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In-Situ Phytoremediation of Crude Oil Polluted Soil

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----------ABSTRACT----------
A leguminous crop [ground nut] was planted in a sandy clay soil artificially polluted with crude oil. The plant survived the fouled soil and showed a faster rate of remediating the soil than natural attenuation. Total hydrocarbon content of the soil was analyzed weekly via collected soil samples. 487g of groundnut seeds was used in the experiment which lasted for fifteen (15) weeks. A regression model was developed for the phytoremediation process. The developed model is useful for prediction and environmental control studies.

KEY WORDS: *Crude oil, Legume, Phyto-remediation, Sandy-clay soil*

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I. INTRODUCTION

Tens of thousands of petroleum–contaminated sites exist and the petroleum industry must either clean-up the sites or be penalized. Ex-situ and in-situ techniques of cleaning up crude oil contaminated soil such as excavation, land filling, incineration and soil washing, land farming and bioventing can be costly [1]. It has been shown that a specialty fibre crop with excellent oil sorbency capacity and high protein content called KengroBiosorb can stimulate the degradation of crude oil in contaminated beaches [2]. Phyto-remediation was defined as the use of green plants to remove pollutants from the environment or to render them harmless [3]. Phyto-remediation can also be defined as the use of green plants and the root associated soil organisms, soil amendments and agronomic techniques to remove certain or render harmless environmental contaminants [4].
Different Researchers at different times have reported the various methods phyto-remediation can be applied to a contaminated soil.

Different applications of phyto-remediation:
1.1 Phyto-remediation of metal**:**Phyto remediation of metals is a cost-effective green technology based on the use of specially selected metal-accumulating plants to remove toxic metals including radionuclide, from soil and water. Phyto-remediation takes advantage of the fact that a living plant can be compared to a solar driven pump which can extract and concentrate particular elements from the environment [3]. For successful phyto-remediation both plants and microbes must survive and grow in the contaminated soil [5]. White and others [2012] as well as Raskin [2012] identified Several subsets of metal phyto-remediation such asphyto-extraction, rhizofiltration, phyto-stabilization and phyto-volatization have been identified [3, 5].

a) Phytoextraction: High biomass metal-accumulating plants and appropriate soil amendments are used to transport and concentrate metals from the soil into the above ground shoots.
b) Rhizofiltration: Plant roots grown on aerated water, precipitate and concentrate toxic metal from polluted effluents.
c) Phyto stabilization: plants stabilize the pollutants in the soils thus, rendering them harmless.
d) Phytovolatilization: Plants extract volatile metals [e.g. mercury and selenium] from soil and volatilize them from the foliage.

1.2 Phytoremediation of organics: It was asserted that legumes occurring naturally in oil-contaminated areas have the potential to clean-up petroleum hydrocarbons [6]. The aesthetic value is greater than that of other remediation techniques [6].Targets of this technology are PCBs [polychlorinated biphenyls], trichloroethylenes [TCE], poly-aromatic hydrocarbons [PAHs], pesticide residue, various explosives and other toxic organic pollutants deposited in soils and around us by industries. It was reported that phyto-remediation of organic pollutants takes the advantage of the fact that living plants carry out a plethora of chemical reactions energized by sunlight, which metabolize or mineralize organic molecules [3, 5].From prior research, it can be deduced that the sole aim of phytoremediation is to degrade pollutants or at least limit their speed in the environment by plants and associated micro-organisms. In this research, a leguminous plant was planted in a crude polluted soil to ascertain the rate of remediation. Although in [6] it was asserted that legumes occurring naturally in oil-contaminated areas have the potential to clean-up hydrocarbon. This research adopted the method of introducing the plant [legume] after pollution.

II. MATERIALS AND METHOD

2.1 Materials:

1. Groundnut seeds
2. Crude oil
3. 500ml measuring cylinder

2.2 Method:

The experiment was set-up in a Sandy clay soil. One square meter of land was marked out. Another one square meter of land was marked out and observed as a control. The soil samples from the two plots were taken for total hydrocarbon content [THC] analyses. Plot A& B were polluted with about 500ml of crude oil respectively. About 487g of groundnut was weighed with a triple beam balance and planted in plot A. Nothing was done in plot B. It was left to natural attenuation. The soil samples from the two plots were collected weekly for fifteen weeks and analyzed as done in [7].

III. RESULTS AND DISCUSSION

The hydrocarbon content of the two plots (the remediating and the control plots) was measured weekly and the results were as shown in Table 1.

Table 1: Hydrocarbon content of the two Plots [Plot A and Plot B] measured weekly after pollution

WEEKS	PLOT A [mg/100g]	PLOT B [mg/100g]
1	120.0	150.0
2	112.5	112.5
3	82.5	90.5
4	67.5	67.5
5	57.0	51.0
6	57.0	49.5
7	47.0	51.0
8	47.0	50.0
9	44.0	49.0
10	42.5	48.5
11	39.0	46.0
12	35.0	44.0
13	34.5	41.0
14	30.0	40.5
15	27.5	38.0

Mathematical Modeling: A regression model was obtained using LINEST software in Microsoft excel. The data utilized for the modeling are shown in Table 2 below.

Table 2: Data for regression modeling

WEEKS	CONC. THC, mg/100g	G/NUT APPLIED, g
1	120	487
2	112.5	0
3	82.5	0
4	67.5	0
5	57	0
6	57	0
7	47	0
8	47	0
9	44	0
10	42.5	0
11	39	0
12	35	0
13	34.5	0
14	30	0
15	27.5	0

5.356673	18.40586444	-415.8252804
2.127119	13.50876164	223.2727568
0.468425	99.02368243	#N/A
5.287209	12	#N/A
103689.5	117668.2762	#N/A
#N/A	#N/A	#N/A
#N/A	#N/A	#N/A
#N/A	#N/A	#N/A

Using the regression model:

$$Y = a_o + a_1x_1 + a_2 x_2 \qquad (1)$$

Where Y = Amount of Remediating agent needed for clean-up

x_1 = Time in weeks

x_2 = concentration of Pollutants after time, t.

a_o and a_1 = Intercepts; a_0 and a_1 = slope

Substituting values from table 2; a mathematical model for the phytoremediation process was obtained as:

$$Y = -415.8 + 18.4x_1 + 5.5x_2 \qquad (2)$$

IV. DISCUSSIONS

Table 1, shows the results obtained from the experiment. It can be deduced that Plot A [soil sample treated with groundnut] showed a much higher rate of remediation than Plot B [control]. By week 3, the plant was seen sprouting in the crude oil polluted soil. Very slow rate of remediation was noticed in weeks 5 and 6 as well as 7 and 8. This could be attributed to the fight of the young shoot to overcome the crude in the soil which could be initially hindering other nutrients intake. After this, the groundnut plant further develops by taking up the crude as part of its mineral especially when the leaves are formed.The regression model for obtained can be used in the prediction and remediation of crude oil pollution in soil using groundnut as a remediating plant.

V. CONCLUSION

Groundnut, a leguminous crop can be used to remediate a sandy-clay soil polluted with crude oil.Groundnut was found to remediate better than natural attenuation process. The total hydrocarbon content was reduced to 22.9% of the initial content by ground nut plants.The developed mathematical model is useful for use in any environment and can be adapted for clean-up of soils polluted by exploitation of crude deposits.It is recommended that further research be done in the direction of determining the form of phytoremediation.

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