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## Multistage *in situ* bioremediation of aquifer contaminated with petroleum pollutants

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The locality of the company Niteks-Benetton in Niš (Serbia) was contaminated over several years with petroleum products due to the continuous pollution from leaking tanks. Ground waters (GW) which contained dissolved hydrocarbons and a floating layer of an oil pollutant (Light Non-Aqueous Phase Liquid - LNAPL) were treated with filtration-adsorption remediation technique, using the columns filled with natural inorganic hydrophobic adsorbents, and *in situ* bioremediation based on the principle of “bipolar” model, which was developed and tested by some of the authors of this research. *In situ* bio/remediation of GW and soil layers in contact with groundwater was accomplished by chemical and biological stimulation, augmentation and aeration in closed “bipolar” system (pumping out – pumping in), with adsorption in the “external unit”. This combination of methods is original and applied for the first time. Natural microbial processes in groundwater were additionally stimulated by chemical or physical increase in the aeration capacity. Bioaugmentation was achieved by injection of biomass of zymogenous microorganisms isolated from treated polluted GW [1,2].

Basic characteristics of treated GW are shown in the Table. The change in the content of the “mineral oil” – total petroleum hydrocarbons and the consortium of chemoorganoheterotrophic and hydrocarbon degrading microorganisms in the samples of water treated by bipolar system are shown in the picture.

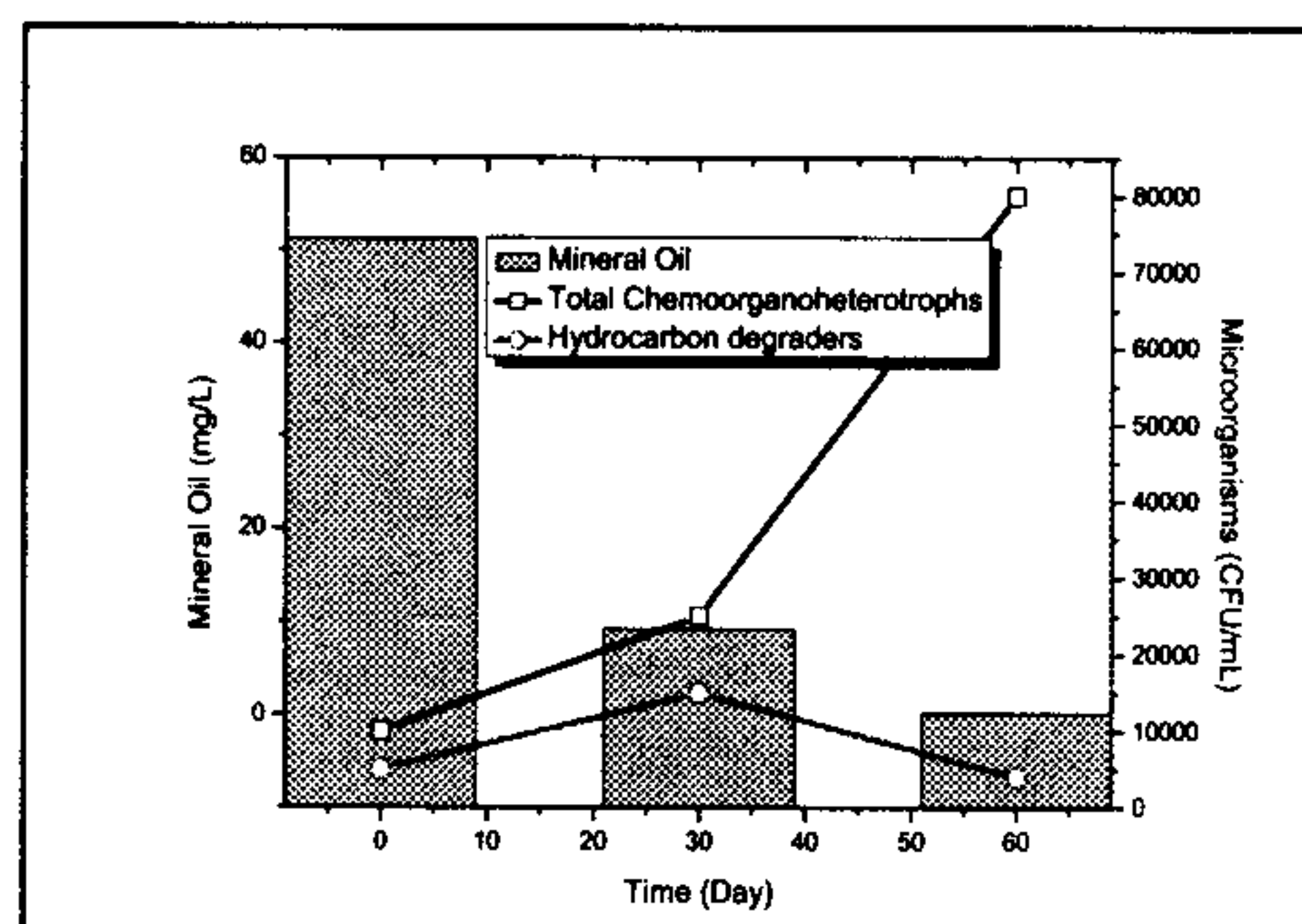
Basic characteristics of the GW during the treatment

Date [2012 Y]	t <sub>water</sub> [°C]	pH	NTU	O <sub>2</sub> [mg/L]	O <sub>2</sub> [%]
May, 1	15.4	6.9	80	3.4	34
June, 1	16.1	6.9	22	8.5	86
July, 1	16.9	7.0	5	8.8	91

After the *in situ* treatment, quality parameters of purified-waters complied with statutory criteria for groundwater which should not be treated.

### References:

1. S.A. Fam, D.M. Falatko, J.E. Higgins, S. Mountain, A.J. Pirelli, M. Gaudette, A universal design approach for *in situ* bioremediation developed from multiple project sites, Remediation Journal, 22 (4), 49–74, 2012
2. T.C., Hazen, In situ groundwater bioremediation, Lawrence Berkeley National Laboratory, 2010, (<http://escholarship.org/uc/item/6s84h5qk>)



Changes in concentrations of microorganisms from „mineral oil“.