Research Journal of
Environmental Toxicology

ISSN 1819-3420

Academic Journals Inc.

www.academicjournals.com

Research Journal of Environmental Toxicology 1 (3): 116-123, 2007
ISSN 1819-3420

Effects of Time of Application of Crude Oil to Soil on the Growth of Maize (*Zea mays* L.)

O.M. Agbogidi, P.G. Eruotor and S.O. Akparobi
Faculty of Agriculture, Delta State University,
Asaba Campus. Delta State, Nigeria

Abstract: Field experiments were conducted at the Delta State University, Asaba Campus Teaching and Research Farm and at Delta State Polytechnic, Ozoro during the 2003 and 2004 cropping seasons to evaluate the effects of time of application of crude oil to soil on the growth of seven maize varieties viz., composite suwam 1, Hybrid 3x-yx, AMATZBR w, TZBRSYN w, AMATZBR y, TZBRSYN y and Ozoro local. 0, 5.2, 10.4, 20.8 and 41.6 mL of the oil per stand of maize served as the treatments. The experiment was laid out in a split-split-plot design with four replications. Results obtained showed that soil treatment with crude oil at four Weeks after Planting (4 WAP) died within 24 h while the plants without crude oil treatment remained intact. At 6 WAP, only the maize varieties subjected to 41.6 mL of the oil withered while composite (suwan 1), Hybrid 3x-yx and the Ozoro local withered and died on exposure to 20.8 mL of the oil. No significant differences ($p \geq 0.05$) were observed in the plants height, leaf area and stem diameter of the maize varieties tested at 8 WAP. This study has shown that the time of application of crude oil to soil has a significant effect on the growth of maize.

Key words: Time, application, crude oil, soil, growth, maize

INTRODUCTION

Since the discovery of oil in Nigeria, the nation prospered through the petroleum industry, while for the oil producing communities, it is a story of untold socio-economic and environmental devastation through spills, pipeline explosion, destruction of the ecosystem and pollution (Agbogidi *et al*., 2005). Nigeria is basically an agricultural country whose rural population is engaged largely in farming.

Maize is commonly grown in the Niger Delta-the hub of Nigeria's oil industrial activity. Though frequent spills have been reported (Awobajo, 1981; Ekekwe, 1981; Nwankwo and Ifeadi, 1983; Freedman, 1991), very few systematic studies have been conducted to evaluate the effects of crude oil on cereals especially maize. The objective of this study was to determine the effect of time of application of crude oil to soil on the growth of maize with a view to recommending the same to maize growers in oil producing areas of Nigeria.

MATERIALS AND METHODS

The study was carried out in the Teaching and Research Farm of the Department of Agronomy, Delta State University, Asaba Campus, Delta State, in 2005. Asaba is located at latitude 06°14'N, longitude 06°49'E of the equator (Asaba Meteorological Bulletin, 2003). Asaba lies in the tropical rainfall zone. The rainy season is usually between April and October, with an annual rainfall range of 1505 to1849.3 mm. The mean temperature is 28±6°C. The relative humidity is 69-8% and the monthly

Corresponding Author: O.M. Agbogidi, Faculty of Agriculture, Delta State University, Asaba Campus. Delta State, Nigeria

sunshine is 4.8 bars (Asaba Meteorological Bulletin, 2003). The other location was Ozoro (Delta State College of Agriculture Research Farm) in Isoko-North Local Government Area of the State. The area lies between latitude 6°13¹E and longitude 5°33¹N and it is under the rainforest ecological zone. Ozoro experiences double peak periods of rainfall i.e., between June/July and September /October, respectively. The annual rainfall is 2800 mm while the mean annual temperature is 31°C and relative humidity 76-90% (College of Agriculture Meteorological Station, Ozoro, 2003). Ozoro is an oil producing community with reported case of oil spillages.

A split-split-plot design with four replicates was used at each location for each set of maize varieties. Between row spacing was 0.75 m and within row spacing was 0.25 m. Two seeds were planted and the maize seedlings were thinned to one plant per hill or stand when seedlings were 12-15 cm tall or at knee level.

The experimental area was hoe-weeded as and when due to enable the plants develop under non-limiting conditions. In order to determine the minimum level of contamination that will cause damage to the plants, low levels of 0.0 (control), 5.2, 10.4, 20.8 and 41.6 mL of crude oil were applied per stand. Six stands of maize plants per sub-sub-plot per treatment were used. The oil was slowly poured from a beaker into the soil around the maize stand (ring application) at 3 WAP. Applications were carried out at 5 and at 7 WAP on fresh sets of maize plants. The volumes of crude oil used were 5.2, 10.4, 20.8 and 41.6 mL/plant. There was a control without crude oil. Visual observations of growth and development followed. Data were taken both from the contaminated and uncontaminated sub-sub-plots.

Parameters assessed were plant height (cm), leaf area (cm^2) and stem diameter (collar girth) (cm). Plant height was measured from soil level to terminal bud using a measuring tape. Leaf area was derived from the length and breath measurements of the longest leaf per plant per sub-plot and correction factor value of 0.75 was used to multiply the value of the length times breathe following the procedure of Curnard (1971). The stem diameter was determined with the use of calibrated veneer caliper. Data collected were subjected to analysis of variance and the treatment means were separated with the Duncan's multiple range tests using SAS (1996).

RESULTS AND DISCUSSION

The exposure of the maize seedlings to the crude oil at three weeks after planting showed mortality even at low concentration All the three weeks old maize seedlings from the seven varieties died within 1-24 h of the oil application with no yellowing or wilting symptoms for about 36 h after the fall. The rate and time of plant drooping were dependent on the oil concentrations. Plants subjected to higher levels of 20.8 and 41.6 mL of oil drooped earlier than those exposed to 5.2 and 10.4 mL of the oil at both locations. At 48 h after oil application, wilting of collapsed seedlings was observed and it was almost completely severe at the zone of disrupted tissue. At 72 h after crude oil application, there was observed withering (yellowing and death of the seedlings).

Five weeks old maize plants exposed to crude oil did not succumb to the injurious effect as rapidly as those exposed to the experimental spill at 3 WAP. At higher treatment levels (20.8 and 41.6 mL), their drooping and eventual death stretched over a period of 2-4 days. Although maize varieties AMATZBR w, TZBRSYN w, AMATZBR y and TZBRSYN y did not droop and die at 20.8 mL oil application, yellowing of the lower leaves was observed about two weeks after oil application. Other morphological observations included root rot, stem rot, drying of lower leaves and leaf burnt. Crude oil was observed to have noticeable effects on the morphology, growth and vigour of the plants.

The mean plant height values with the application of 5.2 mL of crude oil at 6 WAP were significantly greater than those with the treatments including the control plants at $p \leq 0.05$ (Table 1).

Table 1: Effects of different crude oil levels on plant height (cm) of maize at 6 WAP within Anwai and Ozoro locations

	Crude oil levels in soil (mL)				
Maize varieties	0	5.2	10.4	20.8	41.6
Anwai					
Composite (suwan 1)	140.00c	143.00d	134.01c	0.08d	0.03a
Hybrid 3x-yx	142.67c	158.74c	135.64c	0.02d	0.04a
AMATZBR w	162.33b	169.35ab	156.04ab	135.20	0.01a
TZBRSYN w	148.00c	156.34c	144.89bc	141.61b	0.06a
AMATZBR y	148.33c	157.87c	145.32bc	140.12b	0.05a
TZBRSYN y	146.67c	163.76b	136.76c	133.35c	0.03a
Ozoro local	172.67a	180.72a	168.54a	0.04d	0.03a
Ozoro					
Composite (suwan1)	142.23c	146.33d	138.07c	0.06d	0.61a
Hybrid 3x-yx	155.56b	160.00b	150.00b	0.40d	0.10a
AMATZBR w	166.22ab	171.23ab	156.09ab	151.63a	0.09a
TZBRSYN w	149.10c	158.56b	146.00bc	140.23b	0.02a
AMATZBR y	150.23c	159.88b	147.44bc	143.24ab	0.04a
TZBRSYN y	143.82c	166.87ab	138.36c	134.28c	0.03a
Ozoro local	175.77a	188.68a	172.66a	0.05d	0.02a

Means in the same column with same letter(s) are not significantly different ($p \geq 0.05$), using DMRT

Table 2: Effects of different crude oil levels on leaf area (cm^2) of maize at 6 WAP within Anwai and Ozoro locations

	Crude oil levels in soil (mL)				
Maize varieties	0	5.2	10.4	20.8	41.6
Anwai					
Composite (suwan 1)	180.46d	182.67d	179.04d	0.41d	0.04a
Hybrid 3x-yx	182.43d	190.33d	180.6d	0.34d	0.08a
AMATZBR w	193.80c	198.00c	189.90c	188.64c	0.12a
TZBR.SYN w	210.75bc	220.67bc	204.58bc	201.81b	0.09a
AMATZBR y	254.06ab	269.60ab	251.92ab	246.34a	0.14a
TZBRSYN y	245.56b	246.76b	242.63b	241.36ab	0.06a
Ozoro local	284.46a	290.00a	273.77a	0.32d	0.07a
Ozoro					
Composite (suwan 1)	182.42 d	185.87d	180.30d	0.11d	0.05a
Hybrid 3x-yx	190.40 c	194.66d	186.53c	0.12d	0.01a
AMATZBR w	195.62c	199.07c	190.82c	180.10c	0.05a
TZBRSYN w	212.77bc	216.79bc	206.72bc	200.06b	0.02a
AMATZBR y	256.17ab	270.56ab	252.87ab	248.89a	0.01a
TZBRSYN y	248.88b	254.48b	243.76b	239.38ab	0.08a
Ozoro local	287.56a	296.00a	284.67a	0.04d	0.06a

Means in the same column with same letter(s) are not significantly different ($p \geq 0.05$), using DMRT

Death of Composite (suwan1), Hybrid 3x-yx and Ozoro local was also observed on exposure to 20.8 mL of the crude oil while none of the maize varieties survived when subjected to 41.6 mL of the crude oil at both locations (Table 1). The leaf area (Table 2) and the stem diameter (Table 3) of the maize seedlings at 6 WAP followed the same trend in response to the application of different levels of crude oil as that obtained for the plant height (Table 1). The effects of different crude oil pollution levels on plant height, leaf area and stem diameter of the seven varieties of maize at 8 WAP are indicated in Table 4-6, respectively. No significant differences ($p \geq 0.05$) were recorded in the growth variables of the maize varieties exposed to crude oil treatments in both Anwai and Ozoro locations at 8 WAP. At 8 WAP, crude oil treatment of soil had no significant effects on the growth, morphology and vigour of the maize plants.

Three weeks old maize plants were more susceptible to crude oil effects than five and seven week old plants in the varieties studied at Anwai and Ozoro locations. The maceration of tissues of the basal stem segment of three weeks old maize plants where they had contact with experimental spill, possibly resulted in leakage of cell materials, loss of turgor and inevitable collapse of the tender plants. It also suggests damage to cell membrane by penetrating hydrocarbon molecules. Baker (1970a) and

Table 3: Effects of different crude oil levels on stem diameter (cm) of maize at 6 WAP within Anwai and Ozoro locations

	Crude oil levels in soil (mL)				
Maize varieties	0	5.2	10.4	20.8	41.6
Anwai					
Composite (suwan 1)	6.20b	6.37b	6.17b	0.01b	0.10a
Hybrid 3x-yx	6.07b	6.47a	6.02b	0.41b	0.12a
AMATZBR w	6.17b	6.27b	6.10b	6.04a	0.10a
TZBRSYN w	6.08b	6.28b	6.06b	6.01a	0.04a
AMATZBR y	6.05b	6.31b	6.02b	6.00a	0.06a
TZBRSYN y	6.06b	6.30b	6.01b	6.00a	0.02a
Ozoro local	6.27b	6.66a	6.09b	0.03b	0.01a
Ozoro					
Composite (suwan1)	6.23b	6.50a	6.05b	0.02b	0.02a
Hybrid 3x-yx	6.18b	6.43b	6.09b	0.06b	0.06a
AMATZBR w	6.20b	6.28b	6.10b	6.03a	0.08a
TZBRSYN w	6.21b	6.26b	6.18b	6.14a	0.07a
AMATZBR y	6.60a	6.68a	6.45a	6.20a	0.06a
TZBRSYN y	6.15b	6.41b	6.02b	5.97a	0.05a
Ozoro local	6.88a	6.98a	6.84a	0.24b	0.21a

Means in the same column with same letter(s) are not significantly different ($p \geq 0.05$), using DMRT

Table 4: Effects of different crude oil levels on plant height (cm) of maize at 8 WAP within Anwai and Ozoro locations

	Crude oil levels in soil (mL)				
Maize varieties	0	5.2	10.4	20.8	41.6
Anwai					
Composite (suwan 1)	208.67ab	208.65ab	207.76ab	204.67ab	203.46ab
Hybrid 3x-yx	190.33c	190.41c	184.43c	183.13c	180.33c
AMATZBR w	209.67ab	209.56ab	207.76ab	205.46ab	202.08ab
TZBRSYN w	209.00ab	208.14ab	208.04ab	206.58ab	204.84ab
AMATZBR y	203.74b	203.69b	202.91ab	201.82b	201.76b
TZBRSYN y	198.33c	198.31c	188.43c	187.84c	185.04c
Ozoro local	214.00a	214.00a	213.02a	216.03a	210.03a
Ozoro					
Composite (suwan 1)	213.76ab	213.14a	208.55ab	206.11a	205.56ab
Hybrid 3x-yx	193.44cd	193.38c	186.45c	182.23c	180.34c
AMATZBR w	214.10ab	214.18a	209.88ab	205.10ab	202.11b
TZBRSYN w	212.00ab	212.14a	211.63ab	207.98ab	205.10b
AMATZBR y	205.76b	205.34b	204.78ab	201.83b	201.11b
TZBRSYN y	191.02d	191.00c	189.56b	188.09c	187.06c
Ozoro local	219.00a	218.13a	216.06a	213.04a	212.06a

Means in the same column with same letter(s) are not significantly different ($p \geq 0.05$), using DMRT

Table 5: Effects of different crude oil levels on the leaf area (cm^2) of maize varieties at 8 WAP at Anwai and Ozoro

	Crude oil levels in soil (mL)				
Maize varieties	0	5.2	10.4	20.8	41.6
Anwai					
Composite (suwan 1)	350.38c	350.33c	350.10c	350.02c	348.08c
Hybrid 3x-yx	362.96c	361.67c	361.01c	360.00c	356.10bc
AMATZBR w	376.72bc	376.32bc	374.24bc	373.26b	371.61b
TZBRSYN w	364.33c	366.00c	349.36c	346.54c	345.46c
AMATZBR y	405.94ab	404.01ab	401.48b	400.08ab	96.16ab
TZBRSYN y	398.81b	398.48b	387.16bc	384.69b	380.97b
Ozoro local	456.96a	456.74a	446.66a	441.94a	441.46a
Ozoro					
Composite (suwan 1)	355.48c	355.56c	351.22c	350.12c	345.59c
Hybrid 3x-yx	367.92c	367.84c	351.64c	350.00c	48.00bc
AMATZBR w	378.70bc	378.44bc	375.60b	375.89b	374.72b
TZBRSYN w	366.54c	366.01bc	350.44c	348.34c	347.31bc
AMATZBR y	408.96ab	407.13ab	403.61ab	403.50ab	401.88ab
TZBRSYN y	399.86b	399.00b	389.24b	388.35b	386.43b
Ozoro local	458.98a	458.81a	450.01a	449.05a	447.10a

Means in the same column with same letter(s) are not significantly different ($p \geq 0.05$), using DMRT

Table 6: Effects of different crude oil levels on the stem diameter (cm) of maize varieties at 8 WAP at Anwai and Ozoro

	Crude oil levels in soil (mL)				
Maize varieties	0	5.2	10.4	20.8	41.6
Anwai					
Composite (suwan 1)	7.23a	7.83a	7.20a	7.08a	7.06a
Hybrid 3x-yx	7.00a	7.58a	6.48a	6.47a	6.40a
AMATZBR w	7.13b	7.83a	7.10a	7.08a	7.01a
TZBRSYN w	7.70a	7.95a	7.46a	7.34a	7.22a
AMATZBR y	8.14a	8.26a	7.90a	7.81a	7.76a
TZBRSYN y	7.07a	7.19a	7.08a	7.00a	6.98a
Ozoro local	8.01a	8.08a	7.52a	7.40a	7.34a
Ozoro					
Composite (suwan 1)	7.30a	7.46a	7.23a	7.20a	7.09a
Hybrid 3x-yx	7.07a	7.18a	6.69a	6.62a	6.60a
AMATZBR w	7.18a	7.24a	7.12a	7.10a	7.06a
TZBRSYN w	7.73a	7.77a	7.53a	7.50a	7.45a
AMATZBR y	8.16a	8.18a	7.96a	7.88a	7.82a
TZBRSYN y	8.10a	8.14a	7.12a	7.06a	7.01a
Ozoro local	8.05a	8.08a	7.66a	7.45a	7.38a

Means in the same column with same letter(s) are not significantly different ($p \geq 0.05$), using DMRT

Gill *et al*. (1992) reported penetration of living cells/tissues by oil while Van Overbeck and Blondeau (1975) maintained that hydrocarbons dissolve the plasmalemma and open it up by displacing fatty molecules. The young and tender tissues at the base of the three weeks old maize plants seemed particularly susceptible to this injurious effect. These tissues could have ruptured accordingly and leakage of cell contents that resulted could have accounted for the slimy feel of this softened zone. In the same vein, severe disintegration of cells could have taken place in the soft, slimy basal stem segment. This finding corresponds with the report of Baker (1970a). The observed faster and earlier drooping and collapsing of three weeks old maize plants exposed to higher levels of oil is in accordance with the findings of Baker (1970a) and Anoliefo (1998) that the age of plant and level of oil pollution seem to be exerting the most influence an agricultural lands and crops. Baker (1970a) further maintained that high doses of oil are more damaging than low doses due to increased anaerobic processes because there is increased utilisation of oxygen during soil degradation and this limits normal diffusion processes. This further confirmed the reports of Udo and Oputa (1984) and Agbogidi and Eshegbeyi (2006) that such poor growth could be attributed to suffocation of plants caused by the presence of inadequate air created by oil pollution.

The relative tolerance shown by the older maize plants (five week old and seven weeks old plants) may be due to their already cutinised root system. Oily scum on soil surfaces would impede oxygen and water. The anaerobic conditions created in subsoil as a result, would aid the persistence of oil. This condition makes water and essential nutrients for growth unavailable to plants (Odu, 1981). This also causes some toxic elements to be more readily available to plants thereby causing reduction in plant growth and or death (Awobajo, 1981). Similarly, death of the three weeks old maize plants subjected to all the levels of the oil including 5.2 mL and those of the five weeks old plants exposed to 41.6 mL of oil in the two locations could be attributed to the phytotoxic, hydrophobic and other stress imposing properties of crude oil. Nelson-Smith (1974) stated that the low boiling points of unsaturated hydrocarbons such as benzene, toluene, xylene and naphthalene were the most toxic components in crude oil. Similar reports have been made by Spreight (1991) and Sheretz (1998). Nelson-Smith (1974) further maintained that toxicity of crude oil was a function of the presence of these substances. The eventual death of the maize plants exposed to 41.6 mL of the oil as observed in this study could have stemmed from the toxicity of sulphides and heavy metals including manganese consequent upon the displacement of air by crude oil. Similar reports have been made by Garner (1971) and Bamidele and Agbogidi (2006). It could be probably due to a softened zone of macerated tissue at the base of seedlings that had contact with the crude oil. A weakened and usually slimy feel was typical of every collapsed seedling where the young stem had contact with the applied crude on the soil surface. Overton *et al.* (1994) had also observed that aromatic compounds in crude oil appeared to be more toxic to higher plants than aliphatic. While Odu (1972) and McCown and Deneke (1992) also reported poor performance of plants growing in oil-polluted soils, Baker *et al.* (1993) reported that oil spillage caused death of seedlings and defoliation in mangroves. The death of the maize plants may also be linked to the absorption into the tissues of high aromatic hydrocarbon components, which are very toxic. This could have led to the disturbance of osmotic balance within the plant tissue. This observation agrees with prior findings of Wilkins (1985) and Kinghorn (1989) that an alteration in the osmotic balance of plants results in poor metabolic activities and subsequent death. Crude oil penetration into the lower stem segment of five weeks old maize plants and seven weeks old maize plants could have been extremely slow or tissues in the region could be tougher and more tolerant than the three-weeks old seedlings. It may also be suggested that the combined effects of the residual phyto-toxicity of the applied crude oil and the progressively stressful conditions imposed in their root system by the oil gradually broke the resistance of the three weeks old maize plants hence they easily succumbed.

The observed poor growth in five-weeks old maize plants (AMATZBR w, TZBRSYN w, AMATZBR y and TZBRSYN y) exposed to 20.8 mL of the crude oil may also be due mainly to the difficulties in the absorption of water and nutrients by roots and also to excess of heavy metals for example manganese and iron. Udo and Oputa (1984) maintained that poor growth of plants in oil-polluted soils could be attributed to suffocation or consumption of oxygen by increased microbial activity. The disturbance of the plant-water relationship bringing about interference in the nutrient supply to plants could be considered as the primary cause of the poor plant growth in oil/gas polluted soils. Ogri (2001) posited that petroleum products impact an inhibitory effect on plant growth and development in various ways including inhibition of photosynthesis brought about by cellular impermeability. Growth reduction in crude oil polluted soils as observed in this study may also be attributed to a disruption in aeration and biological properties of the soil. This observation is in line with the findings of Dean (1968). Poor growth has also be related to adverse changes in soil-plant-water relationships and some workers including Adams and Ellis (1960), Schwendinger (1968), Baker (1970a), Terge (1984), Udo and Oputa (1984), Anoliefo and Vwioko (1994), Overton *et al.* (1994), Bamidele and Agbogidi (2000) and Odjegba and Sadiq (2002) regarded these relationships as the over riding factor accounting for poor growth of plants in oil polluted ecosystems. The researchers also attribute it to an adulterated structure of the soil. There was increase effect of oil pollution in the soil. This observation further confirmed earlier report of Gill *et al.* (1992) that root stress reduces leaf growth via stomatal conductance.

The observed chlorosis in five weeks old maize plants apart from the three varieties that died when subjected to 20.8 mL of the crude oil two weeks after the crude oil application may be due to chlorophyll destruction and cell injury. Baker (1970b) and Odjegba and Sadiq (2002) have separately demonstrated that oil affects photosynthesis and starch formation because hydrocarbons in oil tend to accumulate in the chloroplast where there is a higher lipid content than in the rest of the cytoplasm. Baker (1970b) further maintained that oil constituents could dissolve in the lipoid phase of the grana, thereby causing an increase in distance between individual chlorophyll molecules and other disruption of sub-microscopic structures required for photosynthetic activities. Yellowing of leaves may also be interpreted as a synergistic effect of some heavy metals present in the soil as a result of crude oil application to soil. This report is in accordance with the work of Bossert and Bartha (1984). Heavy metal build up in soils following oil pollution has also been reported by Gudin and Syratt (1975) Udo and Oputa (1984), Freedman (1991), Nicolotti and Eglis (1998) and Siddiqui and Adams (2002). The observed luxurious growth in five weeks old maize plants, which received 5.2 mL of oil indicated enhancement of growth (fertilizer effect). Growth stimulation of a variety of plants as a result of the presence of crude oil seems to be a fairly usual phenomenon. Schwendinger (1968) reported that plants tolerate up to 3% crude oil pollution by weight while nodule formation, development and growth in soya bean was enhanced in the soil treated with 0.75% of crude oil. This study has shown that time of application of crude oil to soil has a significant effect on the growth of maize.

REFERENCES

Adams, R.S. and R. Ellis, 1960. Some physical and chemical changes in the soil saturated with natural gas. Soil Sci. Soc. Am. Proc., 24: 41-44.

Agbogidi, O.M., B.C. Okonta and D.E. Dolor, 2005. Socio-economic and environmental impact of crude oil exploration and production on agricultural production: A case study of Edjeba and Kokori communities in Delta State of Nigeria. Global J. Environ. Sci., 4: 171-176.

Agbogidi, O.M. and O.F. Eshegbeyi, 2006. Performance of *Dacryodes edulis* (Don. G., H.J. Lam) seeds and seedlings in a crude oil contaminated soil. J. Sustainable For., 22: 1-13.

Anoliefo, G.O. and D.E. Vwioko, 1994. Effects of spent lubricating oil on the growth of *Capsicum annum* (L.) and *Lycopersicon esculentum* (Miller). Environ. Pollu., 88: 361-364.

Anoliefo, G.O., 1998. Oil spill: Effects of spent lubricant on plant life. In: Infotect today, October, 1998.

Awobajo, A.O., 1981. Analysis of oil spill incidents in Nigeria (1976-1980). In: Proceedings of an international seminar on the petroleum industry and the Nigerian environment, NNPC, Warri, pp: 57-63.

Asaba Meteorological Bulletin, 2003. National meteorological report. In: Meteorological Bulletin 2003, Lagos.

Baker, J.M., 1970a. The Effects of Oil on Plants Physiology. In: The Ecological Effect of Oil Pollution on Littoral Communities. Cowell, E.B. (Ed.). Applied Science Publishers. London, pp: 88-98.

Baker, J.M., 1970b. The Effects of Oil on Plants Physiology. In: The Ecological Effect of Oil Pollution on Littoral Communities. Cowell, E.B. (Ed.). Applied Science Publishers., London, pp: 88-98.

Baker, J.M., D.I. Little and E.H. Owens, 1993. A Review of Experimental Shoreline Oil Spills. In: Proceedings of the 1993 Oil Spill Conference. American Petroleum Institute. Washington, DC., pp: 583-590.

Bamidele, J.F. and O.M. Agbogidi, 2000. Toxicity of odidi petroleum oil and its water soluble fraction on three aquatic macrophytes. Nig. J. Sci. Environ., 2: 113-121.

Bamidele, J.F. and O.M. Agbogidi, 2006. The effects of crude oil on the seedling growth of *Machaerium lunatus* (L.) G.F.W. MED. J. Discovery Innovation, 18: 104-108.

Bossert, I. and R. Bartha, 1984. The Fate of Petroleum in Soil Ecosystems. In: Petroleum Microbiology. Atlas, R.M. (Ed.). Macmillan Publishing Co., New York, pp: 434-476.

College of Agriculture Meteorological Station, 2003. Ozoro, Delta State, Nigeria

Cunard, A.C., 1971. Maize Agronomy. World Crops, 3: 24-28.

Dean, R., 1968. The chemistry of crude oils in relation to their spillage on the sea. J. Applied Ecol., 2: 1-6.

Ekekwe, E., 1981. The Funiwa-5 oil well blow out. In: Proceedings of an international seminar on petroleum an the Nigerian environment, NNPC, Warri, pp: 64-68.

Freedman, B., 1991. Environmental Ecology: The Impact of Pollution and Other Stresses on Ecosystem Structure and Function. Academic Press, London, pp: 5.

Garner, J.H., 1971. Changes in soil and death of weedy ornamentals associated with leaking. Natural Gas Phyto-Pathol., 61: 892-897.

Gill, L.S., H.G.K. Nyawuame and A.O. Ehikhametalor, 1992. Effect of crude oil on the growth and anatomical features of *Chromolaena odorata* L. News Lett., 5: 46-50.

Gudin, C. and W.J. Syratt, 1975. Biological aspects of land rehabilitation following hydrocarbon contamination. Environ. Pollut., 8: 107-112.

Kinghorn, R.F., 1989. An Introduction to Physics and Chemistry of Petroleum. John Wiley and Sons, New York, pp: 342.

McCown, D.D. and F.J. Deneke, 1992. Plant Germination and Seeding Growth as Affected by the Presence of Crude Petroleum Oil. In: Proceedings of Symposium on the Impact of Oil Resource Development on Northern Plant Communities. University of Alaska Publication, pp: 44-51.

Nelson-Smith, A., 1974. Oil Pollution and the Marine Ecology. Paul Clerk Scientific Ltd., London, pp: 236.

Nicolotti, G. and S. Eglis, 1998. Soil contamination by crude oil: Impact on the mycorrhizosphere and on the revegetation potential of forest trees. Environ. Pollut., 99: 37-43.

Nwankwo, N. and C.N. Ifeadi, 1983. The status of oil spill contingency planning in Nigeria. In: Proceedings of the international seminar on the petroleum industry and the Nigerian environment. NNPC, Port Harcourt, pp: 93-105.

Odjegba, V.J. and A.O. Sadiq, 2002. Effects of spent engine oil on the growth parameters, chlorophyll and protein levels of *Amaranthus hybridus* L. The Environmentalist, 22: 23-28.

Odu, C.T.I., 1972. Microbiology of soils contaminated with petroleum hydrocarbons1: Extent of contamination and some soil and microbiological properties after contamination. Am. J. Inst. Pet., 58: 201-208.

Odu, C.T.I., 1981. Degradation and weathering of crude oil under tropical conditions. In: Proceedings of seminar on the petroleum industry and the Nigerian environment. Fed` Ministry of Works and Housing and NNPC, Warri, pp: 84-91.

Ogri, O.R., 2001. A review of the Nigerian petroleum industry and the associated environmental problems. The Environmentalist, 21: 11-21.

Overton, E.B., W.D. Sharp and P. Roberts, 1994. Toxicity of Petroleum. In: Basic Environmental Toxicology. Cockrham, L.G. (Ed.). CRC Press, Inc., pp: 133-156.

Schwendinger, R.B., 1968. Reclamation of soil contaminated with oil. J. Ins. Pet., 54: 182-197.

Siddiqui, S. and W.A. Adams, 2002. The fate of diesel hydrocarbons in soils and their effect on the germination of perennial ryegrass. Environ. Toxicol., 17: 49-62.

Sheretz, P.C., 1998. Petroleum products. A Bulletin released by Virginia Department of Health, Richmond Virginia, pp: 2.

Spreight, J.G., 1991. The Chemistry and Technology of Petroleum. M. Dekker Publishers, New York, pp: 209.

Statistical Analytical System (SAS), 1996. User's guide. Statistics version, Raleigh, N.V. USA., pp: 956.

Terge, K., 1984. Effect of oil pollution on germination and vegetative growth of five species of vascular plants. Oil Pet. Pollut., 2: 25-30.

Udo, E.J. and C.O. Oputa, 1984. Some studies on the effect of crude oil pollution of soil and plant growth. J. Biol. Applied Chem., 29: 3-14.

Van Overbeck, J. and R. Blondeau, 1975. Mode of action of phyto-toxic oil. Weeds, 3: 55-65.

Wilkins, M.B., 1985. Advanced Plant Physiology. Pitman Publishing Ltd., London, pp: 432.