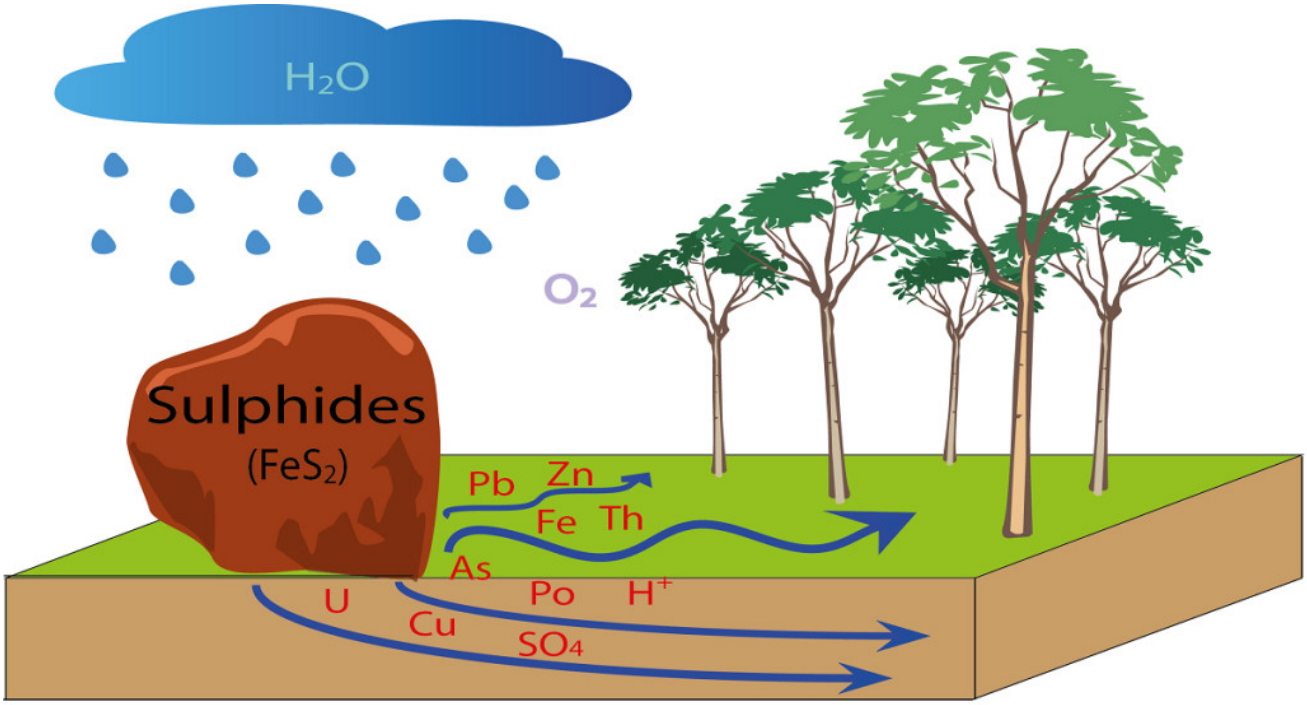
Is the behaviour of the isotope polonium-210 conditioned by the acidity of the waters?

The Acid Mine Drainage (AMD) is a phenomenon that takes place when sulphide minerals are exposed to atmospheric conditions. In the presence of oxygen and humidity, the sulphides are oxidised releasing the elements contained in the rocks to the waters and increasing their acidity (pH = 1.5-3.0; Fig. 1). The result is an important increase in the concentration of dissolved ions and the metal load in the waters, but also in radionuclides such as uranium, thorium or polonium. The AMD is a natural an inevitable process that occurs whenever the sulphide minerals are exposed to the surface conditions; however, the mining activities enhance it since they increase the volume and surface of exposed minerals.



$$FeS_2 + {}^{7}/_{2}\,O_2 + H_2O \longrightarrow Fe^{2+} + 2SO_4{}^{2+} + 2H^+$$

Fig. 1. Graphical scheme of how Acid Mine Drainage is generated. When the sulphides (containing pyrite, FeS_2) are exposed in the earth surface and in contact with water (H_2O) and oxygen (O_2) those are oxidized. The result, as shown in the equation, is that iron (Fe), sulphate (SO_4) and protons (H^+) are released into waters. The releasing of H^+ causes an increase of the acidity of waters. Eventually, the acid waters cause that other elements contained in the rocks, like metals (e. g.: lead, Pb; zinc, Zn; iron, copper, Cu), metalloids (e. g.: arsenic, As), and radionuclides (e. g.: uranium, U; thorium, Th; polonium, Po), are easily released.

One of the largest sulphide deposits in the world is located in the province of Huelva (SW Spain), known as the “Iberian Pyrite Belt”. There is an important number of abandoned mines and a vast amount of mining wastes due to the exploitation of the sulphide deposits, which makes it one of the most affected by AMD zones in the world (Fig 2).

The aim of this study has been to evaluate whether the behaviour of the isotope ^{210}Po is affected by the AMD or not. In order to do this, water samples from 22 reservoirs (affected by AMD in a different degree and with pH values ranging from 2.52 up to 9.18) in the Huelva province, were collected and analysed.

The ^{210}Po is a radioactive isotope which decays into ^{206}Pb in a natural way by emitting radioactivity. This activity is measured in bequerels (Bq) and one Bq is one decay per second. The ^{210}Po can be found either dissolved or associated to the particulate matter in natural waters. Therefore in order to have an idea of the amount of radioactivity which is contained in the water or in the particulate matter, the parameter used is the activity concentration which is the amount of decays per second in a litre (Bq/L) or in a kilogram (Bq/Kg). This is what has been measured for the ^{210}Po present in the dissolved and particulate components of the waters analysed.

Fig. 2. Photography of waters affected by Acid Mine Drainage in the Huelva area. The red and orange colours are due to the iron oxides and oxi-hydroxides.

The activity concentration of dissolved ^{210}Po in all the studied reservoirs does not differ from the normal values reported for natural freshwaters, which is lower than 3 mBq/L. In the same way, the activity concentration of ^{210}Po associated to the particulate matter is in general within the values found in other areas not affected by AMD (lower than 300 mBq/g). Moreover, no relation has been found between these parameters and the pH of the waters. These results indicate that the ^{210}Po concentration seems to be unaffected by the acidity of the waters.

The distribution coefficient (K_d), which is the ratio between the ^{210}Po activity concentration in the particulate and dissolved matter, has also been studied here taking into account that a high

K_d indicates that the isotope is mainly associated with the particulate matter. The results indicate that the K_d in these waters is also in the range of the natural freshwaters, between 10^3 and 10^6, however, the K_d is lower when the pH is lower, which indicates that the more acidic is the water the more tendency of the ^{210}Po to be dissolved.

To sum up, the activity concentration of ^{210}Po in dissolved and particulate matter is consistent with the normal values in natural systems. Therefore the main conclusion is that the AMD and the acidity of the waters have no influence on its behaviour. Nevertheless, a slight influence on the distribution of this radionuclide between the two phases has been identified in the way that under acid conditions it tends to be dissolved.

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