Journal of Environmental Protection and Ecology 18, No 4, 1398–1402 (2017)

Soil pollution

ASPECTS *in situ* OIL POLLUTED SOIL PHYTOREMEDIATION WITH PASTURE PLANTS

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Abstract. Oil compounds, name Total Petroleum Hydrocarbons (TPH) in soil chemistry, content in polluted soil cause dramatic changes of physicochemical and biological topsoil characteristics and destruction of ecosystems. Selecting and applying appropriate strategies for *in situ* phytoremediation of the oil soil polluted with 95.5 ± 25.0 g TPH kg^{-1} D.M., leads to their rehabilitation by planting and maintaining crops of pastures with grasses and leguminous species. The oil polluted soil addition of 50 t ha^{-1} fertiliser with nitrogen content, like stabilised sewage sludge, mixed with adsorbents material, i.e. fly ash waste derived from power plants that uses fossil fuel or volcanic indigenous tuff has led to installation of abundance and healthy culture. The areas were covered by grasses and leguminous species was up to 90% of sown areas. Resulting harvest from treated variants with fertiliser mixed with adsorbents material were 2–3 times higher versus harvests obtained from fertilised variants in the absence of fly ash on indigenous volcanic tuff. The harvest characteristics obtained on oil polluted soil fertilised with sewage sludge mixed with fly ash or volcanic tuff were correlated with national forage norms.

Keywords: total petroleum hydrocarbon, fertiliser, *in situ* phytoremediation, pasture.

AIMS AND BACKGROUND

Concerns regarding the sustainable development of each country, but also worldwide, are the result of a series of problems hanging over mankind: poverty, environmental degradation, uncontrolled expansion of urbanisation, the uncertainty of employment, inflation, unemployment. When it comes to economic miscalculation – neglecting the cost of degradation and damage to the environment and human health, it has caused costs that need to be borne by the entire society threatened by worsening environmental hazards. The present study aims to assess the efficiency

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of using a mix of pasture plants for phytoremediation of soils polluted by petroleum products in areas neighbouring railways. Additionally, we observed the restoration of affected ecosystems and the quantity and quality of resulting crops.

The phytoremediation technique has been reported in the literature as a cost-efficient remedy based on plants. Applying variants of phytoremediation to soils polluted by total petroleum hydrocarbons (TPH) led to good results in terms of restoration of affected ecosystems. Previous studies identified plant species that metabolize /reduce the amount of oil accumulated in polluted soils[1] and examined the effect of fertilisation on phytoremediation efficiency when applied to oil polluted soils[2–5]. An increased efficiency in reducing TPH in soil was observed after 14 weeks of cultivating plants as perennial ryegrass (*L. multiflorum* Lam.) which formed vigorous intertwined roots in the case of fertilised variants. Good results for biodegradation of TPH in soil have been also observed when using leguminous plants as *Medicago* spp.[6] Growing vegetables on soils polluted by TPH determines the biological fixation of atmospheric nitrogen and leads to reducing the amount of nitrogen fertilisers in phytoremediation processes. This phytoremediation is important for polluted areas that show a major deficiency of nitrogen and where C/N ratio is high[7].

EXPERIMENTAL

The study was conducted on variants of soils: polluted and fertilised soil, PF variant; fertilised and treated with fly ash polluted soil, PFC variant; fertilised and treated with indigenous volcanic tuff polluted soil, PFT variant. The lots had a surface of 16 m^2 and there was a 1 m distance left between them. It was used 50 t ha^{-1} organic fertilisers resulting from the municipal wastewater treatment plants in absence/presence of amendments, i.e. amount of 50 t ha^{-1} fly ash or 5 t ha^{-1} crushed volcanic tuff. The fly ash resulted from coal combustion in power plant and the crushed indigenous volcanic tuff was obtained from Marsid quarry in Romania. The mix of plants used in the phytoremediation process included grasses and leguminous species: *Lolium* spp., *Festuca* spp., *Medicago* spp., *Trifoliun* spp. Seeding was done in April. The agricultural works of cultivation, maintenance, and harvesting were carried out according to the specific procedures for these plants. The initial amount of TPH in soil was 95.5 ± 25.0 g kg^{-1} D.M. The method for TPH determination was described by Masu et all.[3] The metal content determined in the crop was compared to national norms.

RESULTS AND DISCUSSION

Pastures plants were cultivated on polluted and fertilised in absence/presence of amendments soil variants. Tolerant plants were selected at the high levels of soil pollution with TPH. Table 1 shows the way gramineous and leguminous plants were cultivated at the end of the warm season on variants fertilised in the absence/presence of fly ash or crushed tuff. The crop presented in September a high occupancy of the sowed surface, respectively occupancy of 75% on the variant fertilised in the absence of amendments. When the addition of amendments was used, the overall occupancy degree on the sowed surface reached 90%.

Table 1. Cultivation of gramineous and leguminous plants on variants fertilised in the absence/presence of fly ash or crushed tuff

No	Occupancy degree (%)	Soil variants		
		PF	PFC	PFT
0	overall occupancy degree on the sowed surface – *G*	75	90	90
1	gramineous plants on *G*	30	55	50
2	leguminous plants on *G*	40	35	40
3	overall degree of area not occupied by plants on *G*	25	10	10

Table 2 shows the amounts of successive harvests obtained from the studied variants. Different amounts resulted from the successive harvesting of the plants. The amounts resulted from the first harvest from the fertilised variant were 219.5–230.8 g/lot. The amount harvested from variants fertilised and treated with fly ash respectively tuff was higher, 416.6–720.2 g/lot. The highest harvested amount 616.8–720.2 g/lot resulted from the variants fertilised and treated with tuff. The second harvest had the highest results from all three harvests reaching up to 2370.5–2585.5 g/lot on the variant fertilised and treated with fly ash and 3560.4–4075.5 g/lot on the variant fertilised and treated with tuff. Thus, the amount harvested on variants treated with fertiliser and fly ash or tuff increased by 1.8 and 2.8%, respectively, compared to the harvest from the variant fertilised without amendments. The third harvest in September was lower than the harvest in July. Table 2 shows that the addition of fly ash resulted in an increase in the total harvested amount by 46.5–51.4% compared to harvested amount from fertilised variant without adding fly ash. When using organic fertiliser and tuff for treating polluted soil, the harvest increased by 67.5–67.8% compared to the total harvest resulted from the variant without additions. The addition of fly ash to the polluted and fertilised soil variant resulted in significant increases in the harvest. Therefore, in order to optimise the phytoremediation, the volcanic tuff can be replaced with fly ash resulting from the combustion of lignite.

Table 2. Green biomass from experimental variants

No	Variant	Green biomass (g/lot)			
		harvest 1	harvest 2	harvest 3	total
1	PF	219.5–230.8	1270.4–1420.5	309.2–502.5	1789.1– 2153.8
2	PFC	416.6–418.8	2370.5–2585.5	897.5–958.5	3684.5–3962.8
3	PFT	616.8–720.2	3560.4–3575.5	1390.5–1825.5	5567.7–6121.2

Table 3 shows the amounts of metals bio accumulated by the harvested plants. The harvested biomass did not bio accumulate Cd and Cr and other metals do not represent a potential danger.

Table 3. Metal bioaccumulated in harvest

No	Metal (mg kg^{-1} D.M.)	Metal in biomass (mg kg^{-1} D.M.)			*Maximum Romanian limit for organic matter with 12% humidity
		PF	PFC	PFT	
1	Cu	8.3	10.9	9.0	–
2	Fe	347.7	355.2	279.0	–
3	Mn	37.5	44.1	47.0	–
4	Ni	5.0	9.1	5.5	–
5	Pb	10.4	10.6	9.6	50
6	Zn	31.2	39.7	31.9	–

* Order 74/2011, National Veterinary Food Safety Authority Ed., Official Monitory, 876/2011, Bucharest, Romania.

CONCLUSIONS

The message of sustainable development is consistent with the perspective reconciliation between economy and nature: without an adequate protection of the environment, it is impossible to achieve development objectives. Damage to the environment and human health revenge on future productivity, and vice versa, without economic growth we cannot obtain environmental resources. Countries with a high development potential in terms of finances, economy and human and technological resources, have multiple opportunities to project sustainability. At the same time, a certain threshold of endurance of the environmental problem arises as a means of survival for the entire planet, making the globalisation of sustainable development actions essential. One can apply for TPH polluted soils with in the amount of 95.5 ± 25.0 g kg^{-1} D.M. variations with methods of phytoremediation by using pasture plants. Pasture plants cover in 5 months approximately 75% of the polluted and fertilised surface. The addition of a waste as lignite fly ash determined the increase to 90% for the surface covered by vegetation. The amount of harvest in the first year of vegetation was on the variant fertilised with fly ash twice as high compared with the results on the variant fertilised without fly ash. The harvested biomass was in accordance with the admitted standards regarding bio accumulated metal content. Using common pastures plants for cultivating oil-polluted soil led to good results for both landscape remediation as well as desirable characteristics for crops obtained from variants treated with organic fertilisers and fly ash or volcanic tuff.

REFERENCES

1. K. E. GERHARDT, X. D. HUANG, B. R. GLICK, B. M. GREENBERG: Phytoremediation and Rhizoremediation of Organic Soil Contaminants: Potential and Challenges. Plant Sci, **176** (1), 20 (2009).
2. A. BAGHINA, I. RADULOV, A. BERBECEA, A. MOISUC, C. STROIA: Sewage Sludge Fertilisation Influence on Main Soil Chemical Features. J Environ Prot Ecol, **15** (1), 217 (2014).
3. S. MASU, L. COJOCARIU, D. M BORDEIAN, M. HORABLAGA, F. MORARIU: Phytoremediation of Oil Polluted Soils and the Effect of Petroleum Product on the Growth of *Glycine max*. Rev Chem Bucharest, **67** (9), 1774 (2016).
4. N. MERKL, R. SCHULTZE-KRAFT, M. ARIAS: Influence of Fertilizer Levels on Phytoremediation of Crude Oil-contaminated Soils with the Tropical Pasture Grass Brachiaria brizantham. Int J Phytoremediat, **7** (3), 217 (2005).
5. P. E. NDIMELE, C. A. KUMOLU-JOHNSON, M. A. ANETEKHAI: The Invasive Aquatic Macrophyte, Water Hyacinth {*Eichhornia crassipes* (Mart.) Solm-Laubach: Pontedericeae}: Problems and Prospects. Research Journal Environmental Sciences, **5** (6), 509 (2011).
6. L. PARVAN, C. SARBU, T. COROIANU: Use of Liquid Fertilizers and Adsorbents in the Bioremediation of the Soil Polluted with Crude Oil, Part. 1. J Environ Prot Ecol, **16** (1), 194 (2015).
7. L. PARVAN, C. SARBU, T. COROIANU: Use of Liquid Fertilizers and Adsorbents in the Bioremediation of the Soil Polluted with Crude Oil, Part. 2. J Environ Prot Ecol, **16** (1), 199 (2015).

Received 25 September 2017
Revised 24 October 2017