



Available online at <http://journal.walisongo.ac.id/index.php/jnsmr>

## Kinetics Study of Cd<sup>2+</sup> and Zn<sup>2+</sup> Metal Ion Adsorption Using Zeolite 4A

Ervin Tri Suryandari<sup>1</sup>, M.A. Zulfikar<sup>2</sup> and M. Nasir<sup>3</sup>

<sup>1</sup>Department of Chemistry, Faculty of Sciences and Technology, Universitas Islam Negeri Walisongo Semarang, Indonesia

<sup>2</sup>Department of Chemistry, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, Indonesia

<sup>3</sup>Chemical Research Centre of Indonesian Institute of Sciences, Indonesia

### Abstracts

Corresponding author:  
wikasmara@yahoo.co.id  
Received: 06 November  
2017, Revised: 17  
November 2017, Accepted:  
01 Desember 2017.

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<sup>2+</sup> and Zn<sup>2+</sup> 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<sup>2+</sup> adsorption process followed the pseudo-second-order model with a value of  $k = 0.205 \text{ g mg}^{-1} \text{ min}^{-1}$ ,  $R^2 = 0.998$ , while the Zn<sup>2+</sup> adsorption process followed the pseudo-second-order model with a value of  $k = 0.087 \text{ g mg}^{-1} \text{ min}^{-1}$ ,  $R^2 = 0.995$ . ©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 beside as waste. This waste including as kind of hard metal that dominant in water amongs the metal Cd<sup>2+</sup>

dan Zn<sup>2+</sup> 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 because has more luck among economic character and not has a poison effect on secondary and very effective to absorb hard metal compared with other process. One of potential material more be used to process for adsorption is zeolit, zeolit is the material that its existence 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 gravity adsorbent, temperature, concentration of solution.

This research heads for making certain about kinetic mode in needle when process of metal absorption  $Cd^{2+}$  and  $Zn^{2+}$  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  $Cd^{2+}$  and  $Zn^{2+}$  by zeolit 4A is used kinetic mode of pseudo order one and pseudo order two. The reaction of order one is a reaction that its speed is suspended for one of essence has reacted or comparable with one of its reactant power. The linear equation of one order reaction is explained in formula as follows (Bulut, Ozacar, Sengil, 2008).

## 2. Methodology

### *Material and tool*

The ions of hard metal will be used in this research are  $Cd^{2+}$  ion and  $Zn^{2+}$  ion while. The main solution of  $Cd^{2+}$  be made to dissolving Cd ( $CH_3OO$ ) $2.4H_2O$  into aquadest as far as had concentration in 1000 ppm. The tools were used among analytical balance, stirring motor, spectrophotometer for reserving atom (SSA), pumpkin for measure, erlenmeyer and glass chemistry. Zeolit used in adsorbent is zeolit 4A by measure 325 mesh from Sigma Aldrich.

### *The Stages of Adsorption and Analysis*

The method was used on this research is batch method. In this batch method the adsorbate was mixed straightaway with adsorbent 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  $Cd^{2+}$  50 ppm as much as 50 ml. Then the solution is mixed by stirring motor in speed 200 rpm on room temperature with variations 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  $Zn^{2+}$  is too.

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

$$\% \text{ Adsorption} = \frac{C_i - C_e}{C_i} \times 100\% \quad (1)$$

where  $C_i$  dan  $C_e$  are the head and final for the concentration of metal's ion in solution (mg L<sup>-1</sup>). Whereas the total for metal's ion that can be adsorbed by adsorbent unit in equilibrium with sample volume, can be counted for formula as follows:

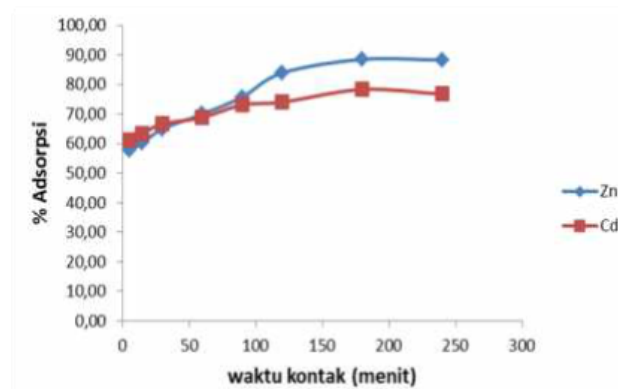
$$q_e = \frac{C_i - C_e}{m} \times V \quad (2)$$

where  $V$  is sample volume (L) and  $m$  is the specific gravity of adsorbent (g) in used. The head concentration and already adsorption process are measured by spectrophotometer 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.** Influence for time and motion study about adsorption by Zeolit 4A (Analyze's condition: the specific gravity of adsorbent 0,1 g, volume 50 ml, the time for stirring 200 rpm, head concentration 50 mg/L).

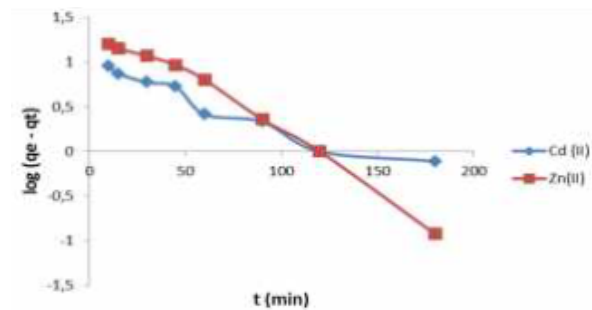
From Figure 1 above seen that increase capacity for adsorption adsorbent was in accordance with time and motion study, at first minutes of adsorption  $Cd^{2+}$  and  $Zn^{2+}$  metals by Zeolit have indicated significant increasing, but almost all of active Zeolit's sides interacted with metal's ion, adsorption's speed in decreased until wouldn't happen increase for capacity of absorption. This increase for capacity of absorption 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  $Cd^{2+}$  and  $Zn^{2+}$  to interact Zeolit. Already adsorption for metal of  $Cd^{2+}$  and  $Zn^{2+}$  each one go on 180 minutes, the total for metal's  $Cd^{2+}$  and  $Zn^{2+}$  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 mechanism 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  $Cd^{2+}$  and  $Zn^{2+}$  and get parameter's values in kinetic adsorption.

#### *The Reaction of Pseudo Orde One*

Plot between  $\log (q_e - q_t)$  versus  $t$  in equation of kinetic Pseudo orde one for metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  adsorption by Zeolit 4A could be referred to Figure 2.



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

From Figure 2 could be seen that plot between  $\log (q_e - q_t)$  versus  $t$  produce result the straight line by declivity near 1. But in Table 1 could be referred to big difference between the value  $q_e$  gotten with experiment result. This case indicates that the Pseudo orde 1 kinetic doesn't conform to metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  adsorption process by Zeolit 4A. Because in adsorption process makes possible happen a interaction ion interfunctional adsorbat group and adsorbent than tried used for orde two equation to describes the dynamic of adsorption metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  in Zeolit 4A.

The reaction of Pseudo orde two plot between  $t/q_t$  versus  $t$  in equation of Pseudo orde two kinetic for metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  adsorption by Zeolit 4A could be referred to Figure 3 as follows :

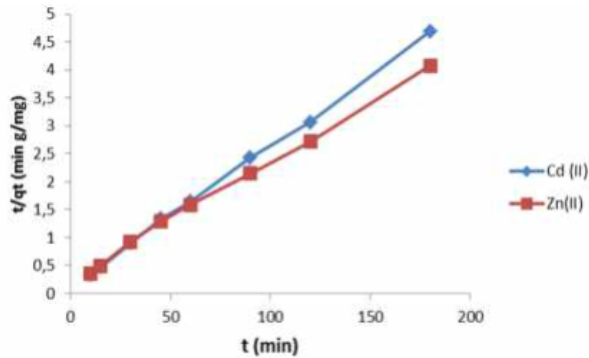


Figure 3. The mode of orde two kinetic

From the Figure 3 could be refered that the plot between  $t/q_t$  versus  $t$  produce straight line by value  $R^2$  approached more than 1 (upper 0,99) well for  $Cd^{2+}$  and  $Zn^{2+}$ . Besides in Table 1 could be refered that the value  $q_e$  gotten from produce of accounting approached the value  $q_e$  gotten from produce of experiment. This case indicated that the process of adsorption for metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  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  $Cd^{2+}$  and  $Zn^{2+}$  adsorption process uses Zeolit 4A as absorben as follows :

Tabel 1. The Parameter of metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  adsorption kinetical

Ion logam	$q_e$ eksperimen (mg/g)	<i>pseudo orde satu</i>		<i>pseudo orde dua</i>			
		$k_1$ (menit <sup>-1</sup> )	$R^2$	$q_e$ (mg/g)	$k_2$ (g mg <sup>-1</sup> menit <sup>-1</sup> )	$R^2$	$q_e$ (mg/g)
Cd (II)	39,16	0,004	0,974	8,375	0,205	0,998	40,00
Zn (II)	44,24	0,008	0,956	23,77	0,087	0,995	47,62

#### 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  $Cd^{2+}$  and  $Zn^{2+}$  will be more and more increase. The adsorptions of metal's ion  $Cd^{2+}$  and  $Zn^{2+}$  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<sup>-1</sup> minute<sup>-1</sup> and 0,087 g mg<sup>-1</sup> minute<sup>-1</sup>.

#### Acknowledgment

Writer expresses thanks to IsDB UIN Walisongo and ITB's routine donation that have given financial support to this research this research.

#### References

- [1] Atkins P., (1990): Physical Chemistry, Oxford University Press, Oxford
- [2] Bulut, Emrah., Ozacar, Mahmut., Sengil, Ayhan., 2008, Adsorption of Malachite Green Onto Bentonite: Equilibrium and Kinethics Studies And Process Design, MicroporousAnd Mesoporous Materials, Elsevier, 115, 234-256
- [3] Erdem, E., Karapinar, N., and Donat, R., 2004, The Removal Heavy Metal Cations by Natural Zeolites, Journal of Colloid and Interface Science, 280, 309-314, Department of Chemistry Engineering, Faculty of Engineering, Pamukkale University, Denizli, Turkey
- [4] Pallar, H., 1994, Pencemaran dan Toksikologi Logam Berat, Jakarta: Rineka Cipta, hal: 152.
- [5] Sag, Y., Aktay, Y (2002), "Kinetics Studies on Sorption of Cr (VI) and Cu (II) ionsby Chitin, Chitosan and Rhizopus Arrhizus", Biochemical Engineering Journal, 12, hal 143-153