PHYTOREMEDIATION OF HYDROCARBON-CONTAMINATED SOIL, USING PLANTS

Smaranda Masu
National R & D Institute for Industrial Ecology ECOIND, Branch of Timisoara, 1 Regina Maria, Square, 300004, Timişoara, Romania; e-mail: smarandamasu@yahoo.com

ABSTRACT
Applying the complex treatment of sewage sludge fertilization and amendment of indigenous volcanic tuff of Marsid, caused a grass coverage degree of 85%. Plants grow similarly to those on normal agricultural soil. The reduction efficiency of Total Petroleum Hydrocarbons (TPH), from the soil fertilized with anaerobically stabilized sewage sludge of 25t/ha D.M. and amended with indigenous volcanic tuff 2.5 t/ha is of 33.7%, during a four month period, with over 10% more than the efficiency of reduction of the Total Petroleum Hydrocarbons content from the soil of the experimental variant fertilized with sewage sludge in the absence of amendments.

INTRODUCTION
Oil spills due to accidental or deliberate oil pipes damage can affect large areas of land. In this case only the presence of hydrocarbons in itself affect soil properties. But in most cases, hydrocarbons spreading, on soils, is associated with industrial activities. Oil dispersion occurs generally during its transport processes from the extraction site to processing plants. The presence of petroleum hydrocarbons (TPH) affects the structure or aggregation state of the soil, water retention capacity in soil, soil density and soil temperature [1-3]. Water retention capacity decreases dramatically in the presence of total petroleum hydrocarbons in the soil. Water is unable to infiltrate into the soil when the soil contains 150 ml of oil/kg D.M. soil. Instead, water retention capacity decreases in soils heavily polluted and therefore reduces the capacity to degrade organic compounds by microorganisms that can biodegrade petroleum hydrocarbons, only in aqueous medium. The presence of petroleum hydrocarbons increased the C : N ratio [4-5]. This determines the decrease of nitrogen content relative to carbon content. Micronutrients such as magnesium and calcium increased in the soil with the introduction/addition of oil. Petroleum hydrocarbons act on polluted soil similarly with herbicides, thus, these substances kill plants or cause a marked alteration plant tissues. Effects on plants vary depending on the properties of hydrocarbons present in the mixture of total petroleum hydrocarbons. Plants of certain families have higher tolerance for the presence of petroleum in the soil, than other plants. Thus, for a soil polluted with TPH in which the C: N is high initially, deficient nitrogen may become non bioavailable for plants for some time. [5-7]. Remediation processes by fitodegradation apply to soils containing organic pollutants. Assimilation of petroleum hydrocarbons is affected by their hydrophobic nature, their solubility and polarity. Compounds with moderately hydrophobic and polar characteristics are more likely to be taken over by absorption from plant roots.

Degradation of pollutants is accelerated by soil aeration (by plowing) and the addition of nutrients (fertilizer agents) [4-7].

MATERIALS and METHODS
Selected plants with proved potential for phytoremediation of soils contaminated with petroleum hydrocarbons was of grass, *Lolium perenne*. The experimental soil variants are: 1) Normal soil, control, adjacent to the polluted land – M; 2) Oil polluted soil – P; 3) Oil polluted soil, fertilized with sewage sludge from the municipal water treatment plant, of Timisoara (25t/ha D.M.) – PB;) 4) Oil polluted soil fertilized with sewage sludge,

(biosolids) originating from municipal wastewater plant of Timisoara (25t/ha D.M.) and treated with indigenous volcanic tuff (2.5 t/ha) – PBT. Amount of seed used for sowing grass plants is 250 grains/ vegetation pot.

Analytical determination of TPH: 3-5 g of soil are weighed into a conic glass-stoppered of 50 ml, then 5 g of anhydrous Na_2SO_4 and 25 ml of CCl_4 are added; shaken in a shaker for 30 minutes at a speed suitable for the entire soil to come in contact with the extraction agent, then filtered through medium porosity filter paper in a 50 ml glass cylinder. Wash the beaker and filter paper 3 times with 3 ml of CCl_4, which is added to the filtrate; evaporate the filtrate on water bath at a temperature of maximum 75°C until complete removal of the solvent. Dissolve the residue in 3 portions of petroleum ether, of 15, 10 and 5 ml and pass (with any undissolved parts) through a column filled with aluminum oxide and then collect the eluate in a weighed porcelain crucible; petroleum ether evaporates at room temperature and is weighed to constant weight; the same is done with a control sample obtained from 28 ml CCl_4 which evaporates and it is resumed with petroleum ether as described above.

$$\text{Total Petroleum Hydrocarbons} = \frac{(m_2 - m_1) - (m_4 - m_3)}{m} \times 1000 \quad [\text{ppm}]$$

where: m_1 - mass of the sample capsule without residue, in mg; m_2 - mass of capsule with sample residue, in mg; m_3 - mass of capsule without control residue, in mg; m_4 – mass of capsule with control residue, in mg; m - mass of dry soil sample in mg.

RESULTS

Analysis of *Lolium perenne* plants cover on the variants of the experimental study is presented in Table 1. Picture 1 shows the cultures formed on the 4 experimental variants. It is noted that plants grown on control soil cover the entire area cultivated, on the polluted soil the covered area is minimal, and on the treated variants plants install easier.

Table 1. Characterization of *Lolium perenne* plants' covering of the sown area during 29.03>>>>.2012, Sowing date 29.03.2012

Crt no.	Sample	n*	Abundance index [%]			
			16.04.2012	23.04. 2012	04.05. 2012	14.05.>>>2012
1	M	6	100	100	100	100
2	P	6	5	10	10	10
3	PB	6	15	30	60	70
4	PBT	6	50	75	75	85

* number of observations

On the oil polluted soil plants sprout with delay and cover only 10% of the sown area, after four month from sowing. The addition of fertilizer stimulates germination and plant development as follows: after one week of vegetation the surface covered was about 15%, but it increases gradually. The culture of *Lolium perenne* covers, between 3-6 weeks of vegetation, 70% of the cultivated area. Addition of fertilizer and indigenous tuff led to the installation of a vegetative layer on 85% of the sown area, after only 4 weeks from sowing. On the control variant, plants cover the area 100%, ever since the sprouting phenophase. Plants are mowed regularly.

Figure 1. Experimental variants, 04.05.2012

Analysis of some biological factors from *Lolium perenne* plants in the experimental study is shown in Table 2.

Table 2. Biometric measurements in cm, of plants from *Lolium perenne* species cultivated in the four experimental variants, Sprouting date, 11.04.2012,

Crt no.	Sample	*n	Plant height [cm]				
			16.04. 2012	23.04.2012	04.05.2012	14.05.2012 harvest no.1	01.08.2012 harvest 4
1	M	4	5-8	10-12	10-14	10-14	12-14
2	P	6	5-6	5-6	9-10	9-12	8-10
3	PB	6	5-8	8-10	9-11	9-12	11-13
4	PBT	6	5-9	10-12	10-14	10-14	13-16

* number of observations

Table 3 shows the quantities of TPH from soils cultivated with *Lolium perenne* plants, for the four experimental variants, after a period of 45 and 90 days, respectively, of plant development and the reduction efficiency of petroleum hydrocarbons using this culture.

Table 3. Quantities of TPH soils cultivated with *Lolium perenne,* for the four experimental variants, after a period of 45 and 90 days, respectively, of plant development.

Crt. no.	Simple	TPH content [mg/kg D.M.]			Removal efficiency Col 3 vs. Col 1 [%]
		29.03.2012	14.05. 2012	01.08.2012	
		Col 1	Col 2	Col 3	
1	M	25.650	24.360	21.430	16.5
2	P	1067.742	1053.097	998.230	6.5
3	PB	1067.742	994.633	842.252	21.1
4	PBT	1067.742	943.512	707.498	33.7

CONCLUSIONS

Phytoremediation of the petroleum hydrocarbons polluted soils and fertilized with sewage sludge and cultivated with *Lolium perenne* species, determined:

1. Plants install slowly, and cover 70% of the cultivated area and degrade 21.1% of the TPH from the polluted soil during a period of time of four months of plant development;
2. Indigenous volcanic tuff addition (25t/ha D.M.), to the sewage sludge determined the installation of the plants in a proportion of 85% of the cultivated area. *Lolium spp.* plants determine a reduction efficiency of the TPH from the polluted soils up to 33.7% during a period of 4 months of vegetation.

LIST OF REFERENCES

[1] Kalali A., Ebadi A., Rabbani A., Moghaddam S.S.,, (2011), Response surface methodology approach to the optimization of oil hydrocarbon polluted soil remediation using enhanced soil washing, *International Journal of Environment Science and Technology*, 8, p. 389-400.

[2] USEPA, (2006), United States Solid Waste and EPA 542/F-06/013, *In Situ Treatment Technologies for Poluated Soil, Engineering Forum Issue Paper,* Environmental Emergency Response November Protection Agency, 5203P, www.epa.gov/tio/tsp

[3] USEPA, (2006), U.S. Environmental Protection Agency Office Phytoremediation of Petroleum Hydrocarbons, Amanda Van Epps, *Environmental Careers Organization U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response Office of Superfund Remediation and Technology Innovation,* Washington DC, August 2006, www.epa.gov/clu-in.org

[4] Schnorr J.L, Licht L.A., McCutcheon S.C., Wolfe N.L., Carriera L.H., (1995), Phytoremediation of Organic and Nutrient Poluants, *Environmental Science and Technolology,* 29, p. 318-323.

[5] Bizecki Robson D, B., (2003), *Phytoremediation of Hydrocarbon-Poluated Soil Using Plants Adapted to the Western Canadian Climate*, A Thesis, Department of Soil Science, University of Saskatchewan, Saskatoon,

[6] Ndimele P.E., (2010), A. Review on the Phytoremediation of Petroleum Hydrocarbon, *Pakistan Journal of Biological Sciences*, 13, p. 715-722.

[7] [Reilley K.A., Banks M.K., Schwab A.P., (1996), Dissipation of polycyclic aromatic hydrocarbons in the rhizophere, *Journal Environmental Quality*, 25, p. 2012-1019.