PHYTOREMEDIATION OF CRUDE OIL CONTAMINATED SOIL USING VETIVER GRASS (Chrypsopogon zizanioides).

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Abstract

Environmental pollution is generally caused by two main factors that include high rate of industrialization and rapid increase in population thereby putting more pressure on natural resources such as petroleum. As a result the petroleum industry affects the environment through oil spills causing many negative effects on human health and the surrounding ecosystem due to presence of toxic compounds in crude oil such as the Polycyclic Aromatic Hydrocarbons (PAHs) that is potentially carcinogenic to humans. The aim of this research is to investigate the efficiency of Chrypsopogon zizanioides also known as vetiver grass with the aid of bio surfactants and N.P.K. fertilizer in dissipating and containing organic pollutants in the soil. It is specifically focused on the 16 Polycyclic Aromatic Hydrocarbons (PAHs) classified by United States Environmental Protection Agency (US EPA) as priority pollutants. The general methodology involved a glasshouse experiment by growing the plant C. zizanioides in a freshly spiked oil contaminated soil and a weathered hydrocarbon contaminated soil from where the soil samples were treated with ramphnolipids including (95% (Mono-Rhamnolipid dominant) and 95% (Di-Rhamnolipid dominant) produced by Pseudomonas aeruginosa and N.P.K. fertilizer to promote plant and the microbial biomass. Some of the control samples were left uncontaminated (oil free) while others were left unplanted (plant free) to investigate the growth of the plant in the absence of oil and the fate (degradation) of crude oil in the absence of the grass. Thereafter, soil samples were collected periodically on monthly basis and the concentration of PAHs was assessed in the laboratory via Gas Chromatography Mass Spectrometry (GC MS). The result of this research has already indicated an improvement in plant and microbial biomass in all the samples treated with N.P.K. fertilizer and rhamnolipids after a period of 72 days. More plant culms and heights were observed to have emerged in samples treated with N.P.K. fertilizer only followed by samples treated with N.P.K. and biosurfactants. Furthermore, there has been a reduction in the concentration of the PAHs in the crude oil contaminated soils as a result of the combined action of C. zizanioides, ramphnolipids and N.P.K. fertilizer as compared to the control samples. It also highly anticipated that C. zizanioides may help in breaking down the PAHs in the weathered hydrocarbon contaminated soil.

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Introduction

➢ Soil contamination often occur through oil spills as a result of the exploration and exploitation of oil and gas which affects human health and the surrounding ecosystem as shown graphically in figure 1. (Gupta, 2006; Kang, 2014).

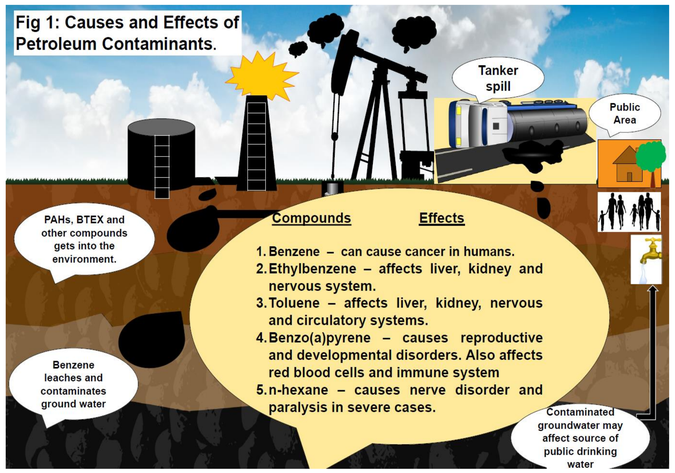

Fig 1: Causes and Effects of Petroleum Contaminants.

➢ Soil treatment through engineering and chemical methods add more harm to the environment (Batty and Dolan, 2013). As a result scientists are exploring the use of plants as a cost effective and environmentally friendly approach for cleaning the environment (Szczygłowska et al., 2011; Mench et al., 2009).

➢ Most research on phytoremediation of organic contaminants have focused on rhizodegradation (Badri et al., 2009; Maqbool et al., 2012). However, the importance of phytodegradation using a tolerant plant such as Vetiver grass is yet to be fully elucidated. Hence, the need to conduct a research using vetiver grass under the influence of N.P.K. fertilizer and biosurfactants for a cost effective, environmentally friendly and sustainable approach for cleaning crude oil contaminants in the soil.

Motivation : To create a cost effective, environmentally friendly, and sustainable approach for restoring the environment.

General Aim : To determine the tolerance and efficiency of **Vetiver grass** in treating crude oil contaminants in the soil particularly the Polycyclic Aromatic Hydrocarbons (PAHs) that are capable of causing cancer and effects in humans.

Method

➢ The experiment was conducted in a glasshouse by growing vetiver grass in a freshly spiked crude oil contaminated soil under the influence of bio-surfactants and N.P.K. fertilizer as graphically represented in figure 2.

➢ Some of the control samples were left uncontaminated while others were left unplanted.

➢ The bio distribution of oil was analyzed with GC MS to determine the level of degradation of polycyclic aromatic hydrocarbons in the contaminated soil.

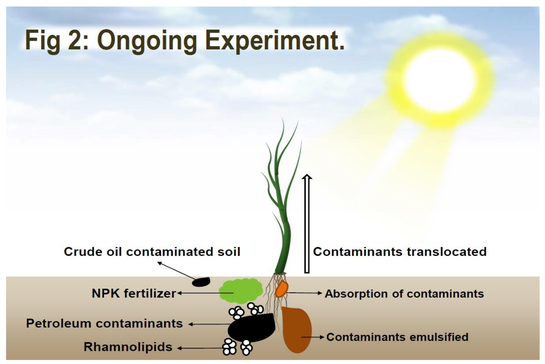

Fig 2: Ongoing Experiment.

Ongoing work

The ongoing work involved growing vetiver grass in a weathered crude oil contaminated soil under the influence of N.P.K. fertilizer and biosurfactants to determine the efficiency of the plant in treating the weathered soil. It particularly focuses on the US EPA 16 PAHs that have been classified as priority pollutants.

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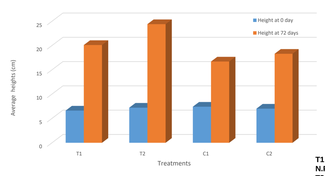
Preliminary Results

1. Plant biomass

The result has indicated improvement in plant biomass after a period of 72 days with more plant culms and heights emerging in samples treated with N.P.K. fertilizer only as shown in figure 3A followed by samples treated with N.P.K. and biosurfactants as shown in figure 3B. The three elements in the fertilizer including nitrogen, phosphorus and potassium (N.P.K.) are generally essential for promoting plant growth (Priyadarshani et al., 2013; Kumar and Nikhil, 2016).

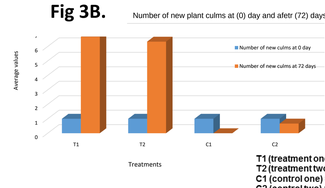
Fig 3A. Length of vetiver grass at (0) day against (72) days



T1 mean value = 20.1, SD ± 0.72
T2 mean value = 24.4, SD ± 2.51
C1 mean value = 16.7, SD ± 1.99
C2 mean value = 18.2, SD ± 1.40

T1 (treatment one) = soil + oil +vetiver + biosurfactants + N.P.K.
T2 (treatment two) = soil + oil + vetiver + N.P.K.

Fig 3B. Number of new plant culms at (0) day and afetr (72) days



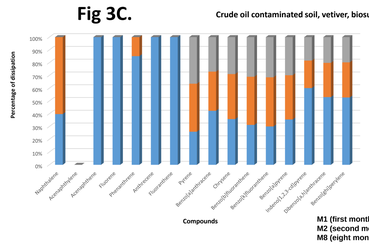
T1 mean value = 6.66, SD ± 0.81
T2 mean value = 6.33, SD ± 2.98
C1 mean value = 0, SD ± 0
C2 mean value = 0.66, SD ± 0.57

T1 (treatment one) = soil + oil +vetiver + biosurfactants+ N.P.K.
T2 (treatment two) = soil + oil + vetiver + N.P.K.
C1 (control one) = soil + oil + vetiver.
C2 (control two) = soil + oil.

2. GC MSC Analysis

The results from GC MS analysis has indicated reductions in the concentrations of PAHs in the crude oil contaminated soil where much of the reduction occurred in samples treated with N.P.K. fertilizer and biosurfactants as shown in figure C. This is followed by the samples treated with N.P.K. fertilizer only as shown in figure D as compared with the samples containing crude oil and crude oil and vetiver grass only as shown in figures E and F below.

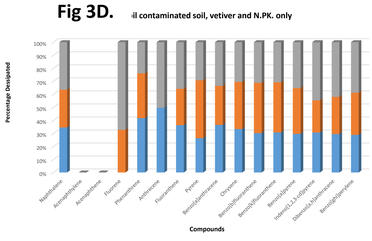
Fig 3C. Crude oil contaminated soil, vetiver, biosurfactants and N.P.K



M1 mean value = 42.83, SD ± 22.31
M2 mean value = 32.69, SD ± 8.67
M8 mean value = 27.69, SD ± 14.08

M1 (first month) = soil+oil+vetiver+biosurfactant+N.P.K.
M2 (second month)=soil+oil+vetiver+biosurfactant+N.P.K.
M8 (eight month) = soil+oil+vetiver+biosurfactant+N.P.K.

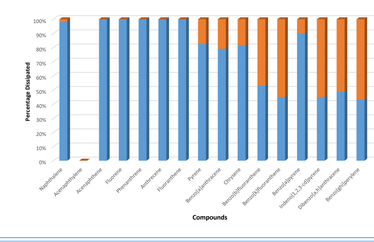
Fig 3D. il contaminated soil, vetiver and N.PK. only



M1 mean value = 32.28, SD ± 5.22
M2 mean value = 33.26, SD ± 9.23
M8 mean value = 30.49, SD ± 11.89

M1 (first month) = soil + oil only.
M2 (second month) = soil + oil only.
M8 (eight month) = soil + oil only.

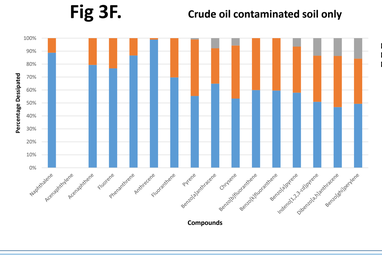
Fig 3E. Crude oil contaminated and vetiver only



M1 mean value = 32.28, SD ± 167.32
M8 mean value = 7.80, SD ± 8.65

M1 (first month) = soil + vetiver only.
M8 (eight month) = soil + vetiver only.

Fig 3F. Crude oil contaminated soil only



M1 mean value = 20.1, SD ± 0.72
M2 mean value = 2481.18, SD ± 72.39
M8 mean value = 16.10, SD ± 0

M1 (first month) = soil + oil only.
M2 (second month) = soil + oil only.
M8 (eight month) = soil + oil only.

Experimental outcome

The results of this study has demonstrated the plant growth promoting potentials of N.P.K. fertilizer and biosurfactants on vetiver grass during phytoremediation after a period of 72days. Most of the samples treated with the N.P.K. fertilizer (T2) and acombination of N.P.K. fertilizer and biosurfactants (T1) have performed efficiently in promoting the growth of vetiver grass by producing more plant culms and heights. Whereas the control samples with no additives (C2) or oil only (C1) have performed poorly.

It has also demonstrated the potentials of using N.P.K fertilizer and biosurfactants to enhance the uptake and dissipation of organic contaminants in the soil.