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ANALYSIS OF FACTORS INFLUENCING Cu(II) SORPTION BY CLINOPTIOLITE

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Abstract

The effects of initial metal concentration and pH, as well as the sorbent mass and particle size, on Cu(II) sorption by natural clinoptilolite were evaluated and compared. Full factorial experimental design at two levels was applied. Statistically significant factors were determined considering residual Cu(II) concentrations as a system response.

Introduction

Heavy metals are major pollutants of some ground and surface waters and are often present in industrial or urban wastewaters. Among different methods for water purification, sorption processes are widely investigated using natural and synthetic materials. Clinoptilolite is naturally occurring zeolite, which sorption properties toward heavy metal cations, NH_4^+ , inorganic anions and organic substances were intensively studied [1]. The effectiveness of sorption process can be significantly influenced by variation of operating conditions. The objective of this work was to analyze and compare the effects of initial solution pH, initial metal concentration, sorbent mass and particle size, on Cu(II) removal by natural clinoptilolite, using experimental design methodology [2].

Materials and Methods

The experiments were conducted in batch conditions, at $20 \pm 1^\circ\text{C}$. Variable amounts of solid phase (clinoptilolite, Vranjska Banja, Serbia) were equilibrated for 48 h on a horizontal shaker with 20 mL of Cu(II) solutions. Independent variables and their levels are given in Table 1, while Table 2 presents

coded experimental conditions based on full factorial design and defined by the statistical software. After filtration, residual concentrations of Cu(II) ions were measured by Perkin Elmer Emission Spectrometer Plasma 400, at $\lambda=222.78$ nm.

Table 1. Variables and their levels.

Factor	Level	
	-1	+1
A - initial pH	3	5
B - sorbent mass (g)	0.1	0.4
C - initial Cu(II) conc. (mol/L)	0.0002	0.005
D- particle size (mm)	<100	1-3

Table 2. Experimental design matrix

Results and Discussion

The study of full factorial design consists of exploring all possible combinations of the factors considered in the experiment. Using residual Cu(II) concentrations as system response, Pareto chart (Fig. 1a) and Main effect plot (Fig. 1b) were constructed by statistical software (MINITAB).

In Pareto chart, the absolute values of effects are compared and information about their statistical significance at a confidence interval of 95% is provided. Each bar length in Pareto chart is proportional to the standardized effect, produced by variation of a given factor between lower and higher level [2]. The change of initial metal concentration influenced process the most. The variation of sorbent mass and the interaction between initial Cu(II) concentration and sorbent mass as well produced statistically significant effects.

The Main effect plot (Fig 1b) gives information on whether the change between

two variable levels decreased or increased the selected system response [2]. The horizontal line in the graph represents the overall mean response of the system, for both levels of all factors. From the Fig. 1b, it can be concluded that decrease of concentration and increase of sorbent mass caused reduction of aqueous Cu(II) concentration, while the effects of initial pH and sorbent granulation were negligible.

Finally, for the investigated range of variables, the following mathematical model can be used for process description:

$$Y = 155.3 - 18.26 B + 150.78 C - 16.95 BC$$

where Y is residual Cu(II) concentration, whereas B, C and BC represent effects of sorbent mass, initial metal concentration and their interaction, respectively.

Factor				Response(Y)
A	B	C	D	Cu (mg/L)
1	-1	-1	-1	4.01
1	1	1	1	289.71
1	1	1	-1	233.18
-1	1	1	1	286.39
1	1	-1	1	3.91
-1	1	-1	1	7.21
-1	-1	1	-1	341.47
1	-1	1	-1	328.90
-1	-1	1	1	350.82
-1	-1	-1	-1	10.97
1	-1	-1	1	8.27
-1	1	1	-1	274.16
1	1	-1	-1	1.66
-1	-1	-1	1	0.05
-1	1	-1	-1	0.04
1	-1	1	1	343.94

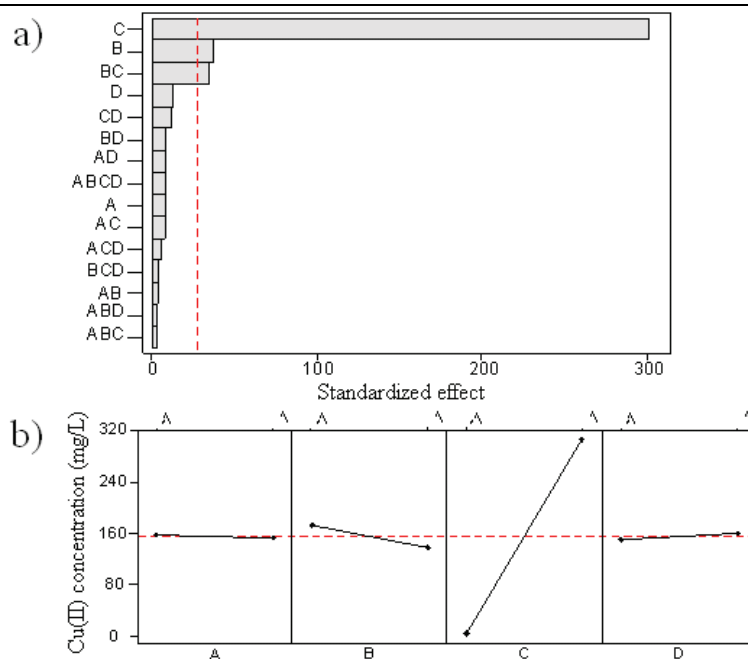


Figure1. a) Pareto chart and b) Main effect plot for residual Cu(II) concentrations

Conclusion

The influence of process variables (initial solution pH, initial metal concentration, sorbent mass and particle size) on Cu(II) removal from aqueous solutions by clinoptilolite was investigated using full factorial design. The effect of initial metal concentration was the most pronounced, followed by the effect of sorbent mass and interaction effect between sorbent mass and sorbate concentration. The empirical equation practical for process description was derived.

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