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Effects of Oil Spillage on Soil Fertility in Oleh and Irri Communities of Delta State

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ABSTRACT

This research work was done to determine the effects of crude oil spillage on soil nutrients. It was done by analyzing some essential parameters found in the soil to determine the rate of loss or loss values of these nutrients in the soil. These parameters are pH, Total Microbial Population, Nitrogen, Phosphorus, Potassium, Sodium and Calcium. Soil samples were collected from Oleh/Irri communities in Isoko South of Delta State and were analyzed. Data obtained from the studied contaminated soil was treated and compared to the control soil samples. From the results obtained, the following were significantly reduced; pH concentration of the polluted soil from 6.20 to 5.32, Total microbial population variation was from $3.3x10^5$ to $1.9x10^5$ cfu/g, Nitrogen from 900 to 300 mg/kg, calcium from 172.5 to 77.5mg/kg, potassium from 857.5 to 686.3 mg/kg and sodium from 267.5 to 215mg/kg, but phosphorus from 5.00 to 5.33 mg/kg. The obtained data was subjected to statistical analysis using the Chi Square method at 5% level of significant and results showed that there is a significant effect of crude oil spillage on soil nutrients.

Keywords: Crude oil, Soil nutrients, Oil industries

INTRODUCTION

Soil is an important component of the environment, it is a major resource of the earth with a lot of potentials, and it is the basis of human civilization. The role of soil in food productivity cannot be over emphasized. Soil is the great provider of food. Man has depended on plant which grows from the soil from time immemorial. Man depends on plant for food, clothing, shelter, medicine, and the oxygen we breathe, to mention but a few[1-5]. Without plants from the soil there will be no life on earth. Due to its dynamic physical, chemical and biological functions, soil to farmers and most people is this layer at the earth surface that supports the growth of plants of all kinds. When the soil can no longer produce or yield good crops, enough food cannot be available for the increasing population. This shows the decline nature of the soil. Crude oil spillage is defined as the explosion or running out, upsurge flow of oil over an area on the earth surface or environment, due to both human and natural factors such as pipe burst, corrosion of pipes, over pressure, malfunctioning of equipments, sabotage and blowout. As noted by Ekundayo, the resultant environmental problem arising from oil spillage is well pronounced in soil fertility. Oil spillage have been known to exhibit various deleterious effects on both plants and microorganisms, crude oil spillage on soil generally retard plants growth, reduces aeration by blocking air space between soil particles, hence create condition of anaerobiosis and causes root stress in plant which also reduces leaf growth. This work is aimed at determining the effect of oil spillage on physical and chemical properties of the soils [6,7].

MATERIALS AND METHODS

Method of sample collection

Soil samples were collected from oil polluted site, and other soil samples were collected from non-oil polluted site, which is the control. At the both oil polluted and non-oil polluted soils, the designated potions were divided into quadrant of 1m x 1m, and soil samples were randomly collected from a predetermined depth of 0-10cm layer from the top soil being the threshold of cassava cultivation. A total of eight (8) soil samples collected with four (4) soil samples each from oil polluted and non-oil polluted soils. The mean of these soil samples was determined and used for the study. The soil samples collected were placed in a labeled polythene bags for easy identification and secured with elastic rubber band, before taken to the laboratory for further processing and analysis [8].

Procedure for the digestion of soil samples

The soil was dried at room temperature and then sieved with a 2mm mesh sieve and 2.5g of the sample was then weighed into a 300cm^3 conical flask. A 5ml of the acid was added to the sample and then placed in a fume cupboard while it was heated until white fumes appeared. The heated sample was removed from the fume cupboard and allowed to cool, and then 50 ml of distilled water was added [9,10]. The cool solution was filtered completely with a wash bottle into a 100ml Pyrex volumetric flask, the solution was then made up with distilled water. The soil extract and the standard solution were then aspirated into the air acetylene flame of various 220 (fast sequential) Atomic Absorption Spectrometer [11].

ELECTROMETRIC METHOD

Soil pH was determined using the standard electrometric method as reported by Ekpo.20 ml of distilled water was added to 20.0 g of each of the soil samples. The lump of the soil was stirred to form homogenous slurry, then pH meter was immersed respectively into the sample and allowed to stabilize at 28ocand pH of the sample was then recorded.

Determination of total microbial count

The soil samples (composite and the control) were crushed respectively to break the large aggregates and was air-dried for 5 hours. The samples were sieved through a 2 mm sieve to remove the large particles, debris, and stones in them. They were in turn placed in two different bowls. Microbiological analysis to determine microbial count was carried out with 1.0g of the soil sample collected from each bowl and was diluted using serial dilution. The population of viable bacterial and fungal cells in each soil sample was determine by inoculating 1.0 ml aliquots from the 103 – dilution into nutrient agar and sabouraud dextrose agar respectively by the spread plating technique. Sabouraud dextrose agar was then made selective for fungi by the incorporation of 1 ml chloramphenicol. Incubation was 28^0C for 48 hours and 5 days for both bacteria and fungi. The determination of the effect of crude oil spillage on the Gram distribution of soil bacteria was obtained by Grain staining bacteria colonies after incubation and expressing the Grams positive and Gram-negative colonies from the polluted and unpolluted soil as percentage representative. The nutrient agar and sabouraud dextrose agar were prepared following the information on both containers about 15 ml of nutrients agar was aseptically added to the soil suspension in each petri-dish. And the prepared media was also poured into the petri-dish with the soil suspension. The micro-organisms were cultured (cultivated) using the prepared media, nutrient agar and sabouraud dextrose agar for bacteria and fungi, respectively. The media was poured up to 15 ml in each different petri-dish containing 1 ml of the suspension and could solidify and incubated at 28ocfor 48 hours and 5 days `for both bacteria and fungi.

TOTAL MICROBIAL COUNTING

The colonies were counted using the colony counter following the laboratory conventional method and the readings were obtained for both the polluted soil sample and the control.

Determination of nitrogen in soil

Extracting Solution: 100 g Sodium Acetate was dissolved into about 500ml distilled water, and 30ml of 99.58% acetic acid was diluted with distilled water to1 litre.

Brucine preparation: 2.5 g of brucine sulphate was dissolved in 100ml of glacial acetic acid. Stored in the dark (this reagent should be handled with care as it is very toxic).

Procedure for determination of nitrogen in soil

1 teaspoon of carbon black, 20 ml of sodium acetate (extracting solution) was added to 5 g of each soil samples in 50 ml beakers. Shaken for 15minutes and filtered the extracting from the soil. 2.5 ml of bruin reagent, 10ml of conc. H_2SO_4 were added to 5 ml of the filtrate and stirred for30 seconds and allowed to stand for 5 minutes. 10 ml of distilled water was added to the solution and allowed to cool for 15 minutes, read at absorbance of 470. Using 5 ml of distilled water, the process was followed to prepare the blank solution for the analysis.

Determination of phosphorus in soil

12g of ammonium molybdate was dissolved in 250ml of distilled water. 0.2908 g of antimony potassium tart rate was also dissolved in 100ml of distilled water. The two dissolved reagents were stored in glass vessel in dark cold compartment. 1.056 g of ascorbic acid was dissolved in 200ml of reagent A and mixed. Sodium bicarbonate (NaHCO3) solution 0.5m was adjusted to pH of 8.5 with NaOH and then addition of mineral oil to avoid exposure of the solution to air.

Procedure for determination of phosphorus in soil

1 teaspoon of carbon black and 40ml of extracting solution (Olsen's solution) were added to 2 g of each soil samples in 100 ml volumetric flask. The solution was shaken for 30 minutes on mechanical shaker. The flask was immediately shaken before pouring the suspension into the funnel. 10 ml of distilled water, 4 ml of reagent B was added to 5 ml of the soil extract, and was made up to 25 ml, timed for 5 minutes and read at absorbance 882.using 2 ml of distilled water, the process was followed to prepare the blank solution for the analysis.

DETERMINATION OF POTASSIUM IN SOIL

Procedure for determination of potassium in soil

20 ml of Conc. H_2SO_4 and 7 ml of conc. HCl were added to 2.0g of each soil samples in a beaker, and then heated until white fumes comes out.

Distilled water was added, filtered, and made up to100 ml of standard flask. Analysis result was obtained from the AAS machine.

Determination of sodium in soil

77.08 gm of ammonium acetate was dissolved in distilled water and made up to 1 litre. The pH was adjusted to 7.0 with glacial acetic acid or ammonia solution. 2.542 gm of dried NaCl (AR at 110oC for 1 hr) was dissolved in distilled water and the volume was made to 1 litre. i.e. 1000ppm Na solution. 10 ml of 1000 ppm solution was diluted to 100 ml. The concentration of the sodium is 100 ppm. 2, 4, 6, 8 and 10 ml of 100 ppm Na solution was taken in separate 100 ml volumetric flask and the volume was made up with distilled water. Thus 2, 4, 6, 8 and 10 ppm Na solutions were maintained, and readings were taken on the Flame Photometer.

Determination of calcium in soil

5ml extract was pipette out, 10 drops each of $NH_2OH.HCL$, $K_4Fe(CN)_6$, TEA and 10% NaOH was added to raise pH to 12.5. Drops of calcon indicator were added and titration was done against standard EDTA. The end point produces a change of colour from red to blue. The value obtained from Ca was used to calculate the Ca in the soil samples, respectively.

RESULTS AND DISCUSSIONS

The following results were obtained from the experiment carried out on the contaminated (crude oil impacted soil) and control soil samples.

Table 1: Result of Analyzed Samples

Soil Parameter	Composite sample	Control sample
pH	5.32	6.20
Total microbial Population (cfu/g)	1.9×10^5	3.3×10^5
Nitrogen (mg/kg)	300	900
Phosphorus (mg/kg)	5.33	5.00
Calcium (mg/kg)	77.5	172.5
Potassium (mg/kg)	686.3	857.5
Sodium (mg/kg)	215	267.5

Table 2: Variation of analyzed samples

PARAMETER	VARIATION
pH	± 0.88
Total microbial population (cfu/g)	$\pm 1.4 \times 10^5$
Nitrogen (mg/kg)	± 600
Phosphorus (mg/kg)	± 0.33
Calcium (mg/kg)	± 95
Potassium (mg/kg)	± 171.2
Sodium (mg/kg)	± 52.5

It was observed from the results of the pH shows that the oil impacted soil with the values of 5.32 (Table 1) is relatively acidic while that of the control soil sample with the value 6.20 is slightly acidic. Thus, the pH value of the oil impacted soil sample is relatively acidic than the control soil with a variation of ± 0.88, indicating that the spillage may have had some direct impact in lowering the pH value of the soil. It is more likely that the production of organic acids by microbial metabolism is responsible for the differences.

The soil pH, however, can be improved by aeration to complete the microbial agricultural lime to provide some buffering capacity to the soil as explained by Osam. Basically, of the 16 essential elements for plant growth, 5 are macro nutrients (N, P, K) and calcium belong to the micronutrient constitutes, while Na belong to the needed group of elements for plant growth. The concentration of macronutrients and micronutrients in both soil samples are inherently low compared to acceptable range 15000, 2000, 10000 and 5000 mg/kg of N, P, K and Ca respectively as recommended for agricultural soils (HSE-ENV, 2004). The concentrations of extractable macronutrient from the crude oil polluted soils, Nitrate 300 ± 600 mg/kg, phosphorus 5.33 ± 0.33 mg/kg, calcium 77.5 ± 95 mg/kg, potassium 686.3 ± 171.2 mg/kg and sodium 215 mg/kg ± 52.5 mg/kg, while total microbial population $1.9 \times 10^5 \pm 1.4 \times 105$ cfu/100 ml (Table 2).

From analytical results, the concentrations of extractable nutrients from the oil impacted soil samples, calcium, potassium, sodium, and chloride were higher than the control sample as indicated above. Meanwhile, Phosphorus is lower than that of the control soil sample. It is unlikely that the oil released is directly responsible for the loss of soil nutrients. Soil nutrients elements increased because of the bacterial biodegradation of oil in the anaerobic environment of the oil-blocked soil pores.

Nevertheless, the intense infusion of degradable hydrocarbon likely stimulated aerobic and anaerobic microbial metabolism. Figure 1 shows the

Indices of oil polluted and unpolluted (control) soil from Oleh/Irri communities, Isoko-South of Delta State. Also the analytical values indicate that the concentration of the soil nutrients (parameter) are higher than the values recommended for agricultural supplemental applications are required. The analyzed concentration of crude oil in the oil polluted soil can create anoxic conditions in soils because the oil film reduces gaseous diffusion and increases the presence of anaerobic organisms, which depletes available oxygen.

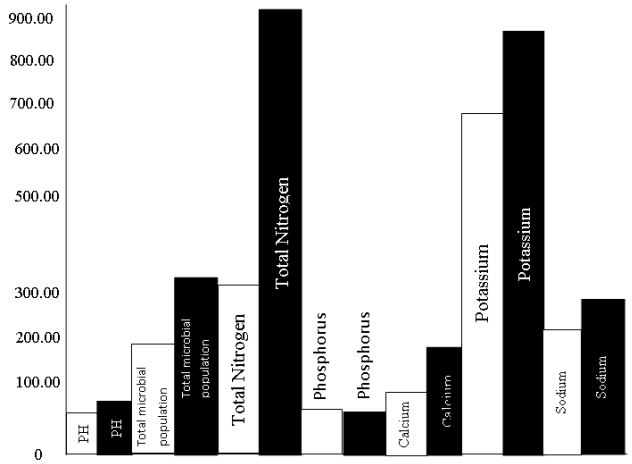

Figure 1: Indices of oil polluted and unpolluted (control) soil from Oleh/Irri communities, Isoko-South of Delta State

VARIATION IN THE LOSS OF SOIL NUTRIENTS BETWEEN CONTROL

It was observed that there was variation in loss of phosphorus of the polluted soil with a value of ±0.33mg/kg.
Subsequently, nitrogen, calcium, potassium, and sodium showed a significant high variations of + 600 mg/kg; + 95mg/kg; + 171.2mg/kg; and 52.2mg/kg respectively.
The total microbial population was + 1.4 x 10^5CFU/g. While there was reduced pH variation of +0.88, total microbial population was also of reduced variation of 1.4 x 10^5CFU/g.
One factor responsible for the reduction and increase values is absence or reduced presence of microorganisms in the soil, resulting in faster and higher degradation of the environment polluted with crude oil.

STATISTICAL ANALYSIS

Statistical analysis using Chi Square method at 5% level of significant, showed that the calculated value was 128.80, while Chi Square tabulated value was 1.24 and 14.4. The alternate H_1 was therefore accepted, which shows that there is a significant difference in the effect of crude oil spillage on soil nutrients.

CONCLUSION

Conclusively, analysis has shown from this research that crude oil spill on the soil has a significant effect on the physical-biological-chemical properties of the soil. The presence of crude oil in the soil caused the soil to experience degradation that resulted to decrease in total microbial population, decrease in pH value and slight decrease in phosphorus when compared to control soil samples. The absence of required microorganisms in oil polluted soil lead to the high values of the soil parameters chloride, nitrogen, calcium, potassium and sodium obtained during the experimental analysis of the crude oil polluted samples. Thus, the aims and objectives of this research work were achieved, having observed the effects of crude oil spillage on the soil and its consequences on the growth of plants.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest in this publication.

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