International Journal of Bacteriology and Mycology ISSN 2932-7521 Vol. 8 (1), pp. 001-003, January, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Short Communication

Effect of gas flaring on soil microbial spectrum in parts of Niger Delta area of southern Nigeria

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Accepted 21 July, 2019

Effects of gas-flaring on soil bacterial spectrum in parts of Niger-Delta area of Southern Nigeria was investigated using culture techniques and some ecological factors. While temperature decreased away from the flare points (60^{o}C to 28^{o}C), pH values, changed from acidic (4.0 – 4.2) to near neutral (6.4 – 6.6) away from the flare point. Moisture content also increased away from the flare. Bacterial load of Total Heterotrophic bacterial count (THBC), Petroleum degrading bacterial count (PDBC) and Total coliform count (TCC) also increased away from the flare points. The most affected by the Gas flaring was the coliforms. Bacterial species were also affected as only three *Pseudomonas*, and *Bacillus* species were found 10m away from the flare. The number increased to seven with the addition of *E. coli*, *Enterobater*, *Flavobacterium* and Micrococcus species at 100m away and finally 10, at 200m away with *Citrobacter*, *Staphylococcus* and *Lactobacillus* species. The same trend was observed in all the flaring sites examined. The results indicated adverse ecological and bacterial spectrum modifica-tions by the Gas flaring.

Key words: Gas flaring, soil, bacteria, oil.

INTRODUCTION

Crude oil, a naturally occurring complex mixture of liquids and gases, mainly of hydrocarbon contents, is found thousands of metres below the earth crust and brought to the surface by drilling (Ifeadi and Nwankwo, 1989; Ake, 1979). Crude oil is accompanied by varying quantities of extraneous substances such as water, inorganic matters and gases. The removal of such substances does not change the state of the crude oil. (Wills, 2000; Bailey et al., 2000). Nigeria, like other oil producing countries, benefits as well as suffers from its positive and negative effects of crude oil drilling such gas flaring (Ake, 1979; Awobajo, 1981; Adeniye et al., 1983). After the initial separation of crude oil into gas, oil and water, the oil is sent to refineries for fractional distillation, the gas is usually flared while the water is discharged into the environment (Wills, 2000; Zara and Paul, 2000). Gas flaring is the controlled burning of natural gases associa-ted with oil production. The consistent flaring has left a devastating effect on the surrounding environment of the Niger Delta Area, where the activities of oil exploration and exploitation is greatest (Adeniye et al., 1983).

With a daily crude oil output in excess of two million barrels per day, Nigeria has over 200 gas flaring sites, some of which have been on continuously for over 20 years. While about 22 billion standard cubic feet (SCF) of natural gas is produced daily, about 75% of this quantity is being flared (Bailey et al., 2000). This work is therefore aimed at investigating, the effect of gas flaring on the surrounding bacteria in relation to the temperature, pH and soil moisture content.

MATERIALS AND METHODS

Four different gas flaring stations were chosen for this work. These were Oshie flow station (owned by NAOC Ltd) (Egbema West Flow Station (SPDC), Ebocha Flow station (NAOC) and Obagi Flow Station (Elf Nigeria Ltd). All the stations lie within the Niger Delta Area of Nigeria. Soil samples were collected from three spots of each of the stations. These were 10, 100 and 200 m away from each flare site and a control taken much outside the flow station area. Ten fold serial dilution with sterile physiological saline as diluent was carried out with each soil sample collected and inoculated on nutrient agar (NA), mineral salt agar (MSA) and McConkey agar (MCA) using the spread plate technique as described by Chessbrough (1987). Cultures on NA gave total heterotrophic bacterial count (THBC) while that on MCA gave total

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Table 1. pH, temperature (T) and moisture content (MC) of the various soil samples.

Distance from flare point (m)	Obagi			Ebocha			Egbema West			Oshie		
	pH	T (°C)	MC (%)	pH	T (°C)	MC (%)	pH	T (°C)	MC (%)	pH	T (°C)	MC (%)
10	4.2	60	18	4.0	55	15	4.2	50	18	4.3	52	15
100	5.0	46	26	5.1	41	21	5.2	41	25	5.0	40	20
200	6.1	33	35	6.3	32	35	6.3	31	34	6.3	31	31
Control	6.6	30	45	6.7	29	41	66	30	40	6.7	29	35

Table 2. Total heterotrophic bacterial counts of each soil samples in relation to distance from the flare point.

Distance (m)	Bacterial counts (cfu/g)			
	Obagi	Ebocha	Egboma West	Oshie
10	1.1×10^2	1.2×10^2	1.4×10^2	1.2×10^2
100	5.1×10^5	6.0×10^5	5.3×10^5	1.7×10^5
200	5.1×10^4	4.3×10^5	2.2×10^5	2.2×10^4
Control	3.3×10^5	4.8×10^5	2.6×10^5	3.0×10^5

Table 3. Total coliform count of the various soil samples in relation to distance from the flare point.

Distance (m)	Bacterial counts (cfu/g)			
	Obagi	Ebocha	Egbema West	Oshie
10	0.4×10^2	0.2×10^2	0.5×10^2	0.4×10^2
100	1.6×10^5	1.7×10^5	2.1×10^5	1.8×10^5
200	3.6×10^4	3.3×10^4	1.1×10^5	4.9×10^4
Control	4.1×10^4	3.9×10^4	2.1×10^5	6.1×10^5

coliform count (TCC) as described by APHA (1985). The MSA culture using vopour-phase transfer technique as described by Okpokwasili and Amanchukwu (1988) gave the petroleum degrading bacterial count (PDBC).

The pH of the various soil samples was determined from supernatant obtained after 1:1 (w:v) mixture of soil sample was made with sterile distilled de-ionized water. The pH was determined using a PYE UNICAM model 291 mkz pH meter with a combined glass electrode. The temperature of each soil sample was determined with Mercury-in-glass thermometer, which was placed 2-3 cm into the soil. The thermometer was left for 5 minutes to stabilize and read before withdrawal. This was done at the site of collection. The moisture content of each soil sample was determined using the method of APHA (1985). 10 g of each soil sample was heated in a hot air over for 8-12 h at 80°C till a constant weight was obtained. The difference between the initial weight and the consistent final weight obtained was taken as the weight of the moisture. Microbial species observed were sub-cultured to obtained pure isolates. These were further subjected to macroscopy, microscopy (after starring) and biochemical tests for characterization and identification according to Chessbrough (1987), Cowan and Steel (1976).

RESULTS AND DISCUSSION

In all flow stations examined, the most acidic was the samples collected at 10 m away from the flare jets, followed by the 100 m. There was not much difference between the 200 m samples and the control in each case (Table 1). A similar trend was also observed with the temperature and the moisture contents. As expected, the hottest spot was nearest to each flare jet and it gradually decreased away from the flare point. All the soil samples examined had the least moisture content in soil at 10 m (10 to 12%), followed by 100 m (15 to 19%). The 200 m soil samples had 23 to 28% and controls had 29 to 30% moisture content.

The same trends were observed in the various types of bacteria cultured. The bioload from the 10 m samples were the least, followed by the 100 m and the 200 m samples. The difference between 200 m and the control in each station examined was not significant (Table 2). Total coliforms counts were seriously low for the 10 m (0.1×10^2 to 0.4×10^2 cfu/g) and 100 m (1.6×10^3 to 2.1×10^3 cfu/g) samples. However, there was a sharp increase at 200 m samples (3.3×10^4 to 1.1×10^5 cfu/g) which was not much different from the values obtained in the controls (3.9×10^4 to 2.3×10^5 cfu/g) (Table 3). Table 4 shows that the gas flaring affected the oil degrading bacterial species as values obtained from the 10 m samples were the least. Of the various bacterial species isolated in the work, only *Bacillus* and *Pseudomonas* were found in the 10 m samples. These increased to five

Table 4. The Petroleum-degrading bacterial counts of the soil samples in relation to distance from the flare point.

Distance from flare point (m)	Bacterial counts (cfu/g)			
	Obagi	Ebocha	Egbema West	Oshie
10	1.1 X 10^{2}	1.0 X 10^{2}	0.8 X 10^{2}	0.7 X 10^{2}
100	2.1 X 10^{2}	2.4 X 10^{3}	2.0. 10^{3}	1.3 X 10^{3}
200	3.9 X 10^{4}	4.3 X 10^{4}	3.4 X 10^{4}	6.2 X 10^{4}
Control	4.2 X 10^{4}	4.6 X 10^{4}	3.6 X 10^{4}	6.6 X 10^{4}

species (*Bacillus*, *Pseudomonas*, *Escherichia*, *Enterobacter* and *Corynebacterium*) in 100 m samples. Additional bacteria species including *Lactobacillus*, *Staphylococcus*, *Citrobacter*, *Flavobacterium* and *Micrococus* were obtained from the 200 m samples.

The results obtained in this work show a marked trend as all parameters considered showed a gradient away from the flare points in all the flow stations. This picture indicates that crude oil, though is of high economic value to Nigeria, has adverse gas flaring effect accompanying it (Adeninye et al., 1983; Amund et al., 1987). The low pH values at the flare points could be attributed to the acidic oxides produced by the flaring. Atmospheric nitrogen and carbon one forced to combine with elemental oxygen forming acidic oxides which dissolve in rain water to give dilute carbonic and nitrous/nitric acids (Hewitt et al., 1995; Botkin and Keller, 1998). Similarly, the heat produced from the flaring point is highest at the flare point as expected. The low moisture content close to the flaring point is a direct effect of the heat (Botkin and Keller, 1998). The gas flaring had adverse effect on all groups of bacteria examined.

When the distance increased to 200 m away from the flare point, more bacterial species were isolated. Prescot et al. (1999) and Chessbrough (1987) stated that *Bacilli* are good spore formers hence can survive very harsh environmental conditions like in the 10 m samples. Similarly, *Pseudomonas* has been implicated as the major crude oil degrader (Ibe and Ibe, 1983; Amund et al., 1987; Jain, 1992; Amund, 2000; Bezharauh et al., 1994). The other micro-organism isolated has been variously observed in different soil samples (Prescot et al., 1999; Robert et al., 1995; Gibson and Subramarian, 1997).

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