Layman's Report

LIFE DIANA - LIFE16 ENV/GR/000461
Co-funded by the European Commission under the LIFE "Environment and Resource Efficiency" Programme
PROJECT DETAILS

Project Title: Development of a pilot unit for the valorisation of Petroleum Refinery Sludges to new added-value raw materials LIFE DIANA

Project Duration: 01 July 2017 - 31 December 2021

Total Project Budget: 2.051.585€

Total Eligible Project Budget: 1.662.085€

EU Contribution: 983.995€

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Participating Entities

MOTOR OIL

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

POWER MEDIA PRODUCTIONS

Rafina Pikermi Municipality
The LIFE DIANA project aims at the valorization of Petroleum Refinery Sludges, currently classified as hazardous wastes, and their efficient transformation into products that will be used in other industrial activities. The Petroleum Refinery Sludges treated with properly modified industrial minerals available in Greece and other countries, will result in the production of a valorized mixture and the ultimate conversion of a hazardous waste material into a higher added value commercial product called Engineered Soil. The produced Engineered Soil can be used in various development stages of landfill construction. Due to its tailored properties, the Engineered Soil is able to substitute the materials currently used in landfills for the creation of the various layers.
In Greece, the petroleum refineries produce approximately 34,000 tons of Petroleum Refinery Sludges per year, while the corresponding Petroleum Refinery Sludges quantities produced in Europe are estimated to around 1,000,000 tons. Available technologies for the treatment of Petroleum Refinery Sludges include incineration, biodegradation and thermal plasma treatment. Due to the complex and inconstant composition of Petroleum Refinery Sludges, cost-effective treatment and proper disposal pose considerable technical and industrial challenges worldwide.
LIFE DIANA is the result of long-term research activities of the Laboratory of Metallurgy of the School of Mining and Metallurgical Engineering of NTUA. In the framework of the project, more and focused lab-scale experiments determined the exact stabilisation process of Petroleum Refinery Sludges with the use of specific industrial materials. Initially, during those lab-scale experiments, all Petroleum Refinery Sludges samples and industrial minerals were physio-chemically characterized and categorized following their other parameters, by comparing their sorption stability and capacity. After having determined the Petroleum Refinery Sludges exact composition and raw materials properties, the lab-scale experiments defined the operational conditions of the integrated stabilisation process (feeding rate, temperatures etc.) that transform Petroleum Refinery Sludges to a Valorised Sludge Mixture and then to Engineered Soil.

The Petroleum Refinery Sludges stabilization is a chemical process which involves an initial mixing of the hazardous refinery sludge with the stabilizing mineral, followed by the main core of the process in which the produced mixture pollutants are immobilized and restrained.

2 pilots served as demonstration sites of the innovative stabilization process:

- Lab-scale experiments
Pilot 1

Pilot 1 is the stabilization unit within the Motor Oil Hellas premises, where the petroleum refinery sludge was stabilized in the Engineered Soil. The pilot equipment components are highly customized to the materials of the process, to establish the righteous conditions during the stabilisation process. The key parts of the equipment are: the mixer (for the mixing of Petroleum Refinery Sludges with the reagents), the two silos (to store the stabilizer and sludge) and the screw conveyors to facilitate transportation of the materials all across the pilot.
Pilot 2

At Pilot 2, located in Attica’s Prefecture landfill site, the produced Engineered Soil was used and tested as vegetation, daily, top and bottom cover of landfilling.

Two different intervention areas have been constructed in the second pilot area:

1. The first area is divided in four sections (each section corresponds to one test), which aims to evaluate the use of the Engineered Soil as a) daily cover b) bottom liner and c) top layer cover.
   The monitoring of the engineered soil performance was achieved through physical, chemical and biological analyses of the samples regularly collected from the four leachate tanks.

2. The second area served as the testing site for the evaluation of the Engineered Soil use as a vegetation cover.
   The engineered soil was tested as vegetation cover by monitoring plants’ growth.
   Different plant species have been planted in the Engineered Soil such as oleander, quince and myoporum.
The engineered soil was subjected to standard leachability/extractability test: ELOT EN 12457.02 in a liquid to solid ratio (L / S) = 10 L / Kg for materials with particle size below 4 mm.

- According to the results of the chemical analysis of the wash solutions, the engineered soil meets the criteria for acceptance of waste in landfills for non-hazardous waste.

- **Classification of the products with AASHTO system**

![Graph showing cumulative particle size distribution](image)

- Based on the results of the analyses the Engineered Soils are classified in category **A-1-b Stone fragments, gravel and sand**.
• Flammability test
For the assessment of Engineered Soil in the event of a fire, the flash point of the materials was measured in an external laboratory. Two measurements were made in accordance with the ASTM D92 mod and ASTM D 93 mod standards, based on which the Engineered Soil has a flash point greater than 100 °C according to ASTM D 93 and 180 °C according to ASTM D92.

✓ The assessment of the external laboratory concludes that: “according to the parameter considered, the sample is not classified as flammable” (European Regulation 1272/2008).

• Water permeability
According to the Greek legislation the criterion for a soil to be accepted as insulating layer at the bottom of a landfill is the permeability ≤10-9.

✓ Engineered soil is very close to this requirement.
✓ The engineered soil is suitable for application as daily cover in a landfilling operation.
✓ In order to meet this prerequisite, Engineered Soil can be used as bottom layer of landfills combined with a GCL liner, as shown in the following scheme.

Lysimeter results
The results of the analyses performed on the leachates of each lysimeter show that:

✓ The pollutants concentrations in the lysimeters leachates are the same or lower than the Fyli landfill leachates.
✓ The engineered soil can be used in landfills without causing adverse effects in the operation of the landfill.
✓ After proper treatment, the lysimeter leachates meet the criteria in order to be reused for irrigation purposes within the landfill boundaries, along with the Fyli landfill leachates.

Vegetation results
✓ All plants in engineered soil developed good growth with no foliage toxicity and infections.
✓ The engineered soil can be used as vegetation cover for rehabilitation and restoration purposes (e.g. quarries, landfills)
Life Cycle Assessment

A Life Cycle Assessment was performed and proven that the use of LIFE DIANA technology for the treatment of Petroleum Refinery Sludges affects positively the entire life cycle of the holistic process, compared to existing waste treatment methods such as bioremediation, incineration, solvent extraction and pyrolysis.

Global Warming Potential impact for the treatment of 1,000 kg of Petroleum Refinery Sludges.

Energy required for the treatment of 1,000 kg of Petroleum Refinery Sludges.

Overall project outcomes

- The environmental and land footprint of the oil refining industry is reduced. 1,500 tons of petroleum refinery sludge were stabilised into 3,000 m3 of engineered soil.
- The innovative material, the Engineered Soil, can be used as daily cover, bottom layer or vegetation cover in landfills without causing adverse effects in the operation of the landfill.
- A business model was agreed among the partners engaging stakeholders of industrial waste, mineral raw materials providers and Engineered Soil end users (landfills, quarries etc.).
- The LIFE DIANA technology is considered as a viable competitor against the other technologies existing in the market of sludge treatment.
- Job opportunities were created.
1st workshop, 6 of May 2019 at N.J.V. ATHENS PLAZA HOTEL

2nd workshop, 4 of October 2021, on line at TEAMS platform

FINAL CONFERENCE, 16th December 2021, through the TEAMS platform

Three thematic sessions were organized in accordance with the great interest of the participating stakeholders:
1) Regulatory framework – Networking with other projects,
2) The role of industrial minerals in the development of environmentally sustainable solutions, 3) Environmental rehabilitation and waste management: a market with challenges and opportunities.

Through the open discussions, interesting topics were raised and possible synergies were identified for the project’s sustainability.
• The **1st general video of the project** which presents the innovative solution proposed by the LIFE DIANA project was completed at the beginning of the project and it is available on the website in English and Greek version.

**Introduction to the Life Diana Project**

• The **2nd video** is dedicated on the petroleum refinery sludge pilot plant describing the stabilisation process and the production of the engineered soil. It was created in Motor Oil Refineries in Corinth. It is also uploaded on the website in English and Greek version.

**Pilot installation at the Refineries of Motor Oil Hellas**

• The **3rd video** was created in the area of pilot 2 showing the 2 sites where the Engineered Soil is tested as top, daily, bottom and vegetation cover. It is also uploaded on the website in English and Greek version.

**Pilot installation of the Municipality of Rafina-Pikermi at Fili Landfill**
MOTOR OIL HELLAS (MOH) - COORDINATOR
MOTOR OIL since its establishment in 1970 is committed to being a leader in the petroleum refining business. It’s the second crude oil refining and trading company in Greece, its market share amounts to approximately 34% of the Greek market while the company achieves 50% of the exports of the sector.

NATIONAL TECHNICAL UNIVERSITY OF ATHENS (NTUA)
NTUA is the oldest and most prestigious technical university in Greece with 9 schools. Today NTUA has more than 7000 students, employs 700 persons as academic staff and more than 2500 researchers.

POWER MEDIA PRODUCTIONS (PMP)
PMP was founded in 1991 and is a prestigious company in media productions, recordings, dubbing, subtitling, audio post-production and advertising, on radio, television and other digital media.

MUNICIPALITY OF RAFINA-PIKERMI (RAFIMUN)
RAFIMUN was established in 1994 and since 2011 has been connected with the municipal community of Pikermi. It currently extends to 41.84 sq.km and its inhabitants amount to over 16,000 inhabitants.