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ADVANTAGES OF USING THE ELECTRO-KINETIC METHOD FOR SOIL DEPOLLUTION

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Abstract

In the present paper the electro-kinetic depollution is compared with the thermal depollution. The need for a high degree of depollution for soils contaminated with liquid petroleum products is complemented by the economic need not to destroy the pollutant. The study contains a set of experimental data of laboratory activity to compare a new method of depollution with already known and industrially applicable methods. Thermal methods of depollution, combustion and desorption, are methods that have a high degree of depollution, but destroy the pollutant. Electro-kinetic depollution is based on physical principles that cause the migration of the pollutant for the purpose of collecting it without destroying it. The paper presents comparatively the degree of depollution rates achieved by the three methods and the costs obtained for them. In addition, for the electro-kinetic method particular attention has been given to both the recovery of pollutants and the properties of the water used in the process so that it does not become a new source of pollution.

***Key words**: depollution, electro-kinetics method, petroleum products, soil.*

INTRODUCTION

Soil is the environmental factor that connects the other two factors with which man is directly connected and without whom life would not be possible: water and air.

A possible soil pollution can have effects on both the ground and the water through the water circuit in nature, but also the air through the evaporation phenomenon.

With the development of refineries and the discovery of new deposits of crude oil, soil pollution has grown, affecting all the stages of crude oil transformation into finished product, starting with extraction, and continuing with transport and refining.

Soil depollution is a difficult action because of the fact that existing technologies have a high cost, and affordable ones have a fairly long time, when the soil is unusable. There is a constant concern of authors in finding new forms of decontamination and, where appropriate, existing ones can be upgraded (Popa et al., 2016; 2017; 2018).

In the present paper there are presented by comparison three technologies of depollution, two thermics methods, already existing and with industrial applicability and a new methodphysicaly, which has not yet been implemented at industrial level but the results obtained show it as a feasible alternative in the field of technologies of depollution.The idea started from literature data, in which the authors presented various possibilities for electric depollution (Streche et al., 2013). Also, variants of the use of electrodes have been studied and an attempt has been made to set up such an installation (Han et al., 2004; Li et al., 2018; Lysenco et al., 2018; Ren et al., 2014; Risco et al., 2016). Thus, a new depollution stand presented by the authors was designed (Popa M. & Negoita L.I., 2018).

MATERIALS AND METHODS

Thermal decontamination methods applied at the laboratory level are achieved by: direct contact with the combustion flame and by heating without contact with the flame upon desorption. We considered from the outset the complete combustion of the pollutant when applying the combustion, so a degree of depollution of 100%. Experimental assemblies are shown in Figures 1 and 2.

For electro-kinetic (EK) method we needed an experimental assembling consisting of 9 electrodes (eight anodes and one cathode), a known volume vessel in which we tracked the

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effect of the electrode field created by the electrodes and a source that transformed the alternating current in continuous current of 5 and 12V (Popa M. & Negoita L.I., 2018). Experimental assembly is shown in Figure 3.

Figure 1. Experimental installation for combustion

Figure 2. Experimental installation for desorption

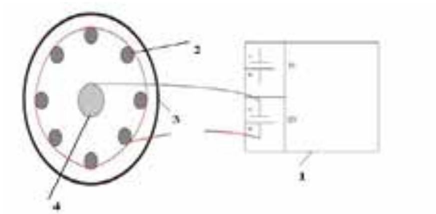

Figure 3. Experimental installation for electro-kinetic method: 1-power source; 2- anode; 3- vessel with soil; 4-cathode

In addition, for analysis we used the kit CRISON CM35 for determining the water properties before and after use. This kit is presented in Figure 4.

Figure 4. Kit CRISON CM35 for water analyser

RESULTS AND DISCUSSIONS

In order to have results to report the efficiency of the electro-kinetic method, we have operated the modules for combustion and desorption depollution.

For combustion, we used a sample of 100 g of soil to determine organic material and a sampleof soil contaminated with 5% diesel oil. The operating time of the combustion was 30 minutes, after which an organic material content of 16.8% lost by incineration and a 100% depollution rate was obtained (Table 1).

Table 1. Combustion results

Sample	Mass of the sample after combustion, g	Weight lost by combustion, g	Degree of depollution %
Sample witness	83.2	16.8 (organic material)	100
Contaminated, 5% diesel	78.2	21.8 (16.8 g organic material + 5 g diesel oil)	

For desorption, we also used a sample of 100 g of soil to determine organic soil material and a sample contaminated with 5% diesel oil.

The desorption module operating time was the same as for the 30 minutesof combustion. We obtained an organic material lost by desorption of 5.6% and a degree of depollution of 80% (Table 2).

Table 2. Desorbtion results

Sample	Mass of the sample after desorption, g	Weight lost by desorption, g	Degree of depollution,%
Sample witness	94.4	5.6 (organic material)	80
Contaminated 5% diesel oil	90.4	9.6 (5.6 g organic material + 4 g diesel oil)	

For electrokinetic decontamination, the electrodes were arranged as in Figure 3. In attempting to develop such a method, the first step was to "make" electrodes in a variation as close as possible to the recommendations of the specialists (Streche et al., 2013).

The electrodes are connected to a current source that allows operation at two different voltages: 5V and 12V.

The experiments started with the 5V voltage. In the first phase, the soil sample was polluted with 5% diesel oil.
The soil sample was then watered for four days, as follows: in the first three days with 200 ml of water and on the fourth day with 100 ml of water.
In total, 700 ml of water was used. All this time, the source was powered.
The total volume of water collected on the fifth day was 150 ml (Figure 5).

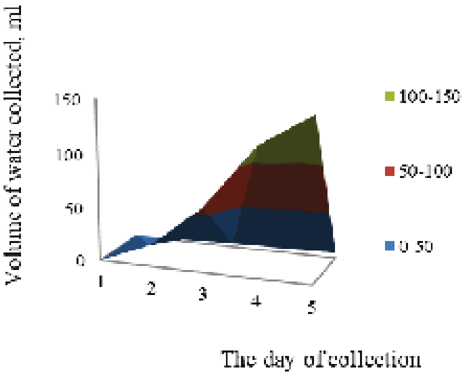

Figure 5. Water collected after 5 days

After five days it was found that at the 5 V voltage and the 5% diesel oil concentration, no pollutant was moved to the cathode.
For this reason, the concentration of the pollutant was considered too low and increased from 5 to 10% for the diesel oil pollutant, but the supply voltage also increased from 5 to 12V.
In the electro-kinetic process we used distilled water to generate the electroosmosis phenomenon, an essential factor alongside electromigration and electrophoresis.
The volumes of soil, distilled water and diesel introduced and subsequently partially collected, are shown in table below (Table 3).
An experimental without electrodes module was also used.

Table 3. Decontamination degrees and water usage for EK method

Working days for 12V 10% diesel oil		Sample soil 1800g soil + 200g diesel oil (240 ml)	
		With electrodes	Without electrodes
Day 1	Water used	300 ml	300 ml
Day 2		300 ml	300 ml
Day 3		300 ml	300 ml
Day 4		300 ml	300 ml
On days 5 and 6 the current was not stopped. Only the water supply was interrupted.			
Collected on day 7	Water	540 ml	500 ml
	Diesel oil	50 ml	30 ml
Decontamination degree, %		21	12.5

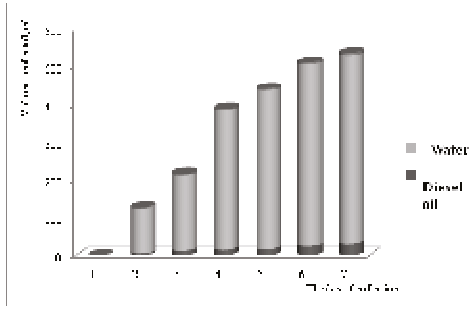

Figure 6. The time variation of collected volumes

Following the passage of water through soil types and especially under the influence of the electric field, it changes its properties. The way water changes its characteristics is important due to the fact that after treatment of the soil and water it must be subjected to the initial properties. The modified water properties allow us to categorize it as the wastewater to be treated (Table 4).

Table 4. Properties of water (used and clean)

Properties	Clean distillate water	Water from electrode module	Water from witness module	Potable water
pH$^{27°C}$	7.84	11.72	10.17	7.15
Conductivity$^{27°C}$	0.272 mS/cm	4.49 mS/cm	0.608 mS/cm	1.342 mS/cm
Salinity $^{27°C}$	10.34 mg/l	2.36 mg/l	294 mg/l	661 mg/l

CONCLUSIONS

Based on the results obtained, referring to the properties of the soils and in comparison with the methods already known, we can state the following:

The method of electro-kinetic depollution is a method which allows the recovery of a certain proportion of the pollutant.

The electro-kinetic depollution method can only be used as a preliminary method of depollution.

The lack of results after 5V operation and the occurrence of a degree of depollution, but especially the collection and separation of the used water pollutant at 12V, can be considered to operate at a higher voltage to obtain depollution degrees, respectively a higher recovery.

There is a degree of depollution and recovery of the larger product in the presence of the electric field than in the absence of it.

The degree of depollution of the new method is inferior to the degree of depollution of the thermal methods, but recovering polluting products by using the electro-kinetic depollution method constitutes an economic advantage.

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