BIODEGRADATION OF PETROLEUM HYDROCARBONS IN AN ARTIFICIAL POLLUTED SOIL

BIODEGRADAREA HIDROCARBURILOR DIN PETROL ÎNTR-UN SOL POLUAT ARTIFICIAL

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Abstract: *Biodegradation is the process by which organic substances are broken down by the enzymes produced by living organisms. The term is often used in relation to ecology, waste management and environmental remediation (bioremediation). Some microorganisms have the capacity to degrade, transform or accumulate petroleum hydrocarbons. Bioremediation of petroleum hydrocarbon contaminated soils has been recognized as an efficient, economic, versatile and environmentally good treatment. Inadequate bioavailability of the hydrocarbons to microorganisms due to low solubility is a limiting step in biodegradation. So, it must be found a method to increase the microorganisms activity. This research is based on the microorganisms activity increase by adding natural absorbent biodegradable and bacterial inoculums. 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 results obtained in greenhouse experiment concerning the bioremediation of artificial polluted soil using a natural hydrocarbon absorbent product and bacterial inoculums to enhance the biodegradation of petroleum hydrocarbons. The plant use in the experiment was maize. These are some preliminary results, therefore the experimental research will continue in Green House on the same polluted soil.*

Rezumat: *Biodegrarea este un process prin care substanţele organice sunt degradate de enzimele produse de microorganismele din sol. Termenul este adeseori utilizat în legatură cu ecologia, managementul deseurilor şi remedierea mediului inconjurator (bioremediere). Unele microorganisme au capacitatea de a degrada, a transforma sau a acumula hidrocarburile din petrol. Bioremedirea solurilor contaminate cu hidrocarburi din petrol este o metodă eficientă, economică şi fără impact asupra mediului înconjurător. Biodisponibilitatea hidrocarburilor la activitatea microorganismelor este proporţională cu solubilitatea acestora, factor limitativ al biodegradării. De aceea, se încearcă găsirea unei metode de creştere a activităţii microorganismelor. Această cercetare are la bază creşterea activităţii microorganismelor prin adăugarea unui produs biodegradabil natural şi a inoculului bacterian. Eliminarea hidrocarburilor din petrol din mediul este o cerinţă obligatorie în promovarea unei dezvoltări durabile. În această lucrare sunt prezentate rezultatele obţinute în cadrul unui experiment realizat în casa de vegetaţie privind bioremedierea solului poluat artificial cu hidrocarburi din petrol prin utilizarea unui produs natural biodegradabil şi a inoculului bacterian pentru a creşte rata biodegradabilităţii. Planta utilizată a fost porumbul. Rezultatele prezentate sunt preliminarii, cercetarea va continua în casa de vegetaţie pe acelaşi sol poluat.*

Key words**:** *biodegradation, artificial polluted soil, petroleum hydrocarbons*
Cuvinte cheie**:** *biodegradare, sol poluat artificial, hidrocarburi din petrol*

INTRODUCTION

Crude oil contamination/pollution is a frequent and very serious problem all over the world, also in Romania, mainly at the transformer stations. Biodegradation of petroleum hydrocarbons in the environment may be limited by a large number of factors. An important limiting factor in the bioremediation of contaminated/polluted soils is often the low

bioavailability and solubility of the hydrocarbon (MOLNÁR et al., 2005).

The hydrocarbon degrading microorganisms occur in most environments, where hydrocarbons may serve as organic carbon sources. Bioremediation, is based on the use of microorganisms or microbial processes to degrade environmental contaminants, and offers several advantages over the conventional chemical and physical technologies. It can be a cost effective, environmental friendly technology. Biodegradation is defined as the biologically catalyzed reduction in complexity of chemical compounds (ALEXANDER, 1994; PEPPER, 1996).

Bioaugmentation is frequently used for the enhancement of the biodegradative capacities of soils contaminated with poorly degradable crude oil hydrocarbon compounds (HWANG and CUTRIGHT 2002).

Augmentation is the reinoculation of indigenous microorganisms directly isolated from the contaminated soil (MARGESIN et al. 2000) or the inoculation of a specific consortium. A fast degradation rate can be observed after bioaugmentation with microorganisms adapted to the contaminant (VOGEL 1996).

MATERIAL AND METHODS

The aim of this research was carried out to prove the efficiency of a biodegradable product of the existing microorganisms and the inoculation of microbial consortium on the bioremediation process in crude oil contaminated soil.

To achieve data concerning the bioremediation of polluted soil with petroleum hydrocarbons was realized a greenhouse experiment.

The soil used in experiment was s cambic chernozem from Teleorman. The plant used in experiment was maize.

The experiment had 11 experimental variants with soil polluted 5% and 10% crude oil, treated with 50g, 100g and 200g ECOSOL, inoculated and no-inoculated with bacteria selected according to the experimental scheme presented in table 1.

Table 1

The experimental scheme of the variants from Green House

Experimental variant	The name of experimental variant	Crude oil concentration (%)	ECOSOL Treatment (g)	Bacterial inoculums
V_1	Control	-	-	-
V_2	Polluted soil	5	-	-
V_3	Polluted soil	10	-	-
V_4	Polluted soil	5	50	-
V_5	Polluted soil	5	50	Yes
V_6	Polluted soil	5	100	-
V_7	Polluted soil	5	100	Yes
V_8	Polluted soil	10	100	-
V_9	Polluted soil	10	100	Yes
V_{10}	Polluted soil	10	200	-
V_{11}	Polluted soil	10	200	Yes

RESULTS AND DISCUSSIONS

The results obtained in the second experimental year shows that the biodegradation processes take time according to the existing literature data. A decrease was recorded in time and this agrees with the observation existing in scientific literature.

This study was necessary to observe the influence of the treatment with ECOSOL and bacterial inoculums on biodegradation rate of petroleum hydrocarbons. It was registered an increase of biodegradation in time. Soil samples were sampled and analyzed in the beginning of the experiment, after 1 month, 2 months, 3 months, 4 months and 5 months.

The maize plants grew up in the experimental variants with unpolluted soil and soil polluted with 5% crude oil. In the experimental variants with soil polluted with 5% crude oil the maize harvest was two times lower than control. The high concentration of crude oil determined the unappearance of maize plant in the experimental variant with soil polluted 10% crude oil. The phytotoxicity was to higher in these plots.

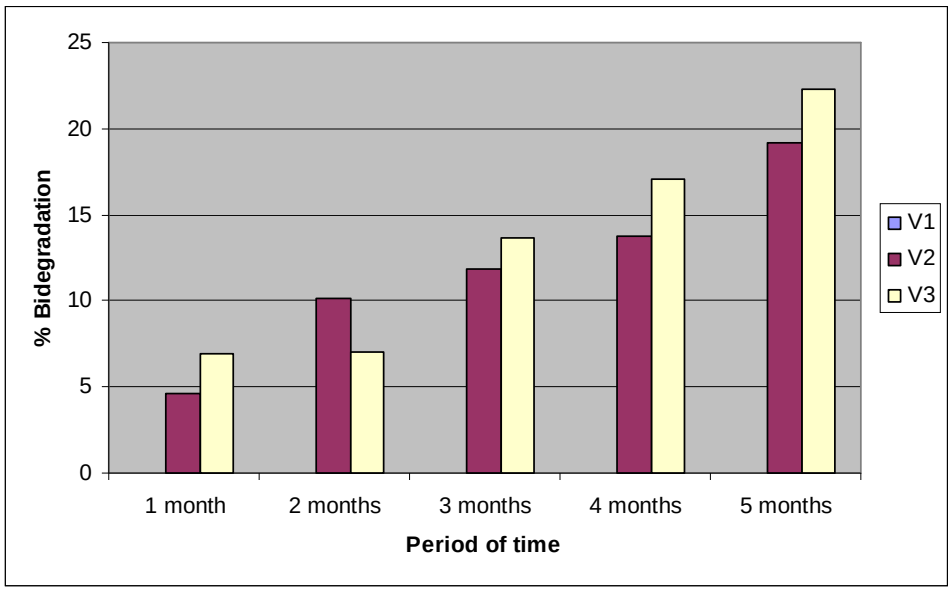

Figure1. Biodegradation of petroleum hydrocarbons in time in unpolluted soil, polluted soil with 5% crude oil and polluted soil with 10% crude oil (V_1,V_2, V_3)

The biodegradation of petroleum hydrocarbons 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 biodegradation values were higher in experimental variants with polluted soils compared to the control suggesting the biodegradation of crude oil.

The biodegradation increases in time, reaching a value by 19%, respectively 22% in the polluted soil with 5%, respectively 10% crude oil.

The biodegradation of petroleum hydrocarbons in the polluted soil with 5% crude oil conditioned with 50 g ECOSOL is presented in figure 2. As it can be observed, the biodegradation rate increases in time with 21% in the case of V_4 experimental variant comparatively with the inoculated variant V_5 in which the increase was by 39%.

The biodegradation of petroleum hydrocarbons in the polluted soil with 5% crude oil conditioned with 100 g ECOSOL is presented in figure 3. The biodegradation rate increases in time reaching a value by 30% in both experimental variants.

As it can be observed, in the experimental variants polluted with 5% crude oil, conditioned with 50 g ECOSOL, respectively 100 g ECOSOL, the increase of biodegradation were by 21%, respectively 30%. In the experimental variants polluted with 5% crude oil, inoculated with bacteria, conditioned with 50 g ECOSOL, respectively 100 g ECOSOL, the increase were by 39%, respectively 30%.

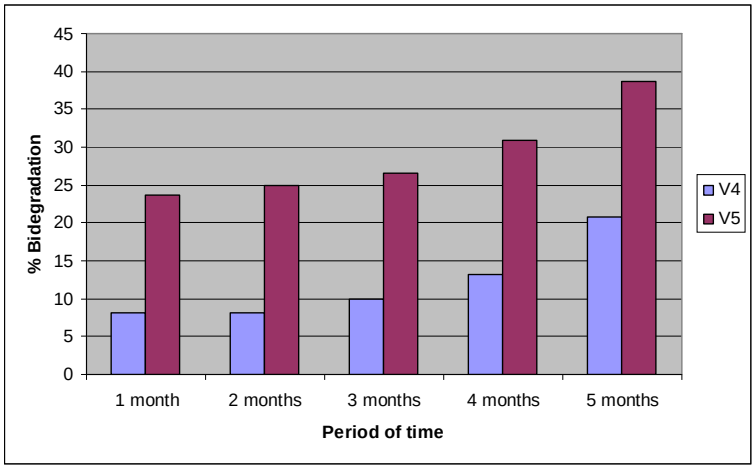

Figure 2. Biodegradation of petroleum hydrocarbons in the polluted soil with 5% crude oil conditioned with 50 g ECOSOL (V_4 and V_5)

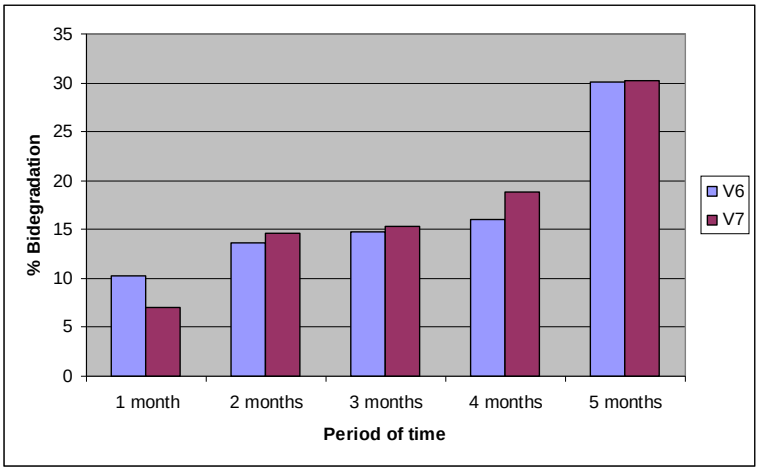

Figure 3. Biodegradation of petroleum hydrocarbons in the polluted soil with 5% crude oil conditioned with 100 g ECOSOL (V_6 and V_7)

The treatment recommended to remediate a polluted soil with 5% crude oil could be the treatment with 1050 g ECOSOL/m^2 polluted soil, 0-40 cm depth, and bacterial inoculums.

The biodegradation of petroleum hydrocarbons in the polluted soil with 10% crude oil conditioned with 100 g ECOSOL is presented in figure 4. As it can be observed, the biodegradation rate increases in time reaching a value by 13% in the case of V_8 experimental variant comparatively with the inoculated variant V_9 in which the increase was by 20%.

The biodegradation of petroleum hydrocarbons in the polluted soil with 10% crude oil conditioned with 200 g ECOSOL is presented in figure 5. The biodegradation of petroleum hydrocarbons increases with 13% in V_{10} experimental variant and with 18% in the inoculated variant V_{11}.

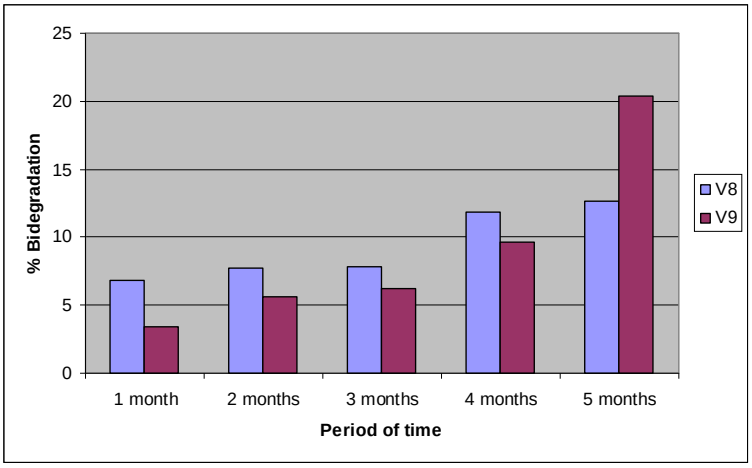

Figure 4. Biodegradation of petroleum hydrocarbons in the polluted soil with 10% crude oil conditioned with 100 g ECOSOL (V_8 and V_9)

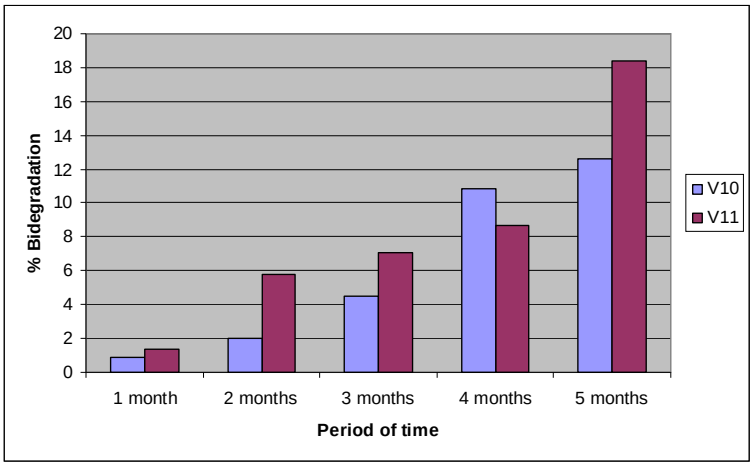

Figure 5. Biodegradation of petroleum hydrocarbons in the polluted soil with 10% crude oil conditioned with 200 g ECOSOL (V_{10} and V_{11})

In the experimental variants polluted with 10% crude oil, conditioned with 100 g ECOSOL, respectively 200 g ECOSOL, the increase of biodegradation rate were by 13%, in both experimental variants. In the experimental variants polluted with 10% crude oil, inoculated with bacteria, conditioned with 100 g ECOSOL, respectively 200 g ECOSOL, the increase were by 20%, respectively 18%.

The treatment recommended to remediate a polluted soil with 10% crude oil could be the treatment with 2100 g ECOSOL/m^2 polluted soil, 0-40 cm depth, and bacterial inoculum.

CONCLUSIONS

The maize plants grew up in the experimental variants with unpolluted soil and soil polluted with 5% crude oil. In the experimental variants with soil polluted with 5% crude oil the maize harvest was two times lower than control. The high concentration of crude oil determined the non-appearance of maize plant in the experimental variant with soil polluted 10% crude oil. The phytotoxicity was to higher in these plots.

The treatment recommended to remediate a polluted soil with 5% crude oil could be the treatment with 1050 g ECOSOL/m^2 polluted soil, 0-40 cm depth, and bacterial inoculum.

The treatment recommended to remediate a polluted soil with 10% crude oil could be the treatment with 2100 g ECOSOL/m^2 polluted soil, 0-40 cm depth, and bacterial inoculum.

The research will continue in Green House to obtain more data concerning this important environmental problem.

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