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LABORATORY STUDIES ON THE SIMULATION OF ACCIDENTAL POLLUTION OF SOILS

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Abstract

This paper is part of a comprehensive study on soil pollution with liquid petroleum products. An experimental model to simulate the natural state of soil horizons was imitated in the laboratory. By cracking underground or aboveground pipes, which carry liquid petroleum products, the ground - underground – groundwater system undergoes changes. If immediate action is taken, the system is less affected and remediation does not require costly techniques. If the accident is found after a long time, the oil stain can seriously affect the soil and remediation methods do not provide good efficiency. Pollutant migration, in the proposed arrangement, has been studied for several soil types. For each soil type there were determined: capillarity, permeability and retention capacity, size distribution and density. Pollutant migration, a petroleum product, was studied both on horizontal and vertical direction. There were calculated the travel speeds of pollutant in the two directions and it was measured the width of the oil spill. Future research aims the remediation of these soils through methods that can be applied in the laboratory.

***Key words**: soil, contaminated, oil products, migration.*

INTRODUCTION

It is observed that in the world, and also in Romania, deliberate discharges of oil to soil or water, which leads to economic, social and environmental issues, are reported every year. Ensuring protection of soil quality provides, among other things, the use of remediation processes and technologies designed to neutralize or block the flow of pollutants and ensure the effectiveness and enforcement of legislation on the protection desired soil quality.

There are concerns on this issue and this paper is part of a large study in this direction.

MATERIALS AND METHODS

In the laboratory it was simulated an experimental model to imitate the natural state of soil horizons. The experimental setup on which the measurements were made is shown in Figure 1. By breaking underground or above-ground pipes, which carry liquid petroleum products, ground - basement – groundwater system suffers transformation. If immediate action is taken, that system is less affected and remediation does not require costly techniques. If the accident is found after a long time, the oil stain can seriously affect the soil and remediation methods do not provide good efficiency. Pollutant migration in the proposed arrangement has been studied for several types of soils. For each type of soil there were determined the following properties: capillarity, permeability, retention capacity, size distribution and density.

Before performing the experimental scheme, the pipe was cracked. Pollutant migration, a petroleum product, was intended both on the horizontal and vertical direction. There were calculated moving speeds on the two-way directions and it was measured the width of the oil stain. Future research directions pursue the remediation of these soils through methods that can be applicable in the laboratory.

Figure 1. The experimental scheme

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RESULTS AND DISCUSSIONS

Each soil type was analyzed in the laboratory and there were determined properties whose values are presented in Table 1.
Soil capillarity is the phenomenon of rise of possible pollutants in soil structure, in this case a liquid petroleum product.
Permeability is the property of soil to allow flow of a liquid product through its structure.
Retention capacity is the amount of liquid product embedded in saturated soil structure analysis.
Retention capacity varies inversely with the soil permeability.
Size distribution is the percentage distribution of the size of soil particles.
The particle size conditions the physical properties of the soil and their filtration capacity.
The determination of size distribution was made by sifting method.
Figures 2 and 3 shows the properties values. variations.

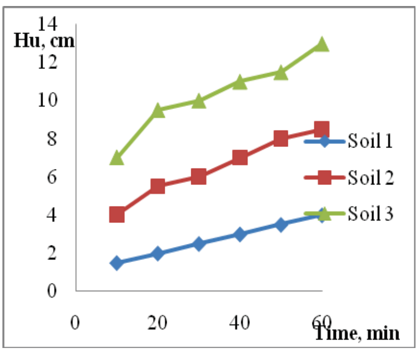

Figure 2 Variation of capillarity

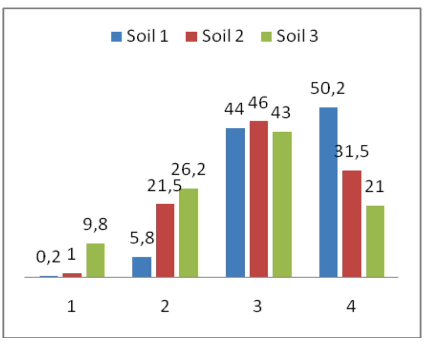

Figure 3. Variation of granulometry

Table 1. The soil test results

Analysis	Soil 1	Soil 2	Soil 3
Capillarity, cm liquid			
10 min	1,5	4	7
20 min	2	5,5	9,5
30 min	2,5	6	10
40 min	3	7	11
50 min	3,5	8	11,5
60 min	4	8,5	13
Permeability, cm/h			
P 15 min,	21	312	456
P 30 min,	22	116	112
P 45 min,	18,67	55	80
P 60 min,	18	26	58
P_{medium}	19,92	127	177
Retention capacity, kg/m^3	290,18	96	358
Size distribution, g/sieve (S)			
S 1 d=0,06mm	0,2	1	9,8
S 2 d=0,12mm	5,8	21,5	26,2
S 3 d=1,5mm	44	46	43
S 4 d=2,5mm	50,2	31,5	21
Real density kg/m^3	1,54	2,05	2,43

The dimensions of the pipe and the tank are shown in Table 2.

Table 2. Pipe and tank size

Pipe	Thickness, mm	1
	Diameter, mm	18
Tank	Height, cm	19
	Width, cm	31,5
	Length, cm	50

In order to express the speed of the pollutant on vertical direction in a soil based on the nature of the pollutant, the type and structure of the soil, it was studied the ascendent and desscenent speed of oil in the soil.
Tables 3-5 present the measured values in h_a and h_d of the pollutant front, both ascendant and descendant (Patrascu, 2005).

Table 3. Variation in height and pollutant fronts up and down for 1 h soil 1

Time, min / h, mm	15	30	45	60
h_a	15	30	43	50
h_d	11	23	35	45

Tabelul 4. Variation in height and pollutant fronts up and down for 1 h soil 2

Time, min / h, mm	15	30	45	60
h_a	15	18	22	28
h_d	14	16	19	24

Tabelul 5. Variation in height and pollutant fronts up and down for 1 h soil 3

Time, min / h, mm	15	30	45	60
h_a	23	27	33	45
h_d	26	34	40	48

Since ascending and descending speeds are variable over time, calculation is made incrementally for each time interval between two consecutive measurements.

The obtained values will be used to calculate the average speed in each range time. Ascendant and descendant speeds (w_a and w_d) are calculated based on h_a and h_d at different times from the start of the experiment.

$$w_a = \frac{\Delta h_a}{\tau_m}, \quad \text{mm/min} \tag{1}$$

$$w_d = \frac{\Delta h_d}{\tau_m}, \quad \text{mm/min} \tag{2}$$

Table 6. The variation Δh_a şi Δh_d for soil 1

τ_m, minute	7,5	7,5	7,5	7,5
Δh_a, mm	15	15	13	13
Δh_d, mm	11	12	12	10

Tabele 7. The variation Δh_a şi Δh_d for soil 2

τ_m, minute	7,5	7,5	7,5	7,5
Δh_a, mm	15	3	6	6
Δh_d, mm	14	2	3	5

Table 8. The variation Δh_a şi Δh_d for soil 3

τ_m, minute	7,5	7,5	7,5	7,5
Δh_a, mm	23	4	6	12
Δh_d, mm	26	8	14	4

Table 9. Variation of ascendant and descendant speeds

Type soil	Ascendent speed, w_a, mm/min	Descendent speed, w_d, mm/min
Soil 1	2	1.46
	2	1.6
	1.73	1.6
	1.73	1.33
Soil 2	2	1.87
	0.4	0.27
	0.8	0.4
	0.8	0.67
Soil 3	3.06	3.47
	0.53	1.06
	0.8	1.87
	1.6	0.53

CONCLUSIONS

The penetration of oil residues at a certain depth in the soil is influenced by humidity, particle size and density, pollution intensity, viscosity and density of the pollutant.

Soil samples were analysed using laboratory methods already described in the literature, a constant concern for this area already existing (Patrascu, 2005; Popa, 2014).

The direction and speed of the pollutant depend mainly on the viscosity and permeability of the soil.

The main acting force over the pollutant is gravity. Therefore, if the soil is permeable pollutant infiltrates in the soil predominantly in vertical component. Also, there is a lateral pollutant impregnation due to dispersion, which is controlled by the porosity of the soil.

Whatever the size of the crack of a pipe, the evolution of the pollutant in soil is influenced by soil properties and discharged pollutant.

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