ARE SOIL AND BIOREMEDIATION IN FOCUS OF SUSTAINABLE GREEN CHEMISTRY AND ENGINEERING?

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INTRODUCTION

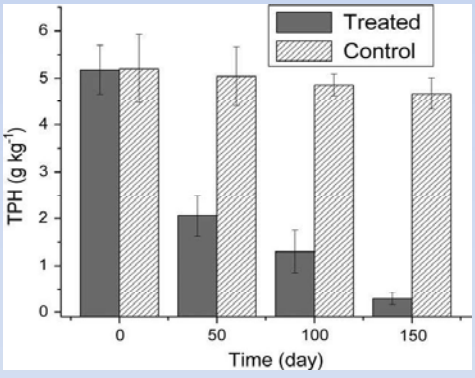
Usually the interest in, investigation of, development and application of principles of green chemistry and engineering are directed towards concrete chemical substances and processes and the same applies to fuels as one of key resources for the survival of civilization.

On the other hand, soil is the most dynamic four-stage (solid-liquid-gaseous-biological stage) ecosphere which is essential for the provision of food to the ever-growing population of our planet. At the same time, soil is exposed to all forms of devastation, including extensive and heavy pollution by a variety of dangerous substances, among which components of oil and oil derivatives are the most frequent pollutants. Also, spontaneous paedogenesis is the slowest process by far in comparison to the anthropogenic devastation of soil. The application of non-pathogenic microorganisms (plants to a smaller extent and an insignificant number of animals) for biological transformations and decontamination of the polluted soil and the disintegration of pollutants under the controlled conditions are bioremediation procedures that most often result in the complete mineralization, producing clean soil and soilfield material with consortia of microorganisms and humic substances that are fundamental for fertility.

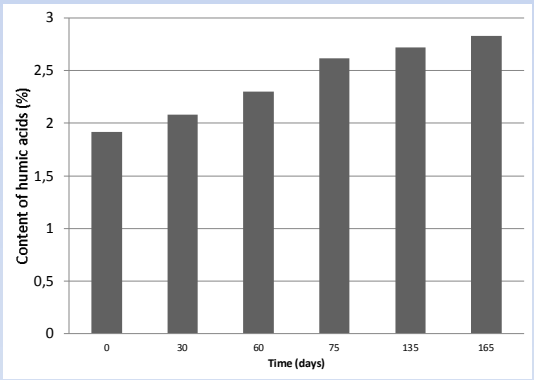
Bioremediation is a (bio)technology which is compatible with all the principles of green chemistry and engineering and it is sustainable since it conserves and generates the soil as a "non-renewable" resource.

EXPERIMENTAL

This paper comprises results of our multi-year work on microbiological disintegration of oil and oil derivatives through the application of selected and adapted consortia of zymogenous microorganisms, staring from the laboratory level to *in situ/ex situ* bioremediation procedures applied to thousands of tons. The initial levels of pollution were up to cc. 40 g/kg DM total petroleum hydrocarbons and after maximum 6 months the concentration was reduced to cc. 0.5 g/kg DM (99% efficacy) with the disintegration and persistent steranesand triterpanes (hopanes) and a segment of the NSO-fraction! The concentration of humic substances was reduced at the beginning to be increased in the end. The composition of the consortium of microorganisms changed, depending on the bioremediation stage, *i.e.* the stage of decomposition of pollutants, but the total number amounted to 10^8-10^{10} CFU/g all the time (Beškoski et al. 2011, Miletić et al. 2014).



Reductions in TPH concentrations during bioremediation (bar is ± standard deviation for five measurements).



Content of humic acids

CONCLUSIONS

To conclude, our results as well as data obtained by other investigators confirm that attention should be paid to soil and bioremediation in the light of interpreting pedosphere and biological processes in it as sustainable ecological "raw material", harmonized with the principles of green chemistry and engineering particularly due to the absence of negative effects on the environment.

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