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NEW LABORATORY TECHNIQUES ON SOIL DECONTAMINATION

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Abstract
The paper presents a study on the possibility of electrical decontamination of soils contaminated with liquid petroleum products. The study involves the characterization of a soil type by: capillary, permeability, retention and granulometry. Electrically polluting is done with the help of stainless steel electrodes arranged radially in a vessel. The pollutant-diesel oil product was characterized by density and viscosity. The experiment had a duration of one week and determined the degree of polluting and the influence of polluting soil on it. Also, the germinating potential on such a depolarized soil was verified.

Keywords: *diesel oil, electrode, soil*

Introduction
The soil chosen for the study is a brown soil that has been characterized in the laboratory. The pollutant used in the study, a liquid petroleum product, was characterized by representative physical properties, which give information on penetration into the soil structure.
Choosing the method of polluting contaminated soil with liquid petroleum products should take into account several factors. Several types of soils and various methods of polluting at the laboratory level have been studied (Popa & Negoita 2016, Popa & Onutu 2016, Popa et al 2017). Among the methods of depollution applied at laboratory level less studied is the electrical method (Han et al 2004, Li et al 2018, Lycenko et al 2018, Ren et al 2014, Risco et al 2016a). Starting from literature data (Streche et al 2014) a device has been designed which involves the existence of electrodes mounted inside the soil sample polluted with a liquid petroleum product.

Materials and Methods
Soil preparation for analysis consisted in drying it, thus establishing the water content. The physical properties were determined on the devices presented below (Patrascu et al 2008). The soil capillary capacity was determined on the device in Figure 1.
The soil permeability was determined on the device of Figure 2. At the same time the soil retention capacity could be calculated.

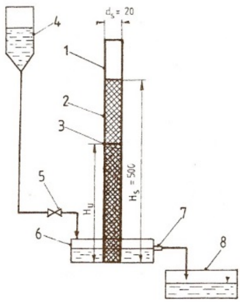


Figure 1. Experimental assembling for capillary determination (Patrascu et al 2008) 1-tube glass; 2-layer earth; 3-front moisture; 4-liquid supply vessel; 5-clamp; 6-vessel with constant liquid level; 7-nozzle overflow; 8- collector vessel.

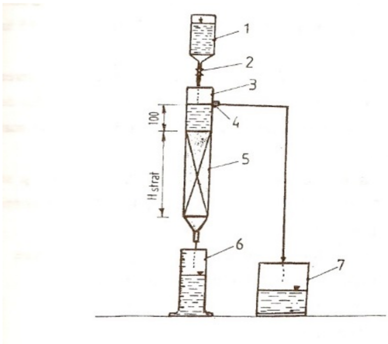


Figure 2. Experimental installation for permeability determination (Patrascu et al 2008) 1-pot supply; 2-clamp; 3-tube Wolff; 4-spout jet; 5-layer soil; 6-cylinder graduated; 7-collector vessel.

The device on which granulometric distribution was determined is shown in Figure 3.

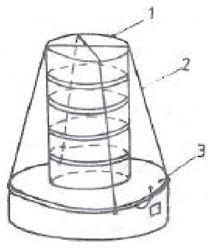
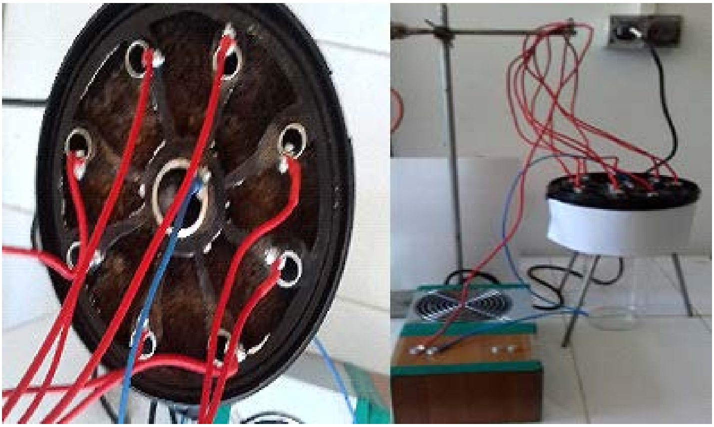


Figure 3. Experimental assembling for granulometry determination (Patrascu et al 2008) 1-sieves; 2-elastic clamping struts; 3-vibrator system.

The electrical depollution was done on the experimental assembly shown in Figure 4.



a ***b***

Figure 4. Experimental installation: a-electrodes arrangement; b-general assembly.

The method of depollution used was the electrical method. Laboratory-based electrodeposition technique was carried out on an experimental assemblage involving the use of stainless steel electrodes, a cathode and eight anodes inserted into the soil polluted with the petroleum product according to a recommended model in the literature (Risco et al 2016 b). The cathode was immersed in the center of the soil surface and the anodes were submerged radially on the soil surface as in Figure 4a. Two supply voltages for electrodes, 5V and 12V, were chosen. The polluted sample was periodically wetted and the vessel was provided with a bottom hole, through which water and the petroleum product were collected.

Results and Discussion

Capillarity is the property of the soil to allow a pollutant to penetrate vertically, from bottom to top, into the soil structure. The wet layer height was set for both water and petroleum products – Diesel oil, measured from 10 to 10 minutes for one hour. The results obtained are shown in Table 1.

Table 1. Measured values for soil capillarity

1.	Soil type	Brown soil	
2.	Liquid	Water	Diesel oil
3.	$H_{u,10}$, mm	29	37
4.	$H_{u,20}$, mm	36	56
5.	$H_{u,30}$, mm	43	68
6.	$H_{u,40}$, mm	52	85
7.	$H_{u,50}$, mm	55	89
8.	$H_{u,60}$, mm	60	99

Permeability is the property of the soil to allow the upstream pollutant to penetrate, so the soil retention capacity can also be established. Also, determination was made for both water and petroleum product. The permeability was calculated from 15 to 15 minutes and an average was determined, Pm.

$$P_\tau = V_\tau \cdot 60/\tau \quad (1)$$

where Vτ - volume of liquid filtered through the layer during t = 15, 30, 45, 60 minutes, cm^3. The results obtained are presented in Table 2. The retention capacity was calculated with relation (2).

$$C_R = (m_f - m_o) \cdot 10^3 / V_{strat} \quad (2)$$

where, m_o - the mass of the dry soil sample, g and m_f the soil sample mass at the end, g, the volume of soil layer, cm^3.

Table 2. Results obtained for permeability and retention capacity

Soil type	Brown soil	
Liquid	Water	Diesel oil
P_{15}, cm^3/h	1100	100
P_{30}, cm^3/h	1080	104
P_{45}, cm^3/h	1055	90
P_{60}, cm^3/h	876	89
P_m, cm^3/h	1028	96
C_R, kg/m^3	450	325

Granulometry is the percentage distribution of soil particles, which is achieved by the sieve method. The results are shown in Table 3.

Table 3. Granulometric distribution of soil

Soil type		Sieve 1 1,5 mm	Sieve 2 0,49 mm	Sieve 3 0,2 mm	Sieve 4 0,12 mm	Sieve 5 0,088 mm	Sieve 6 0,06 mm
Brown soil	m_i, g	55	32	6	5,3	1,2	0,5
	%	55	32	6	5,3	1,2	0,5

The physical properties of the pollutant that influence the penetration into the soil structure are density and viscosity. They were determined at several temperatures, 20, 40 and 60 °C.

Table 4. The properties of petroleum product

Temperature, °C	Density ρ, kg/m^3	Viscosity $\mu \cdot 10^6$, kg/ms
20	840	**5,1**
40	820	**4,1**
60	813	**3,2**

The physical properties of diesel oil have led to a complex definition of the soil-polluting system, to conclusions on the penetration of the pollutant into the soil structure. Controlled pollution of a soil with petroleum product has taken place. Experimental results after electrical depollution are shown in Table 5.

Table 5. The results of electrical depollution

The day of collection	Electrical voltage, V			
	5V 5% pollutant		12V 10% pollutant (200 ml)	
	Volume of water, ml	Volume of pollutant, ml	Volume of water, ml	Volume of pollutant, ml
1	0	-	0	0
2	15	-	180	5
3	70	-	260	12
4	140	-	335	22
5	160	-	420	28
6	180	-	480	36
7	220	-	560	40
Degree of depollution, %	-		20	

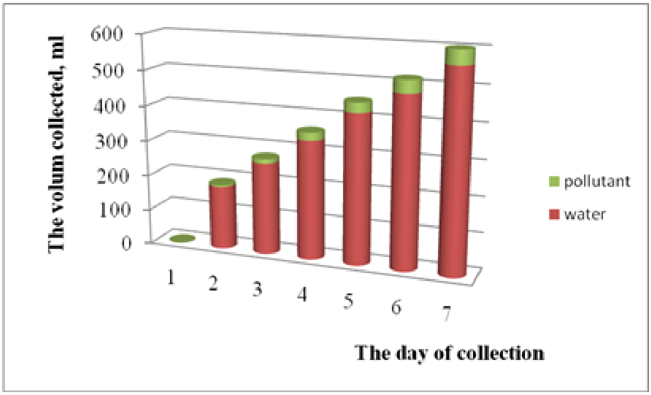


Figure 5. The collected volumes of water and pollutants at 10% and 12 V

1. The polluted product with 5% diesel oil was watered with water for five days and for another two days the sample was left under the action of electric current at 5V without watering. After one week the collected water was measured. It was found that at this concentration of pollutant and with the voltage of 5V was not collected and petroleum product.
2. The sample was polluted with 10% diesel oil and the electrical voltage was increased to 12V. He was also watered with water for five days and another two days operated under electric current. Compared to the initial volume of 200 ml of diesel, a volume of 40 ml of diesel was collected, together with water, which means a degree of depollution of 20%.

For the verification of the germination potential, three samples, coded as in Figure 6, were prepared, where 1 - pure soil sample, 2- electrically depolluted soil, 3 - soil polluted with 10% pollutant.

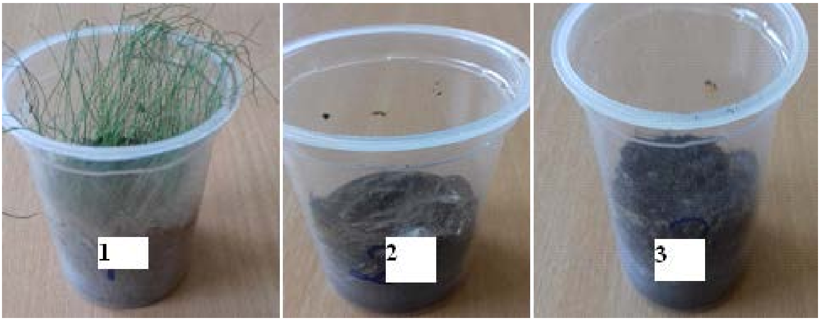


Figure 6. Verification of germination potential

Conclusions

The electrically polluting method is the only method to recover the pollutant. Increasing the voltage used (from 5V to 12V) and the concentration of petroleum product (from 5% to 10%) leads to the idea of obtaining a higher degree of depollution.

The electric method can be successfully applied to soils with low permeability and high retention capacity and high capillary capacity.

Only 20% can be explained by the fact that the duration of action of the electrodes on the soil sample was only one week.

As far as the germination potential verification is concerned, it can be restored only in the presence of clean soil mixed with the one undergoing the electrical depollution method.

As future research directions, the authors consider changes: concentrations and thermal voltages, soil types, types of electrodes.

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