

# **EFFECTIVE CLEAN-UP OF OIL SPILLS CONTAMINATION IN NIGER DELTA BY RDK-RECOWELL**

RDK-RECOWELL Environmental Eco Solutions Nigeria Ltd and their international partners (RDK-RECOWELL Solutions Group) have equipment and competence with available pioneering products and technologies in Oil Spill Clean-ups and remediation. All our equipment, products and technologies to be applied for this project are environment friendly.

## **Statement of the Problem**

Oil production in the Niger Delta has been bedevilled with pipeline damages, leakages and destructions over many decades. Failure to effectively clean up the oil spills has resulted in social disturbances and upheavals with some Oil Companies being driven out of some Niger Delta areas. The ecology of the area has been severely damaged. Vegetation, livelihood and health of the people have been negatively impacted.

Clean up attempts have failed due to many factors as listed in the UNEP report OF 2912. The Foreword stated as follows:

*"The history of oil exploration and production in the Niger Delta is a long, complex and often painful one that to date has become seemingly intractable in terms of its resolution and future direction.*

*It is also a history that has put people and politics and the oil industry at loggerheads rendering a landscape characterized by a lack of trust, paralysis and blame, set against a worsening situation for the communities concerned."*

## **Products and Technologies**

RDK-RECOWELL solution is a unique combination of various technologies and expert services that can be applied on many kinds of environmental remediation and clean-up challenges.

The combination may be applied in-situ, on-site or ex-situ, and depending on the methodology used, the same technologies, products and services may take a variety of roles in the total solution.

The solution may be used for the remediation and clean-up of complex sites, including but not limited to:

- Soil
- Ground Waters
- Rivers, Lakes, Ponds and Other Water Areas, including areas with mangrove trees
- Sediments
- Coastline, Beaches

Fig 1. RDK-RECOWELL total clean-up solution.

RDK-RECOWELL has collected a patented combination of new pioneering and revolutionary products for bio-remediation of oil spill devastated ecosystems.

#### RDK-RECOWELL TKK On-site soil processing platform:

Used for contaminated soil mixing with ORS-SORB nutrients, moisture control, water, absorber, microbe activity enhancers like enzymes and bioactivators. Scalable solution from a small-scale version as an add-on to an excavator to an extremely large scale mobile unit on truck trailer.

Large scale system uses automated feeders and various sensors for high degree of control, resulting in optimum mixture for remediation and use of products while at the same time maintaining 400tn/h mixing rate.

#### RDK-RECOWELL surface oil degradation by KEEEN Oil Spill Control:

Our KEEEN Oil Spill Control product includes 8 strains of oil degrading non-pathogenic microbes with high-performance enzymes and non-toxic bio-activators. These components are capable of digesting oil molecules and all organic substances. They are used on surface spills on both water and soil, mixed with soil in combination with oxygen source such as EKOGRID™ in deep soil or Air Shaker in water.

#### RDK-RECOWELL ORS-Sorb® absorption technology:

A superb capillary action based absorbent that comes in two different versions, original and special, capable of absorbing either liquids less dense than water or all liquids. It is biodegradable making it highly suitable for in-Situ use as combination with other RDK-RECOWELL technologies, for example as a top soil moisture control and a nutrient source.

ORS-Sorb® is available as ready-to-use powder, pillows (small spills) and as containment booms.

#### RDK-RECOWELL electro kinetic oxidation solution, EKOGRID™:

Electro Kinetic Oxidation Technology that utilises certain electro kinetic and electrochemical reactions to both enhance bioremediation and directly break down organic pollutants in soil and ground water.

The patented pulsing voltage creates redox reactions e.g. electrolysis on the pore surfaces, and the electro-osmotic forces move the charged contents of the pore water quickly back and forwards. Freshly formed oxygen and hydroxyl radicals will oxidise and split hydrocarbon chains to lighter fractions. The final end products are carbon dioxide and water.

### Treatment and technology combinations

#### Remediation of the Mangrove forest, water bodies and bottom sediment:

The complexity of the remediation and restoration of the Mangrove forests is partly to do with its vital role in shielding and protecting the immediate surroundings and beyond. RECOWELL technologies address this complexity by offering the following:

- Special vehicles and fleet of boats and barges
- Clean-up of water bodies and exposed soil
- Remediation of the bottom sediment
- Harvesting and planting new forest

#### Soil and Ground Water remediation in-situ:

For organic contaminants, for example:

- Aliphatic Hydrocarbons ie. Petrol, Diesel, Heavy Oil
- BTEX, Other Aromatic HC and PAH
- Chlorinated HC such as TCE, DCE
- Natural Organic Hydrocarbons, Lignins

All technologies in combination, depending on the soil properties and surrounding conditions. TTK Bio-augmentation with ORS-Sorb® and KEEEN Oil Spill Control for top soil, mangrove trees and surface waters, Ekogrid™ for deep soil and ground water. Depending on the level and type of contaminants, nutrient additions and continuous monitoring for ideal microbe activity. These technologies, as an option, may further be boosted by injection of KOREnzyme, a technology that would boost the spilled crude recovery up to 50% to 60%.

#### Free phase NAPL (Non-aqueous Phase Liquids) removal from soil, ground water or water bodies:

Large scale skimming and filtration solutions based on ORS-Sorb® Original powder, booms, skimmer, Oil Separator (pressing apparatus). KEEEN Oil Spill Control applied both after mechanical cleaning and treatment of used ORS-Sorb® powder. Ekogrid™ for treatment of sediments.

#### Free phase DNAPL (Dence Non-aqueous Phase Liquids) removal from deep aquifer bottoms or basins:

Selective pumping of free phase, selective injections of catalysts to enhance accelerated bioremediation and Ekogrid™ is applied for oxygen and free radical formation.

#### Soil remediation in biopiles, on-Site or ex-Situ:

Same as for in-situ, TTK bio-augmentation used for soil mixing with ORS-Sorb®, KEEEN Oil Spill Control and water. The optimum mixture of soil and solutions may be piled on a heap or alternatively mixed on-site and returned back into its original Isoil bed. In both cases Ekogrid™ is applied for oxygen and free radical formation.

#### Bioremediation expert services

The application of RDK-RECOWELL total solution requires a variety of expert services from many fields of science and engineering. For example soil science, microbiology, chemistry, electrical engineering, construction and management of a fleet of heavy machinery.

For example, following analyses are essential for the start of any project. Planning on details of the project are started based on the results and findings. Soil analyses should contain at least following information:

- Soil fertility analysis
- Structure and quality of the soil
- Granulation report of the soil
- Level and type of pollutants
- Moisture content in the soil
- Ground water depth
- pH of the soil

3D modelling of the site for planning of remediation, restoration and landscaping activities.

Installation and commissioning of the systems and machinery:

- Bio-augmentation system
- Excavators, trucks and special vehicles as required by site conditions
- Skimmers and filtrations systems
- Pressing / contaminant separator for ORS-Sorb®
- Installation of electrical grid for Ekogrid™
- Power source: Solar panels, wind turbines or hybrid solution
- Optional: amphibious vessels larger coastal area waters or smaller water ways with spray guns, boom reels, skimmers, power packs and floating storages for storing collected oily absorbents.
- Optional: barges equipped with cutters, crushers and storage containers for harvesting dead mangrove forests.

Continuous monitoring throughout the project:

- Remote monitoring and adjusting the system
- Sampling and Laboratory analyses – at agreed intervals throughout the project lifecycle
- The following parameters to be monitored in the soil/GW samples:
  - Concentrations of the contaminants
  - Dissolved Oxygen (GW)
  - CO<sub>2</sub> (GW)

- Total Nitrogen
  - TOC (Total Organic Carbon)
  - THC (Total Hydrocarbon Content)
- Maintenance and troubleshooting, supervision of the mechanical conditions of the electrical grid, and measurements on site, of the correct functioning of the Control Unit for Ekogrid™

RDK-RECOWELL has the technical expertise, products, the technology and the capability to effect a total oil spill clean-up and restore the ecology of the land and waters back to its natural self by the use of bio-remediation with ecosystem restoration. RDK-RECOWELL has developed a pioneering bio-remediation product for oil spill clean-up in the last few years. This partnership innovation brings to Nigeria new, more advanced and efficient technologies of oil spill clean-up. Our products, expertise and technologies are poised to solve the age old oil spill clean-up problems in the Niger Delta, in accordance to the UNEP recommendation and Federal Government directives.

### Case Niger delta

RDK-RECOWELL Environmental Ecosolutions Ltd was selected by the Federal Ministry of Environment, to pilot the execution of the clean-up and remediation of the contaminated sites in Ogoni land, Nigeria.

RDK-RECOWELL Technology for soil remediation was demonstrated in Kwawa between April 27<sup>th</sup> and May 12<sup>th</sup>, 2017.

The demonstration site was an impacted swamp land (1050 m<sup>2</sup>), and was contained from other surrounding impacted areas by open trenches to redirect runoff. The procedure adopted involved baseline investigation of the level of Total Petroleum Hydrocarbon (TPH) in the impacted area and application of the RDK-RECOWELL total solution by using the "Soil and GW remediation in-Situ" methodology explained in this document.

After 80 days of demobilizing from site, the average TPH of top soil (0-0.5m) had been remediated to 4,800mg/kg from the baseline average of 14,660mg/kg, while at 1.0m depth, the value recorded was 310mg/kg from baseline average of 5,256mg/kg.



Fig 2. Kwawa site during the process and after the treatment.

## PROPOSAL TO OIL COMPANIES

### RDK-RECOWELL Profile, Objectives and Proposal

RDK-RECOWELL Environmental Eco-Solution Company Limited has teamed up with their European partners, and seek collaboration with oil companies operating in Nigeria to embark upon clean-up and control of oil spill devastation sites, on both water bodies and land, across their production area in the Niger Delta, to restore these back to their original ecosystem bio-diversity.

- **Vision:-** Restore areas affected by oil and other organic compounds in an ecologically and economically sustainable manner.
- **Mission:-** Provide environmentally friendly solutions to areas impacted or affected by organic contaminants using best global products and practices.
- **Core Values:-** Continuous research and education to take appropriate action in conformance with United Nations environmental standards for the benefit of humanity and the ecology.
- **Strategic Areas of Focus:-** Bio-regeneration of devastated areas for sustainable development.
- **Strategic Goals:-** Research and delivery of services to meet or exceed best global standards.
- **Action Plans:**
  - Identify areas of need
  - Utilize best products and practices.
  - Engage appropriately with respective authorities.
  - Deliver best services for humanity and the environment.

The endeavour would enhance economic productivity and management efficiency of your area of production.

- Polluted water bodies shall be restored to normalcy. This will revive the aqua-culture industry in the impacted areas.
- Deprived land masses shall be restored to tenure facilitation to also revive plants and crops cultivation.
- People can return to and live on the land.
- The RDK-RECOWELL bio-remediation agent and partner technologies shall improve and restore the eco-system to its sublime state which has hitherto, supported and sustained fauna and flora.

RDK-RECOWELL performance in the global market and Nigeria to date is evidenced by industry, and domestic stages of work our partners have done on oil spill clean-up. We completed a pilot demonstration of our technology in May 2017 in the Kwawa community in Ogoniland and this has been hugely successful, the results will be evidenced in our presentation to your company.

RDK-RECOWELL partners have certificates of compliance with ISO management system standards, and other accolades, and the company has all the necessary certificates and clearance to operate in Nigeria. We shall be available for a presentation of our technology at any time we are invited to do so. We are the solution to the oil Spill contamination in the Niger Delta.

Our tentative proposal to be discussed includes the following:

- Memorandum of Understanding
- Identification and characteristics of project site
- Project budget based on soil and groundwater volume and level of contamination
- Initial project plan and schedule:
  - cost implication of the solution and cost efficiency to oil companies
  - description of how the oil companies are expected to participate in the project
  - effectiveness of the products and total solution
  - proof that the microbe is safe to local environment
  - time frame for remediation to a level below 5000 mg/kg
  - description of how we do remediation in the mangrove area (swamp)
  - a list of sites where the RDK-RECOWELL companies have done successful projects

- optional products of potential other uses (eg. KEEEN Fire, ORS+KEEEN combination)

## Optional services

Cleaning and restoration of mangrove areas  
within RDK-RECOWELL project sites

A waterway, wide or small

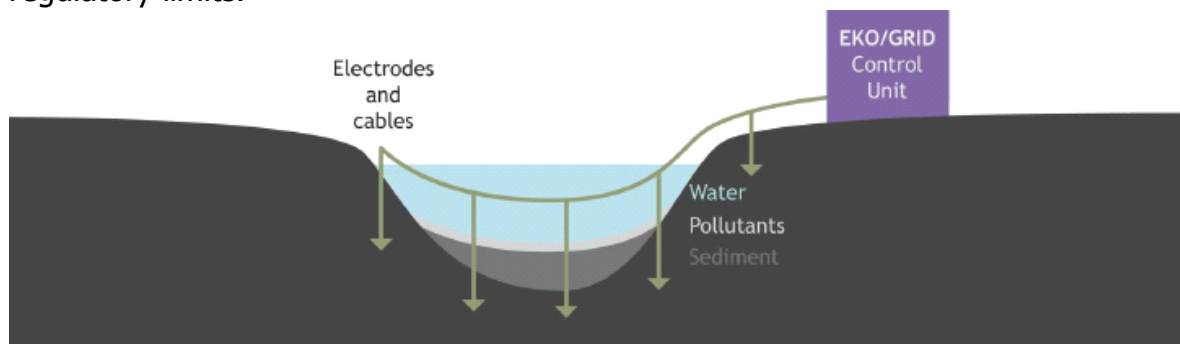
Suggestion to use Mobimar, Suokone and Aquamec technologies in addition to the ORS-Sorb, Oil Spill Control and EKOGRID.

Assumptions and suggestions:

- The subject area may have a wide river deep enough for an oil recovery vessel to operate on (draught 2,6 meters)

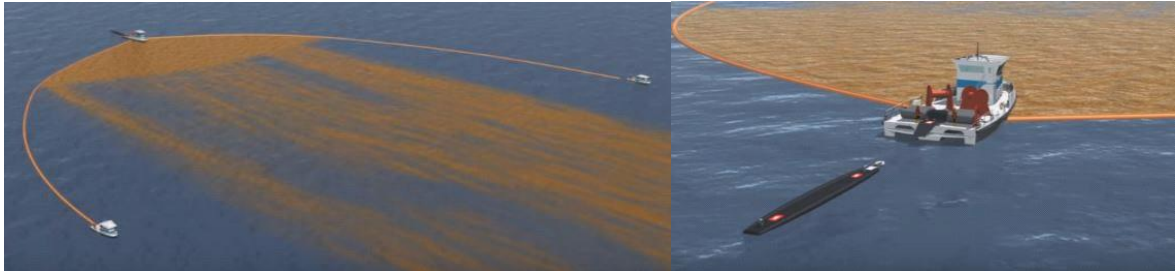


- It has oil spill polluted shores and sediments. Apply EKOGRID™ on the bottom sediment of the water way, let it stay working until you have reached the desired regulatory limits.





- There is occasionally visible oil on the water surface. Remove this by pulling containment booms with workboats from the Mobimar CORS mother vessel as close to shores as you can and let the oil flow towards the mother vessel. Spray ORS-Sorb on the oil to absorb it and initiate bioremediation. Collect the absorbed oil into floating tanks behind the vessel. Press the oil out from the absorbent for reuse using ORS recycler press. Treat the ORS-Sorb with Oil Spill Control to ensure bioremediation and eventual safe biodegradation.



- The mangrove roots are stained by oil which is cleaned off by spraying Oil Spill Control on them to release oil from the plants. These will be accessed by smaller boats, hydrocopters and/or swamp buggies, equipped with appropriate RDK-RECOWELL spraying, skimming and collection equipment.



- On some areas the mangrove trees have died due to oil pollution. They may often reside along smaller waterways and swamplands. Use Aquamec Watermaster or a CAT swamp bug to access these mangrove areas. Use grabbers and cutters and chippers to make tarred wood chips for easier transportation and handling. Crush the chips into a transport barge. During low tide we harvest, crush and collect the oily wood chips and transport the barge away during high tide. For this we use a floating cutter and wood chipper in a locally supplied barge designed for swamp and tidal water areas. The grabber and chipper can be attached both on an excavator, workboat, barge, etc.



Watermaster



CAT Swamp buggy



Grabber/cutter



Chipper

- Dead trees should be removed and replaced by new plants. E.g. Suocco s 500, the most efficient crawler tractor in the market, equipped with mechanical power take-off. It is efficient, versatile and adaptable for different purposes. The crawler roots up stumps and evens the top soil for planting.



RDK will investigate the exact mangrove species growing on the target area, grow new trees in its nursery and plant them back into the cleaned, restored locations.

## Tank Cleaning and Degassing

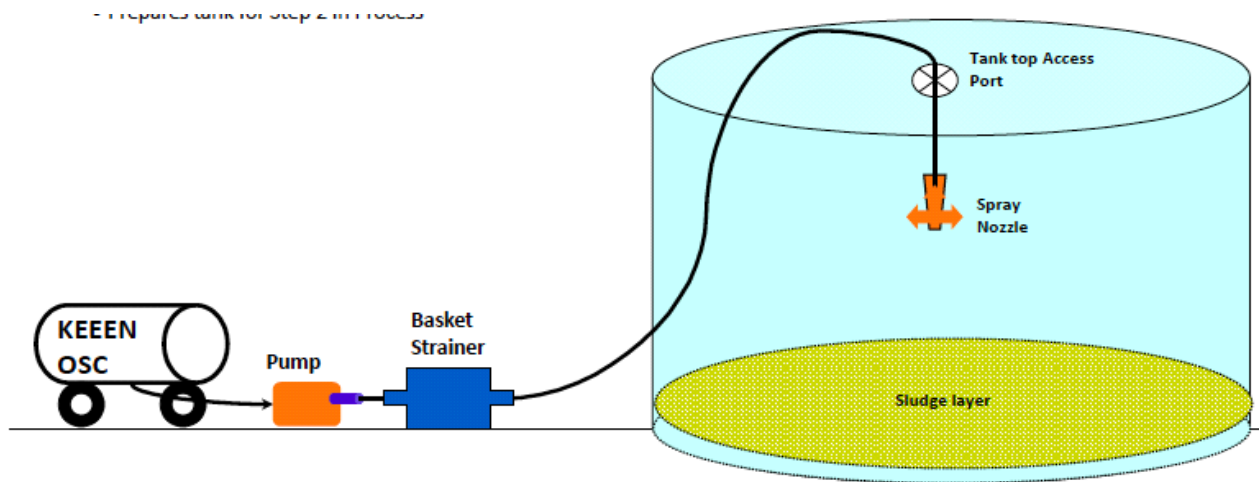
Bioremediation Method

By KEEEN and ORS-SORB®

### Step 1 – Spraying and Degassing

- Set up and test circulation pumps
- 1 pump (250-450 gpm) will be required for cleaning most tank sizes
- Standard 2" to 3" circulation lines should be adequate
- Consult with nozzle supplier to size spray nozzle with the size of existing tank and pump

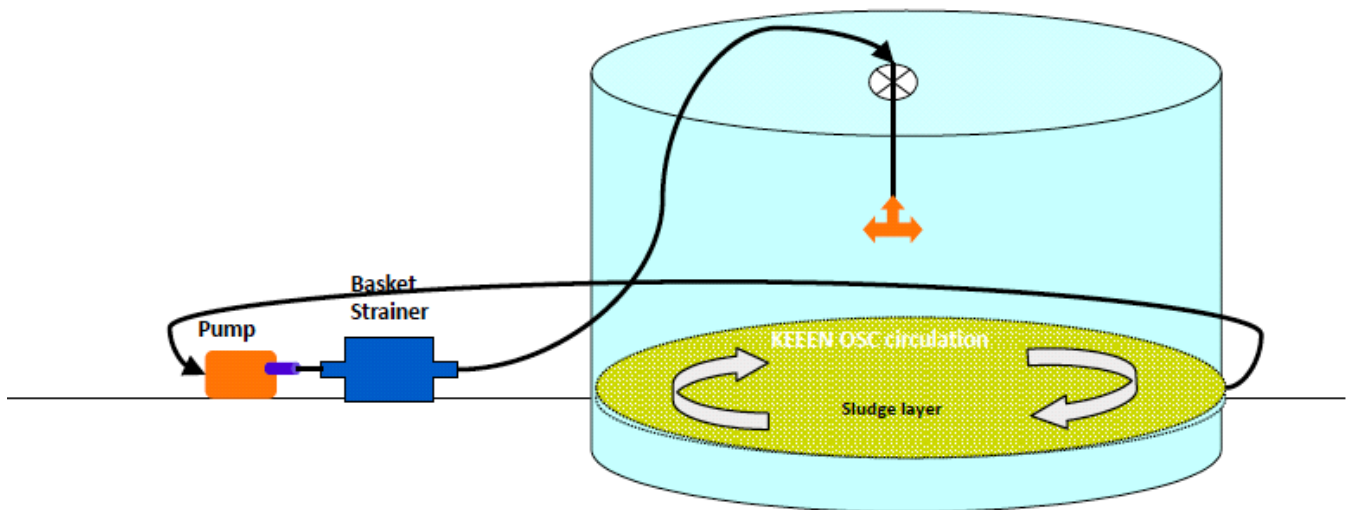
- Place a basket strainer at output of pump
- Dilute and mix KEEEN OSC product as directed in material storage tank
- Pump solution into tank through topside access port
- Pressure and flow should be as per nozzle specs
- Airless, Sherwin Williams, Gamajet, Butterworth or Cloud nozzle (or similar) is recommended to use
- Spraying process degasses the tank and cleans top and side surfaces inside the tank
- Solution settles on bottom of tank over the sludge layer (estimated to be 50-100 mm thick)
- Amount of solution is calculated to cover sludge with 2 feet of solution
- Prepares tank for Step 2 in Process



#### Step 2 – Circulation and Degreasing of Sludge

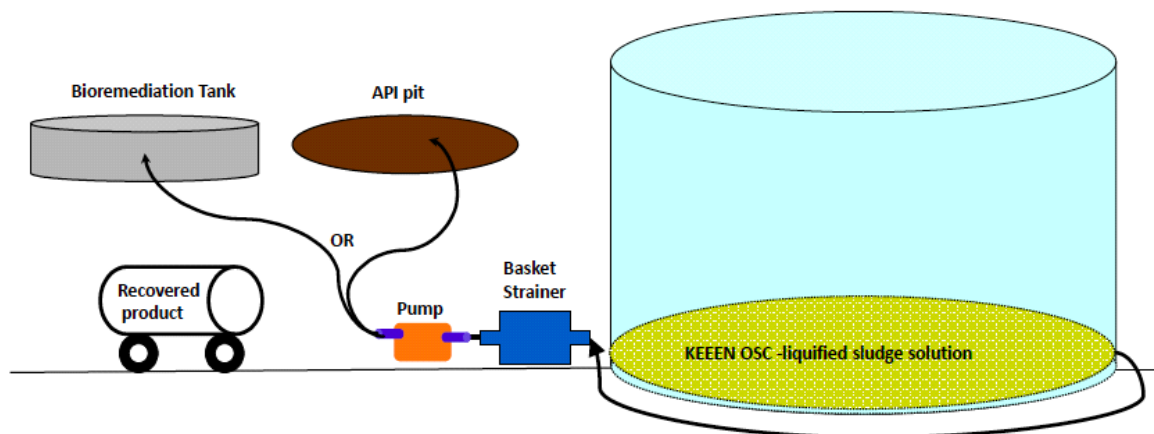
- Using circulation pump, circulate KEEEN solution throughout the tank
- Pump solution out of the tank through lowest access port - a floor sump is typically used
- Suction line returns to pump and solution is re-sprayed back into the tank after passing through the basket strainer
- Basket strainer will capture all the freed solids from the sludge layer in the tank
- Monitor pressure gage. If pressure drops, empty basket strainer and resume pumping.
- Circulate KEEEN OSC for 24 –36 hours
- Dissolves sludge into solution
- Separates solids from hydrocarbons which will float on top of the solution
- Prepares tank for Step 3 in Process





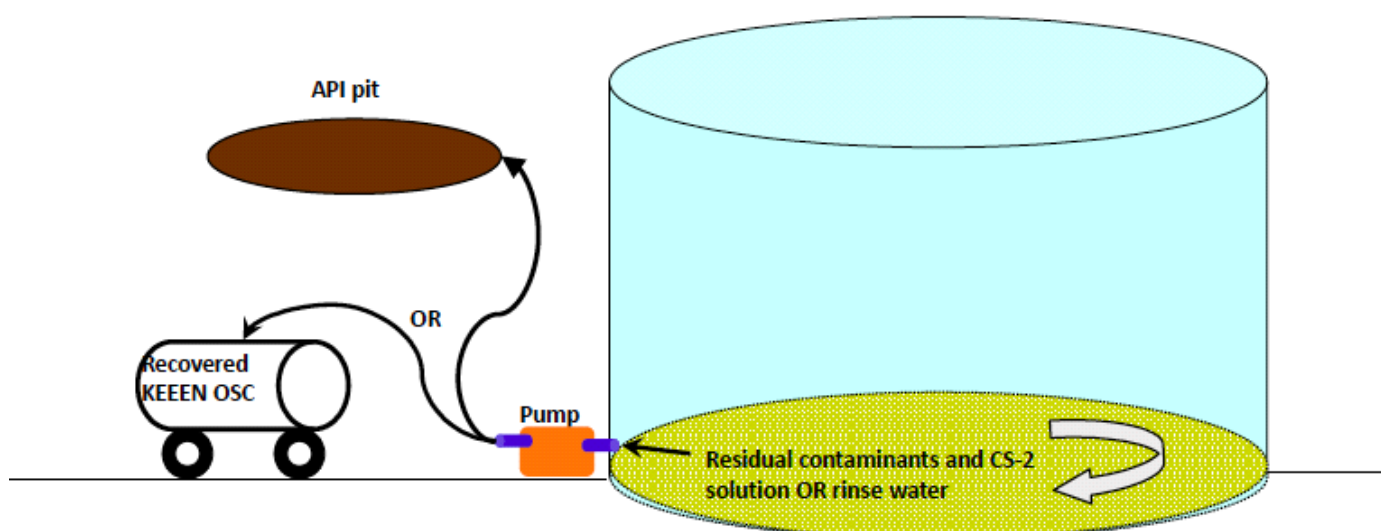
### Step 3 – Solution Evacuation and Liquefied Sludge Removal

- After 24-36 hours, solids in sludge are liquefied and pumped from the tank
- Hydrocarbons are separated from solids in sludge and emulsified into KEEEN OSC solution
- Solids are recovered from the basket strainer and are ready for removal from site
- Reconfigure pump to evacuate wastewater from the tank
- Pump wastewater from the tank
- Oily wastewater can be pumped to API pit
- Alternately, this wastewater can easily be bioremediated using microbial additives like KEEEN Oil Spill Control, if desired



### Step 4 – Second Cleaning (if necessary)

- Repeat steps 1 and 2 with second batch of KEEEN OSC solution
- Inner tank surfaces should be very clean
- Remaining KEEEN OSC solution should be fairly clean
- Remove spray nozzle from the tank
- Pump KEEEN OSC out into storage tank for re-use as first wash on next tank
- If second cleaning is not needed, spray water through nozzle for 3-4 hours
- Remove nozzle
- Pump out tank, send wastewater to API pit



#### Step 5 – After rinsing with water (1-2 times)

- Whole tank need to be rinsed thoroughly with water to minimize the growth of microbes after cleaning with KEEEN solution. This is very important to note!
- If maintenance requirements dictate, an air mover (such as a COPUS blower) can be introduced into the tank to dry tank and promote air circulation after water rinsing.

#### Step 6 - Waste water recycling

- Remaining oily waste water can be recycled using bioremediation method. Wastewater is mixed with ORS-Sorb® absorbent. Absorbent enhances the bioremediation process because of its composition. ORS-Sorb® contains Nitrogen and relatively high air volume. Absorbents' purpose in the recycling process is not primarily to absorb the liquids but to boost the biological bioremediation method by enabling good living conditions to the microbe to work in the most effective way. Waste is left on insulated area until it is completely oil free. Oil free waste can be put into nature, fields, ground or where desired.

### SOLUTIONS

- Circulation pump method is suitable for most tank sizes when pressure is adjusted and circulation system is built to meet the criteria. High-pressure system is used with high pressure and vacuum trucks or tank trucks with hoses and manual high-pressure washing without circulation system.
- Alternatively, it is possible to absorb the oil from the tank bottom using ORS-Sorb® absorbent. Absorption can be done before and/or after the washing, if considered necessary.
- Solutions and methods to be used are considered and decided at each site case specific. Different solutions can be used separately or combined. Consulting at the beginning of the project is an essential part of the process.

### PRODUCT FACTS

#### KEEEN Oil Spill Control

- Inflammable, non-toxic, non-pathogenic, non-hazardous

- Biodegradable and designed for use in bio remediation with microbes.
- Cost effective, easy to use, faster, and more efficient solutions.
- Render volatile vapors inside tanks harmless.
- Render fuel spills inflammable.
- Reduce LEL or lower explosive levels to zero quickly.
- Remediate wastewater and contaminated soils.
- Reduce downtime and are less disruptive than other methods.
- Offered in powerful concentrates to reduce expenses.
- Environmentally friendly and do not contribute to pollution.
- Certified product. Authorized certification authorities such as TÜV, OMIC, SGS, NSF and Intertek West Lab have tested the product.

#### ORS-Sorb®

- Very fast. Absorption is immediate. Absorbed ORS-Sorb® is ready for cleaning immediately or later if desired, absorbed liquid stay in ORS-Sorb® capillary pipes.
- High Capacity. 1 liter of ORS-Sorb® absorbs 0,9 liter of oils or liquids. ORS-Sorb® does not expand nor swell. Absorption is based on strong capillary action.
- Suitable for all liquids. (Exclusion: very strong inorganic acids, such as sulfuric acid, phosphoric acid, hydrochloric acid etc.)
- Environmentally friendly, Non-toxic, 100% Recyclable, Biodegradable
- Non-flammable. Flaming point of ORS-Sorb® is 2000° Celsius. Suitable for fire extinguishing and in absorption of burning liquids.
- Certified product. Authorized certification authorities such as Det Norske Veritas (DNV), Ecolabor, Sintef, Intertek West Lab and Environmental Enterprices USA have tested the product facts.

## FIRE PREVENTION

By KEEEN Fire and KEEEN Oil Spill Control

Oil or gasoline spill on a flat surface can be prevented by spraying a predetermined solution of Oil Spill Control to form a cover over the whole spill area of flammable liquid.

Burning spill area will be extinguished by spraying the KEEEN Fire product over the burning area. Probability of self-ignition is extremely low.