Eco-Phytochemical Studies of Plants in a Crude Oil Polluted Terrestrial Habitat Located at Iwhrekan, Ughelli North Local Government Area of Delta State

Edema, N.E.[2], Obadoni, B.O.[1], Erheni, H.[2] and Osakwuni, U.E.[2]

1. Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria.
e-mail: berndonis@yahoo.com
2. Department of Botany, Delta State University, Abraka, Delta State, Nigeria.

Abstract: Eco-phytochemical studies and analyses of soils from crude oil impacted and unimpacted sites at Iwhrehkan in Ughelli North Local Government Area of Delta State were carried out. The vegetation was sampled using a 1m x 1m quadrat along the diagonals of the heavily impacted area. A total of 3952 plants belonging to six families (Poaceae-4 species; Asteraceae-2 species; Melastomataceae-2 species; Convolvulaceae, Euphorbiaceae and Tiliaceae 1 species each) were encountered in the field. *Paspalum vaginatum* was most abundant and had a frequency of 75.1% while *Ipomoea involucrata* had the least frequency of 13%. Heavy metallic ionic concentrations of Zn, Cd, Fe, Co, Cr, As and Hg were significantly higher in crude oil polluted soil compared to the control. In contrast, sulphate, phosphate, nitrate and ammonium ions concentrations were higher in the unimpacted soil samples. Polycyclic aromatic hydrocarbons (PAH) concentrations were similar in unimpacted soil samples while they varied from one to the other in the polluted soil. Tissue analyses of mature cassava root tubers from crude oil contaminated soil showed lower concentrations of SO_4^{-2}, PO_4^{-2} and NO_3^- but higher NH_4^+ compared to the control. [Nature and Science. 2009;7(9):49-52]. (ISSN: 1545-0740).

Key words: Eco-phytochemical, crude oil, terrestrial habitat.

1. Introduction

Crude oil is a naturally-occurring hydrocarbon compound used by humans in a variety of ways: fuelling of cars, lorries and trucks; heating of homes, cooking gas and other fractions utilized in the manufacture of synthetic products. Industrialization coupled with an ever-increasing demand for petrochemicals have resulted in prospecting for more oil wells with consequent pollution of the environment. Okoloko (1974) reported the main causes of oil pollution in Nigeria to include discharge from sludge, production tests, drilling mud, spills from pipelines, well-blow outs, gas flaring and sabotage.

The effects of oil pollution vary according to the type and amount of oil involved, time of the year, degree of its weathering and age of the plant species concerned (Ajiwe, *et al* 1996). Crude oil is phytotoxic because it creates unsatisfactory conditions for plant growth ranging from heavy metal toxicity to inhibited aeration of the soil. Heavy metals such as Cu and Zn are essential for normal plant growth, although elevated concentrations of both essential and non-essential metals can result in growth inhibition and toxicity symptoms (Hall, 2002). Toxicity symptoms observed in plants exposed to oil pollution include chlorosis, necrosis, stunted growth, suppression of leaves, enormous reduction in biomass to stomatal abnormalities (Baker, 1970).

Contamination of soils by crude oil does not seem to have any adverse effect on *Fusarium moniliform* (Okafor, 1987). This species of fungus is able to utilize crude oil hydrocarbon as a source of carbon and energy for growth. Plants may tolerate sites polluted with petroleum hydrocarbon by creating a soil environment rich in microbial activity that can change the availability of organic contaminants or enhance their degradation (Cunningham and Lee, 1995).

This study is aimed at: i) identifying plant species that can tolerate crude oil polluted sites; ii) ascertain the levels of polycyclic aromatic hydrocarbons and heavy metals in impacted soils, and iii) absorption of heavy metals by cassava – the staple food of the people.

2. Materials and Methods

2.1 Study area. Ughelli, one of the big towns in Delta State is located at latitude 5.30^{0}N and longitude 5.58^{0}E. Iwhrekan, where the spill occurred is a small farming Community about 10 km from Ughelli. The bushes around Iwhrekan are cross-crossed with oil pipelines conveying crude oil to an oil terminal at Escravos. The major crop cultivated by the people is cassava; the natural vegetation is evergreen tropical rainforest but presently transiting to derived savanna as a result of excessive cultivation, reduced fallow period caused by increased population pressure. The spillage occurred on the 14th of April, 2006 due to vandalization, covered an area of 15 hectares (both heavily and slightly impacted areas). This study was carried out between August and September, 2006; no treatment was applied to the field before the samples were collected.

2.2 Sampling techniques. A heavily impacted area measuring 500 m x 500 m with the source of the spill at the centre was marked out with pegs. Two line transects were made diagonally each passing through the spot where the pipeline was vandalized. The vegetation was sampled using a 1 m x 1 m quadrat, laid along the transects at intervals of 10 m. In all, 128 quadrats were laid. Sampling along the diagonals was aimed at ensuring proper coverage of the sampled area. The data were analyzed using three quantitative measures: frequency, abundance and density.

Frequency was the number of quadrats in which a species occurred expressed as a percentage of the total number of quadrats. Density was recorded as the number of plants per m^{-2} for each plant expressed over all quadrats laid; while abundance referred to the total number of plants encountered in the field for each of the species.

Ten soil samples each collected at a depth of 10 cm from the heavily impacted and unimpacted sites were taken with a soil corer. Each sample lot was properly mixed to form homogenous mixtures. The soil samples were analyzed for polycyclic aromatic hydrocarbons (PAH), ionic concentrations of some heavy metals, phosphate, sulphate, nitrate and ammonium ions.

Tuberous roots of cassava also from heavily polluted and unpolluted sites were uprooted and analyzed for some heavy metallic ion concentrations. The soil and tuberous roots of cassava were analyzed using standard laboratory procedures as outlined by AOAC (1984).

3. Results and Discussion

A total of three thousand, nine hundred and fifty two (3, 952) plants belonging to six families were encountered in the field. The families consisted of Asteraceae–2 species, Convolvulaceae–1 species, Euphorbiaceae–1 species, Melastomataceae–2 species, Poaceae–4 species and Tiliceae–1 species (Table 1). *Paspalum vaginatum* (Sw) was most abundant among all the species with a frequency of 75.1% and a density of 10.41 m^{-2} , indicating that this species had the greatest potential to survive in oil polluted soils. *Eragrostis tenella* Linn was encountered in 64 quadrats with a frequency of 50 % compared to *Dissotis erecta* (Guill and Pers.) Dandy which occurred in 64 quadrats, had an abundance of 183 and a frequency of 50%. *D. erecta* had the same distribution with *Eragrostis tenella* Linn but a lower density of 1.42 (Table 1).

Of importance was the localized occurrence of *Digitalia longiflora* (Retz.) Pers. in only 32 quadrats with second highest abundance of 577 and a density of 4.5. This limited spread may be due to the topography of the land – which was sloppy and the species was found mainly at the upper end of the slope which did not permit the seepage of the crude deeply into the soil. The least abundant plant in the field was *Ipomoea involucrata P. Beauv* with a frequency of 13% and a density of 0.2 (Table1). Soils contaminated with crude oil contain polycyclic aromatic hydrocarbons (PAH) and heavy metals that are toxic to plants. The adverse effects of petroleum and its compounds on plant growth had earlier been reported by Gill *et al,* (1992) on *Chromolaena odorata* (L) R.M. King & Robinson. Wang and Lau (1985) had reported phytoxicity of heavy metals to the roots of *Cynodon dactylon* (Linn.) Pers. and *Eleusine indua* Gaertn. Also, the inhibition of plant growth by harmful metallic ions present in petroleum was reported by Winter, *et at* (1976).

The concentrations of anions and cations present in impacted and unpolluted soil samples varied considerably (Table 2). Phosphate, sulphate and nitrate ionic concentrations were higher in the control (unimpacted soil) compared to polluted site (Table 2). This indicated that crude oil spillage could make vital plant nutrients unavailable to plants. Total petroleum hydrocarbon (TPH) content was higher in impacted soil samples (Table 2). The toxic nature of crude oil and its components was responsible for the low number of plant families encountered in the field. Iwherekan is located in the heart of tropical rain forest known for high species diversity; many other taxa had been smothered by the spill.

The survival of cassava *(Manihot esculenta Gantz)* in the heavily impacted area was significant as it was the stable food of the people. Cassava stands smothered by crude oil were observed regenerating just below the soil surface. This showed that the economic crop was able tolerate oil-polluted site. The results of the comparative analyses of tuberous cassava roots from both crude oil impacted and unimpacted sites are presented in Table 3. Nitrate, sulphate and phosphate ions assayed in the tuberous roots of cassava from impacted soil were significantly lower than their concentrations in the unimpacted area. This showed that crude oil may have reduced the uptake and availability of these ions to cassava (Table 3). The concentrations of Cr, As, Co and Hg were similar in both cassava samples even through they were higher in impacted soil; this indicated that cassava may have a mechanism of excluding or detoxifying heavy metals thereby ensuring its survival in the polluted soil.

Baker (1980) had reported two basic strategies to heavy metal tolerance: metal exclusion and metal detoxification. The excluders prevent metal uptake into roots, avoiding translocation and accumulation in shoots (De Voss *et al.* 1991). The plants have a low potential for metal extraction but could be used to stabilize the soil. Conversely, hyperaccumulators absorb high levels of heavy metals in their cells.

About 400 species of plants that hyperaccumulate heavy metals had been reported by Prasad and Feitas (2003). Among the families documented by them to be heavy metal accmulators were Asteraceae, Brassicaceae, Caryophylaceae, Cyperaceae, Cunouniaceae, Fabaceae, Poaceae, Violaceae, Lamiaceae, Euphorbiaceae and Flacourtiaceae. In this study, members of the family Poaceae were most abundant and frequent and most tolerant to crude oil contamination. Gibson and Pollard (1988) reported that heavy metal tolerance was common in the family Poaceae. This confirmed the dominance by Poaceae in the polluted site.

The results of the study suggested that plant species documented in this report were tolerant to crude oil contamination and by extension some heavy metals which are usually high in crude oil polluted habitats. It had presented a short list of plants likely to be used in revegetating crude oil polluted lands.

Table 1. Plant species encountered in the field: their abundance, frequency (%) and density (m^2)

Plant Species	*Family*	*Number of quadrats species occurred*	*Abundance*	*Frequency (%)*	**Density (m^{-2})**
Minihot esculenta Crantz	Euphirbiaceae	64	288	50	1.78
Pasalum vaginatum (Sw)	Poaceae	96	1333	75.1	10.41
Eragrotis tenella Linn	Poaceae	64	525	50	4.10
Dissotis erecta (Guill & Perr) Dandy	Melastomataceae	64	183	50	1.42
Clappertonia ficifolia (Wild)	Tiliaceae	32	123	26	0.96
Leersia hexandra (Sw)	Poaceae	80	448	63	3.50
Aspillia africana (Pers) C.D. Adams Adams	Asteraceae	64	131	50	1.02
Digitalia longiflora (Retz.) Pers	Poaceae	32	557	26	4.5
Bidens pilosa Linn	Asteraceae	32	99	26	0.77
Dissotis rotundifolia (Sm) Triana	Melastomataceae	47	219	37	1.7
***Ipomoea involucrata* P. Beauv.**	Convolvulaceae	16	26	13	0.2

Table 2. Polycyclic aromatic hydrocarbon (PAH), Chemical properties and total petroleum hydrocarbon (TPH) contents of soils from impacted and unimpacted sites.

PAH	*Unimpacted soil sample (ppm)*	*Impacted soil sample (ppm)*	*Chemical properties*	*Impacted soil sample (ppm)*	**Unimpacted soil sample (ppm)**
Acenaphthalene	<0.001	0.085	pH	5.60	4.95
Benzo (k) fluoranthene	<0.001	0.000	Zn^{++}	16.70	8.70
Anthracene	<0.001	0.145	Cd^{++}	2.50	0.42
Benzo (a) anthracene	<0.001	0.112	Fe^{++}	36.75	21.06
Benzo (b) fluoranthene	<0.001	0.105	Co^{++}	19.40	6.10
Benzo (g) perylene	<0.001	0.000	Mn^{++}	65.80	51.70
Benzo (a) pyrene	<0.001	0.075	Cr^{++}	6.15	1.16
Chrysene	<0.001	0.036	As^{++}	0.21	<0.01
Dibenz (ah) anthracene	<0.001	0.000	Hg^{++}	0.11	<0.01
Fluranthene	<0.001	0.000	SO_4^{2-}	345.60	417.80
Flurine	<0.001	0.000	PO_4^{3-}	0.89	22.75
Indoeno (1,2,3) pyrene	<0.001	0.000	NO_3^-	116.30	267.26
Phenthrene	<0.001	0.000	$NH_4{}^+{}_4$	216.40	579.30
Pyrene	<0.001	0.000	TPH	8625.4	<1.0
perylene	<0.001	0.714			

Table 3. Concentration of ions in the tuberous roots of cassava obtained from impacted and unimpacted sites.

Ions	*Impacted soil (ionic concentrations ppm)*	**Unimpacted soil (ionic concentrations ppm)**
Zn^{++}	20.8	54.7
Cd^{++}	<0.01	<0.01
Fe^{++}	188.6	128.0
Co^{++}	<0.01	<0.01
Mn^{++}	885.6	228
Cr^{++}	<0.01	<0.01
As^{++}	<0.01	<0.01
Hg^{++}	<0.01	<0.01
SO_4^{2-}	3043.36	17722.9
PO_4^{3-}	478.36	975.7
NO_3^-	38.42	93.5
$\mathbf{NH_4^+}$	96.05	8.75

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3. **Correspondence to:**
4. Obadoni, B.O., Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria. E-mail: berndonis@yahoo.com

5. **References**
6. Ajiwe VL, Ogbuagu TJO and Dabbs WC. Pollution control in petroleum resources industries. Environmental Review 1996; 2: 15-17
7. Association of Official Analytical Chemis (A.O.A.C.) Official Methods of Analysis In F. Benjaimin (edn) 14th edn. Washington DC, USA,1984.
8. Baker JM. The effects of crude oil on plants. Environmental Pollution 1970*;* 1: 27-44
9. Baker JM. Accumulators and excluders-strategies in the response of plants to heavy metals. J. of Plant Nutrition 1981 *;* 3: 643-654
10. Cumingham SO and Lee SR. Phytoremediation: Plant-based remediation of contaminated soils and sediments. Bioremediation Science, Application, Regulation and Technology. Soil Science Society of America. Special Publication. Madison, 1995; pp 145-156.
11. De Voss CHR, Schat H, De Waal MAM, Voojs R and Ernst WHO. Increased resistance to copper-induced damage of root cell plasmalemma in copper-tolerant *Silene cucubalus. Physiol. Plant-rum 1991;* 82: 523-528
12. Gibson JP and Pollard AJ. Zn tolerance in *Panicum virgatum* L. (Switch grass) from the pitcher mine area. Proc. Oklahoma Academy of Science 1988;68:45-48
13. Gill LS, Nyawanwe HCK and Ehikhametor A. Effects of crude oil on the growth and anatomical features of *Chromolaena odorata.* Journal of Chromolaena *1992;* 5: 1-9
14. Hall JL. Cellular mechanisms for heavy metal detoxification and tolerance. J. Exp. Bot 2002*;* 53: 1-11
15. Okafor I. Effects of crude oil on the biology and pathogenicity of seedbome fungi of maize. Ph.D Thesis University of Port Harcourt, Nigeria, 1987.
16. Okoloko GE. The Problem of Oil Pollution in Nigeria. In Proceedings of Ghana's Scope Conference on Environment and Development in West Africa, 1974.
17. Prasad MNV and Feitas H. Metal hyperaccumulation in plants-Biodiversity prospecting for plytoremediation technology. Electron J. Biotechnol, 2003*;* 6(3)
18. Wang MH and Lau WM. Root growth of *Cynodon dactylon* and *Eleusine indica* collected from motorways at different concentrations of lead. Environ. Res 1985*;* 36: 257-267.
19. Winter K, Daniel RO, Batterlon JC and Ballon C. Water-soluble components of four oil chemical characteristics and effects on growth of water plants. Marine Biology 1976; 36: 269-276.

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