contact time and particle size of the bioadsorbent. The removal of Pb (II) metal ions is influenced by the particle size of the adsorbent, which is best to occur at a particle size of 30 mesh, at a contact time of 240 minutes. The highest removal efficiency of Pb from wastewater for 10 mesh adsorbent: 53.34\%, 20 mesh: 54.86\% and 30 mesh: 65.67\%.
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