Research Article / Review Article FUPRE JOURNAL 8(3): 40-46 (2024)

FUPRE Journal

of

Scientific and Industrial Research

ISSN: 2579-1184(Print) ISSN: 2578-1129 (Online)

http://fupre.edu.ng/journal

Wood Ash Assisted Maize Plant Reduction of Total Petroleum Hydrocarbon on Weathered Crude Oil Polluted Soil

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ARTICLE INFO

Received: 12/12/2023
Accepted: 14/05/2024

Keywords

Maize plant, Petroleum hydrocarbon, pollution, Soil, Wood ash

ABSTRACT

The aim of this study is to examine the effect of wood ash in association with planted maize in the remediation of total petroleum hydrocarbon in weathered crude oil polluted. In the study, soils were artificially polluted with weathered crude oil (50g Kg^{-1}). Soil pollution, treatment, incubation and analysis were done using standard laboratory protocol. The wood ash used for soil treatment is alkaline with pH of 10.2, the ash also contained remarkable quantity of essential nutrients. There was a reduction in the level of pH and nutrients at the end of the incubation period. The sample treated with ash in association with planted maize recorded the highest reduction. There is also a decline in total petroleum hydrocarbon soil after the remediation period in the entire samples, ash and maize plant combination gave the highest reduction at the end of the remediation period. Therefore; this research has shown that wood ash assisted maize plants in synergistic relationship enhanced the reduction of total petroleum hydrocarbon in soil than singly ash and maize plants strategies.

1. INTRODUCTION

Crude oil contains three major components, these are parafins, napthenes and polycyclic aromatic hydrocarbon, the main environmental challenge of crude oil exploration, refining and transportation is the contamination of the environment (Emegbetere et al., 2014., Oghoje et al., 2023., Ugbune et al., 2023a., Edo et al., 2024). Contamination of soil with crude oil is major problem through the globe, contaminated soil by petroleum hydrocarbon constitute health hazard to man and crops (Daâssi & Qabil Almaghribi, 2022), it reduces the agricultural productivity of soil. The poisonous problem of petroleum hydrocarbon to human, microorganisms, plants and animals have been documented by several researcher (Haider et al., 2021). Over the years different strategies for the removal or decontaminated petroleum hydrocarbon from soils have been developed. One of the strategies is chemical oxidation, the efficient of this strategy hinges on soil matrix. A combination of hydrogen peroxide and ferric ion is applied to soil. Hydrogen peroxide is strong oxidants that produced hydroxyl ions during the

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reaction of Fentons while ferric ion served as catalyst. Hydroxyl ions are capable of destroying contaminants available in soil (Zhang et al., 2022). Several researcher have demonstrated that removal of crude oil from soil at lower pH by applying Fenton's reagents have shown to be very effective (Akpoveta et al., 2018). Another method of petroleum hydrocarbon removal from soil is the physical removal of soils, this done by physical method of soil washing with organic solvents. Thermal method is another methods of petroleum hydrocarbon removal, in thermal method contaminated soil is heated to temperature between 200 to 1000°F to raise the vaporization and separation of soil contaminants with low boiling point (Falciglia et al., 2020). In recent times the use of plant (phytoremediation) for the removal petroleum hydrocarbon from soil has gained popularity. Phytoremediation is an efficient, solar driven method for the removal of contaminates from the soil of large contaminated farm land.

Microorganisms is also capable to degrade hydrocarbons and use them as carbon and food (energy) for growth and survival (Hossain et al., 2022). This strategy which is known as bioremediation can be applied to degrade soil that is polluted with petroleum hydrocarbon, this strategy reduced petroleum hydrocarbon into poisonous forms. It uses bacterial or fungi to degrade pollutants that is poisonous to the environment (Kebede et al., 2021). The bacterial or fungi may be indigenous to polluted area or isolated from another location and brought to contaminated soil (Tatarin et al., 2024). The aim of bioremediation is the deployment of microbes, animals and, animals to reduce the potential toxicity of hydrocarbon pollutant in soil or water by degrading, changing and immobilizing these unwanted substances (Anekwe & Isa, 2023). The products of petroleum hydrocarbon are carbon dioxide, water and poisonous inorganic salts and cell biomass (Samuel et al., 2023). The product of incomplete biodegradation are compounds that simple (simpler aromatic ring removal of halogens) but physico-chemical properties different the parent hydrocarbon (Ogheneoruese et al., 2022). In addition ozone which is a chemical method is also used in the removal of petroleum hydrocarbon from soil, removal of petroleum from soil by ozone is an in situ treatment (Edo, 2023).The remediation methods of contaminated soil have their own disadvantage, physical method is time consuming and very costly, thermal method is not eco-friendly as low molecular weight could cause air pollution and inflammability, chemical methods may pose environmental threat to nearby soil and living organisms due to side reaction (Edo, Samuel, et al., 2024). Bioremediation and phytoremediation is eco-friendly but time consuming. Therefore, there need to seek for combinations of methods that will be faster and green in the remediation of crude oil polluted soil. The study is aim in using wood ash in association with maize plants in the remediation of weathered crude oil polluted soil.

2. MATERIALS AND METHODS

The uncontaminated soil use for this study was obtained from agricultural land in Mosogar, Delta state (5.8790° N, 5.7334° E). The soil was dried under normal atmospheric condition. The dried soil was filtered using 2mm sieve before contamination with weathered crude oil and analysis. The ash used for the soil treatment was collected from local kitchen.

2.1 Weathered crude oil polluted soils and ash treatment

The soil was artificially polluted with weathered crude (50g kg^{-1}). The polluted soil sample were allowed on an attenuation of14 days for stabilization period before the application of ash. A 50% water holding capacity was maintained through the incubation period.

After 14 days treatments period, 100g of ash was applied to soil. The treated soil were agitated thoroughly, deionized water was then added and maintained at 50% water holding capacity and incubated in a greenhouse for 20 days.

2.2 Determination of Physico-chemical Properties of Soil and Total Petroleum Hydrocarbon (TPH)

Soil texture was analyzed using hydrometer procedure R. Determination of pH was done following Black method (Bahadori & Tofighi, 2016). (Wieczorek et al., 2022) procedure was used for phosphorus analyses. Potassium and magnesium was determine using absorption atomic spectroscopic (AAS). Concentration of total petroleum hydrocarbon (TPH) was analyze using Gas Chromatography/ flame ionization detector (Simeon, 2020).

2.3 Quality control and data processing

Analytical grade reagents were used for sample extraction and analysis. Standard methods were employed in soil pollution and treatment this is to ensure reliable results for the research. Mean of triplicate data were done and data presentation were carried using relevant tables and statistical bar charts.

3. RESULT AND DISCUSSION

The result of soil texture of unpolluted soil indicate that the soil is sandy-loam, it composed of 74 .20 sand, 2.41 silt and 23.39 clay. Sandy-loam is a typical soil for agricultural activities in Nigeria (Akinde et al., 2020). The pH of the soil is 5.81, the nutrients level of soil revealed 1.04 phosphorus, 1.02 nitrogen, 0.99 sodium, 0.89 potassium, 0.88 magnesium and 0.74 mg/kg calcium.

3.1 Mean physico-chemical properties of wood ash

The physiochemical properties of wood ashes obtained from is depicted in Table 1. The pH of the ash revealed alkaline (10.50 pH).

Table 1: **Mean pH and nutrients level of wood ash**

Parameters						
pH	P(%)	N(%)	Na(mg/kg)	K(mg/kg)	Mg(mg/kg)	Ca(mg/kg
10.50	9.21	1.54	0.07	0.51	10.12	11.61

The pH of the ashes could aid the remediation of polluted soil. The ashes constitute 9.21 mg/kg phosphorus, 1.54 mg/kg of nitrogen, 0.07 mg/kg of sodium, 0.52 potassium, 10.12mg/kg of magnesium and 11.61 of calcium. The level of phosphorus, nitrogen, sodium , potassium and magnesium and calcium is an essential nutrients for microbes degrading contaminants.

Mean effects of wood ash assisted with maize plant on physiochemical properties of weathered crude oil polluted soil

The effects of wood ash assisted maize plant on physiochemical properties of weathered crude oil polluted soil is shown in Table 2. The results suggests that there is a decrease in level of pH as the concentration of crude oil content increases from 50g to 200g, this decrease could be due to acidic nature of crude oil.

Table 2: Mean level of essential nutrients on soil amended with wood ash

Period of Remediation	Parameters							
	pH	P(%)	N(%)	Na(mg/kg)	K(mg/kg)	Mg(mg/kg)	Ca(mg/kg)	
Day 10	7.1	4.2	0.6	0.4	0.3	5.11	5.61	3.4
Day 20	6.5	3.1	0.4	0.3	0.2	3.21	3.93	2.8

Table 3: Mean level of essential nutrients on soil amended with wood ash assisted maize plant

Period of Remediation	Parameters						
	pH	P(%)	N(%)	Na(mg/kg)	K(mg/kg)	Mg(mg/kg)	Ca(mg/kg)
Day 10	6.0	3.1	0.4	0.3	0.2	3.9	4.7	2.7
Day 20	6.0	2.0	0.2	0.1	0.1	1.9	3.0	2.1

The reduction of pH could also be due to the production of carbon dioxide (CO_2) during biodegradation of crude oil (Farahabadi & Lashkarbolooki, 2023). A complete degradation results in detoxification by mineralizing pollutants to CO_2, water (H_2O), non-poisonous inorganic salts, and cell biomass (Kuspanov et al., 2023). The CO_2 dissolves in soil water to form weak acid. Essential nutrients revealed a decline as the period of incubation increases. Earlier report of (Ugbune et al., 2018., Ugbune et al., 2021., Moran & Bedford, 2024) reveal that decrease in essential nutrient at low pH is as result of formation complex by nutrients. The study also revealed highest reduction in with ash assisted maize plants, follow by maize, closely follow by ash amended soil and control the least. The highest recorded in ash assisted maize plant remediation is due to utilization of hydrocarbon degrading microbes and adsorption of nutrients by maize plants. The reduction in concentration of nutrients in ash amended soil could be attributed to the usage of hydrocarbon degrading microbes which used them as food and energy during petroleum hydrocarbon soil degradation (Ugbune et al., 2023b).

Mean effects of wood ash assisted maize plant on the remediation total petroleum hydrocarbon of weathered crude oil polluted soil

The result of the effects of wood ash assisted maize plant on remediation of weathered crude oil polluted soil is given in Table 3. The results demonstrate a reduction in the level of total petroleum hydrocarbon in all the investigated samples. The lowest reduction was discovered in control soil closely followed by maize plant sample while the sample with ash and maize plant has the highest reduction.

Table 4: Mean level of total petroleum hydrocarbon on soil amended with wood ash wood and ash assisted and maize plant combination

Period of Remediation	Remediation (mg/kg)			
	control	ash	maize plant	ash+ maize plant
Day 10	5,346.45	4,123.63	4,000.10	3,894.54
Day 20	5,100.45	2,542.30	2,300.20	2,112.34

The reduction of total petroleum hydrocarbon (TPH) on ash amended soil could be due to degradation of TPH bacterial/ fungi. Increase in reduction of TPH due to the addition of nutrients to soil has been reported in several studies(Chicca, Becarelli, & Di Gregorio, 2022). The reduction with of ash assisted maize plants combination could be due to the synergistically effects of ash and maize plants. The reduction of TPH by plants (phytoremediation) has also been reported by many researchers to reduced TPH in soil (Yuan et al., 2023). The used of wood ash in combination with maize plant have proved as better strategy for the cleaning of crude oil polluted soil.

4. CONCLUSION

The wood ash used for soil treatment is alkaline with pH of 10.2, the ash also contained remarkable quantity of essential nutrients. There was a reduction in the level of pH and nutrients as the incubation period increased. The sample treated with ash in association with maize plant has the highest reduction. In the same vein, there was reduction in the concentration of total petroleum hydrocarbon as the incubation time increases. The sample treated with ash in association with planted maize recorded the highest reduction .Therefore; this research has shown that wood ash combined together with maize plants in synergistic relationship efficiently reduced total petroleum hydrocarbon polluted than singly ash and maize plants techniques.

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