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EFFECTS OF GAS FLARING ON THE MICROBIAL AND PHYSICOCHEMICAL PROPERTIES OF SOILS IN DELTA STATE

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ABSTRACT

This study was carried out to determine the impact of gas flaring on microbial and physicochemical characteristics of soil around Ebedei and Kwale Flow Stations in Delta State, Nigeria. Soil samples were collected around Ebedei, in Ukwuani local government area, and Kwale, in Ndokwe West local government area both in Delta State, as well as in their environs. While the soil samples were collected for the analysis of physical, chemical and biological properties of the soil. The highest concentration of the heavy metals was obtained at 10m away from the flaring sites ($P < 0.05$). In both Ebedei and Kwale, the Fe concentration is significantly higher (1080.33 and 1080.68 mg/kg, respectively) that the other two heavy metals. However, there was a significant difference in the concentration of Zn between Ebedei and Kwale ($P < 0.05$). In both Ebedei and Kwale, the ECEC concentration is significantly higher (8.16 and 6.57 meq/100g, respectively) that the other chemical parameters. The physicochemical properties were similar at the different distances away from gas flaring sites ($P > 0.05$). EC decreased from 119.12μs/cm (at 10m) to 50.4 (at 100m) and then to 44.37 (at 200m). pH value remained acidic ranging from 4.97 (at 10m) to 5.9 (at 200m); moisture content ranged from 3.25% (at 10m) to 5.89% (at 200m); organic matter ranged from 1.07% (at 10m) to 1.61 % (at 200m); NO_3 reduced sharply from 10.35 mg/kg (at 10m) to 3.92mg/kg (at 100m) and then to 2.4mg/kg (at 200m); phosphate dropped from 0.91mg/kg at (at 10m) to 0.95mg/kg (at 100m) to 0.42mg/kg (at 200m). There was a significant difference in the amount of some physicochemical properties in the soil samples collected from the gas flaring areas in Ebedei and Kwale ($P<0.05$). Ebedei, Kwale and environs constitute part of the most vegetative and productive areas of the Niger Delta region, these areas are also rich in several pharmacological properties and water resources. The Government should ensure the enforcement of laws aimed at minimizing the amount of gas flared into the atmosphere. Urgent efforts should be geared at cushioning the effect of gas flaring on the communities affected, probably by compensating them or, by relocating them to a more environmental friendly settlement with compensations.

Keywords: Effects, gas flaring, microbial, physicochemical

INTRODUCTION

Gas flaring is one of the most challenging problems facing the world today (**Emam, 2015**). According to **Raji and Abejide (2013)**, gas flaring is a means of disposing of waste gases that are a natural by-product of oil production, and occurs during the processing of crude oil through the top of a pipe or stack in which the burner and igniters are located (**Raji and Abejide, 2013**). The quantity of carbon emitted by these flare is about 2525000.00 tonnes of carbon per day, and this signifies danger for the affected communities (**Ubani and Onyejekwe, 2013**).

Attempt has been made by individuals, government, non-governmental organizations, World Institutions like UNO, World Bank, most especially by scholars to address the lingering environmental pollution associated with flaring of gas in the Niger Delta. Some reports have been made on the causes and effects of oil and gas on a particular environment like the Niger Delta region. The claim generally is that gas flaring has continued to impact negatively on the soil and vegetation in the oil-producing community of Niger Delta. It is on the bases of these on-going environmental challenges in Ebedei and Kwale, that this present study has become important.

The purpose of this study is to investigate the impact of gas flaring on, human, microbes and the environment at large, in Kwale, Umutu and their environs. This aim is intended to be achieved through the following objectives:

1) Evaluating the chemical composition of the soil in a gas flaring environment, in comparison with a non-gas flaring environment.
2) Evaluating the microbial make-up of the soil in a gas flaring environment, in comparison with a non-gas flaring environment.
3) Compare the physical parameter of the soil in a gas flaring environment with a non-gas flaring environment.

Since natural gas is valuable, companies in developed countries would rather capture than flare gas. There are however, there may be several reasons why it may be necessary to flare gas during drilling, production or processing (**Ohio EPA, 2014**). According to **Ajugwo (2013)**, gas flaring has impact on climate change, acid rain, and agriculture. Distinct data on the magnitude of the gas flaring remains elusive. The amount of gas disposed of through flaring over the last decade has trended down moderately, despite a sizeable increase in crude oil production (**Ismail and Umukoro, 2012**).

Gas flaring is most serious in countries where investment is difficult such as Nigeria. Focus here would be on the two of the most sited gas flaring areas in Delta State (**Ismail and Umukoro, 2012**). Nigeria, like other oil producing countries, benefits as well as suffers from the positive and negative effects of crude oil drilling such gas flaring. 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. Gas flaring is the controlled burning of natural gases associated 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 (**Ismail and Umukoro, 2012**).

Nigeria flares 17.2 billion m3 of natural gas per year in conjunction with the exploration of crude oil in the Niger Delta. This high level of gas flaring is equal to approximately one quarter of the current power consumption of the African continent. Even though we have grown to be fairly dependent on oil and it has become the center of current industrial development and economic activities, we rarely consider how oil exploration and exploitation processes create environmental, health, and social problems in local communities near oil producing fields (**Ismail and Umukoro, 2012**).

Study Location

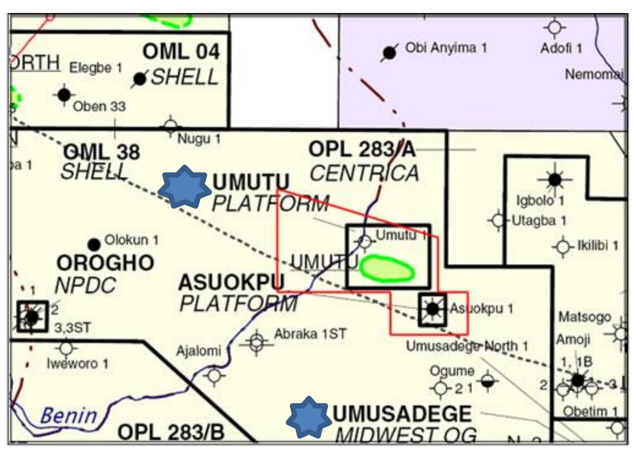


Figure 1 Map of Study sites
Source: Platform Petroleum Limited, 2017.
= The Two Study Locations

Platform Petroleum is located Ebedei, Ukwuani local government area, while Midwester oil and Gas is located in Kwale, Ndokwe West local government area both in Delta State.

MATERIALS AND METHODS

The methods used in this study was the methods used by **Ehiowemwenguan *et al.*, (2014**) and **Ukpong and Okon, (2013**), with some variations.

Physico-chemical Analysis

The physico-chemical tests included the determination of temperature, pH, electrical conductivity, soil moisture content, effective cation exchange capacity, some heavy metals and some selected trace metals using the methods of **Owolabi *et al.*, (2014**).

Soil Temperature Measurements

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.

Soil Moisture Content Measurement

Moisture content of the soil samples was determined using dry weight method (**Walkley and Black, 2007**). The loss in weight of the sample during drying is the moisture content. It will be calculated using the formula below: It was calculated using the formula below:

$$\%\ \text{Moisture content} = \frac{W_3 - W_1}{W_2 - W_1} \quad X \quad \frac{100}{1}$$

Where, W_1 = weight of the dried dish without soil sample
W_2 = weight of the dish + weight of soil sample before drying
W_3 = weight of the dish + weight of soil sample after drying.

Soil pH Measurement

The pH of the various soil samples was determined from supernatant obtained after 1:1 (w:v) mixture of the soil samples were made with sterile distilled water. The pH was determined using a PYE UNICAM model 291mkz pH meter with a combined glass electrode.

Electrical Conductivity

The filtrates obtained from the measurement of pH were used for the determination of electrical conductivity of the Soil.

Effective Cation Exchange Capacity

Effective cation exchange capacity was determined by the method described by **Nkwopara *et al.* (2012**). Exchangeable cations were extracted with ammonium acetate (NH4OAC). While calcium (Ca) and magnesium (Mg) were evaluated by ethylene diamine tetra-acetic acid (EDTA) titration method, potassium (K) and sodium (Na) were determined by flame photometry.

Soil Microbes

Effects of gas-flaring on soil bacterial spectrum were investigated using culture techniques and some ecological factors. Soil samples were collected from three spots of each of the stations; 10m, 100m and 200 m away from each flare site and a control taken much outside the flow station area. Tenfold serial dilution with sterile physiological saline as diluents was carried out with each soil sample collected and inoculated on nutrient agar (NA), mineral salt agar (MSA) and MacConkey agar (MCA) using the spread plate technique. Microbial species observed was sub-cultured to obtained pure isolates for identification.

Data Collection and Analysis

The data used in this study were obtained by two means. While soil samples were collected from sites to determine, microbial, chemical and physical properties of the soil/ environments. Analysis of variance was used to test the difference in concentration of the physicochemical parameters as well as the difference in microbial loads.

RESULT

TABLE I Comparison of metal conc. in the soils of Ebedei and Kwale

	Location	N	Mean	df	T	p
Fe conc.(mg/ kg)	Ebedei	12	1080.33± 52.12	22	-0.12	0.99
	Kwale	12	1080.67 ±53.40			
Zn conc. (mg/kg)	Ebedei	12	5.44 ± 1.16	22	4.08	0.00
	Kwale	12	3.54 ± 1.12			
Cu conc. (mg/kg)	Ebedei	12	2.62 ± 0.82	22	-1.09	0.29
	Kwale	12	2.94 ± 0.62			

Significance: P < 0.05

TABLE II Comparison of metal conc. in the soils of Ebedei and Kwale

Metal	Location	Distance	Mean ± SD	df	F	P value
Fe (Iron)	Ebedei	10m	1068.39 ± 8.48	3, 8	0.98	0.45
		100m	1083.96± 15.14			
		200m	1049.17± 16.60			
		Control	1119.80± 101.68			
	Kwale	10m	1045.19± 16.30	3, 8	0.99	0.45
		100m	1082.34± 12.54			
		200m	1075.35± 26.12			
		Control	1119.82± 101.71			
Zn (Zinc)	Ebedei	10m	6.29± 0.68	3, 8	2.76	0.11
		100m	5.60±0.32			
		200m	5.71± 1.23			
		Control	4.15± 1.25			
	Kwale	10m	4.58±0.56	3, 8	5.23	0.03
		100m	3.07± 0.49			
		200m	2.36±0.49			
		Control	4.15±1.25			
Cu (copper)	Ebedei	10m	3.17± 0.44	3, 8	14.79	0.00
		100m	2.98± 0.35			
		200m	1.37±0.18			
		Control	2.95± 0.47			
	Kwale	10m	3.56± -0.83	3, 8	2.01	0.19
		100m	2.54± 0.41			
		200m	2.71± 0.36			
		Control	2.95±0.47			

Significance: P < 0.05

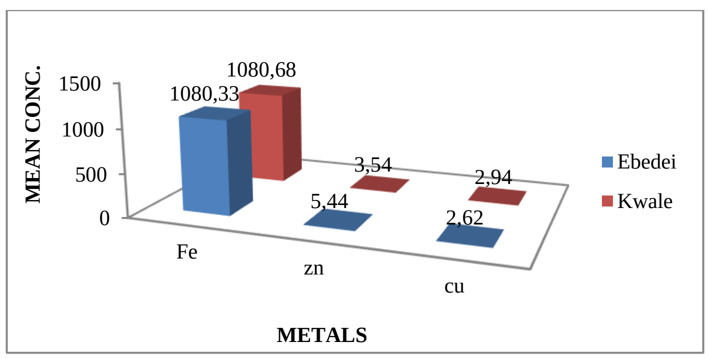


Figure II Metal concentration in the soils of Ebedei and Kwale

Figure II shows the difference in heavy metal concentration in the soils of the two communities explored by two oil companies. Figure II showed that in both Ebedei and Kwale, the Fe concentration is significantly higher (1080.33 and 1080.68 mg/kg, respectively) that the other two heavy metals. The result presented in Table I shows that there were significant differences in the concentrations of Zn obtained from soils at different distances in Kwale (P < 0.05); and Cu obtained from soils at different distances in Ebedei (P < 0.05). The highest concentration of the heavy metals were obtained at 10m away from the flaring sites. The result presented in Table II shows that there is no significant difference in the occurrence of two heavy metals (Fe and Cu) in the two communities, [t(22)= -0.12, *p*> 0.05; and t(22)= -1.09, *p*> 0.05]. However, there was a significant difference in the concentration of Zn between Ebedei and Kwale [t(22)= 4.08, *p*< 0.05].

TABLE III Comparison of other chemical concentration in the soils

	Location	N	Mean	df	T	p
Ca conc. (meq/100g)	Ebedei	12	2.86± 1.53	22	1.05	0.31
	Kwale	12	2.23± 1.39			
Mg conc. (meq/100g)	Ebedei	12	0.67± 0.32	22	0.49	0.63
	Kwale	12	0.62± 0.17			
Naconc. (meq/100g)	Ebedei	12	1.00± 0.32	22	-0.4	0.97
	Kwale	12	1.01± 0.23			
K conc. (meq/100g)	Ebedei	12	0.79± 0.45	22	0.57	0.57
	Kwale	12	0.69± 0.34			
EA conc. (meq/100g)	Ebedei	12	2.64± 0.42	22	0.32	0.75
	Kwale	12	2.57± 0.64			
ECEC conc. (meq/100g)	Ebedei	12	8.16± 2.99	22	1.23	0.23
	Kwale	12	6.57± 3.33			

Significance: P < 0.05

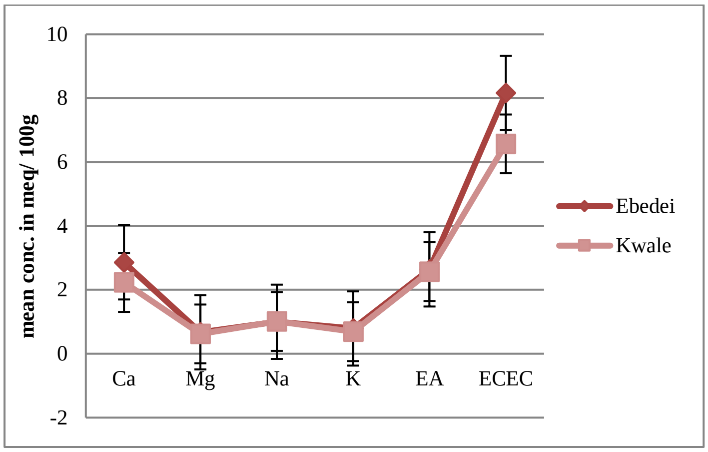


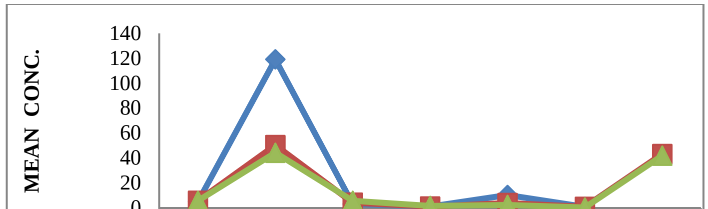
Figure III Comparison of other chemical concentration in the soils of Ebedei and Kwale

The results presented in Figure III shows the difference in the concentration of other chemical parameters in the soils of the two communities explored by two oil companies. Figure III showed that in both Ebedei and Kwale, the ECEC concentration is significantly higher (8.16 and 6.57 meq/100g, respectively) that the other chemical parameters. The result presented in Table III shows that there is no significant difference in the concentration of Ca, Mg, Na, K, EA and ECEC in the soils of the two communities (p > 0.05).

Table IV Physicochemical properties of soils from different distances in Ebedei and Kwale

	Location	N	Mean ± SD	df	T	p
10m	Ebedei	18	25.88± 48.86	34	0.35	0.73
	Kwale	18	20.67± 40.15			
100m	Ebedei	18	11.73± 19.35	34	0.21	0.83
	Kwale	18	10.43± 17.27			
200m	Ebedei	18	9.45± 14.73	34	-0.24	0.82
	Kwale	18	10.75± 17.93			

Significance: P < 0.05



	PH	EC	MC	OM	NIT	PHOS	TEM P.
10m	4,97	119,12	3,25	1,07	10,35	0,91	43,01
100m	5,7	50,4	4,18	1,3	3,92	0,95	43,3
200m	5,9	44,37	5,89	1,61	2,4	0,42	41,85

Figure IV Physicochemical properties of Ebedei and Kwale soils at different distances from gas flaring site

The result presented in Table IV shows that the physicochemical properties of the soils obtained from Ebedei and Kwale did not differ significantly from each other based on the distances (P > 0.05). This implies that the physicochemical properties were similar at the different distances away from gas flaring sites. Figure IV however showed that, electrical conductivity (EC) decreased from 119.12μs/cm (at 10m) to 50.4 (at 100m) and then to 44.37 (at 200m). The pH value remained acidic ranging from 4.97 (at 10m) to 5.9 (at 200m); moisture content (MC) ranged from 3.25% (at 10m) to 5.89% (at 200m); organic matter (OM) ranged from 1.07% (at 10m) to 1.61 % (at 200m); nitrate (NO_3) reduced sharply from 10.35 mg/kg (at 10m) to 3.92mg/kg (at 100m) and then to 2.4mg/kg (at 200m); phosphate also dropped from 0.91mg/kg at (at 10m) to 0.95mg/kg (at 100m) to 0.42mg/kg (at 200m).

Table V Physicochemical properties of soils from different distances away from gas flaring sites in Ebedei and Kwale

		N	Mean ± SD	df	F	p
Ebedei	$10m^a$	21	28.2833± 45.46	3, 80	3.99	0.01**
	$100m^b$	21	16.1394± 21.01			
	$200m^b$	21	14.0888± 17.89			
Kwale	$10m^a$	21	23.9239± 37.91	3, 80	3.72	0.02**
	$100m^b$	21	15.2340± 19.99			
	$200m^b$	21	15.2026± 19.98			

Significance: P < 0.05; *values with different superscripted letters are significantly different*

The results presented in Table V showed that the physicochemical properties of the soil samples vary significantly among the three distances (10m, 100m, and 200m), for Ebedei (P<0.05) and for Kwale (P<0.05). The result further showed that the major point of significance is between 10m and other distances. Table VI showed that there were significant differences in the microbial counts between 10m distance and other two distances in Ebedei [F= 18.29, *p*< 0.05] and in Kwale [F= 18.92, *p*< 0.05].

Table VI Microbial Load of soils at different distances from gas flaring sites in Ebedei and Kwale

		N	Mean	Std. Deviation	df	F	P
Ebedei	10m**	9	1.77×10^{-1}	1.20×10^{-1}	3, 32	18.29	0.00**
	100m	9	3.11×10^{-3}	2.31×10^{-3}			
	200m	9	6.77×10^{-3}	4.49×10^{-3}			
	Control	9	8.00×10^{-3}	7.92×10^{-3}			
Kwale	10m**	9	1.77×10^{-1}	1.09×10^{-1}	3, 32	18.92	0.00**
	100m	9	2.43×10^{-2}	3.23×10^{-2}			
	200m	9	5.66×10^{-3}	6.83×10^{-3}			
	Control	9	8.00×10^{-3}	7.92×10^{-3}			

Significance: P < 0.05

DISCUSSION

The resultant effects of gas flaring are the damaging effect on the environment due to acid rain formation, greenhouse effect, global warming and ozone depletion. The dispersion pattern of pollutants at ground level depends on the volume of gas flared, wind speed, velocity of discharge and nearness to the source of flaring (**Abdulkareem, 2005**). This study revealed that there was a significant difference in heavy metal concentrations among the chemical parameters in the soil of Ebedei [$p < 0.05$]; and among the heavy metal concentration in Kwale [$p < 0.05$]. In Ebedei and Kwale, the Fe concentration is significantly higher (1080.33 and 1080.68 mg/kg, respectively) that the other two heavy metals. There is no significant difference in the occurrence of two heavy metals (Fe and Cu) in the two communities, [$p > 0.05$]. However, there was a significant difference in the concentration of Zn between Ebedei and Kwale [$p < 0.05$]. Heavy metals concentration was generally higher in polluted soils that was near the gas flaring sites [10m] than in less polluted soils, that is farther from the flaring sites. **Nkwopara *et al.* (2012**) in there study on 'Some Physico-Chemical Characteristics of Arable Soils Around Selected Oil Exploration Sites in The Niger-Delta Region of Nigeria' reported that heavy metals concentration was generally higher in polluted soils. **Seiyaboh & Izah (2017**) in their study on A Review of Impacts of Gas Flaring on Vegetation and Water Resources in the Niger Delta Region of Nigeria' found that gas flaring alters water ions (especially sulphate, carbonate, nitrate), pH, conductivity heavy metals (such as lead and iron) concentration especially in rainwater. It also affects vegetation leading to decrease in growth and productivity probably due to changes in soil quality parameters. **Nkwopara *et al.* (2012**) reported that the physical parameters had high significant correlation association in unpolluted soils than in polluted soils.

The study also revealed that, there was a significant difference in the concentrations among the chemical parameters in the soil of Ebedei [$p < 0.05$]; and among the concentration of other chemical parameters in Kwale [$p < 0.05$]; In both Ebedei and Kwale, the ECEC concentration is significantly higher (8.16 and 6.57 meq/100g, respectively) than the other chemical parameters [Table IV and Figure V]. This study revealed that there was no significant difference in the concentration of Ca, Mg, Na, K, Exchangable Acidity and Effective Cation Exchange Capacity in the soils of the two communities ($p > 0.05$). The physicochemical properties of the soils obtained from Ebedei and Kwale did not differ significantly from each other based on the distances ($P > 0.05$). Electrical conductivity (EC) decreased from 119.12µs/cm (at 10m) to 50.4 (at 100m) and then to 44.37 (at 200m). The pH value remained acidic ranging from 4.97 (at 10m) to 5.9 (at 200m); moisture content (MC) ranged from 3.25% (at 10m) to 5.89% (at 200m); organic matter (OM) ranged from 1.07% (at 10m) to 1.61 % (at 200m); nitrate (NO_3) reduced sharplyfrom 10.35 mg/kg (at 10m) to 3.92mg/kg (at 100m) and then to 2.4mg/kg (at 200m); phosphate also dropped from 0.91mg/kg at (at 10m) to 0.95mg/kg (at 100m) to 0.42mg/kg (at 200m).

There was a significant difference in the amount of some physicochemical properties in the soil samples collected from the gas flaring areas in Ebedei and Kwale ($P<0.05$). **Atuma & Ojeh (2013)** reported that the soils found in Ebedei have high composition of sand and soil temperature and are acidic. The soil electrical conductivity, Phosphorous, Nitrogen, Potassium and Sodium were very low. They added that as flare distance increases, so also the organic carbon, electrical conductivity and Nitrogen increase. **Orji *et al.* (2015**) revealed influence from the Gas flare especially in the pH, Temperature and Moisture content of Soils. The pH showed the least value (most acidic) of 5.12 at depth of 5cm and distance of 200m away from the flare. The high acidity observed in the area is likely from such sources as acid rain. The Soil Temperature at 200m and 5cm depth, recorded the highest value (39.7 0C) and the least value (270C) km was observed at 35km (control site) away. The least value for Moisture content (5.83%) was recorded at 200m and the highest (15.38%) at the control site. The values obtained from both in-situ and laboratory tests, showed that the gas flare has negatively influenced the Soil pH, Moisture content and Temperature.

The study revealed that the physicochemical properties of the soil samples vary significantly among the three distances (10m, 100m, and 200m), for Ebedei ($P<0.05$) and for Kwale ($P<0.05$). The result further showed that the major point of significance is between 10m and other distances. The study further revealed that there was no significant difference in the microbial counts obtained at both locations [$p > 0.05$]. However, the fungal count was slightly higher in Ebedei. In Kwale the highest count was obtained for Total Aerobic count. There were significant differences in the microbial counts between 10m distance and other two distances in Ebedei [$p < 0.05$] and in Kwale [$p < 0.05$]. **Ezeigbo *et al*. (2013**) showed a decrease in microbial load of the soil samples as distance approaches the Flow-Stack. The total bacterial counts were low (3.0×10^1 cfu/g) when compared with 2.9×10^5 cfu/g obtained from the control. The total coliform counts were also adversely affected by the flare. A value as low as 2.0×10^1 cfu/g was obtained 10m from the flare stack compared with 6.0 x 104 obtained from the control. **Braide *et al*. (2016**) reported that microbial load increased the farther the distance from the flare site. This agrees with the report in this work.

CONCLUSION

Ebedei, Kwale and environs constitute part of the most vegetative and productive areas of the Niger Delta region, these areas are also rich in several pharmacological properties and water resources. However, these resources are constantly under threats by the activities of man with respect to gas flaring in particular. Despite the huge benefits accrued to gas, it is constantly flared into the environment. Gas flaring is known to have impact on human and animal health, as well as on the economy and the environment at large. This study has shown that; there was a decrease in microbial load of the soil samples as distance approaches the Flow-Stack; gas flaring affected the heavy metal concentration as well as the concentrations of the physicochemical parameters in the soil, and hence, the effect of agriculture which is the main stack of the residence. Based on the forgoing, the following recommendations were made: the Government should ensure the enforcement of laws aimed at minimizing the amount of gas flared into the atmosphere, and Urgent efforts should be geared at cushioning the effect of gas flaring on the communities affected, probably by compensating them or, by relocating them to a more environmental friendly settlement with compensations. Also, organic fertilizers should urgently be made available to the communities to improve their farm yields.

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