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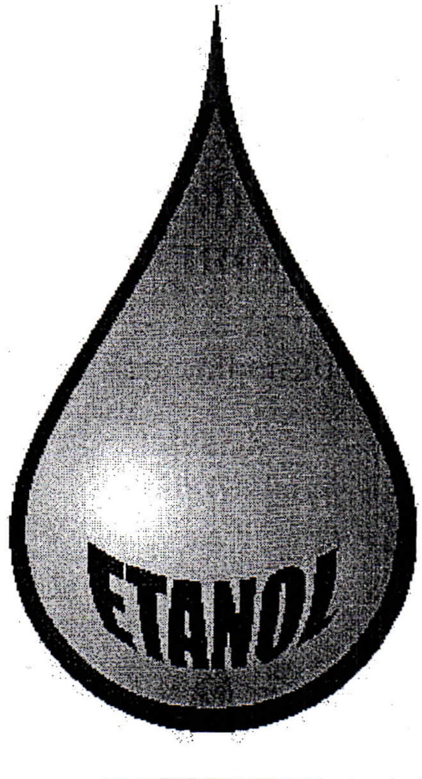

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ELECTROKINETIC MODEL USED FOR THE TREATMENT OF SOILS POLLUTED WITH HEAVY METALS

Corneliu Bogatu[1], Victor Verbitchi[2], Lucian Dragut[2], Ioan Harjan[2]
Dan Ionescu[2], Neculai Dragomir[3]

[1]National R & D Institute for Industrial Ecology – ECOIND, Branch in Timisoara, P-ta Victoriei nr.2, phone/fax : 0256 2202369, e-mail: boggatu@yahoo.com , Romania
[2]National R & D Institute for Welding and Material Testing - ISIM Timişoara, Bv. Mihai Viteazul nr. 30, 491828, izabela@isim.ro , Romania
[3]Banat University of Agricultural Sciences and Veterinary Medicine – USAMVB, Timişoara, Calea Aradului nr. 119, phone: 0256 277116, e-mail: dragomir_ne@yahoo.com, Romania

ABSTRACT

Electroseparation of zinc from two soils samples by using of a laboratory installation, in which metal is accumulated in a supported tuff layer, is presented in this paper. Optimum parameters for the treatment of soil-supported tuff systems by electroremediation process were: voltage 25 V, current 48 – 69.5 mA, pH 2.1-3.8 at anode and 5.5-6.5 at cathode, pH of supported tuff 5.4-6.5, samples humidity 29 –31.5%. Efficiencies for zinc retaining in supported volcanic tuff mass from soil sample containing 186 mg/Kg d.s., were 65-72.3%, after 72 hours. Analysis of metal concentrations evolution versus time, showed the existence of a homogeneous electromigration process.

INTRODUCTION

Electrokinetic treatment is used for separation and concentration of heavy metals, radioactive elements, organic compounds, from polluted soils, sediments and sludges [1,2,3].

Electrokinetic treatment of soil, known as electrorestoration or electroremediation, was applied for remediation of soils polluted with oil products (gasoline, mineral oils, kerosene), organic compounds (benzene, toluene, ethylbenzene, xylene, phenols, halogenated hydrocarbons), metals (Zn, Hg, Cd, Ni, Pb, Cr, Cu, Fe), radioactive elements (Cs 137, Sr 90, Co 60, etc). When separation process of compounds is finished, pollutants concentrated at electrodes are removed by precipitation, adsorption, ionic exchange, or concentrated solutions accumulated in electrodes chambers are pumped outside, for the treatment [4,5,6].

There are two types of laboratory installations used for soil electroremediation: with electrodes placed direct in soil, or in chambers consisting on different materials, which allow pH control. Electroseparation of zinc from two soils samples by using of a laboratory installation, in which metal is accumulated in a supported tuff layer, is presented in this paper.

MATERIALS and METHODS

In order to investigate the possibility of electrochemical processes application for soil remediation, a laboratory installation was developed. Laboratory model has the following components: power supply (1), distribution box (2), anodic electrodes (3), cathodic electrodes (4), chambers for electrodes (5), cell for soil samples electrolysis (6).

As anodes, graphite cylindrical electrodes were used, with diameter of 6 mm, and lengh 300 mm; cathodes were of stainless steeel, with diameter of 6 mm, and length 300 mm.

Networks of 9 electrodes were used, both for anode and cathode zone; distance between networks was 30 cm.

Chambers for electrodes consisted of ceramic material; in fact they were ceramic vessels, with L = 320 mm, l = 160 mm, h = 120 mm, and wall thickness of 10 mm. Vessels from ceramic material, are useful for humidity control in soil samples, because they allow water to pass slowly through walls to soil.

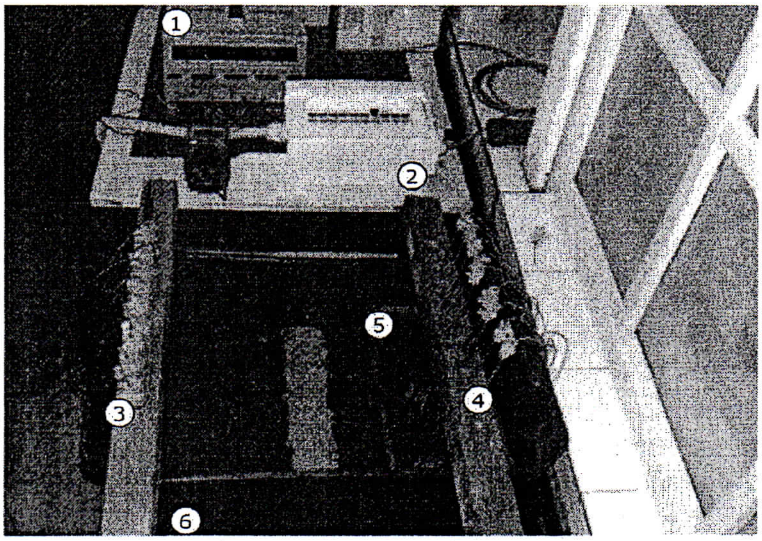

Fig. 1 Laboratory installation for soil electroremediation.

Two soil samples, with the following indicators were used in electrokinetic experiments:
soil l, humus = 3.2 % , carbonates = 0.15 %, pH = 7.2, dried substance = 82 %, copper = 4.2 mg /Kg d.s., zinc = 34.6 mg /Kg d.s.; soil ll, humus = 3.1 % , carbonates = 1.2 %, pH = 6.1, dried substance = 85 %, copper = 5.8 mg /Kg d.s., zinc = 41 mg /Kg d.s.
In electrolysis cell, were introduced 4 kg of soil and 1 kg of supported zeolite. In order to test zeolite for metals retaining from polluted soils, at 5 cm of cathodes network was introduced a native volcanic tuff layer. The particles of volcanic tuff had dimensions between 0.4-1.2 mm, and its zinc content was 11 mg/Kg d.s. Humidity of soil – zeolite system was about 29 %.
Previously, native volcanic tuff was treated with aluminium chloride solution, in order to obtain so called, supported zeolite.
For increasing of zinc concentration from soils, they were treated with zinc chloride solution; by zinc analysis from soils 3 days after solution introduction, zinc content was 186 mg/Kg d.s in soil l, and 188 mg/kg d.s.in soil ll. In every experiment, the following indicators were analysed versus time: current, pH, metal concentration. Voltage was the same in all tests, 25 V. Evolution of concentrations were analysed in three zones: a)anodes zone; b)supported tuff zone; c)cathodes zone. In every zone, sampling of soil from three points was done: left, central, and right side of soil sample, from electrolysis cell, fig. 1.

RESULTS

The results of electrokinetic process application for zinc separation from soil sample l, are presented in table 1. Process is slow and zinc decreasing from soil took place simultaneously with zinc accumulation in zeolite layer. Similar evolution of concentrations onto three directions, showed the existence of an homogeneous electromigration process, table 1.

Table 1. Zinc evolution in soil sample l and in supported zeolite layer during electrochemical treatment, versus time.

Sample/ location	Time, hours								
	8	16	24	32	40	48	56	64	72
	Concentrations, mg/Kg d.s.								
Sample1: 10 cm from anode, left side	175	170	164	154	141	122	92	68	43
Sample 2: 10 cm from anode, central side	173	168	160	151	137	115	88	64	41
Sample 3: 10 cm from cathode, right side	177	172	167	156	143	130	96	74	45
Sample 4: supported tuff, left side	41	69	105	147	195	274	352	445	510
Sample 5: supported tuff, central side	47	73	111	162	224	290	438	468	522
Sample 6: supported tuff, right side	36	65	96	145	210	267	382	430	490
Sample 7: 3 cm from cathode, left side	180	174	168	160	147	132	110	83	58
Sample 8: 3 cm from cathode, central side	176	171	162	157	142	128	102	74	52
Sample 9: 3 cm from cathode, right side	178	172	165	152	144	137	114	92	53

Zinc concentrations decreased slowly versus time, and after 32 hours values from soil samples 1, 2 and 3, (sample 1 = 154 mg/Kg d.s., sample 2 = 151 mg/Kg d.s., sample 3 = 156 mg/Kg d.s.) table 1, were closed with those determined from zeolite layer, samples 4, 5 and 6 (sample 4 = 147 mg/Kg d.s., sample 5 = 162 mg/Kg d.s., sample 6 = 145 mg/Kg d.s.). Taking into account, that in the beginning the content of metal from soil sample was 186 mg zinc /Kg d.s., in 4 Kg of soil there were 744 mg zinc /Kg d.s.; because in supported zeolite, were accumulated 507.3 mg zinc /Kg d.s., an efficiency of 68.1 % for zinc separation was computed, after 72 hours.

Table 2. pH and electric current evolution versus time in soil sample l and in supported tuff layer, during zinc electroseparation process.

Parameter	Time, hours								
	8	16	24	32	40	48	56	64	72
Voltage, V	25.1	25.1	25.1	25.1	25	25	25	25	25
Current, mA	62.4	55.4	53.0	52.3	51.2	50.6	48.2	46	43.7
pH anode	3.5	3.2	2.9	2.7	2.5	2.5	2.4	2.3	2.2
pH central soil zone	6.1	5.5	5.2	5.1	4.9	4.8	4.6	4.5	4.5
pH supported tuff	6.4	6.2	6.1	6.0	5.8	5.8	5.7	5.7	5.6
pH cathode	6.5	6.3	5.9	5.7	5.6	5.6	5.6	5.8	5.8

For pH control in cathodic zone, 0.01 M nitric acid was added from time to time; pH was kept in this soil zone between 5.8- 6.5. pH evolution in electrodes zones and in supported tuff layer, are presented in table 2. In anodic zone, after 8 hours pH was 3.5; then, a slow decrease of pH took place up to 2.2-3.2. In central side of soil sample, after 32 hours pH became 5.1, and after 64-72 hours was 4.5-4.6.

In supported tuff layer, a small decreasing of pH took also place, from 6.4 in the beginning of the process, up to 5.6 at the end of electroremediation process
The current recorded in the first hour, 62.4 mA, decreased as process proceded, and after 72 hours it reached 43.7 mA, a decrease of about 30 %. Similar results were recorded for soil sample ll, with humidity of 31.5 %.
The experiments concerning metals redistribution in soil–supported tuff systems, showed that process is slow, zinc concentrations decreasing form soil sample took place simultaneous with zinc concentrations increasing in tuff layer. Similar evolution of metal concentrations on different directions in this systems, showed the existence of a homogeneous electromigration process. Transport process of zinc in soils and its accumulation in supported tuf versus time, was linear.

CONCLUSIONS

1. A laboratory installation was realized, for treatment of soils polluted with metals. Optimum parameters for treatment of soil-supported tuff systems by electroremediation process were: voltage 25 V, current 48 – 69.5 mA, pH 2.1-3.8 at anode and 5.5-6.5 at cathode, pH supported tuff 5.4-6.5, samples humidity 29 –31.5%.

2. Efficiencies for zinc retaining in supported tuff mass from soil sample containing 186 mg/Kg d.s., were 65-72.3%, after 72 hours. Analysis of metal concentrations evolution versus time, showed the existence of a homogeneous electromigration process.

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