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Phytoremediation Of Crude Oil Polluted Soil: Effect Of Cow Dung Augmentation On The Remediation Of Crude Oil Polluted Soil By Glycine Max

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ABSTRACT

Enhanced remediation of crude oil polluted soil by *Glycine max* through augmentation of such soil with cow dung was evaluated in this study. The soil was contaminated artificially with 25g, 50g and 75g crude oil. The total petroleum hydrocarbon content, the soil pH, moisture and organic matter contents of the soil were determined. More TPH was lost from soils augmented with cow dung than from the non-augmented soil. The pH, moisture content and organic matter content were more in the augmented soils than from the non-augmented soil. Significant differences were noticed between the augmented soils and the non-augmented soil (p<0.05, p<0.01, p<0.001). The results obtained in this study show that augmenting crude oil polluted soils with cow dung will enhance remediation and restoration of crude oil polluted soil.

Key words: Crude oil, Contamination, Remediation, *Glycine max*, Cow dung

Introduction

Contamination of existing and potential agricultural lands is a major problem associated with the processing and distribution of crude and refined petroleum products in many oil producing countries (Ayotamuno et al., 2006). The problems of pollution have led to the exploration of many remedial approaches to effect the clean up of the polluted soils. Pollution control strategies involving physico-chemical methods have often aggravated the problem rather than eliminate it. Biodegradation is recently being favoured as a good option for the remediation of polluted sites mainly because it uses inexpensive equipment, environmentally friendly and simple.

Phytoremediation is one of the forms of biodegradation which involves the in situ use of plants and associated microbes for the remediation of polluted sites. It has been evaluated by several research studies to remediate petroleum polluted soils (Merkel et al. 2005; Issoufi et al., 2006; Sarkar, et al., 2005; Diab, 2008). Several plants have also been described to have phytoremediation potentials to clean up petroleum polluted soils (Frick et al., 1999; Njoku, 2008; Njoku et al. 2009).

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The efficacy of plants to remediate petroleum polluted soils depends amongst other factors on the nutrient availability in such soil. The ability of cow dung augmentation to enhance the growth of *G. max* grown in crude oil polluted soil had been reported in our earlier studies (Njoku et al., 2008). Amadi and Uebari (1992) and Ogbogohodo et al. (2004) reported that amending crude oil polluted soil with poultry dung improved soil fertility and the growth of maize in such soil. According to Pilon-Smits (2005), the ability of plants to grow quickly is one of the factors that favour phytoremediation.

The present study sought to investigate the influence of augmenting soils with cow dung on the potentials of *G. max* to clean up crude oil polluted soil. The objectives were to determine if the addition of cow dung to crude oil polluted soil would enhance the ability of *G. max* to clean up such soil and to evaluate the impact of cow dung augmentation on the pH, moisture and organic matter contents of crude oil polluted soil.

Methodology:

The study was conducted in a screen house in the botanical garden of the University of Lagos, Nigeria using 18 experimental pots of 25cm diameter and 15cm depth. Each pot was filled with 5000g of sandy loam soil and the pot were then divided into three experimental groups. The experimental groups were treated with crude oil equivalent to 25g, 50g, and 75g respectively. Five days after treating the soils with crude oil, each experimental group was further divided into two sub-experimental groups- one sub-experimental group for each treatment group was augmented with 100g of partially decomposed cow dung using the method described by Ayotamuno et al (2006). The polluted soils were properly mixed with the cow dung dung using hand trowel.

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Seven seeds of the *G. max* (TGX 1448-1E) were sown at a depth of 2cm in each pot. The pots were watered at 2 days intervals with 700mls of water. Soils samples were obtained from the pots on the day of sowing of the seeds and subsequently at every 21 days for 105 days. The soil samples were analysed for pH, moisture and organic matter content. Only the soil samples collected on day 105 were used to analysed for the TPH content of the soils. The results obtained from soil samples with cow dung were compared with those from soils without cow dung.

The soil samples were air-dried and sieved through a 2-mm mesh. The total petroleum hydrocarbon present in the soil was extracted using n-hexane as was described in Njoku *et al.*, (2009). The amount of TPH present in the soil was determined gravimetrically using the methods of Okolo *et al.* (2005). The amount of TPH lost from the soil was determined as the difference between the initial level of TPH and the level of TPH found in the soil at the end of the study.

The pH of the soil samples was determined according to the method of Eckert and Sims (1995) using 1:1 soil-water mixture. The pH was read from the pH meter when the electrode was dipped into the slurry of the soil-water mixture. The determination of the soil moisture and the soil organic matter content was done gravimetrically. For the soil moisture content, the method described by Schneekloth *et al.* (2002) was used which involved oven drying the soil to constant weight at 105°C. The formula:

\[
\text{% soil moisture} = \frac{\text{initial weight of soil} - \text{the oven dried weight of soil}}{\text{initial weight of soil}} \times 100
\]

was used to calculate the % moisture content of the soil.

In the case of the organic matter content, the method described in Krishna (2008)) was used. The oven dried soil was burnt in a muffle furnace and the final weight was noted. The % organic matter content was calculated as:

\[
\text{% organic matter content} = \frac{\text{initial weight of soil} - \text{final weight of burnt soil}}{\text{initial weight of soil}} \times 100
\]

The influence of cow dung on the ability of *G. max* to remediate crude oil polluted soil is shown in figure 1. Generally more total petroleum hydrocarbon was lost from the soil augmented with cow dung than in soils without cow dung. However it was only in soils polluted with 75g crude oil that cow dung had significant effect (p<0.01) on the ability of *G. max* to remediate crude oil polluted soil.

Figures 2,3, and 4 show the influence of augmenting crude oil polluted with cow dung on the ability of *G. max* to affect the soil pH, percentage moisture content and the percentage organic matter content respectively. The pH of the cow dung augmented soil was generally higher than the pH of the non-augmented soil. However the significant impact of cow dung augmentation on the pH of the soils (p<0.001) was only noticed as from day 21 of the study. For the percentage moisture content of the soils, augmenting the soils with cow dung also enhanced the amount of moisture accumulated in the soils. For soils with 50g of crude oil, the addition of cow dung made significant impact only the day of planting (day 0) (p<0.001) while for soils with 75g crude oil significant difference between the moisture content of the augmented and non-augmented soil was noticed only on final day of sampling (p<0.01)

In the case of the percentage organic matter content, there was higher organic matter in soils augmented with cow dung than soils without cow dung. The percentage organic matter content of soil polluted with 25g of crude oil and was augmented with cow dung was generally significantly higher than that of soil with same quantity of crude oil but no cow dung (p<0.05). The percentage organic matter content 75g crude oil polluted soil augmented with cow dung was only significantly higher than that of soil with same quantity of crude oil but no cow dung on day 21 of study (p<0.05).

Discussion:

Our previous study on the effects of the growth of *G. max* on crude oil contaminated soil (Njoku *et al.*, 2009) showed that without augmentation *G. max* can enhance the removal of TPH from soil contaminated with crude oil. However, according to Adedokun and Ataga (2007), soil amendments or additives are needed to increase the activities of microbes and for effective bioremediation of polluted soil. The result from the current study shows that efficacy of *G. max* to remove TPH from soil can be enhanced with the amendment of such soil with cow dung. This is similar to what some earlier researchers have noticed. For instance, Okolo *et al.* (2005) reported increased degradation of crude oil in soil augmented with poultry manure while Mbah *et al.* (2009) reported that amendment of spent oil contaminated soil with organic wastes led to improved soil physical properties and increased agronomic parameters of such soil. Also Davies and Wilson (2005) reported that soil amendments improve the physical properties of such soil like water retention, water permeability, water
infiltration, drainage, aeration and structure of soil. This will lead to more degradation or remediation polluted soil.

The implication of the influence of cow dung on the removal of crude oil by G. max is that the addition of cow dung G. max can be appropriately used to remove crude oil from soils or at least reduce the level of crude oil in soils to a manageable level. More so, the use of cow dung as the source of manure in this study is significant because it reduces the cost of using inorganic fertilizers which further reduces the cost of phytoremediation. In addition since cow dung can be found in almost all parts of the country, it can easily be obtained at little cost. This also reduces the cost of cleaning up crude oil polluted soils. However, excess cow dung should not be used in this type of study as it may make the microbes to abandon the crude oil and feed on the nutrients provided by the cow dung or any other form of manure.

Organic matter is an important source of nutrients in the soil and it also enhances some properties of soil like water retention (Schumacher, 2002). The availability of nutrients in the soil not only promotes the growth of plants, it also enhances the growth and activities of soil microbes. As it is well known, phytoremediation mechanism (rhizoremediation) involves the interaction of plants and associated microbes in their rhizosphere. The higher accumulation of organic matter in the soils amended with cow dung noticed in this study can therefore mean more nutrients for the plant and microbial growths. This will in turn lead to removal of more crude oil from the augmented soils as has been reported in this study. This is in conformity with the idea of Shimp and Pfender (1984) that organic matter from wastes can influence the ability of micro-organism to degrade pollutants. Furthermore, Godbout et al. (1995) reported that bacteria seem to be able to survive in organic matter which according to Kaestner and Mahra (1996) appears to be essential for degradation. It is possible from this study that organic matter from wastes enhanced higher microbial population which degraded the toxic compounds in spent lubricant oil amended plots.

The higher accumulation of soil moisture by the soils augmented with cow dung is good for the remediation of crude oil. As was noted by Hutchinson et al. (2001) availability of soil moisture is an important factor in the remediation of hazardous organic compounds. This is similar to the views of Merkl et al. (2005) who included water content as one of the factors that affect phytoremediation. Water helps to increase the solubility of material and subsequently facilitate the absorption and degradation of the materials within the plants. The increase in the soil moisture due to availability of cow dung would mean better growth of the artificial drought created by crude oil pollution. The better growth of the plants due to availability of water in turn leads to more secretion of exudates and cell sheds from plant roots (Smith, 1990; Burken and Schnoor, 1996). These help to facilitate the activities of crude oil degrading microbes required in the remediation of crude oil polluted soil. It also suggests that cow dung helps the soil to increase its water retention capacity which facilitates plant growth.

Conclusion and recommendation:

From the findings of this study, it has been observed that cow dung augmentation of crude oil polluted soil can help to enhance the efficiency of G. max in reducing the quantity of TPH in the soil. However, it is being recommended here that cow dung addition should be at a moderate level to avoid the symbiotic microbes at the rhizosphere from abandoning feeding on crude oil for the nutrients in the cow dung.
**Fig. 2:** The pH of crude oil polluted soil. Legends show the amount crude oil added to the soil and whether the soil was augmented or not. c means significant difference between augmented soil and non-augmented soil at p<0.001.

**Fig. 3:** The percentage moisture content of crude oil polluted soil. Legends show the amount crude oil added to the soil and whether the soil was augmented or not. a, b and c mean significant difference between augmented soil and non-augmented soil at p<0.05, p<0.01 and p<0.001 respectively.
Fig. 4: The percentage organic matter content of crude oil polluted soil. Legends show the amount of crude oil added to the soil and whether the soil was augmented or not. a means significant difference between the augmented soil and non-augmented at p<0.05

References


