# EVALUATION OF THE INFLUENCE OF GAS FLARE ON SOME PHYSICAL PROPERTIES OF SOILS OF THE IMMEDIATE ENVIRONMENT OF GAS FLARE SITE IN DELTA STATE, NIGERIA

Supported by tetfund

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**Received: December 14, 2023 Accepted: March 28, 2024**

**Abstract:** This research assessed the influence of gas flaring on some physical properties of soils of the immediate environment to gas flare site in Delta state, Nigeria. The study entailed collection of nine soil samples from a gas flare site at Kwale. The samples were collected between distances of 200m to 2.250km away from the flare site and a control sample at varying depths of 5cm, 10cm and 15cm respectively. The essence of employing this methodology is to establish possible link between soil physical properties and the impact from the heat and gases produced from the gas flare in the study area. The results revealed influence from the gas flare especially in the pH, temperature and moisture content of the soil. The pH showed the least value (most acidic) of 5.12 at depth of 5cm and 200m away from the flare. The soil temperature at 200m and 5cm depth recorded the highest value (39.7 $^{o}$C) and the least value (27 $^{o}$C) was observed at 35km (control) away from the flare site. The least value for moisture (5.83%) was recorded at 200m and the highest (15.38%) for the control site. The values obtained from both insitu and laboratory tests, showed that the flare has negatively impact the soil pH, moisture content and temperature.

**Keywords:** Gas Flare, Soils, Evaluation, Influence, Environment

## Introduction

Gas flaring is the burning of natural gas and other petroleum hydrocarbons at flare stacks in oil fields during operation. It is used to dispose of associated gas. Low flare stacks bring the flare close to nearby vegetation and soil. They are used to eliminate gas, which is released via pressure relief valve when needed to ease the strain on equipment. Soil temperature increases towards the flare site and so reduces the soil moisture content. This shows that soil moisture content and $P^H$ are affected directly with closeness to the flare site. Recently, under the Kyoto Treaty there is carbon trading, garbage collecting companies in some developing nations have received a carbon bonus for installing gas collection devices for the methane gas produced at their landfills, preventing methane from reaching the atmosphere. After the burning, this gas is converted to heat, water and Carobon dixodie ($CO_2$) and according to the IPCC Third assessment report (TAR), Climate Change 2001, as Methane ($CH_4$) is 23 times more powerful greenhouse gas than Carbon dioxide ($CO_2$) the greenhouse effect is magnified in the same order.

On oil production rigs, in refineries and chemical plants, its primary purpose is to act as a safety device to protect vessels or pipes from over-pressure due to unplanned upsets. Whenever plant equipment items are over-pressured, the pressure relief valves on the equipment automatically release gases (and sometimes liquids as well) which are routed through large piping runs called flare headers to the flare stacks. The released gases and / or liquids are burned as they exit the flare stacks. The size and brightness of the resulting flame depends upon how much flammable material was released.

Steam can be injected into the flame to reduce the formation of black smoke. The injected steam does however make the burning of gas sound louder, which can cause complaints from nearby residents. Compared to the emission of black smoke, it can be seen as a valid trade off. In more advanced flare tip designs, if the steam used is too wet it can freeze just below the tip, disrupting operations and causing the formation of large icicles. In order to keep the flare system functional, a small amount of gas is continuously burned, like a pilot light, so that the system is always ready for its primary purpose as an over-pressure safety system. The continuous gas source also helps diluted mixtures achieve complete combustion. Enclosed ground flares are engineered to eliminate smoke, and contain the flame within the stack.

The World Bank estimates that over 150 billion cubic meters of natural gas are flared or vented annually, an amount worth approximately 30.6 billion dollars, equivalent to 25 percent of the United States' gas consumption or 30 percent of the European Union's gas consumption per year. The largest flaring operations occur in the Niger Delta region of Nigeria. The leading contributors to gas flaring are (in declining order): Nigeria, Russia, Iran, Algeria, Mexico, Venezuela, Indonesia and the Untied States.

Flaring of associated gas releases emissions rich in carbon, nitrogen, and sulfur oxides and soot. The low height of flare stacks ensures local pollution at ground level and nearby dry deposition, as well as close heating of surrounding vegetation and soil.

The intense heat from gas flares are likely to harm the fertility of the surrounding soils. The obvious signs are the poor vegetation growth and scorched soils around gas-flare locations.

Acid deposition decreases the soil pH. However, the effect of acid deposition on a particular soil ecosystem is influenced by such factors as acid sensitivity, neutralization capability, concentration and composition of acid reaction products, and the amount of acid added to the system. The basic cations ($Ca^{2+}$, $Mg^{2+}$, and $K^{+}$) are replaced by hydrogen ions or soluble metals and are lost through leaching. Increased acidity reduces activity of soil micro-organisms sensitive to low pH, thus decreasing decomposition of plant residues and the recycling of essential plant nutrients. The concentration of trace-metal ions in soil-solution increases (including aluminum, copper, iron, zinc, boron, manganese, chromium, and nickel) to levels that may be phytotoxic, Phosphorus, resulting in a reduced availability of plant phosphorus. Plant uptake of molybdate is reduced. Nitrification by the main autotrophic genera involved (Nitrosomonas and

Nitrobacter) is inhibited; thus, $NH4+$ is the main form of nitrogen taken up by plants instead of $NO_3^-$. There is reduced symbiotic nitrogen fixation by legumes, except the Rhizobium strain, which is acid tolerant. (R.E. Akpojivi and P.E. Akumagba, 2005).

The existence of such gas flare stacks in most parts of the Niger Delta area including Kwale (study area) necessitated this study.

This study therefore investigated the effect of gas flaring on some soil physical properties.

## Location of Study Area

The study area , Kwale is located in Ndokwa West L.G.A of Delta State. It is underlain by the continental sands of Benin formation. The area has a flat topography and is situated by the bank of river Niger.

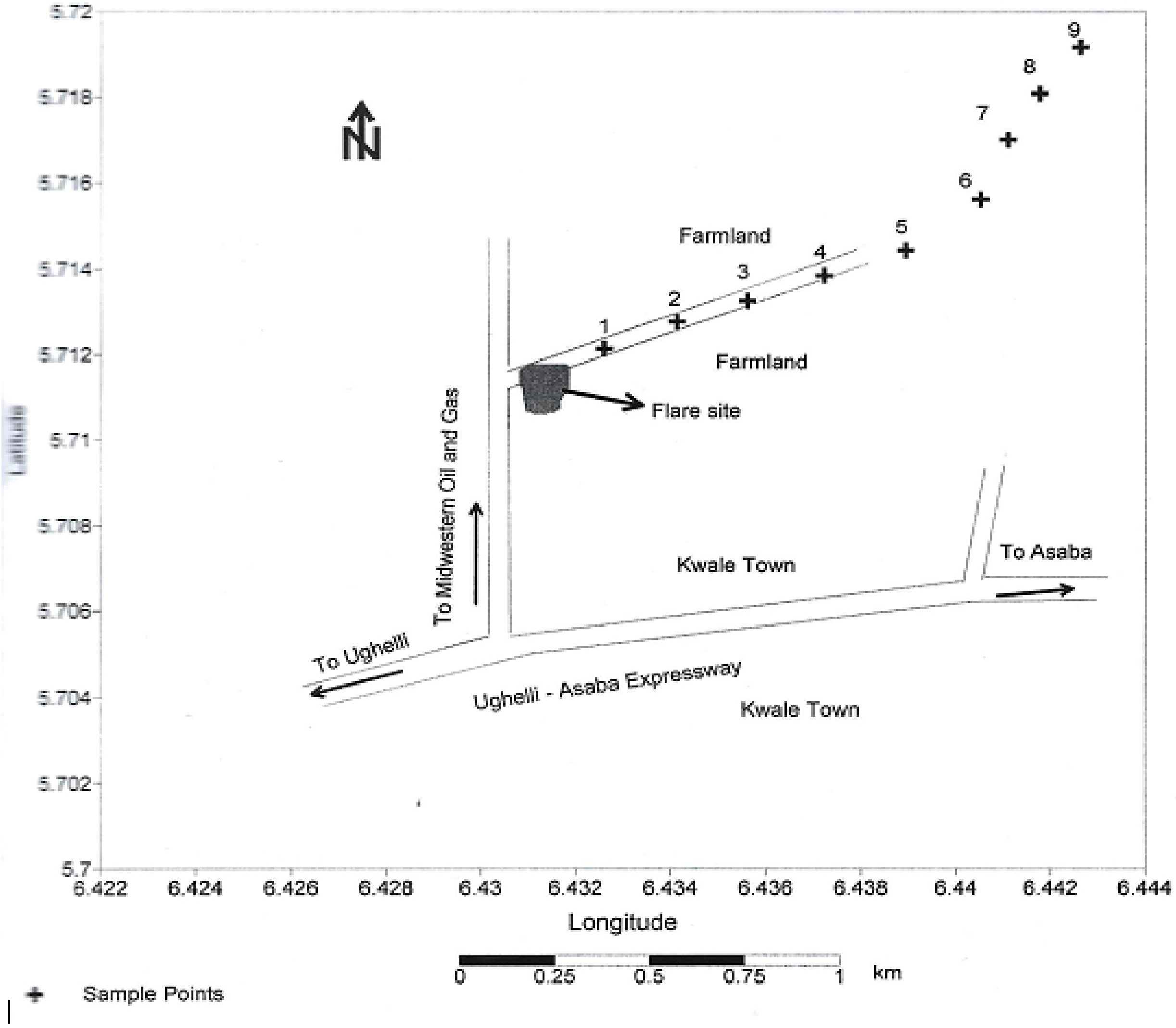

Figure 1.0: Sketch map of study area showing the sample points.

## Literature Review

According to Scherr et al. (2001), pollution by the oil industry is destroying the vital resources on which they depend. Land degradation can take a number of forms, including nutrient depletion, soil erosion, salinization, agrochemical pollution, vegetative degradation from overgrazing and the cutting of forests for farmlands.

Some of the substances released into atmosphere are either inert biologically or detrimental because they cause stress to plants, animals and micro-organism (Cowling, 1991).

Some authors opined that flared gas has a lot of environmental implications. For instance, gas flaring is observed to reduce atmospheric quality through the release of pollutants like carbon (C), nitrogen oxide ($NO_2$), sulphur oxide ($SO_2$) and lead (Pb), among others into the atmosphere. (Okon, 2000; Obi, 2001).

Gas flaring has been reported by many researchers to be a major cause of low agricultural productivity, fishing and hunting in the Niger Delta, thereby impoverishing the inhabitants. (Alakpodia, 2000; Daudu, 2001).

Gas flaring is reported to cause acid rain within the flares microenvironment (Odjugo, 2002).

According to Alakpodia (2000), gas flaring significantly affects not only the microclimate but also the soil physio-chemical properties of the flare sites. Some of the substances released alters the surface and ground water quality, aggregate nutrient deficiencies in soils, or accelerate the soiling, weathering or corrosion of engineering and cultural materials. He said there is visible change in soil characteristics that is close to a flare site.

Gas flaring destroys the vegetation and destabilized the eco-system (Ogbonanya, 2003).

Metabolically regulated plant processes, such as water and nutrient uptake can be diminished below optimum rate at both low and high temperature, resulting in temperature dependent growth and yield pattern. For instance, corn yields were observed to increase almost linearly as a function of soil temperature between 15 – 25°C, above 25°C the yield decreases. (Allmaras et al, 1964).

Some of the substance released into the atmosphere are primary destroyers of the atmosphere (Okeagu *et al*, 2006).

Some authors opined that excessive heat either kills or scares away most of the micro and macro organisms that would have helped to improve the soil through further breaking down of the soil particles, decaying and decomposition of the organic matters (Alakpodia, 2000 and Akpobome 2004).

Temperature increases in areas close to flare sites to an extent results in higher temperature when compared to other areas thereby increasing the areas evaporation rate (Odjugo, 2007).

Some authors opined that gas flaring is found to have significantly affected the health of the inhabitants of Otujeremi, Igbide, Olomoro and Ubeji, causing ailments like respiratory, eye, skin and intestinal diseases (Efekodo, 2001; Odjugo, 2004a; Otuaga, 2004). While oil spillage and effluent discharges are the major sources of land and water pollution by the oil industries, the air is polluted through gas flaring (Odjugo, 2004a; 2005 and 2007).

According to Atevure, (2004), there is an implication that Nigeria has one of the worst rate of gas flaring in the world because Nigeria flared 76% of its natural gas. He said that Gas flaring is a common practice in the oil production processes that is not restricted to Nigeria. Libya for instance flares about 21% of its natural gas, while Saudi Arabia, Canada and Algeria flare 20%, 8% and 5% respectively.

The low combustion efficiency of Nigerian flare stack (60 – 80%) results in a large portion of the gas emitted being methane and since methane has a higher global warming potential (64 aginst 1 for $CO^2$) (Sawaragi et al, 1978).

According to Abdulkareem *et al*, (2010), around 18 cubic meters of the total gas produced is associated gas, most of which is flared, with small amount re-injected into the sandstone sponge while the remaining is sold to electricity generating stations and industries. Abdulkareem et al (2006). The extent of human damage attributable to gas flaring is unclear, but doctors have found an unusual high incidence of asthma, skin and breathing problems in oil producing areas.

Abdulareem *et al*, (2002), Combustion of associated gas during gas flaring greatly affects the surrounding environment and particular crops planted within the vicinity of gas flare stations.

According to Thomas et al, (1999), The Nigerian oil industry probably contributes more than any other company of these serious global commons environmental problems. As carbon dioxide and methane are the main greenhouse effect and consequently, this phenomenon has been confirmed to raise the average global temperature by about 0.5°C within the last century.

According to Akudo, et al, (2012), gas flaring increased soil temperature by between 12.6 degrees Celsius and 23.4 degrees Celsius and reduced soil moisture at 5cm by 18.6% and 2.8%. It is also established that changes on soil temperature and moisture contents is significant with distance away from flare sites.

According to UN economic commission for Africa categorized Nigeria as gas surplus country, and still has limited associated gas sales, as 68% of the gas is flared and as a result has been associated with climate change and related warming, deforestation and acid rain with attendant impact on agriculture and other physical infrastructure (Onosode, 1996).

## Methodology

The research method employed for this study includes

- Field study
- Analytical method

### *Field Study*

Field study of the sample area was made on reaching the field, geographical locations where noted with the aid of a global positioning system (G.P.S). Soil samples were collected from nine different locations in Kwale, and a control from Amai with distances of 200m, 500m, 750m, 1km, 1.250km, 1.500km, 1.750km, 2km, 2.250km, and 35km away from the flare site at a depth of 5cm, 10cm and 15cm respectively. The soil samples were put in a dark polyethene bag properly labeled and then taken to the laboratory for analysis. Before the samples were collected, also atmosphere temperature was measured at each location where soil samples were collected, and soil temperature was measured at each depth where soil samples were collected using thermometer (testo 915-1).

### *Analytical Method*

Soil samples were taken to the laboratory for analysis, and all analysis were conducted at biological sciences laboratory, Novena University Ogume, Delta State. This started by weighing the containers when empty with a weigh balance, the containers in which soil samples were put and the weight before and after drying.

Also an oven was used to dry the soil samples at a temperature range of 110°C. The drying of the samples lasted six (6) hours. The container in which the samples were put was weighed when empty, and then the figures were recorded. The same process was repeated with samples and it was repeated after the samples had been dried in the oven model MINO/30.10g of the soil sample was weighed with a weighing dish into a 250ml beaker. 50ml of screened distilled water was measured into it and was stirred for thirty minutes with the aid of a magnetic stirrer after which the pH was measured with pH meter (fisher automatic tetrameter Model 36 – pH (AOAC, 2003).

## Results

The results of the laboratory analysis are presented in table 1.0 below. Figure 1.1 – 1.3 are charts that represent variations in temperature, moisture content, and pH of soils in the study area.

**Table 1.0: Results of Insitu and Laboratory Analysis**

| Distance from flare site | 200m | 500m | 750m | 1km | 1.250km | 1.500km | 1.750km | 2km | 2.250km | (Control) 35km |
|---|---|---|---|---|---|---|---|---|---|---|
| Air temperature $^o$C | 39.2 | 35.5 | 36.8 | 37.5 | 39 | 40.8 | 40.7 | 35.3 | 37.2 | 27.2 |
| Latitude | 5$^o$42’49.0 “N | 5$^o$42’51.05 “N | 5$^o$42’54.68 “N | 5$^o$42’57.46 “N | 5$^o$43’06.52 “N | 5$^o$43’08.97 “N | 5$^o$43’13.69 “N | 5$^o$43’15.01 “N | 5$^o$43’16.20 “N | 5$^o$44’52 “N |
| Longitude | 6$^o$52’33.38 “E | 6$^o$25’36.82 “E | 6$^o$25’41.76 “E | 6$^o$25’46.32 “E | 6$^o$25’50.93 “E | 6$^o$25’53.51 “E | 6$^o$25’55.20 “E | 6$^o$5’57.32 “E | 6$^o$5’58.9 “E | 6$^o$12’24 “E |
| Soil Temperature $^o$C (5cm) | 39.7 | 34.2 | 36.1 | 36.9 | 39.6 | 39.1 | 37.1 | 35.1 | 35.8 | 27 |
| Temperature $^o$C (10cm) | 38.9 | 32.3 | 35.8 | 36.3 | 38.6 | 35 | 35.3 | 34.9 | 35.8 | 27 |
| Soil temperature $^o$C (15cm) | 38.2 | 32.3 | 36.5 | 36.6 | 39.8 | 38.6 | 35.3 | 34.9 | 35 | 26 |
| Moisture content % (5cm) | 6.98 | 6.26 | 9.09 | 6.99 | 6.75 | 10.83 | 7.14 | 7.92 | 9.21 | 13.90 |
| Moisture content % (10cm) | 8.38 | 7.39 | 10.55 | 6.16 | 7.77 | 11.81 | 8.03 | 9.03 | 8.44 | 15.38 |
| Moisture content % (15cm) | 5.83 | 8.13 | 7.68 | 7.11 | 6.58 | 6.35 | 13.23 | 8.51 | 14.69 | 14.38 |
| pH (5cm) | 5.12 | 5.21 | 5.33 | 5.30 | 5.43 | 5.50 | 5.67 | 5.86 | 5.89 | 6.62 |
| pH (10cm) | 5.06 | 5.15 | 5.26 | 5.27 | 5.33 | 5.41 | 5.40 | 5.77 | 5.77 | 6.18 |
| pH (15cm) | 5.09 | 5.12 | 5.25 | 5.27 | 5.18 | 5.12 | 5.60 | 5.70 | 5.70 | 5.78 |

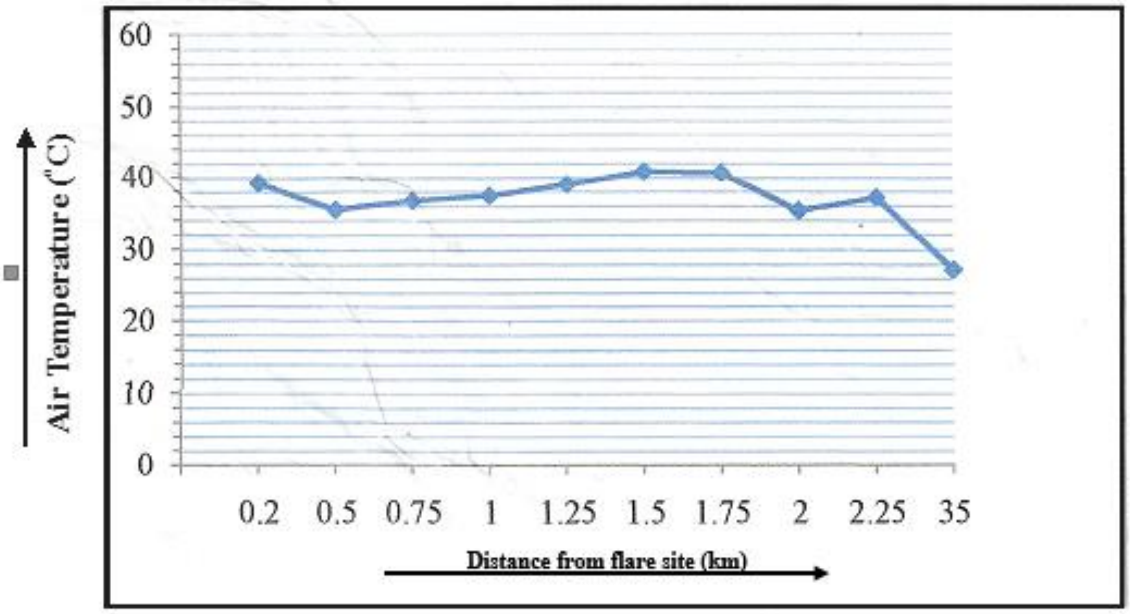

**Figure. 1.1:** Changes in air temperature with respect to distance from flare site.

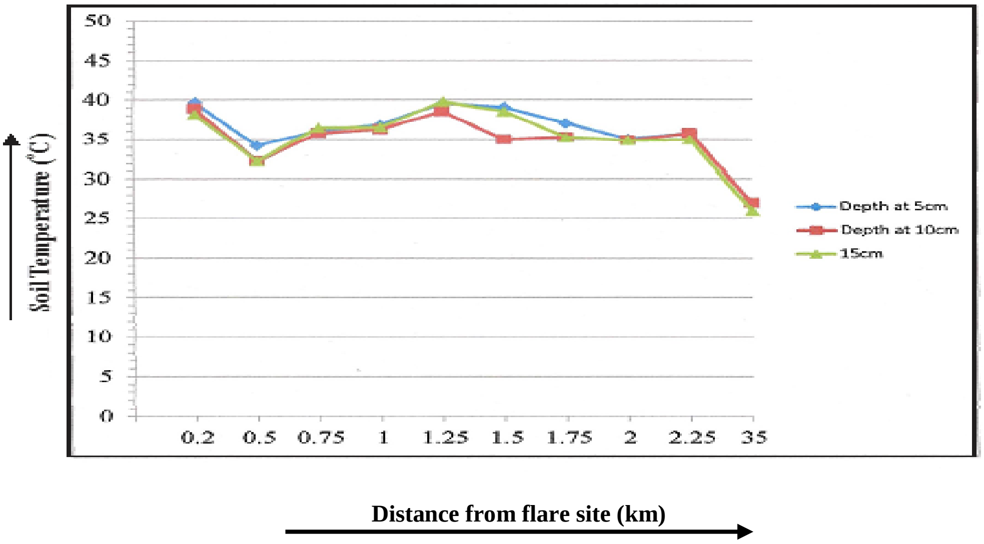

**Figure. 1.2**: Changes in soil temperature with respect to distance from flare site.

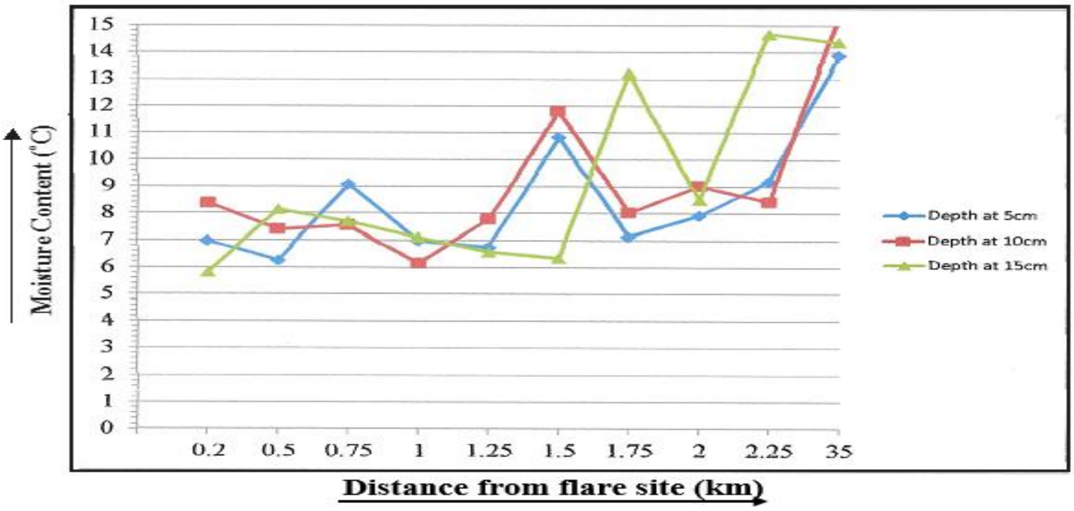

**Figure. 1.3:** Changes in soil moisture content with respect to distance from flare site.

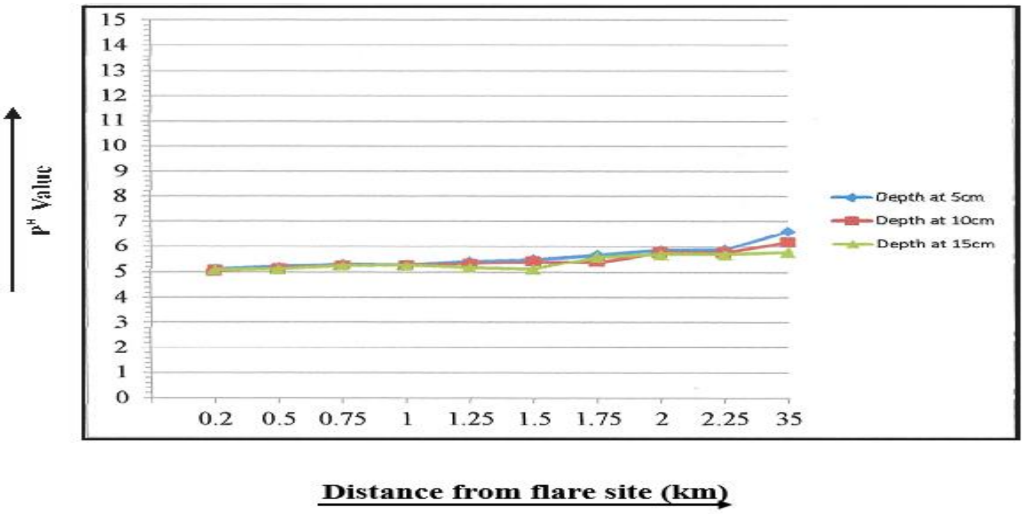

**Figure. 1.4:** Changes in $P^H$ value with respect to distance from flare site.

## Discussion of Results

The table above (table 4.0) shows results of both insitu and laboratory measurement. The air and soil temperature for instance revealed significant influence from the gas flaring sites.

The main atmospheric temperature taken between 200m – 2.250km is 38°C while that taken from the control site (35km away) is 27.2 °C. Soil temperature at depth of 5cm and distance of 200m away from the flare recorded the highest value (39.7 °C) and the least value (27 °C) was observed at the control site (35km). This trend of decrease in soil temperature away from the flare was also observed at 10cm and 15cm depth. This shows that a simple relationship exist between soil temperature and distance of soil from flare site.

This least value for soil moisture content (5.83%) was observed at 200m away from the flare site and (15.38%) for control. This trend of increase in soil moisture content as we go away from the flare sites revealed that the soil will lack adequate amount of moisture due to heat from the gas flare.

The least value for pH (5.12) was recorded at the depth of 5cm and a distance of 200m away from the flare site and the highest value at 6.62 at control site. This trend of increase in pH values away from the flare is also observed in soil samples collected at 10cm and 15cm respectively. This shows that the soil in the area is acidic and does not meet the WHO standard for permissible limit.

The charts (Fig 4.1 – 4.4) shown above, explained further the relationships between the distance from flare site and atmospheric temperature, soil temperature, moisture content and pH.

The atmospheric temperature (fig 4.1) reveals a steady decline in readings away from the flare site and as such the heat from the flare has more impact in the overall atmospheric temperature in areas close to the flare.

Soil temperature also showed very high values close to the flare site and declines away from the flare site with the least value recorded at the control site about 35km away. The heat therefore affected the topsoil around the flare facility more than it did affect soils far away.

The moisture content results shown by the chart (fig 4.3) shows that all soils from the depth range (5 – 15cm) was influenced by the heat of the flare. A steady increase in soil moisture content was noticed in the chart as we move further away from the flare site.

The pH value (fig 4.4) has shown a distance but imperceptible increase from the point closest to the flare site (200m) up to the control site. The chart (fig 4.4) shows low PH at (200m) and continues to increase up to control site revealing that soils at close distance to the flare site has high acidity, a condition that will impede plants growth and development.

A similar trend of increase in soil temperature at the closest distance to flare site (200m) and decrease in soil moisture content at the closest distance to the flare has been observed in a study of the impacts of distance on soil temperature and moisture content in a gas flare site at Ebedei in Ukwuani by Akudo, et al (2012).

Alakpodia (2000) and Akpobome (2004) also observed that soils at very close distance to gas flare sites are impoverished because the heat from the gas flare hinders the process of eluviation's and hydrolysis which could have enhanced the formation of clay minerals needed for plants.

## Conclusion

Flaring of associated gas in oil fields during operation affects soil fertility adversely. PH values changes from acidity to near neutral as we move away from the flare and moisture content of the soil increases as we go away from the flare site. It is therefore pertinent to say that soils close to flare sites will not have needed nutrients to support good plant yield.

**Acknowledgement:** The assistance rendered by Dr. Ernest Akudo during the experiment are acknowledged.

**Conflict Of Interest;** There is no conflict of interest

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