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The effect of organic poultry fertilizer in bioremediation of soil artificially polluted with diesel fuel

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Abstract. The influence of organic fertilizer from poultry in bioremediation of soil artificially polluted with diesel fuel was monitored for a period of 12 weeks. There were 12 soil samples (400 g of soil each sample) of which three control samples were polluted in a controlled way with 6%, 8% and respectively 10% diesel fuel, then were treated with different quantities of poultry manure. Soil samples thus prepared were kept in the laboratory for a period of 12 weeks, during which they were watered and homogenized. In order to determine the effect of organic fertilizer from poultry in soil bioremediation, concentration determination of total petroleum hydrocarbons was carried out at 3, 6, respectively 12 weeks. The highest percentage loss of 78.43% of total petroleum hydrocarbons' concentration was recorded for the soil sample which was polluted with 6% diesel fuel and treated with 80 g of poultry manure. Research aimed at optimizing the parameters in order to determine the optimum time required for the bioremediation of the soil contaminated with diesel fuel and treated with poultry manure.
Key Words: soil bioremediation, organic fertilizer, poultry manure, fuel contamination.

Introduction. Every year, large quantities of oil and oil products get into the environment due to human activities and unforeseen accidents, therefore soil pollution with oil products is a big problem that causes lots of negative effects (Khamforoush et al 2013). Once they permeated the soil, petroleum products remain unchanged for a long time causing substantial damage to natural ecosystems (Obire & Anyanwu 2009). Petrol is vital to many industries, is of great importance in maintaining industrialized civilization, also being raw material for many chemical products, including pharmaceuticals, solvents, fertilizers, plastic materials (Kiran & Patel 2010). The technology for bioremediation of soil contaminated with petroleum hydrocarbons is based mainly on biodegradation and refers to the complete degradation of organic pollutants. The bioremediation process is usually carried out by bacteria, fungi and plants are involved in the reduction or elimination of toxic pollutants (Pankaj & Vivek 2012). At present day there are several known methods of soil bioremediation but the microbiological degradation is one of the most promising ones, being applied in the decomposition and stabilization of organic waste (Haug 1993). Microbiological degradation has also proven its efficacy in the remediation of the soil contaminated with petroleum products (Meghraj et al 2011; Macaulay & Rees 2014).

Microorganisms having the ability to degrade petroleum hydrocarbons are widely distributed in soil and water, but they may be present in insufficient amount, thus requiring the inoculation of microorganisms in the contaminated soil (Hung-Soo et al 2008).

Microorganisms (bacteria, yeasts and fungi) use petroleum hydrocarbons as carbon and cellular energy source and are widely distributed in nature; there were identified more than 100 bacterial strains that contribute to the degradation of petroleum hydrocarbons (Banerji et al 1995). Microorganisms having the ability to degrade petroleum hydrocarbons are represented by bacteria such as *Achromobacter*,

Acinetobacter, *Actinomyces*, *Bacillus*, *Burkholderia*, *Exiguobacterium*, *Microbacterium*, *Nocardia*, *Pseudomonas*, *Spirillum*, *Streptomyces* and fungi or yeasts such as *Allescheria*, *Aspergillus*, *Candida*, *Debaryomyces*, *Mucor*, *Penicillium*, *Saccharomyces* and *Trichoderma* (Hung-Soo et al 2008).

Manure from chickens contains all the essential nutritive substances that are necessary for the growth and development of plants. These substances are represented by nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, manganese, copper, zinc, chlorine, boron, iron and molybdenum. The balance of these elements varying depending on a number of factors such as age, diet, bedding type and moisture content. Fresh manure from poultry contains uric acid while the urea and ammonia are present in small amounts (Mohamed et al 2010). Application of poultry manure leads to an increase in the number and diversity of microorganisms in the soil, especially in sandy soil (Mohamed et al 2010).

The purpose of this research is to reduce the concentration of petroleum hydrocarbons by stimulation of the bioremediation process of soils contaminated with diesel fuel using organic fertilizer from poultry.

Material and Method. In this study we followed the evolution of total petroleum hydrocarbons in soil artificially polluted with 6%, 8%, 10% diesel fuel and treated with different quantities (40 g, 60 g, 80 g) of poultry manure. In order to conduct this study, soil samples were taken randomly, in modified structure, from a depth of 0-15 cm. Soil samples were taken from Bonţida village, Bonţida Township which is located in Fizeşului plain in the north-west of Transylvania Plateau. Regarding the bioremediation of soil contaminated with petroleum hydrocarbons (diesel fuel) by treatment with organic fertilizer from poultry, the sampled soil was previously dried for a period of one week at laboratory temperature (23-25°C). Afterwards the soil was passed through a sieve with an aperture of 2 mm and manure from poultry was dried outdoors for a period of 4 days at a temperature of 25°C.

In order to investigate the degree of degradation of total petroleum hydrocarbons, the soil sampling, with no history of petroleum hydrocarbons pollution was artificially contaminated with 6%, 8% and respectively 10% diesel fuel and treated with 40 g, 60 g and 80 g of poultry manure. 12 samples were prepared soil of which 3 are control samples (C1, C2, and C3) which haven't been treated with manure. The prepared soil samples, shown in Table 1, were kept in the laboratory for a period of 12 weeks at an average temperature of 23°C, were watered at an interval of 2-3 days (40 mL of water per sample) and mixed for homogeneity and aeration. Concentration determination of total petroleum hydrocarbons, in order to determine the effect of organic fertilizer from poultry in soil bioremediation, was performed in SC Tonnie SRL Laboratories, using the OCMA-310 Oil analyzer, over a period of 12 weeks at different time intervals as follows: 3rd week of testing, 9th week of testing and respectively 12th week of testing.

Table 1

Soil samples contaminated with diesel fuel and treated with organic poultry fertilizer

Sample	*Soil quantity (g)*	*% of diesel fuel*	*Manure type*	*Manure quantity (g)*
C1	400	6	-	-
c1g1	400	6	poultry	40
c1g2	400	6	poultry	60
c1g3	400	6	poultry	80
C2	400	8	-	-
c2g1	400	8	poultry	40
c2g2	400	8	poultry	60
c2g3	400	8	poultry	80
C3	400	10	-	-
c3g1	400	10	poultry	40
c3g2	400	10	poultry	60
c3g3	400	10	poultry	80

Results and Discussion. Using 40, 60, and 80 g of organic fertilizer from poultry in bioremediation of soil contaminated with 6% diesel fuel has a positive effect in terms of reducing the concentration of total petroleum hydrocarbons as shown in the graph in Figure 1. Reduction of the concentration of total petroleum hydrocarbons in soil treated with 40 g of manure from poultry is 60.78%, it is 70.58% for soil treated with 60 g manure from poultry and 78.43% respectively for soil treated with 80 g of manure from poultry at the end of the testing period. In the control sample, the concentration reduction of total petroleum hydrocarbons at the end of the twelve weeks of testing is 33.33%.

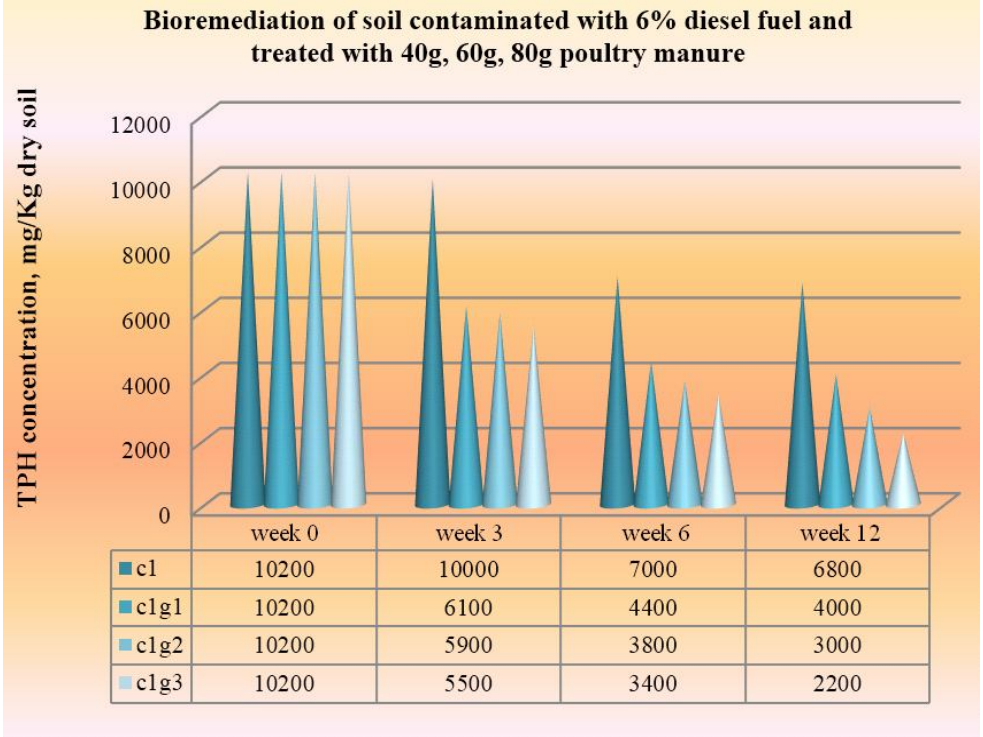

Figure 1. Evolution of total petroleum hydrocarbons in soil contaminated with 6% diesel fuel and treated with 40, 60, and 80 g poultry manure.

In bioremediation of soil contaminated with 6% diesel fuel and treated with 80 g of poultry manure recorded the highest loss in percentage of concentration of total petroleum hydrocarbons as shown in the graph in Figure 1. For the sample contaminated with 6% diesel fuel and treated with 80 g of poultry manure, in the first three weeks the loss in percentage of concentration of petroleum hydrocarbons was 46.07%, after six weeks it was 66.66% and the highest loss in percentage of 78.43% was recorded at the end of the testing period.

The graph in Figure 2 shows the reduction of total petroleum hydrocarbons at the end of the twelve week period of time, from soil samples contaminated with 8% diesel fuel and treated with 40 g, 60 g and 80 g of manure from poultry. For soil polluted with 8% diesel fuel and treated with 40 g of poultry manure is recorded a concentration reduction of total petroleum hydrocarbons of 58.08%. For the soil sample treated with 60 g poultry manure, after the first three weeks of testing the rate of degradation of petroleum hydrocarbons increased with 46.32%, after six weeks with 54.21% and at the end of the testing period of time of twelve weeks is recorded a concentration reduction of total petroleum hydrocarbons of 63.97%. Treatment of soil with 80 g of poultry manure positively influences the bioremediation of soil artificially polluted with 8% diesel fuel, thus, emphasizing a reduction of 67.64% of the concentration of total petroleum hydrocarbons at the end of the twelve weeks of testing and of 54.58%, respectively 58.82% for the first two tests. As for the control sample, there is a smaller reduction in the concentration of total petroleum hydrocarbons of 30.15%, the evolution of

concentration of total petroleum hydrocarbons being proportional to the quantity of organic fertilizer that is used in the treatment of soil.

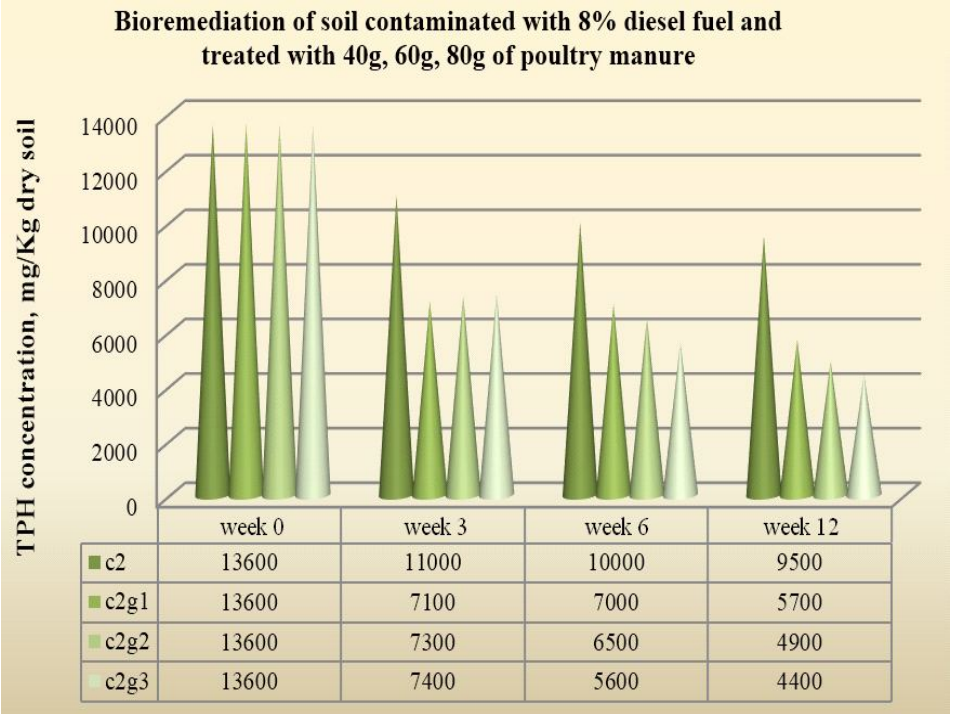

Figure 2. Evolution of total petroleum hydrocarbons in soil contaminated with 8% diesel fuel and treated with 40, 60, and 80 g of poultry manure.

The Figure 3 shows that the concentration evolution of the total petroleum hydrocarbons in soil samples contaminated with 10% diesel fuel and treated with different quantities of poultry manure.

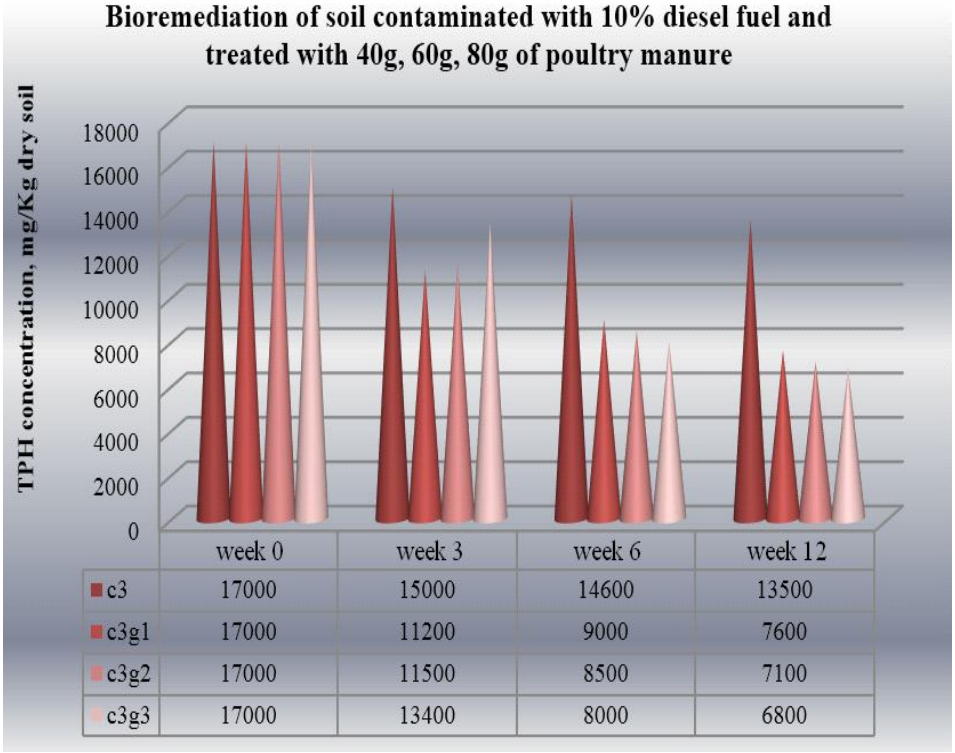

Figure 3. Evolution of total petroleum hydrocarbons in soil contaminated with 10% diesel fuel and treated with 40, 60, and 80 g of poultry manure.

From the graph in Figure 3 we conclude that using poultry manure (40 g) in bioremediation of soil contaminated with 10% diesel fuel improves reduction of the concentration of total petroleum hydrocarbons by 55.29%. In bioremediation of soil artificially polluted with 10% diesel fuel and treated with 60 g of poultry manure is recorded a decrease with 58.23% of the concentration of total petroleum hydrocarbons in the soil.

For soil contaminated with 10% diesel fuel and treated with 80 g poultry manure is recorded an increase of up to 60% in the rate of degradation of petroleum hydrocarbons by the end of the testing period. After the first three weeks there is a decrease of the concentration of total petroleum hydrocarbons by 21.17% and after six weeks by 52.94%. For soil contaminated with 10% diesel fuel and which isn't treated with poultry manure, after twelve weeks the rate of degradation of petroleum hydrocarbons was 20.58%.

The graph in Figure 4 highlights a reduction of the concentration of total petroleum hydrocarbons in the control samples (C1, C2, C3), reduction that fluctuates between 20.58% and 33.33%. This percentage loss is due to the natural attenuation process.

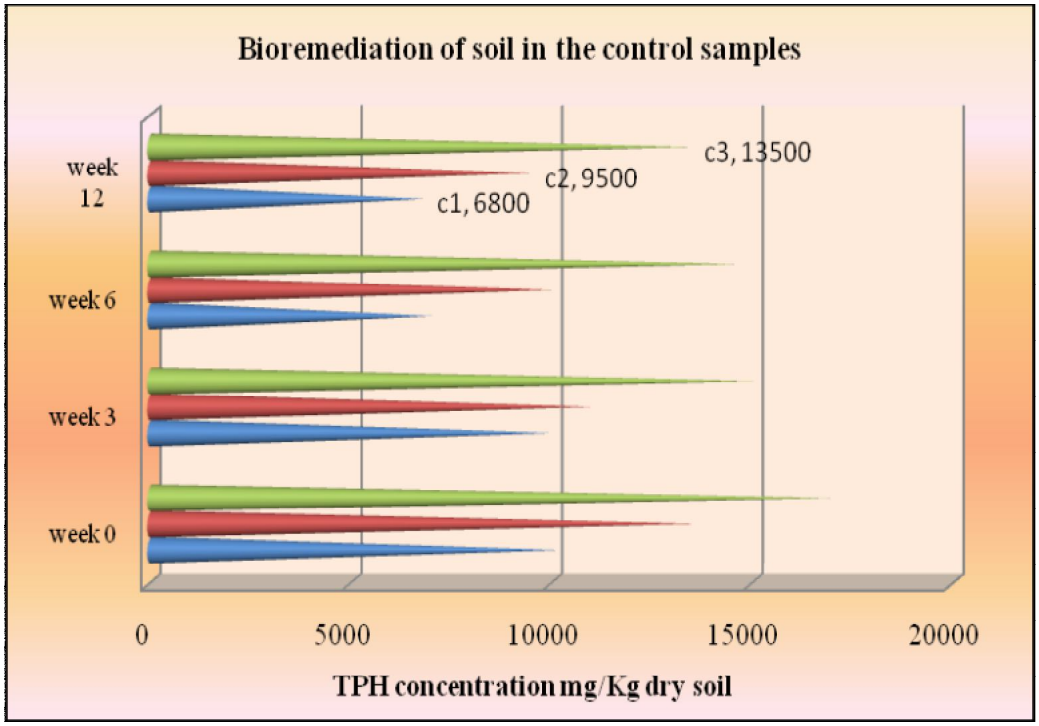

Figure 4. Evolution of total petroleum hydrocarbons in soil contaminated with diesel fuel and without poultry manure.

As shown the graph in Figure 5, for bioremediation of soil contaminated with 6, 8 and 10% diesel fuel and treated with different quantities of 40, 60, and 80 g of organic fertilizer from poultry, the reduction of the concentration of total petroleum hydrocarbons is influenced by the degree of soil contamination and by the quantity of manure that is used.

For soil contaminated with 6% diesel fuel and treated with 90 g of poultry manure is recorded the highest percentage of concentration reduction of total petroleum hydrocarbons, namely 78.43%. In this sample the concentration of total petroleum hydrocarbons at the end mark of 12 weeks is 2,200 mg/kg of dry soil, value that is above the intervention threshold according to the MAPPM 756/1997 Order.

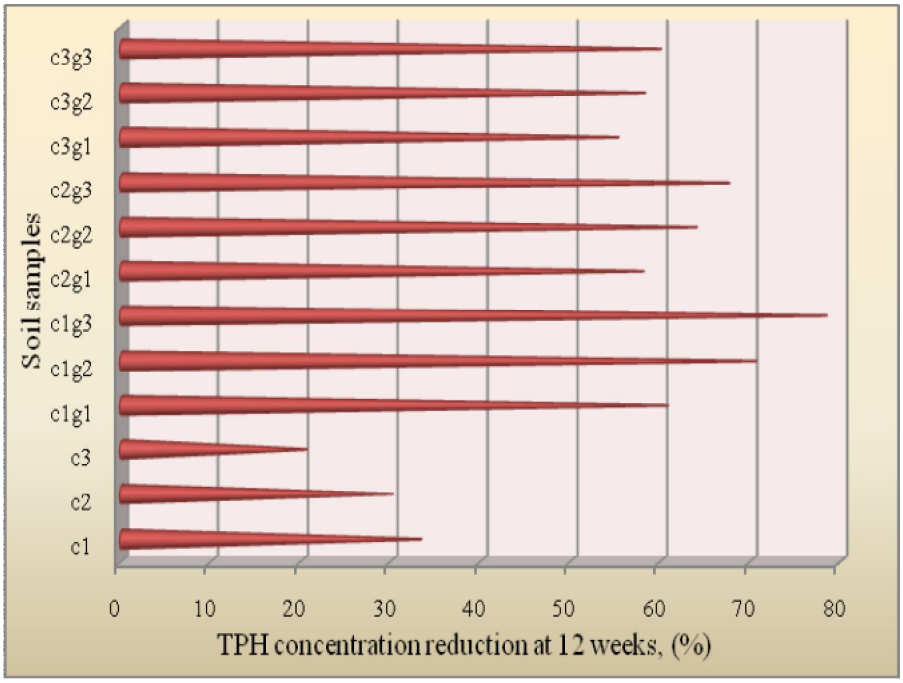

Figure 5. TPH reduction (%) for samples contaminated with 6, 8, and 10% diesel fuel and treated with different quantities of poultry manure.

Conclusions. From the conducted experiment we can conclude that by stimulating the process of bioremediation of soils using organic fertilizer from poultry, the concentration reduction of total petroleum hydrocarbons is influenced by the quantity of manure and by the degree of contamination of the soil.

Poultry manure, containing nourishing elements such as nitrogen, phosphorus, potassium and a high amount of microorganisms, has an important role by stimulating the bioremediation process of petroleum hydrocarbons polluted soil.

Based on previous research conducted over a period of 6 weeks, we notice an increase of the soil's reparation percentage by the end of the 12 weeks of testing.

At the end of the 12 weeks of testing, the lowest percentages in reduction of the concentration of total petroleum hydrocarbons are recorded for samples of soil contaminated with 10% diesel fuel, they increase for soil samples contaminated with 8% diesel fuel and are significantly increased for soil samples contaminated with 6% diesel fuel.

For the soil sample artificially polluted with 6% diesel fuel and treated with 80 g poultry manure is recorded the highest percentage loss of 78.43% in the concentration of total petroleum hydrocarbons and for soil samples contaminated with diesel fuel but which weren't treated with poultry manure, the degree of degradation of petroleum hydrocarbons is much lower.

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