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Implementation of a process for the treatment of hydrocarbon-contaminated soil using petroleum production water

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Abstract.

Oil-Pipeline and Oil-Well accidents, and leaky underground storage Oil-tanks can all permanently contaminate massive areas of soil, making them economically useless as well as dangerous to the human health, biological resources, and ecosystems. There are many method of treatment of these contaminated soil by hydrocarbons [1]: stabilization/solidification, bioremediation [2], incineration, soil washing, etc. The present work focuses on the treatment of the contaminated soil by the hydrocarbons with soil washing process using oilfield producedwater (PW). The methodological approach consists of researching the optimum conditions of soil washing based on the optimum of moisture'sparametersbetween PW and contaminated soil such as Liquid/Solid ratio and Liquid/Solid contact time. Another parameter was analysed, it is the successive wash test. The contaminated soil before applying the treatment has 1900 ppm of Total Petroleum Hydrocarbons (TPH). After many washing test, the optimum parameters of test were fixed as follow: The optimum of Liquid/Solid ratio was 100 ml / 100 g and the optimum of Liquid/Solid contact time was 5 minutes.With these optimum conditions and after 4 successive soil washing, we succeeded to reduce the percentage of residual TPH in contaminated soil from 1,9%(1900 ppm) to 0,1% (100 ppm).

Keywords: Petroleum industry, Produced Water (PW), Contaminated soil, Total Petroleum Hydrocarbons (TPH), Soil washing.

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1 Introduction

In a context of very strong environmental, energy and societal pressures, including the need for the protection of water resources and the limitation of gas emissions, water management and decreasing the quantity of contaminated soil by hydrocarbons have become a major challenge for the oil industry.

In order to remove these contaminants, many different in-situ or ex-situ remediation technologies have been developed throughout the years to mitigate the risk imposed by soil contamination such as stabilization/solidification, bioremediation, incineration, soil washing, etc. [3]

On the other hand, large volumes of Produced Water (PW) are generated with oil pumping operations. This PW can be used to clean contaminated soil by hydrocarbons with soil washing process.Washing tests have been executed in laboratory scale followed by analyses to evaluate the release of TPH content from soil to the aqueous phase and determine the optimum conditions for an effective washing.

2 Methodological approach.

The soil washing treatment was based on the following steps to reduce the amount of hydrocarbons stored in the soil;

1- We have tried to select the optimum liquid/Solid ratio (ml/g) of produced water at ambient temperature and after 20 minutes of liquid: solid contact time: 100/100, 200/100, 400/100, 800/100.

2- After having selected the optimum Liquid/Solid ratio, we limited the solid: liquid contact time to see the optimum time for dissolving hydrocarbons in produced water: 5, 10 and 20 minutes.

3- A series of successivewashes were carried out in compliance with the optimum Liquid/Solid ratio and the optimumcontact time in order to reduce the concentration of residual TPH in the soil.

3 Results

The amount of hydrocarbons present in the contaminated soil before applying the treatment method was determined as TPH= 1900 ppm. Our objective is to transfer the maximum of hydrocarbons from the soil to produced water. For that, the optimal conditions of soil washing were determined by assessing the quantity of hydrocarbons remaining in the soil after each wash test.

3.1 Liquid/Solid ratio optimization

The washing conditions are:

- ✓ The amount of contaminated soil: 100g
- ✓ The volume of formation water in ml: 100, 200, 400, 800
- ✓ Liquid/Solid ratio: 100/100, 200/100, 400/100, 800/100
- ✓ Ambient temperature: between 19 & 21°C
- ✓ Liquid/Solid contact time : 20 minutes
- ✓ Agitation speed: 110 rpm

The residual hydrocarbons in soil after washing test are registered in table below

Table 1. Variation of TPH as a function of Liquid/Solid ratio.

Sample name	Liquid/Solid ratio (ml/g)	TPH (ppm)
S1	100/100	1100
S2	200/100	1300

S3	400/100	1700
S4	800/100	1700

3.2 Liquid/Solid contact time optimization

The washing conditions are:

- ✓ The amount of contaminated soil: 100g
- ✓ The volume of formation water in ml: 100 ml
- ✓ Liquid/Solid ratio: 100/100
- ✓ Ambient temperature: between 19 & 21°C
- ✓ Liquid/Solid contact time : 5, 10, 20 minutes
- ✓ Agitation speed: 110 rpm

The table below summarizes the obtained result of TPH

Table 2.Variation of TPH as a function of Liquid/Solid contact time.

Sample name	Liquid/Solid contact time(min)	TPH (ppm)
S4	5	700
S5	10	800
S6	20	1100

3.3 Successive wash test

Successive washing consists of four consecutive washes on the same sample in order to produce four different extracts under the following conditions:

- ✓ Liquid/Solid contact time 5 minutes
- ✓ Liquid/Solid ratio: 100/100
- ✓ Ambient temperature: between 19 & 21°C
- ✓ Agitation speed: 110 rpm

TPH in soil were measured in each water rinse and recorded in the table below

Table 3.Variation of TPH as a function of Successive washing.

Flushing number	TPH (ppm)
1	700
2	700
3	300
4	100

4 Discussion

4.1 Liquid/Solid ratio optimization

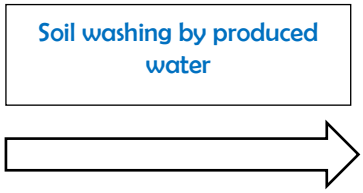
Since the solubility of a chemical compound in the aqueous phase is commonly defined as the maximum amount of compound per unit volume in the aqueous phase, it is noted that the amount of hydrocarbons increases in the organic phase and decreases in the aqueous phase when the volume of water is increased. This means that the significant release of hydrocarbons was carried out in the lowest water volume (100 ml in this experiment).

4.2 Liquid/Solid contact time optimization

It was observed that when the contact time has been reduced to 5 minutes, the transfer of hydrocarbons from soil to water becomes more important than when the contact time is 20 minutes.

4.3 Successive wash test

It was observed that at the end of a series of successive washes, the lowest amount of TPH remaining in soil is carried out after rinsing a soil sample four times in succession under the selected conditions (t = 5 min and ratio 100/100).



5 Conclusions

As a result, the application of soil washing with produced water as a method of treating hydrocarbon contaminated soil, has allowed us to reduce the percentage of residual TPH in soil from 1.9% (1900 ppm) to 0.1% (100 ppm).

These results obtained with the washing conditions below:

- ✓ Liquid/Solid ratio: 100 ml / 100 g
- ✓ Ambient temperature: between 19 & 21°C
- ✓ Liquid/Solid contact time : 5 minutes
- ✓ Agitation speed: 110 rpm
- ✓ Rinsing the contaminated soil four times in succession

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