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Determination of Total Petroleum Hydrocarbon (TPH) and some Cations (Na^+, Ca^+ and Mg^{2+}) in a Crude Oil Polluted Soil and possible Phytoremediation by *Cynodon dactylon L* (Bermuda grass)

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Abstract

Determination of total petroleum hydrocarbon (TPH) and some cations (Na^+, Ca^{2+} and Mg^{2+}) in a crude oil polluted soil and possible phytoremediation by *Cynodon dactylon L.* (Bermuda grass) was studied. The soil samples (A, B, C and D), each weighing 5kg were collected. Samples B, C and D were polluted with crude oil at different concentration (B: 30ml/kg, C: 50ml/kg and D: 100ml/kg). Sample A was unpolluted. Total petroleum hydrocarbon and some cations were determined after seven days of pollution and after two months of phytoremediation by *Cynodon dactylon L.* and the results were compared. The result showed that mean TPH concentration decreased after remediation. Mean TPH concentration in the soil samples before remediation were (477.0mg/kg, 887.4mg/kg, 1156.17mg/kg and 2105.0mg/kg), while values after remediation were (67.7mg/kg, 383.6mg/kg, 357.6mg/kg and 291.0mg/kg) with percentage decrease of 85.8, 56.7, 66.8 and 86.2 in A,B,C and D respectively. The result showed that *cynodon dactylon L.* has the ability to clean-up crude oil polluted soil. Analysis of the plant stems for TPH concentration between the unpolluted sample A. and the most polluted sample D., showed that sample D. has mean TPH concentration of 785.19mg/kg and A. 82.58mg/kg, with percentage increase of 89.4. This significant increase ($p>0.05$) in TPH concentration after remediation in sample D. than A., clearly indicates that *cynodon dactylon L.* is responsible for the decrease in TPH concentration after remediation. The result of cation analysis after pollution showed that Mg^{2+} and Ca^{2+} had no significant difference in the soil samples irrespective of the level of pollution ($p<0.05$). Na^+ concentration increases with increase in the level of pollution.

Key words: Total petroleum hydrocarbon, Phytoremediation

1. Introduction

Oil spillage as a result of petroleum industry activities and pipe-line vandalization is a frequent occurrence in oil producing region of the world. Conventional oil spill clean-up technique involve physical and chemical process that do more damage to the aquatic ecosystem than the oil spill itself. Consequently, the need arises to evolve or develop a more environment-friendly technique that will not only clean-up the environment but also restore the aquatic ecosystem to its status before the spill. Phytoremediation is the use of plants to detoxify, transform and extract pollutants from its site to a form that is less harmful or harmless (Frick *et al,* 1999).

The principle of phytoremediation is based on certain plant natural ability to bioaccumulate, degrade, or render contaminants harmless in soils, water or air. Contaminants such as crude oil and its derivative have been mitigated in phytoremediation projects. Plants such as mustard plant, alpine pennycress and pigweed have proven to be successful at hyperaccumulation of crude oil and its derivatives in soil (Mendez and Maier, 2008).

Phytoremediation of polluted soil involves: uptake of crude oil from soil or water, accumulation or processing of these chemicals via lignifications, volatilization, metabolization, mineralization and the use of enzymes to break down complex organic molecules into simpler molecules (ultimately carbon dioxide and water) and increases the carbon and oxygen content of soil around the roots, which promote microbial/fungal activity and decay of root tissues (Hong *et al,* 2001).

*Cyndon dactylon L.*also known as Bermuda grass is a grass native to North and East Africa, Asia and Australia and Southern Europe. The name is derived from its abundance as an invasive species on Bermuda (Walker *et al,* 2001). It creeps along the ground and root wherever a node touches the ground, forming a dense mat. *Cynodon dactylon*

*L.*reproduces through seeds, runners and rhizomes. Growth begins at temperature above 15^oC with optimum growth between 24 to 37^OC. In winter; the grass becomes dormant and turns brown. Growth is promoted by full sun and retard by full shade (Kaffka, 2009).

2. Materials and Method

Soil,, Crude oil and Runners and Rhizomers of *Cynodon dactylon L.*

2.1. Sample Collection

Loam soil was collected from State Primary School, Choba, Obio/Akpor Local Government Area of Rivers State Nigeria.
Crude oil was obtained from GE oil and Gas, Onne oil and gas free zone, Onne Port, Rivers State, Nigeria.
Runners and Rhizomers of *Cynodon dactylon* was collected from State Primary School, Choba, OBio/Akpor Local Government Area of Rivers State.

2.2. Analysis

2 grams of soil samples were weighed into a clean extraction container. 10mls of extraction solvent (pentane) added into the sample and mixed thoroughly and allowed to settle. The mixture was carefully filtered into a clean solvent rinsed extraction bottle, using filter paper. The extract was concentrated to 2ml and then transferred for clean up / separation.

2.3 Clean Up/ Separation

1cm of moderately packed glass wool was placed at the bottom of 10mm 10 x 250mm loup chromatographic column. Slurry of 2g activated silica gel in 10mls methylene chloride prepared and placed in the chromatographic column. To the top of the column was added 0.5cm of sodium sulphate. The column was rinsed with additional 10mls of methylene chloride. The column was pre-eluted with 20mls of pentane which flowed through the column.
Concentrated aliphatic fraction was transferred into a bottle for G.C analysis API. (1994).

2.4 Metal Analysis

For each of the metals, AAS is calibrated using standard solution of the metal.
5grams of soil sample was digested in 20mls of hydrogen chloride on a heating mantle to near dryness. The extract was aspirated directly into the AAS.

3. Result/ Discussion

The use of *cynodon dactylon L.* in the remediation of crude oil polluted soil has been investigated in this research. *Cynodon dactylon L.* from this work has demonstrated its ability to clean-up crude oil polluted soil. The result of mean total petroleum hydrocarbon (TPH) concentration after remediation showed a significant decrease when compared with the mean TPH concentration before remediation.
Sample A was not polluted with crude oil. Before remediation, sample A had mean TPH concentration of 477mg/kg and 67.7mg/kg after 2months of phytoremediation by *Cynodon dactylon L.* with a percentage decrease of 85.8 after remediation. Sample B was polluted with 150ml of crude oil. Before remediation, the mean TPH concentration of sample B was 887.4mg/kg and 383.6mg/kg after two months of phytoremediation, with a percentage decrease of 56.7. Sample C was polluted with 250ml of crude oil before remediation; sample C had mean TPH concentration of 1156.17mg/kg and 357.6mg/kg after two month of phytoremediation by *cynodon dactylon L.* with a percentage decrease of 66.8. Sample D. was polluted with 500ml of crude oil. Before remediation, it had mean TPH concentration of 2105.00mg/kg and 291.03mg/kg after two months of remediation by *cynodon dactylon L.* with a percentage decrease of 86.2. The mean TPH concentrations of these samples are illustrated in fig. 1 with bar chart. The first bar in each sample illustrates the mean TPH concentration before remediation, the second bar illustrates the mean TPH concentration after remediation and the third bar shows the percentage decrease after 2months of phytoremediation by *Cynodon dactylon L.* (Bermuda grass).

Fig. 2 shows a bar chart illustrating the mean concentration of some cations (Na^+, Ca^{2+} and Mg^{2+}). The result showed that there is no significant difference in the concentration of Mg^{2+} and Ca^{2+} in the soil samples irrespectively of the level of pollution ($P<0.05$). Na^+ concentration increased with increase in the level of pollution.
Fig. 3 is a graph that illustrates the mean hydrocarbon concentration of Plants from the unpolluted sample A. and most polluted sample D. The graph showed that the concentration of hydrocarbon fraction in sample D were higher than that in A. The result showed that mean total petroleum (TPH) concentration of the plant from unpolluted sample A were 82.53gm/kg and 785.1mg/kg in the plant from most polluted sample D, with percentage increase of 89.4.

Fig 1. Bar Chart Illustrating The Mean Total Petroleum Hydrocarbon Concentration Before And After Remediation, And The Percentage Decrease After Remediation.

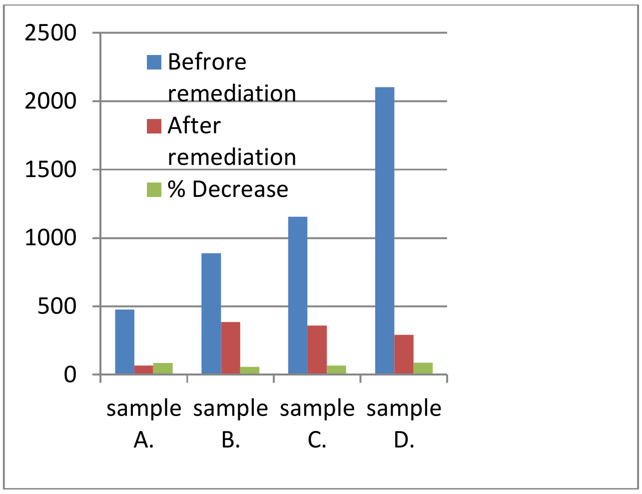


Fig 2. Bar Chart Illustrating The Mean Total Concentration Of The Cations

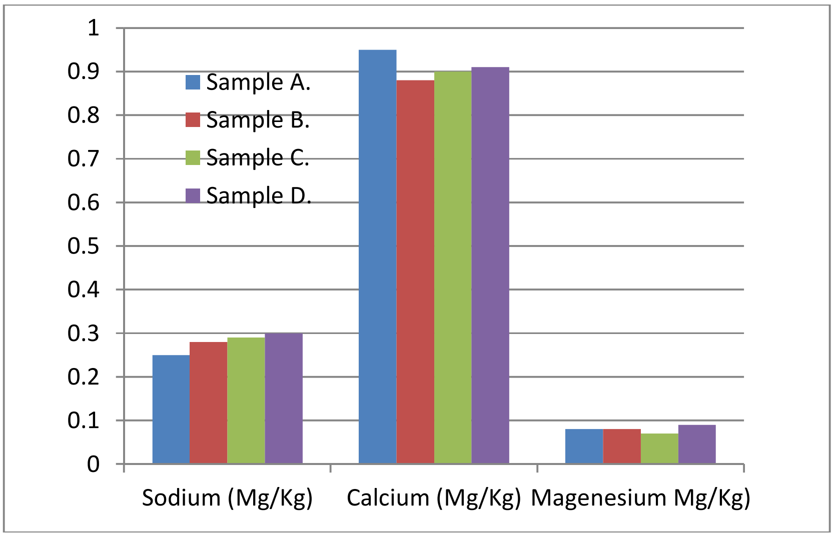
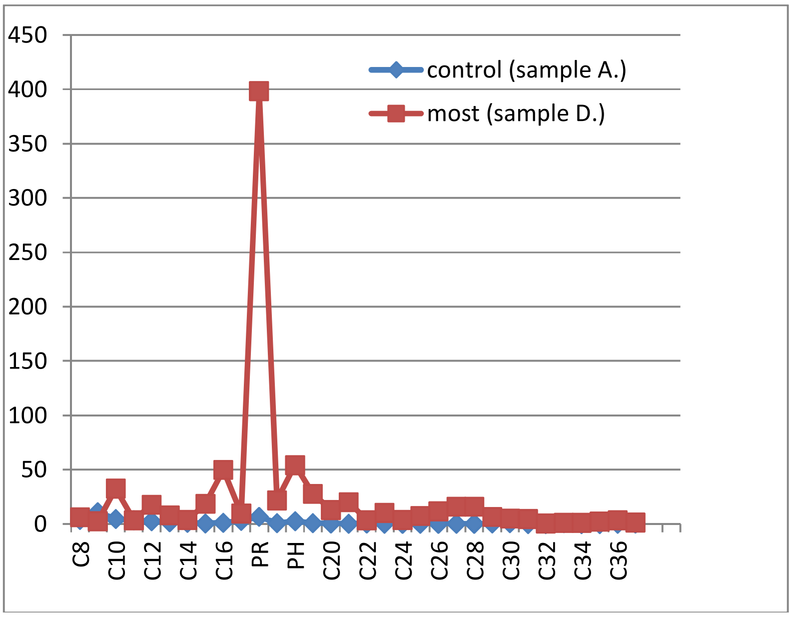


Fig 3. Graph Illustrating The Concentrations Of Hydrocarbon Fraction In The Plant From Sample A. (Control) And Most Polluted Sample (D.)



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