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**Archives of Applied Science Research, 2011, 3 (3):514-521**

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**ISSN 0975-508X**
**CODEN (USA) AASRC9**

# The Omoku old pipeline oil spill: Total hydrocarbon content of affected soils and the impact on the nutritive value of food crops

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## ABSTRACT

*The post crude oil spill impact assessment of Omoku soils, four years after oil-pipeline leakage, was carried out, using soil samples obtained at two core depths of 0-15 cm and 15-30 cm, for the gas chromatographic determination of the total hydrocarbon content (THC). Cassava tuber samples harvested from crude oil impacted soils were used for the proximate analysis by the methods of Association of Official Analytical Chemists. All the surface soils from the sampled plots (quadrats) had higher THC than the control (15.58±0.16mg/kg), while the sub-surface soils from the sampled plots except quadrat 21 (20.56±0.23mg/kg) had higher THC relative to the control (with 39.48±0.24mg/kg). Proximate analysis showed that the cassava tubers grown on the crude-oil impacted soil contained 63.95±3.40% moisture; 0.58±0.10% ash; 0.44±0.05% crude protein; 1.20±0.05% crude lipid; 1.56±0.12% crude fibre; 32.27±1.30% total carbohydrate; and calorific value of 141.64 Kcal/100g sample. Comparative proximate analyses of the cassava tubers harvested from oil-spilled soils over those from the non-oil-spilled soils revealed increases in moisture content (4.91%), ash (13.8%), lipid (74.2%), fibre (9.62%) and decreases in protein content (68.2%), total carbohydrate (12.3%) and calorific value (6.38%). These indicate that the oil impacted soils had not been fully rehabilitated at the time of sampling.*

**Key Words**: Remediation, Proximate analysis and Pollution.

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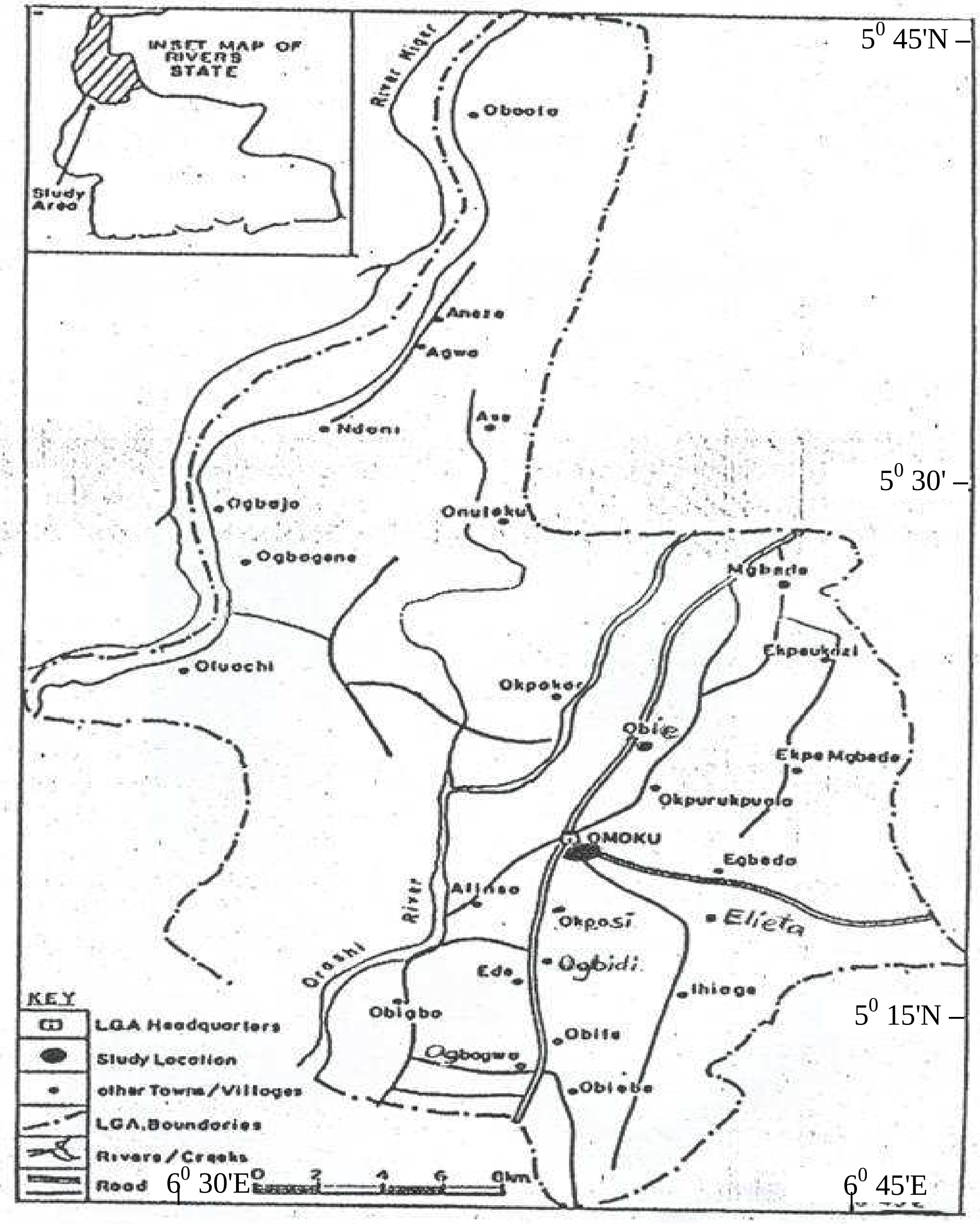
## INTRODUCTION

The increasing explorative and exploitative activities of oil companies in all the nook and cranny of the Niger Delta area of Nigeria, and the successful drilling and piping of the crude oil to their refining/storage depots have led to a number of incidental discharges or spills of crude oil into the environment. Most of the terrestrial ecosystems and shorelines in the oil producing communities however encompass important agricultural land and are under continuous cultivation [1]. The Niger Delta region of Southern Nigeria has a large number of oil and/or gas fields. The gases and/or oils are exploited, explored and conveyed to their refining/storage depots mainly through pipelines which criss-cross the sensitive ecological terrains of the communities in this region.

**FIGURE 1: Map of the study site**




On land and in swamps, the pipelines are specially trenched according to soil conditions and topography, among other factors. The soil ecosystem is usually polluted by crude oil when it is incidentally discharged (spilled) into the environment, due to various reasons ranging from failure of production equipment to operational mishaps, or intentional damage to production facilities, otherwise known as sabotage [2].

One of the methods of determining whether an area is polluted is by estimating the total hydrocarbon content (THC) of impacted soil. Records of THC taken seasonally would enhance our ability to confirm the extent of pollution, especially by comparing the data from virgin areas or available baseline data from regulatory bodies. Usually, when oil spills on shore or near shore, it inevitably affects the soil ecosystem, a prime factor in agricultural productivity. Any contact with oil may result in damage of soil properties and plant communities [3]. Oil exerts adverse effects on soil conditions, microorganisms and plants [3][4][5]. Oil has been reported to be increasingly deleterious to soil biota and crop growth [6]. The spilled oil may also, sometimes, result in serious conflagration that may consume several acres of arable land [2][7][8]. Usually, clean-up (remediation) measures are carried out by oil prospecting companies in oil impacted areas in compliance to the directives of the Federal Environmental Protection Agency (FEPA) of Nigeria. The effectiveness of the clean-up measures adopted by the oil prospecting companies in many cases is doubtful, judging from the retarded growth of plants in such oil impacted soils, as well as chlorosis of leaves of plants, dehydration of plants and the attendant low agricultural yield that still manifest many years after the recorded incidence of the spill and purported clean-up [2]. It is against this background, predicated by the crude oil leakage of Omoku Old Pipeline of April, 2002 that we decided to investigate the total hydrocarbon content (THC) of soils affected by the oil spillage four years after the recorded incident of the spill and purported clean-up, with a view to determining the effect of the spill on the productivity and/or nutritive value of food crops grown in the oil impacted soil.

## MATERIALS AND METHODS

### 1.2.1. Site Description

The study site is the Old Pipeline Road in Omoku, the headquarters of Ogba/Egbema/Ndoni Local Government area of Rivers State, Nigeria. The site (figure 1) is located east of Orashi River, bounded by Okposi (South), Obie (North) and Egbada (East), at the border of the mangrove swamp forest of the Niger Delta, near the fresh-water swamp complex.

The spillage occurred in April 2002, and emanated from a high pressure pipeline leakage, spilling several thousands barrels of crude oil into the environment (Fig. 2).

**FIGURE 2: Superficial patches of the spilled oil on soil and vegetation**

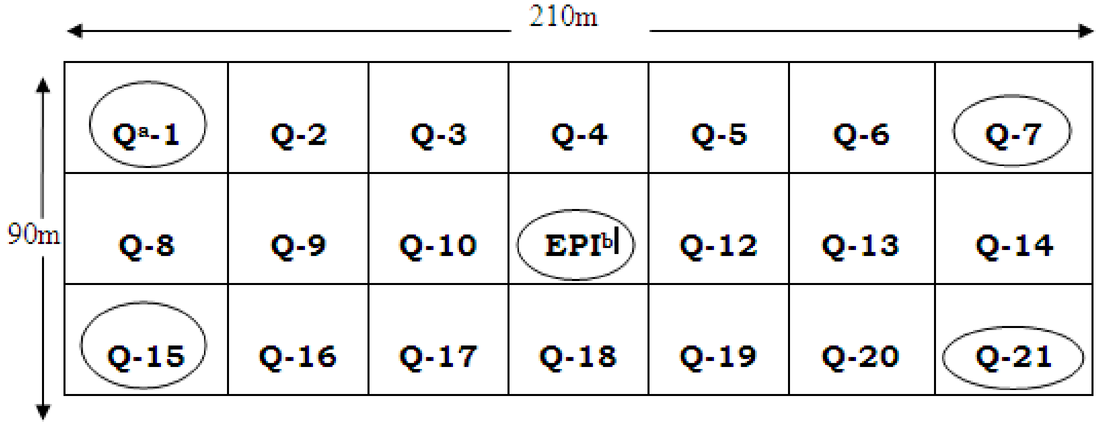
A geographically similar virgin area, unaffected by the oil spillage, located five kilometres adjacent to the oil-polluted site was chosen as a control (reference) site

### 1.2.2. Field Reconnaissance and Sampling Techniques

Field reconnaissance surveys were carried out to confirm the occurrence of oil spill and assess the extent of oil pollution.

Soil samples were collected on the second day of field reconnaissance according to the following method: a sampling area measuring 210m long by 90m wide was delimited around the epicentre of the oil spill polluted site. The area was divided into 21 grid plots, each measuring 30m by 30m, and about 25% of these plots (exactly 5) selected diagonally across the epicentre as shown in figure 3.

**FIGURE 3: Experimental layout of the study site**




KEY
[a]*Q: Quadrat*
[b]*EPI: Epicentre*
*Circled quadrats were the sampled ones.*

From each of the grid plots (quadrats) three replicate soil samples were taken from two core depths: top surface (0-15cm) and sub-surface (15-30cm). This was done by removing litter from the predetermined area inside each quadrat, using a long trowel. The same three replicate soil samples were also taken from the control site for each of the top surface and sub-surface depths. The samples were wrapped with aluminium foil, labelled accordingly, and taken o the laboratory for subsequent analyses. For the cassava tubers, three replicate tubers each were harvested from the oil-spilled site and non-oil spilled (control) site. They were also labeled accordingly and taken to the laboratory for the proximate analyses.

### 1.2.3. Soil pH analysis

Soil pH was determined according to the standard electrometric method as reported by Nwinuka *et al* [9].

### 1.2.4. Determination of total hydrocarbon content (THC)

The determination of the THC of the soil samples was carried out by the use of gas chromatographic (GC) technique as reported by Osuji, [10].

### 1.2.5 Proximate analysis of cassava tuber

The proximate composition of the cassava sample was determined using the methods of the AOAC [11].

(a) Moisture content – Thermal drying (air oven) method was used in the determination of moisture content of the sample.
(b) Ash content – This was determined by using the ignition method.
(c) Crude protein content – This was estimated by the use of macro-Kjeldahl method of Kjeldahl [12], to determine first, total organic nitrogen (TON). Percentage crude protein was obtained by multiplying the TON by the factor 6.25, since proteins on the average contain 16% nitrogen.
(d) Crude lipid content – This was done by using soxhlet type of the direct solvent extraction method as reported by Nwinuka *et al* [13].
(e) Crude fibre content – This was estimated by the AOAC acid and alkaline digestion methods [11].
(f) Total carbohydrate content – This was calculated by difference, as reported by Nwinuka *et al* [13].
(g) Calorific values – The calorific values of the cassava tuber (Kcal/100g of sample) were calculated using the Atwater factors of 4, 9 and 4 for protein, lipid and carbohydrate, respectively, to multiply their mean values as reported by Onyeike *et al* [14].

### 1.2.6 Statistical Analyses

Sample mean was calculated for the three replicate samples. The standard deviations were used to calculate the standard errors (± S.E) as reported by Osam [2]. Standard error (S.E) was estimated at the 95% confidence level by multiplying the standard error with 1.96.

## RESULTS AND DISCUSSION

### 2.1.1. Soil pH

Top surface and sub-surface soils have mean pH values of 6.04±0.05 and 6.14±0.03 respectively, which indicate that the oil-spilled soils were slightly acidic. The control site has a slightly alkaline pH of 7.04±0.06 and 7.43±0.07 for the surface and sub-surface soils respectively. Thus, the pH of the oil-impacted soils (at both depths) was relatively lower than the background control soils. While the oil spill may have had some direct impact in lowering the pH, it is more likely that the production of organic acids by microbial metabolism is responsible for the difference [15]. The soil pH can be elevated by aeration to complete the microbial-mediated oxidation of organic acids, followed by the addition of agricultural lime to provide some buffering capacity to the soil [2].

### 2.1.2 Total hydrocarbon content (THC)

The result of the total hydrocarbon content (THC) for each sampled plot is given in Figure 4. HC's of the soils give an empirical insight into the level of hydrocarbon pollution on site [1][2]. All the surface soils from the sampled plots had higher total hydrocarbon contents than the control (15.58±0.16mg/kg); while all the sub-surface soils from the sampled plots except quadrat 21 (20.56±0.23mg/kg) had higher THC relative to the control which has 39.48±0.24mg/kg. These results indicate that the THC of the oil-spilled soils was higher than that of the control in both the surface and sub-surface soils. In other words, the remediation carried out at the oil-spilled site was not effective as a good number of the sampled plots contain high level of hydrocarbon concentration that far exceeds the 50 mg/kg compliance baseline limit set for petroleum industries in Nigeria [16].

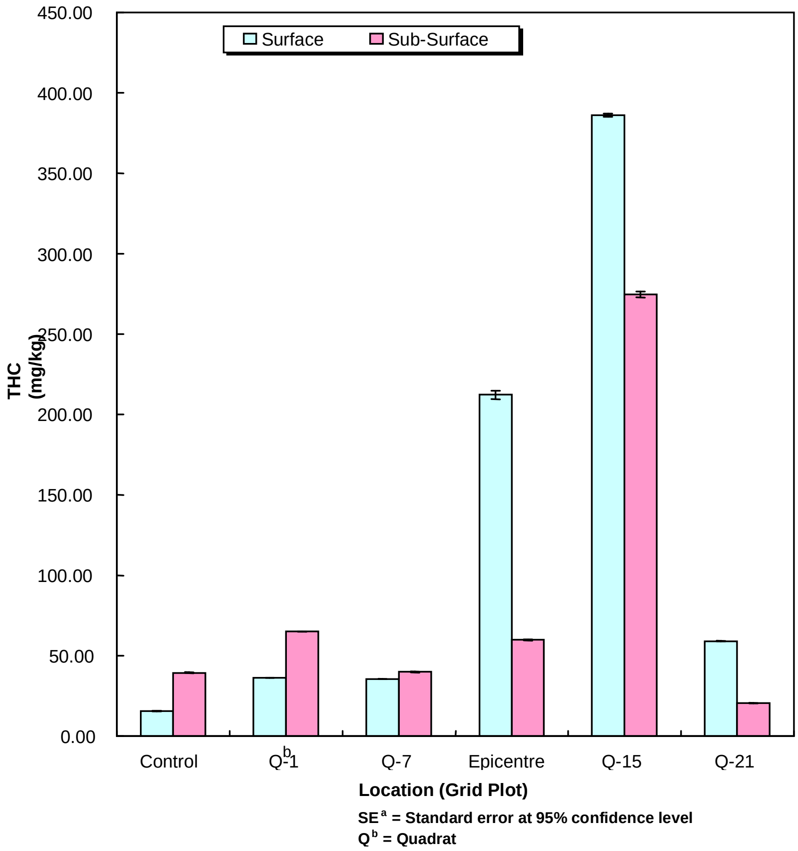



**Figure 4: Mean THC, mg/kg (±S.E[a]) of oil spilled soils at Omoku Old Pipeline Road**

The observed concentration of petroleum hydrocarbon in the oil impacted soil is capable of creating anoxic conditions in surface and sub-surface soils because the oil film reduces gaseous diffusion and increases the presence of anaerobic organisms, which deplete available oxygen [1][10]. Depletion of oxygen in the affected soil environment increases the stress to living organisms (both surface and subterranean biota), some of which may eventually die of asphyxiation [1][10]. Plant growth particularly is discouraged which in turn affects animals that depend on such plants for food and shelter.

### 2.1.3. Proximate analyses of cassava tuber

The proximate composition (on dry weight basis) and calorific values of the cassava samples studied are given the table legend below.

The crude protein, total carbohydrate and calorific value of the cassava tubers harvested from the non-oil impacted soil was higher than those of the tubers harvested from the crude-oil impacted soils. This indicates that the oil spill affected the productivity or yield of the cassava crop. Wegwu and Onyeike [17], reported a similar observation for *Telfairia occidentalis* grown in crude-oil contaminated soil. It is therefore apparent that the oil-impacted soils need supplements, in the form of fertilizers if the calorific value of the cassava tubers and possibly other food crops are to be enhanced, which means an additional cost (burden) to the peasant farmers.

**TABLE 1: Percentage proximate composition (±S.E[a]) and calorific value of cassava tuber harvested from oil-spill and non-oil-spilled-soils.**

| CONSTITUENT | PROXIMATE COMPOSITION (%) | |
|---|---|---|
| | POLLUTED TUBER | UNPOLLUTED TUBER |
| Moisture | 63.95 ± 3.4 (+ 4.91) | 60.81 ± 0.26 |
| Ash | 0.58 ± 0.10 (+ 13.8) | 0.50 ± 0.15 |
| Crude protein | 0.44 ± 0.05 (- 68.2) | 0.74± 0.08 |
| Crude lipid | 1.20 ± 0.05 (+ 74.2) | 0.31 ± 0.07 |
| Crude fibre | 1.56 ± 0.12 (+ 9.62) | 1.41 ± 0.03 |
| Total carbohydrate | 32.27 ± 1.3 (-12.3) | 36.23 ± 0.29 |
| Calorific value (Kcal/ 100g sample) | 141.64 (-6.38) | 150.67 |

*[a]S.E: Standard error for the three replicate samples.*
*Values in parenthesis indicate % increases (+) or decreases (-) for the samples grown in oil-spilled soils over the control (unpolluted).*

## CONCLUSION

The result of all the variables investigated in this study shows that despite the remediation adopted at the Omoku Old Pipeline crude oil leakage site, a substantial amount of petroleum hydrocarbons was present in the soil. These findings indicate that the containment measures carried out by the oil producing company at the time of leakage was ineffective. To reduce the risk of possible conflagration on the hitherto arable agricultural land, more effective mitigating measures should still be carried out on the site.

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