CEPTA – Centre for Sustainable Alternatives,
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Remediation of Hydrocarbon-Contaminated Soil by Vermicompost Tea

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Place of remediation

Disposal site of liquid industrial waste – in company Bučina DDD, s.r.o. Zvolen

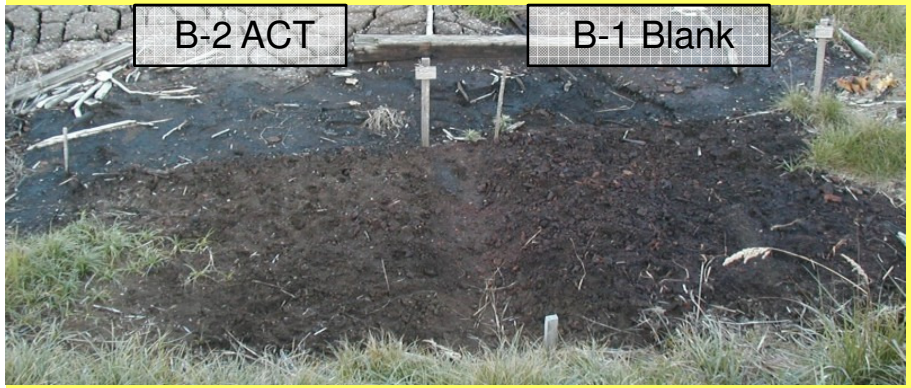
Liquid waste from wood impregnation was disposed here.

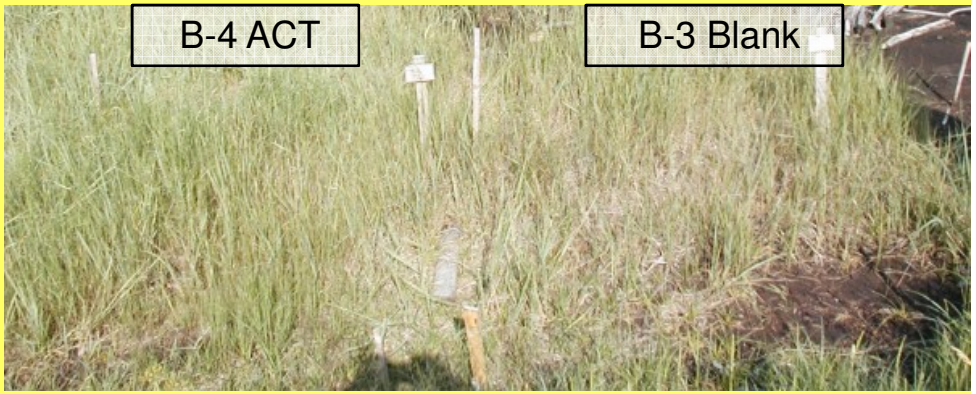
The main contaminant are rests of impregnation oil.

Experimental sites

- soil is highly contaminated by hydrocarbons (25 – 33 mg of non-polar extractives per g of soil)
- 4 experimental sites were estabmished:

Site	Area [m^2]	description	application
B-1 Blank	4	almost without vegetation	water (15 l/m^2)
B-2 ACT	4	almost without vegetation	ACT (15 l/m^2)
B-3 Blank	2,25	covered by vegetation	water (15 l/m^2)
B-4 ACT	2,25	covered by vegetation	ACT (15 l/m^2)





Vermicompost

Vermicompost – compost made by earthworms (e.g. *Eisenia foetida*)

By digestion of organic matter, earthworms produce excrements – lumpy mixture of inorganic substances, humus and organic matter, enriched by high amount of microorganisms from alimentary tract of earthworms.

Vermicompost tea - ACT

Vermicompost tea - Aerated Compost Tea (ACT) – mixture of solved nutritiens enriched by non-phatogenic microorganisms. This combination is benefitial for plants, it improves plant growth and biological condition of soil, and also suppresses plant – pathogenic microorganisms.

Hypothesis:
Rich microflora in ACT is assumption for decomposing of hydrocarbon contamination. Plant-benefitial properties of ACT are assumption for remediation of soil.

Preparation of ACT:
vermicompost tea was brewed 24 hours in 850 l extraction vessel by intensive aeration.

Experiment

Experiment duration: 09/2006 – 10/2007 – 2 vegetation seasons: end of the vegetation season 2006, whole vegetation season 2007

Total number of ACT/water applications:

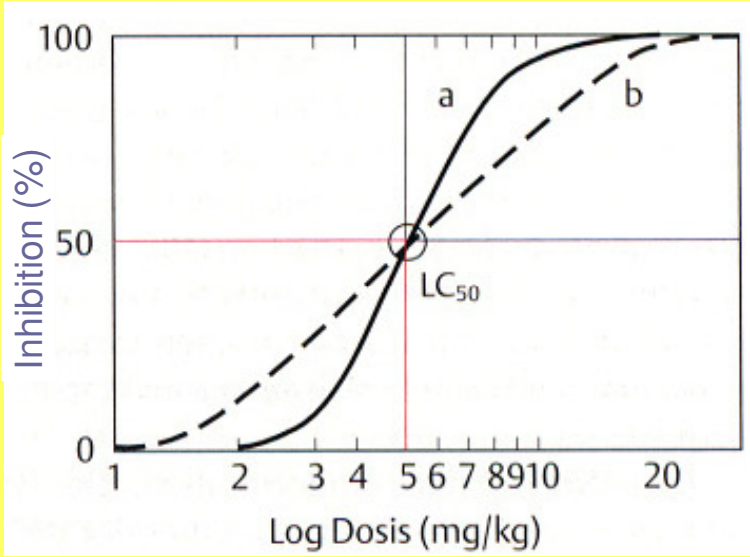
7; (1 application per 1 – 2 month during vegetation season)

Total number of soil sampling for **ecotoxicity** and **hydrocarbon analysis**: 4 (before the first application, at the end and at the beginning of the vegetation season, and after all applications)

Other research:

- **botanic research** - sampling and measurement during the vegetation season 2007
- **microbial research** – sampling and measurement during 2007

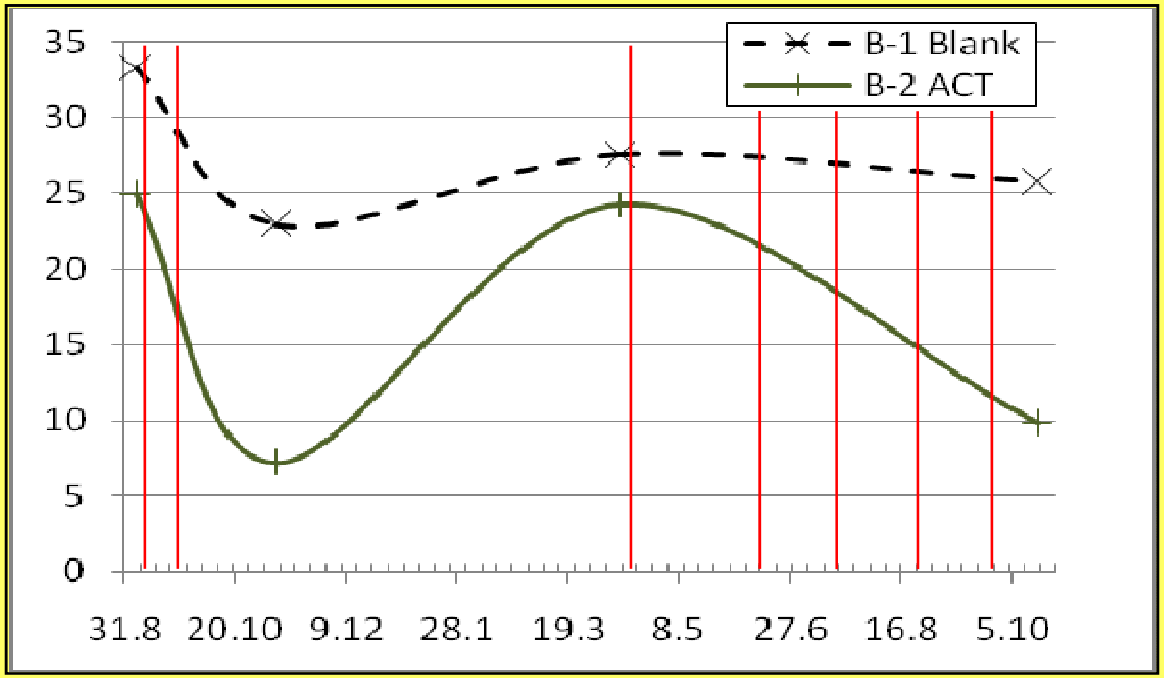
Ecotoxicity – property of matter, compound or part of the environment (e.g. soil, water), which has a detrimental effect on living organisms
EC_{50} – concentration of sample (dosis) that causes 50 % inhibiton of tested organisms



Acute toxicity was expressed like EC_{50} and it was measured by:

- Cress (*Lepidium sativum*) according to OECD guidelines No. 208
- Duckweed (*Lemna minor*) according to ISO 20079
- Daphnids (*Daphnia magna*) according to OECD guidelines No. 202

Hydrocarbons – quantitative analysis

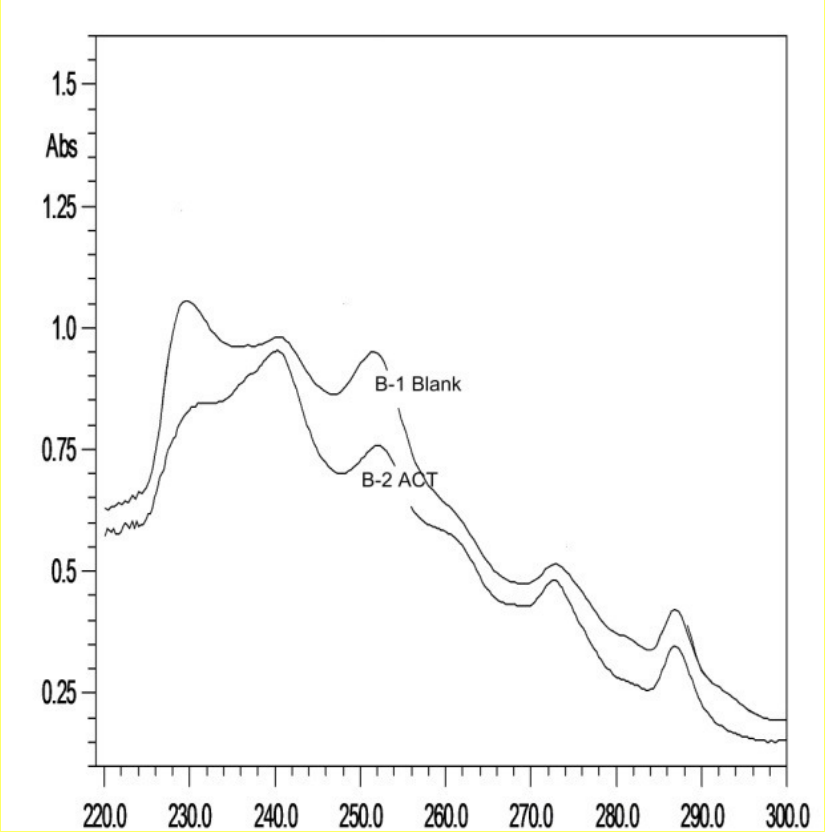


Hydrocarbons expressed like non-polar extractives in mg.g^{-1} of soil at experimental sites. Red lines are applications of water/ACT.

- there is a natural fluctuation (cca 15 – 30 %) in hydrocarbon content in soil – assumption: hydrocarbons are washed by rainfall and after that they are rose again by capillary attraction

- despite natural fluctuation, there is an evident decrease of hydrocarbon content due to ACT application (61 %)

Hydrocarbons – qualitative analysis

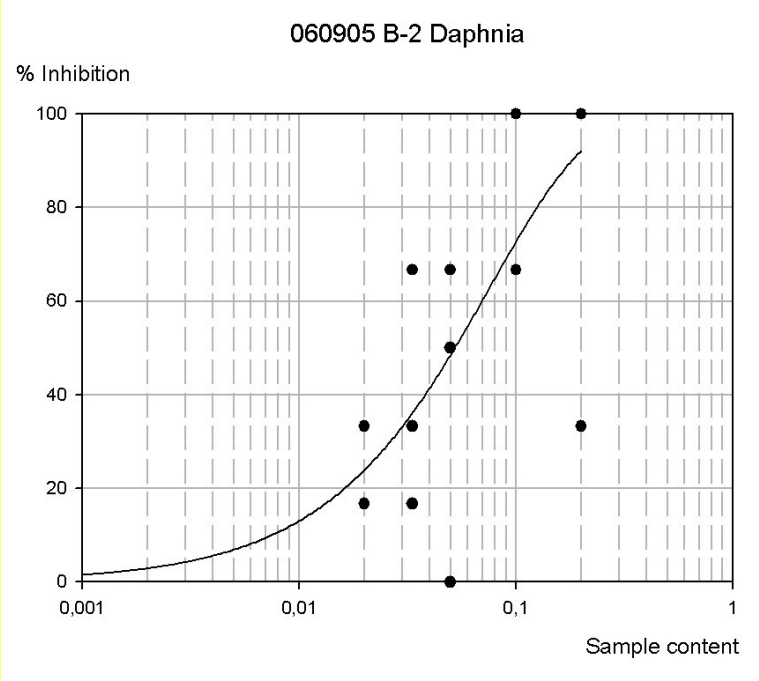


• at the end of the experiment heavy hydrocarbons like PAHs (fluoranten, fenantren, pyrene etc.) still remain in the soil

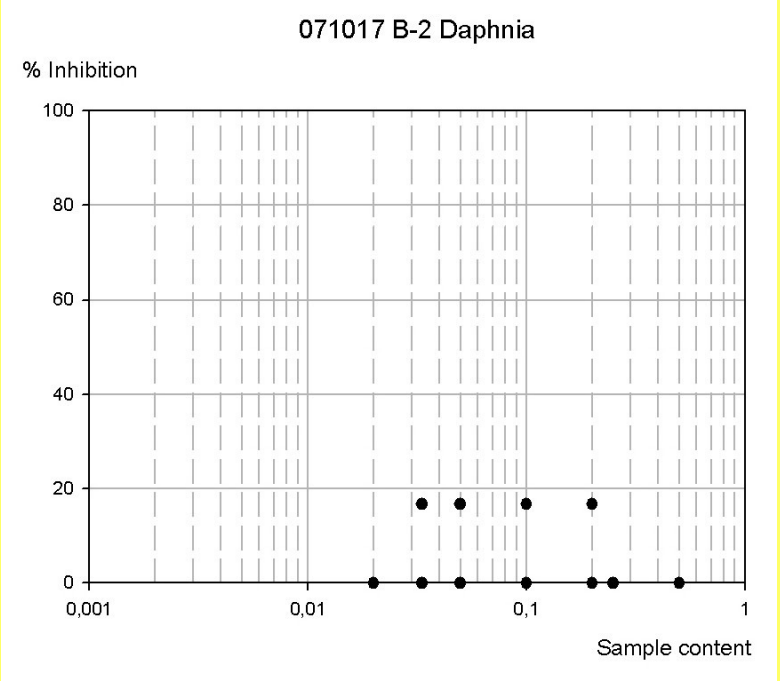
• PAHs are a problem for ensymatic system of common microorganisms. Only special, patented tribes of microorganisms can decompose PAHs.

Qualitative (spectral) analysis of non – polar extractives in soil of experimental sites after all applications. Peaks prove presence of PAHs. Axis x is wavelenght λ [nm].

Toxicity by daphnids (*Daphnia magna)*
according to OECD guidelines No. 202

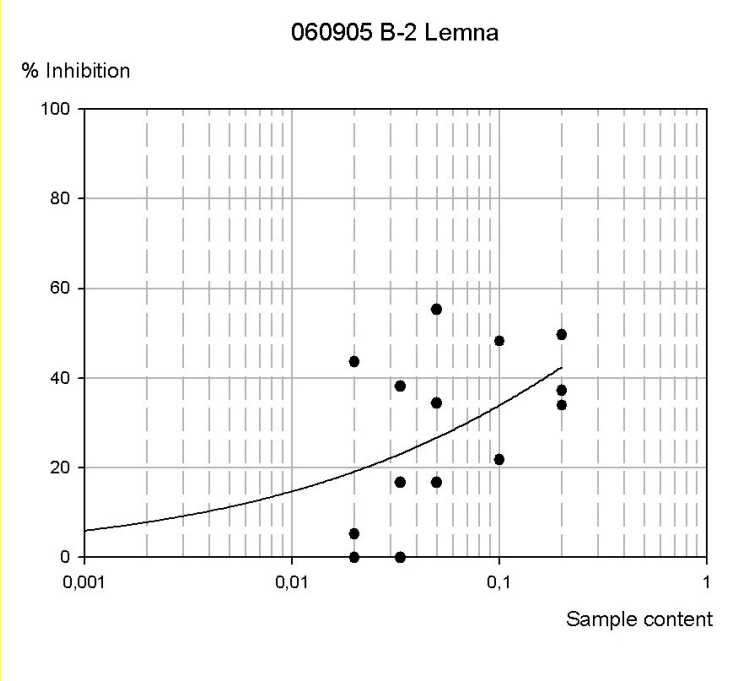


Site B-2 ACT before first application of ACT
EC_{50} = 0,0522

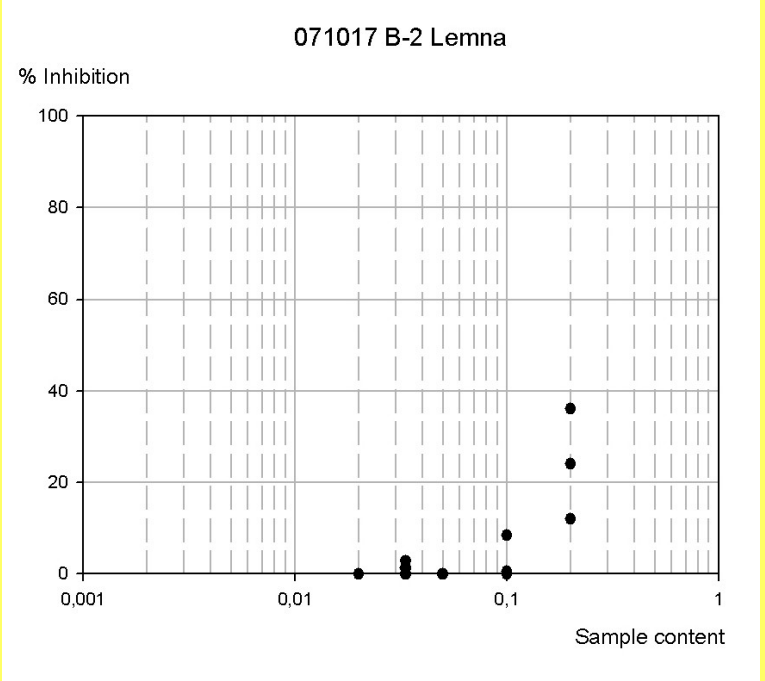


Site B-2 ACT after all applicatios of ACT
EC_{50} = n.d.

Toxicity by duckweed (*Lemna minor*)
according to norm ISO 20079



Site B-2 ACT before first application of ACT
EC_{50} = 0,3439



Site B-2 ACT after all applicatios of ACT
EC_{50} = n.d.

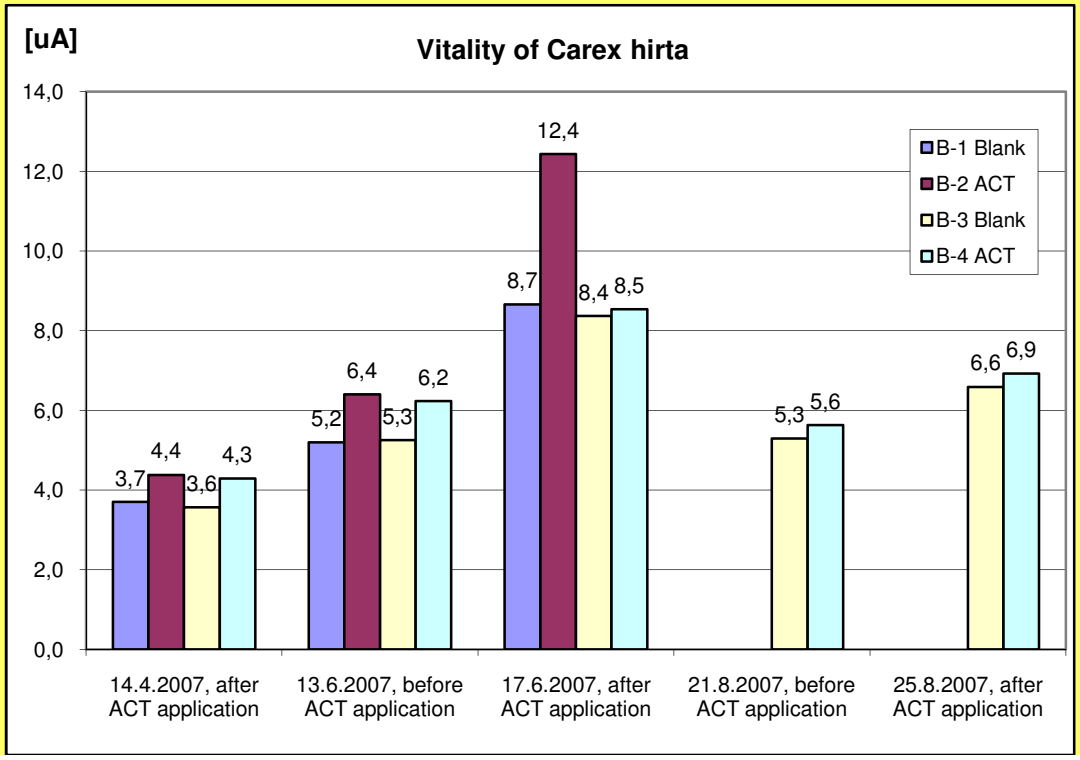
Botanical research

Carex hirta is a resistent species of herb, which is tolerant to hydrocarbon contamination of soil. It has grown at every experimental site.

No. of individuals of Carex hirta at experimental sites

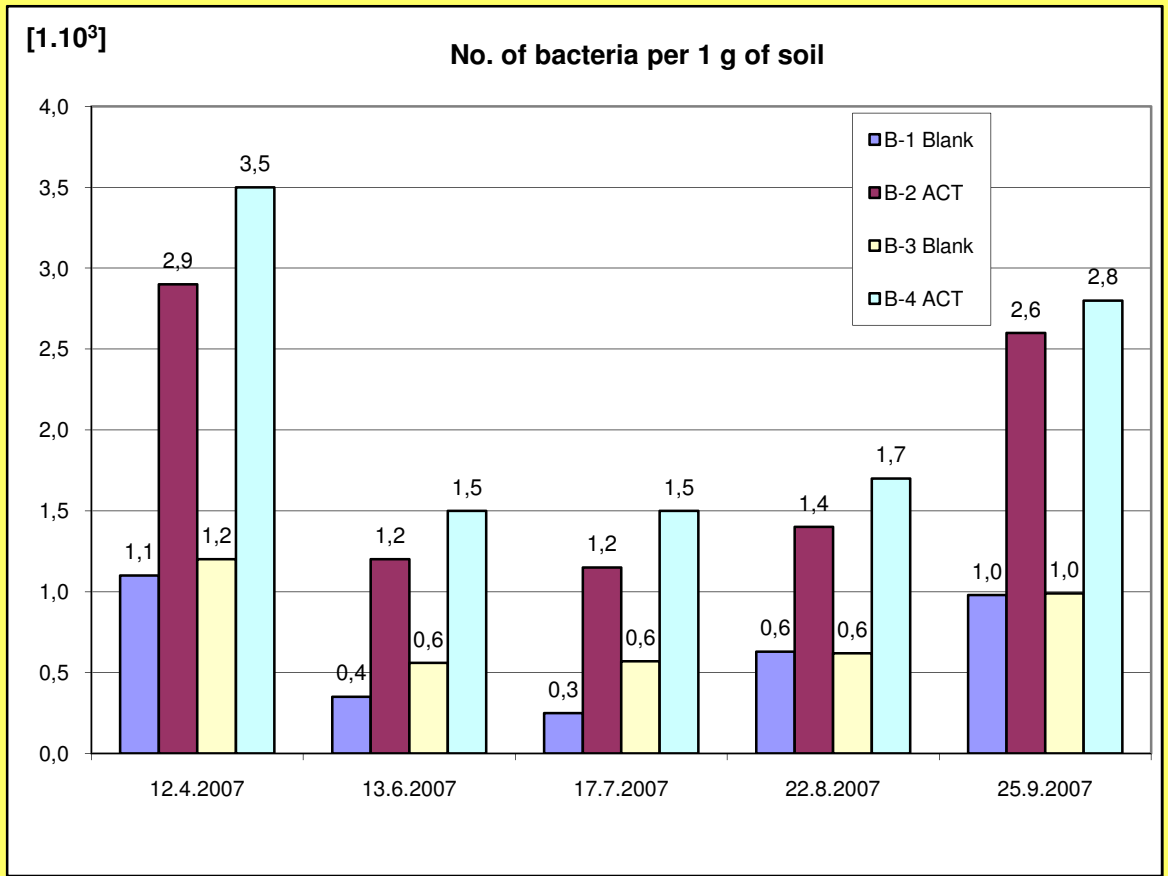
Site	No. of individuals [pc]		
	21.4.2007	30.7.2007	difference
B-1 Blank	18	21	+3
B-2 ACT	61	76	+15

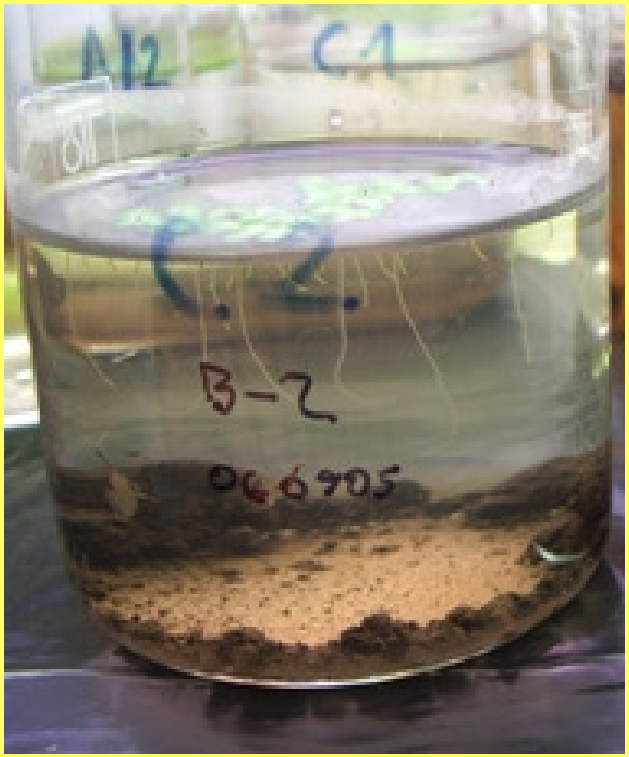
- At ATC sites, *Carex hirta has higher increment, larger and longer leaves and also better vitality (Graph).*



Microbial research

- nor in ACT, nor at experimental sites were found indicators of faecal pollution (enterococcus, thermotollerant coliform bacteria, coliform bacteria)
- at ACT sites there were much more bacteria and micromycetes than at the sites without application ACT (Blank)





Conclusion

• There was a significant reduction of the non-polar extractives content in soil (approximately 60%) due to the application of ACT

• ACT decomposes light hydrocarbons; polycyclic hydrocarbons as PAHs were not decomposed even after 7 applications of ACT during two vegetation periods

• The ecotoxicity tests showed significant decrease of ecotoxicity of contaminated soil. Vitality of plants and density of microorganisms were increased at the sites with application of ACT.

• ACT seems to be a relatively cheap agent for decontamination and remediation of soil contaminated by light fractions of oil (gassoline, petroleum kerosine, etc.)

• ACT is non-toxic natural product, beneficial for plants. Application in-situ has not secondary detrimental effects on the environment.

Ekotoxicological laboratory - CEPTA

Beside other activities we are focusing at ecotoxicology; acute toxicity of soil, sediments, water and waste water, different leachates...using:

- higher plants - cress (*Lepidium sativum*), alternatively wheat (*Triticum aestivum*), radish(*Raphanus sativus*), lettuce (*Lactuca sativa*), following OECD guidelines 208

- water plants - Duckweed (*Lemna minor*) according to ISO 20079 (STN 75 7747)

- water organisms – Daphnids (*Daphnia magna*) according to OECD guidelines No. 202; STN EN ISO 6341 (STN 75 7742)

- luminiscent bacteria (*Vibrio fischeri*), according to STN EN ISO 11348 (STN 75 7745)...

This research was realised in the frame of project BIODEG I ("Evaluation of pro-biotic effects of natural microorganic cultures from vermicompost tea on compost process and soil remediation", No. of contract: 141-51-018), in the programme INTERREG III A, with the support of European Union funds. We would like to thank to main project partners: KUKKONIA, Technical University in Zvolen
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