Electrocoagulation as a method to treat high metal content in acid mine drainage

Stylianou Marinos[1,2*], Montel Etienne[2], Zissimos Andreas[3], Christoforou Irene[3], Dermentzis Konstantinos[4], Agapiou Agapios[1]

[1]Department of Chemistry, University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus
[2]Almyras Cultural and Environmental Workshop, Non-Governmental Organization, Agia Varvara, Nicosia, Cyprus
[3]The Geological Survey Department, Ministry of Agriculture, Natural Resources and Environment, Republic of Cyprus, 1 Lefkonos Street, 1415 Lefkosia, Cyprus
[4]Department of Chemistry, International Hellenic University, 65404 Agios Loucas, Kavala, Greece
Corresponding author: Tel: +357 22 895433; E-mail address: stylianou.a.marinos@ucy.ac.cy

Introduction:

- Cyprus has a long standing history of mineral exploitation, especially with copper, a metal derived from its rich sulfide deposits exploited for 4000 years now [1].
- The island was perhaps one of the earliest producers of copper derived by the smelting of sulfides [2].
- The Cyprus sulfide deposits were largely mined by open-pit methods; though there were also underground workings. Most of the open pits worked in past mining years have been abandoned and rain water has filled some of the craters.
- The environmental problem of Acid Mine Drainage (AMD) is created by the presence of pyrite ore which was brought to the surface by the mining activities [3].
- Water contaminated with heavy metals is a serious issue which has a toxic impact on the environment and on human health [4].
- The present research study investigated the efficiency of electrocoagulation (EC) process on the removal of heavy metals from AMD samples from an abandoned open-cast mine.

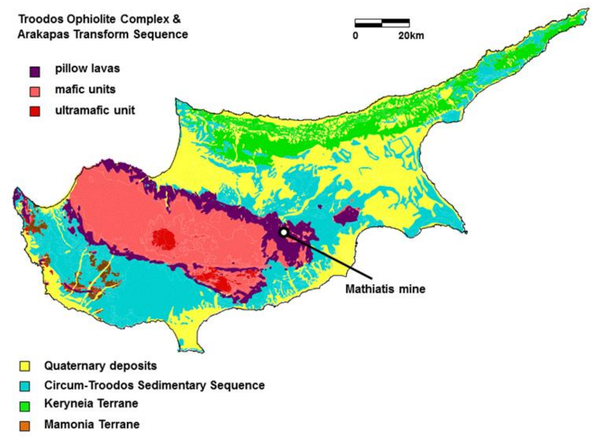

Figure 1. Simplified geological map of Cyprus showing the location of Mathiatis mine.

Materials and methods:

- AMD samples were collected from North Mathiatis mine, located between the villages of Agia Varvara and Mathiatis in Nicosia district, which is a typical example of an abandoned open-pit sulfide mine out of many in Cyprus. The samples were placed in closed containers and stored at 4 ^{o}C. The main physico-chemical characteristics of AMD samples before their treatment are presented in Table 1.

- The EC studies were performed in batch mode experiments using vertically positioned aluminum electrodes (anode and cathode) in a 0.5 L reactor connected to a single channel DC power supply (Programmable, 150W Tenma®) of 0-30 V and 0-5 A.
- Three commercially obtained aluminum plates of size 10 cm x 5 cm x 0.3 cm immersed in a 4 cm depth with an effective area of 20 cm^2 each were used as electrodes in the experiments.
- The inter-electrode distance was 0.5 cm.
- The reactor was agitated to avoid the mass transport over the EC reactor.
- After each treatment, samples were filtered (Whatman® Grade 2: 70mm ∅, 8μm) and analysed through ICP-MS for measuring the % removal of the respective pollutants.
- All experiments were conducted at ambient (~25^{o}C) temperature.

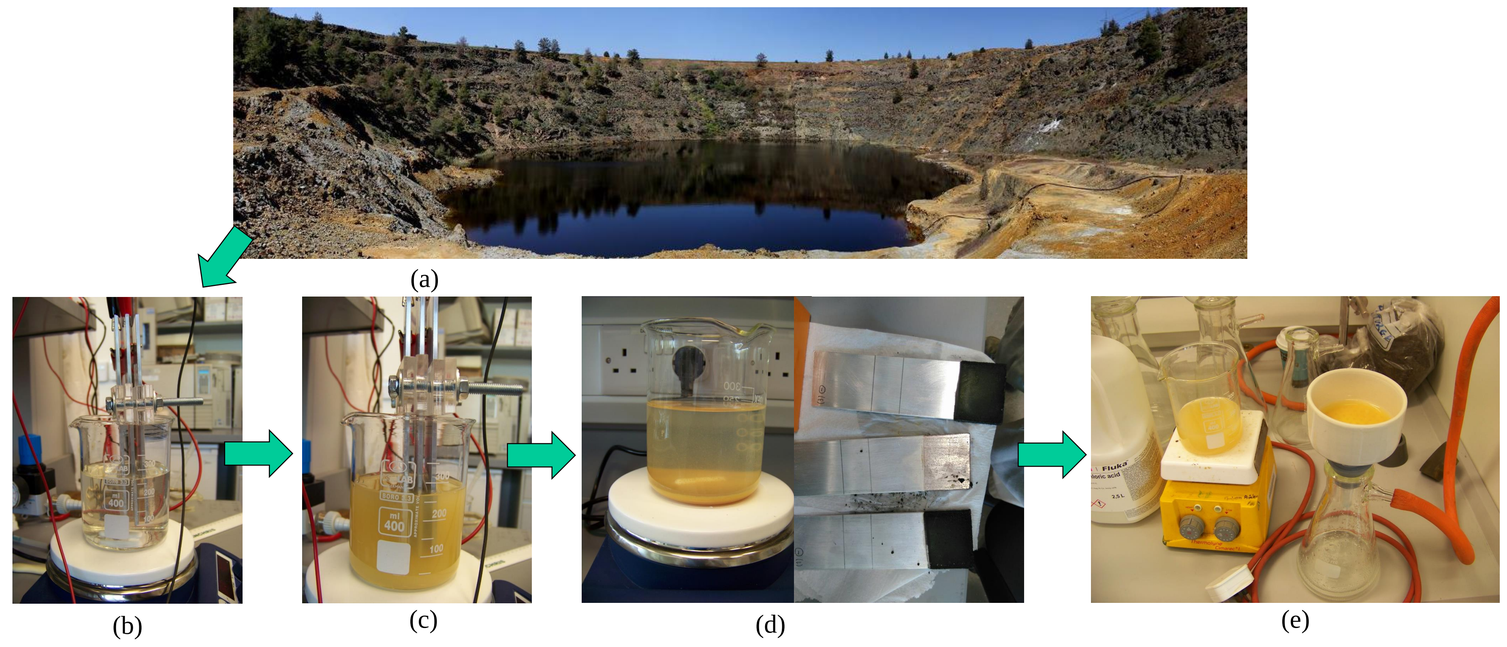

Figure 2. Experimental procedure of electrocoagulation process: (a) The abandoned open-pit at North Mathiatis mine, (b) AMD sampled from the mine, (c) The EC process, (d) Settling time and the electrodes after the EC, (e) Filtration of processed liquid and collection of settling material for further analysis.

Results:

Table 1. AMD samples characteristics.

No	Parameter	Unit	Initial concentration
1	Cd	mg/L	0.042
2	Cu	mg/L	3.93
3	Zn	mg/L	31.400
4	Mn	mg/L	19.780
5	Fe	mg/L	88.8
6	B	mg/L	5.43
7	S	mg/L	1398
8	SO_4^{-2}	mg/L	4373
9	pH	--	2.6
10	EC	mS/cm	9,15
11	TDS	g/L	5.66

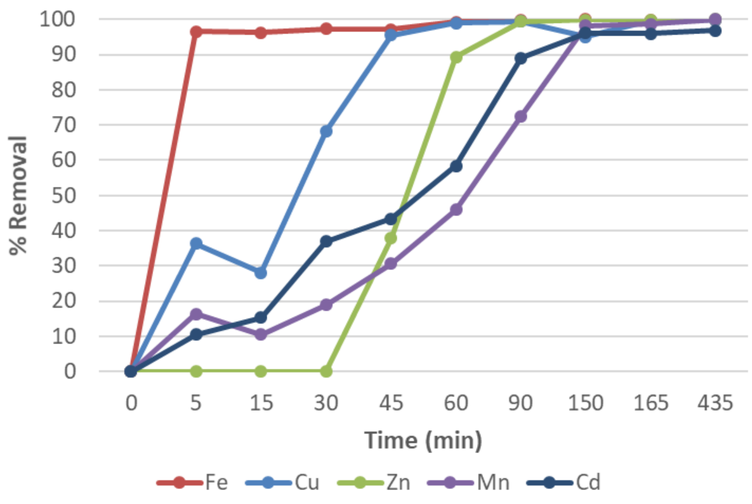

Figure 3. % removal of specific metals after the EC process through time.

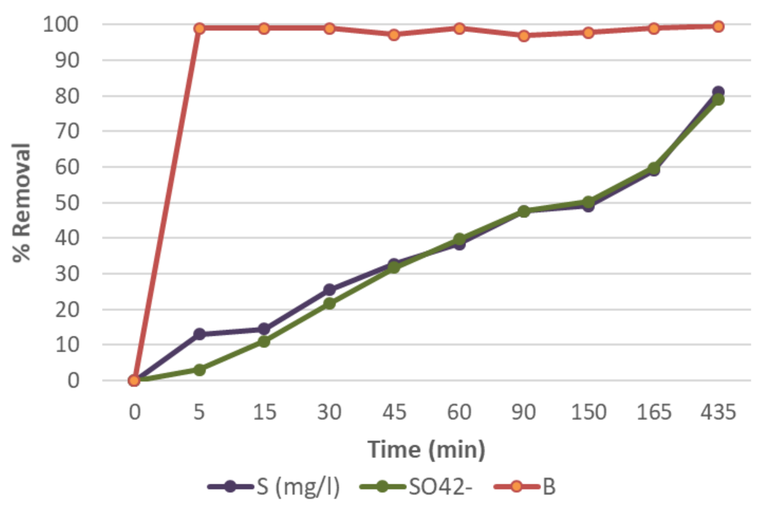

Figure 4. % removal of sulfur and boron after the EC process through time.

Conclusions:

- ~100% removal of specific metals was achieved: Fe (5 min) > Cu (45 min) > Zn (90 min) > Cd and Mn (150 min).
- The total S and SO_4^{2-} concentrations were decreased.
- EC process enabled the removal of Boron.
- Aluminium electrodes can be effectively used for the removal of metals via EC process.

References

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