EFFECT OF GAS FLARING ON THE PHYSIO-CHEMICAL AND MICROBIOLOGICAL PROPERTIES OF AGRICULTURAL SOILS IN UBEJI, WARRI SOUTH LOCAL GOVERNMENT AREA, DELTA STATE

Yusuf Adamu Datti and Okonkwo Henry Nduka
Industrial Safety and Environmental Technology Department,
Petroleum Training Institute Effurun Delta State Nigeria

ABSTRACT

The study seeks to determine Nitrate, bacteria, fungal count, pH, temperature and moisture content levels of soil around Warri Refinery and Petrochemical Company (WRPC) flare. Soil samples were collected at five sampling distances from the flare stack (10m, 50m, 100m, 150m and 200m) and a control. The results from the analysis shows nitrate levels were 0.0022mg/kg at 10m, and 0.0250mg/kg at 200m, with the control showing the highest concentration. The results showed a decrease in microbial number in the soil closer to the flare stack. The total bacteria count was 26 x10^3 cfu/g at 10m and 52 x10^3 cfu/g at 200m. The total fungi count were 19x10^3 cfu/g at 10m and 51x10^3 cfu/g at 200m. The results shows that the soil was more acidic closer to the flare with pH value at flare site as 5.97 at 10m than at 200m with a pH of 7.03. The lowest temperature recorded was 26.9°C at 200m with a corresponding highest moisture content of 34.26%. Similarly the highest temperature recorded was 28.3°C with a corresponding lowest moisture content of 15.46%. Chi Square statistical tool concludes there exist a significant difference at 5% confidence level the properties of the soil investigated at distances from flaring point. This study recommends that crops which respond to high temperature should not be planted within flare areas. And there is need to enforce the existing legislations which will control the activities of companies in the oil industries to comply with preserving the environment while carrying out production activities.

Keywords: Soil, Nitrate, Microbes, pH, Flare Site

INTRODUCTION

In the early development of oil and gas production, operators did not consider natural gas as a useful product and therefore vented or burnt off into the atmosphere at the well through a process called gas flaring. According to Ighu (2016), gas flaring is the controlled burning of unutilized natural gas that is associated with crude oil when it is pumped from the ground. A flare system which is similar to the lighting of a burner tip on a gas stove, is made up of a flare stack and pipes that feed gas back to the stack, and the gas flows into a vertical pipe and is immediately lit to burn off. Since the inception of the petroleum industry, gas flaring has been an integral part of the operation associated with the exploration and refining of crude oil in Nigeria (Kuranga, 2002). Reports by Ogodo (2003) reported that the acid deposition from gas flare have deleterious effects on the fertility, pH and microbial spectrum of the surroundings soils. Wild, (1993); Grant (1995) also reported that “Gas Flaring impoverishes soils”. In addition, the free disposal of gas, flaring generates tremendous heat which has direct heating and increased water loss effects on nearby plants, with severe wilting and death ensuing (Mauseth, 1998). Other consequential impacts are de-vegetation of farmland and other forms of ecological damages, emigration of wildlife and subsequent decline in hunting, loss of recreational and aesthetic devaluation, destruction of mangrove swamps and salt marsh, production of heat stress, excessive noise, acid rain, forced population migration, resettlement and other aspect of rehabilitation of the affected individuals and communities where gas is flared.

Correspondence Author: Yusuf Adamu Datti yusuf_ad@pti.edu.ng
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The problem of gas flaring has long been a major source of conflict between oil companies and host communities, and the need for proper evaluation of the problems generated is of paramount importance. The issue of gas flaring is a global phenomenon with its attendant environmental consequences. Garba, (2008) reported on the review of the regulatory, environmental and socio-economic issues relating to gas flaring in Nigeria and concluded that phase-out of gas flaring in Nigeria in 2008 was feasible, depending on the commitment of the government in achieving that objective. Reports by Botkin and Keller, (1998) revealed that the effect of gas flare stack on moisture content conducted some on selected soil sample shows that the moisture content increased away from the flare and then concluded that the low moisture content close to the flaring point is a direct effect of heat from the flare. The flares have contributed large volumes of greenhouse gases as well as several dangerous toxin released into the atmosphere, polluting the air, soil the ecosystem. The impact of gas flaring on soil is obvious, especially when considered on the basis of the long duration of the flaring. Exchangeable cations are one of the most important chemical bases of soil fertility; deficiencies of these mineral elements are responsible for poor nature of tropical soil. However, the cation Exchange capacity (CEC) of the soils under gas flaring is very low and reduces the fertility and nutrients of the soil. Finnveden and Ekval, (1998), and Dauda, (2001) reported that exchangeable cation or base (Ca; Mg’, K’ and Na’) in soils under gas flaring is low. Also Odjugo (2007) observed that organic matter and total nitrogen decline in gas flaring sites and also exhibits increasing pattern with increasing distance from the flares. Investigations revealed that this decline is brought about by intense heat, which affects the process of the formation of organic matter and total nitrogen formation. Alakpodia, (2000) reported a very low mean value of organic matter (1.83%) and total nitrogen (0.08%) of soils under gas flaring in Niger Delta, Nigeria. Dung, Bombomand Agusomu (2008) investigated the spatial variability effects of gas flaring on the growth and development of cassava (Manihot esculenta) and waterleaf (Talinum triangulare) crops commonly cultivated in the Niger Delta, Nigeria. The results suggest that a spatial gradient exists in the effects of gas flares on crop development. The study attributed increased temperatures around the gas flare as the most likely cause of crop retardation. Reports by Odjugo and Osemwenkhae, (2009) observed that the air temperature, soil temperature at 5 cm and 10 cm depths increased as one moves closer to the flare site. Similar reports by Oseji, (2007), Odjugo, (2009) and Julius, (2011) suggested that increase in temperature associated with gas flare contributed to low agricultural productivity and cause changes in the natural ecosystem. This work is therefore aimed at investigating the effect of gas flaring on the physio-chemical and microbiological properties of agricultural soils in Ubeji, Warri South Local Government Area.

METHODOLOGY
The temperature of each sample was taken at the site by immersing the bulb of the thermometer in the soil and the reading taken in °C taken after 5 minutes. Soil samples were collected at distances of 10m, 50m, and 100m, 150m and 200m using an auger and kept in sterile plastic bags. The samples were transported to Microbiology Laboratory for analysis in refrigerated coolers to arrest microbial growth. Soil pH was determined by adding 20g of air dried soil into 20ml distilled water and the contents stirred occasionally with a glass rod and then allowed to stand for 30 minutes. The electrodes of the pH meter were inserted into the suspension and the pH reading recorded. The moisture content of each sample was determined by the method weighing 5g of each soil sample into a crucible and then heated in a hot air oven for a period of 8 hours at 80°C till a constant weight was obtained. The weight of the moisture was determined from the difference between the initial and final weights obtained.

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Air dried samples were placed in an oven at 105°C for 24 hours until they were brittle and crisp. A portion (1g) of dried, disaggregated and sieved soil sample were placed in 50 mL, Teflon beakers and then digested with 10 mL of HNO₃-HCLO₄-HF to near dryness at 90°C on a hot plate. The digests were filtered into a 50 mL volumetric flask using Whatman No. 42 filter paper. Nitrate (NO₃⁻) and nitrite (NO₂⁻) concentrations in the soil distillates were then determined by using spectrophotometer (Model 2000) at a wavelength of 543nm.

Each sample of soil was vigorously shaken in 10ml of normal saline. An aliquot (1ml) was transferred into the test tubes and diluted serially in ten folds up to 10⁵. From the dilutions of 10³ and 10⁴ of each soil sample, 0.1ml each aliquot was transferred into freshly prepared media plate and spread in duplicate on surface of the solidified media of Nutrient agar, MacConkey agar and Potato dextrose agar. The mixture was evenly spread on each medium. The inoculation plates were incubated at 37°C for 48 hours while inoculated plates of Potato dextrose agar were kept at room temperature for 48 hours, after which the plates were examined for growth. Discrete colonies were counted and recorded as total microbial count in the sample and expressed as colony forming units per gram of soil sample (cfu/g).

The Chi-square ($\chi^2$) was used to determine whether there exist any significant difference in the concentrations of nitrates, microbes, pH, temperature and moisture content concentration at distances from the flare at 5% level of significance.

Hypothesis
- $H_0$: Gas flaring has no adverse effects on soil fertility.
- $H_1$: Gas flowing has adverse effects on soil fertility.

RESULTS
Table 1 presents the effect of gas flaring on soil nitrates, bacteria, fungi, pH, temperature and moisture content investigated in soil at 10m, 50m, 100m, 150m and 200m away from the gas flare stack of Warri Refinery and Petrochemical.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Distance (m)</th>
<th>10</th>
<th>50</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate (mg/kg)</td>
<td></td>
<td>0.0022</td>
<td>0.0114</td>
<td>0.095</td>
<td>0.051</td>
<td>0.025</td>
<td>0.089</td>
</tr>
<tr>
<td>Bacteria count (cfu/g)</td>
<td>2.6×10³</td>
<td>3.3×10³</td>
<td>3.9×10³</td>
<td>4.7×10³</td>
<td>5.2×10³</td>
<td>5.3×10³</td>
<td></td>
</tr>
<tr>
<td>Fungi count (cfu/g)</td>
<td></td>
<td>1.9×10³</td>
<td>2.2×10³</td>
<td>2.9×10³</td>
<td>3.8×10³</td>
<td>5.1×10³</td>
<td>5.7×10³</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>5.97</td>
<td>6.03</td>
<td>6.27</td>
<td>6.71</td>
<td>6.38</td>
<td>7.03</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td></td>
<td>28.3</td>
<td>27.7</td>
<td>27.5</td>
<td>27.3</td>
<td>26.9</td>
<td>23.5</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td></td>
<td>15.46</td>
<td>21.23</td>
<td>26.37</td>
<td>28.78</td>
<td>34.26</td>
<td>41.86</td>
</tr>
</tbody>
</table>

Source: Field Survey, 2020

DISCUSSION OF RESULT
The Nitrate concentration did not follow a pattern. This may be due to the direction of wind and slope of the land (in a case of run-off). The soil samples collected had a Nitrate concentration of 0.002mg/kg at 10m, 0.0114mg/kg at 50m, 0.095mg/kg at 100m, 0.051mg/kg at 150m, 0.025mg/kg at 200m and 0.089 at the control. This result could also be attributed to the heat radiation from the flare that could have a detrimental effect on the soil by destroying the bacteria which help the soil to convert Nitrogen to Nitrate for soil to support plant growth.
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A decrease in total microbial counts was obtained as distance increased towards the flare. The total bacterial counts was low, $2.6 \times 10^3$ cfu/g at 10m, as compared to $5.2 \times 10^3$ cfu/g at 200m and at the control $5.6 \times 10^3$ cfu/g (Table 1). The difference between 200 m and the control in each station examined was not significant. This trend in the bacteria population shows that the gas flaring affected the bacterial species as values obtained from the 10 m samples were the least as compared with those at 200m and the control. Counts of heterotrophic fungi were highest ($5.1 \times 10^3$ cfu/gm) at 200 m and lowest ($1.9 \times 10^3$ cfu/gm) at 10m from the flare. Fungal population was generally lower than those of the bacterial population. This is understandable as most fungi thrive at room temperature. This result is an indication that gas flare hinders the growth of bacterial and fungal population. This finding is in consonance with the works of (Stavishenko et. al, 2002), showed that fungi population is low in oil and gas region in Siberia. This picture indicates that gas flaring had adverse effect on bacterial and fungal number examined. When the distance increased to 200 m away from the flare point, more bacterial and fungal number were observed (Chessbrough, 1987 and Prescott et al. 1999).

The pH of the soil at control, 10m, 50m, 100m, 150m and 200m from the flare stack were 7.03, 5.97, 6.03, 6.27, 6.71 and 6.38 respectively. These results show that except for the control all soil sampled were all acid in nature with the soil at 10m from the flare as being the most acidic. This result suggests the possible effects of the gas flaring on the pH of the soil. This agrees with the findings of Okeke and Okpala (2014) and Obi, Osang and Pekene (2017) that reported that gas flaring alters the pH of the soil. The acidity of the soil samples in WRPC environs could be attributed to the continuous flaring which produces acidic oxides of nitrogen, carbon, Sulphur which dissolves in rain water to form acid rain. High soil acidity creates chemical and biological conditions which may be harmful to plants and microorganisms (Nwaogo, Onyeze and Nwabueze, 2010).

The soil temperatures increased as distance approaches the flare. The highest temperature $28.3^\circ C$ was observed at 10m, while the lowest 26.9 was observed at 200m from the flare. While the control recorded $23.5^\circ C$. This excessive and continuous heating can also be attributed to the reduction in soil moisture (Botkin and Keller, 1998). This increased temperature and a corresponding reduction in soil moisture can also affects the photoperiodicity required for plant flowering and fruiting. The percentage soil moisture content obtained from this study ranged from 15.46% at 10m – $34.26\%$ from the flare and $41.86\%$ at the control.

$H_0$ represent that Gas flaring has no adverse effects on soil fertility and $H_1$ represent Gas flaring has adverse effects on soil fertility. Test of hypothesis result using Chi-square ($X^2$) shows that $X^2$ calculated is 4.8999 and $X^2$ tabulated is 23.3. Since $X^2_{cal} < X^2_{tab}$. Hence it means the alternative hypothesis ($H_1$) is accepted while the null hypothesis ($H_0$) is rejected. The results obtained showed that gas flaring has adverse effect on the physio-chemical and microbiological properties of the soil.

CONCLUSION

In Nigeria, a substantial amount of associated gas or produce natural gas are flared into the environment. This study evaluated the effect of gas flaring around agricultural farmland in Ubeji, Warri South Local Government Area, Delta State, Nigeria. The study concluded that there were significant variations across all the distances investigated except for the control. The lower values in the soil parameters investigated in area close to the flare suggests its impact on soil nutrients which may affect the productivity of vegetation being cultivated in the area.

RECOMMENDATIONS

In the light of findings, it was recommended that, there is the need for the oil and gas companies to adopt zero tolerance to flaring of associated gas. Government should effectively implement the gas flare-out policy and empower regulators to deal with violators with stiff penalties to serve as deterrents to others.
Government should sensitize the entire public through Public Awareness Scheme and Programme on the issues of gas flaring effects on the environment and as well as on individuals health conditions.

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