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REMEDY OF SOILS CONTAMINATED WITH PETROLEUM HYDROCARBONS USING BIODEGRADABLE ABSORBENT

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Abstract: In this paper, we present a method of remediation of oil–polluted soils, using a biodegradable material, it is a material made of natural peat–type fibers. The rate of absorption of petroleum hydrocarbons by the peat is influenced by the size of the particles, the smaller they are, the higher the degree of absorption of petroleum products. We analyzed the absorption efficiency of petroleum hydrocarbons by the peat. By using peat for depollution, the soil is purified from petroleum products through sorption, soil fertility is improved, peat is rich in biogenic substances beneficial to the development of bacteria that reduce petroleum hydrocarbons.
Keywords: soil pollution, biodegradable absorbent, material, granulosity

INTRODUCTION

Greenhouse gas emissions from the environment are methane released from agriculture and natural gas handling and carbon dioxide, obtained from the burning of fossil fuels. Oil and hydrocarbon pollution, affects the environment and human health. Hydrocarbons are frequently used as a fuel source. Some uses of these compounds are derived from natural gas and petroleum. The latter are transformed, in turn, into propylene, ethylene or synthesis gas. Soil pollution with petroleum hydrocarbons results from anthropogenic sources resulting from industrial, agricultural and other activities (burning of fossil fuels for heating homes, incineration of waste, oil spills, burning of gasoline and diesel) and from natural sources (burning of waste, forest fires, volcanoes) (*Rocha, I. et al, 2019, Ambaye, T.G. et al., 2022, Rada, E.C. et al., 2019*).

Through pollution, soils change their physical and chemical properties, seed germination and crop growth are affected (*Evans, M. et al., 2016*). These polluted soils contain polyaromatic hydrocarbons, phenols, long–chain toxic hydrocarbons and must be remediated before they can be safely used.

Over time, methods have been sought to remediate the soil polluted with petroleum hydrocarbons, taking into account: the type of hydrocarbons, the characteristics of the location, the use of the depolluted land, the costs of depollution. Worldwide, researchers have turned their attention to finding the best methods for remediating soils polluted with petroleum hydrocarbons. Thus, treatment techniques were used for soil depollution: biological, physical, chemical, thermal and bioremediation, the use of biodegradable absorbents such as peat, which is rich in humic substances and has a high capacity to absorb pollutants from the soil, was tried (*De–Chang, Li et al., 2018, Olkova, A., 2022, Ghaly AE and Pyke, 2001*). By using peat for depollution, the soil is purified of petroleum products through sorption, soil fertility is improved, peat is rich in biogenic substances beneficial to the development of bacteria reducing petroleum hydrocarbons (*Gao Y.C. et al., 2014*).

The toxicity of hydrocarbons varies depending on: unsaturated compounds, the content of low–boiling compounds, acids and aromatic substances. The oil is more toxic the higher the concentration of these compounds. Once inside a plant, oil can migrate into the intercellular spaces and vascular system. Damage to cell membranes is achieved by the penetration of hydrocarbon molecules, which leads to leakage of cell contents, and oil can enter the cells.

In this work, the biodegradable absorbent peat is analyzed, which is rich in humic substances and has a high capacity to absorb pollutants from the soil (*Prodea, I.M., Sporea, N., 2018*).

CHARACTERIZATION OF THE SOIL – SUBSOIL – GROUNDWATER SYSTEM

The speed of movement of the liquid pollutant in the vertical or lateral direction is dependent on the characteristics of the pollutant (composition,

density, viscosity, polarity, etc.) and on the characteristics of the soil – subsoil – groundwater system (soil composition, soil structure, humidity) (*Popa, M, 2018*).

The characterization of the soil – subsoil – underground water system is carried out by establishing the thicknesses of the specific layers up to the first impermeable layer and by analyzing the characteristic parameters that influence the dispersion of pollutants (*Popa, M, 2018*).

Figure 1 shows the structure of the soil – subsoil – underground water system, the sizes of the layers varying between very large limits, depending on the geology and concrete conditions in the respective area (*Popa, M, 2018*).

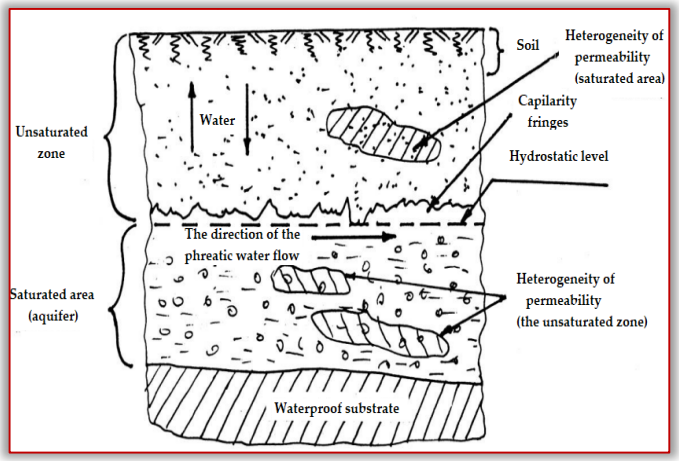

Figure 1 – The structure of the soil – subsoil – underground water system (Popa, M, 2018)

Figure 2 shows the specific areas that form over a relatively long period of time in the case of spilling a large amount of oil product on the soil surface. The liquid pollutant can reach the first water table and migrate with it, at a relatively high speed, to areas far from the place where the polluting incident occurred.

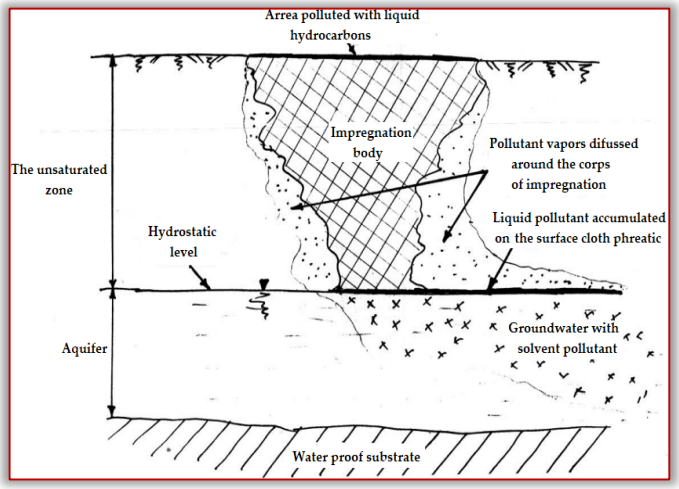

Figure 2 – Migration of a liquid petroleum pollutant in the soil–subsoil–groundwater system (*Popa, M, 2018*)

The toxicity of hydrocarbons varies depending on: unsaturated compounds, the content of low–boiling compounds, acids and aromatic substances. The oil is more toxic the higher the concentration of these compounds. Once inside a plant, oil can migrate into the intercellular spaces and vascular system.

Damage to cell membranes is achieved by the penetration of hydrocarbon molecules, which leads to leakage of cell contents, and oil can enter the cells. Hydrocarbons reduce the rate of transpiration by blocking stomata and intercellular spaces, reducing photosynthesis. Due to oil pollution, mitochondria are damaged, respiration rate increases. These negative effects occur depending on: plant species, environmental conditions and the amount of oil (*Odukoya, L. et al, 2019*). The classification of petroleum hydrocarbons is shown in figure 3. They are classified into heterocyclic and aromatic aliphatic hydrocarbons (*Balint, 2021; Bojan et al., 2021*).

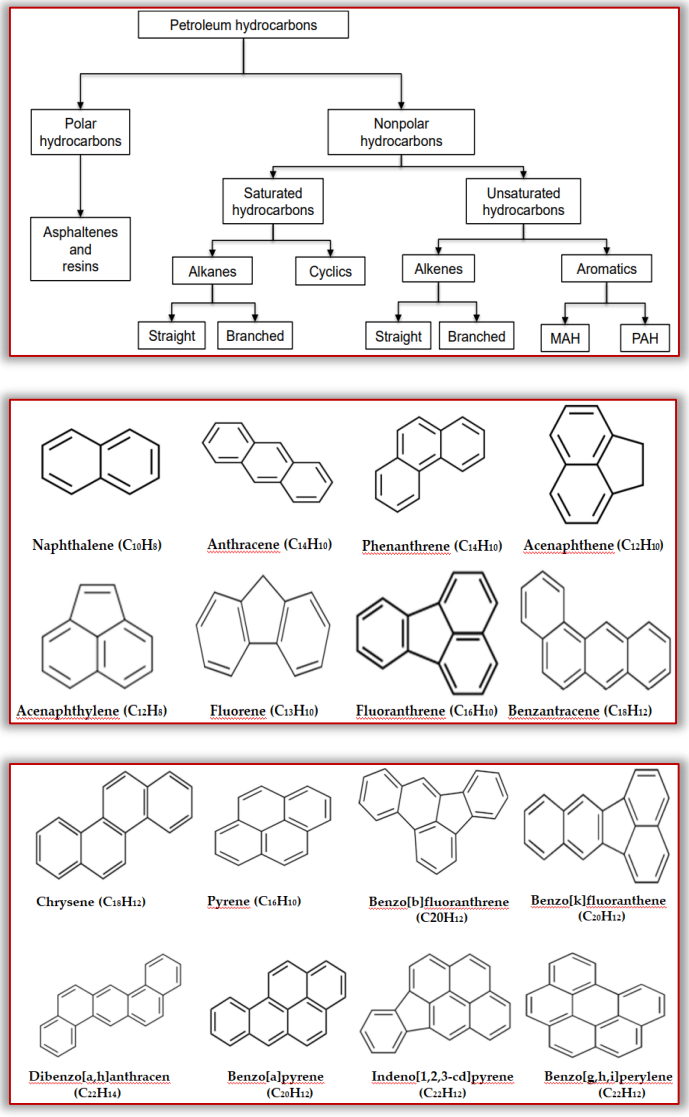

Figure 3 – Types of petroleum hydrocarbons *(Odukoya, L. et al, 2019)*
PAH –Polycyclic aromatic hydrocarbons, Monoaromatic hydrocarbons

SOURCES OF SOIL POLLUTION WITH PETROLEUM HYDROCARBONS

Soil pollution with oil is due to oil spills during the loading of tanks, during transport, accidental spills. The sources can be anthropogenic, from human activities (*Shahzadi, 2021*).

Annually, 1.7–8.8 million metric tons of petroleum hydrocarbons are spilled into the environment (*Shahzadi, 2021*).

Petroleum hydrocarbons are transported in the environment starting from production, transport, storage, then move into air, water, soil and terrestrial and aquatic ecosystems.

The sources of soil pollution with petroleum hydrocarbons are shown in figure 4.

Figure 4 – Sources of soil pollution with petroleum hydrocarbons *(Ambaye, T.G. et al, 2022)*

BIOREMEDIATION OF SOILS CONTAMINATED WITH PETROLEUM HYDROCARBONS

Peat (figure 5), obtained from the processing of peat moss, has the following characteristics presented in table 1.

Table 1. Physico–chemical characteristics of peat.

Peat	Values
physical condition	solid
pH	3.5–6
dry density	68.5 [g/dm^3]
auto–ignition temperature	200–260 [^{0}C]
humidity	8.5 [%]
specific weight	60–90 [g/l]
peat moss	85–87%
water and other organic elements	15 –13%

The natural biodegradable absorbent peat is applied to the polluted soil. This is a method of in situ treatment of oil–polluted soils. The humidity of the soil used in the experiment was 14% (g/g) and the average temperature of the soil was 14^{0}C. The rate of absorption of petroleum hydrocarbons by peat is influenced by the size of the particles, the smaller they are, the higher the degree of absorption of petroleum products.

Figure 5 – Biodegradable absorbent

Table 2 shows the sorption capacity of petroleum hydrocarbons by the peat depending on the granulation size. It is observed that the smaller the granulation, the higher the gasoline absorption capacity.

Table 2. Particle size of petroleum hydrocarbon sorbent (*Novoselova, L.Yu, Sirotkina, E. E. 2008*).

Particle size composition of the proposed sorbent	Particle size [mm]	Sorption capacity, for diesel fuel [g/g]
Plant residues	>3	4.10
Coarse fraction	2–3	5.52
Medium fraction	1–2	7.34
Small fraction	0.5–1	7.35
Coarse dust fraction	0.25–0.5	6.23
Fine dust fraction	≤0.25	6.04
Medium and small fractions (1 : 1.5)	–	7.50
Medium and small fractions (1 : 1)	–	7.71

The content of petroleum hydrocarbons in the treated soil (TS) and in the untreated soil (NS) for all 60 days of the experiment period is shown in figure 5. It can be seen that at the end of the experiment, in the soil treated with absorbent material based on peat, the hydrocarbons oil tankers were absorbed in a percentage of 95%.

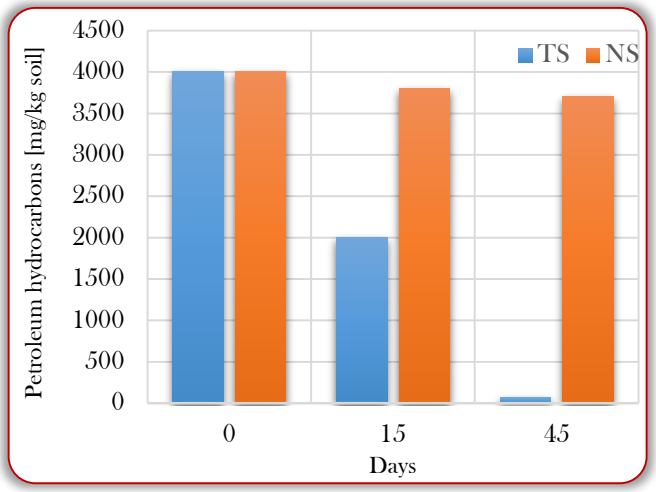

Figure 6 – Petroleum hydrocarbon content

The efficiency of removal of petroleum hydrocarbons is calculated with formula (1), (*Prodea and Sporea, 2018*).

$$\eta_i = \frac{PH_i - PH_j}{PH_i} x100 \quad [\%] \qquad (1)$$

where: j–day of the experiment; PHi the initial concentration of hydrocarbons; PHj the concentration of hydrocarbons from certain days of the experiment.

CONCLUSIONS

The topic addressed is part of the current concerns regarding research in the field of remediation of polluted soils. The need for research derives from the extent and degree of complexity of the problem of soil pollution, the impact of human activities on soil quality intensifying over the last decades due to population growth, extensive exploitation of natural resources, the development of industries and even agriculture.

In this paper, the role of biodegradable absorbent material for the recovery of gasoline–polluted soil was observed. By adding the biodegradable absorbent material to the polluted soil, the properties of the soils were improved. The absorption of petroleum hydrocarbons is 95%. This is a method of in situ remediation of soils polluted with petroleum hydrocarbons.

The effectiveness of soil remediation treatment depends on several factors: the concentration of pollutant applied, the type of contaminants, the amount of soil to be treated, and other factors.

The rate of absorption of petroleum hydrocarbons by the peat is influenced by the size of the particles, the smaller they are, the higher the degree of absorption of petroleum products.

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