BIOREMEDIATION - TECHNOLOGY FOR DECONTAMINATION OF SOILS POLLUTED WITH PETROLEUM HYDROCARBONS

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Abstract. *The pollution of soil with petroleum hydrocarbons prevents unfolding processes of water infiltration in soil, its circulation and the exchanges of the gaseous substances with the atmosphere. The biodegradation speed of the pollutants by the microorganisms is influenced of some factors: nutrients, soil type, humidity, temperature, pH, the type and the metabolism of the microorganisms. The spill of the crude oil in the soil results in numerical growth of bacteria populations, with a concomitant reduction in their diversity, respectively with the predominant species that degrade hydrocarbons to simpler compounds, determining their gradual disappearance.*

Keywords: bioremediation, soil polluted, petroleum hydrocarbons

1. INTRODUCTION

The pollution of soil with petroleum products, is part of the most obvious environmental problems with which Romania faces in the recent years, given by the increasing pace of accelerated and intensive use of these substances to meet the needs of fairness and of energy. The pollution of soil with petroleum hydrocarbons prevents unfolding processes of water infiltration in soil, its circulation and the exchanges of the gaseous substances with the atmosphere.On the heavily polluted soils are no longer developed any kind of vegetation, being disrupted the activity of soil microorganisms, too. By this type of pollution is disturbed the ecological balance of the soil and of the groundwaters.

There is a tendency in the world to develop simple, fast, cheap and effective methods to assure by applying them in-situ the blocking of the migration of the pollutants from the crude oil product spill area into underground or others neighboring areas, the destruction of pollutants and the restore the natural frame [1]**.**

The remedy process of the soils polluted with hydrocarbons through biological procedures is known as the bioremedy. The biodegradation of the petroleum hydrocarbons is based on a side by using the indigenous microorganisms, already existing in nature and adapted to the respective pollutant and on the other side, by introducing the alohtone microorganisms. Therefore, in the depollution process often appears the need to select from the multitude of microorganisms existing in nature those that correspond to the pursued aim. In this respect, bacteria of interest are selected from polluted environments and then are subjected to a screening laboratory, which allows the selection of those strains or associates who exhibit the best performance in degradation of the residual hydrocarbons. Bioremediation is the decomposition of organic pollutants, by using the microorganisms and specific biostimulus, into harmless inorganic substances (CO_2 and water). This method is an economical and safe way to decontaminate the polluted soils with the petroleum hydrocarbons and organic compounds. (tab.1)

Table 1. Effect of microbial biodegradation of petroleum hydrocarbons

Petroleum hydrocarbons	Initial concentration (ppm)	Biodegradation (%)	Time (days)
Excerpt petroleum	50.000	99.0	7
Sludge resulting from extracting petroleum	50.000	99.0	14

2. THE ELEMENTS INVOLVED IN THE BIOREMEDIATION PROCESS

One of the element involved in the bioremediation process is the pollutant agent. This is biodegraded after soil microbial activity. The biodegradation speed of the pollutants by the microorganisms is influenced of some factors: nutrients, soil type, humidity, temperature, pH, the type and the metabolism of the microorganisms.

The nutrients needed for cell growth are nitrogen, phosphorus, potassium, sulphur, magnesium, calcium, manganese, iron, zinc, copper and other microelements. For the biological activity going under optimal conditions and to provide the necessary nutrients the ratio C: N: P must be about 100:10:1.

The development of the microorganisms is also influenced by the *humidity*, the optimal domain being between 25 - 85%, because the water assures the transport of the nutrients, it favors the enzymatic catalysis, it maintains the osmotic pressure of the cells.

The temperature influences the microbial activity in the soil. The bidegradation rate is low at low temperatures, so in cold climates the bioremediation could be ineffective in the cold seasons if the bioremediation is not performed in a climate-controlled chamber.

The soil *PH* influences the solubility, respectively the availability of many soil constituents, by altering the biological activity of the microorganisms. PH-ul must be situated between optimal values of 5,5 - 8,5.

Another very important element in the biodegradation of the hydrocarbons is the oxygen concentration, this influencing the microbial activity from soil. Depending on the oxygen content in the soil, the degradation processes can be of aerobic or anaerobic type. The biodegradation of the crude oil is particularly active in aerobically, which can be explained because all known biochemical pathways works involving the oxygenases and the molecular oxygen.

Microorganisms present a particularly ecological importance, because they can be used to depollution of soils contamined with hydrocarbons. In this respect it was observed the fact that lots of microorganisms have the capacity to use the hydrocarbons both in gaseous state and liquide and solide state from the aliphatic, aromatic and asphaltic series, which use them as carbon and energy source.

Microorganisms used in this process are mainly those indigenous, but can be used microorganisms isolated elsewhere and instilled on the contaminated soils, too. For the completely degradation of the light hydrocarbons are necessaries more bacteria species. The indigenous populations of bacteria presented in soil contain the necessary mix of bacteria to make possible the degradation [4].

The microorganisms that participate in the biodegradation of hydrocarbons are: bacteria, fungus, yeasts, as well as algae, but the most important groups are bacteria and fungus. (tab.2.)

Table 2 Types of microorganisms that degrades petroleum hydrocarbons

Bacteria	Yeasts	Filamentous fungi	Algae
Achromobacter, Acinetobacter, Actinomyces, Alcaligenes, Anabaena, Bacillus, Brevibacterium,Corynebacterium Flavobacterium, Micrococcus, Mycobacterium, Nocardia, Nostoc, Oscillatoria, Pseudomonas, Spirillum, Vibrio	*Candida Rhodotorula Rhodospirillum Saccharomyces*	*Aspergillus Cladosporium Fusarium Gliocladium Paecilomyces Trichoderma Trichosporium*	*Amphora Chlorella Chlamydomonas Dunaliella Petalonia Porphyridium Ulva*

3. THE BIODEGRADATION OF THE HYDROCARBONS FROM THE PETROLEUM IN SOIL

The spill of the crude oil in the soil results in numerical growth of bacteria populations, with a concomitant reduction in their diversity, respectively with the predominant species that degrade hydrocarbons to simpler compounds, determining their gradual disappearance. The pollution with large doses of crude oil destroys almost completly the vegetation, but in the aerobically conditions, after more or less prolonged periods it occurs the degradation and the returning to relatively normal status of plant species, affected by the pollution with the hydrocarbons from the petroleum.

The energy source for the bacteria is represented, either by the sun energy, or by the chemical energy. The chemical energy can result from the organic or anorganic sources. The bacterian organisms can use this energy through the oxidation-reduction reactions. Though the organisms use this energy to synthesize new cells and maintaining the existing ones, the efficient use of this energy is quite small. The carbon sources, which bacteria can use them, are the organic compounds or carbon dioxide.

Except the basic chemical conditions for the development and the reproduction of the microorganisms, during the biodegradation processes of the petroleum hydrocarbons, must meet the following goals, too (fig.1.):

- The existance of an electron giver, which act as a source of reducing;
- The existance of an electron acceptor, which oxidates the reducing agent, in order to provide the means of releasing the energy stored in molecules;
- The presence of water, as an essential component in the metabolic process.

The effects of the soil pollution with crude oil are variables depending of his quantity and composition, as well as of the soil nature and of vegetation type from the polluted area. The very small quantities of hydrocarbons can be beneficial for the microbial activity, and implicitly for the fecundity of the soil, because, for example, the soil treatment with small amounts of toluene initially causes a temporary decrease of the number of microorganisms, followed by an increasing from the initail level of 5 x 106 cell/g up to 40 x 106 cell/g. [2]

The phenomenon is based on the fact that many microorganisms from the soil can use, as carbon and energy source, the toluene, and other compounds of xylene, naftalene, chlorebenzene or nitrobenzene type, as well. [3]

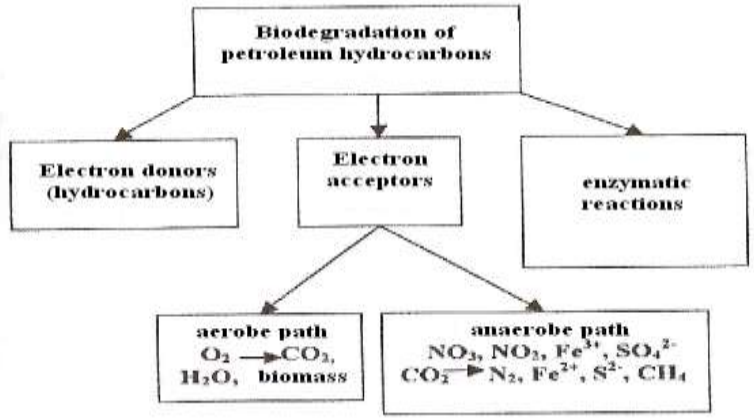

Fig. 1.Schematic representation of degradation processes petroleum hydrocarbons

4. THE ADVANTAGES AND DISADVANTAGES OF THE BIOREMEDIATION

The most important advantages of the bioremediation are:

- Bioremediation, being a natural process, is perceived as a possible treatment process on the contaminated materials
- Another advantage of the bioremediation consists in, this process can be done on the spot, without causes major disfunctions of the activity.
- The operation costs are smaller than other applied conventional procedures (washing, cremation, thermal desorption).
- There are eliminated the problems regarding the waste storing

Between the bioremediation disadvantages we can mention:

- The bioremediation is limitated only to the biodegradable compounds.
- It is difficult to extrapolate from the laboratory conditions to the large scale (field).
- The bioremediation does not fit well on the compact, clay soils, where the oxygen or the nutrients are difficult to be introduced in the treatment area
- The bioremediation process lasts much longer than other treatments, as excavation, the cremation of soil.

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