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Full Length Research

Using rice husks manure and seaweed extract to optimize the phytoremediation efficiency of guinea grass (*Megathyrsus maximus*)

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ABSTRACT: Combating environmental degradation through eco-friendly procedures had become a major challenge to environmentalists. This work was done to investigate the possibility of using organic wastes to enhance the phytoremediation of contaminated environments. Virgin soil samples were contaminated with petroleum derivatives (spent motor engine oil, petrol, diesel and kerosene) in a volumetric ratio of 25%:25%:25%:25%. These contaminated soil samples were divided into 7 groups, and were amended with different concentrations and combinations of rice husk manure and seaweed extracts, before guinea grass was transplanted into them. Total petroleum hydrocarbons (TPH) of all the soil samples (virgin, polluted and remediated) were determined in accordance with approved procedures. Findings of the experimental program depicted that rice husk manure phytoremediation enhancer, but combining it with moderate quantity of seaweed extract gave a better result. The TPH concentration in the SAM 2, SAM 3 and SAM 4 soil samples at the end of the experiment declined by 52.23, 61.99 and 70.47%, respectively. While the TPH concentration in the SAM 5, SAM 6 and SAM 7 soil samples, at the end of the experiment declined by 56.91, 66.64 and 61.17%, respectively. The study revealed that extremely high organic materials concentration (as in the case of SAM 7), was detrimental to the remediation process. Findings from this work depicted that proper harnessing of rice husks, which are readily available in Nigeria, can be effectively exploited to augment the remediation of petroleum polluted sites.

Keywords: Environmental degradation, organic materials, remediation, rice husk, total petroleum hydrocarbons.

INTRODUCTION

Environmental pollution caused by total petroleum hydrocarbons (TPH), has instituted a serious threat globally, resulting from eco-toxicity caused by their strong persistent nature (Hussain *et al.,* 2019). Although the quest for green energy is increasing globally, due to environmental concerns caused by fossil fuels; the demand for crude oil is still on the high side. Nigeria accounts for about 2.8% of the total world crude oil production, having the capacity of producing approximately 2.2 million barrels of crude oil in a day (OPEC, 2022). Crude oil exploration and exploitation have a lot of negative environmental consequences and require proper monitoring (Amadi *et al.,* 2018). Niger Delta environment has suffered from age-long neglect from oil production companies, and oil criminals (Kadafa, 2012). Grifoni *et al*. (2020) reported that petroleum pollution resulted largely from oil exploration, production, transportation, indiscriminate disposal of spent petroleum derivatives, etc. Resulting from a wide range of anthropogenic activities in crude oil value chain, these

consequences are more pronounced in the developing and underdeveloped countries, driven by massive corruption and lack of monitoring/prevention equipment.

Accumulation of these toxic substances in the environment resulting from crude oil production, utilization and spills, could be hazardous to living things (Isitekhal *et al.*, 2013). It had been proven that crude oil and its derivatives had a negative impact on the ecosystems, as they cause serious alterations in the soil/water physiochemical and microbial properties (Hinojosa *et al*., 2004; Akpokodje *et al*., 2019). Udom *et al*. (2012) reported that petroleum hydrocarbons have the ability of hindering the growth and yield of some leguminous crops. When animals are persistently exposed to hydrocarbons, it can lead to severe health problems such as kidney diseases, cancer, liver failure, etc (Lloyd and Cackette, 2001). Excessive TPH concentration in the environment is detrimental to the ecological system because soil and plants tissues tend to accumulate them; thus, destructively influencing the plants' physiological (photosynthesis, nutrient absorption, etc.) activities (Zuzolo *et al.,* 2021). This makes proper remediation of the environment inevitable.

Globally, remediation of the polluted environment, using eco-friendly materials has become a major concern. This is because of the existing remediation procedures have some serious shortcomings (Okoh, 2006; Kumar and Gopal, 2015). Enhancing the phytoremediation capacity of plants through the utilization of microorganisms/nutrient stimulants, has proved successful in the remediation of organic oil contaminated soils and water (Kumar and Gopal, 2015; Amadi *et al*., 2018). Organic materials rich in nitrogen [N], phosphorus [P] and potassium [K] usually act as green-stimulant; hence enhancing the bioremediation of petroleum polluted environment (Tanee and Jude, 2017). These essential nutrients (N, P and K) aid the performance of microorganisms required for the degradation of hydrocarbons.

Although numerous investigations had been done on remediation of petroleum hydrocarbons contaminated soils, literature on the optimization of phytoremediation of organic oil spill soils through the use of rice husks and seaweed are still scanty. Therefore, the purpose of this study is the optimizing the phytoremediation potential of guinea grass (*Megathyrsus maximus*) through the application of rice husks manure and seaweed extract.

MATERIALS AND METHODS

Research location

This research was done at the research centre of the Delta State University of Science and Technology, Ozoro, Nigeria. The study covered duration of 8 months (from August 2021 to February 2022). Ozoro had two major climatic seasons (wet and dry), and the wet season is characterized by bimodal rainfall pattern (Eboibi *et al*., 2018).

Materials

Rice husks manure and seaweed extract

The rice husks manure was produced through composting under in-vessel condition for four weeks. While the seaweed extract was procured from an agro-allied shop located at Ughelli, Delta State, Nigeria.

Guinea grass

The young guinea grasses were uprooted from a fallow area with the university research centre.

Petroleum products

The kerosene, petrol, spent motor engine oil and diesel were procured from a filling station at Oleh, Delta State, Nigeria.

Stimulation of crude oil polluted soil

Topsoil was collected from a virgin spot at the research centre of the Delta State University of Science and Technology, Ozoro. The soil was air-dried, crushed, sieved with 2 mm gauged nylon sieve and poured in a perforated barrel. To this soil (inside the barrel), 5 L of spent engine oil, 5 L of kerosene, 5 L of petrol and 5 L of diesel were added, and left to stabilize for one week. This is to allow the soil to acclimatize to the new environmental condition, and the excess petroleum products to drain through the soil.

After the acclimatization period, the contaminated soil was mixed thoroughly to get a homogeneous mixture, before each pot was filled with 10 kg of the polluted soil.

Experimental setup

The pots containing the polluted soil were divided into seven lots, at the rate of three pots per lot, and amended with different therapies shown in Table 1. The amendment percentage was taken by the weight of the contaminated soil.

Phytoremediation process

Three stands of guinea grass plant were transplanted into each pot, and closely monitored for the duration of 14 weeks. The guinea grass was transplanted one week after

Table 1. Experimental arrangement.

Sample code	Amendment
SAM 1	None
SAM 2	10% RHM
SAM 3	20% RHM
SAM 4	30% RHM
SAM 5	10% RHM + 1% SW
SAM 6	20% RHM + 2% SW
SAM 7	30% RHM + 3% SW

RHM = rice husks manure; SW = Sea weed extract.

amending the polluted soil with the treatment therapies. This window period was allowed for the rice husks manure to discharge some of its nutrients in the soil, pending the planting of the guinea grass.

Throughout the experimental duration, the plants were watered when necessary just to keep the soils moist, and systemic pesticide was applied when necessary. Disease symptoms were not observed; therefore, fungicide was not used during the experimental period. All the pots were placed in an open space, where they received direct sunlight and rain water through the experimental period.

Samples collection

At the end of the experimental period, soil samples were randomly collected with the aid of a glass tube from the rhizosphere region (0 – 0.4 m depth) of the soil. Rhizosphere region of the soil is the area within which the plants roots system had the highest influence.

Determination of the soil TPH

The individual soil samples were air-dried and sieved with a 2 mm gauge nylon sieve. The dried soil samples were digested, and their TPH content was determined based on the approved procedures stated by American Petroleum Institute (API) (1994).

Statistical analysis

Microsoft Excel was used to analyze the effect of the various organic treatments on the TPH of the contaminated soil samples. The experiments were replicated three times, and the mean values were recorded.

RESULTS AND DISCUSSION

Impact of the petroleum products on the virgin soil

The impact of the petroleum products on the virgin soil TPH is displayed in Figure 1. As presented in Figure 1, the petroleum products substantial increased the virgin soil TPH concentration from 19 to 3312 mg/kg. This result is in conformity with previous reports of Bello and Anobeme (2015), which stated that petroleum derivatives can significantly increase the petroleum hydrocarbons content of soils and water bodies. TPH are very unruly organic compounds that have the ability of reducing the soils fertility, increasing the soils moisture content and minerals content, and immobilizing the hydrophobic complexes; thereby affecting the soil's geotechnical and ecological role (Devatha *et al*., 2019).

Remediation potential of the various therapies

Figure 2 shows the results of the TPH concentration of the various soil samples after the remediation. As revealed by the findings of this study, the guinea grass has good phytoremediation capacity, as it was about to downgrade the TPH concentration in the soil by 24.64% within the 14 weeks duration. This can be attributed to its good root system. This makes it to have good contact between contaminants. According to Cougnon *et al*. (2017), plants with good root system, can actively explored the contaminated soil, which will then improve the contact made with the soil nutrients, the contaminants and the degrading microorganisms. The removal of TPH from the contaminated soil by the guinea grass, as observed in this study, conforms to the previous reports of Karangwa *et a*l. (2018) that stated that guinea grass can remediate the consequences of crude oil in the soil.

Furthermore, findings obtained from the experimental program (Figure 2), depicted that combined therapy was better phytoremediation enhancer, compared to the single therapy. At the 14th week, the TPH concentration recorded in the SAM 1, SAM 2, SAM 3, SAM 4, SAM 5, SAM 6 and SAM 7 soils were 2496, 1582, 1259, 978, 1427, 1105 and 1286 mg/kg respectively. This revealed that: TPH of the control (SAM 1) declined by 24.64%, TPH of the soil amended with 10% rice husks manure declined by 52.23%, TPH of the soil amended with 20% rice husks manure declined by 61.99%, TPH of the soil amended with 30% rice husks manure declined by 70.47%, TPH of the soil amended with 10% rice husks manure and 1% seaweed extract declined by 56.91%, TPH of the soil amended with 20% rice husks manure and 2% seaweed extract declined by 66.64%, and TPH of the soil amended with 30% rice husks manure and 3% seaweed extract declined by 61.17%.

The higher hydrocarbons remediation observed in the SAM 3, SAM 4 and SAM 6 soils, might be caused by the higher nitrogen and phosphorus percentage present in the therapies, applied to the contaminated soils. Likewise, the poor remediation result obtained in SAM 7 soil, where the soil TPH concentration was higher (1286 mg/kg) than the value recorded in SAM 6 soil, can be attributed to nutrient toxicity. The excess nutrients in the SAM 7 soil can lead to

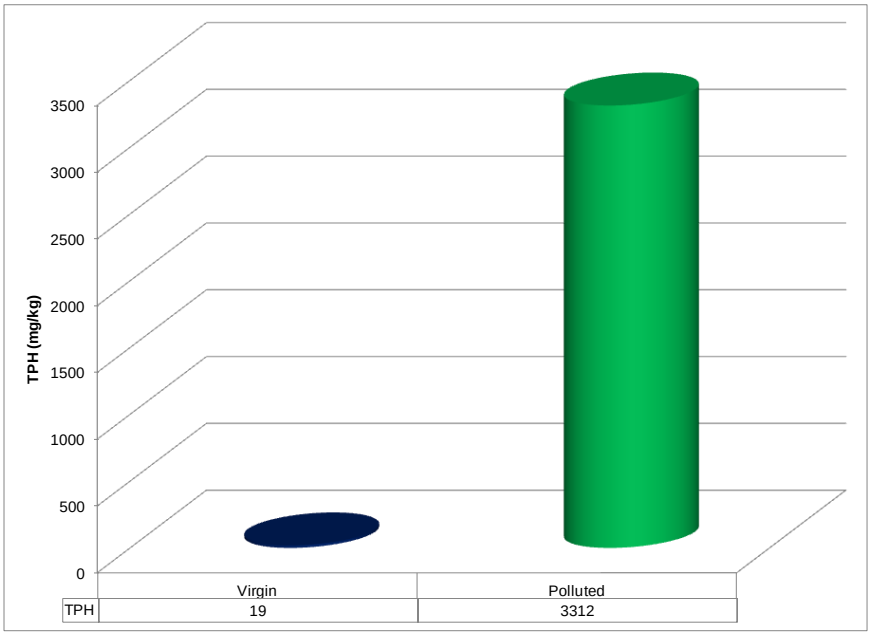

Figure 1. Effect of petroleum products on the TPH concentration of soil samples.

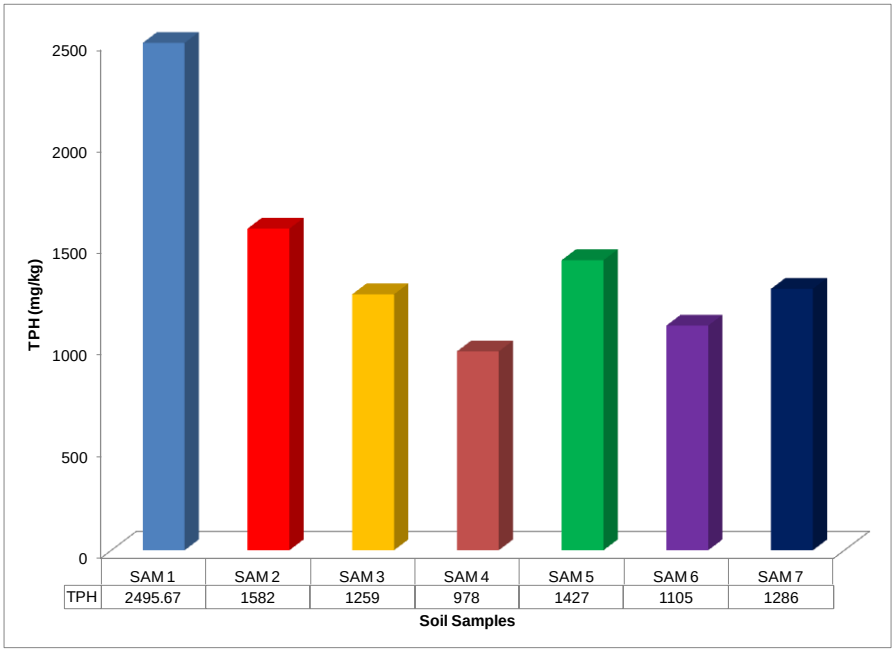

Figure 2. Effect of treatment regime on the TPH of contaminated soil sample.

the poor growth performance of the guinea grass; hence making the guinea grass lose its phytoremediation prospective. Macro-nutrients facilitate microbial growth, thus encouraging plant growth and accelerating petroleum hydrocarbons biodegradation in the soil (Ausma *et al*., 2002; Abioye *et al.,* 2012); but the presence of excess macro-nutrients become toxic to the plant and microbial bioavailability. Zuzolo *et al*. (2021) in their research reported that macro-nutrients help to facilitate amino acid production, which will later enhance the remediation of petroleum hydrocarbons polluted soils. Similarly, Amadi *et al*. (2018) reported that organic materials (e.g. cattle dung)

can enhance the phytoremediation ability of *Caesalpinia pulcherrima* L and *Imperata cylindrica* L in petroleum contaminated soils.

The findings in this study revealed that green materials (rice husks manure), which are locally available in Nigeria, can be used to optimize the remediation of petroleum polluted sites. These materials do not only boost the phytoremediation potential of plants, but also improve the bioremediation action of microorganisms. This they do by creating enabling environment both for the plants and microorganisms.

Conclusion

This work was done to examine the possibility of using organic materials, such as rice husk manure and seaweed extract to improve the remediation ability of plants. Guinea grass was planted in petroleum polluted soils treated with, rice husks manure and combination of rice husks manure and seaweed extract. At the end of the research duration (14 weeks), it was noticed that the rice rusks manure was able to improve the remediation potency of the guinea grass plant. This research finding revealed that combined therapies yielded better remediation results, compared to single therapy. Furthermore, it was observed that moderate combination of rice husk manure and seaweed extract was the best phytoremediation enhancer. High concentration of the rice husks manure and seaweed extract inhibited the remediation process. Results obtained from this study had revealed rice husks, an organic waste massively generated in Nigeria, can be converted into a useful remediation material is crude oil spill areas.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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