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E2KW 2014

Proceedings of the
Energy and Environment Knowledge Week 2014
Toledo, Spain
30th-31st – October

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SPATIAL BEHAVIOR OF ACID MINE DRAINAGE IN A PECULIAR STREAM: PHYSICAL-CHEMICAL EVOLUTION FROM THE SOURCE UNTIL THE TEMPORARLLY RECEPTOR IN THE IBERIAN PYRITE BELT

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1. Purpose

The Iberian Pyrite Belt is a vast concentration of massive sulphide, located in the SW of the Iberian Peninsula. Historically, this area has undergone an intense mining activity, which has left a huge amount of mining facilities and unrestored waste dumps. Mineral-water interaction in the waste dumps is responsible for the generation of acid mine drainage (AMD), causing a strong impact in the water systems. The AMD occurs when the sulfide minerals are in the presence of atmospheric oxygen and humidity, suffering oxidation reactions. As a consequence, metals and acidity are mobilized into the receiving watercourses. Such conditions have created a unique scenario in the world by the extreme degradation that characterizes the network of channels and streams in the IPB.

In this context, widely described in the scientific literature, the present study aims to monitoring a singular channel affected by AMD (Campanario stream), from its origin (in the waste dump) to its confluence with an unpolluted stream. Such monitoring procedure will allow characterizing the physicochemical evolution and the mineral-water processes that regulate it.

2. Methodology.

Sampling took place in early March 2014, in 18 sampling sites established along the Campanario stream. Sampling sites were distributed so that the first nine points are located near the AMD focus (in the base of the waste dump), 3 m apart from each other. The remaining sites were located downstream, obeying to a 20 m distance between each other. pH, electric conductivity and redox potential (EH) were measured *in situ* using a multiparameter equipment (Crison MM40). Water samples were collected according to the usual protocol for AMD affected systems. In the pre-filtered water samples sulfates were determined by photometry and metals by mass spectrometry with inductively coupled plasma (ICP-MS) and optical emission spectrometry (ICP-OES). The obtained data were subjected to a graphical- statistical treatment using the statistical package STATGRAPHICS Centurión XVI.I.

3. Results and discussion.

In the first place, a statistical summary was obtained for each parameter, which shows that the average pH value is 3.00. This variable ranges between a minimum of 2.52 measured downstream, near the confluence with the unpolluted river, and a maximum of 3.29 upstream, at the beginning of the channel. The average value for the electrical conductivity is 3.564 mS/cm and for the EH registered an average value of 395 mV. Sulfates vary in the interval 702.0-3438.0 mg/L, with an average of 1850.9 mg/L. The range values obtained for metals and arsenic is presented in table 1.

Table 1 – Range of variation for metals and arsenic in the Campanario stream

	Ca	Co	Cu	Cd	Fe	Zn	Ni	Pb	As
	mg/L								
Average	207.3	0.380	0.801	0.046	553.8	45.74	0.281	0.024	1.501
Minimum	77.1	0.086	0.226	0.009	49.04	10.15	0.076	0.005	0.004
Maximum	254.5	10.79	1.094	0.057	812.3	53.98	0.329	0.031	5.184

The obtained data was then subjected to a graphic treatment, in which the spatial evolution of each parameter along the channel is represented. Results put in evidence the effect of the hydrolysis process suffered by Fe. This is denoted by a continuous decreased in pH and increase in the concentration of all metals, except Fe. In accordance, this process is marked by the clearly upward trend of EH, which is explained because the channel is exposed to atmospheric oxygen, continuously increasing the water's oxidant capacity as distance increases relatively to the AMD source or focus. The trend is controlled by a mixture of oxidation processes, precipitation, coprecipitation, adsorption, and dilution causing pH changes along the entire channel. The oxidation of sulfides leads to a decrease in pH due to the oxidation of Fe(II) to Fe(III) and subsequent precipitation, which explains the downward trend of the concentration of this metal. These phenomena are clearer at a midpoint of the Campanario stream, where a cascade increases oxygenation. This appears reflected in the spatial graphic pattern of all metals. In all cases, when the Campanario stream reached the unpolluted stream a sharp concentration decrease was detected due to precipitation of metals as consequence of the increasing pH.

The dendogram of cluster analysis shows two groups of sampling points: one includes the two most distant locations, which correspond to the confluence with the uncontaminated river, while the other group contains the rest of the sites. The latter, in turn, is divided into two sub-groups. One from the top of the channel (at the base of the waste dump), where leaching is occurring, till the cascade; and a second sub-group from here until the confluence with the clean river.

4. Conclusions

A mining stream whose waters come from a single waste dump, without any contributions until to the final of the channel was used as key site to evaluate the main control factor of AMD process. The results put in evidence the effects of oxidation, precipitation, sorption and dilution that typically develop under AMD conditions. So, a decrease in pH and Fe is accompanied by rising redox conditions and higher metals concentrations as it will increase the distance to the focus producer AMD.