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PROPOSAL OF A MODEL OF THE HORIZONTAL MOVING OF POLLUTANTS IN A WATER RESERVOIR RECEIVING ACID MINE DRAINAGE IN THE IBERIAN PYRITE BELT (SW SPAIN)

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1. Purpose

In the Iberian Pyrite Belt (SW, Spain) there are numerous water reservoirs that receive input waters from streams affected by Acid Mine Drainage (AMD). These input waters are typically responsible for degradation of water quality due to its low pH values and high concentrations of trace elements and sulphates. When arriving to the reservoirs, the AMD suffers a strong increase in pH. Such an increase promotes the chemical precipitation of most of the metallic load transported by the mining affected-channels, leading to accumulation processes in the bottom of the reservoir.

Among the water dams constructed in the IPB for public supply there is the Sancho reservoir, which is the study object in the present work. The Sancho Dam was built in 1962 and is fed by the Meca River, which in turn, receives water from subsidiary tributaries affected by AMD, mostly generated by the abandoned Tharsis mining complex. The stored water is used for industrial purposes, supplying a pulp mill located 15 km downstream, in San Juan del Puerto (SW-Spain).

This study focuses on the hydrochemical relations observed between the entrance of the water in the reservoir and a point located further away, specifically at the dam. The main goal is to analyze the water parameters in both monitored points, in order to evaluate possible attenuation processes and to propose a spatial evolution model of the pollutants load.

2. Methodology

A weekly sampling campaign was carried out during the hydrological year 2012-2013, yielding a total of 32 days of sampling. The water samples were collected at a point where the river waters enter in the reservoir and at the dam. At each point two water samples were taken for the determination of sulphate and trace elements.

Sulfate was analyzed by photometry, using a photometer of Macherey-Nagel (photometer PF-11) commercial house, while metals and arsenic were determined by Atomic Absorption Spectrophotometer Perkin-Elmer AAS (AAnalyst model 800), equipped with a graphite furnace and air-acetylene flame.

The analytical data were submitted to statistical treatment using STATGRAPHICS Centurión XVI.I, including a statistical summary and cross-correlation functions in order to establish possible correlations between parameters at both sampling points (spatial analysis) and at a same site in different sampling moments (time evolution analysis; one week delay).

3. Results

The statistical summary shows that all parameters have higher average concentration in the entrance of the reservoir, with following order of abundance: Mg> Ca> Zn> Fe> Cu> Al> Pb> Ni> Cd> As> Sb. On the other hand, maximum and minimum values at each point depend on the observed parameter. The maximum values obtained at the entrance are always higher than the ones at the dam, except for Ca (61.77 at the entrance and 63.93 at the dam). Standard deviation, as well as the range, and the variation coefficient are always higher at the entrance.

The cross-correlation function indicates that the majority of parameters are closely related in both points, reaching in some cases correlations of 1, such as for Pb and As. Cd reaches a correlation of 0.9 between the two points, while Mg and Zn achieve values 0.7. The other parameters present correlation coefficients around 0.6, wherein Fe shows the worse correlation with a value of 0.2. The correlation peak occurs at a time $t = 0$ (less than one week) in most cases (Pb, As, Sb, Cd, Mg, Al, As), i.e. increased or decreased concentrations of these elements at a point relative to the other, is reflected in increases or decreases in less than a week time. There are elements, such as Cu or Ni reaching this maximum a week later, while Fe and Ca do it for $t=2$ and sulfate reaches maximum for $t = 3$.

4. Conclusions

The concentrations of trace elements and sulfate in the Sancho reservoir bring out their affection for AMD, with higher pollutant load in the entrance of the reservoir. Results indicate an attenuation of the contamination in the course between the two sampled points. This attenuation can be justified by the raising pH and consequent precipitation of AMD-phases, including iron oxyhydroxisulfates and low crystalline or amorphous materials. These materials have the ability to incorporate sulphate and metals in their structure, but also to retain trace elements by participating in surface reactions, such as adsorption and coprecipitation. The higher values obtained for standard deviation, range, and variation coefficient at the entrance are due to the strongest chemical inertia addressed to the point located at the dam. Here there is a considerable large volume of water and therefore, this point is considerable less sensitive to variation induced by external stimulus.

The cross-correlation function appears as an effective tool for establishing temporal cause-effect relationships between hydrochemical parameters before and after its incorporation into the reservoir. Also, this approach behaves well to determine the response time to the stimulus-induced by meteorological conditions, such as rainy episodes. Thus, these approaches can be useful for application to other regions with water dams suffering from similar problems.