Geochemical study of stream waters affected by mining activities in the SE Spain

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Water pollution by dissolved metals in mining areas has mainly been associated with the oxidation of sulphide-bearing minerals exposed to weathering conditions, resulting in low quality effluents of acidic pH and containing a high level of dissolved metals.

According to transport process, three types of pollution could be established: a) Primary contamination, formed by residues placed close to the contamination sources; b) Secondary contamination, produced as a result of transport out of its production areas; c) Tertiary contamination.

The aim of this work was to study trace element in water samples affected by mining activities and to apply the MINTEQ model for calculating aqueous geochemical equilibria.

The studied area constituted an important mining centre for more than 2500 years, ceasing activity in 1991. The ore deposits of this zone have iron, lead and zinc as the main metal components. As a result, a lot of contaminations sources, formed by mining steriles, waste piles and foundry residues are present. For this study, 36 surficial water samples were collected after a rain episode in 4 different areas.

In these samples, the trace element content was determined by by flame atomic absorption spectrometry (Fe and Zn), electrothermal atomization atomic absorption spectrometry (Pb and Cd), atomic fluorescence spectrometry (As) and ICP-MS for Al.

MINTEQA2 is a geochemical equilibrium speciation model capable of computing equilibria among the dissolved, adsorbed, solid, and gas phases in an environmental setting and was applied to collected waters.

Zone A: A5 is strongly influenced by tailing dumps and showed high trace element content. In addition, is influenced by the sea water and then showed high bromide, chloride, sodium and magnesium content, together with a basic pH. The MINTEQ model application suggested that Zn and Cd could precipitate as carbonate (hidrocincite, smithsonite and otavite). A9 also showed acid pH and high trace element content; is influenced by tailing dumps and also by waters from gully watercourses, transporting materials from Sierra Minera. The MINTEQ simulation showed that Pb and Ca could precipitate as sulphates (anglesite and gypsum).

Waters affected by secondary contamination have been mixed with carbonate materials, present in the zone increasing the pH. Some elements have precipitated, such as Cu and Pb, while Cd, Zn and As are soluble. The MINTEQ model results showed that in A10 and A14, Al could precipitate as diaspore but also carbonates could be formed, particularly dolomite. These model in A12 sample showed that soluble Zn could precipitate as carbonate and Al as oxyhydroxide, similarly than in A13.

A2 and A6 waters are affected by tertiary contamination and showed basic pH, soluble carbonates and lower trace element content. Only Zn, Cd and Al are present. The speciation model showed that in A2, Cd and Zn could precipitate as carbonates while Al as oxihydroxide. In A6, the model suggested that soluble Pb could precipitate as carbonate (hidrocerusite and cerusite) or as hydroxide; Al as diaspore, Ca as calcite and Fe as hematite.

Zone B: All waters are strongly affected by mining activities and showed acid pH, high trace element content and high content of soluble sulphates. The MINTEQ results showed that in B8, Fe could precipitate as hydroxychloride and in B12 could form alunite. In B9, B10, B13 y B14, the model estimates the precipitation of anglesite, gypsum and Fe hydroxichloride (B9 and B10), diaspore in B13 and B14, and gypsum and Fe hydroxychloride in B13.

All the sampling points collected in Zone C are affected by primary contamination, because there are a lot of tailing dumps. C1 showed high trace element content because is a reception point of a lot of tailing dumps. Water samples from C3 to C8 also had acid pH and high trace element content, particularly As, Zn and Cd. In addition, they showed high soluble sulphates. C2 water showed neutral pH, soluble carbonate and low trace element content because is influenced by a stabilised tailing dump. In all samples, except C2, the MINTEQ model showed that a lot of efflorescences could be formed, mainly sulphates.

Zone D: All waters collected in this zone showed acid pH and high trace element content, mainly Zn, Cd and As.

MINTEQ model results showed that elements could precipitate as jarosite but also anglesite in D8 and gypsum in D9, D11 and D12. D1 is affected by secondary contamination, which showed higher pH (still acid) and lower content in soluble salts and trace elements. The MINTEQ model suggested that Al could precipitate as diaspore, gibbsite and alunite.

The applied model is an appropriate tool for the analysis of waters affected by mining activities. The obtained simulations confirm natural attenuation processes.