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EVALUATION OF DILUTION PROCESSES IN STREAMS AFFECTED BY ACID MINE DRAINAGE IN THE IBERIAN PYRITE BELT

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1. Purpose

The Iberian Pyrite Belt (IPB) is one of the most exploited regions in the world since ancient times as a result of the interest produced by its massive sulfide deposits. This intense mining activity throughout the metallogenic province has originated almost a hundred mines scattered through the region, and has resulted in the pollution of the fluvial network by acid mine drainage (AMD). Nowadays, there are a multitude of mining structures that constitute sources of aquatic pollution, mobilizing large amounts of acidity, sulfates and metals into the watercourses. In this large context, the hydrochemical characterization of the mining leachates and respective receiving streams was performed. The cause-effect relationships between processes (namely the significance of the waste dumps as AMD-generating sources) and consequences (contamination degree of the water system as indicated by pH, sulfates and metal load are defined at watershed level).

2. Methodology

The hydrochemical characterization of AMD-generating sources has been carried out to each mining group (80), where waste dumps are the main source of contamination. Thus, a sampling campaign was performed in the rainy season. This was a critical condition for the production of leachate in all mining areas, including small dumps where leaching occurs only briefly after rain. Samples were also collected downstream, in the main watercourse, which represents the global temporary receiving system. Therefore, sampling has been performed in nine sub-watersheds that were defined under the scope of this work for the Spanish sector of the IPB: Trimpancho, Malagón, Cobica, Meca, Oraque, Olivargas, Odiel, Tinto, and Guadamar.

The pH, temperature, electrical conductivity and total dissolved solids were measured *in situ* using a multiparametric portable device (CrisonMM40). To determine the concentration of sulphates, a photometer manufactured by Macherey-Nagel's (Photometer FP-11) was used. Metal and arsenic concentrations in the water were determined using an AAS Perkin-Elmer Atomic Absorption Spectrophotometer (AAnalyst model 800) equipped with a flame spray of air-acetylene, and with a graphite furnace. Later, the hydrochemistry of the two key points (AMD-source and receptor watercourse) was graphically represented in order to express the variations in the water properties promoted by dilution processes.

3. Results

In most of the mining leachates, the values of physical-chemical parameters indicate the presence of AMD processes.



Downstream, in the main watercourses, there were higher pH values and lower concentrations for metals, arsenic and sulfate than registered for most mining leachates. As an example, Figure 1 presents the analysed parameters in the Tinto River watershed. This case was selected to be exposed in the present study because of the paradigmatic nature of the Tinto River, mainly due to its high contamination levels. In the Tinto watershed, Riotinto mine shows highest values for sulfates (3150 mg/L), conductivity (8140 $\mu\text{S}/\text{cm}$), Total dissolved solids (11320 mg/L), Fe (75,1 mg/L), Zn (75,0 mg/L), Mn (25,0 mg/L), Co (12,9 mg/L), Ni (1,4 mg/L) and Al (1,1 mg/L). Follows the concentrations corresponding to Peña del Hierro, La Chaparrita or La Ratera mines. For the other mines, most of the parameters have higher concentrations in the river than in the discharged leachates. In the Tinto river there were also the highest concentration of Mg and Ca. On the other hand, the pH of the river is slightly higher than the minimum found in this watershed (2,13), which corresponds to the Riotinto mine, also below the values measured in most of the remaining mining leachates.

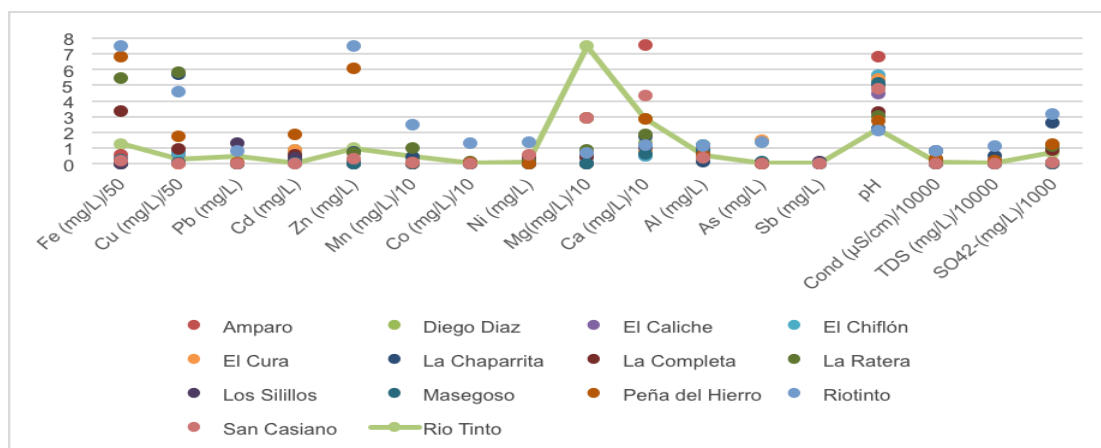


Figure 1 – Concentration of metals, arsenic and physical-chemical parameters in the Tinto watershed.

4. Conclusions

The reduction of metal concentrations, arsenic and sulfates and increasing pH, from AMD-sources to river channels denotes a decrease in water pollution as it moves away from the discharging points due to dilution by mixing uncontaminated water. In addition, precipitation of Fe oxyhydroxides and oxyhydroxysulfates in the affected channels contributes to such a decrease. Coprecipitation and/or adsorption processes on these solid phases also play a role in the attenuation of mining contamination, particularly affecting elements such as arsenic and lead.

The Riotinto mining complex, which occupies the largest area in the watershed, has the greatest impact in the hydrochemistry of the river. It should be noted that the duration of the leachate discharges depends on the size of the waste dumps. The small ones remain dry most of the year, and leaching occurs only briefly after rain. Thus, despite the highly polluting nature of some of them, their contributions may be irrelevant in the overall annual contribution. By contrast, the large dumps produce leachate discharges over several weeks and some maintain a drainage flow the whole year.