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Comparative study of bioremediation of crude oil spillage using *Cissus populnea* stem and root as bio-sorbents

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Abstract

The total petroleum hydrocarbon concentration decrease at the initial and final bioremediation across different variable and the comparative effect of roots and stem of C*isuss populnea* biosorbent were studied. 25 g of soil was weighed into different plate, contaminated with about 10 ml of crude oil, the plate was labeled as BI, CI DI, BF, CF and DF (stem), (root) across 3 g, 6 g, and 9 g variables and A (soil and crude oil mixture) as control for initial and final bioremediation. 1 g of each contaminated soil sample was extracted using mechanical shaker at room temperature and the extracts were analyzed using GC/MS the results showed that the initial treatment of stem biosorbent were 358.47455 ppm, 248.02045 ppm, 249.97273 ppm respectively and the final treatment after 4 weeks of biodegradation were 173.40636 ppm, 70.44364 ppm, 45.60818 ppm and control 757.39864 ppm. The total effect removal of Total petroleum hydrocarbon obtained were 51.6%, 75.2% and 81.8%, while the initial treatment of the root biosorbent were 366.72762 ppm, 347.75909 ppm, 337.04227ppm, after 4 weeks of biodegradation, the Total petroleum hydrocarbon concentration decreases to 143.6982 ppm, 60.05455 ppm, 52.21045 ppm and control 757.39864 ppm and the effect removal were 60.8%, 82.7% and 84.5%.

Keywords: Bioremediation; Crude oil; *Cissus populnea*; Stem; Root

1 Introduction

Crude oil is a naturally occurring liquid with a multifaceted mixture of organic fragments, mostly hydrocarbon with different physicochemical characteristics (Agunobi *et al.,* 2014).

Oil exploitation has increased the rate of environmental dilapidation and has caused food insecurity as a result of death of aquatic animals and crops as well as loss of farm lands and sustainable rivers for fishing activities leading to loss of occupation. There is no doubt that the disastrous effect of oil spill affects agricultural productivity and fishing to be specific, which in the long-run has an adverse effect on the economic life of the inhabitants of this region Paul (2015).

Furthermore, studying the prospects and challenges of environmental impact of oil exploration in the Niger Delta region of Nigeria and the remediation of contaminated lands in the region, argues that resolving the technical dilemma of the clean-up mechanism and identifying social impediments will be the key success driver of the United Nations Environmental Program action plan, which was recently adopted by the government of Nigeria for the clean-up of the Niger Delta. The study further endorses that bioremediation should be adopted considering its low greenhouse effect and the reduced cost burden on the weak and overstretched economy of Nigeria (Osuagwu and Olaifa, 2018). Bioremediation is a process of using living organism to remedy environment problems such as impacted soil and water, some micro-organism in the soil and water naturally feed on some hazardous substances' certain chemicals, that are harmful to people and the environment. Plants source can be used to clean up soil and water environment as presented

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by Choron (2010). However, the exploration and exploitation activities of crude oil comes with diverse negative effects on the environment and indigenous people leaving in the areas of the crude oil activities, such as those in the Niger Delta region. One of these notable and severe effects is the oil spillage (Chebbi, 2001 and 2000).

The spilling of crude oil could be on water or land subject to the location of the source. When crude oil spillage occurred on water environment, it leads to the formation of oil layer which then spreads round the surface of the water from the point source under the impact of several factors such as wind, current or gravity (Owonaro *et al.,* (2019). Various causes of oil spills have been acknowledged which are traceable to the advances and search for development through industrialization, consequential to continuous exploration and exploitation of crude oil (Dimitrakis *et al.,* 2011). The prominent causes of oil spill on water bodies are outlined such as: subsea pipelines leak caused by corrosion or equipment failure e.g. (flange leaks), subsea blowouts due to drilling operations, industrial waste water discharges, oil spill caused by the accidental collision of oil tankers and indiscriminate dumping of ballast water from ships.

2 Material and methods

2.1 Plant Sampling and Sample Preparation

Cissus populnea plants obtain from Michika Local Government Area of Adamawa State; Nigeria was used in this study. The stem, and root of matured plants of *Cissus populnea* grown in highland Michika was collected. The crude oil was collected from NNPC, Jimeta yola and the soil sample was collected from the premises of faculty of agriculture Moddibo Adama University yola. The plant samples collected was freed from twigs and extraneous matter by sifting the Soil, grit, sand and dirt were removed. The sample was rapidly and thoroughly washed under tap water, rinsed with distilled water and then air dried at room temperature for 15 days. The samples (stem and roots) was grounded with an industrial blender (LO 4.0 Visa) and sieved to obtained a powder with known particle size (0.25 mm). After preparation, the material was placed in sealed plastic vials to be used as biosorbent**.**

2.2 Study of the total petroleum hydrocarbon concentration decrease at the initial and final bioremediation across different variable.

2.2.1 Soil preparation

Approximately 25 g of soil was weighed into different plate, contaminated with about 10 ml of crude oil, the plate was labeled as BI, CI DI, BF, CF and DF (stem), (root) across 3 g, 6 g, and 9 g variables and A (soil and crude oil mixture) as control for initial and final bioremediation. The soil pH and humidity was adjusted to 6.5-8.5 while calcium hydroxide solution was applied to maintain a favorable condition for biodegradation and samples were allowed to experience degradation for four weeks before extraction (Adams *et al.,* 2017).

2.2.2 Extraction using mechanical shaking method

A 1 g of each contaminated soil sample was placed in conical flask and mixed with 10 ml of n hexane and covered with Aluminum foil paper to prevent loss of solvent. The mixture was shaken for 30 min with mechanical shaker at room temperature and then filtered using filter paper. The final volume of the extracts was taken and stored in clean small bottles. The extracts were analyzed using GC/MS Agilent Technologies 7890A (Oludele et al., 2021).

3 Results and discussion

3.1 Total petroleum hydrocarbon concentration decreases at the initial and final bioremediation of 3 g, 6 g, and 9 g of stem and root biosorbent.

In this study, we consider and compared the total petroleum hydrocarbon (TPH) decrease in concentration for initial remediation (Fig 1 and 2) and final remediation (Fig 3 and 4). After adding the biosorbents of *Cissus populnea* plant for stem-back and root on the stimulated processed contaminated soil at different variables of 3 g, 6 g, 9 g and control (A) respectively.

A control BI 3 g stem CI 6 g stem DI 9 g stem

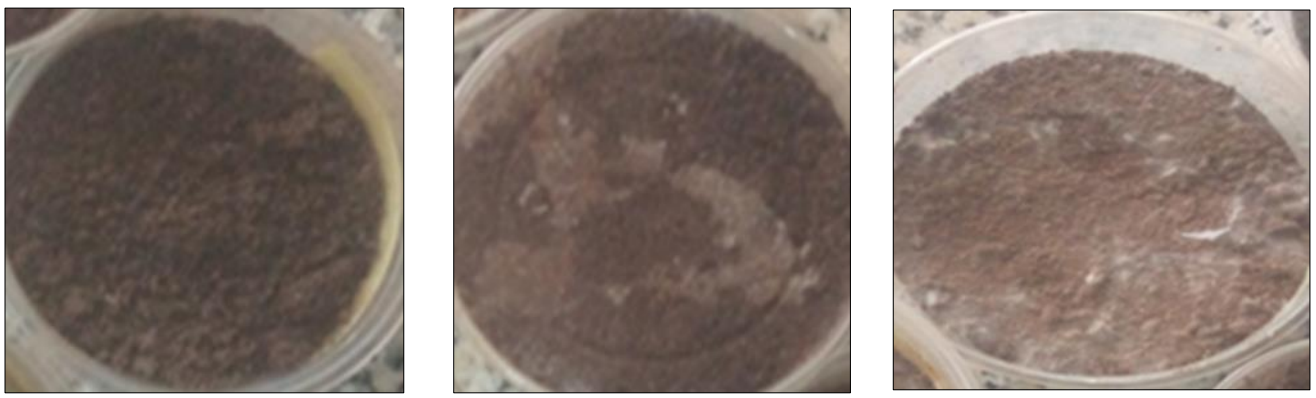
Figure 1 Contaminated Soil without sorbent (A), and Contaminated Soil with Sorbents (BI, CI, DI; 3, 6, 9 g) for Initial Bioremediation

Control A BI 3 g root CI 6 g root DI 9 g root

Figure 2 Contaminated Soil without sorbent (A), and Contaminated Soil with Sorbents (BI, CI, DI; 3, 6, 9 g) for Initial Bioremediation

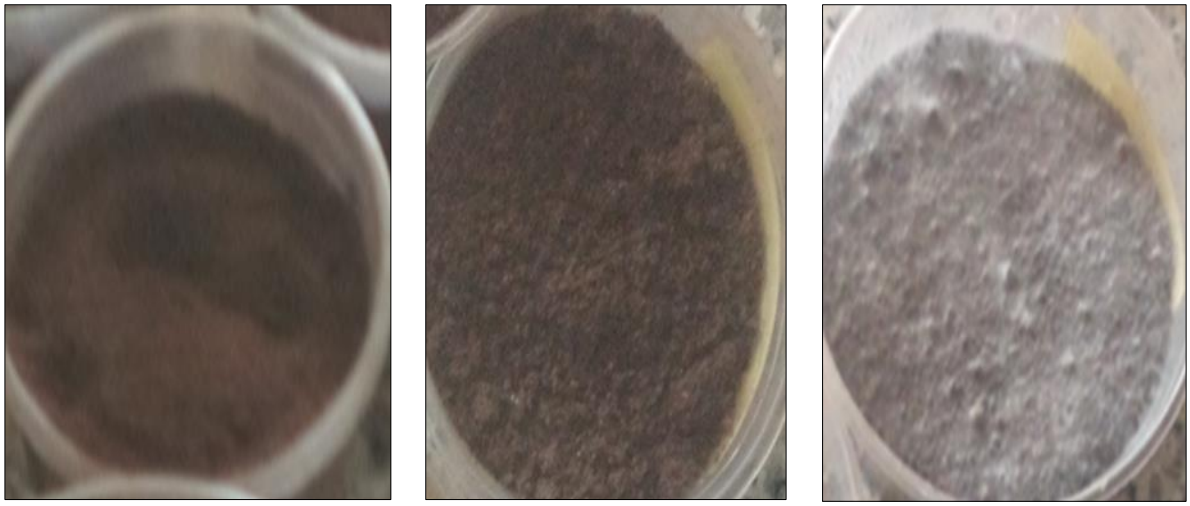
3.2 *Cisuss populnea* Stem biosorbents Treatments.

In figure 1, the initial treatment of stem biosorbent (3, 6 and 9 g) were 358.47455 ppm, 248.02045 ppm, 249.97273 ppm and control 757.39864 ppm respectively. while final treatment after 4 weeks of biodegradation (Fig 3). The Total petroleum hydrocarbon (TPH) concentration decreases observed were 173.40636 ppm, 70.44364 ppm, 45.60818 ppm and control 757.39864 ppm. The stem-back effect total removal of Total petroleum hydrocarbon obtained were 51.6%, 75.2% and 81.8%



BF 3 g Stem CF 6 g Stem DF 9 g Stem

Figure 3 Contaminated Soil with Sorbents of BF, CF, DF for final Bioremediation.



BF 3 g root CF 6 g root DF 9 g root

Figure 4 Contaminated Soil with Sorbents of DF for final Bioremediation

3.3 *Cisuss populnea* Root biosorbents Treatments.

While in figure 2 The Total petroleum hydrocarbon concentration at the initial treatment were 366.72762 ppm, 347.75909 ppm, 337.04227ppm and control 757.39864 ppm at 3 g, 6 g and 9 g of Root biosorbent respectively. After 4 weeks of biodegradation, the Total petroleum hydrocarbon concentration decreases to 143.6982 ppm, 60.05455 ppm, 52.21045 ppm and control 757.39864 ppm (Fig 4) and the Total effect removal were 60.8%, 82.7% and 84.5%.

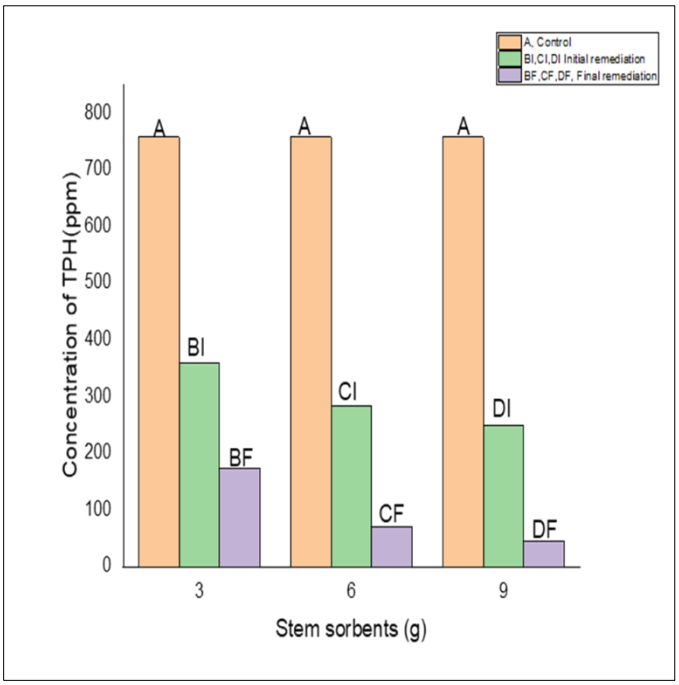


Figure 5 Effect of removal of crude oil from contaminated soil by stem sorbent on plate for initial and final remediation at 36 ℃ for 4 weeks

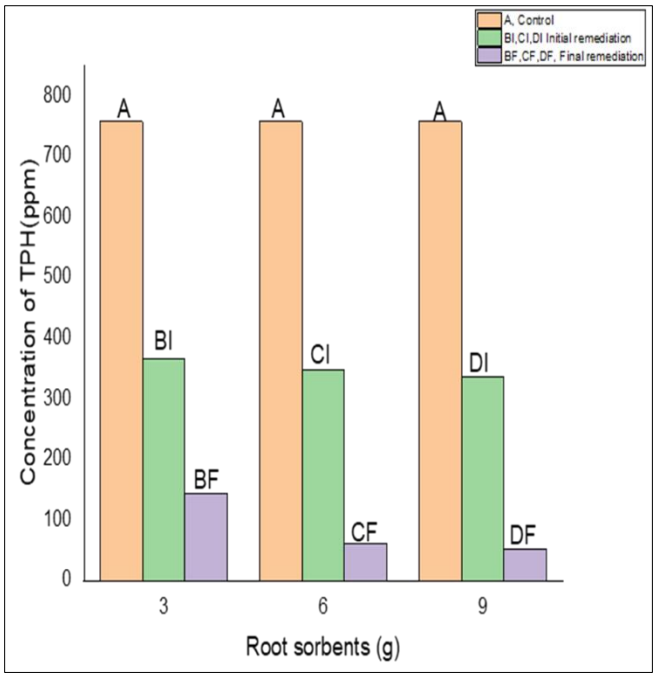


Figure 6 Effect of removal of crude oil from contaminated soil by root sorbent on plate for initial and final remediation at 36 ℃ for 4 weeks

This results shows that the *Cissus populnea* biosorbents stem and root demonstrate capacity to decreases total petroleum hydrocarbon concentration(TPH) in contaminated soil and the higher the grams of the sorbents the lower the concentration of Total petroleum hydrocarbon decreases but comparatively the root biosorbent shows higher removal capacity with slide difference in concentrations with the stem biosorbent, perhaps this could be due to their surface area, porosity and the extent of biodegradation process.

4 Conclusion

In these research work of bioremediation of crude oil spillage using *Cisuss populnea* stem and root as biosorbent for remediation of crude oil spillage in contaminated soil.

The stem and root biosorbent have all demonstrated capacity to decrease total petroleum hydrocarbon (TPH) concentration in contaminated soil both at the initial and final remediation after four weeks of biodegradation. The use of root biosorbent was shown to be more effective in removing crude oil compared to stem biosorbent. However, long-term biodegradation with increase in biosorbent need to be performed to ascertain 100% removal of total petroleum hydrocarbon in the contaminated soil.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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