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The Effect of Bioremediation Technologies on Mobile Potassium Content from Polluted Soil with Crude Oil

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Abstract

This paper presents the effect of bioremediation technologies on mobile potassium content from polluted soil by crude oil. The results obtained showed that in terms of the non-utilization of absorbents, the highest values of mobile potassium were found in variants treated with AH- SG1, new liquid fertilizer with bacterial inoculum, and the lowest values of mobile potassium were found in unfertilized variants or those treated only with mineral fertilizer in $N_{200}P_{200}K_{200}$ dose. The most effective fertilizer to increase potassium levels in the soil material polluted with 3% crude oil was AH- SG1. The fertilizers with potassium humates, significantly increased soil content in potassium at 45 days after treatment. At the application of 16 t/ha peat as an absorbent, the highest values of mobile potassium were obtained after fertilization with AH- SG1 and bacterial inoculum but and without bacterial inoculum the AH- SG1 fertilizer had a very good effect on mobile potassium levels in soil polluted with 3% oil. The application of bacterial inoculum resulted in higher values of mobile potassium in the soil. By applying absorbent Zeba 16 Kg/ha and Zeba 32 kg/ha the highest values of mobile potassium were obtained after treatment with new liquid fertilizer AH- SG2 with bacterial inoculum.

Keywords: *bioremediation, bacterial inoculum, liquid fertilizers, absorbents, potassium*

1. Introduction

Globally, the need to ensure food security for an ever growing population will require more agricultural land or agricultural intensification on currently cultivated land. On the other hand, continued population growth, industrial activities, changes in urban lifestyles and behavior, together with the need for increased mobility will require more land for uses irreversible. This competition factors, if it is not household in a sustainable manner, will cause degradation expansion (unsustainable agricultural practices, contamination soil, crusting, etc.) which will reduce available soil resources (DUMITRU [3]). Romania, as a country with a tradition of producing and oil processing is affected unfortunately by accidental phenomena, unwanted, leading to environmental pollution with crude oil and oil residues from crude oil processing. The development of the oil industry, both the mining and the processing of, including transportation of crude oil and petroleum products, accompanied sometimes by the appearance of secondary phenomena, affecting more or less harmful to the environment and life human. In areas for oil extraction, pollution phenomena oil residues and waste water, sometimes salty, are quite extensive, the impact on ecosystems beyond other human activity intensity (TA-CHEN & al [10]). Agriculture damage from pollution by oil products reach over 50.000 t/year without taking into account indirect losses from environmental factors (TA-CHEN & al [9]). In Romania, the area polluted by scaffolding oil from gas extraction 36.75 % is polluted with hydrocarbons and 63.35 % joint polluted with hydrocarbons and salty water. Area polluted by oil extraction scaffolds is affected by hydrocarbon 35.3%, by salty water 0.4 % and 64.3 % by salty water and hydrocarbon (TA-CHEN & al [9]).. The degree of pollution of the soil increases while oil and oil residues pollution occurs in the same time with the pollution with salty wastewater, capable of eliciting a strong salinization of soils, sometimes turning them into soil with solonchaks properties proper. In such pollution conditions, soil becomes virtually unproductive, being removed completely from the economic network. Crude oil radically alters soil properties, both physical and chemical and biological. It forms an impermeable film on soil surface, which prevents the movement of water in soil and gas exchange between soil and atmosphere, causing roots asphyxiation and favoring the manifestation of reduction process. As the soil becomes anaerobic, decreases the number and metabolic activity of bacteria. Crude oil is rich in organic carbon increased C/N ratio in the soil negatively influencing microbiological activity (TA-CHEN&al [10]). Soil remediation represents a management system on prevention, minimization and mitigation of pollution causes. Physical and chemical methods of remediation of soils polluted with oil, proved ineffective after 1990 may cause a secondary pollution of soil after use, but also because of the extremely high cost. Believes that any chemical compound whose accumulation in nature becomes dangerous for the environment may be considered as pollutant, and its removal using microorganisms can be considered bioremediation (HENIS [7]). In the 80s when the bioremediation of soils is becoming increasingly important, the first experiments were conducted in the laboratory has been used inoculation with strains of microorganisms with degradative abilities (VOICULESCU & al [11]). Watching the effects of oil contamination on microbial biomass was found that adding compost has occurred crude oil degradation (FRANCO & al [4]). USA EPA guidelines suggest that the bioremediation is feasible when there is a microbial population of about 105 cfu/g soil. Thus, a microbial population reduced and insufficient microbial diversity affecting bioremediation efficiency. Bioremediation efficiency is a function of degrading microorganisms ability inoculated to remain active in the natural environment (MARINCA & al [8]). Humic substances have been recently proposed as suitable materials for the microbial degradation of organic pollutants (WIPO, SOYOUNG & al [14, 16]). Humic substances enhance chemical extractability and degradability by increasing specific microorganism (OGUZ & al, HOLMAN & al [15, 17]). Some researchers stated that in situ bioremediation is not a universal panacea (HART & al [6]). Bacteria can't degrade all contaminants, they can degrade too slowly to be practical, and some degradable contaminants may not be available microorganisms because they are closely related to soil particles, but if you make sure the appropriate medium will develop and pollutant attack. It was investigated the biological assimilation of oil residue from Oak Ridge - Tennessee, the rate of oil degradation was 1.425 % in the first month and after three months it amounted to 61.4 % (FRANKE & al [5]). For the decontamination of soil contaminated with aromatic hydrocarbons (particularly benzene) may be used mixtures of humic substances, minerals, and various bacteria (VOGEL & al, United States Patent [12, 13]). Given that oil pollution, oil products and wastes affect the very ability of soil to sustain life, development of a methodology to remedy adapted conditions in Romania is absolutely necessary.

2. Material and methods

In the context enunciated, a trifactorial experiment was organized in the vegetation house of ICPA Bucharest, using the upper horizon (Am) of an aluviosol taken from Comana - Giurgiu and polluted with 3% crude oil. Experiment consisted of 48 variants and 3 repetitions. For performance of the bioremediation experiments on the soil polluted with oil products, four fertilizers were used, which contain humic substances, namely: KH (fertilizer containing potassium humates and microelements); AH-SG1 (fertilizer containing potassium humates in an NPK-type matrix with microelements and 4% monosaccharides, in which nitrogen is in amidic form); AH-SG2 (fertilizer containing potassium humates in an NPK-type matrix with microelements and 8% monosaccharides, in which nitrogen is in amidic form); AH-SH (fertilizer containing potassium humates in an NPK-type matrix and magnesium, in which nitrogen is in amidic form).

Factor 1: absorbents with 4 graduations: without absorbent, Peat 16 t/ha, Zeba 16 kg/ha, Zeba 32 kg/ha

Factor 2: fertilization with 6 graduations: $N_0P_0K_0$; $N_{200}P_{200}K_{200}$; Potassium humate (KH); AH-SH; AH-SG1; AH-SG2. NPK dose applied: $N_{200}P_{200}K_{200}$ kg/ha; KH (potassium humate) dose applied: 650 l/ha; AH-SH (potassium humate in NPK-type matrix) dose applied: 650 l/ha; AH-SG1 (potassium humate in NPK-type matrix with 50 g glucose/l) dose applied: 650 l/ha with 32 kg glucose; AH-SG2 (potassium humate in NPK-type matrix with 100 g glucose/l) dose applied: 650 l/ha with 64 kg glucose

Factor 3: inoculation with 2 graduations, i.e. without inoculation and with inoculation

The quantitative determinations of the heterothrophic bacteria were made by means of the technique of decimal serial soil dilution dispersion on Topping agarized nutrient medium in Petri dishes. The qualitative determinations of the heterothrophic bacteria were made by usual identification techniques: macroscopic techniques (appearance of the colonies: shine, colour, consistency, transparency form, relief, colony edge, pigments diffused in the medium etc.) and microscopic (form, organization, cell dimension etc.), cultures on selective media, physiological diagnostic tests (BERGEY'S, BOCARD & al [1,2]). For the determination of the total nitrogen (N%), we used the Kjeldahl method, disaggregation with H_2SO_4 at 350°C, potassium sulphate and copper sulphate as catalyst – SR ISO 11261:2000, accessible phosphorus (mobile P): according to the Egner-Riehm-Domingo method and colorimetrically dosed with molybdenum blue according to the Murphy-Riley method (reduction with ascorbic acid). Accessible (mobile) potassium: extraction according to the Egner-Riehm-Domingo method and dosing by flame photometry, base saturation degree V% by calculation, petroleum residues determined by the gravimetric method. The bacteria inoculum consisted of strains isolated from soil contaminated with crude oil and tested in the laboratory for its ability to degrade petroleum hydrocarbons as follows: 3 strains belonging to the *Pseudomonas genus*, 2 strains belonging to the *Arthrobacter genus* (*Arthrobacter globiformis* and *Arthrobacter citreus*). In the experiments performed the potassium humate used to obtain the fertiliser was extracted from coal (lignite) with a solution of potassium carbonate. The mixture humic/fulvic present in the matrix of the fertilizer contained about 70 % organic acids, 50% of which are derived from humic acids and 20% from fulvic acids. In AH-SG experimental fertilizer solution was introduced two doses of glucose, thus resulting two variants of fertilizers (AH-SG1 and AH-SG2). Glucose was obtained by purification and concentration of an aqueous solution of nutritive saccharides obtained from starch. Zeba is a superabsorbent polymer, on starch based, created to quickly absorb up to 500 times its weight of water to form a hydrogel in which the humidity is maintained, accessible to the plants. It is able to hydrate and dehydrate repeatedly during a season and to balance the retained moisture in function by the plant requirements. It is applied in the soil to a depth of 10-15 cm. The product is non-toxic and completely biodegradable, having beneficial effects on soil microorganisms. Peat is a natural absorbent peat-based biodegradable, used for the degradation of the hydrocarbons and for absorbing oil. Peat is composed to ± 94 % peat moss and water/various ± 6 %. The absorption capacity is 8-12 times its own weight. Being a product of natural origin, not chemically modified, is non-toxic to living organisms and does not change the characteristics of the environment in which it was applied.

3. Results and discussion

The data presented in Figure 1 showed the combined effects of the studied factors (absorbents, fertilizers, bacterial inoculum) on the evolution of mobile potassium content of polluted soil with 3% crude oil at 45 days after the treatments.

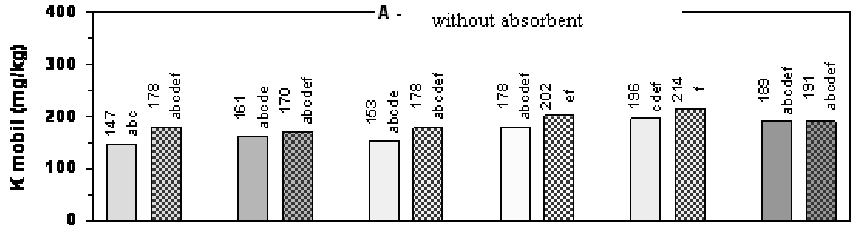


Fig. 1.A The combined effects of the studied factors on mobile potassium content in soil material polluted with 3% crude oil without absorbent

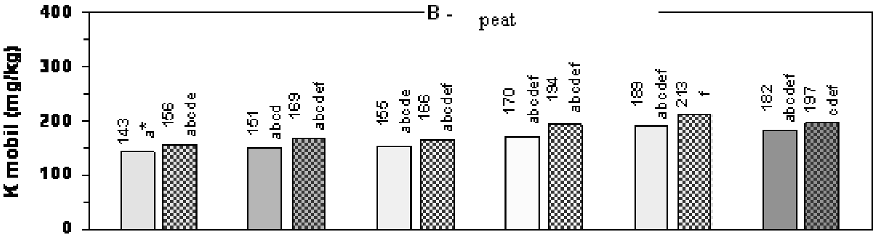


Fig. 1.B The combined effects of the studied factors on mobile potassium content in soil material polluted with 3% crude oil with peat

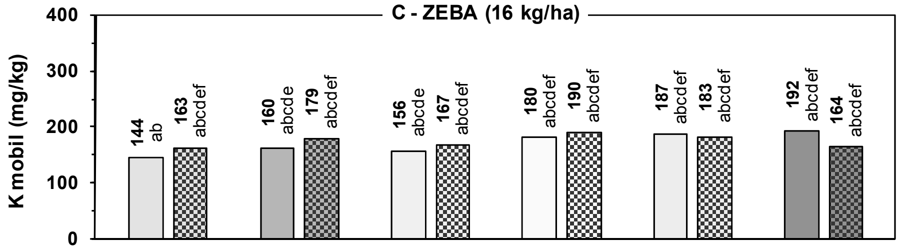


Fig. 1.C The combined effects of the studied factors on mobile potassium content in soil material polluted with 3% crude oil with Zeba (16 kg/ha)

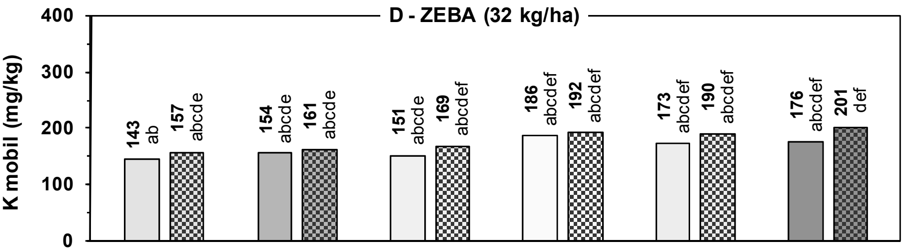
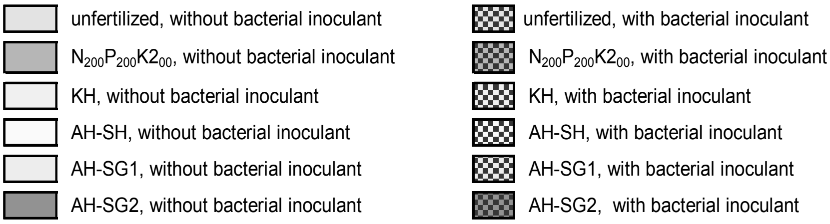


Fig. 1.D The combined effects of the studied factors on mobile potassium content in soil material polluted with 3% crude oil with Zeba (32 kg/ha)



*For the aggregate formed by the 4 charts (1.A, 1.B, 1.C, and 1.D) the values followed by the same letter (a, b, ...) do not differ significantly from each other (TUKEY multiple correlation method – significance threshold 0.05). DL5%= 69,093

In terms of the non-utilization of absorbents (figure 1.A), the highest values of mobile potassium were found in variants treated with AH- SG1 (fertilizer containing potassium humates in NPK matrix with microelements and 50 g/l glucose, applied at a rate of 650 l/ha + 32 kg/ha of glucose) liquid fertilizer with bacterial inoculum (214 mg/kg in comparatively with the untreated sample 178 mg/kg). The most effective fertilizer to increase potassium levels was AH-SG1; in all experimental variants the fertilization with fertilizers on potassium humate based significant increases the soil content in mobile potassium. Figure 1.B presents data that reflect the influence of different types of fertilizers, with or without bacterial inoculum, on a background of 16 t/ha of peat as an absorbent. Amid the application of 16 t/ha of peat as an absorbent, the highest values of mobile potassium content were obtained after fertilization with AH-SG1 (fertilizer containing potassium humate an NPK matrix and microelements and 50 g/l glucose, applied at a rate of 650 l/ha + 32 kg/ha of glucose) with bacterial inoculum, and without bacterial inoculum the AH-SG1 fertilizer had a very good effect on mobile potassium levels in soil (213 mg/kg in comparatively with the untreated sample 156 mg/kg). Figure 1.C presents data that reflect the influence of different types of fertilizers applied alone or together with the bacterial inoculum amid administration of 16 Kg/ha absorbent Zeba. In the context of the application of 16 kg/ha Zeba absorbent, AH-SG1 fertilization (fertilizer containing potassium humate in a NPK matrix and microelements and 50 g/l glucose) resulted a significant increase of mobile potassium content in soil; the fertilizer application AH-SG1 with the bacterial inoculum has not brought an increase of mobile potassium in soil. By the AH-SG2 fertilization (the same AH-SG1 fertilizer but containing 100g/l glucose, which is applied at a rate of 650 l/ha plus 64 Kg/ha of glucose) resulted a very significant increase of the mobile potassium values in soil. It was revealed that amid application 16 kg/ha Zeba absorbent, the biggest mobile potassium values were obtained after treatment with AH-SG2 fertilizer (192 mg/kg in comparatively with the untreated sample 163 mg/kg). Figure 1.D presents data that reflect the influence of different types of fertilizers applied alone or together with the bacterial inoculum, amid administration of 32 Kg/ha absorbent Zeba. It was observed that the background application of 32 kg/ha Zeba absorbent, the biggest mobile potassium values in soil were obtained in variant fertilized with AH-SG2 plus bacterial inoculum (201 mg/kg in comparatively with the untreated sample 157 mg/kg) and the lowest values of mobile potassium in soil were obtained in the variants treated with potassium humates and microelements.

3. Conclusions

In terms of the non-utilization of absorbents, the highest values of mobile potassium content were found in variants treated with AH-SG1 new liquid fertilizer with bacterial inoculum. The most effective fertilizer to increase potassium levels was AH-SG1; in all experimental variants the fertilization with fertilizers on potassium humate based significant increases the soil content in mobile potassium. Amid the application of 16 t/ha peat as an absorbent, the highest values of mobile potassium were obtained after fertilization with AH-SG1 fertilizer with bacterial inoculum. Amid the application of 16 kg/ha Zeba absorbent, the highest mobile potassium values were obtained from the application of liquid fertilizer AH-SG2, as in the case application of 32 kg/ha Zeba absorbent, the highest mobile potassium values in soil were found in variants fertilized with AH-SG2 (similar fertilizer with AH-SG1 containing 100g/l glucose) with bacterial inoculum.

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