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PHYTOREMEDIATION INNOVATIVE TECHNOLOGY (Series 1): *A SHORT-TERM COMPARATIVE ANALYSIS OF REMEDIATION POTENTIAL OF MACROPHYTIC AGRO-FORESTRY SPECIES IN A WATER-HABITAT RELATIONSHIP OF A CRUDE OIL POLLUTED TERRESTRIAL HABITAT*

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ABSTRACT

A short-term ecological study was conducted on the use of Agro-Forestry Species (*Leucaena leucocephala* .Lam de. Wit and *Bauhinia monandra*,Kurz) in enhancing water infiltration of a crude oil polluted terrestrial habitat. *B. monandra* treated soil had no significant effect on water infiltration. Water infiltration was retarded, with the time ranging between 3-43 minutes. While *L leucocephala* treated soil had a significant infiltration rate ranging between 4 -12 minutes. The implication of these for the environmental quality enhancement has also been buttressed by the ANOVA with *B.monandra* infiltration time significantly higher (3.85) than *L. leucocephala* (1.50) at $P \leq 0.05$ (3.49) level of significance.

KEY WORDS: *Leucaena leucocephala, Bauhinia monandra*, Phytoremediation, Crude oil, Water infiltration.

INTRODUCTION

The terrestrial habitat also called "*The Lithosphere*" is an important facet of our environmental media. It consists of the soil and its associated environs (Plants and Animals). This environment (ensued from degrading & weathered rocks, decayed organic materials (DOM), living fauna and soil water and atmosphere) as we know, is liable and a subject of imminent crude oil pollution. This appears to be an inevitable consequence of the extraction, production, refining, transport and, distribution, and increase demand and utilization of petroleum and its products by the society, inter alia environmental problems. When oil infiltrates the soil it has a considerable effect on the soil particularly on the structure and wettability. There is complete breakdown of structure and dispersion of particles, which tend to adhere together thus, reducing the pores and porosity, air and water displaced, aeration and cultivation becomes difficult.

In Nigeria, as in many other countries, the society and its environs have been and is still under such environmental threats as desertification (in the Northern part of the country), flooding (in the South-South Niger Delta region) and riparian erosion (in the eastern region) solid waste problem and industrial pollution. The issue of pollution has been in the frontline burner of our environmental debate. To this end, significant attention has been given to these problems by scientists, politicians and many-concerned interest groups of this country, (Odu, 1977, Kinako, 1984, Odeyemi and Ogunseitan, 1985, Kinako and Zuofa, 1991; and Saro-Wiwa, 1992). In view of this, series of physical and chemical dispersant and barriers have been used for oil pollution containment, especially in the aquatic ecosystem. But none of these options are usually effective in terrestrial habitats, coupled with bioremediation potential investigation, which was only fit for fuel distillate pollutants, (Cox and Cowel, 1979;and Song and Bartha 1990). It has been investigated that strains of micro-organisms could be used for recalcitrant hydrocarbon degradation. But this could stem imminent microbial explosion and possibly health hazard, as majorities are potential pathogens. Should there be a natural self-remediation of a polluted site, this takes a long time (Kinako, 1981). Also there is a lot literature on large scale environmental pollution, but little has been documented on bio-phytoremedition of a polluted site. This study sought to determine the efficiency of using Agro-Forestry species (*Leucaena leucocephala* Lam. De. Wit. and *Bauhinia monandra*. Kurz) for habitat remediation work following terrestrial oil pollution. This is aimed at evaluating the efficacy of using Nitrogen fixing Agro-Forestry plant (*L. leucocephala and B. monandra*) in enhancing bioremediation of crude oil polluted terrestrial habitat, their ecological impact on the polluted soil and on the basis of the data/information obtained, produce an Agro-Forestry habitat remediation technology for oil polluted terrestrial habitat. This is of very vital importance for any national holistic strategy to enhancing the quality of the nation's environment.

MATERIALS AND METHODS

Experimental Design and Site Preparation. *L. leucocephala* and *B. monandra seeds* were procured in Port Harcourt. Germination test was carried out using 50 randomly selected whole seeds of each of the two species. Each species had five replicates and each replicate had 10 seeds placed on the petri dishes. The germination was monitored for seven days at room temperature of about 25^{O}C. From the proposed University of Port Harcourt Botanical Garden, top soil (loam) was collected in bulk from 0-15cm-soil layer, into large plastic buckets and conveyed to the laboratory where polybags (25cm^3) were filled in replicate of treatment and control.

The study sites (micro plots of loam soil replicates) with surface area 78.5cm^2 are polluted in doses of crude oil using the measuring cylinder. The levels of doses (ml) were 25/78.5cm^2, 50/78.5cm^2 and 100/78.5cm^2 and 0ml/78.5cm^2 as unpolluted control replicate. The Agro-forestry species were used as treatment options for the different pollution levels per micro plot, 7 days post-pollution. Healthy 7-day-old seedlings of the two species were planted into the control and polluted soil in the polybags. The growth performance of these

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Table 1: Water (50ml) infiltration time (cm / sec) of *Leuceana leucocephala* treated soil. (Data represent infiltration time in minutes from 10 replicate micro plots at 4 weeks interval).

CV in mil / Period in week	Control	25	50	100
4	5.00±1.19	6.00±3.65	8.00±6.06	4.00±1.67
8	6.00±1.97	13.00±2.66	16.00±5.14	17.00±4.40
12	6.00±6.03	11.00±2.69	13.00±2.45	15.00±3.60
16	7.00±3.13	11.00±3.23	11.00±2.40	12.00±2.70

Key: CV = Crude oil Volume
Mil = Mill

Table 2: Water (50ml) infiltration time of (cm/see) *Bauhinia monandra* treated soil. (Data represent infiltration time in minutes from 10 replicate micro plots at 4 weeks interval)

CV in mil / Period in week	Control	25	50	100
4	5.00±2.05	3.00±1.02	4.00±1.51	3.00±0. 75
8	6.00±2.34	18.00±1.12	32.00±4.83	49.00±5.61
12	6.00±2.33	16.00±1.07	29.00±4.50	46.00±5.17
16	7.00±2.34	14.00±0.92	25.00±4.82	43.00±4.10

Key: CV = Crude Oil Volume
Mil = Mill

Table 3: ANOVA of water infiltration period (minutes) of crude oil polluted loam soil treated with *L. leucocephala* and *B. monandra*.

Soil sample	Fr-ratio	Significance
L. leucocephala treated loam soil.	1.50 Ns	P<0.05 P>0.05
B. monandra treated loam soil	3 85*	

seedlings was monitored over a period of 16 weeks and used as a measure of their level of tolerance of the polluted environment. Post-pollution recuperation of the polluted soils under the seedlings was assessed by means of comparative analysis of the physico-chemical and other edaphic parameter of the polluted soil, such as the water habitat relationship. (Permeability).

Measurement Of Water Infiltration

A comparative assessment of the rate of water infiltration was carried out at the control and polluted sites. (Micro plots) using a glass infiltrometer, (alternatively a glass burrette with tap head) 4.5cm in diameter and 36.0cm long and a stopwatch. The exercise was carried out monthly within the four months of ecological study. At each of the micro plots the infiltrometer was pushed vertically down, 5cm into the soil and 50ml of tap water poured into it. Looking at the period of water movement, the time taken for the water to infiltrate into the soil in relation to repellency was recorded with a stopwatch in minutes and results were substantiated by the statistical analysis of variance (ANOVA) (Andy, 1992)

RESULTS

The levels of phytoremediation effects of the treatment options on water infiltration and repellency study site are presented in Tables 1and 2. The study was conducted at 4 weeks interval (4th, 8th, 12th and 16th weeks) post pollution. L. leucocephala treated soil had (in minutes) averages of 6.00±3.65, 13.00±2.66, 11.00±2.69 and 8.00±3.23, respectively (for light pollution). 8.00±2.06, 16.00±5.14, 13.00±2.45 and 11.00±2.40, respectively (for medium pollution) and 4.00±1.67, 17.00±4.40, 15.00±3.60 and 12.00±2.70, respectively (for heavy pollution) while control had a constant increase from 5.00±1.19 to 7.00±3.13 in the infiltration period. (Table 1). *B. monandra* treated soil had infiltration period (in minutes) averages of 3.00±1.02, 18.00±1.12, 16.00±1.07 and 14.00±0.98 respectively (in light pollution). 4.00±1.51, 32.00±4.83, 29.00±4.50 and 25.00±4.82 respectively (in medium pollution). 3.00±0.75, 49.00±5.61, 46.00±5.17 and 43.00±4.10, respectively (in heavy pollution). Control had increase ranging from 5.00±2.05 to 7.00±2.34 period. This shows that *L. leucocephala* had more impact that *B. monandra* (Table 2). In summary the results have indicated that the time taken for infiltration in *B. monandra* treated soil is highly significant than the infiltration time for *L. leucocephala* treated soil at $P \leq 0.05$.

DISCUSSION

Phytoremediation is the name given to a set of technologies that clean contaminated sites using plants. Plants may remediate man made contaminants through several mechanism some plants destroy organic pollutants by degrading them directly, while some other plants aid in degrading indirectly by supporting microbial communities. Other plants take up inorganic contaminants from soil or water and concentrate them in the plant tissue or root. Using different plants, phytoremediation can be applied as containment, destruction or an extraction technique. It has been applied to point and non-point source hazardous waste control, and has been used in soil, surface water, ground water and sediments (Steven, 2004). The pollution of the terrestrial environment could emanate from pollutant discharge, either natural or homogenic in nature. Such pollutant may be organic or inorganic component. Series of agronomic practices and plant species have been known for their potential to remediation of soil contaminated with organic and inorganic compounds such phytoremediation principle can also be coopted into the restoration of the permeability of a crude oil polluted soil habitat.

From the study report shown that there was increase in water repellency as pollution increased and vice versa. There were changes the physicochemical property of the polluted soil which made the affected habitat become strongly hydrophobic, with the formation of tiny films and tiny drops of moisture over the soil surface instead of being absorbed. Such repellency was also observed by Letey *et al,* (1962), with the hydrophobic soils having low infiltration rates and generating adverse effects on the dynamics of the available soil moisture. Similarly, the effect of oil spill on land pose considerable effect on the structure and wettability of the soil. The more volatile oil components and much of the water evaporate what remained was a dry soil containing aggregates coated with thin layers of heavier oil fractions (hydrophobic portion). The impact of oil in soil indicate that particles tends to adhere together thereby reducing soil pores, which in turn decreases aeration and water movement. Knowing that water content of soil is closely related to oxygen content and aeration, water and air exist in the same pore spaces of the soil. A change in the volume of one affect volume of the other. An increase in one result in a decrease in the other by the same volume and this has a significant effect in promoting anaerobic condition in the affected soil. The findings of this study agree with those of McGill (1976) and Lolomari (1979). Dobson and Wilson (1964) observed that oil entering the soil displaces air and water from the soil pores because, as they put it, there was a complete breakdown of structure and dispersion of soil particles. Odu (1972) reported a similar finding. Such difficulty as cultivation has also been demonstrated by Osborn *et al,* (1967) and also related to unavailable soil moisture. Propagules in soil and incoming ones were both subjected to this formidable physicochemical barrier thereby impeding vegetation regeneration. Water repellent or hydrophobic soils generally have low infiltration rates, generating adverse effects on the dynamics of the available soil moisture.

The impact of agro-forestry species in such hydrophobic loam soil as presented in the study shows that *L. leucocephala* than *B. monandra* is related to high ability for crude oil degradation owing to its phytomicrobial symbiotic association. There was a decline in repellency respect to the observed time of infiltration. The infiltration time (3.85) of *B. monandra* treated soil is highly significant ($P \leq 0.05$) 3.49 compared to *L. leucocephala* treated soil as substantiated by the statistical analysis of variance (ANOVA) in Table3.

The phytomicrosymbiotic activities of *L.leucocephala* enhanced infiltration by the dissolution of hydrophilic component of the crude, which undergoes emulsion with daily flooding or watering. This reduced the impact of crude oil on soil pores. The gradual replacement with air engendered by a shift from water filled micropores to macropores enhances microbial activity, with a reduction in the hydrophobic portion of the oil. *B.monandra* lacks such quality for increased infiltration because it lacks the potential for micro-symbiotic association. The result also shows that *L. leucocephala* has two advantages (microbial symbiotic association for hydrophobic degradation and hydrophilic dissolution or emulsification). On the other hand, *B. monandra* has one, an insignificant hydrophilic dissolution advantage.

CONCLUSION

The results from the treatment options appear to be sensitivity indices (which may be positive or negative response) to oil spillage in terrestrial habitats. The results have shown that biophytoremediation can help improve environmental quality as part of an enhanced programme of improving cleaning processes. Thus the use of *L.leucocephala* in the enhancement of bioremediation of crude oil polluted soil, especially in the oil-polluted Niger Delta area. Is of high remediation potential. It is thus recommended as an integral component of macrophyte remediation technology for crude oil polluted terrestrial habitats.

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