CONCEPT

OIL SLUDGE TREATMENT AND REMEDIATION OF HYDROCARBON CONTAMINATED SITES

uni-recycling

SUMMARY

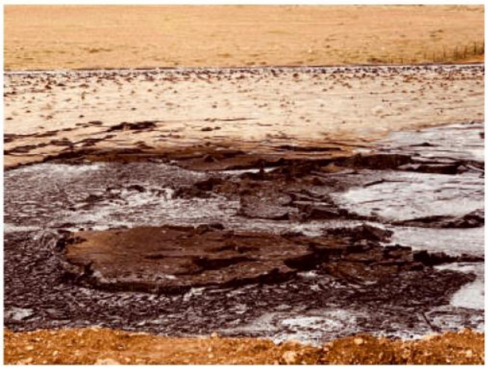
1. INTRODUCTION

The following concept explains the technologies and strategy for oil sludge treatment, and presents the operational management from handling, processing to remediation of the hydrocarbon contaminated sites.

Broadly speaking, oil sludges are generated from the extraction processes, oil production and refining, but also from tank cleaning operations, accidental pollution, and in a small part from the industrial treatment plants of the Refineries. In many situations, oil sludge which is generated are disposed in storage facilities, called generic lagoons or ponds, either natural or properly designed for the storage of such residues. In the images below, we are presenting a few examples of such deposits:

- **Natural storage**


- **Waterproofed natural deposits**

- **Properly designed storage facilities – waterproofed lagoons, concrete separators, etc.**




- **Uncontrolled due to accidental pollution**



The compositions of the materials contained in oil waste deposits is very diverse, but in principal contain mixtures consisting of:

- **Liquid mass** – which depending on the provenance, contains two phases, very different in relative weight and composition – an organic phase comprising a wide range of types of petroleum hydrocarbons, depending on the residual fractions stored in the deposits, and the second phase contains waste water derived either from the contents of products discharged from various processes or from precipitation accumulated during the storage period.

- **Intermediate mass** – consisting mainly of emulsions formed as a result of chemical and thermal processes undergone by the raw material.

- **Solid mass** – consisting of a mixture of minerals and organics contained in the liquid sludge mass and represented by contaminated soils or used as a layer for the formation of storage deposits that have also suffered contamination.

The distribution of liquid and solid phase found in the structure of the storage facilities is not uniform, being distributed on the surface and in depth, according to their relative densities, as follows:

- At the base we will find solid materials with the highest density;

- Above the sedimented solid phase, the consistency of the residues is gradually reduced to surface and can reach to a liquid fraction usually composed of a mixture of water and petroleum products or content, but there are cases when between the two it can be found emulsions that are dependent on the nature of the compounds existing in the liquid oil fraction;

- Sometimes a solid crust of organic or inorganic nature with low density can form in the surface of the deposits.

The deposited waste is thus represented by a diversity of the composition and weight of the phases, which makes each source unique, requiring a specific and particular approach in order to implement the most advantageous technological solutions to achieve the remediation objectives.

In order to be able to manage in an appropriate, optimal, controlled and efficient way the treatment of these residues and thus to achieve the remediation objectives, it is necessary to treat in a specific way depending on each state of aggregations in two management modes, namely:

- Management of liquid phase

- Management of solid phase

In order to achieve successful objectives in terms of remediation but also to create a circular flow through which the obtained fractions can be reused, it is necessary to implement a very well developed management strategy, taking into account that the two management phases (liquid and solid) are interconnected and dependent for obtaining positive and beneficial results.

2. LIQUID PHASE MANAGEMENT

By liquid phase we understand the state of liquid aggregation of oil sludge, which can be homogenized at source and pumped, without the need to apply mechanical methods such as excavation. In order to be able to put into practice the management of liquid phase, it is necessary to go through some steps that consist mainly in establishing the main treatment parameters, based on which the flow of equipment involved in the management of the liquid phase is established.

This steps are mainly based on detailed studies of the sludge for the correct determination of the parameters necessary for the implementation of the process, as follows:

- Primary conditioning module, extraction and pumping of the sludge;
- Laboratory analysis for determination of content and percentage of the fractions contained in the liquid oil sludge;
- Determining of the oil percentage that can be recovered after the treatment process, including its quality parameters;
- Determining the quality of the waste water recovered after the treatment process;
- Determining the solids content and contained hydrocarbons;
- Determining the additives necessary for the treatment process in order to have an optimal separation.

After establishing the minimum necessary parameters, the design of the equipment necessary for the treatment of the liquid phase can be drafted depending on the quality preferences of the liquid fractions resulted from the treatment process.

2.1.FLOW DESIGN FOR LIQUID OIL SLUDGE TREATMENT

Treatment of liquid oil sludge (even with a high degree of viscosity), is performed by using several specialized equipment, which are determined and integrated in the flow according to the preferences and desired treatment results.
The technological flow must be designed in such a way to ensure an optimal line for the liquid phase , and is divided into 3 main groups:

- **Homogenization and extraction group – this group contains different type of specially chosen equipment, taking in consideration the sludge storage structure, for example:**

  - Mixers installed on the side of the storage area (mainly used for concrete structured lagoons) in order to have a controlled homogeneity structure of the sludge - determination of the quantity and type is based on the size and depth of the lagoon;

• Self priming extraction pumps – membrane, vacuum, progrsive cavity pumps, lobe pumps, etc.;



• Dredging machines – sludge mixers will not be needed in this case.


- **Processing group – this group contains the treatment facilities through which the liquid sludge separation of the oil sludge is performed and mainly is consisting of:**

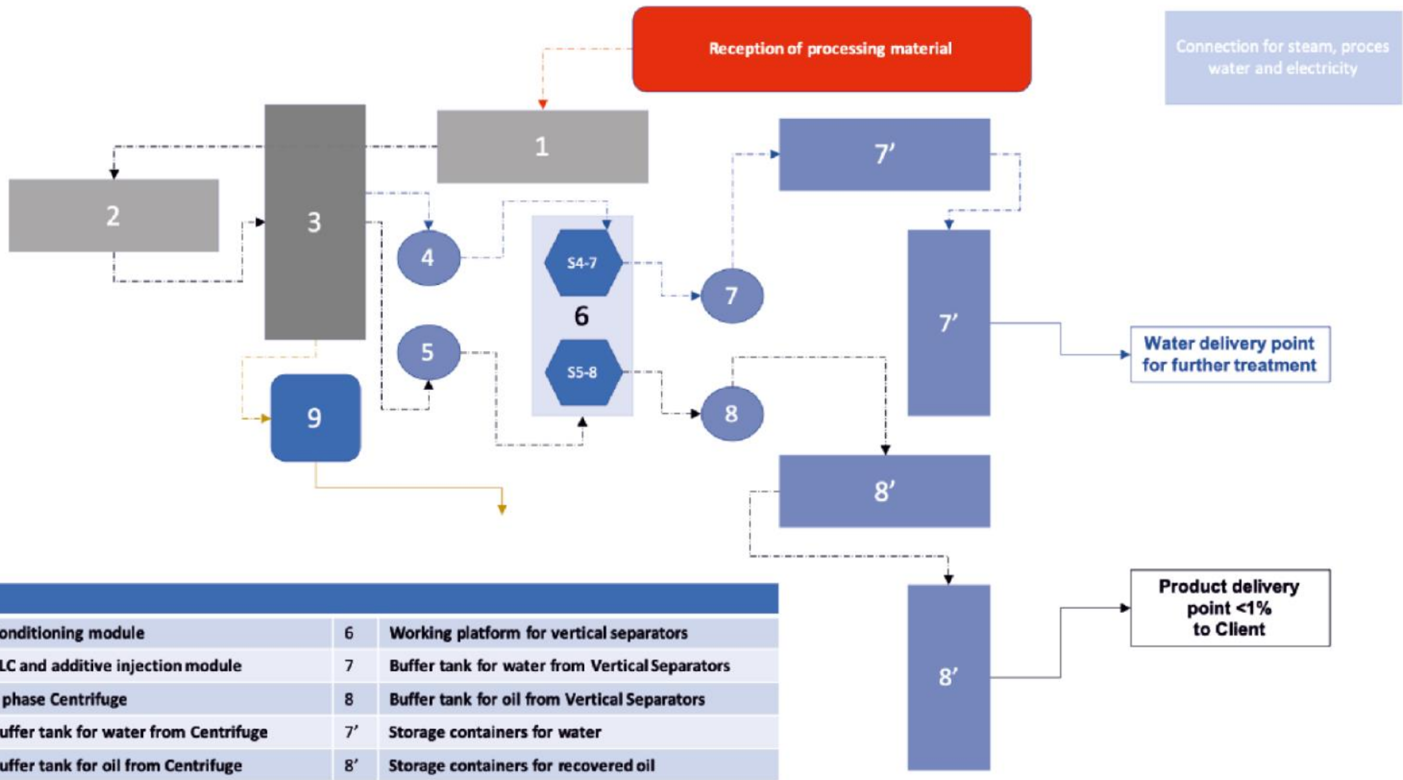
  - Conditioning module – represents the reception stage of the sludge from the initial source (deposit, lagoon, separator, etc.) and contains a heating source in order to increase the efficiency of the additives and the separation process by centrifuge;

  - Centrifuge – processing capacity, productivity and type are to be chosen depending on the performance term, taking into consideration that the productivity is inversely proportional to the quality of the fractions resulted from the process;

  - Vertical separation stage – here are included the vertical separators, through which a greater quality is given to the liquid fractions resulted from the initial separation process.


• Temporary storage group – it is represented by temporary storage facilities of the fractions resulted from the process (waste water, oil and solid), which also have to be dimensioned depending on the productivity of the installations integrated in the technological flow. A mandatory condition is that the temporary storage facilities for petroleum product to be equipped with the possibility of heating, in order to avoid solidification in case of a high paraffin content.

Of course, depending on the specifics of each location, and taking into account that the main advantage of mobility of the entire technological flow, it can be adapted in any conditions to benefit from the increased efficiency that is rendered in the treatment process.
The image below, shows a complete flow of equipment for processing oil sludge deposited in impermeable lagoons from which high-quality reusable liquid fractions are obtained.



Legend			
1	Conditioning module	6	Working platform for vertical separators
2	PLC and additive injection module	7	Buffer tank for water from Vertical Separators
3	3 phase Centrifuge	8	Buffer tank for oil from Vertical Separators
4	Buffer tank for water from Centrifuge	7'	Storage containers for water
5	Buffer tank for oil from Centrifuge	8'	Storage containers for recovered oil
S4-7	Water separator	9	Solid discharge container from Centrifuge
S5-8	Oil separator		

The technological flow is backed by a mobile process laboratory, which has both the role of quality control of the fractions resulted from the process, and inspection of the process, which by the determination results, the process parameters are adapted to the inlet material changes, in this way keeping a constant quality values of the fractions resulted from the process.

2.2 PROCESS MANAGEMENT

In order to achieve the best results, careful monitoring of the development of each complementary activity of the process is essential, thus obtaining an optimal and efficient operation.

The first important step is to ensure a correct homogenization of the sludge in the storage source, thus ensuring an optimal degree of the treatment process, but also with direct proportionality on equipment productivity and the quality of the resulting fractions, avoiding errors of re-processing or obtaining unsatisfactory quality.

The liquid sludge extracted from the storage source, properly homogenized beforehand, is then introduced into the conditioning container which also has the role of heating and dosing process additives directly in the sludge mass to streamline and improve the operation of equipment in the next steps of the process.

Depending on the nature of the sludge – emulsions, high content of paraffins and asphaltenes, low water content, etc. – based on a detailed study is determined the type of additive used in the process and the process parameters for determining the productivity limit, heating temperature, inlet temperature in the first and second separation stage, storage temperature of the recovered to prevent coagulation, type, concentration, mixture if necessary, method and dosing point of the additives in the sludge mass to obtain the best possible results.

The conditioned and heated sludge, depending on the characteristics at temperatures between 70 - 98℃, is then fed in the first separation stage, from where the separated fraction are taken into buffer containers and further directed for an additional physical – mechanical treatment, which has the role of quality improvement in terms of suspended solids, mechanical impurities and water/oil content.

Recovered water

Recovered oil

Solid separated from Centrifuge

The productivity of the centrifuges can ensure the processing of flows between 5 – 20 m^3/h, while the vertical separators can ensure up to 5 m^3/h.

The water recovered from the separation process may undergo additional treatment to meet the conditions of discharge into the sewage system, otherwise it is directed to the industrial waste water treatment plant.
The recovered oil, undertaken through both separation stages, may be further used in the refining process, or depending on preferences as an alternative fuel (water and sediment content <1%).

The solid recovered from the separation process, can be managed by several methods, such as: bioremediation, solidification/stabilization or by thermal processes of co-incineration or thermal desorption.

In order to ensure a correct and transparent reporting process of the circulated quantities, the whole process is provided with calibrated measuring instruments and metrologically approved, with the help of which the volumes entered in the process, the volume of additives and the volume of fractions resulting from the process are recorded.

3. SOLID PHASE MANAGEMENT

By solid phase we understand the state of solid aggregation of material contaminated with petroleum hydrocarbons and which cannot be subjected to the treatment process described above. Usually, the solid phase contaminated with petroleum product comes from several sources, such as:

- Solid fraction resulting from the separation process;
- The decanted contaminated solid fraction contained in the bottom of sludge storage deposits;
- Contaminated soil removed from the construction structure of landfills or from accidental pollution.

Depending on the type, concentration and nature of hydrocarbon contamination, several decontamination technologies may be applied that are specifically adapted taking into account the source of generation and the purpose of subsequent reuse.

Further the main management and decontamination methods are presented taking into consideration the chemical, physical characteristics and the source.

3.1 STABILIZATION / SOLIDIFICATION

Stabilization / solidification technology - is a method that is applied with very good results for soils contaminated with petroleum products up to concentrations of maximum 5-6%.

This method does not involve very complicated logistics, and high productivity and production capacity can be ensured, which can be multiplied depending on the treatment needs.

As this is a treatment involving mechanized principles, and taking into account the geological structure of the contaminated soil for which this technology is implemented, it is necessary to carry out complementary excavation and sorting operations to streamline the proper incorporation of additives used in soil mass for reducing the impact of pollutants, which by implementing this technology eliminates or reduces the negative impact on the environment.

Overview of the operation for a contaminated site with hydrocarbons

3.1.1 EXCAVATION OPERATIONS

The perimeter of the excavations will be established according to the laboratory investigations that indicate the degrees and points of contamination, and the actual excavation is performed systematically based on a grid made with topographic surveys, and will also include the excavation depths so as to there is a clear and transparent record of the volumes of contaminated soil circulated.

The excavation operation will be dimensioned and correlated with the sorting, pre-treatment and treatment, so as to avoid volumes of material that remain stored for a long time, thus limiting the impact on the environment.

The contaminated material resulting from the excavation process will be stored in an entry buffer zone to confirm the destination and establish the recipe for concentrations and dosage of additives.

Depending on the geological characteristics of the contaminated soil, the sorting stage can be considered as necessary to improve the action of the stabilizing additives and their more efficient incorporation into the mass of the contaminated soil, suppressing the negative impact of the contaminants.

3.1.2 SORTING OPERATIONS

Sorting operations will be performed before entering the treatment process, only for the material that is suitable for this stage, in order to adjust the morphological and geotechnical layer, to obtain a granulometry as optimal as possible for absorption in the incorporation of additives in the mass of material for the process treatment, and will be provided by special sorting facilities.

In cases where the contaminated soil has a high stone content, a washing plant can be used in parallel to optimize the decontamination process, the process being performed in a closed circuit, this stage including the treatment of washing water in order to reuse and disposal in sewage system.



3.1.3 STABILIZATION – DOSING OF ADDITIVES

Depending on the provisions of the treatment recipe issued for each batch of contaminated soil (aspects determined by laboratory analysis and with specialized assistance), the excavated material prepared for treatment is introduced into a system of homogenization and dosing of additives, from where it is extracted in a storage area for stabilized material for the issuance of analysis bulletins that will confirm the subsequent destination.

The purpose of the stabilization method is to minimize the rate of migration of the contaminant into the environment and to reduce the level of toxicity of the contaminants, in order to improve the characteristics of the waste to be reused or stored properly.

Stabilization is a process in which contaminants are totally or partially limited by the addition of support material, binders or other modifiers or stabilizers, the aim being both to reduce the toxicity and mobility of the waste and to improve the engineering properties of the stabilized material.

3.2 BIOREMEDIATION

Bioremediation technology is a method that can be applied to relatively lightly contaminated soils (concentrations of 2-4% TPH). In this process, selected microbial cultures are used that grow and consume from existing pollutants, thus reducing the degree of contamination.

Being microorganisms, they need special conditions of pH, temperature and humidity to grow, and if any of the parameters cannot be ensured within the necessary limits for atmospheric reasons, they can lead to the failure of the treatment process.


And in the case of this technology, depending on the needs, the sorting stage can be used through the installation itself, which can also be customized to achieve the loosening and return of the material during the bioremediation process.

Contaminated site polluted with hydrocarbons remediated by Bioremediation technology

3.3 THERMAL TREATMENT TECHNOLOGY

TERMICAL DESORBTION

The thermal desorption technology achieves a high degree of decontamination, being able to be applied up to high concentrations of pollutants (approx. 10% TPH). It is an ex-situ feasible process, in which water and organic compounds from contaminated soil are evaporated through the use of caloric energy.

CO-INCINERATION

In order to be accepted in the co-incineration process, specific laboratory tests will be performed on the contaminated material, which will determine the decisive parameters for choosing this technology, consisting mainly in determining the calorific value, water content, chlorine, sulfur, ash, heavy metals, etc.

In the case of contaminated materials characterized by a TPH component whose value exceeds 200,000 ppm or whose value of lower calorific value exceeds 2500 kcal / kg, they will be directly managed through the co-incineration process.
Thus, the contaminated material will undergo a pre-treatment operation so as to bring them to a semi-liquid consistency, suitable for use in existing installations in the process of burning alternative fuels of clinker furnaces.

3.4 FINAL CONSIDERATIONS

The establishment of the technology for soil decontamination is chosen based on the results of analyzes on the inspection of possible contaminated areas and hydrocarbon concentrations, based on a detailed investigation report that will clearly identify the nature and degree of contamination.

Complementary to the choice of the treatment and management solution of the solid phase, mechanical means are used to carry out the excavations and dislocation of the contaminants in the targeted area.

Subsequently, at the end of the decontamination, the remediation phase can be carried out, which, depending on the preferences, can be carried out so that the affected area can be put back into use for various purposes other than originally designed.

FROM MATURE ASSETS -> BACK TO THE NATURE

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