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# Soil Decontamination by Soil Washing Technique Using Surfactant

**Radha Pandey, Arpan Herbert, Annu Pandey**

***Abstract*— Soil contamination is mainly due to uncontrolled release of petroleum products like underground leakage from storage tanks and above ground oil spills. Hydrocarbons not only affect the quality of soil but also changes its geotechnical properties. This paper aims to investigate the effect of geotechnical properties of soil contaminated with engine oil and evaluate decontamination by soil washing technique using surfactant Brij-35. The geotechnical properties of contaminated soil samples by different proportion of engine oil i.e 2%, 4%, 6% & 8% were determined. Then contaminated samples have been decontaminated by soil washing technique using surfactant and geotechnical properties were determined and compared with contaminated & virgin soil samples. Results shows that Percentage restoration of contaminated soil is same as virgin soil , maximum restoration was found at 4%. Higher percentage of oil lesser will be restoration capacity.***

***Index Terms*— Brij-35 , contamination, decontamination , soil washing.***

## I. INTRODUCTION

Soil contamination due to oil products causes serious environmental problems and detoriate the quality of soil as well. Soil contamination has negative affects on the safety of civil engineering structures [1-3].In oil contaminated sites excessive settlement of tanks, breakage of pipelines etc are expected to take place[4].

Treatment method can be physical, chemical, or biological or their combinations. Various in-situ and ex-situ techniques are being used to remediate the NAPL's contaminated sites such as soil vapour extraction, soil flushing, chemical treatment , bioremediation, physical separation, soil washing etc. for least volatile petroleum mixture , soil flushing (in-situ) and soil washing (ex-situ) are very effective remediation methods. Physical and chemical properties of soil relevant to the experimental work determined as per IS 1498 (1970) has been classified as CH (clay with high plasticity).This research deals with soil washing techniques it removes and separate portion of soil which is most polluted and reduces amount that requires further cleanup. Soil washing with surfactant helps in removal of NAPL's.Although the use of surfactants to remediate contaminants in the subsurface is a relatively new area of application, their use in subsurface systems dates back to 1963 when petroleum sulfonates were patented for widespread use in enhanced oil recovery efforts [5-6].

The surfactant called as amphilic having two parts-hydrophilic group or moiety (polar, water loving) and hydrophobic group or moiety (apolar, water fearing) [7-8] i.e hydrophilic part of surfactant has affinity for water and hydrophobic part has affinity for NAPL's. as shown in Fig 1.

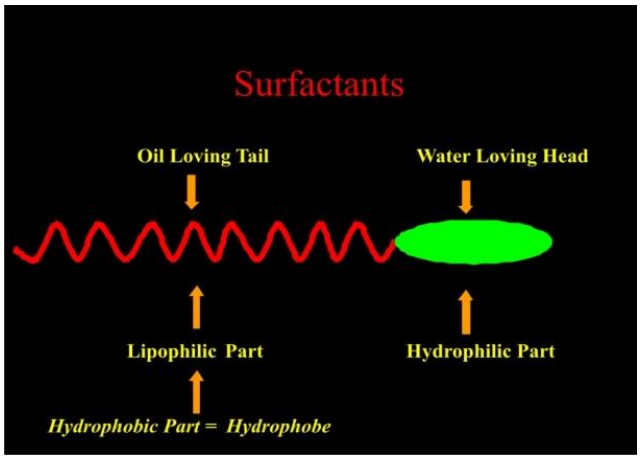


Fig.1 Surfactant Molecule structure

A surfactant molecule that exist as a single unit is called as a surfactant monomer with increase of surfactant concentration, monomers concentration increases upto the concentration at which micelle forms as shown in Fig 2. Minimum concentration at which micelle form called Critical Micelle Concentration (CMC).

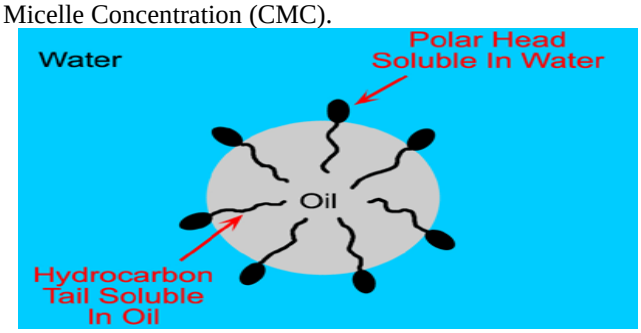


Fig2. Surfactant accumulation (micellization) at the NAPL-water interface

A surfactant works as a remediation tool by lowering the contaminant water interfacial tension and there by causing a degree of contaminant mobility and enhanced contaminant solubility and enhanced contaminant solubility in water[9-10].

## II. MATERIAL AND METHODS

### A. Site Review

The study area was selected as HAL Township, korwa (UP) . This area is situated at 25018'0''N (Latitude) & 76012'0"E (Longitude). The soil samples used in this study were collected from A-375(kitchen garden area), near HAL Dispensary, Samples collected at the depth of 1m below the ground surface and kept in plastic bags approximately 30kg of sample were collected.

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The geotechnical properties of virgin soil were determined as per relevant part of SP36 (Bureau of Indian standard).The initial degree of contamination was fixed at 3% because the State of New Jersey classifies soils with an oil concentration above 3% as hazardous waste[11].

*B. Sample Preparation*

Contamination used in this study is engine oil. Contamination is done by percentage weight of oil with respect to dry weight of soil. Contamination level that has been observed on sites provide a basis for contamination of soil in laboratory at different percentage [12].
Appreciable particles aggregation and change to coarse soil like behaviour in oil contaminated fine-grained soils has been reported as a result of oil mixing [13].

*C. Remediation process by Soil washing using surfactant*

A non-ionic surfactants, BRIJ-35 $CH_3(CH_2)_{10}CH_2(OCH_2CH_2)_{23}OH$ has been used in this research. Surfactant quantity need to be added in plain water is 0.5%( v/v) i.e 5ml surfactant in one liter of plain water.Plain water having surfactant mixed with contaminated soil and stirred vigorously for 5minutes and left for 2hours. Due to presence of surfactant and stirring foam will form. Then wash soil with plain and fresh water twice, care should be taken to allow fine particles to get settled down as shown in Fig 3. Then Decanted solution (soil-water suspension) was allowed to stand in another container for 24hours, so that fine particles get settled down. Lastly, decanted slurry was kept for air drying 6-7 days.

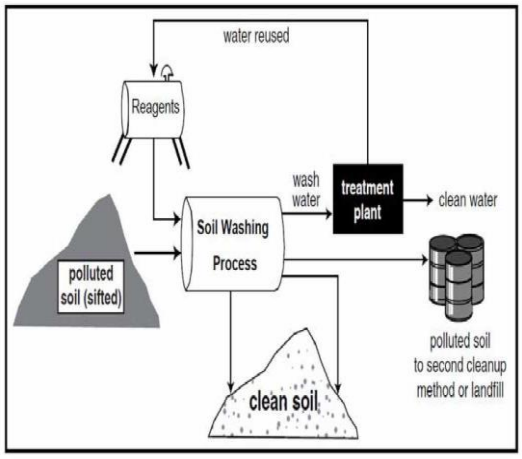


Fig 3. Schematic of ex-situ Soil Washing process (USEPA, www.epa.gov )

## III. RESULTS & DISCUSSION

The optimum moisture content (OMC) and max. dry density (MDD) of the virgin (clean) soil as well their mixes with the contaminant were first determined by light compaction test as per IS: 2720[14].

For the contamination of soil with organic contaminant , engine oil (Castrol CRB 20) was selected. The required quantity of oven dried cooled and pulverized soil was mixed with 2%,4% and 6% & 8% of lubricating oil by dry wt. (e.g for 4% mix, 40g of oil was mixed , with one kg of the dry soil) for the above mentioned purpose, about8kg of soil was sprinkled with the required quantity of oil (for every mix) the content were vigorously mixed with hands for sufficient time in order to break the lumps and then placed in covered containers for saturation for a weeks time.

For Decontamination ,Plain water having surfactant mixed with contaminated soil and stirred vigorously for 5minutes and left for 2hours.Then wash soil with plain and fresh water twice, care should be taken to allow fine particles to get settled down.Then Decanted solution was allowed to stand in another container for 24 hours, so that fine particles get settled down.

Geotechnical properties for all the decontaminated mixes were separately determined on soil sample remolded at their respective compaction characteristics.

The maximum dry density and moisture contents dropped due to the increased content of engine oil.The increased inter-slippage of soil particles reduces the shear strength of soil [15].

*A. Consistency's Limit*

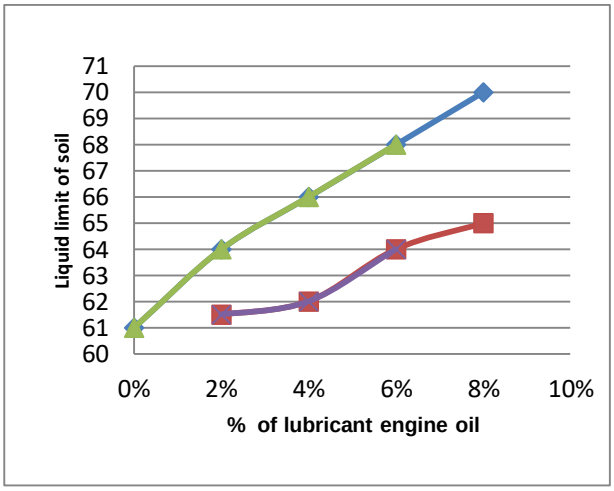


Fig.4 Liquid limit values for a Soil sample

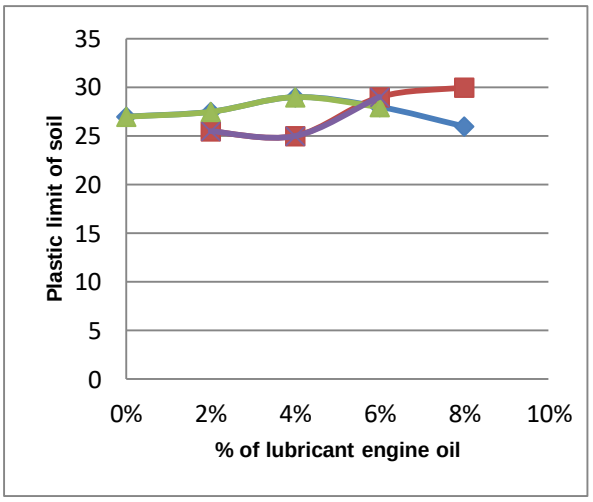


Fig.5. Plastic Limit values for a Soil sample.

*B. Compaction Characteristics*


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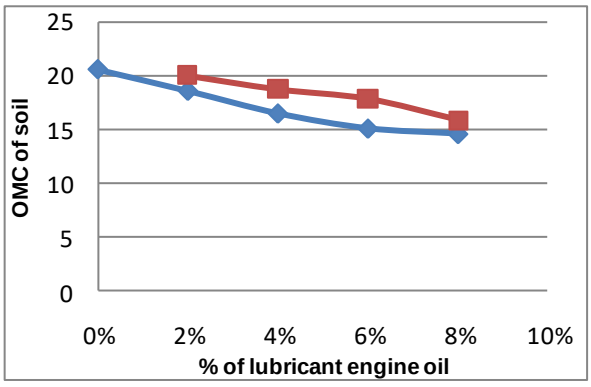


Fig 6. Optimum Moisture Content values for a Soil sample.

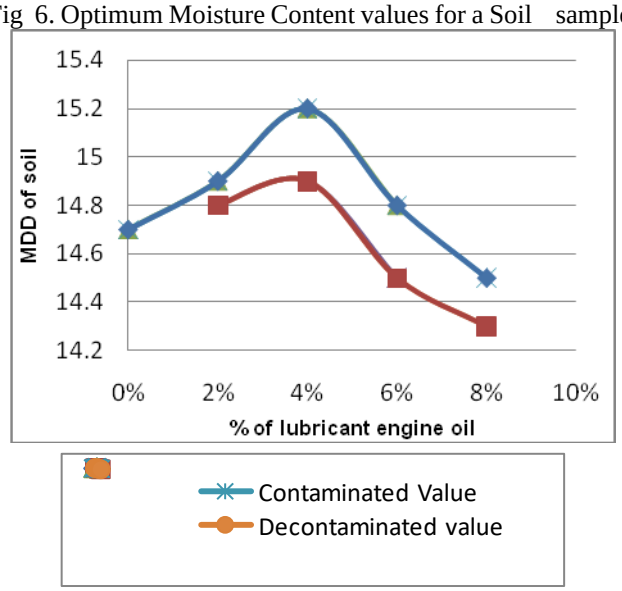


Fig7. Max. Dry Density (MDD) values for a Soil sample

Due to contamination with engine oil, as we can see in above mentioned graphs, Blue line indicates contaminated values.
In Consistency's Limits, liquid Limit keeps on increasing with increase in percent of engine oil as we can see in fig4. And Plastic limit initially increases upto 4% then starts decreasing as shown in Fig.5.
In Compaction characteristics, Optimum moisture content (OMC) keeps on decreasing with the increase in percent of engine oil as shown in fig 6 and Max. dry densiy (MDD) increases initially upto 4% then starts decreasing as we can see in Fig7.
After Soil washing using Brij-35 on contaminated soil samples we can see restoration of geotechnical properties as it was earlier before contamination as we can see in graphs , red line shows decontaminated values. In Consistency's limits, Liquid limit has restored upto 97% shows in fig 4. And plastic limit was found to restored by 92% as we can see in Fig 5.
In Compaction characteristics, Optimum moisture content was restored by 87% as we can see in fig.6 and Max dry density was restored by 98% as shown in fig.7.
Higher percentage of oil lesser will be the restoration capacity i.e. Restoration in properties is of course less as compared to the lower percentage of oil.

## IV. CONCLUSIONS

Remediation of contaminated soils is a practical necessity with respect to geotechnical and environmental considerations.

In this study, the effects of oil contamination on some geotechnical properties are clearly observed on CH (clay with high plasticity) and after soil washing, restoration of geotechnical properties.
Liquid limit, Plastic Limit, Optimum moisture content, Max dry density restored upto 97%, 92%, 87%, &98% respectively.
Percentage restoration of contaminated soil is same as virgin soil for above mentioned properties thus varies from 87 to 98%.

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