Assessment of the Effect of Kerosene Spill on the physicochemical properties of Soil ten years after Spill at Maikunkele, Niger State Nigeria

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Abstract: Assessment of the effect of kerosene spill on the physicochemical properties of soil ten years after spill at Maikunkele, Niger State was carried out. The pH of the KPS increased from 5.52 to 6.48 while that of the KFS was erratic and ranged from 6.06 to 6.85. There was no significant difference in moisture, nitrogen, organic carbon and available phosphorus contents. There was no significant difference between the height, number of leaves and length of leaf of maize plants in both soils indicating that the polluted soil has recovered greatly. It was observed that when the soil was intentionally polluted with kerosene there was no emergence of maize seedlings at any of the concentrations of kerosene (1%, 3%,5%) used indicating a clear case of phytotoxicity resulting from treatment application which would have been the case if kerosene spill still persisted in the impacted soil.

Key words: Kerosene spill, Physicochemical, Soil, Phytotoxicity

I. Introduction

The soil is a key component of natural ecosystems and environmental sustainability depends largely on a sustainable soil ecosystem. In Nigeria, most of the terrestrial ecosystem and shorelines in oil producing communities are important agricultural land under continuous cultivation. Any contact with petroleum hydrocarbon results in damage to soil condition of these agricultural lands, microorganisms and plants. Petroleum hydrocarbon polluted soils are of environmental concern because they are unsuitable for agriculture and recreational uses, and are potential sources for surface and ground water contamination. Generally speaking, high concentration of petroleum hydrocarbon in an environment is harmful to soil biota and crop growth. Oil spills affect soil fertility adversely and cause alterations in soil physicochemical properties (Abii and Nwosu, 2009). However, there are varying reports on the effects of oil spills on soil physicochemical properties. Significant increase in total nitrogen and organic carbon of soil have been observed as a result of oil pollution. The increase in total nitrogen is attributed to increased atmospheric nitrogen fixation during the oil degradation process while increase in organic carbon could be caused by the carbon present in the petroleum or high carbon/nitrogen resulting from petroleum addition to the soil (Ijah *et al.,* 2000). Available phosphorus in soil can also be increased by petroleum spill. This may be due to the production of soluble ferrous phosphate under reducing conditions. In a study by Ijah *et al (2000), it* was observed that available phosphorus of the soil decreased due to oil spill and attributed the decrease to the proliferation of petroleum degrading microorganisms in the soil which utilized the available phosphorus during petroleum biodegradation process. Reduction in moisture content of oil-contaminated soil relative to normal soil has been observed (Obire and Nwanbet, 2002). This has been due to two factors. Firstly, the hydrocarbon in petroleum could render some soil surfaces hydrophobic thereby reducing the water holding capacity of the soil. Secondly, hydrocarbon pollution reduces the bulk density of soil while it increases the porosity of such soil. In such situations, soil aggregates are broken down and dispersion results. The soil is prone to erosion than normal soils (Okoh, 2006). Petroleum pollution also decreases soil pH. The decrease in soil pH could be due to oil breakdown process which results in the building up of acidic metabolites (Celen and Kilic, 2004).

In Nigeria, most of the terrestrial ecosystem in oil producing and non oil producing communities are important agricultural land under cultivation. Any contact with petroleum hydrocarbon results in damage to soil condition of this agricultural lands, microorganisms and plants (Onuoha *et al.,* 2003). The main aim of the study was to assess the physicochemical properties of the soil impacted by kerosene at Maikunkele, Niger State, ten years after the spill, to ascertain if the impacted area has recovered completely. The specific objectives of the study were, to assess the effect of kerosene on the physicochemical properties of the soil and to assess the rates and the total extent at which residual kerosene in the soil was degraded.

II. Materials and Methods

Description of Study Site: The study site was kerosene spilled soil at Maikunkele, Bosso Local Government Area of Niger State, Nigeria. The kerosene spill covered an area of 1800m^2. The spill occurred in August 1998, when a tanker carrying several thousands litres of kerosene spilled its content on a field near Airport Junction at Maikunkele, Bosso Local Government Area of Niger State (Ijah

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et al., 2000). The spillage withered grasses and shrubs for a period of over one year (Ijah *et al.*, 2000). At the time of first sampling in April 2008, the affected site was covered with grasses such as *Ajaratum coinzoides*, *Cylindrica indica*, *Sida acuta, Bohavia diffusa* and *Aspilla africana*, similar to the unpolluted control site. The soil particle analysis revealed that the study site is made up of coarse sand, fine sand, and clay. Thus, the soil is a sandy loam soil with a good drainage system.

Collection of Samples: The kerosene polluted site was divided into two plots of $900m^2$ each. Four soil samples were collected from each plot at random, making a total of eight bulk samples. The kerosene free soil was also divided into two plots of $900m^2$ each and the samples were similarly collected. The samples were collected in polythene bags each month, for a period of six months (April-September) and transported to the laboratory for analysis.

Determination of Physicochemical Properties of Polluted Soil

P^H - using P^H meter: The pH of both kerosene polluted and control soil was determined using pH meter (Crison Micro pH 2000 model). Five grammes (5g) of soil sample was suspended in 25ml of distilled water and mixed well. The pH meter was standardized at pH 7.0 using phosphate buffer solution after which the pH of the soil samples was determined by inserting the electrodes of the pH meter into the partly settled suspension.

Moisture: Moisture content of the soil samples was determined using dry weight method (Black, 1965). The loss in weight of the sample during drying is the moisture content. It was calculated using the formula below:

$$\% \text{ Moisture content} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

W_1 = weight of the dried dish without soil sample

W_2 = weight of the dish + weight of soil sample before drying

W_3 = weight of the dish + weight of soil sample after drying.

Organic matter: Organic matter content was determined using Walkley-Black (1965). This involves the use of 1N K_2Cr_207, H_2SO_4 and Ferroin indicator to titrate with 0.5N FeS04 solution. The percentage organic matter content was calculated according to the formula below:

$$\% \text{ organic matter in soil} = \frac{(NK_2Cr_20_7 - NFeS0_4) \times 0.003 \times 100 \times (f)}{\text{Weight (g) of air-dry soil}}$$

correction factor, f = 1.33

N = Normality of solution × ml of solution used

% organic matter in soil = % organic carbon × 1.729

Nitrogen: Nitrogen content of the soil samples was determined using macro kjeldah method (Black, 1965). The formula below was used to calculate the amount of nitrogen in the soil sample:

$$\text{Amount of nitrogen (\%)} = \frac{V_1 - V_0}{10 \times \text{weight of sample (0.25g)}}$$

V_1 = titre value for the sample

V_0 = titre value for the blank

Available phosphorus: The phosphorus content of the soil was determined using Jackson-Murphey (1962) method. 4.5g of air-dried soil passed through 2mm sieve was weighed into a 50ml capacity centrifuge tube and 30ml of extracting solution was added. The solution was shaken for one minute on a mechanical shaker and centrifuged at 2,000 revolutions per minute (rpm) for 15minutes. The suspension was decanted into an acid washed container 5ml of the extract was pipette into 50ml volumetric flask and distilled water was added to bring up the volume to approximately 40ml, 8ml of Antimony potassium tartarate was added and mixed thoroughly. The absorbance or optical density of the coloured solution was read at 882nm wavelength after 30minutes using spectrophotometer.

Plant Toxicity Studies: To determine if the kerosene polluted soil has recovered, soil was collected from the kerosene polluted site and kerosene free site and 1kg was weighed into each pot. Three pots contained polluted soil while the other three pots contained unpolluted soil. However another three pots that contained unpolluted soil (control) were treated with 1%, 3% and 5% kerosene respectively. Three maize seeds were planted per pot at 1cm depth on a 5cm x 5cm spacing. The experiment were placed outside the laboratory and watered daily. Observation was made on the growth of the plant, plant height, number of leaves, leaf length were recorded at an interval of three days for the period of fifteen days. Plant height was measured from the soil level to the terminal bud using a transparent meter rule, number of leaves were by visual counting of the leaves as the plant grew. Leaf length was measured from the lateral bud to the tip of the leaf (Odjegba and Sadiq, 2002).

Statistical analysis: The physicochemical properties in this study were analysed statistically using parametric tests involving the Analysis of Variance (ANOVA).

Results: The result reveals that the pH of kerosene polluted soil ranged from 6.12 to 6.48 while that of kerosene free soil ranged from 6.06 to 6.85 (Table 1:0). The results revealed that the pH values of kerosene free soil were higher in April to June and in August compared to those of kerosene polluted soil. The moisture content of kerosene polluted soil ranged from 5.45% to 7.60% while that of kerosene free soil ranged from 5.40% to 7.40% (Table 1:1). The moisture content of kerosene free soil were higher in April, May, July and the September than that of kerosene polluted soil. Statistical analysis of the data showed that pH of both sites were significantly different ($P<0.05$). However, no significant difference ($P > 0.05$) existed in the moisture levels of the two sites.

Table 1:0. PH of kerosene polluted and kerosene free soil

Months	kerosene polluted soil	Kerosene free soil
April	6. 21	6.28
May	5.52	6.45
June	6.48	6.85
July	6.12	6.06
August	6.42	6.49
September	6.38	6.32

Table 1:1. Moisture contents of kerosene polluted soil and kerosene free soil

	Moisture level (%) of:	
Months	kerosene polluted soil	Kerosene free soil
April	6.33	6.91
May	5.88	5.94
June	7.60	7.40
July	5.45	5.76
August	5.56	5.40

September	5.55	5.65

The results revealed that the nitrogen content of kerosene polluted soil ranged from 0.014% to 0.018% while that of kerosene free soil ranged from 0.014% to 0.017% (Table 1:3). The results indicated that there was availability of more nitrogen in kerosene polluted soil in April, June and August than kerosene free soil.

Statistical analysis of the data showed that the nitrogen contents of both sites were not significantly different (P>0.05).

The results revealed that the available phosphorus level of kerosene polluted soil ranged from 1.54ppm to 1.95ppm while that of kerosene free soil ranged from 1.47ppm to 1.91ppm (Table 1:4). The phosphorus level of kerosene polluted soil was higher than that of kerosene free soil, throughout the period of study. However, there was no significant difference (P> 0.05) in the phosphorus level of the two sites.

Table 1:3. Nitrogen content of kerosene polluted soil and kerosene free soil

	Nitrogen content (%) of:	
Months	kerosene polluted soil	Kerosene free soil
April	0.018	0.012
May	0.014	0.014
June	0.017	0.015
July	0.016	0.017
August	0.018	0.016
September	0.016	0.017

Table 1:4. Available phosphorus content of kerosene polluted soil and kerosene free soil

	Available phosphorus (ppm) of:	
Months	kerosene polluted soil (ppm)	Kerosene free soil (ppm)
April	1.93	1.91
May	1.54	1.47
June	1.95	1.90
July	1.92	1.88
August	1.87	1.82
September	1.92	1.84

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The results revealed that the organic carbon of kerosene polluted soil ranged from 4.0% to 8.4% while that of kerosene free soil ranged from 4.2% to 8.6% (Table 1:5). The organic carbon of kerosene free soil was higher than that of kerosene polluted soil from April till September (Table 1:5). However, statistical analysis revealed that no significant difference (P >0.05) existed in the organic carbon contents of the two sites.

Table 1:5. Organic carbon content of kerosene polluted soil and kerosene free soil

	Organic carbon (%) of:	
Months	kerosene polluted soil	Kerosene free soil
April	7.6	8.5
May	5.2	5.6
June	4.0	4.2
July	5.8	6.5
August	6.2	6.8
September	8.4	8.6

The results revealed that the height of maize plants (Plate 1*)* in kerosene polluted soil ranged from 3.0 cm to 6.5 cm while in kerosene free soil the height of plant ranged from 2.5 cm to 6.2 cm (Table 1:6). The height of plants in kerosene polluted soil and kerosene free soil increased gradually from 3days to 15days after planting. Generally, the height of the plants were higher in kerosene polluted soil than in kerosene free soil. Using Analysis of Variance, ANOVA, it was revealed that the difference in height of plants between the two sites was not significant (P>0.05).

The results revealed that the number of leaves of maize plants (Plates 1) in kerosene polluted soil ranged from 2.0 to 6.0 while in kerosene free soil the number of leaves ranged from 1.0 to 5.0 (Table 1:6). The number of leaves in kerosene polluted soil and kerosene free soil increased gradually from 3days to 15days after planting. It was however observed that there was no significant difference (P>0.05) in number of leaves in both soils.

The results revealed that the length of leaves of maize plants (Plate 1:0) in kerosene polluted soil ranged from 5.0cm to 24.0cm while in kerosene free soil the length of leaves ranged from 5.0cm to 22.0cm (Table 1:6).

Plate 1:0. Maize seedlings in kerosene polluted soil (KPS) and kerosene free soil (KFS).

Table 1:6. Growth indicators on maize grown on kerosene polluted soil

Time	Height of plants(cm)		Number of leaves		length of leaves (cm)	
(days)	KPS	KFS	KPS	KFS	KPS	KFS
3	3.0	2.5	2.0	1.0	5.0	5.0
6	4.0	3.0	3.0	3.0	7.0	7.0
9	5.5	5.0	4.0	4.0	13.0	12.0
12	6.3	6.0	5.0	5.0	20.0	19.0
15	6.5	6.2	6.0	5.0	24.0	22.0

KPS: Kerosene polluted soil, KFS: Kerosene free soil

The results indicated that the length of leaves in kerosene polluted soil increased sharply from 3days to 15days after planting. Similar trend was observed in the kerosene free soil. Generally, the length of leaves in kerosene polluted soil were relatively longer than those of kerosene free soil. Statistical analysis of the data revealed that there was no significant difference ($P>0.05$) in length of leaves in both soils. The effect of kerosene on various growth parameters of maize is presented in Table 1:7. There was no emergence of maize seedlings at any of the concentrations of kerosene (1%, 3%, 5%) used, which is a clear case of phytotoxicity resulting from treatment application (Plate 1:1). In the control experiment, where no kerosene was applied the seeds germinated and the plants grew (Plate 1:0).

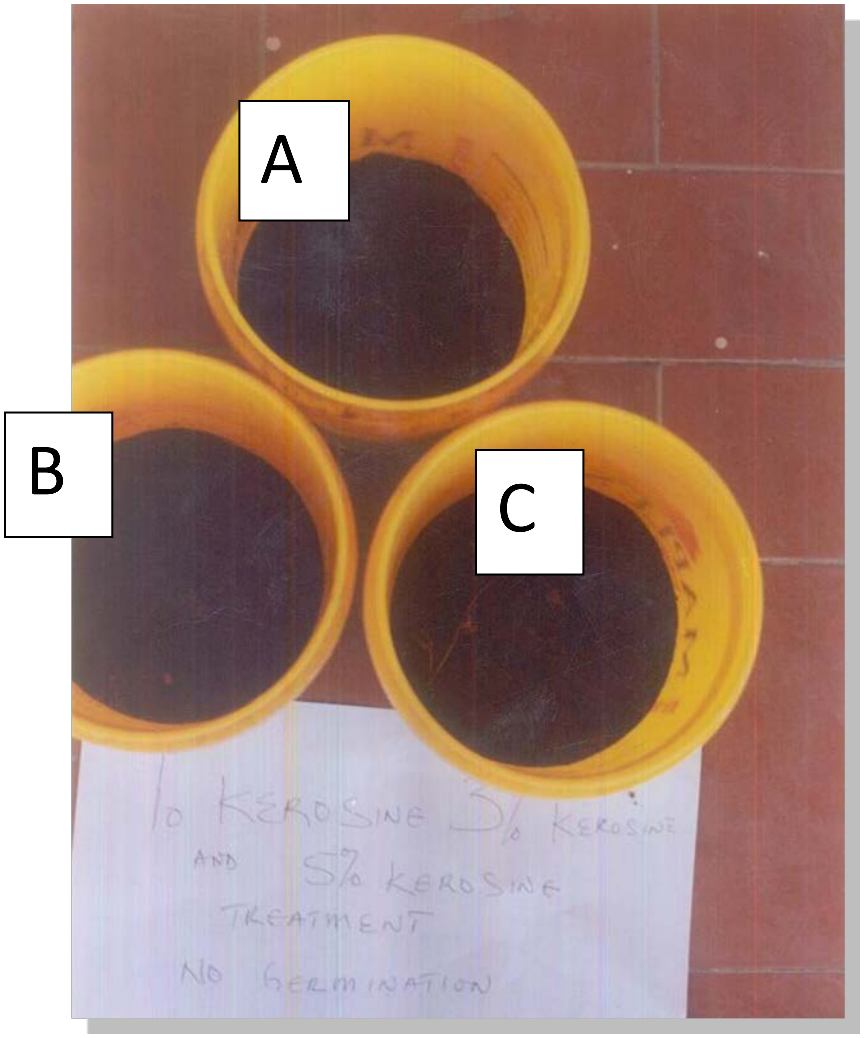

Plate 1:1. Growth parameters of maize in soil intentionally polluted with: A: 1% Kerosene, B: 3% kerosene, C: 5% kerosene.

Table 1:7. Growth parameters of maize in soil intentionally polluted

Kerosene in soil (%)	15 DAP			
	Seed germination	Plant height.(cm)	Leaf number	Leaf length (cm)
1	NSG	-	-	-
3	NSG	-	-	-
5	NSG	-	-	-

DAP : Days after planting, NSG: No seed germination, -: Negative result

III. Discussion

The PH values of kerosene polluted soil were lower as compared to those of kerosene free soil, a finding which is in line with the report of Ijah and Abioye (2003). The decrease in pH of kerosene polluted soil may be due to the increased degradation of kerosene by microorganisms in the soil, which resulted in accumulation of acidic metabolites (Ijah and Abioye, 2003). There was no significant difference in moisture content between kerosene polluted soil and kerosene free soil. This may be due to the fact that kerosene is a light fuel that cannot coat the soil to prevent the penetration of water as compared to heavy oil. The slight increase in nitrogen content of kerosene polluted soil in some sampling months as compared to those of kerosene free soil maybe attributed to the activities of nitrogen fixing bacteria whose presence has been reported in petroleum hydrocarbon polluted soil (Obire and Nwanbet, 2002).The observed increase in available phosphorus in the kerosene polluted soil maybe due to the existence of reducing conditions at the polluted site that made iron phosphate more soluble and which brought some phosphorus into solution (Obire and Nwanbet, 2002). The higher values of phosphorus level in KPS than KFS were in conformity with the findings of Ijah and Abioye (2003). The organic carbon content of kerosene free soil was higher as compared to kerosene polluted soil. However, decrease in organic carbon content of kerosene polluted soil may be due to rapid degradation of kerosene by micro organisms of the soil, since reduced organic carbon in petroleum hydrocarbon is a source of energy for microorganisms (Obire and Nwanbet, 2002).There was no significant difference between the height, number of leaves and length of leaf of maize plants in both kerosene polluted and kerosene free soils indicating that the polluted soil has recovered greatly. It was observed that when the soil was intentionally polluted with kerosene there was no emergence of maize seedlings at any of the concentrations of kerosene (1%, 3%, 5%) used indicating a clear case of phytotoxicity resulting from treatment application which would have been the case if kerosene spill still persisted in the impacted soil. The result of the study is in conformity with the reports of Odjegba and Sadiq (2002) and Hazel (2005) that oil pollution inhibits seed germination and plant growth.

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