Impact of Gas Flaring on Physicochemical Properties of Agricultural Soils in Oshie Oil Field, Rivers State, Nigeria.

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Abstracts

This study is aim at examining the impact of Gas flaring on agricultural soils in Oshie Oil Field. The release of heat into the environment from gas flares has been implicated for affecting the soil physicochemical parameters and its fertility. Composite soil samples were collected from identified and marked points from the field at a depth of 15cm and 30cm respectively using the soil auger. The samples were placed in sterile containers and were properly labeled and sent to the laboratory for analyses using standard methods. The determined parameters were the soil physicochemical parameters as atmospheric and soil temperatures using the mercury thermometer, pH using ASTM D4972 Hanna H1 2211 pH/ORP meter, soil moisture content, total nitrogen and phosphorus using APHA methods and microbiology was done by using the method of Cheesbrough. The results obtained were atmospheric temperatures from 28.2^OC - 44.7^OC, soil temperatures at 15cm depth were 22.0^OC – 42.9^OC and at 30cm depth it ranged from 25.0^OC – 39.3^OC, the soil pH at 15cm depth were 4.12 - 6.32, whereas the soil pH at 30cm depth were 4.32 - 6.51, the obtained values for soil moisture content at 15cm depth was 5.32% -12.91%, while the soil moisture content at 30cm depth were 6.10% - 13.45%, total nitrogen at 15cm depth 0.232% - 0.472% as the total nitrogen at 30cm depth ranged from 0.165% - 0.505%, the phosphorous level at 15cm depth were 0.061% - 1.324% and the values of phosphorous obtained at 30cm depth ranged from 0.072% - 1.581% the total heterotrophic bacteria count at 15cm depth ranged from $1.2x10^2 cfu/g$ - $3.6x10^3 cfu/g$ and the total heterotrophic bacteria at 30cm depth was $2.1 x 10^2 cfu/g$ - $3.6x10^3 cfu/g$. The identified bacteria associated with this Oshie oil field were Bacillus spp, Pseudomonas spp, Corynebacterium spp and Escherichia spp. The obtained results revealed that Gas flaring has negative impact on the soils of Oshie Oil Field by the introduction of thermal pollution due to heat generated and released into the environment. Pollution of the soil by acid rain resulting from emission of nitrogen oxides (NO_X) and hydrogen sulfide (H_2S) from the gas flaring which reacted with water was also noticed. The moisture content of the soils decreased due to increase in temperature of the soils which resulted in high rate of evaporation of soil water molecules. The results also indicated that there was reduction in soil nutrients and microbial growth in population due to the effect of gas flaring on the impacted soils.

1. Introduction

Gas flaring is the controlled burning of natural gas which occur as a result of the activities of oil exploration and exploitation using Flare stacks (Bailey *et al.,* 2000). The gas produced as associated natural gas during oil production varies in composition from location to location; however, the basic components include methane (CH_4), ethane (C_2H_6), propane (C_3H_8), iso-butane (C_4H_{10}), iso-pentane (C_5H_{12}), hexane (C_6H_{14}), carbon dioxide (CO_2), hydrogen sulfate (H_2S), Helium and Nitrogen (Ernest *et al.,* 2015). Other components of the gas flare products include wasteful energies, toxic gases and dangerous particulate matters. In Nigeria, gas flaring activity is high and it mainly takes place in the Niger-Delta region. A gas flare, alternatively known as a flare stack, is an elevated vertical conveyance found accompanying the presence of oil and gas wells, rigs, refineries, chemical plants, natural gas plants, and landfills. Nigeria has over 170 gas flaring point and these has been operational over 30years (Bailey *et al.,* 2000) The gas flared is associated with the formation of nitrogen oxides (NO_X) and sulfides oxides (SO_2) which are responsible for acid rain when it reacts with water in the environment. These findings have shown that gas flaring is responsible for the acid rain problems often experienced in the Niger Delta region (Uyigue & Enujekwu, 2017). The discharge of free gases by flared gas gave rise to serious heat that is experienced over an average radius of 0.5 kilometer and is responsible for thermal pollution (Ezeigbo *et al*., 2013).

2. Experimental Procedures

Location and Procedure for Soil Sample Collection

The Soil Samples were collected at Oshie Oil Field in Ahoada West Local Government Area of Rivers State, operated by Nigerian Agip Oil Company. The samples were collected at an interval of 250 meters for a distance of 2000meters from the Flare stack which provided eight (8) sampling points. The last point of sample collection (2000meters) was considered as the control samples. The soil samples were collected at a depth of 15 cm and 30cm respectively using a hand dug auger and transferred into a well labelled polyethylene bag for analysis in the Laboratory.

Atmospheric Temperature

Atmospheric and Soil Temperatures were measured *in-situ* at each point of sampling using a Thermometer, Model Testo 915-1.

pH

The pH levels of the soil sample were determined in the Laboratory using Hanna HI 2211 pH/ORP meter according to ASTM (1999) method D4972. The pH was determined by dipping the electrode into a 1:25 soil: water suspension that was stirred and allowed to equilibrate for one hour (Umeda *et al,* 2017)

Soil Moisture Content

This was determined by application of APHA (1998) standard as described by Ayotamuno *et al* (2011). 5g of moisture soil sample was weighed into a crucible and transferred into an electric oven for drying and maintained at $105^O C$ for 24 hours. The sample was removed from the oven and allowed to cool in a desiccator for 30 minutes. The sample was reweighed to obtain a constant weight. The equation below was used to calculate the percentage of moisture in the soil samples.

$$\text{\% weight of moisture content} = \frac{Weight\ of\ wet\ sample - weight\ of\ dry\ sample}{Weight\ of\ dry\ sample} \times 100 \qquad (1)$$

Total Nitrogen
This was determined by using APHA (1998) method, 4500-NO$_3$ B.

$$\% \ N = \frac{(T-B) \times N \times 1400}{S} \times 100 \qquad\qquad (2)$$

where, T = Sample Titration (ml), B = Blank Titration (ml), N = Normality of H$_2$SO$_4$,
S = Sample weight (mg)

Phosphorous
This was determined by using APHA (1998) method, 4500-PO$_4^{3-}$ as described in Umeda *et al* (2017). 1g of a representative soil sample was weighed into a clean extraction flask. This was followed by the addition of 10ml of Bray P-1 extracting solution (0.025N HCl and 0.03N NH$_4$F) and shaking immediately for 1 minute and filtered. 5ml of the filtrate was then pipetted into a 25ml volumetric flask and diluted to about 20ml with distilled water followed by the addition of 4 ml of ascorbic acid solution (1.056g ascorbic acid in 200ml molybdate-tartrate solution) and diluted to volume. This was allowed to stand for at least 30 minutes for full colour development before reading from the Spectronic 70 at 730mµ. Phosphorus (PO$_4^{3-}$) concentrations were then calculated after reference to a standard curve.
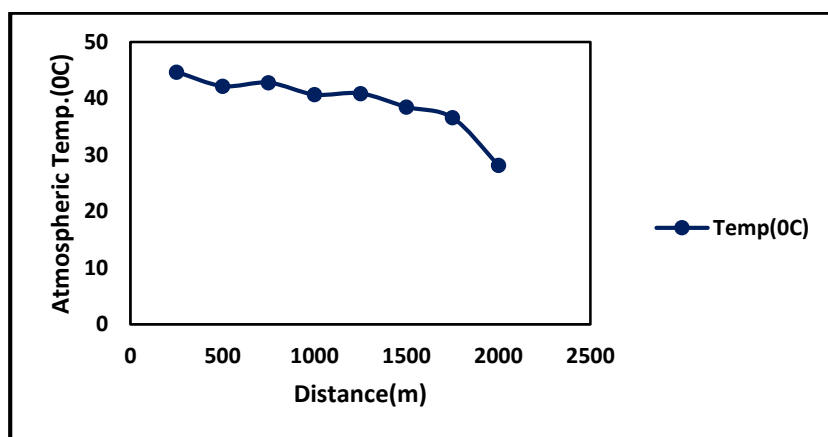
Cultivation of Total Heterotrophic Bacteria
Prepared nutrient agar culture plates were made according to the manufacturer's specification (HIMEDIA) M001-500G, HIMEDIA Laboratories Pvt. LTD Number-400086, India). The culture plates were dried and 0.1ml of the 10^1 diluted soil sample was placed on it and it was spread using a glass rod spreader to dryness on the plate. This was incubated at 37°C for 24hours and the bacterial count was made on the plate after the bacteria have shown growth. The bacteria that did not grow after 24hours were further allowed in the incubator for another 24 hours and readings were made on them. The total bacteria count was made and recorded (Barrow & Feltham, 2003).

3. Results and Discussion

Table 1. *Results of Physicochemical Parameter and Biological Analysis Obtained from Oshie Oil Field*
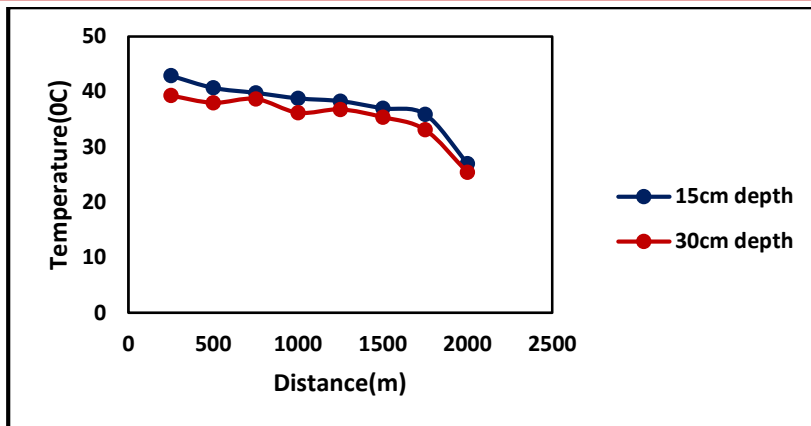
Distance from Gas Flare Stack (m)								
	250	500	750	1000	1250	1500	1750	2000
Atmospheric Temperature(^{0}C)	44.7	42.2	42.8	40.7	40.9	38.5	36.6	28.2
Soil Temperature @ 15 cm Depth (^{0}C)	42.9	40.7	39.8	38.8	38.3	37.0	35.9	27.0
Soil Temperature @ 30 cm Depth (^{0}C)	39.3	38.0	38.7	36.2	36.8	35.4	33.1	25.4
Soil Moisture Content @ 15cm Depth (%)	5.32	5.50	5.58	6.60	6.90	8.12	6.50	12.91
Soil Moisture Content @30	6.10	6.12	6.50	7.10	6.63	6. 86	8.21	13.45

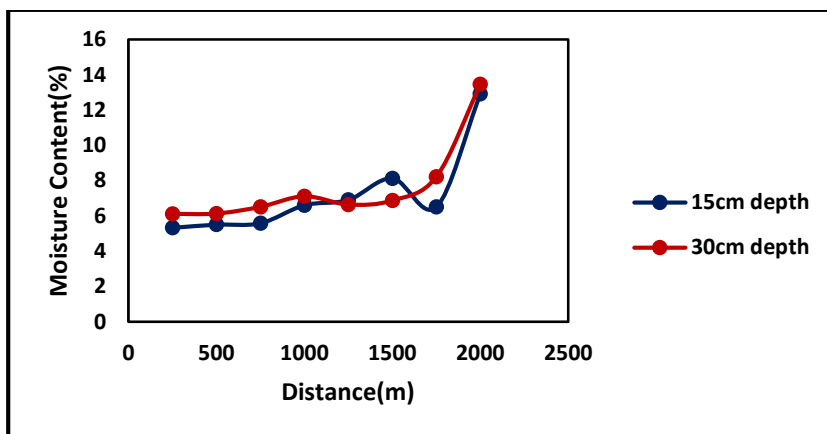| cm Depth (%)								
Soil pH @ 15cm Depth.	4.12	4.35	4.80	5.35	5.57	6.12	6.28	6.32
Soil pH @ 30cm Depth.	4.32	4.68	5.40	5.62	5.10	6.22	6.48	6.51
Total Nitrogen@15cm Depth (%)	0.232	0.246	0.249	0.352	0.374	0.434	0.452	0.472
Total Nitrogen@30cm Depth (%)	0.165	0.202	0.255	0.250	0.278	0.303	0.478	0.505
Phosphorous@15 cm Depth (%)	0.061	0.051	0.072	0.098	0.192	0.213	1.212	1.324
Phosphorous@30 cm Depth (%)	0.081	0.092	0.072	0.098	0.245	0.262	1.421	1.581
Total Heterotrophic Bacteria @ 15cm Depth(cfu/ml)	1.2×10^2	1.4×10^2	2.1×10^2	3.6×10^2	4.4×10^2	1.9×10^3	2.2×10^3	3.6×10^3
Total Heterotrophic Bacteria @ 30cm Depth(cfu/ml)	2.1×10^2	2.5×10^2	2.8×10^2	3.8×10^2	4.1×10^2	2.3×10^3	2.8×10^3	4.8×10^3

Figure 1. *Variation of Atmospheric Temperature with Distance*

Figure 1 shows the variation of atmospheric temperature with distance from the Flare Stack. The graph showed a decrease in temperature as the distance increased away from the Flare Stack. It revealed that the temperature was highest at a distance of 250meters which is closer to the Flare Stack compared to the temperature at a distance of 2000meters which is the control sampling point. This implied that thermal pollution may be very high on the environment closer to the gas flare stack.

Figure 2. *Variation of Soil Temperature with Distance*

Figure 2, shows the variation of Soil Temperature at 15cm and 30cm depth with distance from the Flare Stack. The graph shows a decrease in temperature at 15cm and 30 cm depth with increase in distance from the gas Flare Stack. It indicated that, the highest temperature level was at 250meter compared to the control location. This implied that the temperature has more effect on the agricultural soils closer to the gas flare stack compared to the soils at a distance of 2000 meters away, by increase in thermal pollution to the soils. Also, it showed that the temperature was higher at a depth of 15cm compared to 30cm depth. This indicates that the effect was higher at 15cm depth of the soils compared to 30cm depth, which implied that thermal pollution is more pronounced at the top part of the soils.


Figure 3. *Variation of Soil Moisture Content with Distance*

Figure 3 shows the variation of moisture content at 15cm and 30 cm depth with the distance from the Flare Stack. The graph revealed that the moisture content of the soil increases with the distance away from the Gas flare stack. This indicated that gas flaring has an effect on the moisture content of the soils at close distance to the Flare stack, hence affects the soil quality (Nwaugo, *et al.,* 2006). This may be attributed to high rise in temperature which resulted in optimum evaporation of water molecules from the soil.
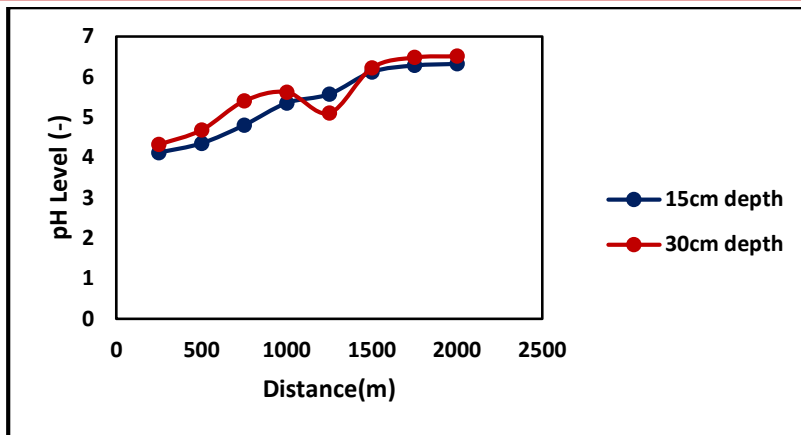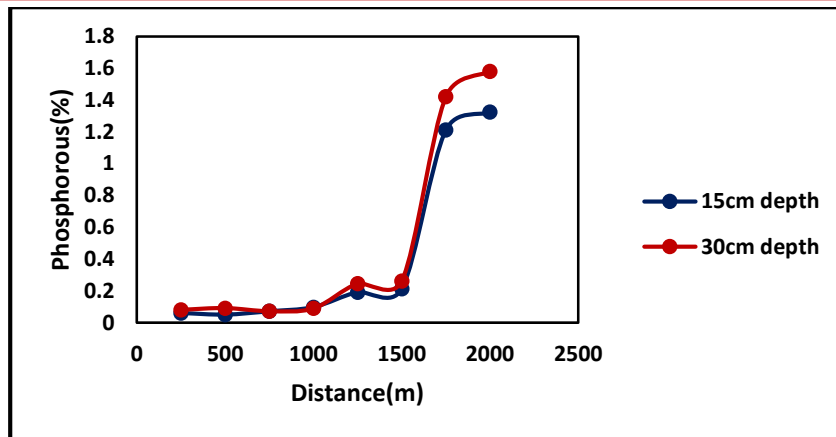
Figure 4. *Variation of Soil pH with Distance*

Figure 4, shows the variation of pH level with the distance from the gas flaring point. The graph showed that the pH level increases with the distance away from the Flare stack. This is because the area closer to the flaring point is expected to have more emission of NO_X and H_2S which reacted with water molecules to form acidic rain. The acidic rain may be responsible for the increase in the acidic level of the soils closer to the Flare stack compared to the soils at a distance of 2000meter used as the control point. Increase in acidity level of the soil affects soil nutrient and fertility negatively, hence affect crop production (Uyigue & Enujekwe, 2017)
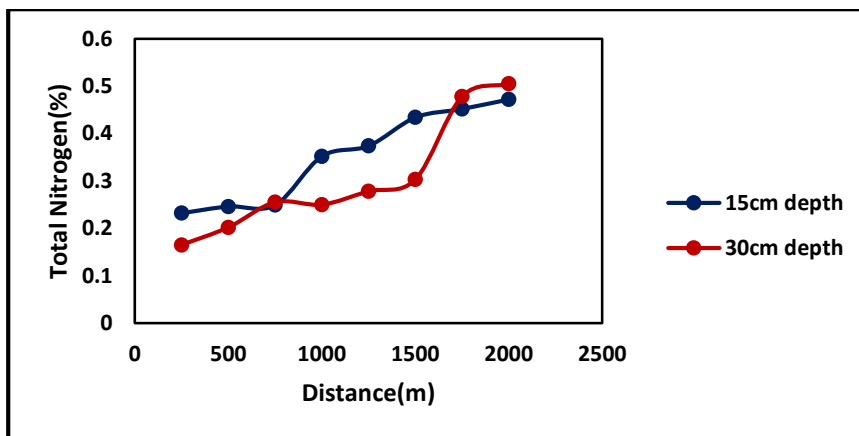

Figure 5. *Variation of Soil Total Nitrogen with Distance*

Figure 5 and Figure 6 shows the variation of Total Nitrogen and Phosphorous with distance from the Gas Flare Stack. Nitrogen and Phosphorous are major soil nutrients, so their presence in the soil have vital role for an effective soil performance. Their presence determines the response of the soil on its usage for agricultural purposes.

Figure 6. *Variation of Soil Phosphorous with Distance*

The graphs (Figures 5 and 6) revealed that the concentration of the soil nutrients increased with the distance away from the gas flaring point. This implied that the gas flaring has a negative impact on the availability of phosphates and nitrates that may be available to plants for nutrition due to the temperature evolved. It also showed that the soil nutrients at the top soil (15cm depth) were mostly affected compared to those at 30cm depth. The effect on the soil nutrient showed a negative effect on the soil fertility which gave rise to low crop production (Otunkor & Ohwovorione, 2015)
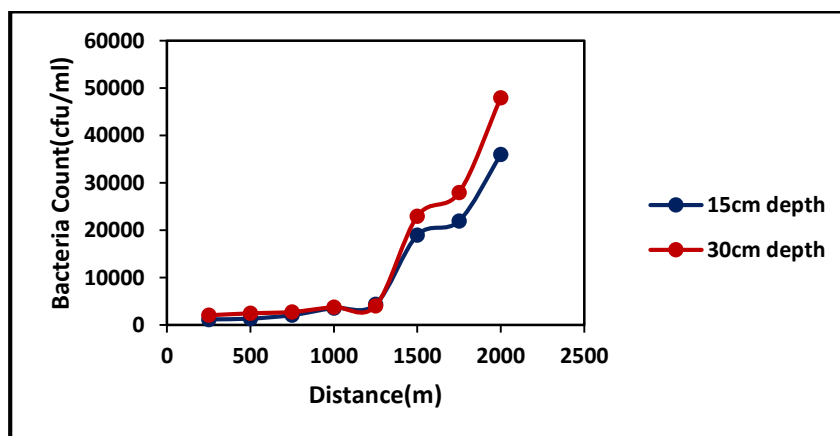
Figure 7. *Variation of Total Heterotrophic Bacteria Count with Distance*

Figure 7, shows the variation of bacteria count with distance. The graph indicated that the bacteria count increased with the distance away from the gas flare stack. This implied that the population growth of the bacteria count increased with the distance away from the stack. This also showed that few bacteria survived at a distance of 250meters.The study revealed that *Bacillus* and *Pseudomonas* species were mostly the surviving species at 250 meters because of the presence of spores which protects the inner part of the cells of *Bacillus* species. Also, appearance of other species such as *Corynebacterium* and *Escherichia* at a distance of 1000meters were noticed. The results showed that gas flaring has negative effect on the growth of microbial population in Oshie Oil Field (Nwaugo, *et al*., 2006)

4. Conclusion
In line with the results obtained in this work, it is clear to state that gas flaring produces negative impact on the soil of Oshie Oil Field in Ahoada West Local Government of Rivers State. This implied that, the occupation of the people being farming is affected by the gas flaring which

results in low agricultural produce due to increase in acidity of the soil and thermal pollution which affects moisture content and other soil parameters. It is necessary and wise for government to come up with policies that will stop gas flaring in Niger Delta.

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