Kinetics Study of Cd\textsuperscript{2+} and Zn\textsuperscript{2+} Metal Ion Adsorption Using Zeolite 4A

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Abstracts

Cd (II) and Zn (II) are examples of heavy metal contaminants in waters that cause serious problems because of their toxicity. Therefore, it is necessary to take effective way to remove heavy metal ions from waters. Adsorption method is widely used because it has several advantages, namely high efficiency, easy handling, reusable, inexpensive, and many choices of materials that are used as adsorbent. One effective adsorbent used is a zeolite because it has high selectivity. This study aims to determine the kinetic model suitable for the process of Cd\textsuperscript{2+} and Zn\textsuperscript{2+} metal ion adsorption using Zeolite 4A as an adsorbent. The study was conducted by varying the contact time (10, 15, 30, 45, 60, 90, 120 and 180 minutes). The results showed that the Cd\textsuperscript{2+} adsorption process followed the pseudo-second-order model with a value of \( k = 0.205 \) g mg\textsuperscript{-1} min\textsuperscript{-1}, \( R^2 = 0.998 \), while the Zn\textsuperscript{2+} adsorption process followed the pseudo-second-order model with a value of \( k = 0.087 \) g mg\textsuperscript{-1} min\textsuperscript{-1}, \( R^2 = 0.995 \). ©2017 JNSMR UIN Walisongo. All rights reserved

Keywords: adsorption, Cd(II)/Zn(II), adsorption kinetics, zeolite 4A.

1. Introduction

The development of industry in Indonesia at this moment has been rapidly, together with the development so it will has more products too bside as waste. This waste including as kind of hard metal that dominant in water amongs the metal Cd\textsuperscript{2+} and Zn\textsuperscript{2+} that made poison metal up and have toxic. The existence of hard metals at area like nickel, copper, kadmium and timbal, zink made problem area up that need more attentions seriously. There are ions of hard metal in industrial cesspool had long times became object in sectors analytic chemistry and area chemistry the
waste had contained hard metal need to get special attention, upon thinking about on certain concentration can give dangerous toxic effect for human life and around area. The research in sector of area specifically prevention of slander for hard metal has been has attention more. The generally the process that be done to handle the waste of metal is with adsorption process, ion exchange, separation with membrane and process of sedimentation.

The adsorption process is more used becouse has more luck among economic character and not has a poison effect on secondary and very effective to absorb hard metal companed with other process. One of potential material more be used to process for adsorption is zeolit, zeolit is the material that it’s existance has more in land, has high capacity in ion conversion. Cheap price, high selectiveness and stable character (Erdem, E., Karapinar, N., and Donat, R, 2004). The adsorption process is influenced by many factors namely time and motion study, PH solution, specific grafity adsorben, temperature, concentration of solution.

This research heads for making certain about kinetic mode in needle when process of metal absorption Cd\textsuperscript{2+} and Zn\textsuperscript{2+} by way of adsorption capacity. The research is done in the manner to vary when connected. The kinetic adsorption is important parameter to evaluate the dynamic process of adsorption when adsorption process the metal’s ion Cd\textsuperscript{2+} and Zn\textsuperscript{2+} by zeolit 4A is used kinetic mode of pseudo orde one and pseudo orde two. The reaction of orde one is a reaction that it’s peed is suspended for one of essence has reacted or comparable with one of it’s reactant power. The linier aqution of one orde reaction is explained in formula as follows (Bulut, Ozacar, Sengil, 2008).

2. Methodology

Material and tool

The ionsof hard metal will be used in this research are Cd\textsuperscript{2+} ion and Zn\textsuperscript{2+} ion while. The main solution of Cd\textsuperscript{2+} be made to dissolving Cd (CH3OO)\textsubscript{2}.4H2O into aquadest asfar as had concentration in 1000 ppm. The tools were used among analitic neraca, stiring motor, spectrofotometer for reserving atom (SSA), pumpkin for measure, erlenmeyer and glass chemistry. Zeolit used in adsorben is zeolit 4A by measure 325 mesh from Sigma Aldrich.

The Stages of Adsorption and Analysis

The metode was used on this research is batch metode. In this batch metode the adsorbat was mixed straightaway with adsorben into erlenmeyer. The experiment of adsorption done by weighing zeolit 4A for 0.1 gram that put into erlenmeyer 100 ml, and added the solution of metal's ion Cd\textsuperscript{2+} 50 ppm as much as 50 ml. Then the solution is mixed by stiring motor in speed 200 rpm on moon temperature with variationes of time study 10, 15, 30, 45, 60, 90, 120 and 180 minutes. And then the solution of sample be filtered with use dry paper and be analyzed by use AAS. The same way of treating for metal’s ion Zn\textsuperscript{2+} is too.

The presentation of metal’s ion has reserved could be counted by formula as follows:

\[
\text{% Adsorption} = \frac{C_i - C_e}{C_i} \times 100\% \tag{1}
\]

where \(C_i\) dan \(C_e\) are the head and final for the concentration of metal’s ion in solution (mg L\textsuperscript{-1}). Whereas the total for metal’s ion that can be adsorpted by adsorben unit in equilibrium with sample volume, can be counted for formula as follows:

\[
q_e = \frac{C_i - C_e}{m} \times V \tag{2}
\]

where \(V\) is sample volume (L) and \(m\) is the specific grafity of adsorben (g) in used. The head concentration and already absorption process are measured by spectrofotometer of atom absorption (SSA).
3. Result and Discussion

Influence for Time and motion study about % Adsorption.

The time and motion study has as purpose to find efficiency and effectiveness for adsorption out where the one of adsorption process will happen the equilibrium on sure time.

![Figure 1](image1.png)

**Figure 1.** Influence for time and motion study about adsorption by Zeolit 4A (Analyze's condition: the specific gravity of absorben 0.1 g, volume 50 ml, the time for stirring 200 rpm, head concentration 50 mg/L).

From Figure 1 above seen that increase capacity for adsorption adsorben was in accordance with time and motion study, at first minutes of adsorption Cd²⁺ and Zn²⁺ metals by Zeolit have indicated significant increasing, but almost all of active Zeolit's sides interacted with metal's ion, adsorption's speed in decreased until wouldn't happen increase for capacity of absorption. This increase for capacity of adsorption presumed happen cause the total for available active sides on hand to Zeolit's surface keep more no filled or the condition is not crystallize yet. So facilitate the metal of Cd²⁺ and Zn²⁺ to interact Zeolit. Already adsorption for metal of Cd²⁺ and Zn²⁺ each one go on 180 minutes, the total for metal's Cd²⁺ and Zn²⁺ be adsorpted seen relative a constant, this case caused with increasing the time and motion study at the longer, active side on Zeolit has filled full and this condition is regarded had reached the equilibrium.

The Act of Determining Kinetic Adsorption Mode

To make certain mecanisme and adsorption speed a media, needed the approach by kinetic mode (Bulut, Ozacar, Sengil, 2008). One of main purpose in this kinetic adsorption research is to making certain suitable mode for kinetic adsorption metal’s ion Cd²⁺ and Zn²⁺ and get parameter’s values in kinetic adsorption.

**The Reaction of Pseudo Orde One**

Plot between log (qe − qt) versus t in equation of kinetic Pseudo orde one for metal's ion Cd²⁺ and Zn²⁺ adsorption by Zeolit 4A could be refered to Figure 2.

![Figure 2](image2.png)

**Figure 2.** The mode of Pseudo orde one kinetic.

From Figure 2 could be seen that plot between log (qe − qt) versus t produce result the straight line by declivity near 1. But in Table 1 could be refered to big difference between the value qe gotten with experiment result. This case indicates that the Pseudo orde 1 kinetic doesn’t conform to metal’s ion Cd²⁺ and Zn²⁺ adsorption process by Zeolit 4A. Becouse in adsorption process makes possible happen a interact ion interfunctional adsorbat group and adsorben than tried used for orde two equation to discribes the dinamic of adsorption metal’s ion Cd²⁺ and Zn²⁺ in Zeolit 4A.

The reaction of Pseudo orde two plot between t/qt versus t in equation of Pseudo orde two kinetic for metal’s ion Cd²⁺ and Zn²⁺ adsorption by Zeolit 4A could be refered to Figure 3 as follows:
Figure 3. The mode of orde two kinetic

From the Figure 3 could be refered that the plot between t/qt versus t produce straight line by value R² approached more than 1 (upper 0,99) well for Cd²⁺ and Zn²⁺. Besides in Table 1 could be refered that the value qe gotten from produce of accounting approached the value qe gotten from produce of experiment. This case indicated that the process of adsorption for metal's ion Cd²⁺ and Zn²⁺ by Zeolit 4A followed the kinetic of Pseudo orde two reactions.

The equation of orde two assumes that adsorption of chemistry (chemisorption) make speed of contoler up (rate limiting step) in adsorption process (Sag and Atkay, 2002). The data of kinetical parameter for metal's ion Cd²⁺ and Zn²⁺ adsorption process uses Zeolit 4A as absorben as follows:

Tabel 1. The Parameter of metal's ion Cd²⁺ and Zn²⁺ adsorption kinetical

<table>
<thead>
<tr>
<th>Ion logam</th>
<th>qe eksperimen (mg/g)</th>
<th>k₁ (menit⁻¹)</th>
<th>R²</th>
<th>qe (mg/g)</th>
<th>k₂ (g mg⁻¹ menit⁻¹)</th>
<th>R²</th>
<th>qe (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd (II)</td>
<td>39,16</td>
<td>0,004</td>
<td>0,974</td>
<td>8,375</td>
<td>0,205</td>
<td>0,998</td>
<td>40,00</td>
</tr>
<tr>
<td>Zn (II)</td>
<td>44,24</td>
<td>0,008</td>
<td>0,956</td>
<td>23,77</td>
<td>0,087</td>
<td>0,995</td>
<td>47,62</td>
</tr>
</tbody>
</table>

4. Conclusion

From the result of research gotten, then can be taken several conclusions among others with increase in times of motion study so % of adsorption for metal's ion Cd²⁺ and Zn²⁺ will be more and more increase. The adsorptiones of metal's ion Cd²⁺ and Zn²⁺ by using Zeolit 4A absorben can be explained followed the mode of Pseudo orde two kinetic the value each k were as big as 0,205 g mg⁻¹ minute⁻¹ and 0,087 g mg⁻¹ minute⁻¹.

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References