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Uses of natural zeolite in the removal of Pb^{2+} from contaminated water

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ABSTRACT: In this paper, we carry out a study on the process of sorption of lead in polluted waters using natural zeolites, with the objective of analyzing their behavior in the purification of water.Experiments are carried out under static and dynamic conditions to determine the influence of other metal ions, such as: Ca (II), Mg (II), K (I) and Na (I), on this process. We demonstrate that the affinity of Pb (II) with regard to zeolite is higher than that of the ions mentioned above. It allows us to use this material in the capture of lead in residual waters. A lineal model of regression was obtained using a computer program called Eureka which relates the capacity of interchange of zeolite with respect to the concentration of the metal ions present in waters. We also studied the selectivity of zeolite in the process of sorption of Pb (II) compared with other heavy metals like Zn (II) and Cd (II).The results achieved in both cases increase the expectancy about the usage of zeolite as a low cost material for purifing waters.

KEYWORDS: Heavy metals; ion exchange; atomic absorption spectrometry.

Introduction

At the present moment, one of the most investigated metals is Pb (II),[2,5,6,7,8] because of its influence on human organisms. For this reason it has been studied in the environment,[3,5] due to its diffussion tendency and use in several branches of industry and technology. Although the employment of zeolites for the elimination of heavy metals in water has been studied (1,9), the problem about matrix effect on the ion-exchange process is not fully discussed.This work analizes the possibility of employing zeolite (in particular mordenite) for the elimination of Pb (II) from contaminated water in the presence of other cations.

The selectivity of mordenite has been studied with respect to Pb (II) in comparison with other heavy metals like Zn (II) and Cd (II).

Material and methods

In our work we have employed natural zeolite (mordenite type) from "San Cayetano", Camagüey, Cuba; with a composition of SiO_2 (50-65 %), Al_2O_3 (8-12%) and others elements. The Ca(II) is the predominant cation in mordenite, (23-42%). There are other important cations in the zeolite like Mg (II), K (I), Na(I). Heavy metal were not detected in the samples by spectral emission analysis.

These experiments were carried under static and dynamic conditions at temperature of 25 C. In static conditions, 10 g of mordenite with particle diameter 0.6-1.0 mm, were used. Zeolite was treated with 100 ml of Pb (II), Ca (II), Mg(II), Na (I), K (I) solutions at different concentrations and pH between 6-9. Zeolite in contact with standard solutions were stirred during 2 hours. Later Pb (II) concentration was determined in a AAS-3 Spectrometer. A flame photometer was used for K (I), Na(I) determination in prepared solutions. The content of Ca(II), Mg (II) in solutions was determined by titration with EDTA.

The Pb (II) concentrations used in the experiment were 1, 10, 20 mg/L, and the concentrations for other ions were variable. Results were treated with the Eureka sofware program on a PC computer. Dynamic conditions tests were carried out by employing 2 and 10 g of zeolite with particle diameter 0.6-1.0 mm introduced in a chromatographic column (diameter 1.1 cm and height 16 cm). Polluted simulated water was prepared containing variable concentrations of Ca (II), Mg (II), Na (I) and K (I).

The elution rate was 3 ml/min. Fractions of 50 ml eluate were taken for analysis.The Pb (II), Zn (II) and Cd (II) solutions of 77 mg/L were employed for determination affinity of Pb (II), Cd (II) and Zn (II) with respect to zeolite. Measurements by atomic absorption spectrometry were made at 283.3, 228.8 and 213.9 nm for Pb (II), Cd (II), and Zn (II) respectively.

Results and discussion

The competitive effect in static conditions of the studied cations in variable concentration ranges in water was not determinant with respect to low concentration of Pb (II).The results are shown in Table 1.

Table 1 - Purification capacity of zeolite in contaminated waters with Pb (II) in three levels of concentration, 1(I), 10(II) and 20(III) mg/L.

Sample No	Ca^{2+} mg/L	Mg^{2+} mg/L	Na^{+} mg/L	K^{+} mg/L	Final Concentration of $Pb^{2+} . 10^2$		
					I	II	III
1	20	10	30	2	0.8	1.8	2.5
2	30	20	50	4	1.0	2.2	2.3
3	45	30	60	5	3.0	3.0	2.9
4	60	40	74	6	0.0	1.7	2.3
5	70	50	80	8	1.0	3.0	3.2
6	90	60	100	10	0.0	3.0	2.7

Maximun averages in Table 1 are below 50 µg/L. Evidently, the final concentration of some cations was greater that initial concentration due to the characteristics of the solution employed and the constitution of zeolite. The latter includes on its structure Ca (II), Mg (II) and other cations.

The treatment of experimental results showed the following linear regression equatios:

$c(Pb^{2+})f = 1.183 + c(Pb^{2+})O + 0.635\ c(K^{+}) + 0.012\ c(Ca^{2+})-$

$0.0073\ c(Na^{+}) - 0.0058\ c(Mg^{2+}) + 0.0039\ pH.$

$c(Pb^{2+})f$ = final concentration.

$c(Pb^{2+})O$ = initial concentration.

In these preliminary resuls, the relative influence of foreign cation on the Pb (II) ion exchange process were shown quantitatively. This is show the with natural zeolites the effectivenes of polluted water purification, in the presence of Ca (II), Mg (II), K (I) and Na (I).

In order to use mordenite in dynamic conditions tests were prepared with Pb (II) concentration of 1, 5 and 11 mg/L. The results obtained appear in Figure 1.

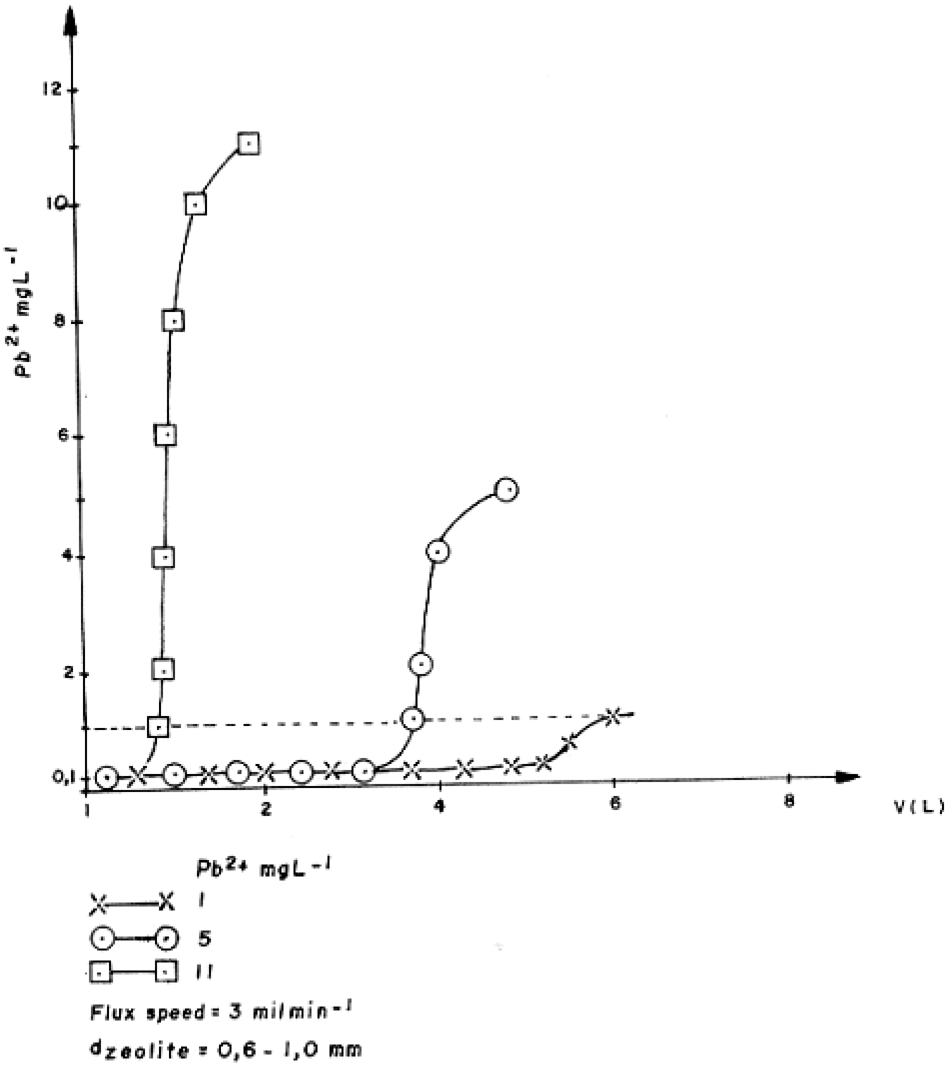

FIGURE 1 - Rupture curve of ion exchange process in mordenite (m zeolite = 2 g).

Some important results: Mordenite can be used for purification of polluted water with low concentration of Pb^{2+} where the process is more effective. Purified water can be obtained with Pb^{2+} level less than 0.1 mg/L. However, using 10 g of mordenite in the same experimental conditions (dynamic conditions), 17 L contaminated water with Pb^{2+} at concentration of 4 mg/L can be treated. The ion exchange capacity calculated is more than in precedent experimental cases (Figure 2).

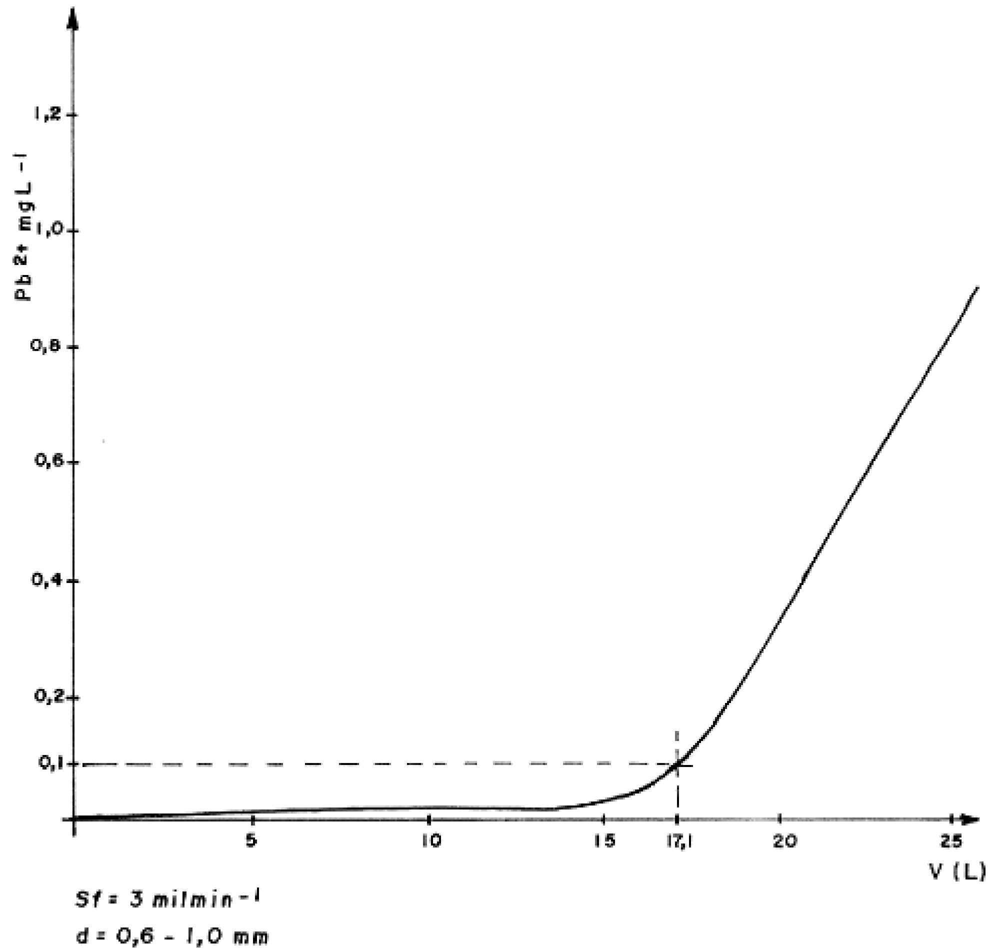

FIGURE 2 - Rupture of ion exchange process in mordenite (m zeolite = 10 g).

The affinity of the other divalent heavy metals, (such as Zn^{2+}, Cd^{2+}, Pb^{2+}) was demonstrated (Figure 3). It has the following sequence : $Pb^{2+} > Cd^{2+} > Zn^{2+}$. This has been reported in others papers.[4]

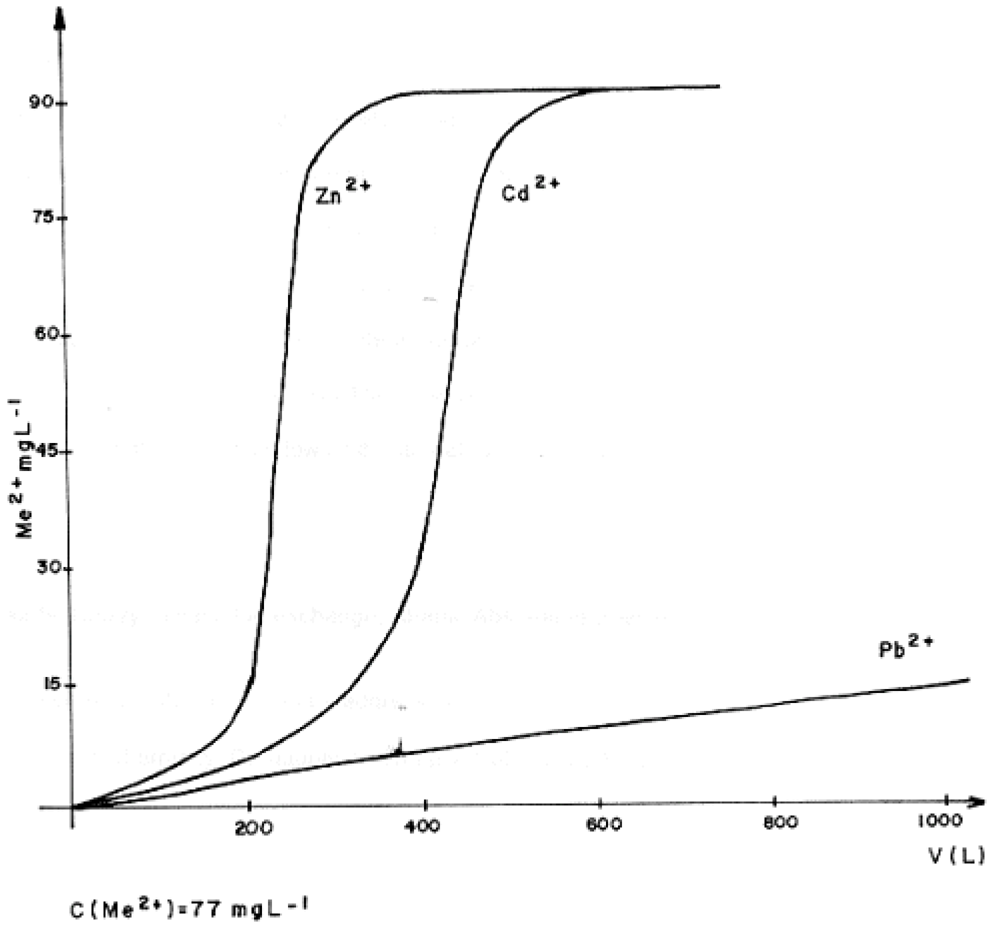

FIGURE 3 - Affinity of the Pb^{2+}, Cd^{2+} and Zn^{2+} with respect to mordenite.

Conclusion

In this work the possibility of using natural zeolites (mordenite type) for the purification of contaminated water with low concentration of Pb^{2+} in the presence of foreign cations like, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and pH between 6-9, has been demonstrated.

Significant benefit in the usage of zeolite as ion exchange material is evident due to its low cost and hig effectiveness in purifying polluted water. In spite of its low ion exchange capacity in comparison with other ion- exchange resins, zeolite could be used for the extraction of Pb^{2+} and after its exhaustion to employ as a raw material in construction.

SEIJÓ ECHEVARRÍA, M., DEL TÓRO DÉNIZ, R., MARTINEZ CASTELLANOS, E., SHERBAKOV, G. A., RODRIGUEZ MOYA, J. J. Usos de zeólita natural na remoção de Pb^{2+} de água contaminada. *Ecl. Quím. (São Paulo)*, v.22, p.15-22,1997.

RESUMO: Neste trabalho efetuamos um estudo no processo de sorção de chumbo em águas poluídas, usando zeólita natural com o objetivo de analizar seu comportamento na purificação da água. Os ensaios foram realizados sob condições estáticas e dinâmicas, para determinar a influência

de outros íons metálicos, como Ca (II), Mg (II), K (I) e Na (I) neste processo. Nós demonstramos que a afinidade do chumbo em relação à zeólita é maior que a dos íons acima mencionados. Isto permite o uso deste material na captura de chumbo em águas residuais. Foi obtido um modelo linear de regressão usando um computador chamado Eureka, que relaciona a capacidade de intercâmbio da zeólita em relação à concentração dos íons metálicos presentes na água. Nós estudamos também a seletividade da zeólita no processo de sorção de Pb(II), comparados com outros metais pesados como Zn (II) e Cd (II). Os resultados obtidos nos dois casos reforçaram as expectativas sobre o uso da zeólita como um material de baixo custo para purificação da água.
PALAVRAS-CHAVE: Metais pesados; troca iônica; espectroscopia de absorção atômica.

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