

Removal of Lead from aqueous phase using Amberlite and natural Zeolite

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Abstract. Two following reason lead (Pb) us to find a way for removing heavy metals (HM) from the water resources, first limitation of water resource and increasing of water scarcity and second increaseing of surface and groundwater contamination by HM, (derived from industrial and municipal wastewater). In this research, Zeolite (Clinoptilolit) as natural and Amberlite (IR-120) as chemical were used as sorbents of Pb. Experiments were done in batch mode under various operational conditions including three size of zeolite and one mean diameter of Amberlite. An splite-plot experimental design was employed with 60 treatments and three replications at Shiraz University, Shiraz, Iran in 2011. The treatment were five different concentration of the Pb contamination and three size of zeolite (0.075, 0.2 and 0.42mm). The concentration for Pb were: 40, 250, 500, 1000. The removing efficiency of the zeolite and Amberlite was measured for Pb. The results showed that the effect of concentration of contamination and zeolite size were statistically significant. It showed that by increasing of the concentration of contamination, absorption of the HM increases linearly by zeolite. Maximum Pb absorption occurred at 1250 mg/l with a value of 59.97 mg for 1 grams of zeolite. The minimum Pb absorption occurred at 40 mg/l with a value of 1.82 mg for 1 grams of zeolite. The results showed that the effect of concentration of HM were statistically significant for Amberlite and it also observed that the absorption of HM by Amberlite increases linearly. Maximum Pb absorption occurred at 1250 mg/l with a value of 62.35 mg for 1 grams of Amberlite. The minimum Pb absorption occurred at 40 mg/l with a value of 1.98 mg for 1 grams of zeolite.

Key words: Absorption, Heavy metal, Amberlite and Zeolite

Introduction

One of the environmental issues is the existence of heavy metals (HM) in the wastewater and its effect on agricultural soils and cultivated plants in areas irrigated with such water. It can harmfully result in the accumulation of metals like Lead, Nickel and Cadmium in the soil. In Taiwan, most of the agricultural lands irrigated with industrial effluents have been contaminated and unusable. Also, more than 40% of the rivers in this country have been contaminated (Rahmani and Ghandi 2005). Therefore, to reuse urban effluents, industrial wastewater and the latex of the factories HM and other contaminant should be removed before irrigation (Mobtaker et al, 2005).

Using superabsorbant is a way of reducing heavy metals in wastewater (Kabiri, 2010). One of the ways of removing or reducing the contamination of wastewater is to use ion exchange resins (Wadu and Okamura, 1998). The adsorption of copper by the cationic resin of Amberlite IR-120 in concentrations of 0.3, 0.5 and 0.7 g L⁻¹ was investigated by Kumarjha et al (2009). The absorption of Pb and Cu using PS-EDTA cationic resin was investigated by Liyuan et al. (2010). In low concentration, the more the capacity of ion ,the more absorption will occur to the resin. Even for the ions with similar capacity, the heavier the molecular weight of ion, the more absorption will occure (Chalkesh. Amiri, 2002). Absorption of Boron by Amberlite was studied by Demircivi and Saygili (2008).

The removal performance Linde 4A zeolite (Na form) on some HM ions (Co^{2+} , Cu^{2+} and Mn^{2+}) in aqueous solutions was investigated by Rashad, et al. (2012). The adsorption of the studied HM metals was strongly dependent on pH, temperature and zeolite dose. The optimum pH for the studied metals was found out to be 6.5. The sorption rate of metal ions could be significantly improved by increasing pH value.

Therefore, cationic resins of Amberlite and Zeolite are a suitable as a source with a good efficiency for water and waste water treatment. In this research, the effect of Amberlite cationic resins and zeolite in reducing of Lead from an aqueous solution is investigated.

Materials and Methods

Cationic resins of sodiomic Amberlite IR-120 of Merck was used with 0.5 mm mean diameter. The zeolite used in this study was provided from the mine of Semnan and was milled in soil mechanics laboratory of Shiraz University and screened with successive sieves (Table 1). Zeolites with 0.075, 0.200 and 0.425 mm diameter were prepared for this research.

A specific amount of the salt of Pb was dissolved in a specific volume of distilled water to achieve the preferred concentration. Then 2 gr of zeolite Clionoptilolit with 0.425 mm diameter in 100 ml was dissolved and the solution phase was shaken for 90 minutes. The solution phase was separated from the solid phase using filter paper and the concentration of solution phase was determined using atomic absorption. This procedure was repeated for 2 gr of Amberlite. According to the studies conducted by Tabatabaei and Light (2004), Demirbas, et al. (2005), Hui, et al. (2005) and Sprynskyy (2009), the major adsorption were occurred in contact time of 90 min. Therefore, the contact time of 90 min was considered. The amount of adsorption was calculated by Eq 1:

$$AR = (C_2 - C_1) / (w) \quad (1)$$

Where AR is the amount of absorption of HM in the unit of the weight of the adsorbent, C_1 is the primary concentration of adsorbent (mg L^{-1}), C_2 is the secondary of concentration adsorbent (mg L^{-1}), and W is the

weight of adsorbent (gr). For Pb pollutant, concentrations of 40, 250, 500, 1000 were selected. The above concentration of aqueous solutions were in contact with Amberlite cation resin and Zeolite, The removal efficiencies were determined.

Result and Discussion

Zeolite Adsorption

The statistical analysis of the effects of different concentration of Pb aqueous solution and the effect of different size of Zeolite on the removal efficiency are showed in Table 2. According to Table 2, the effect of the variance concentration of the aqueous solution and different size of Zeolite on the absorption of Pb by Zeolite is significant ($p < 0.01$). Also the effect of error on the experiment was not significant: therefore the results are acceptable.

The results of Duncan's test showed that different Zeolite absorptions occurred in different Pb concentrations and that different sizes of Zeolite were significant at 1% level of probability (Table 2). Fig 1 shows the effect of different Pb concentrations on the absorption by Zeolite. According to Fig 1, maximum Pb absorption occurred at concentration of 1250 mg L^{-1} with a value of 59.98 mg g^{-1} , whereas minimum absorption was occurred at 40 mg L^{-1} with a value of 1.815 mg g^{-1} .

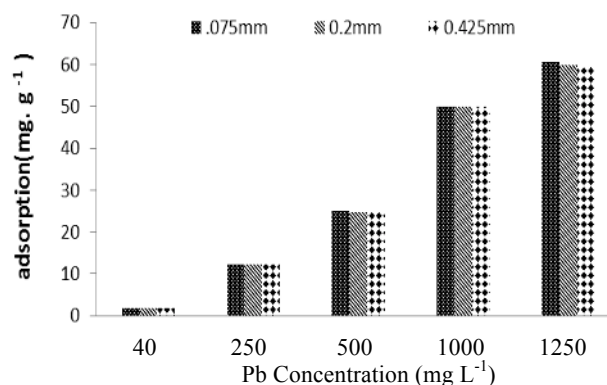


Fig. 1. The effect of different concentration of Pb on the absorption of Zeolite

Table 1. Chemical properties of zeolite (Afrand-Tooska company, 2007)

Location	SiO ₂	Al ₂ O ₃	CaO	K ₂ O	Na ₂ O	Fe ₂ O ₃	MgO	TiO ₂	P ₂ O ₅	LOI
Semnan	66.5	11.8	1.3	2.1	2	1.3	0.8	0.3	0.01	12

Table 2. Analysis of variance of the removal efficiency of Pb, Ni and Cd by Zeolite and Amberlite

	Zeolite				Amberlite			
	df	Mean	F	P	df	Mean	F	P
Conc. of Pb	4	5477	851597**	0.00	4	1920.63	1048042**	0.00
Adverse effect	8	0.10	15**	0.00				
Size of Zeolite	2	0.24	37**	0.00				
Error	30	0.01			10	0.00183		

** significant in level 1%, * significant in level 5%, ns not significant

Amberlite Absorption

The statistical analysis of the effects of different concentrations of Pb aqueous solution on the removal efficiency are showed in Table 2. According to Table 2, the effect of the concentration of the aqueous solution on the absorbed Pb by Amberlite is significant ($p < 0.01$). Also the effective of error on the experiments was not significant: therefore the results are acceptable.

The results of Duncan's test showed that different Amberlite absorptions occurred in different Pb concentrations of Amberlite was significant at 1% level of probability (Table 2). Fig 2 shows the effect of different Pb concentrations on the absorption by Amberlite. According to this Fig maximum Pb absorption occurred at concentration of 1250 mg L^{-1} with a value of 62.35 mg g^{-1} , whereas minimum absorption was occurred at 40 mg L^{-1} with a value of 1.97 mg g^{-1} (Fig 2). The sorption capacity of the Amberlite IR-120 resin for Pb were was also evaluated by Demirbas et al. (2005). They showed that the maximum adsorption capacity of the resin was 19.6, 235.3 and 201.1 mmol/g for Pb, Ni and Cd, respectively.

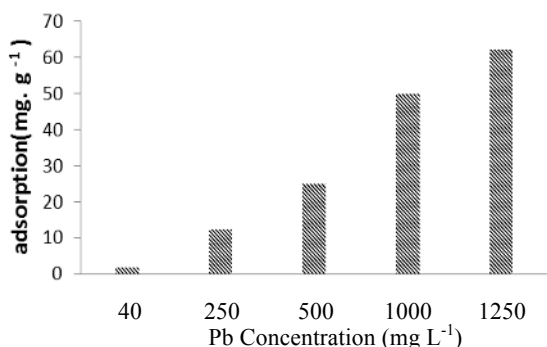


Fig. 2. The effect of different concentration of pb on the absorption of Amberlite

Comparing Amberlite to Zeolite

The absorption of Pd, Ni and Cd in Amberlite (mean diameter 0.5 mm) and Zeolite (mean diameter 0.425 mm) was compared in Figure 3. According to Figure 3 the absorption of Pb, Ni and Cd in Amberlite were more than Zeolite. The absorption of pb by Amberlite were 9.9, 2.2, 0.97, 0.06, 4.3, 3.61 % more than Zeolite in 40, 250, 500, 1000 and 1250 mg L^{-1} , respectively.

The absorption of Ni by Amberlite were 10.36, 3.14, 3.86, 0.94, 0.74 % more than Zeolite in 4, 6, 15, 20 and 40 mg L^{-1} , respectively and for Cd the absorption of Amberlite were 3.76, 5.52, 4.45, 5.35, 2.91 % more than Zeolite in 4, 6, 15, 20 and 40 mg L^{-1} , respectively.

Conclusions

The results shows that:

1. The maximum removal efficiency was 99% in 1000 mg L^{-1} by Amberlite for Pb.

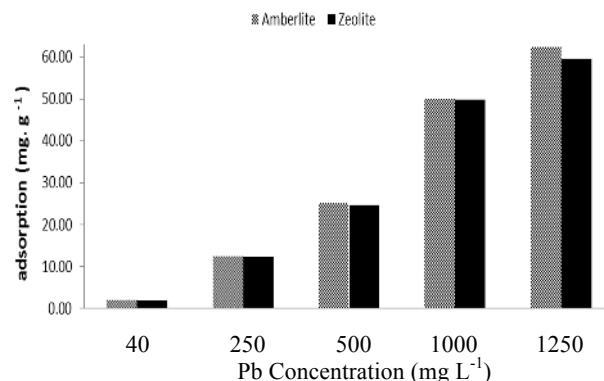


Fig. 3. Comparison of Amberlite and zeolite in absorption of Pb.

2. The minimum removal efficiency of Pb was 88.99% in 40 mg L^{-1} by Zeolite.
3. The absorption of Pb by Amberlite was found to be more than Zeolite.
4. The absorption of Pb by Amberlite was 9, 2.2, 0.97, 0.06, 4.3, 3.61 % more than Zeolite in 40, 250, 500, 1000 and 1250 mg L^{-1} , respectively.

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