RESEARCH ON THE BIOREMEDIATION OF SOILS POLLUTED WITH PETROLEUM PRODUCTS FROM THE EXTRACTION AREA OF SUPLACU DE BARCAU, BIHOR COUNTY

Martin (Boros) Anca Mădălina*, Brejea Radu, Nistor Andrei****

* Environmental Protection Agency of Bihor County, 25 A,Dacia Street, Oradea, Romania,
E-mail: madalinaboros@yahoo.com, madalina.boros@apmbh.anpm.ro
**University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, E-mail: rbrejea@yahoo.com
***SC Ecopro Consult SRL, -31A Padis Street, Oradea, Romania,
e-mail: nistor_andrei_nicolae@yahoo.com

Abstract

The soil contamination has increasingly become a problem of the present that requires durable solutions. There are various bioremediation methods and they are more and more used for attenuating major accidents as well as for systematic contaminations. The decontamination of the soils polluted with petroleum products consists of excavating the lands and treating them ex-situ in order to reintegrate the soil in the agricultural circuit. The technology for reducing the hydrocarbon content from the waste accepted in a bioremediation station is made by applying biological treatments to stimulate the bacterial activity. A prompt and careful planning of the disposal of the waste resulted after the remediation, in accordance with the laws and regulations in force, applicable to the transportation, recycling and disposal of waste, is highly important for the successful completion of a remediation action in an efficient manner from the time and cost point of view. The remediation objectives are derived from the present legal/regulatory requirements and they must be feasible from a technical and economic point of view and they should be realised within a definite time range. The lands polluted with petroleum products from Suplacu de Barcau area are treated in a bioremediation station from that area.

Key words: contaminated site, petroleum product, bioremediation, ex-situ, human health, environmental factors, pollutants, soil decontamination, waste disposal, biological treatments, legislation.

INTRODUCTION

The European Union policies in fields such as agriculture, water, waste, chemical substances and industrial pollution prevention contribute indirectly to soil protection.

The problems related to soil degradation must be solved beyond the degraded areas, and this fact implies high costs. These areas can extended across borders, generating macro-implications when it comes to adopting a specific legislation on environmental protection, especially in the soil - subsoil field.

According to the commitments of Romania towards the European Commission, all the necessary measures must be taken for the protection of human and environmental health against the effects of soil contamination, through the regulation of the measures dedicated to the quality of the environmental factors affected by the confirmed presence of pollutants at levels that represent a significant risk for human and environmental health, taking into account the present and the future use of lands.

The oil extraction industry from the Suplacu de Barcau area has been developing since 1959, when, in the drilling performed for groundwater exploitation, it was noticed that there is asphalt oil field at relatively small depths (200-300m). In 1961 begins the exploitation of the mineral resource through drilled and closed wells, by free eruption. The transport is carried out with tank cars to the bitumen extraction station from Derna. After the extraction of large quantities of crude oil, the area has been developing as there are implemented tank batteries, the Suplac refinery, waste storage facilities, bioremediation stations and various related activities.

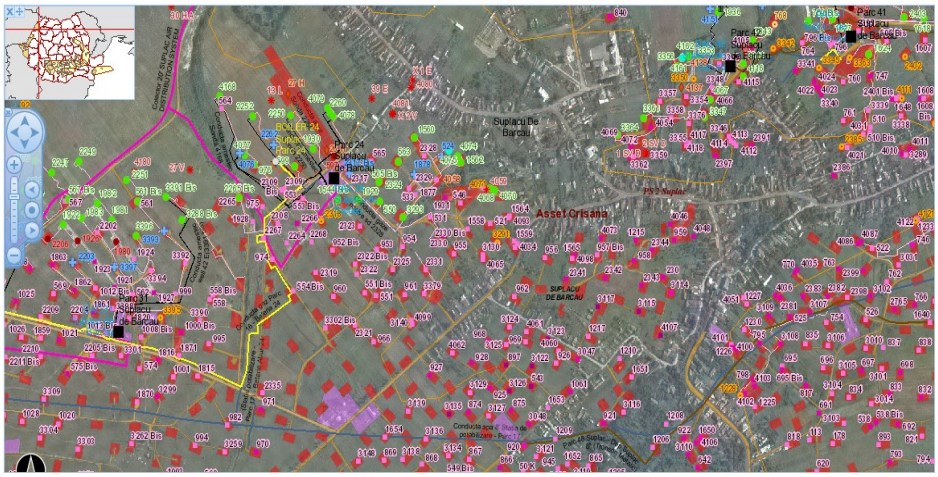

Fig.1. The situation of the polluted lands from the oil exploitation area of Suplacu de Barcau. (OMV Petrom, 2018)

Due to political, economic and environmental changes, the crude oil extraction activity undergoes certain organisation modifications. With Romania's participation in the agreements with the other European and non-European states, Petrom Romania SA has been privatized, the majority of shares being taken by OMV Austria. Following this contract and the environmental international legal requirements, it is obliged to carry out the bioremediation of the lands polluted with petroleum products. The lands polluted with petroleum products are registered based on the exploitation

record and whether there were effects on the environmental factors: surface water, groundwater, soil pollution, subsoil pollution, vegetation, etc.

In Bihor county, there are 17 contaminated sites and 67 potentially contaminated sites, registered until now. In the last 5 years, over 50 sites have been remedied, occupying an area of 29.130 sq m, as well as the areas of the three facilities for storing the derived petroleum products resulted from the storage facilities of Salonta, Beius and Vascau. The quantity of soil contaminated and subject to bioremediation occupied 4,171.3 m^3.

The concentration level of the pollutants in soil are regulated in the national legislation by Order 756/1997 on the assessment of environmental pollution.

Table 1

The reference values for (TPH) according to Order 756/1997 of MAPPM (Romanian Ministry of Environment, Water and Forests) expressed in mg/kg DM

Traces of pollutant	Normal values	Alert thresholds/ Types of use		Intervention thresholds/ Types of use	
		Sensitive	Less sensitive	Sensitive	Less sensitive
1	2	3	4	5	6
Total Petroleum Hydrocarbons (TPH)	<100	200	1000	500	2000

Based on the classification of the land into types of use, according to the urban planning of the locality, they are classified in conformity with Ord. 756/1997, according to article 8:

a) the sensitive land use represents the use of the land for residential and recreational areas, for agricultural purposes, as protected areas or as sanitary areas with restriction regime, as well as the land areas provided for such future use;

b) the less sensitive land use includes all the current industrial and commercial uses, as well as the land areas provided for such future use;

c) if there are doubts on how to classify a land use, the alert and intervention thresholds for the sensitive land use will be considered.

The method of intervention and transportation of the contaminated soil to the bioremediation stations is established according to the results of the laboratory analyses regarding the values of the TPH indicator in the samples collected from the contaminated sites. The remediation of contaminated sites is one of the main components of a sustainable development of the communities on any administrative level. It can form the basis for improving the environmental conditions, the social cohesion and the economic growth.

Fig. 2. The excavation of the soil contaminated with petroleum residue from the perimeter of the Suplacul de Barcau locality

The soils contaminated with petroleum products, accepted at the bioremediation station, undergo various processes in order to reduce the concentration of TPH below the threshold stipulated in the legislation. The 9% average concentration is accepted as result from the waste with TPH content between 0.3% and 15%. By applying biological treatments, the bacterial activity (existing in the soil) is stimulated, which can reduce significantly the content of hydrocarbons from the waste accepted at the bioremdiation station.

The stages of the remediation process consist in:

- Reception and weighing of the contaminated soil
- Initial sample collection in view of analysing the content of TPH
- Sorting and sifting
- Homogenisation
- Selection of necessary nutrients
- Addition of biological material (straw, sawdust, manure, etc.)

The optimal bioremediation parameters are:

- Soil pH – in order to facilitate the bacterial growth, the pH must be comprised between 6 and 8 %, the optimal values being around 7.
- Humidity – the optimal recommended soil moisture is between 40-85% of the water retention capacity (field capacity). The micro-organisms from soil need water for proper growth.
- Soil temperature – influences the bacteria growth speed. The optimum temperature for the microbial activity of most of the bacteria important for the biodegradation of petroleum hydrocarbons is between 10 and 45^0C.
- Concentration of nutrients – the micro-organisms require inorganic nutrients, nitrogen, phosphorus and potassium (N, P, K) in order to grow

and achieve the biodegradation process. Most soils contain nitrogen between 0.2-0.3%, phosphorus between 0.03 and 0.24%, and potassium between 100-300 mg/kg, the latter having the role of activating certain enzymes that catalyse the protein synthesis.

- Micro-elements – copper, manganese, cobalt, zinc, selenium, wolfram and molybdenum have a very important role for the micro-organism.

- Salinity - the assessment of the biodegradation feasibility is obtained by measuring the electrical conductivity µS/m. The biological activity is carried out under normal conditions up to values of electrical conductivity of 4000 µS / cm.

- Oxygen – plays an essential role in the metabolism of aerobic bacteria. The increase of the oxygen quantity can be obtained by aeration, realised through agricultural work, addition of soil aeration agents (straw, sawdust, hay).

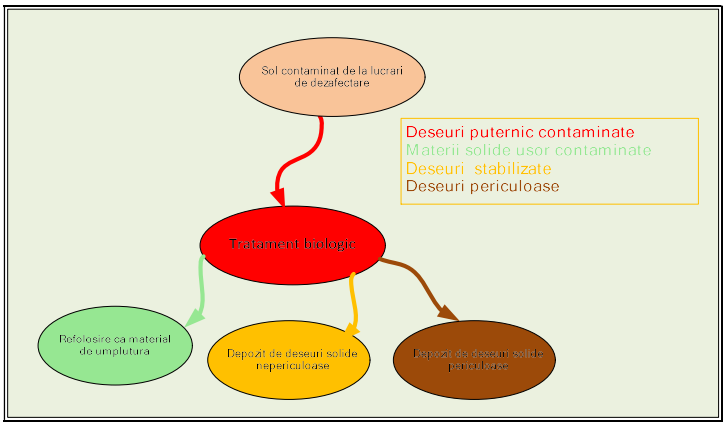

Fig. 3. Contaminated soil waste management scheme (OMV Petrom, 2014)

MATERIAL AND METHOD

With in the bioremediation station at Suplacul de Barcau, a series of stages are carried out, which involve preparing the contaminated soil, arranging the sorted material into mounds of about 200-100 tons with a width of 3m and a height of about 1.6 m.

RESULTS AND DISCUSSION

The soil will be turned over with a Bachus 15:50 aeration equipment and moistened to ensure the optimum humidity, and also the supply of

possible nutrient supplements. The mechanical aeration takes place once a week.

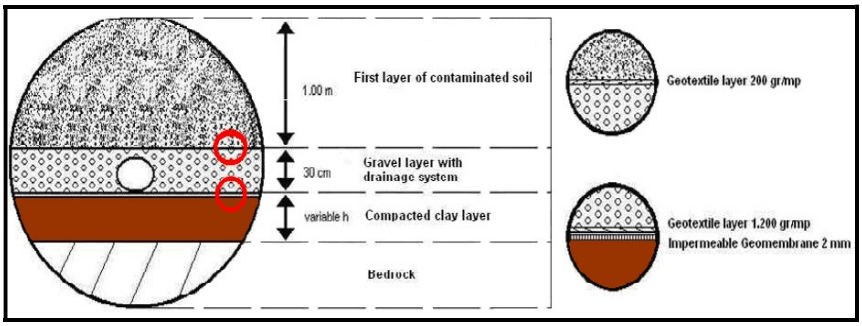

Fig. 4. Plan view of the waste distribution on the storage platform (according to OMV, Petrom, 2014).

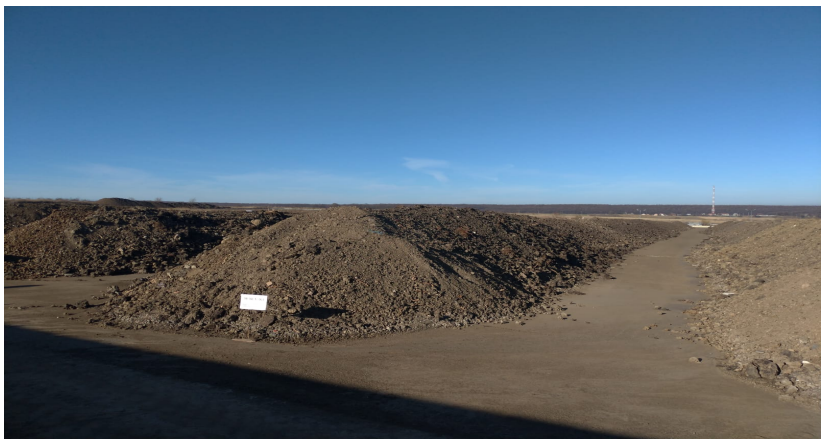

Fig. 5. Aspects regarding the bioremediation of the soil polluted with petroleum products at Suplacu de Barcau

The biological materials used in the bioremediation process are the sawdust, hay and straw with aeration role. The nutrients are applied as follows: 0.250 kg for each m3 of soil. After approximately 2 months, a mixture of NPK in a proportion of 5 kg/1 ton is added, after another 4 months, depending on the results and on the progress regarding the rate of hydrocarbon degradation, it will be decided whether the soil subject to bioremediation needs further treatment for the material to reach an acceptable level in order to be used as a filler soil (its TPH concentration should be below the 2000 mg/kg threshold according to Order 756/1997). If the soil can no longer be treated to the extent required by the law, it will be stored in a storage facility of non-dangerous or dangerous products.

CONCLUSIONS

In the process of bioremediation within the exploitation perimeter of Suplacu de Barcau, a series of stages are carried out, which involve:

- storing the soil contaminated with petroleum products resulted from the oil exploitation activity from Suplacul de Barcau; the solution of a waterproofing platform was chosen, which would ensure the insulation against the site soil, of the stored product, in any environmental conditions, and the monitoring of the waterproofing degree

- the amount of nutrients potentially required for the bioremediation process can be established only based on actual measurements in the field, without a predetermined recipe, the key element in the biodegradation process being the balance of the C: N: P ratio, which also depends on the natural content of nutrients in the soil.

- the bioremediation process itself is a simple process and it consists of arranging the material into mounds on the bioremediation platform, maintaining an optimum humidity and mechanically mixing/re-mixing it with aeration material (straw, sawdust, manure, etc.) in order to provide the necessary oxygen supply.

- biodegradation is a natural phenomenon, because soil, subsoil and groundwater represent the normal living environment for many micro-organisms (bacteria, fungi), which exert a biodegrading action on organic pollutants. The effectiveness of bioremediation depends on the presence of suitable microbial populations, on how they can be grown and maintained in the environment.

The creation of the Suplac bioremediation station lead to finding ways of recovery, treatment and storage of the waste resulted from the activities of extraction and primary separation of crude oil, from the activities of decommissioning certain wells and other related activities.

Through bioremediation stations, the soil is bioremedied and it can be used for different agricultural purposes.

REFERENCES

1. Brejea R., 2009, Tehnologii de protecție sau refacerea solurilor, Editura Universității din Oradea.
2. Brejea R., 2010, Ştiinţa solului – îndrumător de lucrări practice. Editura Universităţii din Oradea.
3. Brejea R., 2011, Practicum de tehnologii de protecție a solurilor, Editura Universității din Oradea.

4. Brejea R., Domuţa C., 2011, Practicum de pedologie, Editura Universităţii din Oradea.
5. Lombi E., R.E. Hamon, in Encyclopedia of Soils in the Environment, 2005, https://www.sciencedirect.com
6. Malschi Dana, 2009. Biotehnologii si depoluarea sistemelor ecologice.(Tehnologii de depoluare biologica. Tehnologii de bioremediere. Reconstructia ecologica). Note de curs si aplicatii practice. Manual in format electronic. Facultatea de Stiinta Mediului,Universitatea Babes-Bolyai. Editura Bioflux, Cluj-Napoca. BIOFLUX, Cluj-Napoca, ISBN 978-606-92028-5-2
7. Micle V., Neag G.,Procedee şi echipamente de depoluarea solului şi a apelor subterane, Editura UT PRESS, Cluj-Napoca, 2009.
8. Mihail Dumitru, Catalin Simota, Mihai Toti, Nicoleta Marin, Reabilitarea solurilor poluate cu hidrocarburi petroliere, Ed. Terra Nostra Iasi.
9. ***Autorizația Integrată de mediu nr.2 –BH, 2017, Agenția pentru Protecția Mediului Bihor.
10. ***Ghiduri de bune practici - The BREF for Hydrocarbons exploration and extraction is developed following the Communications from the European Commission on European energy security strategy (COM(2014) 330 final) and on the exploration and production of Hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU (COM(2014) 23 final/2). The HC BREF is not a part of the information exchange under the IED/IPPC Directive. (Information on the drawing up of the HC BREF can be found at http://ec.europa.eu/environment/integration/energy/hc_bref_en.htm).
11. ***Hotarârea de Guvern nr. 1408/2007 privind modalitățile de investigare și evaluare a plouări solului și subsolului.
12. ***Hotărârea nr. 1403/2007 privind refacerea zonelor în care solul, subsolul și ecosistemele terestre au fost afectate.
13. ***Legea nr. 74/2019 privind gestionarea siturilor potențial contaminate si a celor contaminate.\European Environment Agency https://www.eea.europa.eu/countries-and-regions/romania
14. ***Legea 292/2018 privind evaluarea impactului anumitor proiecte publice și private asupra mediului.
15. ***Manual pentru managementul siturilor potential contaminate si contaminate aferente industriei petrochimice din România, Ministerul Mediului, 2019.
16. ***OMV PETROM , 2014, Raport de amplasament - Stație de Bioremediere și Platformă de Stocare Suplacu de Barcău.
17. ***Ordinului MAPPM 756/1997 pentru aprobarea reglementării privind evaluarea poluării mediului.
18. ***OUG nr. 195/2005 (*actualizată*) privind protecția mediului.
19. *** ”Tehnologie de bioremediere a solurilor poluate cu hidrocarburi petroliere” PROIECT PN-II-PT-PCCA-2013-4-0347, https://www.icpa.ro/proiecte/.