DISTRIBUTION AND ROLE OF BENTHIC DIATOMS AS INDICATORS OF ACID MINE DRAINAGE IN AFFECTED WATER DAMS

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1. Purpose

In mining regions the presence of water reservoirs affected by acid mine drainage (AMD) is a common problem. It is known from scientific literature that AMD produces structurally simple ecosystems dominated by acidophilic and acid-tolerant organisms, either prokaryotes or eukaryotes. From a monitoring perspective, the algae communities, namely the diatoms, are among the most effective ecological indicators of AMD conditions.

This work presents a combination of geochemical, mineralogical and ecological data obtained in water reservoirs located in one of the most paradigmatic mining regions, suffering from AMD problems: the Iberian Pyrite Belt (IPB).

Four water reservoirs located in the same territory – the Spanish sector of the IBP, but storing water for different purposes, were selected to achieve an environmental classification based on the effects by AMD: two mining dams (Gossan and Águas Ácidas), a reservoir for industrial use (Sancho), and one with water used for human supply (Andévalo). The main goal was to characterize the distribution of benthic diatoms, namely in relation with hydrochemistry and sediment properties, and to understand the role of these algae as indicators of severity of AMD contamination.

2. Methodology

Sampling took place at the point where the water enters in each of the reservoirs (Fig. 1). Overall hydrochemical characterization was based on mensal campaigns carried out between October 2011 and May 2012. Algae and sediments were collected in summer 2012. pH, electric conductivity (EC) and total dissolved solids (TDS) were measured in the field. Sulphate was measured by photometry. Metals concentrations in the water were determined by atomic absorption spectrometry.

Mineralogical analyses of the sediments were performed by X-ray diffraction (XRD) on a Philips X'pert Pro-MPD diffractometer, using Cu-Kα radiation. The XRD diffractograms were obtained from powders (fraction <2 mm; fraction < 2 μm fraction) and from oriented aggregates (<2 μm fraction) in the interval 3 to 65º2θ and 3 to 35º2θ respectively. The finest fraction was obtained by the sedimentation method and the particle-size separation based on theoretical Stockes' Law. The clay mineralogy was determined using the oriented preparations, which were submitted to the following treatments: air-dried, ethylene glycol (EG)-solvated, and heated (490ºC). Chemical analysis for metals and metalloids was performed in both grain size fractions by inductively coupled plasma/mass spectrometry (ICP/MS).

Diatoms were sampled from sediments. Identification and quantification were performed in slides mounted with Naphrax®.

3. Results and Discussion

Hydrochemistry

Table 1 presents the average chemical composition of the water. With the exception of Andévalo, the studied dams show typical evidences of AMD affection (low pH and high sulphate and metals contents). The higher concentrations of metals, arsenic and sulphate occur in the mining dams: Águas Ácidas and Gossan.

Table 1 – Physical-chemical properties of the water

Water Dam		µS/cm	mg/L								
	pH	EC	TDS	SO4	Fe	Cu	Zn	Mn	Ni	As	Pb
ÁGUAS ÁCIDAS	3,05	7520	4820	3808	420	7,90	35,24	58,86	2,04	0,01	0,14
ANDÉVALO	6,15	364	231	130	0,67	0,22	0,06	0,32	-	0,01	-
SANCHO	3,41	505	324	196	0,86	0,24	2,91	1,69	-	0,01	0,33
GOSSAN	2,78	2720	1740	936	28,58	4,70	10,64	10,33	0,12	0,01	0,06

Sediments characterization

The most contaminated sediments appear in Aguas Acidas and Gossan. In general, results suggest that Pb, As, Zn and Cu accumulates in the clay size fraction (<2 µm), especially in these two dams (Table 2). Such an accumulation may be related with the mineralogy of this finest fraction. Jarosite and goethite, which compose the typical AMD-precipitates, may be the main responsible hosts for the accumulation of trace elements in Águas Ácidas and Gossan, respectively.

Table 2 – Chemical composition of the sediments in two grain size fractions

Element (mg/kg)	ÁGUAS ÁCIDAS		ANDÉVALO		SANCHO		GOSSAN	
	< 2mm	< 2 µm	< 2mm	< 2 µm	< 2mm	< 2 µm	< 2mm	< 2 µm
Fe	278 140	190 701	84 000	123 661	89 280	90 172	125 826	285 997
Cu	495	1636	124	212	727	321	2 099	1 501
Zn	279	315	127	190	473	332	340	395
As	571	1830	992	1 576	283	283	643	818
Pb	29 126	65 250	125	205	162	170	584	884
S	14 529	54 857	1 210	310	4 187	604	20 897	1 792

Diatom community

The study of the abundance and diversity of benthic diatoms showed that acidophilic diatoms (*Pinnularia acidophila* and *P. aljustrelica*) are dominant in the two mining dams (Águas Ácidas and Gossan), where data about hydrochemistry and sediment geochemistry put in evidence contamination by AMD. On the other hand, in Andévalo dam, dominates the specie *Eunotia exigua*, while acidophilic species, like *Pinnularia acidophila* and *P. aljustrelica* are rare or absent.

4. Conclusions

Hydrochemistry and geochemistry results indicate that the four dams are subject to the effect of metallic loads from polluted rivers, although with different levels: Águas Ácidas > Gossan > Sancho > Andévalo. In accordance, diatom communities have differences in composition and dominant diatom taxa. *Pinnularia acidophila* and *P. aljustrelica* were found dominant in the most acidic dams (Gossan and Águas Ácidas), *Pinnularia subcapitata* was dominant in Sancho and *Eunotia exigua* in Andévalo. Therefore, the obtained results suggest the ability of diatoms to indicate different degrees of AMD affection.