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Agriculture and Agricultural Science Procedia 10 (2016) 452 – 457

Agriculture and Agricultural Science Procedia

5th International Conference "Agriculture for Life, Life for Agriculture"

Studies on the Seed Germination Changes after Thermal Decontamination of Crude Oil Polluted Soils

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Abstract

Given that the world population will reach nearly 10 billion by 2050, removing all the causes that result in reduced yields of cereals and technical plants is vital. It is known that soil affects plants through its physical (texture, structure, density), chemical (nutrients content, pH) and biological characteristics (microbiological activity, soil fertility).

Soils are the key environmental tank to pollutants, storage and persistence of pollutants in soil being dependent on a number of factors: the exchange of air, the burying of pollutants and their biodegradability. This paper aims to emphasize the germination of plants after a polluted soil sample was decontaminated by a thermal method. The soil sample was polluted with 5% oil. The soil sample was characterized by capillarity, being established the maximum height of the moistened layer of 7.6 cm and 14.1 cm for oil, but also permeability of 218.5 cm^3/h for water and 70.83 cm^3/h for oil. Knowing the average permeability, it can be determined the corresponding retention capacity: 873.14 kg/m^3 for water and 776 kg/m^3 for oil. Restoration of the germination potential for the analyzed soil also determined the presence of nutrients required before and after remediation. The analyzed nutrients were nitrogen, phosphorus and potassium. The soil sample had no nitrogen, but phosphorus and potassium were in medium concentration. The soil sample that was polluted with oil and decontaminated by a thermal method, has nitrogen, the potassium content does not change, but the phosphorus content increases.

Peer-review under responsibility of the University of Agronomic Sciences and Veterinary Medicine Bucharest

Keywords: soil polluted, nutrients, decontamination, germination, oil products

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Peer-review under responsibility of the University of Agronomic Sciences and Veterinary Medicine Bucharest
doi:10.1016/j.aaspro.2016.09.014

1. Introduction

In developed areas of human societies, vital elements (water, air and soil) are invaded by residues that exceed the natural power of transformation. the degradation of the environment had a worrying increase, the amount of pollutants growing. Soils represent the key reservoirs of environmental pollutants, the storage and persistence of pollutants in soil being dependent on several factors. of soil structure, humus is the main component, with a role in ensuring a reserve of nutrients. At the moment, full hectares of farmland and forest are polluted with oil, oil waste, refined products and salt water. The problem of the recovery of land contaminated with crude oil can be done by studying the fertility or quantitative characteristics of the exchanges made in the soil. The studies that have been conducted so far refer largely to biological decontamination methods and methods of phytoremediation (Huang, 2004, Nwadinigwe, 2012, Pavel, 2008, Shirdam, 2008, Xu, 1997, Boros, 2014). This paper is a part of an extensive study of the authors on pollution and remediation of soils contaminated by petroleum products (Popa, 2014, Popa, 2015, Onutu, 2015). The studies are conducted in the laboratory, trying to reproduce, as much as possible, the situations encountered in practice. All these techniques aim to recover the germinating potential of the plants.

2. Materials and methods

The present work aims to study the change of the content of nutrients in a soil sample polluted with oil at a rate of 5% and then decontaminated by a thermal method – combustion. There are compared the nutrient content N, P and K. The soil sample subjected to pollution and thermal pollution was firstly characterized by capillarity and permeability. Determination of physical properties was done at laboratory level. Capillarity phenomenon is the rise of a liquid through the spaces between solid particles. The height of the moistened layer was measured from 10 to 10 minutes. Soil permeability is its property to allow the flow of liquid through its structure. From 15 to 15 min it was measured the volume of the liquid that has passed through the layer of soil and it was established a medium permeability expressed in cm3 / h. Retention capacity (RC) is the amount of liquid product that its included in a soil structure. In both the cases, for capillarity the used liquids were water and crude oil.

Determination of nutrients was made by a qualitative method, using a special laboratory kit. In agricultural applications, monitoring the quality of the soil is extremely important for the health and growth of crops. By using this special laboratory kit it is possible to measure the pH and the most important elements for plant growth, nitrogen, phosphorus and potassium. Nitrogen and phosphorus were determined by colorimetric method, and potassium turbidimetry method. High temperatures, above 400 ^{0}C, lead not only to the transformation of the pollutant, but also to the change of both organic and inorganic structure of the soil. The method of decontamination through combustion, in the laboratory, as well as the used equipment was described in a previous paper (Popa, 2014).

3. Results and discussions

The characterization of a type of soil is very important if determinations include characterization in terms of nutrient content in the soil. This addition to the characterization of the soil is important, given that when soil is polluted by accident, it is sought to provide a method of remediation as fast, efficient and economical as possible. All these elements are following an effective decontamination in order for the polluted soil to enter, in most of the cases, the agricultural circuit. The cationic exchange capacity influences the soil fertility, the presence of the Ca and Mg favors the development of humus and soil structure, optimizing water and air regime, plant root uptake and microbiological activity in soil. In soils with a greater presence of H^+ ions, the soil becomes acid, negatively affecting the availability of microelements and macroelements. The basic elements for a balanced soil, which may influence the development of plant, N, P, K (nitrogen, phosphorus, potassium) are assimilated by them depending on the pH values (Neag, 1997). Nutrients are chemicals that plants, animals and people need to grow or survive, and their presence in water, soil and subsoil is normal. However, when their quantities are too high, we are talking about nutrient pollution that is dangerous for health and for our crops. Nutrients (nitrates, nitrites, ammonia, phosphates) get to be in excess in soil and water, either by a wrong fertilization with chemical fertilizers or compost, or by not respecting important rules regarding the positioning and construction of housing and wells or mismanagement of manure and waste that ends up into soil and groundwater. Soil nutrient pollution has negative consequences on crops and the environment. The nitrogen that is absorbed in the soil is converted through various chemical reactions assimilated into amino acids which improve the leaves, stem, root system development and acquisition of absorption function. Nitrogen in plant nutrition deficiency leads to yellowing leaves, to slow or stop their growth. Phosphorus, assimilated by plants in the form of phosphoric acid or phosphoric anhydride is involved in the immune system, increasing the resistance of the plant against crop conditions, the atmospheric administration, pests and insecticides. Potassium is transformed during chemical reactions in potassium hydroxide and assimilated in this form. It enhances the plant's ability to store nutrients in their bodies reserve (rhizomes, tubers). Potassium deficiency in plant nutrition diminishes their growth and development. Capillarity of a layer of soil is represented by the growing phenomenon of a liquid through the spaces between the aggregates solid constituent. The variation of the humidity front against both water and oil face is illustrated in Fig. 1.

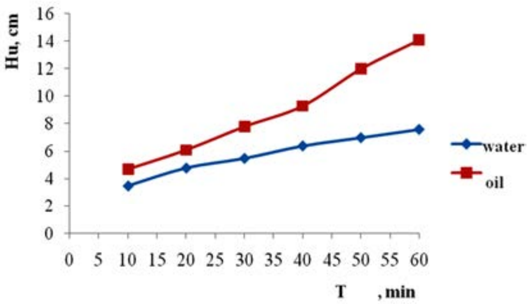


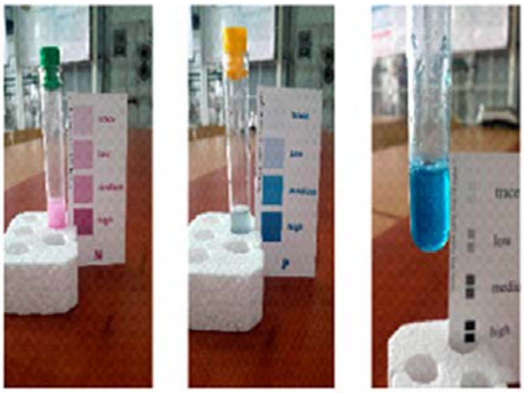
Fig. 1. Front humidity variation in time

The permeability of soil is its property to allow the flow of a fluid through its structure. Soil permeability to liquid petroleum fractions influences the speed with which they are infiltrating the case of discharge or accidental surface at a certain depth.

Table 1. The permeability and retention capacity of the clean soil analyzed

Liquid	Water	Crude oil
mo, g	344.2	560
H_{layer}, cm	6	6
D_{layer}, cm	4	4
V_{layer}, cm^3	75.36	76
V15, cm^3	60	21
V30, cm^3	112	36
V45, cm^3	156	48.7
V60, cm^3	382	62
mf, g	410	619
P15, cm^3/h	60	84
P30, cm^3/h	224	72
P45, cm^3/h	208	64.93
P60, cm^3/h	382	62
Pm, cm^3/h	218,5	70.83
RC, kg/m^3	873.14	776

Using the kit for soil in terms of the content of nutrients, the analyzed soil has an average content of nitrogen, a low phosphorus content and a low potassium content (based on turbidity determination) (Fig. 2).



a b c

Figure 2. Nutrient content in sample clean
a) Nitrogen – medium; b) Phosphorous – low;
c) Potassium – medium

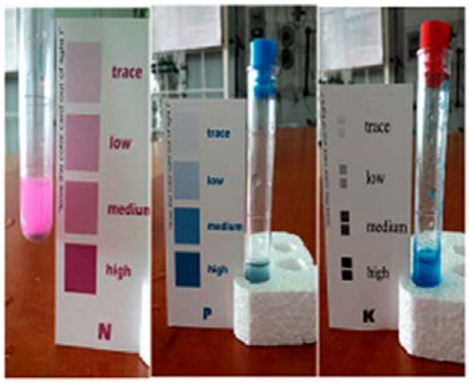


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Figure 3. Nutrient content in sample soil + crude oil
a) Nitrogen – high; b) Phosphorous – low;
c) Potassium – medium

The soil sample was polluted with oil in the laboratory at a rate of 5%. Sample soil nutrient content + oil is shown in Fig. 3. After further consideration, it was determined an average time of 40 minutes for thermal remediation. In these conditions, the entire quantity of pollutant was burned. The results are presented in Table 2.

Table 2. The results of combustion

Test sample	Initial quantity,g	Final quantity, g	Burned quantity of sample, g	% mass burned sample
Unpolluted soil	100	98,6	1,4	1,4 (org. mat)
Soil sample contaminated with 5 % crude oil	100	93,6	6,4	Total burned = 6,4 (organic material + crude oil) Total crude oil burned 6.4-1.4=5

For heat-treated soil there were resumed qualitative determinations regarding nutrient content and results are shown in Fig. 4 and Fig. 5.

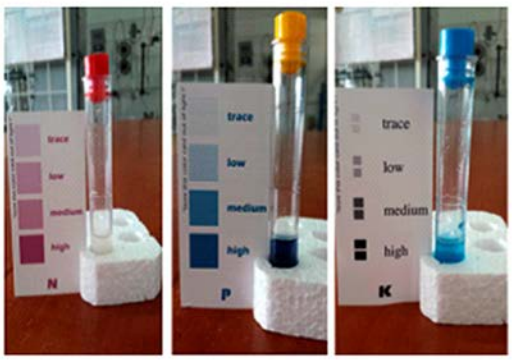

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Figure 4. Nutrient content for clean sample through
thermic decontamination: a) Nitrogen – trace;
b) Phosphorous – high; c) Potassium – low medium

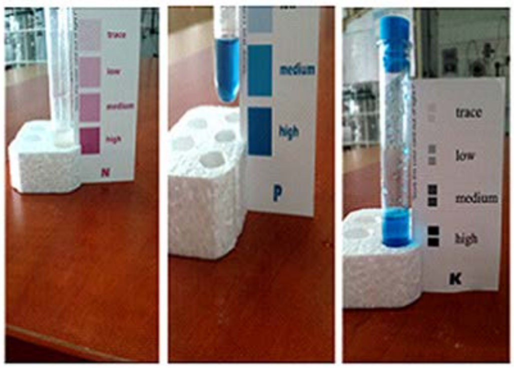

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Figure 5. Nutrient content for polluated sample through
thermic decontamination: a) Nitrogen – trace;
b) Phosphorous – medium-high; c) Potassium – medium

In order to establish the ecological reconstruction, there were prepared six soil samples, simple or mixed, as presented in Table 3. The ecological reconstruction tracked the recovery of the germination potential through the simplest method, thermal de-polluted soil mixed with a clean one, usually having the same type. The germination power that was observed for the six samples was followed for lawn seed, after ten days from sowing.

Due to the presence of all nutrients in unpolluted soil sample, sample 1, the evolution of the development of grass was as expected.

Sample 4 containing unpolluted soil and soil decontaminated obtained from combustion in equal percentages of 50% achieved the same result as the test 1, are the same qualities germ contaminated soil.

Soil contaminated with crude oil from sample 2 was again proven to have qualities germination.

If contaminated soil sample in may because currently 50% grass development has been slower (sample 5).

Samples 3 and 6 shows that the polluted and unpolluted soil loses its germ after remediation thermal qualities.

Table 3. Germinating potential reconstruction results

Soil samples	Soil samples after sowing	Soil samples	Soil samples after sowing
P1 *Clean soil*		P4 50% P1+50%P3	
P2 clean soil + 5% crude oil		P5 50% polluted soil+50% clean soil	
P3 Soil after thermal decontamination		P6 Clean soil after thermal decontamination	

4. Conclusions

The present paper started with the idea of establishing nutrient content change by applying thermal remediation methods. There was a controlled sample of soil from woods polluted by crude oil and 5 % and it was established the optimum remediation time of 40 minutes. In that moment, the whole quantity of crude oil with which the soil was polluted, was burned. The presence of oil in the analyzed soil imposed the checking of the qualitative content of nutrients in the soil so that the germination potential of soil to be recreated. This is more feasible if quick action is taken. For the clean soil there is an average content of each of the aforementioned elements. Following thermal decontamination of the clean soil, nitrogen disappears in soil composition, the phosphorous content increases, as well as potassium, resulting in a level between medium and low. Also, there were undergone analysis on polluted soil with 5% oil and heat-decontaminated immediately after pollution. It appears that in this situation nitrogen is missing, the sample is further enriched with phosphorus and the potassium content remains in a medium to low quantity. There were mixed polluted and unpolluted soil samples in controlled proportions and the results were compared with the initial sample, unpolluted.

Ecological reconstruction is an extremely complex goal that can be integrated as a concept in the context of prevention policies and strategies, assessment of sensitive ecosystems and the remediation. The aim is to restore the ecological restoration processes and components are completely destroyed a site or ecosystem to its state at a time, to a contemporary standard or to a desired condition

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