

Induced Mobilization of As Contained in Metallurgical Waste Using Electrokinetic Remediation Technology: Environmental Implications and Technical Limitations in soil Remediation of Orphan Mining Areas [†]

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Abstract: This work focuses on the analysis of the electrokinetic decontamination of soils with high contents in As. Based on the data obtained from the laboratory on different materials in previous works. It has been sought to combine these with current laboratory and field work to infer the environmental and technical implementation implications of the As mobility in sediments and soils.

Keywords: orphan mines; arsenic; metallurgical waste; pollution; sediments

1. Introduction

In Asturias, diverse geochemical anomalies of As of anthropic origin are located. Some of them are associated with Hg orphan mines. There are many studies that characterize these sites from an environmental point of view, analyzing in turn the risks associated with As and Hg contamination both in sediments and in soils and waters [1–3].

2. Objectives and Methodology

The study area is composed of three different sites with differentiated subsoil characteristics. Two mercury mines, Olicio and El Terronal, the third site is a fertilizer production plant (Nitrastur) by roasting pyrites.

The first laboratory test used Olicio soil; It used a cell of 230 × 250 × 200 mm (Figure 1), this cell has an anodic and cathodic camera, where carbon paste electrodes are housed. The soil to be treated is spill into the center of the cell and water is added until the surface of the soil is completely covered. The generation of current was carried out with a direct current generation system that allowed to select the voltage, in this case 12 V.

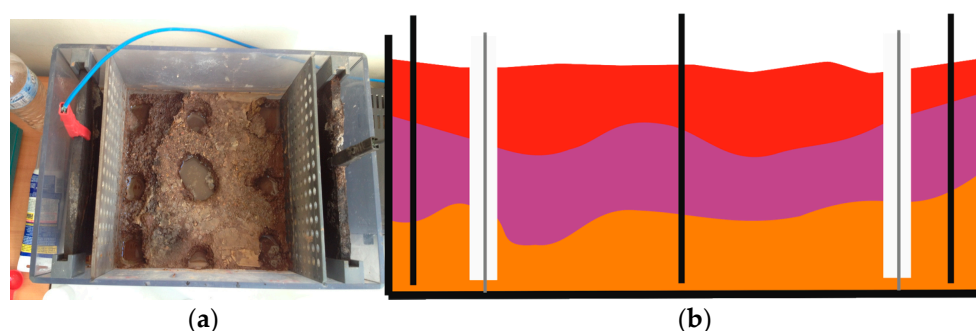


Figure 1. Details of electrokinetic cell with the position of (Olicio) soils samples (a) and Schematic cross section of Nitrastrur laboratory test cell (b).

For soils from Nitrastrur, a cell with dimensions $500 \times 250 \times 1000$ mm was used. The electrodes in this case were iron bars and to simulate the anodic and cathodic compartments they were placed inside a 30-mm diameter grooved tube to allow the passage of water. As in the previous case, the surface area of the cell was covered with water and the current generation was carried out with the same 12 V system.

The field test, an area (1×1 m) was selected for the location of the electrokinetic system in “El Terronal” (Figure 2), which was characterized as a soil constituted by a mixture of metallurgical residues. For the location of the electrodes, four small boreholes were drilled where a grooved 30 mm tube was inserted where the iron bar that constituted the electrode was placed. The power system was a solar panel that allowed the generation of 12 V.



Figure 2. View of selected area for electrokinetic remediation field study and scheme of electrode.

3. Results

The laboratory results showed different behaviors depending on the characteristics of the substrate under test. In the case of mining waste with important natural soil contents (Olicio), and therefore high contents of organic matter, the average content in As was initially 143 mg/kg and the results of the arsenic speciation showed that it was As (V). This barely had mobility, such and the final results obtained showed an average concentration in the cathodic zone of 125 mg/kg and 173 mg/kg in the anodic zone.

The results of the cell, which are shown in Figure 3 show that As (V) could not be mobilized, and while performing the analysis it was found that the carbonates present in the soil samples had been eliminated. These facts corroborate the hypothesis that with the voltages in DC with which it would work in the field would not be possible to mobilize the As (V), as was to be used a system of solar panels 12 V, which does not have the capacity to bring to As (V) sorption of seats occupied in the soils of the study area.

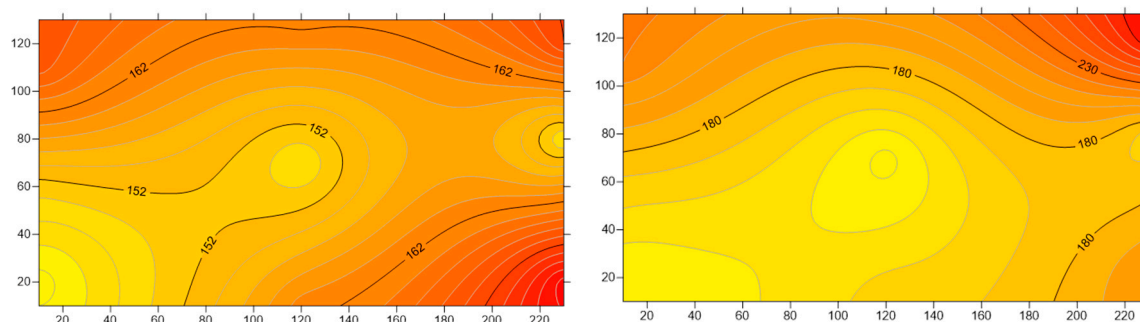


Figure 3. Initial As concentration in laboratory test (left) and Final As concentration in Lab test (right).

In the case of metallurgical waste with hardly any presence of organic matter (Nitrastur) the initial average concentration was 109 mg/kg. In this case, a greater mobility of the As is evident than in the previous case, given that the final results in the anodic zone were 160 mg/kg and in the cathodic zone 60 mg/kg.

Figure 4 (left) represents an initial spatial concentration of As in cell, and Figure 4 (right) a spatial representation of As concentrations at top off the test. Note that it presents a concave front in depletion As area, but in enrichment area there is an irregular front. This was caused by a scaling in one of electrodes that not work properly now.

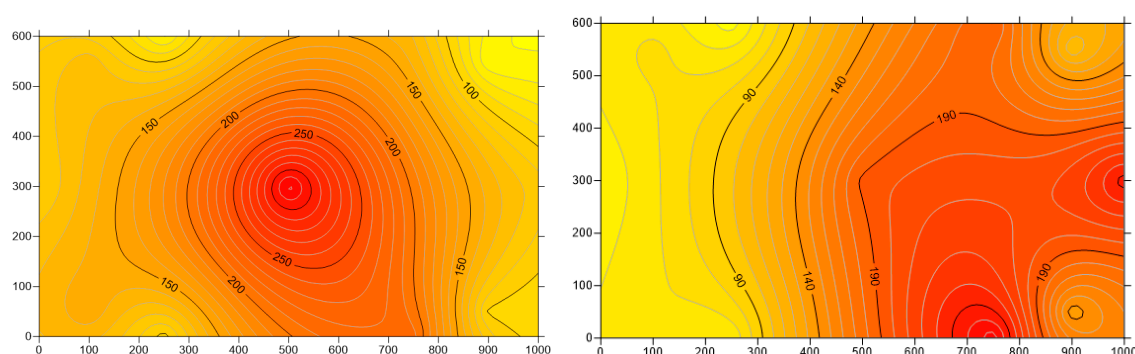


Figure 4. Initial As concentration in laboratory test (left) and Final As concentration in Lab test (right).

For the El Terronal pilot test, the initial mean concentration was 6962 mg/kg, and the results obtained at the end of the experiment showed final concentrations of 4820 mg/kg and 12,371 mg/kg, see Figure 5.

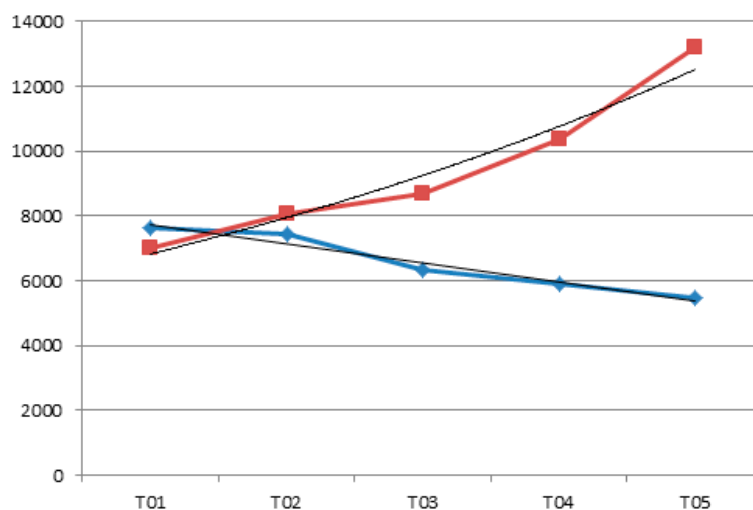


Figure 5. Evolution of arsenic during field work.

4. Conclusions

In the case of soils with a high content of organic matter, a competitive sorption is produced, the As (V) has a greater attraction for occupying the available positions on the surface of the organic matter and the clays present in the soil, making it more difficult to mobilize it through an electrokinetic soil remediation process, especially when the voltage used is 12V. This type of soil is present in many mines of these characteristics located in the Nalón Catchment, Maramuñiz or Brañalamosa (Lena) for example, where vegetation has colonized the tailings limiting erosion, on the one hand, and providing sorption posts for the potential harmful elements (PHE); This explains the low mobility of the As detected in the environment of both mines [1].

On the other hand, the results obtained from the Laboratory experiments with residues with little organic matter, and the pilot scale test carried out in El Terronal, show a greater mobility of the As present. This greater mobility is due to a lower presence of organic matter and clays.

References

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