BIOREMEDIATION OF POLLUTED SOILS WITH PETROLEUM HYDROCARBONS

BIOREMEDIEREA SOLURILOR POLUATE CU HIDROCARBURI DIN PETROL

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Abstract: *Bioremediation is the use of micro-organisms that occur naturally in the environment and degrade contaminants into carbon dioxide and water. Biological processes have been used successfully to remediate soils contaminated with petroleum hydrocarbons and their derivative. Several petroleum hydrocarbons can act as a source of carbon and energy for the growth of soil micro-organisms. Contamination of soil by petroleum hydrocarbons is an important environmental problem. Hydrocarbons are a frequent cause of environmental pollution. Although hydrocarbons in general are biodegradable, the main limiting factor to their effective and complete degradation is their bioavailability to soil micro-organisms. The elimination of petroleum hydrocarbons from the environment is an absolute requirement to promote a sustainable development of our society with low environmental impact. In this paper are presented the preliminary results concerning the bioremediation of contaminated soils using a natural hydrocarbon absorbent product to enhance the biodegradation of petroleum hydrocarbons.*

Rezumat: *Bioremedierea reprezintă utilizarea microrganismelor existente în sol în scopul degradării contaminanţilor în dioxid de carbon şi apă. Procesele biologice au fost folosite cu succes în scopul remedierii solurilor contaminate cu hidrocarburi din petrol şi derivaţii acestora. Hidrocarburile din petrol pot juca rolul de sursă de carbon şi energie pentru dezvoltarea microorganismelor existente în sol. Contaminarea solului cu hidrocarburi din petrol reprezintă o problemă de mediu importantă. Poluarea cu hidrocarburi este frecvent întâlnită. Deşi majoritatea hidrocarburilor sunt biodegradabile, factorul limitativ în degradarea completă a acestora este reprezentat de biodisponibilitatea microorganismelor solului. Eliminarea hidrocarburilor din petrol din mediu este o cerinţă obligatorie în promovarea unei dezvoltări durabile a societăţii noastre cu un impact redus asupra mediului. În această lucrare sunt prezentate rezultate preliminare privind bioremedierea solurilor contaminate cu hidrocarburi din petrol prin utilizarea unui produs natural absorbant pentru a creşte eficienţa procesului de biodegradare a hidrocarburilor din petrol.*

Key words**:** *bioremediation, polluted soils, petroleum hydrocarbons*
Cuvinte cheie: *bioremediere, soluri poluate, hidrocarburi din petrol*

INTRODUCTION

Accidental and deliberate crude oil spills have been, and still continue to be, a significant source of environmental pollution, and poses a serious environmental problem, due to the possibility of air, water and soil contamination/pollution.

Bioremediation is not a new concept and is being increasingly used as a relatively economical environmental remediation technology. Bioremediation, when properly managed, is an environmentally good and low-cost method of treating soils containing organic chemicals.

There has been increasing interest by researchers in the application of organisms and absorbents to contaminated/polluted soils for enhance crude oil biodegradation. Bioremediation is a process that uses microorganisms or their enzymes to transform petroleum hydrocarbons into CO_2 and H_2O.

The most important classes of organic pollutants in the environment are mineral oil constituents and halogenated products of petrochemicals. Therefore, the capacities of aerobic microorganisms are of particular relevance for the biodegradation of such compounds and are exemplarily described with reference to the degradation of aliphatic and aromatic hydrocarbons.

The most rapid and complete degradation of the majority of pollutants is brought about under aerobic conditions. The bioremediation rate is controlled by three major processes: a) the oxygen-transfer process from the air into the aqueous solutions, b) the oil-transfer process from the soil into the aqueous solutions, c) biodegradation rate of oil in aqueous solution.

Bioremediation of polluted soils has an important role in environment protection.

MATERIALS AND METHOD

The main objective of this research is testing the natural hydrocarbon absorbent named ECOSOL. It is tested the capacity to increase the biodegradation of petroleum hydrocarbons by stimulating the soil existing bacteria.

To achieve data concerning the bioremediation of polluted soil with petroleum hydrocarbons was realized a greenhouse experiment. The soil used for this experiment (calcic chernozems) was reaped from arable layer 0-20 cm (Teleorman). This type of soil was chosen because of its currency in our country, also, for its physical, chemical and biological properties favorable to plant growth.

The chemical characteristics of soil used in the experiment are presented in table 1.

Table 1

The chemical characteristics of the soil

Soil type	pH	Organic Carbon (%)	Total Nitrogen (%)	C/N ratio
Calcic chernozem	8,09	2,99	0,279	12,5

The experimental variants are:

- ✓ V_1, control (unpolluted soil);
- ✓ V_2, polluted soil with 5% crude oil;
- ✓ V_3, polluted soil with 10% crude oil;
- ✓ V_4, polluted soil with 5% crude oil + 50 g ECOSOL;
- ✓ V_5, polluted soil with 5% crude oil + 50 g ECOSOL + bacterial inoculum;
- ✓ V_6, polluted soil with 5% crude oil + 100 g ECOSOL;
- ✓ V_7, polluted soil with 5% crude oil + 100 g ECOSOL + bacterial inoculum;
- ✓ V_8, polluted soil with 10% crude oil + 100 g ECOSOL;
- ✓ V_9, polluted soil with 10% crude oil + 100 g ECOSOL + bacterial inoculum;
- ✓ V_{10}, polluted soil with 10% crude oil + 200 g ECOSOL;
- ✓ V_{11}, polluted soil with 10% crude oil + 200 g ECOSOL + bacterial inoculum.

At the beginning of the experiment, the soil was contaminated/polluted with crude oil and conditioned with the natural hydrocarbon absorbent (ECOSOL). After 21 days from pollution, the soil was inoculated with bacteria. The bacterial inoculum was developed from microorganisms that occur naturally in the soil like *Pseudomonas, Mycobacterium, Arthrobacter globiformis* and *Bacillus megaterium.*

RESULTS AND DISCUSSION

The treatment of calcic chernozem with two different concentrations of crude oil and different quantities of the natural hydrocarbon absorbent determined a decrease of total petroleum hydrocarbons.

The preliminary results obtained shows that the biodegradation takes time. A decrease was recorded in time and this agrees with the observation existing in scientific literature.

Each value for total petroleum hydrocarbons concentration represents the mean of 3 replicates.

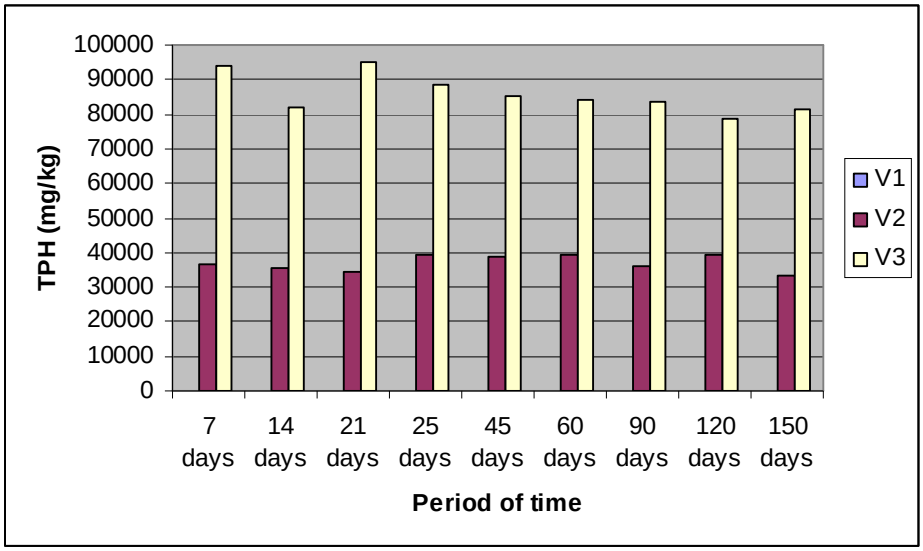

Figure1. The evolution of total petroleum hydrocarbons (TPH) concentration in unpolluted soil, polluted soil with 5% crude oil and polluted soil with 10% crude oil (V_1,V_2, V_3)

The evolution of total petroleum hydrocarbons concentration with time in experimental variant V_1 - unpolluted soil, V_2 - polluted soil with 5% crude oil and V_3 - polluted soil with 10% crude oil is presented in figure 1. The figure shows that total petroleum hydrocarbons values were higher on experimental variants with polluted soils compared to the control suggesting the presence of crude oil.

The total petroleum hydrocarbons concentration decreases in time with 8%, respectively 12% in the polluted soil with 5%, respectively 10% crude oil.

The evolution of total petroleum hydrocarbons concentration in the polluted soil with 5% crude oil conditioned with 50 g ECOSOL is presented in figure 2. As it can be observed, total petroleum hydrocarbons decrease in time with 12% in the case of V_4 experimental variant comparatively with the inoculated variant V_5 in which the decrease was by 17%.

The evolution of total petroleum hydrocarbons concentration in the polluted soil with 5% crude oil conditioned with 100 g ECOSOL is presented in figure 3. The total petroleum hydrocarbons concentration decreases with 20% in V_6 experimental variant and with 25% in the inoculated variant V_7.

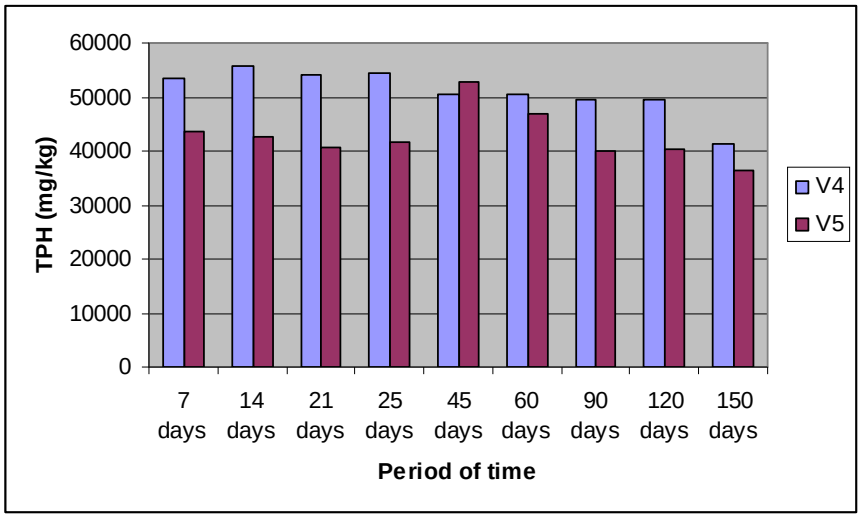

Figure2. The evolution of total petroleum hydrocarbons (TPH) concentration in the polluted soil with 5% crude oil conditioned with 50 g ECOSOL (V_4 and V_5)

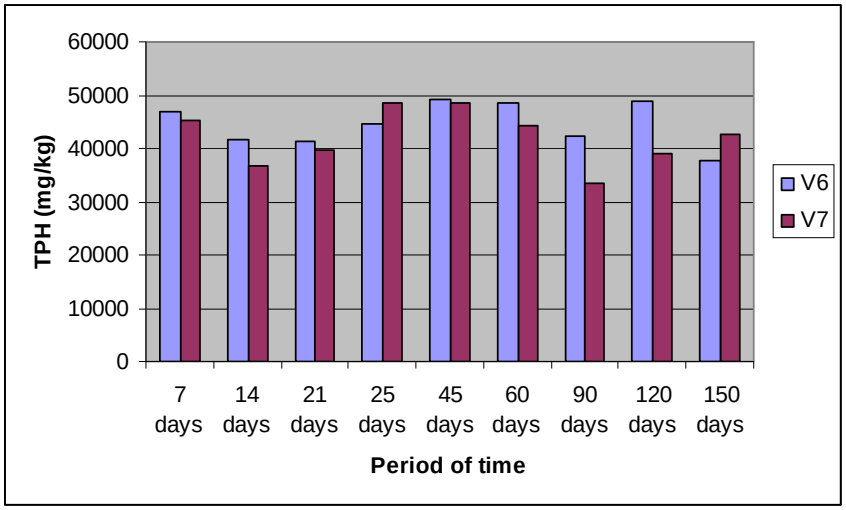

Figure3. The evolution of total petroleum hydrocarbons (TPH) concentration in the polluted soil with 5% crude oil conditioned with 100 g ECOSOL (V_6 and V_7)

In the experimental variants polluted with 5% crude oil, conditioned with 50 g ECOSOL, respectively 100 g ECOSOL, the decrease were by 10%, respectively 20%. In the experimental variants polluted with 5% crude oil, inoculated with bacteria, conditioned with 50 g ECOSOL, respectively 100 g ECOSOL, the decrease were by 17%, respectively 25%.

As a preliminary conclusion, the experimental variant recommended to remediate a polluted soil with 5% crude oil could be the one treated with 100 g ECOSOL and bacterial inoculum.

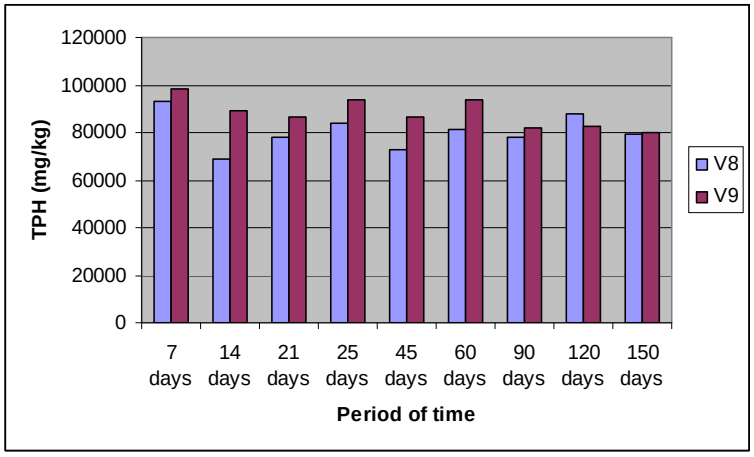

Figure4. The evolution of total petroleum hydrocarbons (TPH) concentration in the polluted soil with 10% crude oil conditioned with 100 g ECOSOL (V_8 and V_9)

The evolution of total petroleum hydrocarbons concentration in the polluted soil with 10% crude oil conditioned with 100 g ECOSOL is presented in figure 4. As it can be observed, total petroleum hydrocarbons concentration decrease in time with 15% in the case of V_8 experimental variant comparatively with the inoculated variant V_9 in which the decrease was by 20%.

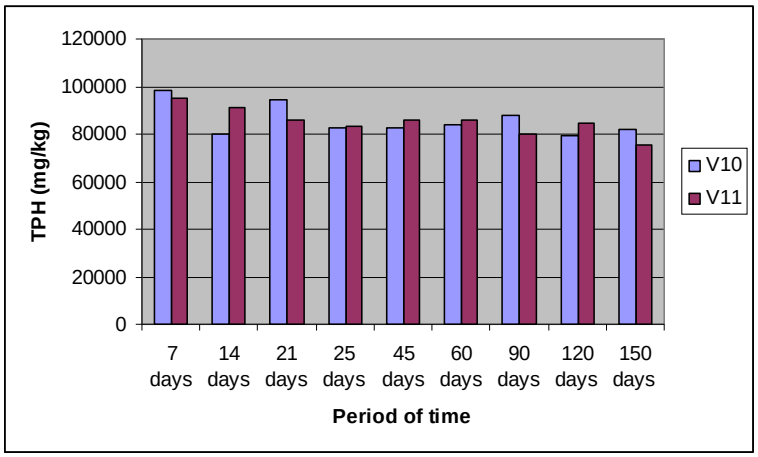

Figure5. The evolution of total petroleum hydrocarbons (TPH) concentration in the polluted soil with 10% crude oil conditioned with 200 g ECOSOL (V_{10} andV_{11})

The evolution of total petroleum hydrocarbons concentration in the polluted soil with 10% crude oil conditioned with 200 g ECOSOL is presented in figure 5. The total petroleum hydrocarbons concentration decreases with 18% in V_{10} experimental variant and with 22% in the inoculated variant V_{11}.

In the experimental variants polluted with 10% crude oil, conditioned with 100 g ECOSOL, respectively 200 g ECOSOL, the decrease were by 15%, respectively 20%. In the

experimental variants polluted with 10% crude oil, inoculated with bacteria, conditioned with 100 g ECOSOL, respectively 200 g ECOSOL, the decrease were by 18%, respectively 25%.

As a preliminary conclusion, the experimental variant recommended to remediate a polluted soil with 10% crude oil could be the one treated with 200 g ECOSOL and bacterial inoculum.

CONCLUSIONS

The experimental research showed the following preliminary conclusions:

- ✓ For a polluted soil with 5% crude oil it is recommended to be treated with 100 g ECOSOL and bacterial inoculum to increase the biodegradation of petroleum hydrocarbons.
- ✓ For a polluted soil with 10% crude oil it is recommended to be treated with 200 g ECOSOL and bacterial inoculum to increase the biodegradation of petroleum hydrocarbons.

The experimental research will continue in Green House on the same polluted soil with plant cultivation to follow the growth and behaviour in function with total petroleum hydrocarbons concentrations, the treatment with ECOSOL and bacterial inoculum.

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