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WASTEWATER TREATMENT FOR ZINC (II) IONS REMOVAL WITH APPLICATION OF A MODIFIED VOLCANIC TUFF-BASED SORBENT

Sosedko Anastasiia, Gennadii Kochetov, Dmytro Samchenko

Kyiv National University of Construction and Architecture, Povitrianykh Syl Ave, 31, Kyiv, 03037, gkochetov@gmail.com, Ukraine

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Introduction

Contemporary industrial development is accompanied by a large scale increase of toxic wastewater discharges, exceeding the natural neutralization capacity of ecosystems. Toxic heavy metals compounds are extremely hazardous pollutants of wastewater flows from electroplating industries. The share of zinc compounds exceeds 70% of the total heavy metals content in industrial wastewater flows. Analysis of the existing methods for treatment of such wastewater flows suggest that the sorption methods are promising ones, but most of them are not cost efficient and do not provide an adequate degree of heavy metals removal. The well-known mineral sorbents based on natural clays have a low sorption capacity. Thus, development of environmentally sound and cost-efficient sorption technologies for treatment of electroplating wastewater with removal of heavy metal ions (in particular zinc) is a fairly relevant objective in the sphere of water resources use.

In this research study, a sorbent based on volcanic tuff was used to remove zinc ions from rinsing wastewater. The sorbent was modified with chemically stable iron-containing solid-phase compounds obtained in the course of treatment of exhausted etching solutions by the ferritization method.

Materials and methods

The sorbent was obtained by ferritization processing of etching solutions with addition of a volcanic tuff hydrosuspension. Volcanic tuff from quarries of the Rivne region of Ukraine was added to the reaction mixture for treatment of etching solutions. The tuff was pre-impregnated by etching solutions and treated with constant stirring at a temperature of 70°C and continuous air aeration for 30 minutes. The ratio of tuff to the resulting ferritization disperse particles was 4:1. This ratio is based on previous sorption studies of modified bentonite clay. As a result, the tuff was modified mainly by finely dispersed particles of magnetite as well as by other iron oxides and oxohydroxides. After separation of the solid phase, a sorbent with ferromagnetic properties was obtained. The concentration of zinc ions in the solution was measured on a Hach-DR 3900 spectrophotometer, the phase composition of the sorbent was determined on an Ultima IV X-ray diffractometer, and sizes of iron-containing particles were determined on a Cilas 990 laser analyzer.

Results and conclusions

The results of experimental research studies of sorption-based treatment of a rinsing wastewater of the zinc electroplating production line are presented in Table 1. Sorption of zinc ions was carried out at pH value of 6.1, temperature 20 °C, the mass ratio of sorbent to Zn^{2+} ions 10 g/100 mg, time of sorption process 30 min.

Table 1. Results of wastewater treatment for removal of zinc ions with application of modified sorbent.

Experiment #	The sorbent base material	Tuff pre-impregnation time by etching solution, hours	Concentration of Zn^{2+} ions		Removal degree, %
			Before treatment, mg/l	After treatment, mg/l	
1	Tuff	-	100	0.43	99.57
2	Tuff	12	100	0.27	99.73
3	Bentonite clay	12	100	0.41	99.59
4	Tuff	16	100	0.32	99.68
5	Tuff	24	100	0.18	99.82
6	Tuff	48	100	1.24	98.76

The structural studies of the sorbent samples indicate that iron-containing ferromagnetic particles (size of about 1 - 30 μm) are evenly distributed in the surface layer of natural materials. Identification of phases in the obtained particles of precipitates suggested the presence of such stable solid phases as δ-FeOOH, Fe_3O_4, and γ-Fe_2O_3.

As a result of the research studies conducted, it can be concluded that in the case of application of mineral sorbents based on volcanic tuff, a high degree of removal of zinc ions from wastewater (up to 99.8%) is achieved, that is higher comparatively to use of a sorbent based on bentonite clay.

The results of the study showed that the ferritization treatment of exhausted etching solutions is a promising method for obtaining a modified natural sorbent, including the use of volcanic tuff. The resulting sorbent is easily separated from the liquid phase on magnetic filters. The developed method could be used for introduction of rinsing wastewater treatment technologies in facility level water treatment systems with organization of circulating water supply at industrial facilities that operate electroplating production lines.