Influence of poultry manure and universal peat on the bioremediation of soil contaminated with diesel fuel

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Abstract. Soil contamination with petroleum hydrocarbons (diesel fuel) is a worldwide problem. Polluted areas require application of depollution/remediation methods. In this paper are presented results of laboratory experiments in which was studied the bioremediation of a soil polluted with diesel fuel, by using manure from poultry. At the same time it was also made a comparison of the treatment efficiency if you also add universal peat. After analyzes it was observed a 67% treatment efficiency for soil samples treated with poultry manure and peat. Treatment yield was 3 percent smaller for samples treated only with manure. Through this experiment we concluded that remediation of soil contaminated with petroleum hydrocarbons can be achieved through efficient use of manure.
Key Words: bioremediation, hydrocarbons, peat, polluted soil, poultry manure.

Introduction. Worldwide, a particular accent is put on soil contamination with petroleum hydrocarbons, which are constituents of oil, gasoline, diesel fuel and a variety of solvents. Among petroleum products, diesel fuel is commonly reported as soil pollutant due to leakage from storage tanks, transport pipes and accidental spillages.

It is very important that the soil polluted with petroleum hydrocarbons is given a special attention in terms of decontamination, the soil being a valuable but non-renewable resource. The need to remedy soil contaminated with petroleum hydrocarbons led to the development of new technologies that focus on destroying pollutants rather than the conventional elimination approach, bioremediation being among these new technologies (Boopathy 2000).

Manure is a valuable source of nutrients to the environment but improper use can lead to environment pollution (Tao & Mancl 2008). Manure is a valuable source of nutrients for cultures and has the ability to improve soil productivity (Lorimor et al 2000). In general, manure means animal urine and feces that contain organic matter and nutrients (Tao & Mancl 2008). Manure properties depend on many factors: animal species, alimentation, animal age, type of bedding, manure management and handling (Tao & Mancl 2008; Lorimor et al 2000). In average, manure contains 20–25% solid substance, with humidity between 75–80% (Tao & Mancl 2008). The main factor influencing the total N and P quantity from manure is represented by alimentation, 55–90% of the N and P content from animal food being excreted in feces and urine (Ogbuewu et al 2012).

Chemical composition of manure differs depending on the species from which it comes (Man & Ilarie 1999). Manure from poultry contains all the essential nutritive substances needed for plant growth and development. These substances are nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, manganese, copper, zinc, chlorine, boron, iron and molybdenum. The share of these elements varies depending on various factors such as age, diet, type of bedding and humidity content. Fresh manure from poultry has a humidity of 60–70% and contains uric acid, while urea and ammonium are present in small quantities (Amanullah et al 2010).

Manure influences physico-chemical properties of the soil by: improving fertility, increasing water and air permeability, increasing humus content, enrichment of soil with useful microorganisms, increasing the amount of carbon dioxide in the soil which helps to solubilize nutritive substances (Madjar & Davidescu 2009).

Worldwide were conducted a series of researches on using organic fertilizer in bioremediation of soil contaminated with petroleum hydrocarbons. At the Federal University of Technology (FUTO), Owerri, Nigeria, in an experiment was observed the evolution of petroleum hydrocarbon concentration in polluted soils and subjected to

bioremediation with poultry manure from the School of Agriculture and Agricultural Technology, FUTO. Experiments were conducted on samples of 100 g soil contaminated with crude oil over which various quantities of poultry manure (30, 60 and 90 g) were added. These samples were monitored for a period of seven weeks. At the end of the testing period it was concluded that:

- total number of heterotrophic bacteria indicated an increase in the microbial population;
- soil fertility and biological activity increases in soils contaminated with hydrocarbons upon applying organic nutrients;
- the highest oil reduction percentage (49.47%) was observed in the sample supplemented with the highest quantity of poultry manure (90 g) (Ibekwe et al 2006).

The purpose of a study conducted in Nigeria was to evaluate and compare the biodegradation performance of manure (poultry, swine and goat) and inorganic chemical fertilizer in bioremediation of soil contaminated with a mixture of petroleum hydrocarbons (kerosene, diesel fuel and gasoline). Following treatment with organic and chemical fertilizer of the soil contaminated with the mixture of petroleum hydrocarbons, it can be observed an improvement of the biodegradation rate of petroleum hydrocarbons, poultry manure presenting the highest treatment efficiency (Agarry et al 2010).

In an experiment conducted in the didactic and research farm of the Faculty of Agriculture and Veterinary Medicine in Nigeria, it was investigated the interaction between oil and manure based on the agronomic characteristics of corn. Poultry manure significantly improved the agronomic characteristics of corn compared to other types of manure. Manure from poultry has a higher potential of remediation of soil polluted with oil compared to the potential of organic fertilizer. Results have shown that by applying poultry manure are obtained better results in remediation of soil polluted with crude oil; as a result it can be used in remediation of soil polluted with oil (Onuh et al 2008).

In another study conducted in order to determine the reduction in oil concentration, the following samples were prepared: PC1 (300 g soil + 10% oil), PC2 (300 g soil + 10% oil + 50 g inorganic fertilizer), PC3 (300 g soil + 10% oil + 50 g chicken excrements), PC4 (unmodified soil) as control sample. Soil samples thus prepared were kept at room temperature (28°C) and every two weeks for a period of ten weeks they were subjected to analyses in order to determine oil loss. The biodegradation study has shown a reduction in oil concentration of 56.3% in unmodified soil, 75% and respectively 87.5% in soil treated with poultry manure and with chemical fertilizer, respectively, after ten weeks (Ijah et al 2008).

Experiments on bioremediation of soil contaminated with diesel fuel have shown that reduction in the concentration of total petroleum hydrocarbons in soil by treating with organic fertilizer from poultry can be achieved obtaining good results: 78.43% (Coste (Bână) et al 2013; Coste (Bână) 2015).

The purpose of this paper is to highlight that by using organic fertilizer from poultry in a mixture with universal peat, a remediation of soil polluted with diesel fuel can be achieved.

Material and Method. Experiments were conducted on soil samples taken from a farmland in Bonţida village. The collected soil was dried at room temperature and passed through a sieve with 2 mm diameter sieve mesh; 3 soils samples were prepared, 400 g each. The 3 soil samples were contaminated with 6% diesel fuel, with a concentration of 10200 mg kg^{-1} dry soil. For soil bioremediation, poultry fertilizer and commercial universal peat were used.

The peat mixture that was used contains: Shagnum peat, black peat, earthworm humus, clay, river sand, its pH is 6.5-7 and has a content of N min. 1000 mg L^{-1}, P_2O_5 min. 100 mg L^{-1}, K_2O min. 300 mg L^{-1}.

For experiments 3 polluted soil samples over which were added different concentrations of bird fertilizer and peat, were prepared as follows:

- C – 400 g soil + 6% diesel fuel;
- C1 – 400 g soil + 6% diesel fuel+ 150 g poultry manure;
- C2 – 400 g soil + 6% diesel fuel + 80 g poultry manure + 70 g peat;

The 3 samples subjected to experimentation were kept in the laboratory at an average temperature of 23°C for a period of six weeks. The samples were watered (40 mL sample^{-1}) every four days and mixed for aeration and homogenization. They were analyzed in order to determine the total petroleum hydrocarbons and total heterotrophic bacteria.

Determination of total petroleum hydrocarbons in the soil samples was conducted over a period of six weeks, analyzes being made at 2, 4 and 6 weeks, respectively.

Tracing the evolution of total heterotrophic bacteria in the soil samples was conducted over a period of six weeks, analyzes being made at 0, 3 and 6 weeks, respectively.

In order to establish the effect which organic fertilizer had in the soil bioremediation process, determination of total petroleum hydrocarbons was conducted at Tonnie Laboratories SRL, using the OCMA-310 Oil Analyzer.

Results and Discussion. Following treatment of soil contaminated with 6% diesel fuel with poultry manure, respectively with a mixture of poultry manure and universal peat, there were recorded modifications of total petroleum hydrocarbon concentration and of total number of heterotrophic bacteria, during the testing period.

Using 150 g organic fertilizer from poultry in bioremediation of soil contaminated with 6% diesel fuel has a positive effect in the reduction of total petroleum hydrocarbon concentration, as shown in the graph in Figure 1.

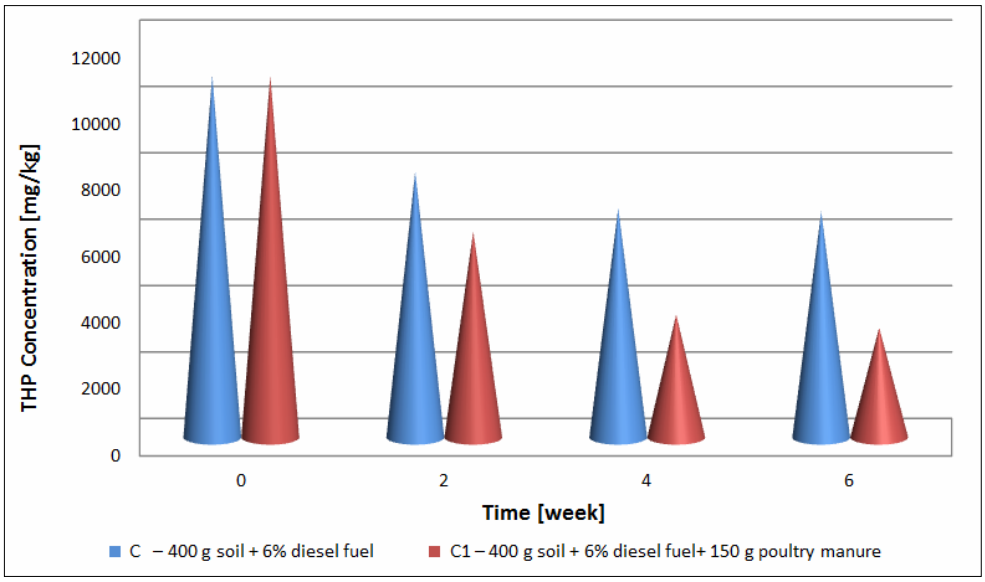

Figure 1. Evolution of total petroleum hydrocarbons in soil contaminated with 6% diesel fuel and treated with 150 g poultry manure.

Reduction of the concentration of total petroleum hydrocarbons in soil treated with 150 g poultry manure is 70% at the end of the testing period (six weeks), 43% and 66% after two and four testing weeks, respectively.

Figure 2 shows a decrease, during the testing period, in the total petroleum hydrocarbon concentration in soil treated with 80 g poultry manure and 70 g universal peat. After the first two weeks of testing, the rate of hydrocarbon degradation has increased by 55%, after four weeks with 65% and at the end of the six week testing period there is recorded a reduction in the total petroleum hydrocarbon concentration of 67%.

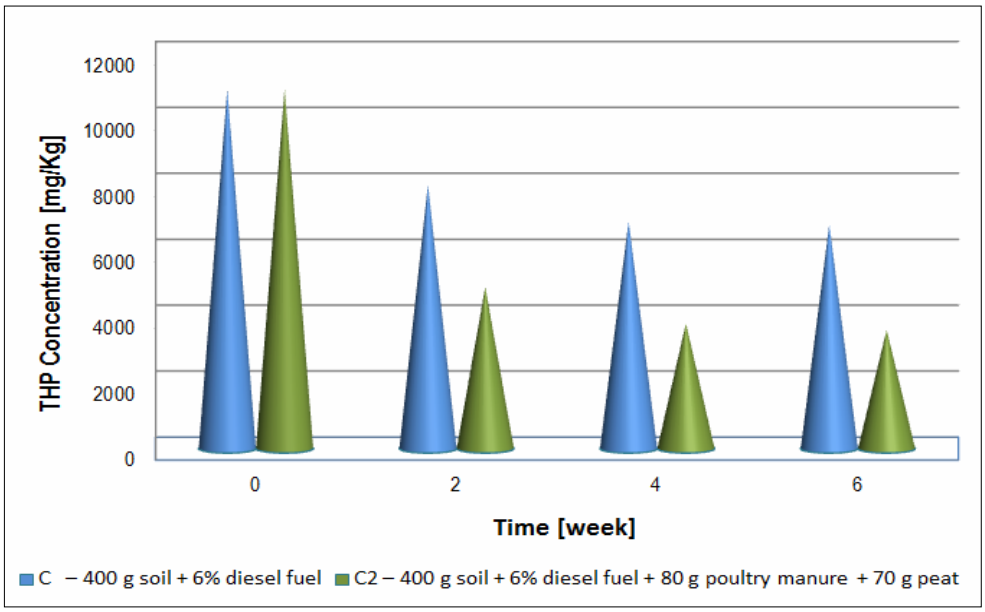

Figure 2. Evolution of total petroleum hydrocarbons in soil contaminated with 6% diesel fuel and treated with 80 g poultry manure and 70 g peat.

Regarding the control sample, as shown in Figures 1 and 2, the reduction of total petroleum hydrocarbon concentration is smaller (37%) at the end of the six week period, compared to the sample treated with poultry manure and respectively manure and peat.

In terms of the evolution of total heterotrophic bacteria in the bioremediation process, soil samples were analyzed at an interval of three weeks.

In Figure 3 is presented the total number of heterotrophic bacteria in the soil sample treated with poultry manure. At the beginning there were $5.3*10^5$, number is increasing due to multiplication of bacteria ($2.1*10^6$) in the third week of testing, after which there is a decrease in the number of bacteria reaching $7.5*10^4$ by the end of the testing period.

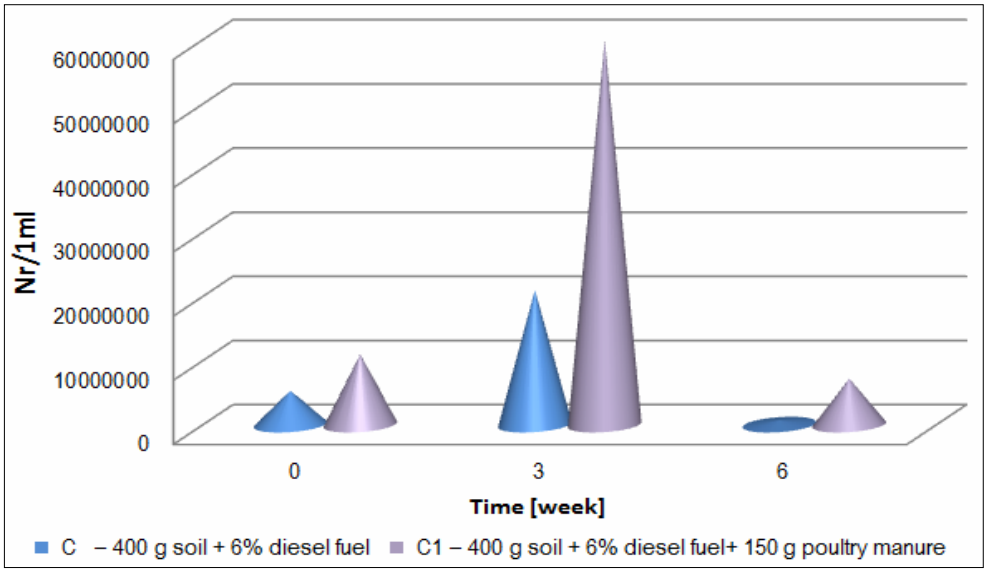

Figure 3. Evolution of total heterotrophic bacteria in soil contaminated with 6% diesel fuel and treated with 150 g poultry manure.

In the soil sample treated with 80 g poultry manure and 70 g universal peat (Figure 4), the first day of testing highlights a total number of heterotrophic bacteria of $2.7*10^6$.

These bacteria multiply reaching a number of $4.8*10^6$ by the third week of testing, after which there is a decrease to $1.04*10^6$ by the end of the testing period.

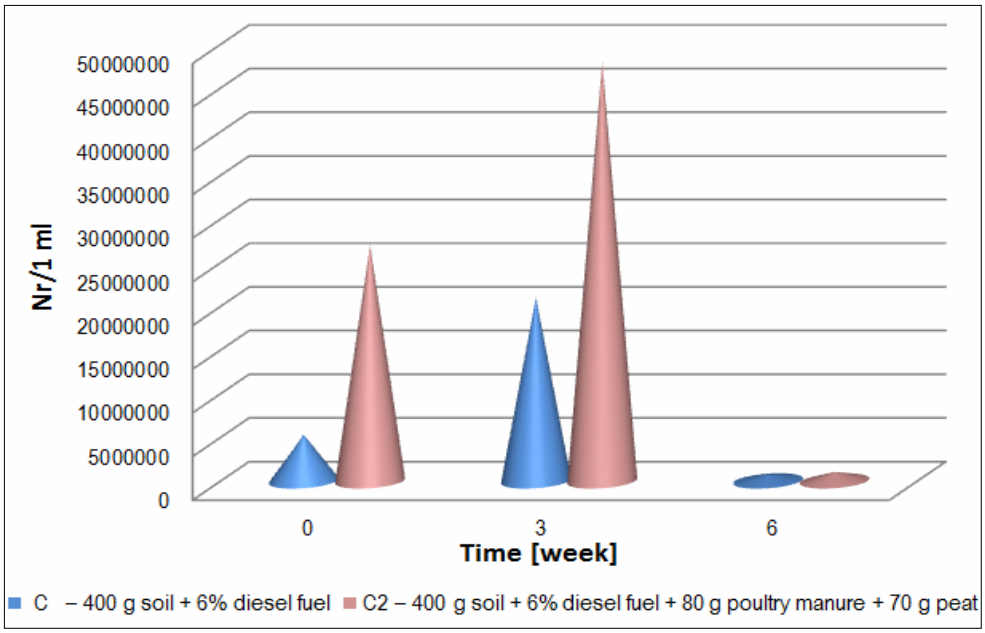

Figure 4. Evolution of total heterotrophic bacteria in soil contaminated with 6% diesel fuel and treated with 80g poultry manure and 70 g universal peat.

As we can observe in Figures 3 and 4, for the control sample, in the first day the number of heterotrophic bacteria (nr/1ml) was $5.3*10^5$ after which it increased to $2.1*10^6$ in the third week of testing and decreased to $7.5*10^4$ in the sixth week of testing.

Analyzing graphs we can observe the evolution of the microbial population during the six testing weeks. Thus, in the three samples, the number of heterotrophic bacteria is smaller in the first day of testing, after which an exponential growth occurs, and after six weeks there is a decrease in the microbial population.

Conclusions. The rate of biodegradation of petroleum hydrocarbons by the end of the testing period (six weeks) is 70% in the soil sample treated with 150 g poultry manure, and 67% in the sample treated with a mixture of peat and poultry manure.

Regardless of the quantity and type of manure that was used, the number of heterotrophic bacteria has the same trend: it is smaller in the first day of testing, after which an exponential growth occurs, and after six weeks it can be observed a decrease in the microbial population.

Given the evolution of total heterotrophic bacteria in the three soil samples, we can conclude that the bioremediation process is influenced by microorganism activity, petroleum hydrocarbons being decomposed by microorganisms.

Through this experiment it was concluded that two problems can be solved at the same time, namely: remediation of soil contaminated with petroleum hydrocarbons and efficient use of manure which, due to growth of livestock, is currently present in higher and higher quantities.

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