

## STUDY REGARDING THE APPLICATION OF BULK BIODEGRADATION IN DECONTAMINATING THE SOILS CONTAMINATED WITH POLICYCLIC AROMATIC HYDROCARBONS, IN ROMANIA

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ABSTRACT. Bulk biodegradation consists of excavating the polluted soil and disposing it in the neighbourhood of the excavation place, in technical conditions favouring the natural aerobic biodegradation. For applying bulk biodegradation, the contaminated soil is excavated and mixed with coarse organic materials (straws, bark rests, stable garbage) having a nutritive role and favouring the aeration.

### ИЗСЛЕДВАНЕ ЕФЕКТА НА ПОЧИСТВАНЕ НА ЗАМЪРСЕНИТЕ ПОЧВИ ЧРЕЗ НАТРОШАВАНЕ И СВЪРЗВАНЕ С ПОЛИЦИКЛИЕНИ АРМАТУРИРАНИ ХИДРОКАРБОНАТИ В РУМЪНИЯ

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РЕЗЮМЕ. Замърсената почва се натрошава, като се отлага в близост до откривката и смесва с естествени твърди органични материали (слама, остатъци, твърди отпадъци), имащи захранваща роля.

#### 1. Introduction

Bulk biodegradation consists of excavating the polluted soil and disposing it in the neighbourhood of the excavation place, in technical conditions favouring the natural aerobic biodegradation. For applying bulk biodegradation, the contaminated soil is excavated and mixed with coarse organic materials (straws, bark rests, stable garbage) having a nutritive role and favouring the aeration. The resulted material is laid on the soil in the neighbourhood, in regulated dumps, having a circumference of a few meters and a height of one meter. [1].

Soil pollution by PAHs in the area, is due the following reasons:

- diesel fuel is loaded into the barrels on the platform of a building located near the entrance to the perimeter;
- in the middle of the perimeter are located underground 10 storage tanks, these tanks are removed and stored directly on the ground outside the perimeter, the other side of the access path;
- a 240-ton oil tank is located in the north of the perimeter;
- a quantity of diesel / oil is stored in metal drums of 200 liters, at the eastern perimeter;
- barrels are located directly on the ground, without retaining structures, and could cause accidental pollution of soil with polycyclic aromatic hydrocarbons;

- in the south perimeter of storage tanks are located seven light and medium oils (hydraulic compressor - H turbine - TB engine - M, Valvoline) with a capacity of 160 tons, which are buried;
- the deposit area is located 2 stops for loading and unloading fuel pumps and three brick warehouses for storage of petroleum hydrocarbon spills are observed.

#### 2. Material and methods

For applying bulk biodegradation in the decontamination of the soils contaminated with HAP, we developed a case study in Romania, in Hunedoara county, within Lupeni Mining Exploitation. Within this exploitation, there is the oil and fuel deposit that presents spots on the soil, due to the storage of the polycyclic aromatic hydrocarbons in inadequate conditions (fig.1).

Pollution site to highlight and quantify the types of pollutants, areas and volumes of affected soil, ditches were dug to collect points. [2].

Points were established for soil sampling, the sampling frequency and method of analysis of polycyclic aromatic hydrocarbons.

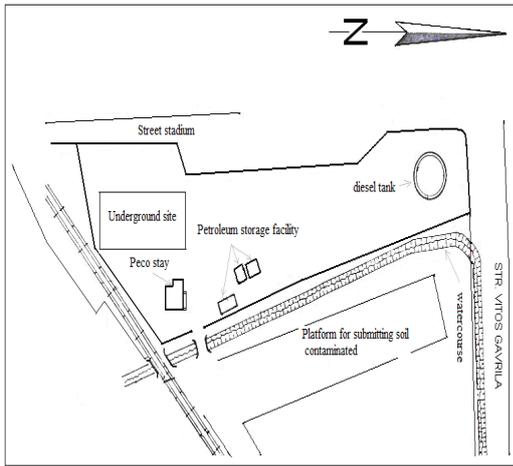


Fig.1. Emplacement of the oil and carburant deposit in E.M. Lupeni-România

Were taken and indicators were determined: heavy metals, fluoride, cyanide, phenols, pH, PAH.

The soil pollution was caused by accidental, because the volume of oil spilled on the ground. Contaminated soil surface is not continuous but only on portions of land around sources of pollution present, which total an area of 70 m<sup>2</sup>.

Maximum penetration depth is 1,5 m, resulting in a volume of soil affected by approximately 100 m<sup>3</sup>.

Maximum depth of penetration of the pollutant in the unsaturated zone was calculated by the following relationship:

$$H = K \cdot \frac{V}{S} \quad [m]; \quad K = \frac{1000}{R \cdot k}$$

$$H = \frac{1000 \cdot V}{S \cdot R \cdot k} \quad [m]$$

where: V= volume of pollutants infiltrated (m<sup>3</sup>)

S= surface area of infiltration (m<sup>2</sup>)

R= retention capacity of pollutants by soil (l/m<sup>3</sup>)

K= dimensionless correction factor depending on the viscosity of pollutants (k=0,3 halogenated solvent, k=0,5 gasoline, k=0,7 for aqueous solution, k=1 for diesel, kerosene (kerosene), k=2 light fuel)

Scheme biodegradation method for the remediation of contaminated soil bulk PAH is shown in figure 2.

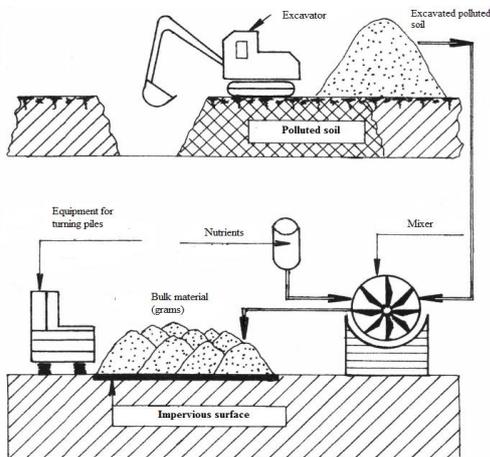


Fig.2. Scheme composting biodegradation in contaminated soil bulk

Method of soil remediation by composting in bulk comprises the following steps:

- excavation of contaminated soil
- mixing with coarse organic material (straw, bark scraps, manure), which fulfill a nutritional role and promote aeration
- depositing, on the soil in the neighbourhood, the resulted material in regulated dumps having a circumference of a few meters and a height of one meter, in technical conditions favouring the natural aerobic biodegradation (fig.3); the laying down of the polluted soil is made on impermeable surfaces, in order to remove the migration risk of the pollutants from the contaminated soil to the supporting soil (fig.4).



Fig.3. Deposition on soil



Fig.4. Impermeable soil submission platform

- for accelerating the degradation process, the main conditions that should be met are: aeration, humidity and nutrient contribution (nitrogen, phosphor, organic substances)
- microorganisms have an important role in decontaminating the soils because they damage most of the organic pollutants; in case of the biodegradation of the oil hydrocarbons, we use the microorganisms such as: Arthrobacter, Achromobacter, Novocardia, Pseudomonas, Flavobacterium; if the autochthonous microorganisms do not face biodegradation, we use "specialized" microorganisms that are developed on a mineral support (zeolites, carbonates, composite materials); we recommend the execution of some biological tests of decontamination in the laboratory or pilot phase
- for developing the microorganisms needed by the biodegradation process of the soil polluted with polycyclic aromatic hydrocarbons, we should meet the following conditions:
  - The temperature of 15÷45 °C (depending on the microorganisms type)

-High permeability (permeability coefficient  $K_f > 10^{-6}$ )

pH = 5,5-8,5

-the fertilizers contribution improves the balance of nutrients – carbon source (polluters), and in case of the stable garbage, the quantity of available microorganisms increases.

- For stimulating the biodegradation of soil polluters, we used ammonium nitrate ( $\text{NH}_4\text{NO}_3$ ) and trisodium phosphate ( $\text{Na}_3\text{PO}_4$ ); nutrients dosing is accomplished depending on the total quantity of polluter present in the soil, so that we could provide an optimal ratio between carbon-nitrogen-phosphor in a proportion of 100:10:1.
- The aeration of the polluted soil dump was accomplished by means of a system of perforated conducts installed at the dump base, in a permeable layer formed of gravel, that allowed regulated and uniform distribution of the air to the entire ensemble of the dump

The biodegradation process is developed according to a chain reaction where the carbonic compounds are changed by successive biodegradation into less and less complex molecules, to the obtaining of some simple subproducts, namely water and carbon dioxide. The products obtained by biotransformation are called *metabolites*. [3].

### 3. Results and discussion

Concentrations obtained were compared with PA (alert threshold) and PI (intervention threshold) (table 1).

By analysing the data in the table, we notice a significant increase of the HAP concentration of oil (mg/kg), determining a value of 1475 mg/kg, compared to 1000 mg/kg admitted as an alert sill.

After applying ulk biodegradation, in the decontamination of the soils contaminated with HAP in frame of Lupeni mining exploitation, we obtained the following results:

- The polluters were destroyed by changing them into water and  $\text{CO}_2$ ;
- The polluters were transferred
- The treatment was complete and it referred at the same time to the soil, to the underground water and to the air contained in the soil
- it is one of the most profitable technologies, with a very good quality/price ratio.

Table 1. Concentrations as indicators of soil samples

Quality indicator	Measurement units	Concentrations obtained	Alert threshold	
			Alert threshold	Intervention threshold
Cadmium	mg/kg	0.7	5	10
Lead	mg/kg	6.2	250	1000
Fluorine	mg/kg	0	500	1000
Free cyanide	mg/kg	0	10	20
Phenols	mg/kg	9	10	40
Sulphates	mg/kg	-	5000	50000
Polycyclic aromatic hydrocarbons	mg/kg	3	25	150
Petroleum hydrocarbons	mg/kg	1475	1000	2000
Copper	mg/kg	1.65	250	500
Nickel	mg/kg	0.15	200	500

### 4. Conclusion

- For applying bulk biodegradation, the contaminated soil is excavated and mixed with coarse organic materials (straws, bark rests, stable garbage) having a nutritive role and favouring the aeration.
- The resulted material is laid on the soil in the neighbourhood, in regulated dumps, having a circumference of a few meters and a height of one meter.
- After applying ulk biodegradation, in the decontamination of the soils contaminated with HAP in frame of Lupeni mining exploitation the polluters were destroyed by changing them into water and  $\text{CO}_2$ , the polluters were transferred.

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