Heat Radiation on the Physical and Chemical Characteristics of Utisols of Obigbo in the Niger Delta

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Abstract: - The soils of the Obigbo flow station were analyzed for the impact of gas flare (heat radiation) on its physico-chemical properties. Sampling points labeled A, B, C, and D were 50m, 100m, 150m and 200m away from the flare barrier and at a depth of 0-15cm, 15-30cm, 30-45cm, 45-60cm. Samples were collected using a pyranometer and transported to the laboratory where it was prepared for laboratory analysis. During the routine soil analysis, pH, organic carbon, total exchangeable acidity and exchangeable (Na^+, K^+, Ca^+, and Mg^{2+}) were done using appropriate techniques. Findings from the study shows that distance from the flare point and depth of soil sampling were sources of variation in soil chemical and nutrient status. Soils from sample locations were generally acidic. Least pH values were obtained at point A. Higher values were obtained at farther distances (B, C. and D). Soils in the sampling area are well drained. Higher percentage organic matter was observed at point D (2.5, 2.3, 1.6, 1.0 at 0-15cm, 15-30cm, 30-45cm and 45-60cm respectively), with a steady decline per increase in sampling depth. Total exchangeable acidity, potassium and sodium were highest at top soil region of 0-15cm but declined as sampling depth increased. Magnesium, ECEC and calcium values followed the order sampling point B>C>D>A.

Key-Words: - Gas Flare, Heat Radiation, Irradiation, Distances, Flow Station, Pyranometer and Ultisols

1 Introduction

The term ‘gas flaring’ is often used to describe the controlled disposal of surplus combustible vapours by igniting them in the atmosphere (Nature Conservation Report, 1986). Gas flaring has resulted in many negative environmental consequences for both plant and animals alike. Since gas flaring is done at temperature ranging from 1300 ^oC – 1400 ^oC [4], this often results in higher temperature in the environment where the gases are flared thus negatively affecting plant, animal and even microbial life. The flaring process is also capable of altering the chemical balance of the immediate surroundings as the product of gas flaring contain sulphides , carbonates, nitrates resulting as hydrogen sulphides (H_2S), sulphur oxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) among others which may be evolved due to the atmosphere of the flaring environment. These acid gasses can be carried many kilometers away and downward as acid deposition (Wet and dry deposition) unto vegetation, soils, and water bodies in communities close to the flare sites [2], depending on the wind speed, direction and the height of flare stacks [1]. As opined by [5], soils are amongst the most valuable and perhaps the most polluted natural resources of a nation. Hence, this study seeks to analyze the effect of distance from the flaring source and depth on changes in physical and chemical properties of the utisols of Obigbo, Niger Delta region of Nigeria.

2 Materials and Methods

The study was set up in the geographical co-ordinates of latitude 92500N and 11125N and Longitude 50000E and 525000E [8] which is the location of the Obigbo North flow station of the Shell Petroleum Development Company Nigeria Limited (SPDC), North East of Port Harcourt, the Rivers State capital. Soil samples were collected from four points labeled A, B, C and D beginning at 50m away from the flare point and at increments of 50 m interval (50 m, 100 m, 150 m, and 200 m). Samples were collected at depths of 0-15cm, 15-30 cm, 30-45 cm and 45-60 cm from each for the minipits. Samples collected were immediately prepared by air drying and transported to the laboratory for analysis. Measurement of Irradiation was done from the wind ward direction using a

Pyranometer at 50 m intervals from the same points were soil minipits were dug for sample collection.

Soil pH was determined in water and in KCL using pH meter by dipping the glass electrode of pH meter into soil/water and soil/salt suspension, as modified by [7]. Exchangeable cations ($Na^+K^+Ca^+$ and Mg^{++}) were determined by 1N Ammonium Acetate (1N NH_4OAC) extraction methods. Na^+ and K^+ in the extract or leachate were determined by complexometric titration method as modified by [3]. Ethylene diaminentetractic acid (EDTA) titration of Ca^{++} + Mg^{++} in the presence of erichrome black T (EBT) indicator was carried out at pH 10. Mg^{++} was obtained as the difference between Ca^{++} + Mg^{++}. Total exchangeable acidity (TEA) was determined by IN K extraction method and titrating the extract with 0.1N, NaOH, using phenolphthalein indicator to a pink end point, as modified by [3]. While organic carbon was determined by the Walkley and Black wet oxidation method and titration with standard ferrous ions as described by [9].

3 Results

The effect of distance and depth from flare point on the pH of surrounding soils is summarized in figs 1. At point A (50 m from flare point), pH ranged from 3.5 (45-60 cm) to 4.5 (0-15 cm). At point B (100 m) from the gas flare point, pH ranged from 4.5 (45-60 cm) to 6.5 (15-30 cm). At point C (150 m from the gas flare), pH ranged from 4.8 (150-30 cm) to 5.7(30-45 cm) 4.8 at 15-30 cm and 5.7 at 30-45 cm. At point D (2000 m). pH ranged from 4.8 (0-15 cm) to 5.6 (30-45 cm), respectively.

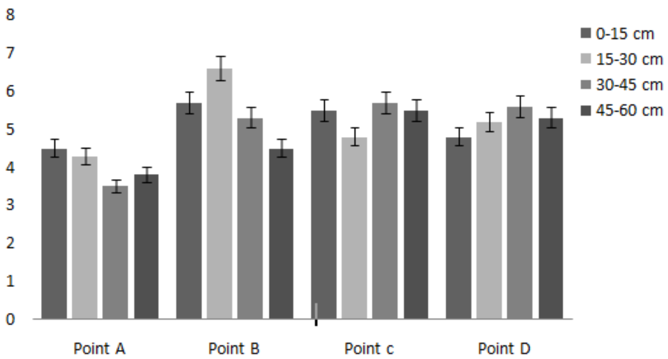

Fig.1: pH of soils in pits at various distances from gas flare point.

The percentage organic matter content for soils at all depths at points A, B and C from the flare point were generally low when compared with point D which showed a relatively higher percentage organic matter content with highest values of 2.53 (0-15cm) followed by 2.36 (15-30). The least percentage organic matter content (0.077) of sampled soil was recorded at point B (100m from flare point) at a depth of 45-60cm and is represented in figure 2 below.

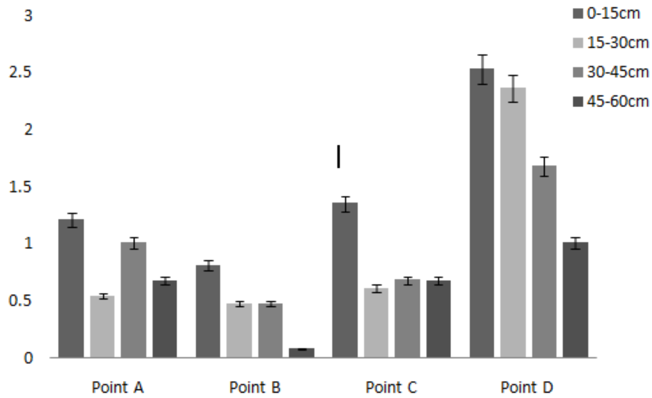

Fig.2: Percentage organic matter in various pits from the gas flare.

The impact of gas flare on total exchangeable acidity of utisols of Obigbo flow station is in (fig.3). The highest values for total exchangeable acidity were observed to be highest at point A (50 m), which was closest to the flare point.

For all distances from the flare point (A, B, C and D), highest total exchangeable acidity were highest at the top soil layer (0-15 cm) but gradually declined per increase in depth. The highest total exchangeable acidity value of 1.85 Cmol/kg was recorded at point A, at a depth of 0-15 cm.

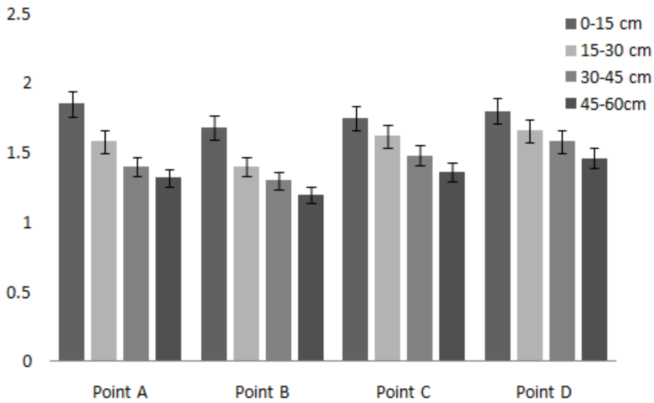

Fig.3: Total exchange acidity (Cmol/Kg) in pits from the gas flare.

Figure 4 summarizes the effect of gas flaring/ heat radiation on soil exchangeable calcium. At all distances from the flare point (A, B, C and D), the highest calcium level were recorded at the top soil layer of 0-15cm but then gradually declines with increase in depth.

The highest value for exchangeable calcium in sampled soil was 0-15 cm in point B followed by same depth in point C, D and A, respectively. The least exchangeable calcium was recorded at the 45-60 cm at the 200 m from the flare point.

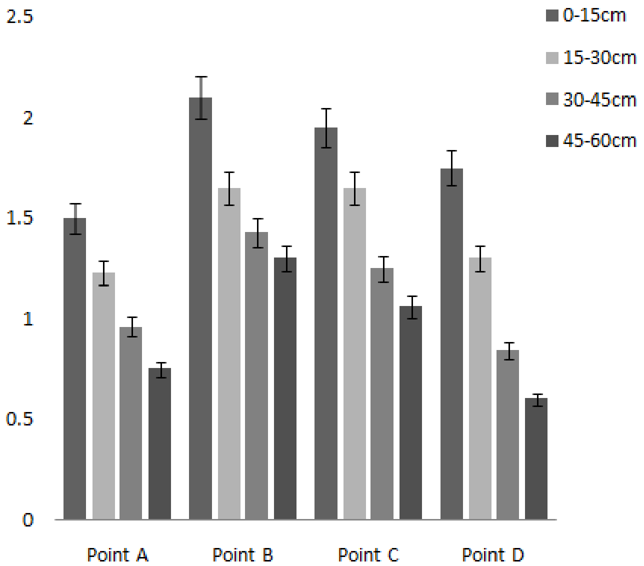

Fig.4: Calcium levels (Cmol/kg) of pits soils at various distances from flare.

Magnessium (Mg) had the highest concentration at point B (100m from gas flare), followed by point C, D and A respectively, all at a depth of 0-15cm. Point A at a depth of 45-60 cm recorded the least value of magnesium.

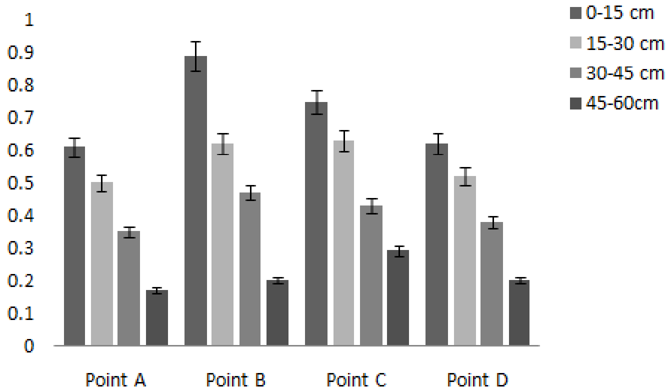

Fig.5: mg levels (Cmol/Kg) of pit soils at various distances from gas flare.

Potassium (K) had lowest values of (0.16) at a depth of 45-60 cm of point A (50 m from flare point). While higher values were recorded at top soil region of 0-15 cm at point A, B, C and D.

Exchangeable potassium increased with increase in distance from the flare point with the highest values (of 0.51) for potassium recorded in the top soil region of 0-15 cm depth at the farthest distance of 200 m from the flare point.

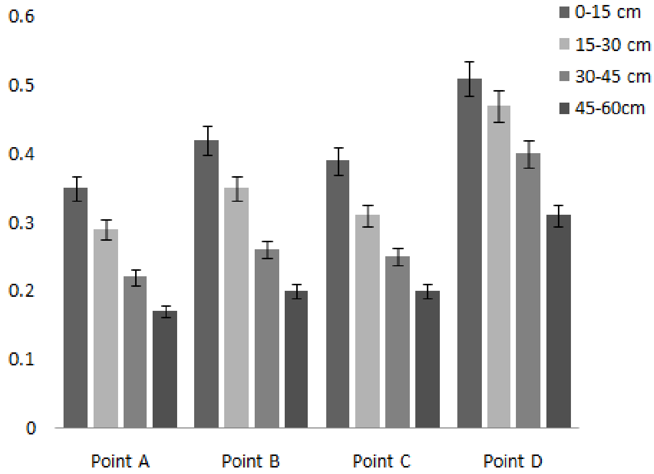

Fig.6: Potassium levels (Cmol/kg) of pit soils at various distances from gas flare.

Moisture content for soil samples (0-15cm) was comparable irrespective of the distance from the flare point. Increase in depth across distances resulted in increase in soil moisture content with a depth of 30-45 cm at point B, D and C recording the highest, second and third highest values respectively (Fig.7).

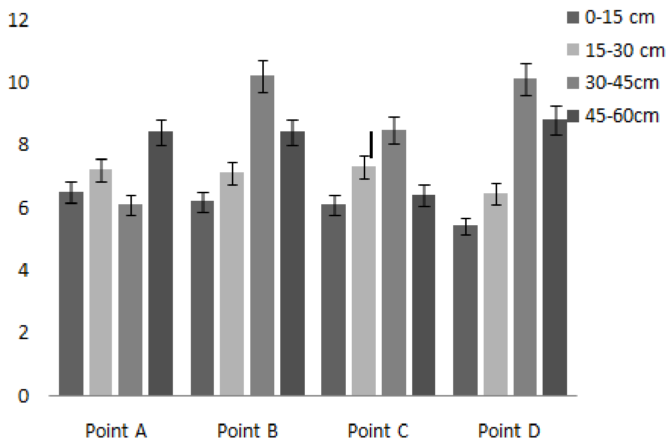

Fig.7: Effect of sampling depth and distance from flare point on soil moisture content.

The summary of the effect sampling depth and distances from source of heat irradiation on the sodium content of sampled soil is presented in figure 8 below. Sodium content for soils generally increased with increase in sampling distance from the flare point.

At all sampling points (A, B, C and D), higher values of sodium were obtained at a depth of 0-15cm with the highest values (10.36) for exchangeable sodium was recorded at point D followed by same depth at point B (9.33) and C (8.66) respectively (Fig.8).

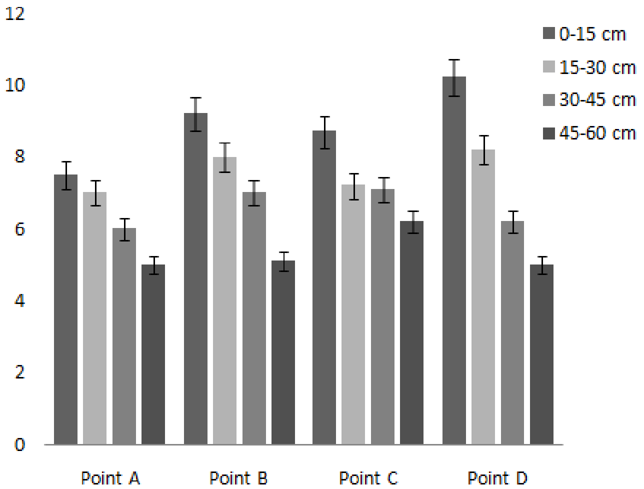

Fig.8: Sodium levels (Cmol/kg) in pits at various distances from gas flare.

Higher E.C.E.C values were obtained at top soil region (0-15 cm) across all sampling distances from the point of gas flare irradiation, at this depth (0-15 cm), point D gave the highest value of 15.05, this was followed by point B, C and A with values of 14.41, 13.49 and 11.88 respectively.

At each sampling distances from the irradiation point, E.C.E.C value declined with increase in sampling depth. The least E.C.E.C values (7.45 and 7.5) were recorded at the depth of 45-60 cm of point A and D.

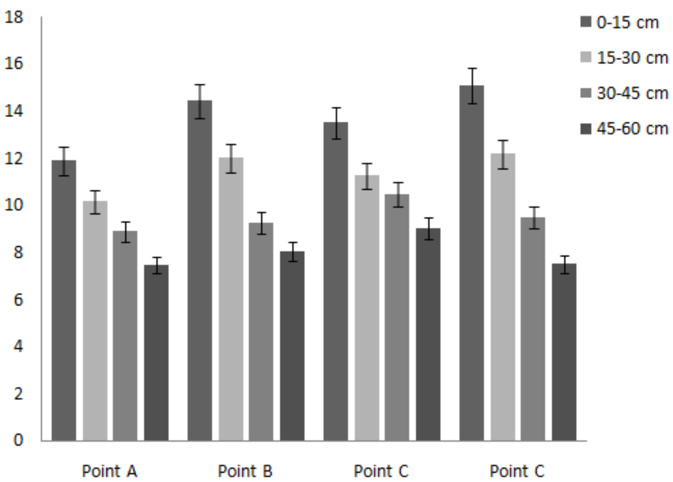

Fig.9: ECEC levels (Cmol/kg) of pits at various distances from flare.

4 Discussion

In the Obigbo flow station the flare stack was geometrically vertical. This implied that most of the effect from the flare would be localized i.e. within the flare barriers. [1] reported that the effect of heat radiation is dependent on the flare temperature, gas flow rate and geometrical design of the flare stack.

This means that since the flare stack is vertical, the impact of the flare would be within the flare barrier which would automatically reduce the impact of the flares outside the barrier. In point A (50 m) away from the flare, the radiation was higher (326.25 w/m^2). pH at this point ranged between 3.5-4.5. Acidity increased with high radiation. Sulphate was also very high at this point. This might also be the reason for the high acidity at this point. Sulphate anions are retained only weakly by soils but they are retrained with soil acidity [6]. The acidity property of the area would have encouraged the sulphate in this area.

Organic matter content values were lower at sampling points closer (points A, B, C) to flare stack. The value however increased as the distance from the flare stack increased to point D (200 m) at a depth of 0-15 cm. Although organic matter values were higher at point D than A, the radiation measurement was highest at point A (50 m) which was at the middle slope of the topo-sequence of the area with moderate elevation. The high organic matter value at point D might be due to its dump site nature few months before sampling was done. [6] reported that an examination of the nature of soil organic matter shows that it consists of organic residues in every stages of decomposition, from undecomposed material through partly decaying vegetable and animal matter to fairly resistant relatively stable substance called humus.

It also would be the reasons for high sulphate values because sulphate anions are absorbed readily by plants incorporated into biomass. Biomass and soil organic matter constitutes large sulphur reservoirs [6].

The soil nutrients calcium (Ca), Magnessium (Mg), and potassium (K) were very low in Obigbo flow stations, although calcium (Ca) and magnesium (Mg) was highest at points B (100 m) and C (150 m) respectively. Potassium had the highest value at 200m away from the flare stack. In all sampling points, there was a decline in the values obtained per increase in depth. This implies the absence of leaching.

[6] Posited that high CEC may be as a result of high organic matter content. This thus explains the cation exchange capacity (CEC) values at point D. Moisture content at the distances away from the flare was high at 30-45cm depth which shows that the soils in the Obigbo flow station area were well drained for agricultural purposes.

5 Conclusions/Recommendation

The study shows that sampling distances and depth were sources of variation in physical and chemical composition of soils in vicinity where gas flaring activities are carried out. Soils around the Obigbo flow station was well drained and were generally low in their nutrient status. The irradiation values observed at the flow stations was less than 350w/m^2, and is within the permissible limit set by the Department of Petroleum Resources (6310w/m^2). Further studies may be conducted to evaluate the effect heat irradiation from gas flaring on soil microbes. The results from such studies will prove invaluable in developing methods and techniques in improving the low nutrient status of soils around gas flaring location and enhance agricultural outputs in such areas.

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