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ScienceDirect
Desalination 206 (2007) 154–162
DESALINATION
www.elsevier.com/locate/desal

Chemical interaction between industrial acid effluents and the hydrous medium

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Received 2 February 2006; accepted 27 March 2006

Abstract

Several industrial effluents are acid and contain numerous chemical ions like fluorides and some heavy metals (Cd, Pb, etc.). These solutions are harmful to the receiving medium according to the Tunisian norm N.T.106 002. In this work, we examined the interaction between an industrial effluent and a hydrous medium. This interaction is predominantly an acid–base reaction type; this is due to the acid character of the industrial effluent and the slightly basic character of the natural solution (groundwater and seawater). We have, in particular, studied the concentration evolution of two elements (Cd^{2+} and F^-) according to the pH in the range of 2.5–6. Especially, we highlight the formation of a solid precipitate during this interaction. The chemical analysis followed by the X-ray diffraction showed that the precipitated solid phase was CaF_2. Two advantages of the formed precipitate are to be mentioned, firstly it contributes to the decrease of F^- rate and secondly to the retention of part of Cd^{2+} initially existing in the industrial effluent. The optimal experimental conditions of decreasing these two ions have been determined for each of the studied waters. We established in particular that the formed solid phase may constitute a barrier against the diffusion of Cd^{2+} in the hydrous medium.

Keywords: Industrial effluents; Groundwater; Seawater; Cadmium; Fluoride

1. Introduction

The industrial liquid wastes are solutions of complex chemical compositions and particularly harmful to the natural environment. This study is related to a real case of a strongly acid solution containing many chemical substances as fluorides and different heavy metals such as cadmium. This type of solution is harmful in the receiving medium according to Tunisian standard NT106.002.

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Presented at EuroMed 2006 conference on Desalination Strategies in South Mediterranean Countries: Cooperation between Mediterranean Countries of Europe and the Southern Rim of the Mediterranean. Sponsored by the European Desalination Society and the University of Montpellier II, Montpellier, France, 21–25 May 2006.

0011-9164/07/$– See front matter
doi:10.1016/j.desal.2006.03.565

The purpose of this work is to study the interactions of an industrial effluent with ground- and seawater. They are acid–basic reactions, taking into account the acid character of the industrial effluent and the slightly basic character of the examined natural solutions.

The evolution of three parameters, pH and F^- and that in Cd^{2+} concentrations, is studied. This option is dictated by the particular harmfulness of these three factors to the natural environment. As a result, the formation of a solid precipitate following the reaction between the industrial effluent and the studied waters was highlighted. The formation of this precipitate is double-advantageous — it contributes to the F^- decrease and to the partial retention of the Cd^{2+} ion.

Finally we deduced that this interaction might be favourable for the environment considering that the formed solid phase would constitute a barrier against the diffusion of Cd^{2+} in the natural environment.

2. Experimental

2.1. Methodology

Taking into account the marked acidity of the industrial effluent and the diversity of ions which it contains (Table 1), we decided to study its neutralization, firstly using soda (0.5 N) and thereafter the retained natural solutions: the groundwater (pH = 7.981) and seawater (pH = 8.078).

The tests carried out allowed the following actions:

- to follow the pH evolution of the medium according to the added reagent quantity,
- to carry out a conductimetric follow-up of the mixture during neutralization,
- to study the distribution of cadmium and fluoride between the liquid and solid phases,
- to carry out matter balances,
- to characterize the solid phase which precipitates.

2.2. Physico-chemical methods of characterization

The sulfate ions were determined by the gravimetric method. Calcium and magnesium were determined by complexometry with EDTA. The potentiometric method was used to determine chlorides; the used potentiometer was TITRINO DMS 716 of Metrohm. The ionometry was used to determine the fluoride ions; the ionometer used

Table 1
Chemical composition of reagents in gL^{-1}

Element	Industrial effluent	Groundwater	Seawaters
pH	2.640	7.981	8.078
Conductivity, ms	15.170	10.300	56.500
Density	1.018	1.006	1.026
Residues dry	19.981	6.260	41.805
Cl^-	0.834	2.115	20.960
F^-	1.840	0.004	0.002
SO_4^{2-}	3.723	3.066	2.822
PO_4^{3-}	3.310	0.148	0.037
K^+	0.147	0.108	0.472
Na^+	3.033	2.530	—
Ca^{2+}	1.643	0.685	0.601
Cd^{2+}, mg L^{-1}*	0.67	0.210	0.270
Mg^{2+}	0.511	0.382	1.398

*direct analysis without standard addition method