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Full Length Research Paper

Petroleum hydrocarbons content in the soil and its accumulation in grasses from oil spill site at Isoko North LGA of Delta State, Nigeria

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This study was done to evaluate the concentration of petroleum hydrocarbons in an oil spill site in Ozoro, Isoko North Local Government Area, and Delta State of Nigeria. The study area was affected by the crude oil spill in early 2019, and the cleanup of the site was carried out almost immediately by the oil company. Five soil samples were collected randomly at two soil depths, the soil surface (0- 5 cm) and 40 cm soil depth. In addition, two kinds of grass, Nettle-leaf goosefoot (Chenopodium murale) and Guinea grass (Megathyrsus Maximus) were collected from the points the soil samples were collected, during January 2020. All the samples collected were analysed for total hydrocarbon content (THC) using standard procedures. The results showed significant concentration in the soil samples; and accumulation of THC in the roots and leaves of the grasses. At the soil surface, the THC ranged between 9,075 and 13,563 mg/kg; while at a depth of 40 cm below the soil surface, the THC ranged between 6,518 and 13,004 mg/kg. The Guinea grass had a higher accumulation of THC (mean = 1258 mg/kg), compared to the Nettle-leaf goosefoot (an average of 922.8 mg/kg). The significant accumulation in the guinea grass is an indication of its phytoremediation. The results will be helpful in planning and monitoring of remediation programmes for crude oil spills sites.

Keywords: Delta State, crude oil spill, total hydrocarbon content, remediation, guinea grass

INTRODUCTION

Petroleum (crude oil) exploration and production activities in Nigeria have improved rapidly, since crude oil was first discovered at Oloibiri in 1956. According to Nigerian National Petroleum Corporation (NNPC), with an average crude oil production of 2.5 million bpd, Nigeria is ranked Africa's largest crude oil producer and sixth in the world. Nigeria crude oils (Brass Blend, Escravos Light, Forcados Blend, etc.) have low sulphur concentration, making them of higher value when compared with crude oils produced from other countries. Currently, Nigeria crude oil reserves stand at 28.2 billion barrels; while the natural gas total reserves stands at 165 trillion standard cubic feet (scf), including 75.4 trillion scf of non-associated gas (NNPC, 2020). Crude oil spills, accidental or saboteur act, are unavoidable during crude oil exploration and production, regardless of the precautionary measures taken and sophistication security systems engaged by the oil companies (Matemilola *et al*., 2018). Petroleum hydrocarbons contamination of the ecosystems has become a global challenge, because of their toxicity and refractory nature (Ite and Semple, 2012).

Contamination of soil by petroleum hydrocarbons can lead to drastic environmental problems. This is because these hydrocarbons components are carcinogenic and neurotoxic in nature (Denys *et al*., 2006; Das and Chandran, 2011). When high concentrations of hydrocarbons released into the ecosystem, it results to death of plants, mortality of animals and fishes that dwell within the ecosystem, and general reduced the functional capacity of the ecosystem (Lotfinasabasl *et al*., 2013). According to Akpokodje *et al*. (2019), the ecosystem can be contaminated with hydrocarbons through the process of petroleum extraction, spills, consumption, illegal refining method, and indiscriminate disposal of petroleum waste products. Researches have shown that oil pollution can caused significant damage to the mangrove and grassland ecosystems (Marmiroli *et al*., 2006). According to Hoff *et al*. (2014), since crude oil is highly viscous in nature, and when deposited on the earth's surface it can form thick and sticky layers, which can either interrupt or completely stop normal biological symbiotic relationships within the environment. Even though, a petroleum product is not highly toxic, being oily in nature, it can cause suffocation and starvation in plants and animals when they are totally immersed in it (Hoff *et al*., 2014).

Phytoremediation is the use of crops/plants, coupled with their associated microbes to degrade contaminants in the environment. It is an effective cleanup method for a wide range of both organic and inorganic contaminants; which makes use of the naturally occurring processes (plants' microbial rhizosphere flora) to degrade and remove the organic and inorganic contaminants in the soil (Salt *et al*., 1998; Pilon-Smits, 2005; Akpokodje *et al*., 2019). Citing McCutcheon and Schnoor (2003), plants have the capability to facilitate biodegradation of hydrocarbons by microbes in their rhizosphere. When crops are grown on contaminated soils, the contaminants are degraded more rapidly than bare soils, which could be attributed to the positive microbial activities effects of the crops (Keller *et al*., 2008). Citing Plata-Chebbah (2000), phytoremediation of contaminated soil with maize and sorghum plants was more efficient in degrading the contaminants than land farming, and better than natural attenuation as a facilitator of soil hydrocarbon degradation. Phytoremediation of hydrocarbon contaminants from the environment (soil) can takes months if not years to attain permissible maximum levels recommended World Health Organization (WHO) (Pilon-Smits, 2005). Phytoremediation is not limited to solid contaminants alone, it can be also be used for liquid and gaseous substrates. For instance, plants have the ability to filter both outdoor and indoor air from pollutants like SO_2, CO_2, nerve gases, dust or soot particles (Jeffers and Liddy, 2003; Morikawa *et al*., 2003; Pilon-Smits, 2005).

Some of the most threaten oil in crude oil spill areas within the Niger Delta region of Nigeria, are the Isoko communities. From literature review, there is dearth of information on the residual petroleum hydrocarbons, in already cleaned up oil spill sites within Delta state. Therefore, the objective of this study was to evaluate residual total hydrocarbon content (THC) in an oil spill site at Ozoro, Isoko North LGA of Delta State, Nigeria. Likewise, the phytoremediation potential of two native grasses (Nettle-leaf goosefoot and Guinea grass) was evaluated in order to determine the situation plant for the remediation of the oil spill site.

MATERIALS AND METHODS

Materials

Site description and characterization

The study site was located in Ozoro community, Delta State, Nigeria. The site witnessed an oil spill during early 2019, which was attributed to criminal activities (oil theft). Ozoro falls within the southern tropical evergreen forest zone and characterized by two climatic seasons (rainy and the dry season). The site is prone to flooding during the wet season. An assessment of the wild vegetation on the site showed that Nettle-leaf goosefoot (*Chenopodium murale*) and Guinea grass (*Megathyrsus maximus*) were dominant.

Soil samples collection

Soil samples were collected top soil (0 – 5cm) and bottom (40cm) from randomly selected points within the oil spill site. All the sampling points were georeferenced, by employing an electronic global positioning system (GPS) receiver. The samples were collected in January 2020, about a year after the oil spill.

Collection of plants samples

Two predominant native grasses, Nettle-leaf goosefoot (*Chenopodium murale*) and Guinea grass (*Megathyrsus maximus*), growing on the pullulated site were uprooted, shaken to remove all sand particles and taken to the laboratory for analysis. The grasses were uprooted from the points where the soil samples were collected. The roots and shoots (leaves) were analysed differently for their THC concentration.

Total hydrocarbon content (THC) determination

The THC concentrations of the soil and plants samples were analyzed the Soxhlet Extraction Method recommended by ASTM D 9071B – 7 (APHA, 1995). All the laboratory analyses were carried out under ambient temperature of 34±4°C.

Table 1. THC concentration in the soil depths and plant's parts.

Position	Soil Depth		Guinea grass		Nettle-leaf goosefoot	
	5 cm	40 cm	Roots	Leaves	Roots	Leaves
1	13563	13011	1255	1297	1064	903
2	11856	9825	672	914	582	492
3	9076	6518	1010	1173	864	855
4	13046	13004	1655	1797	963	1098
5	11823	12931	1062	1109	1053	1266
Mean	11872.8[a]	11057.8[a]	1130.8[b]	1258[e]	905.2[d]	922.8[f]

Columns with the same common letter (superscript) are not significantly difference at p ≤0.05.

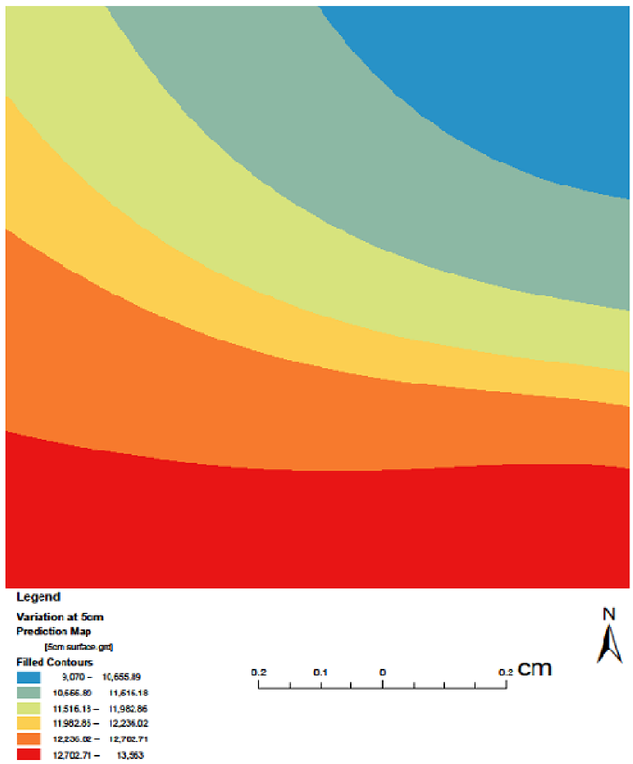

Figure 1. Variation of THC concentration in the soil surface across the study area.

Statistical analysis

Data obtained from this study were analyzed by using the Statistical Package for Social Statistics (SPSS version 20). The means will be separated and compared with the aid of the Duncan's Multiple Range Test (DMRT) at ($p \leq 0.05$). In addition, the maps were plotted by using geostatistical software.

RESULTS AND DISCUSSION

The results showed that there was still residual THC within the cleaned up oil spill area. The THC concentration of the top soil ranged between 9,075 and 13,563 mg/kg (Table 1). Lotfinasabasl *et al.* (2013) reported that the total petroleum hydrocarbons (TPH) concentration at the soil surface of an already cleaned up oil spill area ranged between 0.5 and 17,040 mg/kg with a mean value of 1964.4 mg/kg. A variation map plotted from the spatial distribution of THC concentration in the top soil showed that the southern region of the oil spill area had the highest THC (Figure 1). In the sub soil (40 cm), the THC concentration ranged between 6,518 and 13, 004 mg/kg (Table 1).

With reference to the soil surface THC concentration, the variation map plotted from the spatial distribution of THC concentration at the soil surface showed that, the south eastern region of the oil spill site had the highest THC concentration (Figure 2), and decreases as it moved

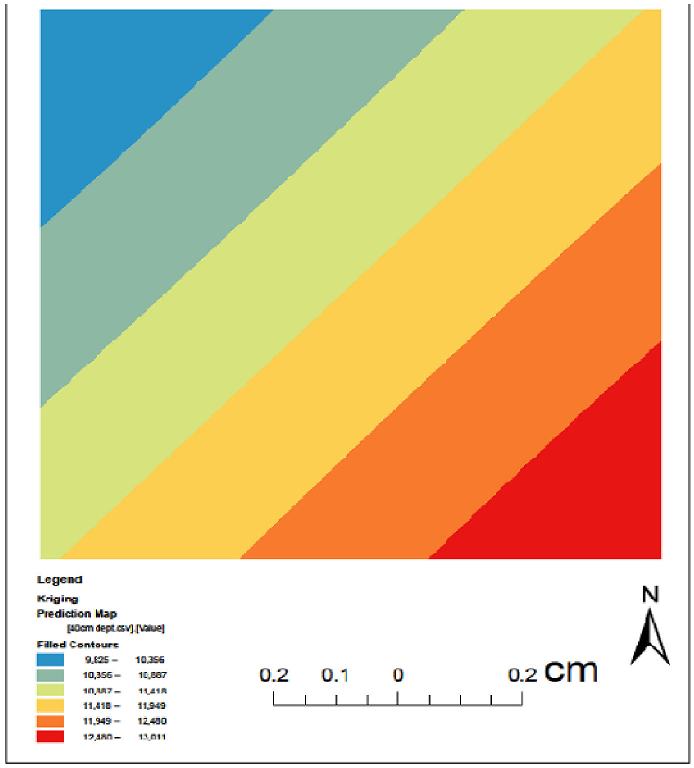

Figure 2. Variation of THC concentration at a soil depth of 40 cm across the study area.

northward. This indicated that the south region of the oil spill area received the highest volume of crude oil during the spillage, or there is an incidence of remediation failure. In all cases, the northern part of the oil spill site had the lowest THC concentrations, when compared with the southern part of the oil spill site. At the soil surface, the North East region had the lowest THC concentration; while at the 40 cm depth, the North West region had the lowest THC concentration. Results showed lower THC accumulation at the subsoil, when compared to the THC accumulation recorded at the top soil surface. But the ANOVA result showed no significant ($p \leq 0.05$) differences between the mean values at the soil surface and 40 cm depth. Similar results were obtained by Lotfinasabasl *et al*. (2013) and Osuji and Adesiyan (2005). Osuji and Adesiyan (2005), the THC concentration of an oil spill site was generally higher at the top soil; but declined as the soil depth increases. In addition, a study by Akpomrere and Uguru, (2020) showed that there was significant amount of residual THC in an already cleaned up oil spill site at Isoko South of Delta State. But contrary to this study results, the THC concentration generally increased with increased in soil depth; this could attributed to the quantity of oil spilled and the nature of treatment applied after the spillage.

Results also showed that the two dominant grasses contained high concentration of THC (Table 1). The Guinea grass was found to have the higher accumulation of THC (mean = 1258 mg/kg) than the from the Nettle-leaf goosefoot (mean = 922.8 mg/kg). The variation map (Figure 3) showed that the THC concentration in the guinea grass leaf decreased from we move from the Eastward region to the North Westward region of the oil spill site. THC accumulation in the Nettle-Leaf Goosefoot grass leaves was found to be highest at the North eastern part of the oil spill site (Figure 4), and decreased generally to the Western region. The Nettle-leaf goosefoot grass leaves samples collected from the North Western region having the lowest THC accumulation.

The THC concentration in the roots of the two grasses also showed significant ($p \leq 0.05$) THC accumulation by the roots (Table 1). Generally, the Guinea grass roots had higher THC (mean = 1130.8 mg/kg) than the Nettle-leaf goosefoot grass roots (mean = 905.2 mg/kg). This indicated that guinea grass roots have higher petroleum hydrocarbons uptake; making it a good phytoremediation agent. Variation maps plotted from the results obtained from this study showed that the THC concentration in the guinea grass roots was highest at the eastern region of the oil spill site (Figure 5), and declined uniformly to the North Western region. In reference to the variation of the THC concentration in the Nettle-Leaf Goosefoot grass roots across the oil spill site, the South Eastern region had the highest concentration (Figure 6), and decreased

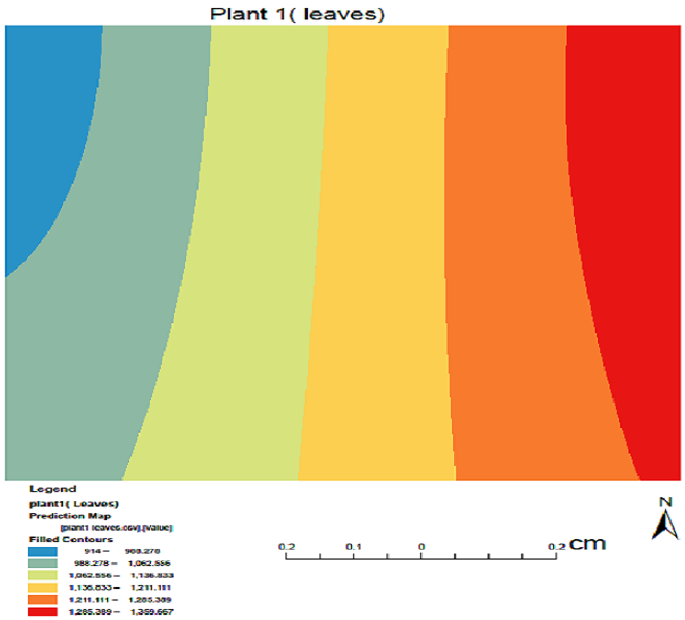

Figure 3. Variation of THC concentration in the guinea grass leaves across the oil spill site.

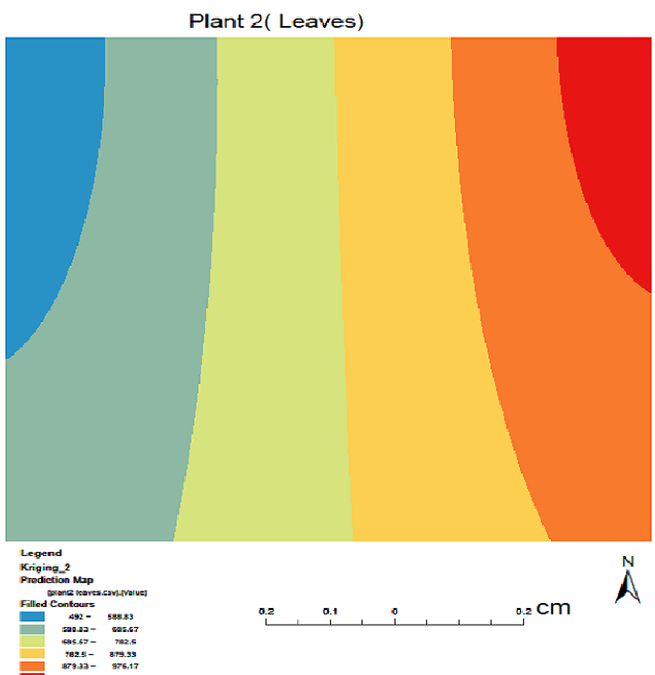

Figure 4. Variation of THC concentration in the Nettle-leaf goosefoot grass leaves across the oil spill site.

uniformly to the North Western parts of the oil spill site. The higher value of the THC concentration in the leaves of the grasses, compared to the roots showed that the grasses have the capability to be employed as

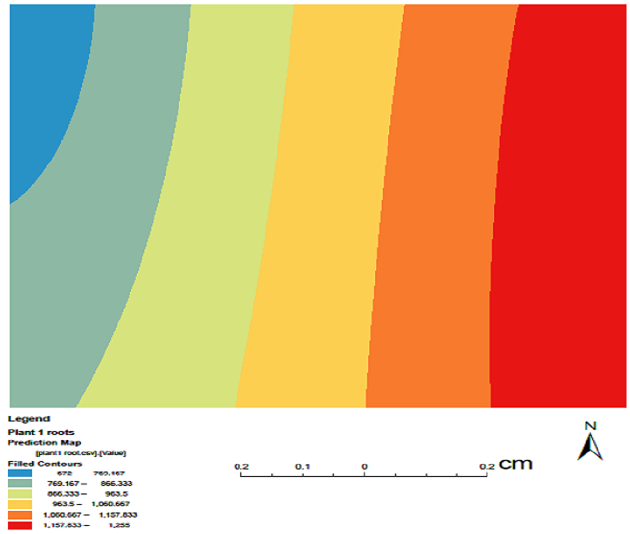

Figure 5. Variation of THC concentration in the guinea grass roots across the oil spill site.

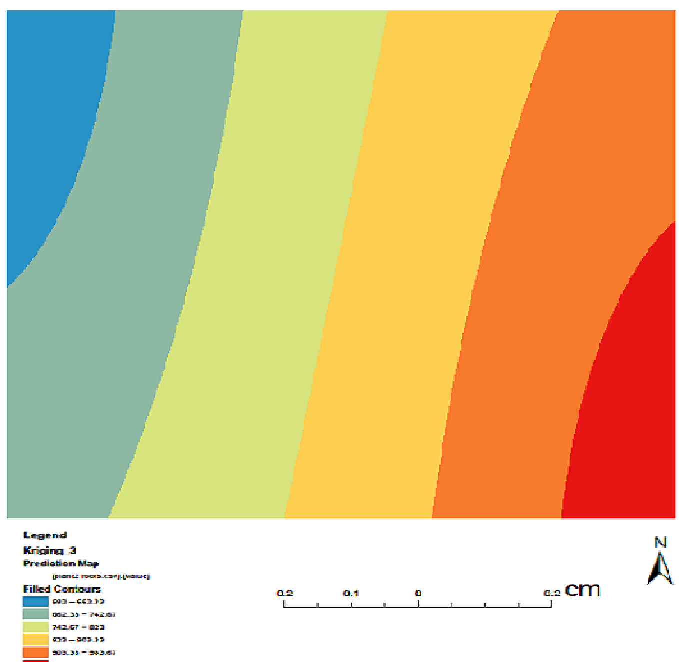

Figure 6. Variation of THC concentration in the Nettle-leaf goosefoot grass roots across the oil spill site.

phytoextraction agent, during remediation of crude oil contaminated soil. According to Satpathy *et al*. (2014), if the THC concentration in the soil is higher than the THC concentration recorded in the plants roots growing on it, it means that the plant only absorbs the THC and does not accumulate. The THC concentration was very high in the soil (11872.8 mg/kg); compared to the roots and leaves of the grasses, a mean concentration of 1130 mg/kg was recorded in the roots of Guinea grass. Favorable plant's characteristics needed for efficient phytoremediation and phytodegradation methods include early establishment, high growth rate, competitiveness, dense root systems, hardy, high tolerance to the contaminant and high levels of degrading enzymes (Olson *et al*., 2003). Results obtained from this study calls for the need for proper remediation follow-up in oil spill sites to safeguard the environment. This is because significant THC concentration was still in the environment by the cleanup of the oil spill site.

Conclusion

The result of this study was carried out to evaluate the residual THC in an oil spill site in Isoko South LGA of Delta state. Soil samples were collected from five spatial locations at two soil depths and their THC analyzed. Results obtained from the laboratory tests showed that the THC concentration at the top soil ranged between 9,075 and 13,563 mg/kg; while at the sub soil it ranged between 6,518 and 13, 004 mg/kg. This is indicative of residual petroleum hydrocarbons in the oil spill still despite the cleaning up. In addition, the variation map showed that at the top soil surface, the south eastern region had the highest THC concentration, and decreases as it moved northward. Furthermore, significant amount of THC was found in the two grasses growing on the oil spill site. The guinea grass roots had higher THC (mean = 1130.8 mg/kg), when compared to the Nettle-leaf goosefoot grass roots (mean = 905.2 mg/kg). This indicates that guinea grass roots have higher petroleum hydrocarbons uptake, in contrast to the Nettle-leaf goosefoot grass, making it a good phytoremediation agent. Results obtained from this study will be helpful in monitoring remediation activities of oil spill sites to safeguard the ecosystems.

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