ANALYSING THE IMPACT OF GAS FLARES IN A TYPICAL NIGER DELTA ENVIRONMENT

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ABSTRACT
This work is an extensive evaluation of the impact of gas flare at KWALE flow station on the following: the effect of Nitrogenous oxides (Ox) as a result of combustion reaction on animals using Rabbit. The other is on the effect of the gas flare on the productivity and field of Soybeans and Maize crops cultivated within given distances; the consequences of temperature variation of the field. Wind characteristics and direction, the distances of interest, the likely effect of carbon dioxide effect on the climate were also investigated. This research shows that the impact of the flare varies directly with the decrease of the distance to the stack. The danger of excess nitrogenous oxides (Ox), carbon monoxide and carbon dioxide decreases as one moves away from the flare. Also the productivity of crops decreases from 100% to 10% or less as one moves further away from the flare station. Bacterial reduction in the species ranges from 10% - 45 % and between 30%-70% in fungi.

KEYWORDS: Gas Flare, Hazardous, Environment, Radiation, Bacterial reduction, climate and temperature changes.

1.1 INTRODUCTION

The objective of this work is to ascertain the extent of damage to plant and animal life in the vicinity of Gas flare. Nigeria being an oil producing country produces a lot of Gas as a by-product of oil exploration. The gas which is associated with oil is flared since facilities for effective utilization of the produced gas is lacking. The problem of gas flaring has also been a subject of litigation between oil companies and host communities and the need for proper evaluation of the problems generated is of paramount importance.

The KWALE flare station located in DELTA STATE by AGIP OIL COMPANY could be traced back to 1975 when the company started operation with a total of 405,447 cubic feet per day of gas flare on the environment. This increased to 65 million cubic feet per day of unused associated gas by 2014.

Gas flaring can be defined as the disposal of natural gases to the atmosphere by burning in the oil fields and refineries when no other use could be made from it at that particular time. Natural gas flares are thought to cause various degrees of pollution. Because of the resultant variation in the air chemistry of the atmosphere, the metrological, biological, chemical parameters and soil conditions in the immediate environment are affected local farmers have complained about retardation of growth and productivity of farm crops around gas flares, as well as scarcity of animals around the gas flare environment.

1.2 Literature Review:

When natural gas is flared or burnt, a combustion reaction takes place. Thus, CnH2 n +x 2 + $\frac{1}{2}$ **(**3n + 1) o_2 ______ nCO_2 + (n + 1) H_2O when n-number of moles. This is an exothermic reaction. For a complete reaction, carbon- dioxide and water vapour are formed; however, when the reaction is not complete, carbon-monoxide. Depending on the location, impurities such as sulphur and Nitrogen, and Hydrogen sulphide are also found with natural gas. These gases undergo a combustion reaction to form acid gases such as Nitrogen oxides, sulphur oxides and hydrogen sulphide (Ox, So_2 , H_2S).

Previous works on the effect of gas flaring on the environment include the studies carried out by Okonkwo (1983) on the toxicological effects resulting from gas flare found out that liver damage and skin problems were common effects associated with flare pollution in Nigeria. Isichiei (1985) observed depression in flowering and fruition in Euphorbia Odorantum as a result of gas flare. Oluwatimilehin (1987) studied the effect of gas flare on okro and palm trees and cassava. In cassava, he found that tubers decreased in height and weight with decreasing distance from the gas flare. Wedding (1989) found that the gaseous compound formed when natural gas is burnt become acidic pollutants and are carried downward and are deposited in soils, streams and lakes and thereby increase the pH of the immediate environment.

Ezeala (1988) studied the sensitivity of pistia stratioles (A fresh water plant) and observed that intensity of gas flare causes reductions in the number of leaves produced during growth;

as the intensity increases, the leaves tend to decay more. Ezeala (1989) observed a decrease in the chlorophyll and reduction in productivity of pistia plant subjected to a condition of very high gas flaring. Ukegbu et al (1982) examined the effect of the flare on the general agriculture and found out that impact decrease as the distance increase from the flare. Egbuna (1970) studied the gaseous emission from gas flares and found out that additionally entrapped sand (silica), heavy metals and incombustibles, present in the gas become ionized at high combustion temperature and chemically-reactive or form free radicals. Adeyemi (1985) studied the toxicity of gas flare on some aquatic organism and reported that in some organisms the phylogenetic position of habital and relative sensitivity decrease as intensities of gas flare increases.

Egbuna (1989) observed that harmful environment heat related effects are obvious, the surrounding soil gets scorched, vegetation and farmlands looked parched, villagers complain of an illness colloquially referred to as “internal heat” which may not be unrelated to the cumulative effect of long exposure to radiant heat from gas flare. Lorius et al (1992) estimated that about half of the temperature changes over the last climatic cycle may be accounted for by the contribution of carbon dioxide and methane from natural gas combustion.

The summary of the above literature shows that gas flaring is very hazardous on the environment. It ranges from the destruction of economic crops, plants and vegetation to rendering the air unsafe for human life. This paper will present the results of the effect of the flare on the soil physical and chemical characteristics on the microbial and meteorological parameters and on growth and yield of maize and soybean crops cultivated at various distances and the direction of atmospheric chemistry variation as a result of the presence of nitrogen oxides due to combustion of nitrogen and carbon dioxide associated with this particular field at KWALE.

1.3 MATERIALS AND EXPERIMENTAL PROCEDURE:

The experimental procedure for this project include: Sample collection from the AGIP LAND LOCATION AT KWALE were the unused gas is flared. This sample where collected at various distance of 100 meters, 500 meters and 900 meters in various directions to the flare. The experimental crops (Maize and Soybeans) were also planted within this grid. The animal of the experimental work, Rabbit was also placed at distances of 100 metres and 500 metres and 1900 metres. The soil sample collected was corked and stored in a freezer for experimental analysis and the field temperatures were respectively recorded at the field at various time intervals. The observation was carried out over 6 months period.

1.4 DISCUSSION OF RESULT:

The results of this work are discussed in section in accordance with the various parameters measured. These parameters are:

1. The physical and chemical characteristics of soil which include soil types and pit values.
2. The microbiological character which include bacterial and fungal identification.

3. The meteorological measurement such as temperature, radiation wind velocity and wind direction.
4. Group growth, development and yield.
5. Identification of the presence of Nitrogenous oxide along side with the flare.
6. Toxological, biochemical and morphological correlation of the nitrogenous oxides (Nox) on the experimental animal.

THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOIL

These include the soil type and pH values. From table 1.0, the results indicate that on the average the soil in all directions and distance from the flares were composed of between 80 – 88% and, 17% silt and 2.5% clay. The soil pH which is presented in Table 2.0 was mainly acidic and it ranged from pH 4.3 to 5.6. From this results it shows both distances and direction of the soil to the flare (within the scope of this work did not affect both the soil physical condition and pH characteristics as shown in Table 1.0

SOIL CHEMISTRY:

The mineral element in the soil is available to plants and soil micro-organism in exchangeable forms. The absolute quantity and pattern of occurrence of Nitrogen, available phosphorus and exchangeable cations in the soil do not seem to be influenced by the flares irrespective of the distance and direction of the soil the flare. Table 3, gives a comprehensive content of the minerals in the soil. The total Nitrogen values ranged from about 0.32% (100%) to about 0.128% (100w); the available phosphorus from about 2.1 ppm (100N) to 1.5ppm (900w). Among the exchangeable cations, calcium seemed to be most predominant than any other cation. The values ranged from 0.15me/100w and 2.57me/100g (900w). In some soils (900E, 900w, 100E, 100S, 500S), exchangeable cations such as manganese and sodium were not detected. This is shown in Table 3.0.

CROP RESULT:

The result presented shows a depression in the glowering and fruiting in maize planted in the ground and in the flare direction as reported by Isichei and Sandford on Euphorbia Odorantum. This study shows substantial reduction in the yield of soybeans seed with decreasing distances to the flare as shown in (Table 8). The morphology of the soybean crops cultivated about 100m from the flare showed distorted growth with clustered nodes and little or no internodes. The leaves were coiled and twisted. However, those features were not observed in maize crops cultivated in the same farm site. In Soybean, there was slot of chaff.

MICROBIOLOGY EVALUATION (MICROBIAL POPULATION):

The results presented in table 4 and 5 on the relative abundance of micro-organism in the soil in relation to the various locations and distances from the flare indicated that both bacteria and fungi were affected in their relative abundance in the soils collected about 100m from the flare in all directions. The percentage reduction in the bacterial population in the soils located about the 100m from the flare ranged from 15% in 100s to 20% in 100 E (table

4.). The reduction in the fungi population ranged from about 15% in 100N to 60% in 100S (table 5.) There was no effect of the gas flare on the bacterial population in the soils collected about 500m and 900 meters away from t he flare in all directions. (Table 4.)
However, fungi seemed to be more susceptible to the effects of the flare than bacteria. Reductions in the fungi species abundance ranged from about 30% (500w and 100w), 35% (500E and 100E) to 40% (9000N) as shown in Table 5.

MICROBIAL IDENTIFICATION:
The various bacteria and fungi isolated from the various soil samples were identified up to genus level as shown in Tables 6 and 7. The results indicated that there was no particular organism that could be specifically associated with any particular location or distance from the flare.

METEOLOGICAL FEATURES (TEMPERATURE):
There was great variation between the temperatures of the various farm sites; the temperature increase with decreasing distance to the flare. The highest temperature values of about 49°C was recorded in August 2013 at 12 noon in the 100m distance East of the flare. In magnitude and within the 100m distances the aerial temperature was the highest compared with the soil and surface temperature in that order. From these result the coolest period of the day seemed to be around 4 am and the hottest being 12 noon (Figure 3.) On monthly basis the heat production from the flare seemed to increase at 12 noon time between July and August. The heat produced in the night nearly around 12 midnight appears uniform throughout the period (Figure 4.) The lowest aerial temperature at that time of the night at 100m distance was 20% N of the flare in October 1999.

The relationship between the aerial and soil temperature was striking. A consideration of a typical 12 noon temperature measurement in July, 2013 is shown in Table 8 as it was with most of the other months, reveals that aerial temperature at 100m to the flare was higher than the soil temperature. This is quite an abnormal situation. However, from 500m to 900m distance, the situation became reversed. A normal situation was obtained in the soil temperature.

FLARE RADIATION:
The flares radiation was measured twice a month for four months. The radiation was generally highest at 12 noon and lowest around 4 a.m. The intensity increased with decreasing distance to the flare. The highest intensity of the flare radiation at 12 noon was observed in August with intensity of about 613 watts per square meter at 100m distance, W, N, and S, of the flare.

WIND SPEED AND DIRECTION:
The wind speed was found to be zero in most cases between 12 midnight and 4 a.m. The highest recorded wind speed was around 6 p.m. n August 1999 with a velocity of about 0.99ml sec. The directions of the wind were mostly SE, NE, NW.

GROWTH PRODUCTIVITY AND YIELD OF MAIZE AND SOYBEAN GROWTH RATE OF MAIZE CROP

The result on growth rate of maize showed similarity in the pattern of growth of the crops cultivated in ridges or beds and those cultivated in bags filled with loam soil. The slight difference between the two methods was that the magnitude of the growth was slightly higher in some cases in crops cultivated in the ground than those in bags filled with loam soil. The result suggested that the effect of the different soil types within the various distances and locations of the flare was "luxuriant" especially those located about 100m from the flare in all directions.

At this stage the 100m crops grew taller than the others. The leaf surface area exposed to the sun was found to be proportional to the plants productivity and yield. The leaf area growth curve for those crops cultivated about 100m away from the flares was not significant but abnormal. This accounts for the luxuriant growth observed in those crops even after harvesting of the other crops.

CHANGES IN MORPHOLOGY OF SOYBEAN PLANT DURING GROWTH:

The soybean crop cultivated about 100m from the flares showed distorted growth; the stems were short with clustered nodes with little or no internodes. While the internodes for soybean stem from these locations on average measured about 0.5cm, those from 900m distances measured about 1.5cm. The leaves of the 100m farm soybean were coiled and twisted. The petioles were abnormally short. These features were not observed in maize crops cultivated on the same farm sites.

CHANGES IN TOTAL CHLOROPHYLL OF LEAVES: SOYBEAN LEAVES.

The results presented showed the total chlorophyll content of the leaves cultivated within the various distances and locations of the flare. Total chlorophyll content decreased with de creasing distance to the flare. The total chlorophyll content of soybean leaves from the control farm was about 4.81mg/gm.

However, there was a yield of about 58-60% for all the crops at 500m and 80 - 90% for those about 900m from the flare. There was equally substantial reduction in the yield of soybean seed with decreasing distance to the flare (Figure 7). Losses in yield range from 80 - 90% in soybean crops cultivated in the ground to 90 - 95% for crops in the bag s located about 500m away. The range was about 25 – 45% for ground crops to about 45 - 50% for crops in the bags. The 900m distance crops showed losses of about 10% for ground crops and about 15% for crops in the bags. Also, the soybean seed resulting from 100m distance crops were fluffy and full of chaff.

MORPHOLOGICAL AND BIOCHEMICAL CHANGES IN THE ANIMAL USED:

The result showed edematous swelling and shortening of cilia on the Rabbit that was exposed at a distance of 100m away from the flare station using ordinary microscope and electronic microscope. At 900 meter, the Rabbit showed a faint edematous swelling and shortening of cilia after a repeated and intensive examination with electron microscope. A significant loss in body weight of 100% and glutathione occurred in the lungs of the Rabbit. For 500 meters a reduction of 45 to 50% was observed and at 900 meters there was very little reduction in the body weight and glutathione of lungs to 10%.

TOXOLOGICAL CORRELATION:

The formation of increasing amounts of highly injurious nitric and nitrous acids throughout the lung, following the inhalation of nitrogenous oxides probably accounts for the irritative properties of the pollutant from the flare. As result of this irritation increase in airways resistance are common humans and animals that are expected for brief periods to concentrations of nitrogen" dioxide (No_2) greater than that 2.00ppm.

CONCLUSION:

Based on this experimental work, the following conclusions are drawn:

1. In the animals continuously exposed to concentration of nitrogenous dioxide above (0.3 - 0.5ppm) and as the distance decreased from 100 meter to 0 meter to the flare; morphological changes and biochemical changes were noticed in the respiratory organs of the experimental animal. These changes include the proliferation of the bronchiolar and alveolar epithelium degeneration and obliteration of mucous membrane showing that the oxides have the ability to set up biochemical reaction in the lungs. This biochemical reaction also causes the decrease in the weight of the animal.
2. The reduction in the productivity of the crops could be attributed to the high dehydration process which takes place in the plant system as result of high radiation of the environment. Therefore too much water comes out from the plants to the atmosphere. For productivity to be optimal photosynthetic process in the plant has to be efficient. Plant has to absorb water and carbon dioxide in order to manufacture its food. The increase in the yield of soybean and maize also decreases as one move away from the flare station showing that the radiation tends to reduce as one move away from the flare.

REFERENCE:

Aaron, D.T Copper enzymes in isolated chloroplasts. Poluphenol oxides in Beta Vugaris plant physical 24, 1-5 (1949)

Abam, D.P.S Horizontal Flare Test" Shell Petroleum Development Company of Nigeria Limited. Technical Memorandum No 883 (1982)

Amadi B.C Environmental Impact of Gas Flaring, case study B.Sc. Thesis, University of Port-Harcourt. (1992).

Dimitriades, B. "Effects of Hydrocarbons and Nitrogen oxides on photochemical smog formation" Environ. Science Technology 6:253-260 (1972)

Egli, D.B and Waelaw I.P Temperature response of seed growth characteristics of soybean Argon. J. 72, 560-564 (1960)

Evans, M.J.L.V. Johnson, R.J. Stephens and G. Freeman. "Renewal of the Terminal Brochoiler Epitheluim in the Rat following Exposure to Ox V Lab Investment 35, 246-257 (1976)."

Freeman, C., and S.C Gram, R,J. Stephen's and N.J. Furiosi, "Pathogenesis of the Nitrogen Dioxide – Induced in the Rat lung. A review and presentation of New observations." Am. Rev. 98–429–443 (1968)

Freeman G., and G.B. Haydon, Emphysema after low level "Exposure to No2 Arch Environ, Health 8:125-128 (1964)"

Hesketh, I.D. Myhre, D.C and Willey, C.R Temperature control of time intervals between vegetative and reproductive events in soybeans. Crop Science. 13, 250-254 (1973)

Isichei, A.O and Sanford, M.W. The effects of waste gas flares on the surrounding vegetation in South Eastern Nigeria. (1980).

Jeffery, P.K and L. Reid "New Observation of Rat Epithelium: A Quantitation and Electron Microscope study", J. Arat 120; 295-320 (1975).

Oluwatimilehin, J.O "The ecological impact of the oil industry in the Niger Delta Area of Nigeria" MSc theisis, University of Ife, Ife Nigeria (1981).

R.H. Perry and C.H. Chiton (Editors) Chemical Engineers Handbook 5th edition McGraw, Hill, New York- London (1973).

Schreiber U. and Heat induced changes of Chlorophyll fluorescence in tact leaves correlated with damage of photosynthetic apparatus. Plants 136, 233 – 238 (1977)

Ukegbu and Okezei, The effect of the flare on general agriculture (1984).

Walkers, J.P, and Colonel. R.P Enumeration of Petroleum degradation of Micro organism (1979)

World Health Organization. Environment Health Criteria 41 oxides of Nitrogen, United Environment Programme and the World Health Organisation Geneva. Switzerland (1977).

Table 1. Soil Composition %

LOCATION	CLAY	SILT	SAND
100E	2.6±0.4	8.6±1.2	88.8±1.4
500E	2.6±0.4	9.7±1.4	87.6±1.3
900E	2.1±0.4	8.7±0.7	89.2±0.7
100W	2.1±0.1	12.7±4.0	85.3±1.0
500W	2.6±0.4	14.5±0.5	82.9±0.5
900W	2.9±0.5	12.1±1.2	85.0±1.0
100S	3.6±0.5	10.7±1.3	86.1±1.5
500S	4.2±0.4	12.9±0.7	83.0±0.7
900S	3.4±0.5	13.4±0.5	82.9±0.4
100N	4.4±0.1	10.0±1.2	85.6±1.2
500N	4.7±0.4	11.9±0.7	83.4±0.6
900N	2.5±0.5	17.0±1.6	80.5±1.8

Figures are mean ±
Standard error
n-9.

TABLE 2. EFFECT OF GAS FLARE ON THE SOIL Ph VALUES

100e	4.8
500E	5.0
900E	4.1
100W	5.2
500W	5.4
900W	4.4
100S	5.6
500S	4.2
900S	4.7
100N	4.3
500N	4.6
900N	4.7

TABLE 3. MINERAL COMPOSITION OF SOILS AT VARIOUS DISTANCES AND DIRECTIONS OF THE FLARE

LOCATION	N% NITROGEN	^{P}ppm	Ca	Mg	M_n	K	N_a	Cu
100E	0.054	4.5	0.24	0.24	0.01	0.06	0.00	0.20
500E	0.052	6.0	0.25	0.12	0.01	0.06	0.08	0.30
900E	0.051	4.0	0.48	0.15	0.00	0.4	0.00	0.30
100W	0.073	13.2	2.4	0.69	0.00	0.10	0.09	0.50
500W	0.047	4.9	0.44	0.20	0.01	0.05	0.08	0.30
900W	0.128	15.0	2.57	0.07	0.00	0.05	0.10	0.70
100S	0.031	4.7	0.15	0.09	0.01	0.05	0.00	0.20
500S	0.034	4.2	0.32	0.15	0.01	0.06	0.00	0.20
900S	0.060	4.8	0.21	0.10	0.01	0.05	0.08	0.40
100N	0.046	2.1	0.34	0.00	0.00	0.04	0.09	0.50
500N	0.046	5.2	0.37	0.01	0.01	0.07	0.11	0.40
900N	0.046	4.8	0.21	0.01	0.01	0.8	0.09	0.50

TABLE 4. FUNGAL COUNT IN COLONY FROM Mg UNTS (CPU) PER Mg WEIGHT OF THE SOIL

LOCATION	CFU/Mg wt of soil
100E	1.033×10^{6}
500E	1.014×10^{6}
900E	1.830×10^{6}
100W	1.09×10^{6}
500W	1.61×10^{6}
900W	1.89×10^{6}
100S	1.183×10^{6}
500S	1.183×10^{6}
900S	1.69×10^{6}
100N	1.163×10^{6}
500N	1.75×10^{6}
900N	1.94×10^{6}

TABLE 5. BACTERIAL COUNT IN COLONY FOR Mg wt OF THE SOIL SAMPLE

LOCATION	CFU/Mg wt of soil
100E	3.1×10^3
500E	2.0×10^3
900E	2.4×10^3
100W	1.4×10^3
500W	2.2×10^3
900W	3.0×10^3
100S	1.2×10^3
500S	2.6×10^3
900S	1.6×10^3
100N	2.0×10^3
500N	2.0×10^3
900N	2.2×10^3

TABLE 6. BACTERIAL SPECIES ISOLATED FROM THE VARIOUS SOIL SAMPLES

LOCATION	NO OF ISOLATES	BACTERIAL TYPE
100E	3	Bacillus sp. Micrococcus flavobecterium
500E	2	Micrococcus: Aeromonas
900E	4	Aeromonas, Micrococcus, Pseudomonas, Flavobacterium
100W	3	Flavobacterium, Micrococcus, Aeromanas
500W	3	Aerococcus, Aeromanas, Serratia
900W	2	Aerococcus and Aeromonas
100S	4	Aeromonas, Flavobacterium, Bacillus, Pseudomonas
500S	3	Aerococcus, Bacillus, Flavobacterium
900S	2	Flavobacterium and Micrococcus
100N	3	Bcillus, Micrococcus, Aeromonas
500N	3	Staphylococcus, Flavobacterium
900N	3	Micrococcus, Serretia, Aeromonas

TABLE 7. FUNGAL SPECIES ISOLATED FROM VARIOUS SOIL SAMPLES

LOCATION	NO OF ISOLATES	TYPE
100E	2	Aspergillus, Aureobassidium
500E	3	Aspergillus, Fusarium, Aureobasidium
900E	3	Aspergillus, Fusarium, Aureobasidium
100W	2	Geotrichum, Aureobasidum
500W	3	Fusarium, Streptomyces, Cunnighenelta
900W	4	Aspergillus, Aureobasidium,
100S		Aspergillus, Yeast, Cladosporrium
500S		Fusarium, Cunnighamella, Yeast
900S		Staptomyces, Geotrichum, Botryotich
100N		Cladosporum, Asperguillus, Aurobasidum, Cunnighamella
500N		Cunnigh amella, Fusarium
900N		Sreptomas, Aspergillus, Aurobasidium

TABLE 8. TEMP, MEASUREMENT VARIOUS DISTANCE AND DIRECTION ON THE FLARE

LOCATION	AERIAL TEMP ^{O}C	SURFACE TEMP ^{O}C	SOIL ^{O}C
100E	36	34	34
500E	30	30	32
900E	30	33	30
100W	35	33	34
500W	31	30	32
900W	29	29	29
100S	36	32	35
500S	32	30	33
900S	31	39	33
100N	38	34	36
500N	33	32	35
900N	29	30	31

TABLE 9. THE EFFECT OF CARBON MONOXIDE ON HUMAN OR ANIMALS

	COHb LEVEL %	**POSSIBLE EFFECT**	**EXPOSURE NEEDED**	
1.	Less than 0.5	No apparent effect	ppm 5ppm	% 0.0005%
2.	Less than 1.0	No apparent effect	10ppm	0.001%
3.	About 2%	Impairment of time interval discrimination	20ppm	0.005%
4.	About 3%	Impairment in visual activity and brightness threshold	30ppm	0.005%
5.	About 5%	Impairment in performance of motor skill change in cardiovascular system.	50ppm	0.005%
6.	About 35%	Loss of consciences	300ppm (4hrs)	0.35%
7.	About 65%	Death	1,600 – 200^{o}pm (1 – ½ hr)	0.2 - 0

4.A.M **Figure (3A) temperature**

<u>°C variation with respect to location and time</u>