African Journal of Biotechnology Vol. 8 (1), pp. 65-68, 5 January, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2009 Academic Journals

Full Length Research Paper

Plant species responses to oil degradation and toxicity reduction in soil

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Accepted 15 July, 2008

A field project located at the Botanical garden of the University of Port Harcourt was designed to evaluate changes in contaminants concentration and toxicity during phytoremediation. Vegetated plots were established by planting different plant species – legumes and vegetable (*Abelmoschus*, *esculentus*, *Telfaria occidentalis* and *Vigna unguiculata*) and applied with sawdust and *chromolaena* leaves at different intensities of oil pollution. Toxicity of the soil was evaluated using germination percentage, flowering, fruit set and weight. The reduction of toxicity was more with legume than vegetables. However, total petroleum hydrocarbon concentration was lower by the end of the study in all the soils planted with the crops.

Key words: phytoremediation, soil degradation and restoration.

INTRODUCTION

The risk of oil spills in the Niger Delta regions in Nigeria is high because of the intensive oil exploration, production, transmission and refining. The clean-up of the oil spill around the environment becomes problematic as a result of cultural and environmental effects associated with most clean-up techniques, hence clean up techniques may do more damage than the oil itself. The need to develop oil spill clean up techniques that cause little or no impact but can effectively remove the spilled oil becomes apparent.

The use of vegetation from the *in situ* treatment of contaminated soil and sediment is an emerging technology that promises effective and inexpensive clean up of certain hazardous wastes (Simeon 1993; Nwoko, 1995). Some of these processes occurs within the plants and involves the degradation or breakdown of organic and inorganic contaminants through internal and external processes driven by the plant. Some contaminants can be absorbed by plants and are then broken down by plants enzymes which may be used by plants themselves as they grow. From literature it has been noted that some plants have chemical metabolites and some plants induced substances than others. This means that differences in their rate of oil degradation and toxicity reduction in soil where they are grown exist. This study is therefore a follow up, to ascertain the diversities or variation in germination, growth and development of different plants species; vegetables and legume in an oil contaminated soil in relation to their abilities in aiding oil depredation.

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MATERIALS AND METHODS

The experiment was carried out at the Botanical garden of the University of Port Harcourt, Nigeria. Seeds of *Abelmoschus esculentus* (vegetable), *Telfaria occidentalis* (vegetable) and *vigina unquiculata* (legume) were procured from the Agricultural Development Project (ADP) in Rivers State Nigeria. The Crude oil used was supplied by the Nigeria Agip Oil Company (NAOC) Ebocha Base, Port Harcourt. Polythene bags measuring 45 x 45 cm perforated three to five (3 - 5) small holes to allow easy drainage was used. They were filled with topsoil collected from the Botanical garden of the University of Port- Harcourt weighing 6600 g, leaving a space of 7.0 cm from the top to make allowance for addition of crude oil and soil amendments.

The soil was polluted in two intensities represented by mild (3%) and severe (6%) crude oil pollution at 200 and 400 ml, respectively. The crude oil was thoroughly mixed with hand trowel. The amendment agents, chromolaena leaves and sawdust, were equally weighed at 50 g each and applied to both 3% and 6% pollution.

Table 1. Germination percentage of plants, grown under different treatments.

Treatment	Number planted	7 DAP			14 DAP		
		A. esculentus	*T. occidentalis*	*V. unguiculata*	*A. esculentus*	*T. occidentalis*	*V. unguiculata*
6%	20	50	-	40	75	80	88
6%+S	20	80	-	70	92	98	95
6%+C	20	55	-	60	95	100	100
3%	20	75	-	75	95	95	100
3%+S	20	82	-	72	95	92	92
3% +C	20	82	-	95	95	100	100
Control	20	85	-	98	95	100	100

DAP: days after planting.

The leaves were chopped with knife before mixing. After application, it was allowed for thirty (30) days before planting was undertaken. The experimental set up consist of the following; control, 3% pollution, 3% pollution with sawdust, (3%+S), 3% Pollution plus chromolaena leaves (3%+C), 6% pollution, (6%), 6% pollution plus sawdust (6%+S), and 6% pollution plus chromolaena leaves (6%+C).

Evaluations

Qualitative and quantitative observations were made. Growth parameters as a measure of quantitative indices used to overtake plant species potentials in oil depredation and toxicity reduction were germination percentage, flowering fruit set and weight.

The germination percentage was carried out for 7 – 14 days after planting respectively, since some of the crops cannot germinate within 7 days, for example, *T. occidentalis*. The percentage germination was conducted by counting the numbers of seeds of plant that sprouted over the actual number planted, multiply by 100. Phonological observations were made on flowering and fruit set while the fruit were weight immediately after harvest with a weighing balance.

Oil concentration in soils planted with the crops was determined using the method of USEPA 1991.

Data collected on two weeks basis especially in oil analysis was analyzed using Annova and Duncan multiple range text (DMRT) according to the statistical analysis system (SAS, 1991).

RESULTS

Phytotoxicity

For quantitative observations, the degree of phytotoxicity showed that *A. esculentus* was most affected followed by *T. occidentalis* and *V. unguiculata.* Plants showed rapid rate of leaf abscission at the initial weeks of study in *A. esculentus* and *V. uguiculata* than in *T. occidentalis* (Table 2).

Germination percentage

The result in Table 1 shows that at 7 days after planting (DAP), germination percentage were more with *V. unguiculata* and *A. esculentus* than *T. occidentalis.* However at 14 DAP, all the crops used in the study gave high germination percentage, though the efficacy was more with *V. unguiculata* and *T. occidentalis* than with *A. esculentus*.

Flowering and fruit set

Flowering among the crops showed differences in their responses. With *A. esculentus*, flowering was observed in most treatments except at 6% pollution soils with amelioration agents. *T. occidentalis* produces flowers more in control and 3% pollution treated with chromolaena leaves than in other treatments. The result with *V. unguiculata* showed a higher progressive flowering ability which was noted in treatments: control, 3% pollution and 6% pollution with amelioration agents. Invariable, the flowering capacity exhibited by *V. unguiculata* than other crops relates also to the numbers of fruit set or fruit production as it was high in the crop than *A. esculentus*, while no fruit flowering was observed with *T. occidentalis* within the experimental period. Moreso, with *V. unguiculata*, fruit weight was highest at 6% pollution with amelioration agents.

Oil concentration

From Table 2, reduction in oil concentration was more in soils with *V. unguiculata*, followed by soils with *T. occidentalis* and highest in soils with *A. esculentus.*

DISCUSSION

The present study supports our previous findings (Offor, and Akonye, 2006) that vegetative components; plants and plant materials exerts remediation processes which aids in oil degradation and soil restoration. From this study, germination percentage was higher initially at 7 DAP with *V. unguiculata* and *A. esculentus* than with *T. occidentalis* which could be related to the physiochemical

Table 2. Physiological observation of plant responses to oil concentrations in soil.

Observation	*T. occidentalis*							*V. unguiculata*							*A. esculentus*						
	C	**3%**	**3%+S**	**3%+C**	**6%**	**6%+S**	**6%+C**	**C**	**3%**	**3%+S**	**3%+C**	**6%**	**6%+S**	**6%+C**	**C**	**3%**	**3%+S**	**3%+C**	**6%**	**6%+S**	**6%+C**
Flowering	+++	+++	+++	+	+	+	+	+	+	+++	-	+	+++	+++	-	-	++	+++	+	+	+++
Fruit set	-	-	++	-	-	-	-	-	+	++	-	-	-	-	-	-	++	-	-	-	-
Fruit weight	-	-	-	-	-	-	-	-	-	-	+++	-	-	-	-	-	-	-	-	-	-
Abscission	-	-	-	-	-	-	-	-	+	-	-	.+	-	-	-	-	+++	-	-	-	-

- = No response; + = mild; ++ = severe; +++ = very severe.

Table 3. Oil concentration in soil planted with crops.

Time in weeks	*T. occidentalis*	*V. unguiculata*	*A. esculentus*
1	77.09 + 10.34a	90.75 + 13.29b	92.79 + 18.36b
2	40.75 + 6.83a	66.60 + 11.25c	49.98 + 10.1b
3	23.85 + 3.05a	37.38 + 3.31b	41.09 + 7.25c
4	28.09 + 1.64a	17.38 + 3.51a	37.38 + 5.50c
5	12.34 + 1.42a	11.20 + 3.31a	13.30 + 2.30b
6	5.63 + 1.03a	5.37 + 1.67a	7.15 + 1.23b

Values followed by the same letter in a row are not significantly significant.

characteristic of the seed/plant. At 14 DAP, germination percentage for *T. occidentalis* and *V. unguiculata* was higher than *A. esculentus*. The result of the 14 DAP could be attributed to the ability of the crops to possess certain physiological qualities that are essential to prevent entry of oil in the seeds/plants tissue (Jones, 1996). Studies has shown that oil can only enter cells after the membrane are injured; that is, the integrity and hardiness of the plant seeds affects the rate of penetration. Hence the seeds of *T. occidentalis* and *V. unguiculata* posses such qualities than *A. esculentus*

Previous studies (Crowley and Bicnnewr, 1996; Haby and Crowley, 1996) has shown that the process of plant degrading hydrocarbon involves the roots of the living plants which function as solar driven pumps that extract and concentrate compound and elements from the soil. In this study, from physiological view and qualitative observation, the different plants species, *V. unguiculata*, *T. occidentalis* and *A. esculentus*, differs in their root differentiation and subsequent penetration into the soil, a necessary ingredient for mineral absorption necessary for plant growth. It is then expected that plants with higher root penetration have a higher rate of modifying the rhizophere by affect-ing a wide range spectrum of biological activities capable of speeding up oil degredation and mineral absorption, thus accelerating plants growth. The higher rate of abscission showed initially with *A. esculentus* and *V. unguiculata* than *T. occidentalis* has then been justified.

Oil degredation in this study (Table 2) was higher in soil planted with *V. unguiculata* followed by *T. occidentalis* than soils with *A. esculentus* in relation to the intensities in the soil. This can also be related to their rhizofilteration abilities. (Lynch, 1990). Furthermore, it has been shown that crops with higher biomass transport more oxygen into the soil thus increasing soil redox reaction potentials, a necessity for increase oil degredation and toxicity reduction (Armstrong, 1978). The fact that oil reduction was higher in soil with *V. unguiculata* could be related to this phenomenon coupled with higher microbial activities associated with the plant (root nodules) than in *T. occidentalis* and *A. esculentus*.

From the study (Table 3), all the crops used showed great responses in oil degradation and toxicity reduction when correlated to their growths.

We recommend that crops to be grown in an oil contaminated soil should be chosen based on their physiological and biochemical qualities especially with capability of degrading and reducing oil toxicity for faster soil restoration, hence legumes and are recommended. However, long term management plan is required for effective and significant reduction in contaminant concentrations when both plant species (legumes and vegetables) are considered in phytoremediation.

REFERENCES

Armstrong W (1978). Root accretion in the Westard Condition. In: Hork DD, Clifford RMM. (Eds) plant life in anaerobic environment. Ann. Dabor. 10: 269-297.

Crowley DE, Bicnnewr MV (1996). Rhizoplane effects on the degradation of 2.5, dichlorobenzoate by a biohiminescand strain of root colinyzing pseudomonas fluorescence. Fams microbias Eco. 20: 79-89.

Haby PH, Crowley AE (1996). Biodegradation of 3 – Chlorobenzoate as affected by Hizodepostion and isolated casbin substrate. 3 Environ. Qual. 25: 304-310.

Jones IK (1996). Soil contamination and physiological qualities of plants. Int. J. Res. 6: 34-38

Lynch JM (1990). Introduction: Some consequences of Microbial rhizosphere competence for plant and soil. In: Lynch JM (eds). The Rhizosphere, John Wiley and Sons. Chichester, pp.1-9.

Nwoko JC (1995). Oil contamination and hazardous effects on plants. J. Biol. Sci. 3(7): 21-26.

Offor US, Akonye LA (2006). Amendment of crude oil contaminated soils with sawdust and chromolaena leaves for plant Protection AJB Vol. 5 SAS (1999): Statistical Analysis system guide statistic SAS institute. In: Carry N.C. USA.

Simeon OI (1993). Remadiation of contaminated soil using sawdust. Niger. J. Bot. 4(1): 45-50.