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THE ENVIRONMENT NUTRIENT PROPERTIES OF SOILS AFFECTED BY HYDROCARBON POLLUTION IN THE IBENO AREA, OF AKWA IBOM STATE.

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ABSTRACT

Soil from areas affected and relatively unaffected by petroleum pollution in Ibeno, Akwa Ibom state were analysed in order to understand the relationship of hydrocarbon concentrations to soil quality, particularly in terms of nutrient availability. Soil sample were obtained randomly from the vicinity of Mobil Tank Farm and Gas Flaring site. Sample were also obtained from the relatively unpolluted settlements of Ukpenekang and Mkpanak. The total hydrocarbon content, exchangeable cations, exchange acidity, available phosphorus and PH of the soils were determined in the laboratory. The results showed that the total hydrocarbon content was highest in the Tank Farm soils. Lower values occurred in the Gas Flaring Soils. In the relatively unaffected soils, Mkpanak had the lowest hydrocarbon content while that of Ukpenekang was higher. The Calcium content was low in the Tank Farm soils and gas Flaring Site soils. But in the relatively unpolluted soils, the calcium values were higher. Also the magnesium nutrient mineral values for the affected soil were lower than the values of the relatively unaffected soils. The most variable cation, whether in affected or unaffected soils was potassium with coefficients of variation ranging from 46.3% at the Tank Farm to 76.9% at Ukpenekang. Sodium values were the lowest values across all sites. The relatively unaffected soils had higher cation exchange capacity than the affected soils. Similarly, phosphorus levels were considerably higher in the unaffected soils than in the affected soils. Bye and large, the unaffected soils were observed to be less acidic than the affected soils.

It was concluded that high hydrocarbon content resulting from petroleum pollution reduced the quality of soils by adversely affecting the levels of the principal soils nutrients available to plants.

INTRODUCTION

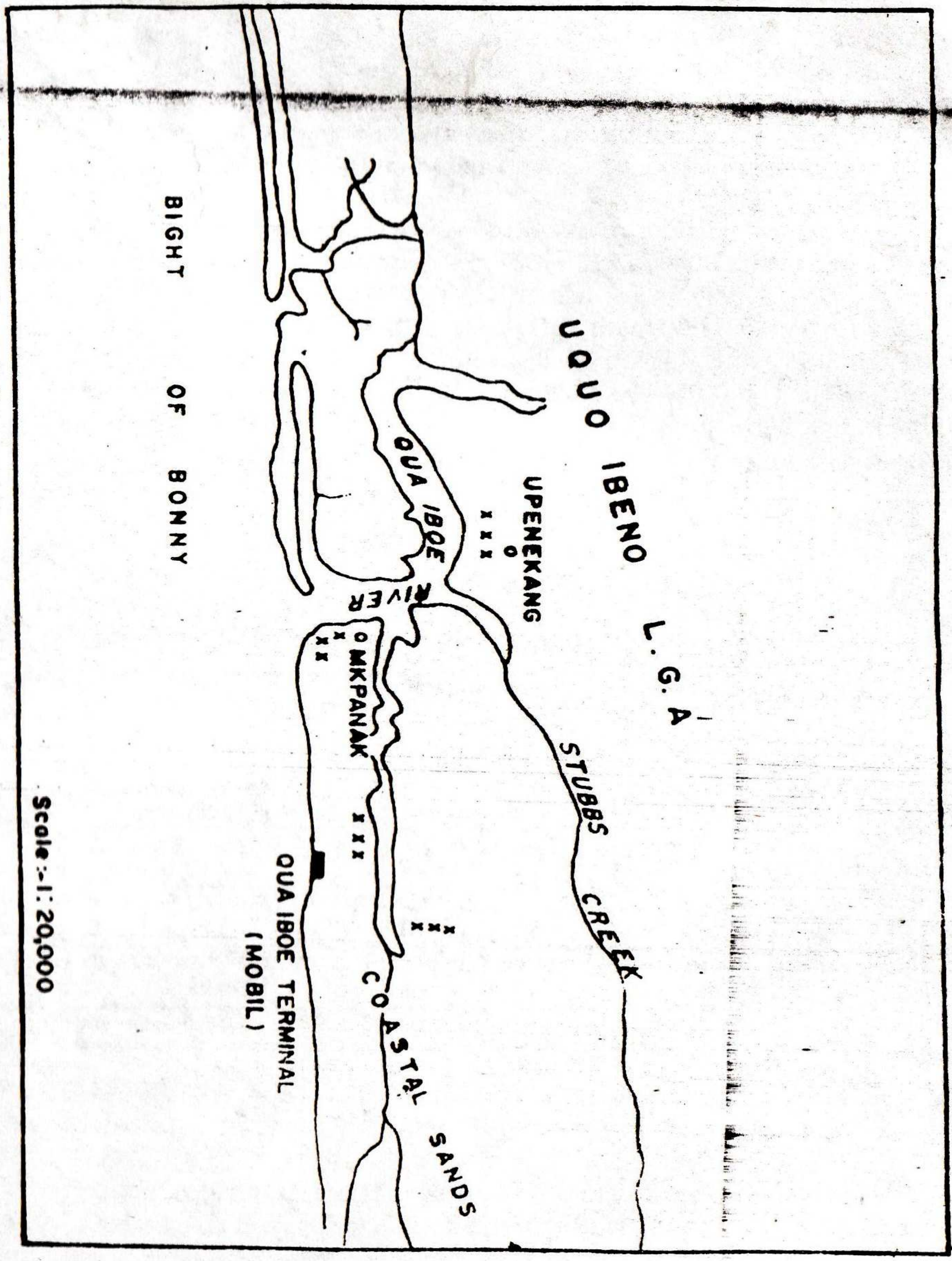
Several published studies both in Nigeria and elsewhere have shown that exploitation of petroleum oil has serious ecological consequences on the environment. Oils spillages contaminate sources of drinking water and fisheries along the fresh water adversely affects the wild life of the environment. The flora in oil producing areas is threatened since species such as mangrove mostly regenerate from seeds rather than by vegetative. Petroleum spillage which results in poor aeration of soils reduces species diversity and inhibit algae metabolism (Boesch et al 1974; soto et al 1975; Vandermeulen & Ahern 1976; Imevbore 1979 ; Fagbai et al 1988).

Arising from the observation that there is widespread damage to vegetation in petroleum producing areas (Fagbai et al 1988) due to contamination of soil (Odu 1972), the present study aims at analysing soils from areas affected and relatively unaffected by petroleum oil pollution, in order to understand the relationships of hydrocarbon concentrations to nutrient availability in the soils. Hence the basic approach is a side-by-side comparison of affected and unaffected sites.

The study area is the coastal .plains sands of South-eastern in Akwa Ibom State, Nigeria. The soils consist of ferralitic sandy deposits in Uquo Ibeno Local Government area where Mobil Producing Nigeria has been exploiting petroleum oil since 1970 (Fig.1). With increased offshore crude oil production (from 137 wells in 37 platform tanks) and the attendant flaring of gas, the lithoral environment has become increasingly polluted, particularly the soils around the facilities.

METHODS

Two noticeably affected sites were chosen for the collection of soil data. The first site was the vicinity of the Mobil Tank Farm while the second was the near-by Gas Flaring site. To enhance comparison between affected and relatively unaffected soils near the settlements of



Study area : xxxx Sampling points

Ukpenekang and Mkpanak lying between 3 to 8 km from these centres of petroleum exploitation activities.

Five 15x15m quadrats regularly spaced at 20m intervals were located across each of the affected and relatively unaffected sites. From each quadrat eight soil samples to a depth of 15cm were obtained randomly for laboratory analysis. Total hydrocarbon content was determined by the carbon tetrachloride extraction method; pH, in 1:2 soil to water suspension using glass electrode; available phosphorus, by the Bray No. 1 Method (Jackson 1962); exchangeable cations (Mg^{++},Ca^{++},-K^{+},Na^{+}), by atomic absorption and flame photometry; exchange acidity, by extraction with barium acetate and titration with NaOH; cation exchange capacity, as the summation of exchangeable cations and exchange acidity.

RESULTS

Table 1 shows the values of total hydrocarbon content in soils across the four sites. The highest level of hydrocarbon occurred at the Tank Farm site with values ranging from 4539.62 ppm to 6224.67 ppm. The mean value for the site was 5795.06 ± 4845.7 ppm. Levels of hydrocarbon decreased with distance from the site and showed the highest coefficient of variation (c.v) within the quadrats (64.6% - 105.6%). These high values are accounted for by spillage during storage and the routine cleaning of these tanks after storage.

The gas flaring site (table 1) have lower levels of hydrocarbon than the Tank Farm on account of fewer incidents of spillage. Values at the site ranged from 894.66 ppm to 1262.51 ppm with moderate coefficients of variation within the quadrats (15.6% - 19.9%). The mean value for the site was 1069.47 ± 181.7 ppm, was mostly accounted for by petroleum oil transported by overland flow from the nearby Tank Farm site.

The relatively unaffected sites at Ukpenekang and Mkpanak had much lower contents of hydrocarbon in soils than the affected sites (table 1). At Ukpenekang, about 3km from the Tank Farm, hydrocarbon content of soils ranged from 25.82 ppm to 56.46 ppm. The c.vs in each quadrat ranged from low to moderate (5.3% - 18.1%). The mean site

value was 39.42 ± 4.5 ppm. Mkpanak, situated about 7km from the Tank Farm had the lowest contents. Values ranged from 10.92 ppm to 22.32 ppm, with moderate c.vs (21.5% - 29.9%). The mean site value was 15.66 ± 3.9 ppm. Since the soil here are sandy the low values were attributed to flushing by overland flow and subsurface seepage.

A correlation was observed between total hydrocarbon contents and some soil nutrient properties. Table 2 shows that the highly affected Tank Farm Site and Gas Flaring Site had lower values of calcium (1.8 ± 0.2 me/100g; 1.4 ± 0.6 me/100g) than the relatively unaffected Ukpenekang (3.2 ± 1.2 me/100g) and Mkpanak (3.4 ± 0.8 me/100g). Variation was lowest for the Tank Farm (c.v = 11.1%) and highest for the total hydrocarbon content in soils from sites affected and relatively unaffected by petroleum pollution in Ibeno. Each value, in parts per million (ppm), is mean for 8 samples.

Table I: Soil Hydrocarbon Content

Affected Sites		Relative Unaffected Sites	
Tank Farm Site	Gas Flaring site	Ukpenekang	Mkpanak
Q_1 6224.67 ± 6573.82 c.v = 105.6%	1094.42 ± 218.14 c.v. = 19.9%	25.82 ± 4.2 c.v. = 16.3%	11.60 ± 2.5 c.v. 21.6%
Q_2 6062.38 ± 5932.50 c.v. = 98.4%	1262.51 ± 200.81 c.v. = 15.9%	36.93 ± 6.7 c.v. = 18.1%	17.36 ± 5.2 c.v. = 29.9%
Q_3 7102.45 ± 4768.70 c.v. = 67.1%	998.34 ± 156.13 c.v = 15.6%	28.52 ± 1.7 c.v. = 5.9%	10.92 ± 2.8 c.v. = 25.6%
Q_4 5082.18 ± 3281.13 c.v. = 64.6%	1097.42 ± 186.14 c.v. = 16.9%	49.38 ± 2.6 c.v. = 5.3%	16.12 ± 4.2 c.v. = 26.1%
Q_5 4539.62 ± 3672.15 c.v. = 80.9%	894.66 ± 147.52 c.v. = 16.5%	56.46 ± 7.3 c.v. = 12.9%	22.32 ± 4.8 c.v. = 21.5%
Site mean 5795.06 ± 4845.7	1069.47 ± 181.7	39.42 ± 4.5	15.66 ± 3.9

C.V. < 15% = Low; C.V. 15-35% = moderate; C.V > 35% = Most variable

Exchangeable bases, exchange acidity, CEC, pH and variable phosphorus of soils from affected and relatively unaffected sites. Each value is mean for at least 30 samples excluding extreme values.

Table 2: Coreletion of Soil Hydrocarbon Content and Nutrient Properties

Soil Property	Affected Sites		Relatively Unaffected Sites	
	Tank Farm Site •	Gas Flaring Site	Ukpenekang	Mkpanak
ca (me/100g)	1.8 ± 0.2 c.v. = 11.1%	1.4 ± 0.6 c.v. = 42.8%	3.20 ± 1.2 c.v. = 37.5%	3.40 ± 0.8 c.v. = 23.5%
Mg (me/100g)	0.57 ± 0.21 c.v. = 36.8%	0.37 ± 0.06 c.v. = 16.2%	1.20 ± 0.4 c.v. = 33.3%	1.40 ± 0.3 c.v. = 21.4%
K (me/100g)	0.54 ± 0.25 c.v. = 46.3%	0.14 ± 0.10 c.v. = 71.4%	0.26 ± 0.2 c.v. = 76.9%	0.31 ± 0.2 c.v. = 64.5%
Na (me/100g)	0.08 ± 0.02 c.v. = 25.0%	0.05 ± 01 c.v. = 20.0%	0.07 ± 0.01 c.v. = 14.3%	0.06 ± 0.02 c.v. = 33.3%
Ex.acidity	0.67 ± 0.09 c.v. = 13.4%	0.82 ± 0.15 c.v. = 18.3%	1.30 ± 0.8 c.v. = 61.5%	0.96 ± 0.42 c.v. = 43.8%
CEC (me/100g)	3.66 ± 0.77 c.v = 21.0%	2.76 ± 0.92 c.v. = 33.3%	8.37 ± 2.61 c.v. = 31.2%	6.13 ± 1.74 c.v. = 28.4%
Av. phosphorus (ppm)	0.06 ± 0.03 c.v. = 50.0%	2.03 ± 0.84 c.v. = 41.4%	79.99 ± 9.14 c.v. = 11.8%	36.65 ± 3.8 c.v. = 10.4%
pH	6.8 ± 0.29 c.v. = 4.2%	6.82 ± 0.02 c.v. = 0.3%	7.09 ± 0.21 c.v. = 3.0%	7.62 ± 0.24 c.v. = 3.1%

• c.v.(15% = low; c.v. 15 - 35% = moderate; c.v) 35% = most variable.}

Gas Site (c.v. = 42.8%), and high c.vs for Ukpenekang (37.5%) and Mkpanak (23.5%) indicate that variation in calcium concentrations is localised. A similar trend was observed for magnesium at the two affected sites (0.57 ± 0.21 me/100g; 0.37 ± 0.06 me/100g), compared with the unaffected sites (1.20 ± 0.4 me/100g; 1.40 ± 0.3 me/100g). Potassium and sodium had higher values at the Tank Farm (0.54 ± 0.25 me/100g; 0.08 ± 0.02 me/100g) than at the relatively unaffected Ukpenekang (0.26 ± 0.2 me/100g; 0.07 ± 0.01 me/100g) and Mkpanak (0.31 ± 0.2 me/100g; 0.06 ± 0.02 me/100g).

Exchange acidity was lower at the Tank farm and Gas Sites (0.67 ± 0.09 me/100g; 0.82 ± 0.15 me/100g) than at the relatively unaffected sites of Ukpenekang and Mkpanak (1.30 ± 0.8 me/100g; 0.96 ± 0.42 me/100g). The values of these nutrient factors were reflected in

the lower cation exchange capacities for the affected sites (2.76 ± 0.92 - 3.66 ± 0.77 me/100g) when compared with the unaffected sites (6.13 ± 1.74 - 8.37 ± 2.61 me/100g). Available phosphorus levels were noticeably different between the affected and unaffected sites. While values were 0.06 ± 0.03 ppm and 2.03 ± 0.84 ppm for the Tank and Gas Sites, those for Ukpenekang and Mkpanak were considerably higher, being 79.99 ± 9.4 ppm and 36.65 ± 3.8 ppm respectively. pH values for affected sites (6.85 ± 0.29; 6.82 ± 0.02) and for unaffected sites (7.09 ± 0.21; 7.62 ± 0.24) indicated that unpolluted soils were less acidic than the polluted soils.

DISCUSSION

Except where oil spillage on land occurs in a large scale covering a wide area, the immediate pollution of the soil - environment is localized to the vicinity of the spillage. Variation in total hydrocarbon content of soils indicate decreasing concentration from spillage sites. However, this spatial variation depends on the topography. Where slopes are steep, petroleum oil is transported by overland flow in films to considerable distance from the spillage site. Micro - depressions on the soil surface trap petroleum sludge resulting in variability of hydrocarbon contents within the polluted sites. The surface soil is affected as the oil film impairs aeration and evaporation thereby making the soil to be increasingly waterlogged. Since oil tends to block soil pores, replenishment of nutrients by surface flow and subsurface seepage from coastal and upland areas is impaired. This accounts for the lower levels of soil nutrients in polluted sites than the relatively unpolluted sites.

CONCLUSION

Petroleum oil pollution of soils can be controlled if drainage channels are constructed around storage facilities such that spillage can be channelled into treatment pits. The effectiveness of the method would depend upon the quantity of spillage involved. Large quantities of petroleum sludge clearly degrade the nutrient status of soils and consequently the biota of the ecosystem. The impact of the poor soil nutrients is low agricultural productivity.

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