Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. III, 2014
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, ISSN-L 2285-6064

INFLUENCE OF THE DEGREE OF CONTAMINATION ON THE EFFICIENCY OF TREATING OIL POLLUTED LOAMY SOILS WITH THERMAL DESORPTION

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Abstract

The purpose of the hereby paper is to present and interpret the results of the lab experiments performed using soil samples of loamy texture, containing three pollutant concentrations (16710.66; 26300.68 and 39256.68 mg/kg dried substance). In the decontamination process, we opted for three time intervals for keeping the samples in the oven, at 350 °C. The results of the experiments indicate that the efficiency of thermal desorption is influenced by the degree of contamination, which shows the importance of choosing the optimal parameters of the thermal desorption treatment process.

Key words*: contamination, depollution, thermal desorption, soil, crude oil.*

INTRODUCTION

Environment protection has become a necessity due to the fact that it was damaged as the industrial activities developed (Buliga, 2002).
Petroleum products can affect soil, one of the three elements of the geographic environment, and through it, affects the life of human beings, animals and plants (Buliga, 2002).
In order to establish remediation methods, the properties of the soils subject to decontamination are of great importance, because the connections among the pollutants and organic substances, clay and soil porosity, influence the destruction of hydrocarbons (Wick et al., 2011).
The use of thermal treatments for improving the soils polluted with petroleum products is widely spread worldwide, being one of the most complex activities in the domain of environment protection (Lee et al., 1999; www.petroleumclub.ro).
Due to the experience obtained by treating contaminated soils with thermal desorption, the company S.C. SETCAR S.A. Brăila states that the value of the hydrocarbons concentration in the soil must not exceed 10 % and humidity should not be over 15 %. Exceeding these limits reduces the efficiency of the technology very much (www.setcar-braila.ro).
The choice of using direct thermal desorption for decontaminating soils shows that the petroleum products in the soil sustain combustion, improving the efficiency of the treatment process (www.setcar-braila.ro).

MATERIALS AND METHODS

Figure 1 shows a simplified plan of the experimental research.
The extraction of the soil samples was performed in the commune of Bonţida, Cluj County, according to the state standards (STAS) 7184/1-75 (STAS 7184/1-75), in the depth interval of 0 – 20 cm.
The decontamination process was performed in the laboratory, using soil samples with loamy texture (figure 2).
For each test we weighed 100 g soil, of which we removed the foreign materials (pebbles, leaves), we polluted them with three quantities of pollutant and we determined the quantity of pollutant of the initial sample and the final one (after the decontamination process).
The quantity of pollutant in the soil samples was determined according to the state standards

(STAS) SR 13511/2007 (SR ISO 13511, 2007), using the Soxhlet method.

The quantity of crude oil in the tested samples is compared to the values of the established alert threshold (1000 mg/kg dried substance) and intervention threshold (2000 mg/kg d.s.) for the less sensible soils, according to Order no. 756 of March 11th 1997 (Order no. 756, 1997).

The equipment needed to apply the technology of thermal desorption was the electric oven with chamber and silicon carbide bars.

The main parameters observed during these experiments were the degree of contamination and the duration of treating the soil samples in the thermal desorption system.

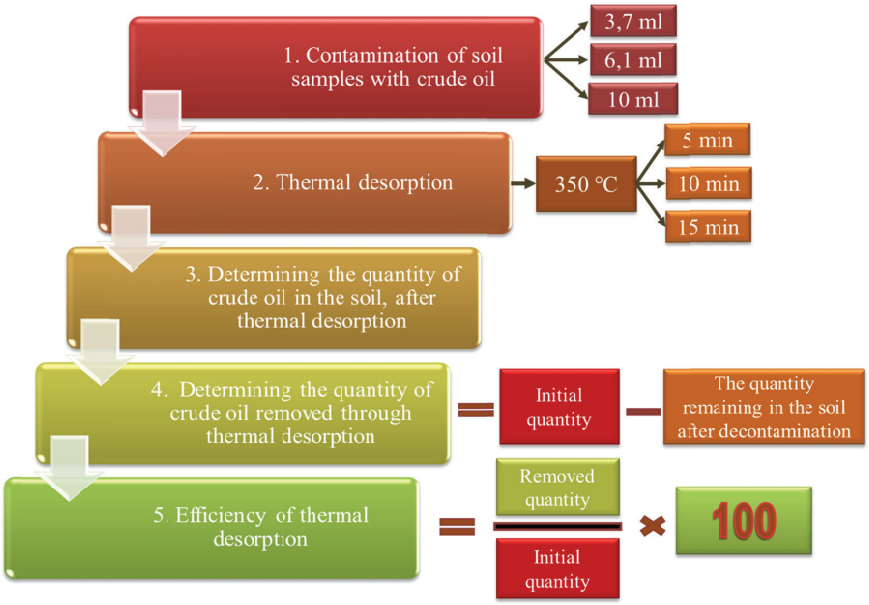

Figure 1. The experimental research plan

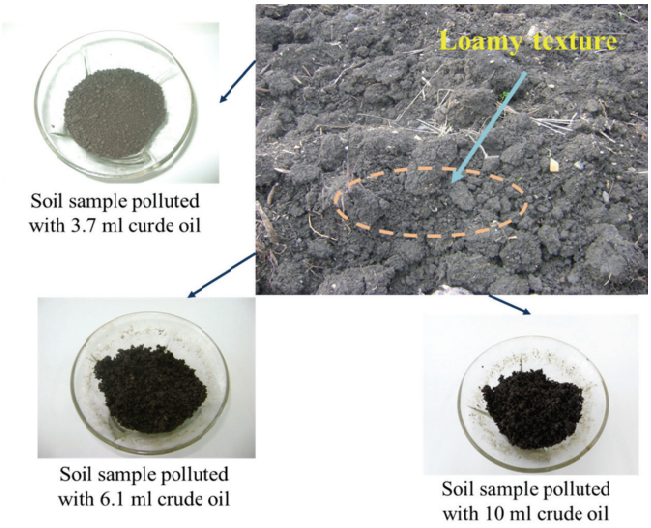

Figure 2. The loamy texture contaminated with the three quantities of crude oil

RESULTS AND DISCUSSIONS

The results obtained after calculating the content of crude oil existing in the control samples are given in table 1. It can be observed that the standard values are highly exceeded.

Table 1. The initial value of the quantity of crude oil in the control samples

Crt. No.	Sample [cm]	Quantity of pollutant [ml]	Initial quantity of pollutant [mg/kg]	Humidity [%]
1.	SA	3.7	16,710.66	22.82
2.	SB	6.1	26300.68	22.82

By analyzing the results (figure 3), after performing thermal desorption on samples SA and SB, it can be observed that the quantity of pollutant in the soil decreased as the duration of treatment of soil samples in the oven increased. The biggest decrease of the concentration was obtained for sample SA, followed by SB.
Studying samples SA, we can observe that the content of crude oil existing in the samples after the desorption performed during the specified amount of time, has dropped below both alert and intervention thresholds, according to Order no. 756 of March 11th 1997 (Order no. 756, 1997).

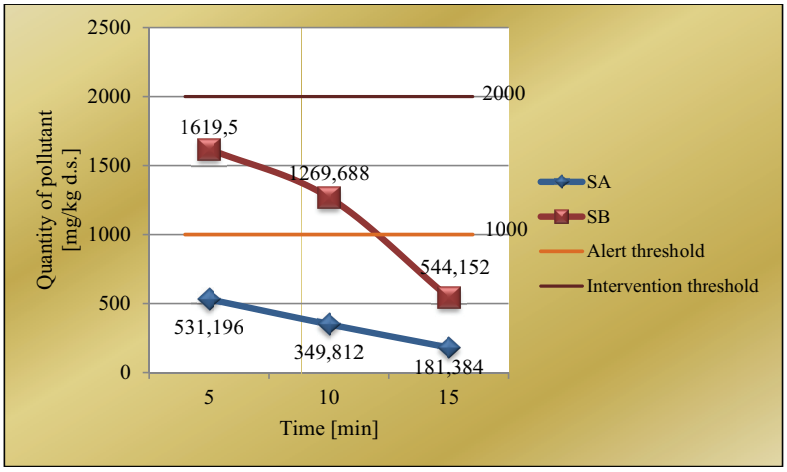

Figure 3. Variation of the quantity of crude oil in the soil samples SA and SB

For the samples SB treated in the oven for 5 and 10 minutes, the quantity of crude oil has dropped only below the intervention threshold, while for the sample kept in the oven for 15 minutes, the value decreased below both thresholds.
The evaluation of the efficiency of the decontamination process using thermal desorption was accomplished by calculating the final extraction efficiency, using relation 1:

$$\eta = \frac{m_{analyte}(solvent)}{m_{analyte}(sample)} \cdot 100[\%] \qquad (1)$$

where: - **$m_{analyte}$(solvent)** – concentration of pollutant extracted through thermal desorption at different temperatures and amounts of time of exposure in the oven, in mg/kg d.s.;

- **$m_{analyte}$(sample)** – initial pollutant concentration, existing in the soil (which can be extracted using the Soxhlet method), in mg/kg d.s.

The interpretation of diagram 4, depending on the level of contamination, reveals that the pollutant was extracted from the soil, with high efficiencies, ranging between 93.84 ÷ 98.91 %.
The results of the performed experiments indicate that: as the duration of treating the samples in the oven increases, the decontamination degree is greater. The highest efficiency is obtained for sample SA, kept in the oven for 15 minutes.

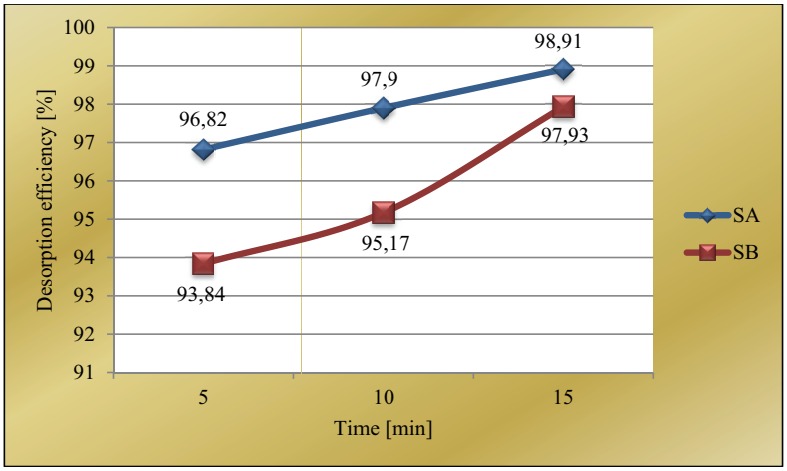

Figure 4. Efficiencies of the decontamination of soil samples depending on the level of pollution

CONCLUSIONS

The results of the experiments performed on soils with loamy texture, polluted with crude oil, treated at 350 °C, indicate a very high efficiency of the thermal desorption decontamination process.

The duration of the treatment is a determining factor in the process of thermal desorption, as we have found during the experiments: as the duration of treatment increases, the decontamination degree increases as well.

By comparing the two concentrations, it can be observed that for a low contamination, the efficiency is higher, and in case of greater pollution, the efficiency is lower.

The highest efficiency of thermal desorption proved to be for sample SA, kept inside the oven for 15 minutes.

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*** www.setcar-braila.ro/desorbtie-termică-directă_2_619_1.htm, Direct thermal desorption. Description of the mobile unit for direct thermal desorption (DTD).