SOIL POLLUTION ASSESSMENT OF A GAS FLARE SITE IN THE NIGER DELTA REGION

ABSTRACT

Aim: The aim of this research was to investigate the level of pollutants deposition on soil generated from a gas flaring site.

Study Design: The Soil Samples for this study were picked from two sets of locations (a proposed gas flare site situated at Ogbogu Gas plant and two control sites sfrom a primary source of local farm lands). A total number of eighteen samples were collected from the five different sampling spots as designated using the global positioning system (GPs).

A contaminated Site and three farm lands within Ogbogu and Ebocha community were mapped at 20m, 50m, 100m, 500m & 700m from the gas flare site and mapped with GPs location at two different sampling depths (0-15 & 15-30) cm.

A Control Site and two (2) farm lands within Idu Ekpeye community were mapped outside the area of concentration from the gas flare sites. These locations were chosen to determine by comparative assessment, the impact of gas flaring on the soil properties of the contaminated sites.

Place and Duration of Study: This study was carried out in Ogba/Egbema/Ndoni Local Government Area of Rivers State. This area was chosen for this study because of the high volume of petroleum activities. Oil and gas processing, production, transportation and utilization for power generation occur daily in the area resulting in numerous cases of environmental degradation and pollution.

Methodology: This research explores and presents a method of analysing the environmental impact of gas flaring in the Niger Delta so as to provide the data required for the complete analysis and evaluation of the various observed and noted health and environmental effects of gas flaring in Niger Delta. Different samples at various proximities at 200m, 500m, 1000m, 5000m and 7000m from the flare site using a hand aguar equipment sampled at depths of (0-15)cm and (15–30)cm were taken and measurements and experimentations were meticulously carried out.

Results: The results obtained in this research show a marked trend as all the parameters considered indicated a gradient away from the flare points in all the flow stations such as soil pH changing from acidic (4.0-4.2) to near neutral (6.4-6.6) away from the flare points and the average low soil moisture content of (17% - 23%) as against 40% for the (10m and 20m) and control distance. The quantity of carbon emitted by these flares are about 2,525,000.00 tonnes of carbon per day. These values portray a bad omen for the affected communities.

Conclusion: Contamination of agricultural soils by trace metals creates a serious risk of the introduction of these xenobiotics into human food chain. The soil fertility is being reduced as this study has revealed an increase in temperature along-side an increase in gas flaring and flare distances.

This study recommends that gas flaring should be seen as a violent action against the people and that the flared gas should be channelled to meeting the ever increasing demand for energy in the industrial sector of the economy.

Keywords: Gas Flaring, Air Quality, Gas Emission, Meteorological data.

1.0 INTRODUCTION

Gas flaring is one of the most challenging and important energy and environmental problems facing the world today. When discussed publicly, gas flaring elicits comments like “extravagant squandering” or “monstrous and unnecessary.” The fact is, approximately 150 billions of cubic meters of natural gas are flared in the world each year, representing a 15 to 20 billion dollar waste of resources and a 260 to 400 million metric ton contribution to global greenhouse gas emissions [1] [2].

Gas flaring issue first received global attention a decade ago, coinciding with growing awareness of the climate impact of fossil fuel use. Previously, gas flaring had been often thought of as a human right issue in the developing world rather than a global energy problem. While human right issues are still of paramount concern, perceptions of the problem are widening. Concerns about the scarcity of oil and gas resources and high prices since 2005 have galvanized interest in flare solutions as the value of the commodity has increased. The issue is large-scale flaring of natural gas associated with oil, not routine and transient flaring for

operational or safety reasons [3] [4]. Natural gas flaring occurs in places where remoteness or economic considerations have driven governments and producers to burn off gas in order to produce the oil associated with it, and the issue is global, not local. While some countries, such as Russia, Nigeria, and Iran are often singled out for criticism, significant levels of flaring and venting occur on every continent, and global failures in both governmental policy and industry practice have allowed the issue to remain unresolved. Governments with non-transparent policies and weak environmental regulations are particularly likely to flare large amounts of gas. The problem is exacerbated through policy distortions and ineffective oversight and enforcement measures [5].

The bulk of the gas flaring activities are in the Niger Delta region of Nigeria [6] [2]. It is located in the South-South District of the Southern Region of Nigeria and is surrounded by small communities such as Batan, Odidi 1 and Odidi2, Escravos, Ekpan, etc. These communities within Niger Delta area are just a few kilometers apart. The inhabitants of these communities are predominantly fishermen. Apart from fishing, farming is another economic activity these villages are engaged in.

From the view point of cooperate researchers, Gas flaring has been argued to be of particular importance, since most oil and gas companies operation is surrounded with gas flaring and power plants in Nigeria.

Thus, in principle, gas flaring offers a route to growth, because there will be oil production and business opportunities but with high level of pollution risk to the socio-economic and environment of communities in the region that these operations take place [1]. Therefore, there is need to control the level of gas flares and power plants through adequate approach and policies. The aim of the study is to estimate the impact of Gas flaring and power plant emissions on the soil environment in the Niger Delta region and to procure an adequate approach to address these practices.

2 MATERIALS AND METHODOLOGY

2.1 FIELD SAMPLING EQUIPMENT

Sampling equipment, forms and data acquisition materials used during the field work include:

- Hand Auger for soil sampling
- Foil packs for soil and sediment samples
- Black polyethene bag (Big and small) for samples collection.
- Sample identification label and masking tape.
- GPS for coordinate mapping & Camera
- Hand towel, cutlass and rubber hand gloves
- Field sampling sheet/book and 2 Sets of cooler and ice packs.
- Distilled water and brush to decontaminate the sampling equipment.
- Sampling containers for water samples.

2.2 SITE SELECTION, SOIL SAMPLE COLLECTION AND PREPARATION

The Soil Samples for this study were picked from two sets of locations (a proposed gas flare site situated at Ogbogu Gas plant and two control sites) came from primary source of local farm lands.

Sampling Location/sites collection was done considering the following;

1) A contaminated Site; three farm lands within Ogbogu & Ebocha community were mapped at 20m, 50m, 100m, 500m & 700m from the gas flare site mapped with GPs location at two different sampling depths (0-15 & 15-30) cm.
2) A Control Site; two (2) farm lands within Idu Ekpeye community were mapped outside the area of concentration from the gas flare sites. These locations were chosen to determine by comparative assessment, the impact of gas flaring on the soil properties with the contaminated sites.

2.2.1 Labeling of Soil Samples

A hand augar of 4ft was used for Soil Sampling at the designated GPs points at 0-15 & 15-30cm depths, wrapped in black polythene bag and foil plate, it was properly labeled using a masking tape.

The soil samples were labeled as stated below; Sample Identification, Sample Location, Date of Sampling, Parameters required, and Time of Sampling.

2.2.2 Sample Transportation and Storage

The soil samples were transported in a Van with a way bill to the Integrated Environmental Services Limited laboratory for analysis under an ice cooler at 4□C. The samples were preserved according to the recommended practices as contained in the Department of Petroleum Resources in Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (DPR EGASPIN 1991 edition, revised 2002). Laboratory analysis on the samples was conducted also according to the standard analytical methods by EGASPIN 1991 edition, revised 2002.

2.2.3 Soil Sample Preparation

The Sampled soil was allowed to air dry for five days. This was followed by sieving the soil through a 2-mm stainless steel mesh to remove large stones and debris to obtain soil samples with particles <2mm. The soil was thoroughly mixed in order to obtain a representative sample (soil) and was stored at room temperature (22 °C) in the laboratory until trials test and further analyses.

All instruments/equipment used for this soil analysis were calibrated to standard and certified, solvents used for analysis were also standardized before running the analysis.

2.3 MEASUREMENT OF SAMPLE PARAMETERS

2.3.1 Determination of Soil pH (Electrode method, ASTM d4972-01 (2007)

To determine the pH of the Soil samples, the following materials were used: Sieve soil, Plastic beakers (50 or 100ml), a glass stirring rod, and a Ph meter (Hanna). 10.0g of wet soil was weighed into a beaker and 50.0ml of distilled water was added and stirred using a glass rod and allowed to stand for 30minutes. The pH electrode was carefully inserted into the swirl suspension and its reading was recorded after 15 seconds of settling. The electrode was rinsed with distilled water after each measurement and calibration was checked periodically.

2.3.2 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 de-ionized water. The pH was

determined using a multi parameter Hanna equipment model 9811 meter with a combined glass electrode.

2.3.3 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.

2.3.4 Soil Moisture Content Measurement

The ALPHA (1985) method was used to determine the moisture content of each soil sampled. 10g of each soil sample was heated in a hot air for 8-12hrs at 80° C until 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.

2.3.5 Determination of the Exchangeable Cations

Ca+, Mg ++, K. ASTM

2.5g of the wet soil samples was weighed into a 50ml Erlenmeyer flask and 15ml of extracting solution containing 1M NH4O AC, pH= 7.0 was pipetted to form a mixture. The suspension was stirred using a magnetic stirrer for 10mins, it was allowed to settle and filtered using a Whatman separating paper. The extract was run in Atomic Absorption Spectrometer (AAS) to determine its Ca, Mg, K, Na in respective samples (Daniel et al, 2021).

2.3.6 Determination of Heavy Metals Using Aqua-Righa Method

1.0g of the air dried soil samples was weighed into a beaker. A mixture of concentrated HCL and Nitric acid in ratio 3:1 solution was added (7.5ml HCL and 2.5ml of HNO_3) to 10ml of the mixture, swirled and kept in the fume cupboard. Samples were digested at the temperature of 60^0C on a hot plate for 20mins until white fumes ceased. The contents were then cooled for 10mins. 10ml of deionised water was added and filtered using separating filter paper. The resultant solution was analyzed with an atomic absorption spectrophotometer (AAS) Buck scientific 210/211VGP model using EGASPIN 1991 Revised 2002 edition and ASTM method for each metals analysis. The absorption of absorbance of the test solution of Iron (Fe), Zinc (Zn), Copper (Cu), Nickel (Ni), Cadmium (Cd), Lead (Pb) and Magnesium (Mg) produced from the sample solution at various wavelengths were measured using air acetylene flame [7]

2.4 COLLECTION OF DATA

Five sampling points were selected within the study area at different points; 200m, 500m, 1000m, 5000m and 7000m with two control stations away from the area of concentration (AOC). Each of the selected point was mapped using a Global Positioning System (GPs) at various proximities from the flare locations, measurements and experimentations were meticulously carried out on Soil sample

2.4.1 Soil Sample Data

Five soil samples were collected from 200m, 500m, 1000m, 5000m and 7000m from the flare site using a hand aguar equipment sampled at depths of (0-15)cm & (15–30)cm wrapped in foil plate and black polyethene bag as replicate.

3. RESULTS AND DISCUSSION

3.1 Assessment of Soil Quality Parameters at Strategic Distances for the Selected Communities

Analyses of the effects of gas flaring in the two communities were done separately because of cross contamination and due to the fact that Ogbogu and Ebocha gas is still being flared, while in Idu, there was no gas flaring activities. It must be categorically stated that gases flared are in decreasing order of NOx (Nitrogen Oxide)>SOx (Sulphur Oxide) >CO (Carbon Monoxide)>VOC (Volatile Organic Compounds)>SMP (Small Particulate Matter) at increasing distance [8]. Thus, the analyses in this section compared the environment of the two communities to see the difference and similarities (if any) as regards the number of gas flaring points, distance of farms from the points and effects of the flare on the farms. In Ebocha, there are two gas flaring stations owned by Agip Nigeria Oil Company. The result of the preliminary soil sampling carried out to determine the environmental conditions of these locations is as presented in Figures 1-8.

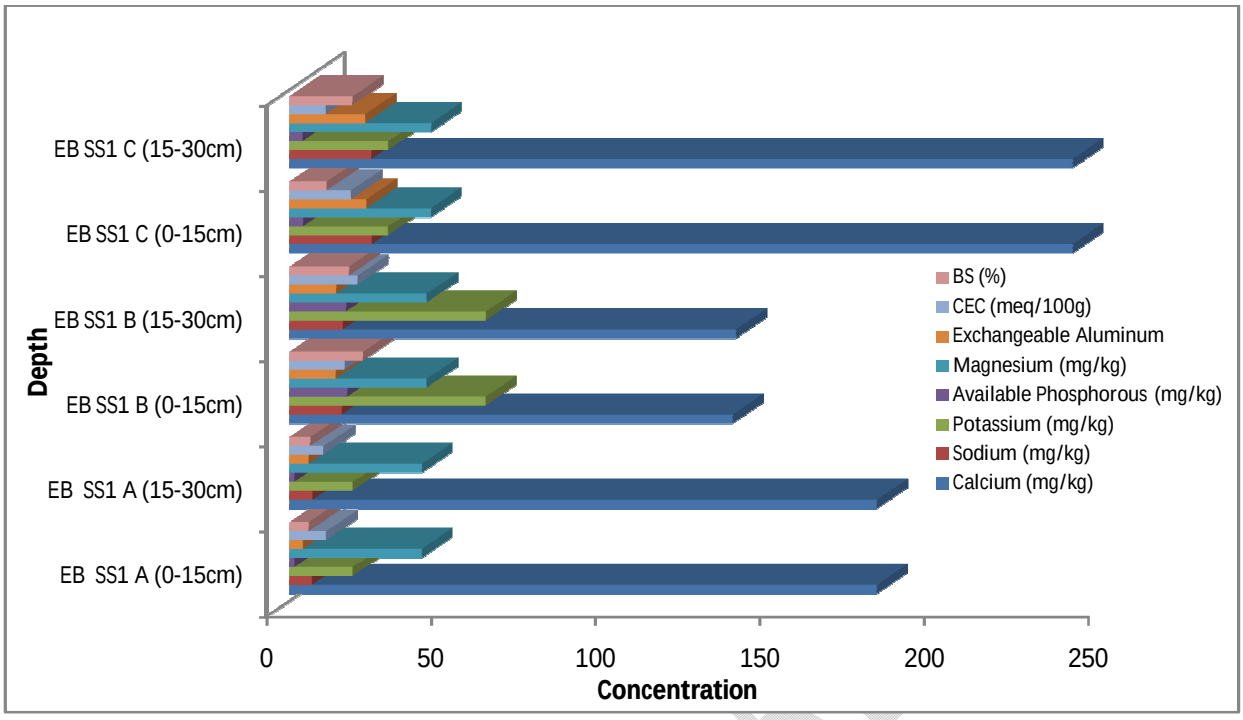

Figure 1: Soil Physicochemical Properties 20m from Flare Point

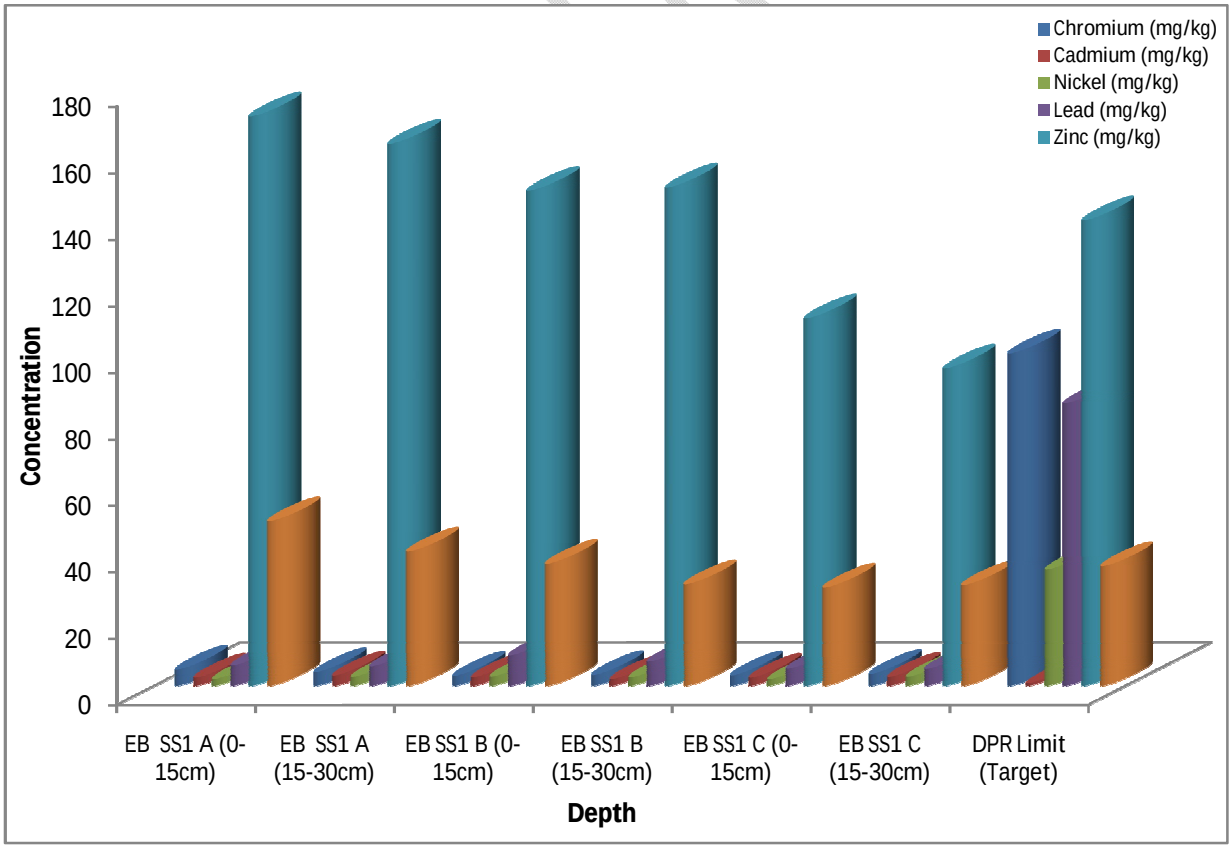

Figure 2: Heavy Metals Properties at 20m away from Flare Point.

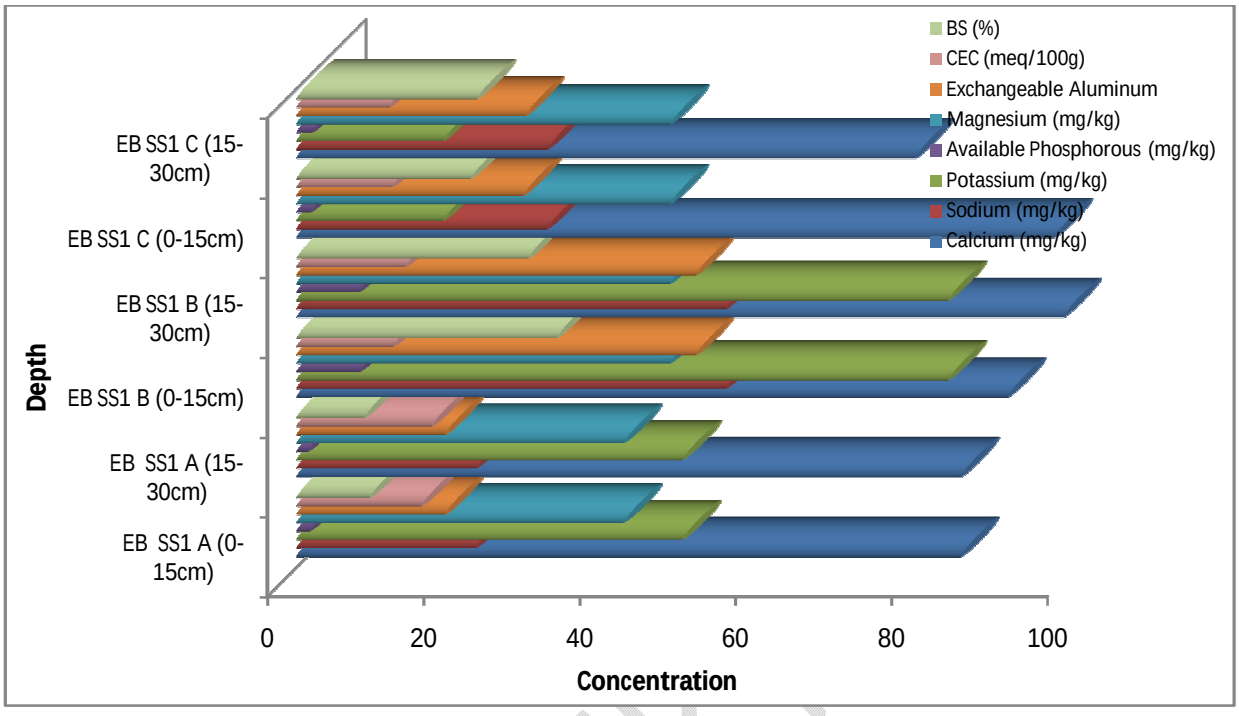

Figure 3: Soil Physicochemical Properties 50m from Flare Point

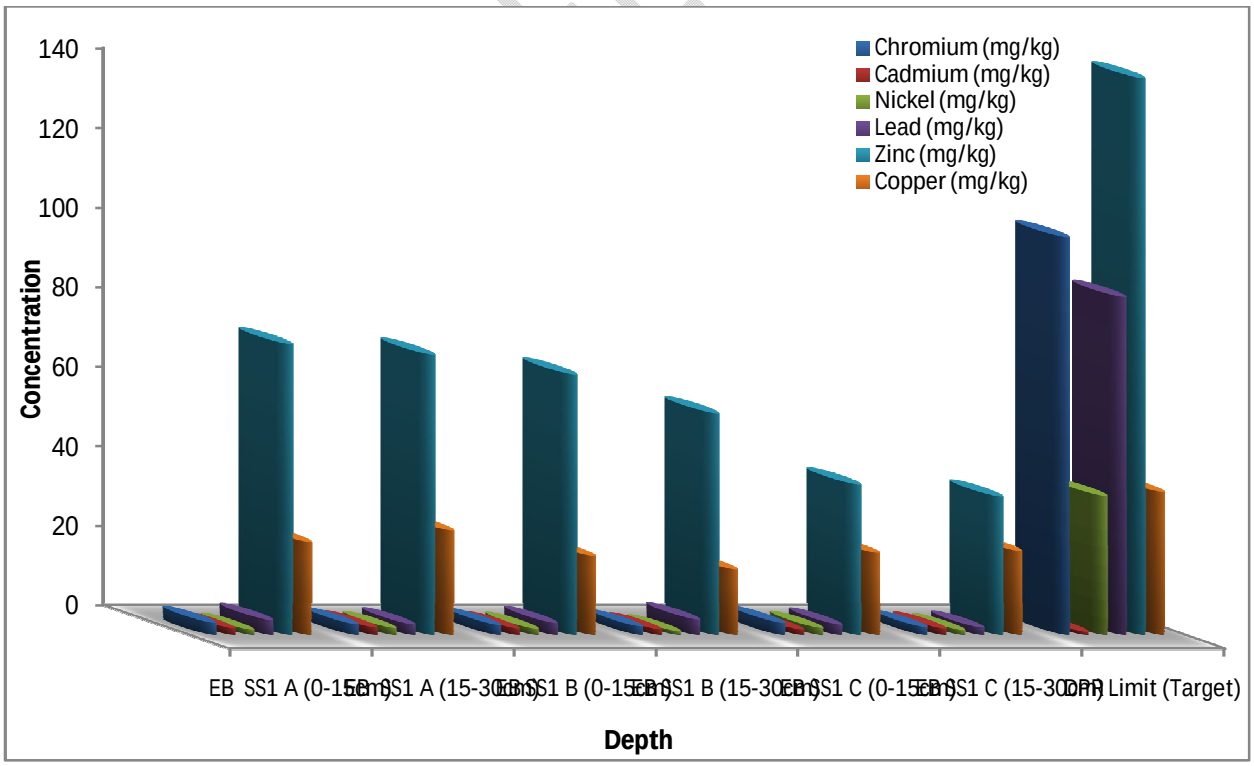

Figure 4: Heavy Metals Properties at 50m away from Flare Point

From the results as shown in Figure 1,2,3,4,5 and 6, it was observed that the soil closer to flare sites has relative high acidic content than other soils and reduction in total organic content of the soil and its trace metals also increases. The studied Soils are fast losing their fertility and capacity for sustainable agriculture due to the acidification of the soils by the various pollutants associated with gas flaring in the area. This Study shows that gas flaring significantly affects not only the microclimate but also the soil physico-chemical properties of the flare sites and it also reduces the micro-organism efficiency of the soil known as bacterial spectrum modification [8] [9].

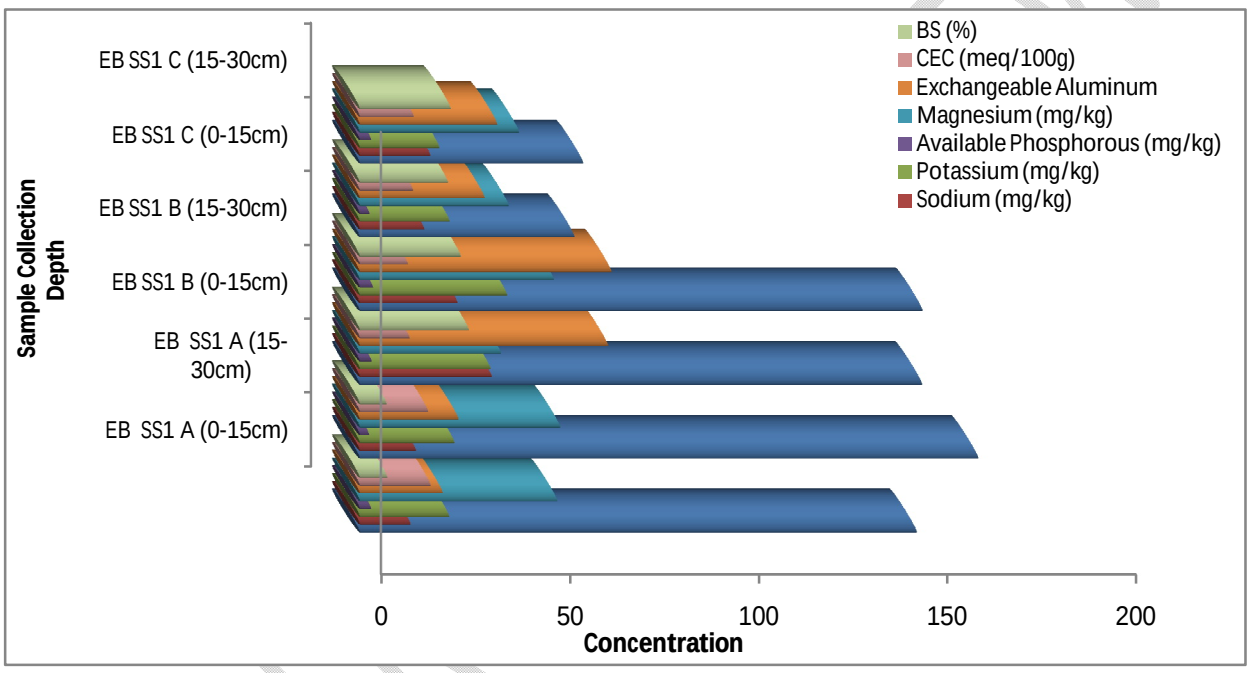

Figure 5: Soil Physicochemical Properties 100m from Flare Point

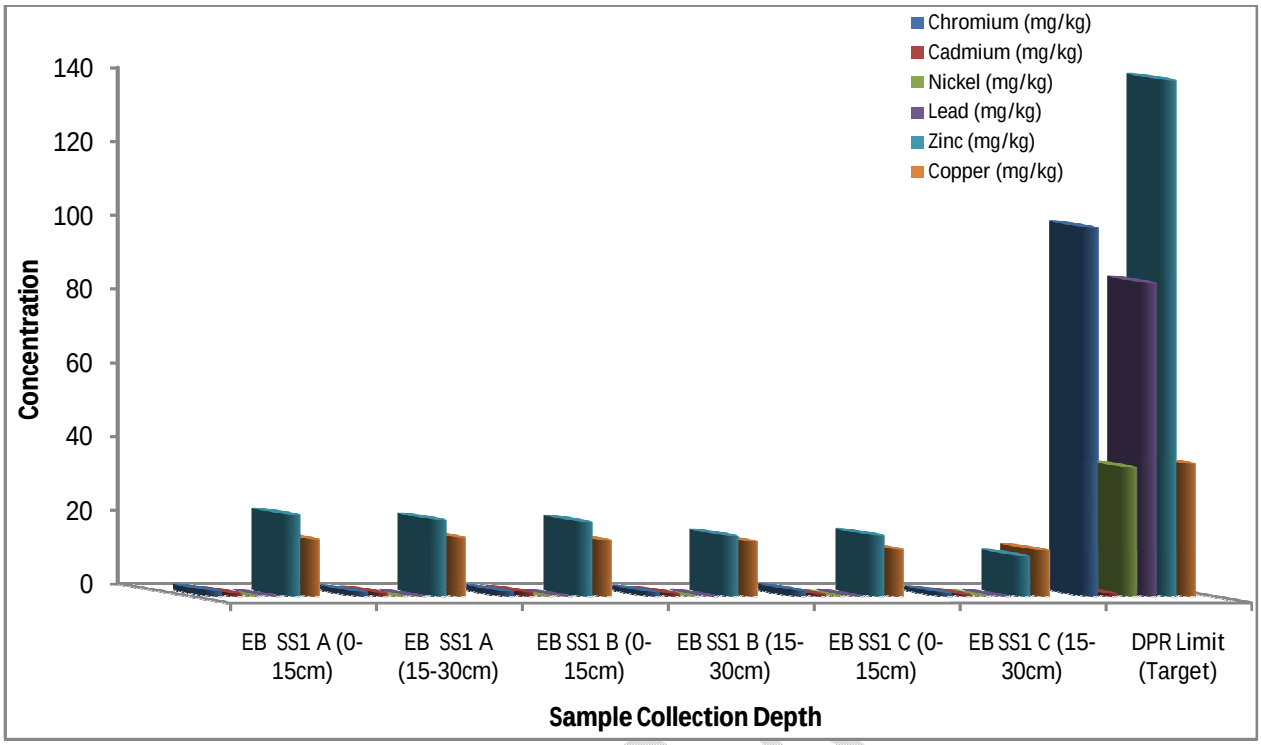

Figure 6: Heavy Metals Properties at 100m away from Flare Point

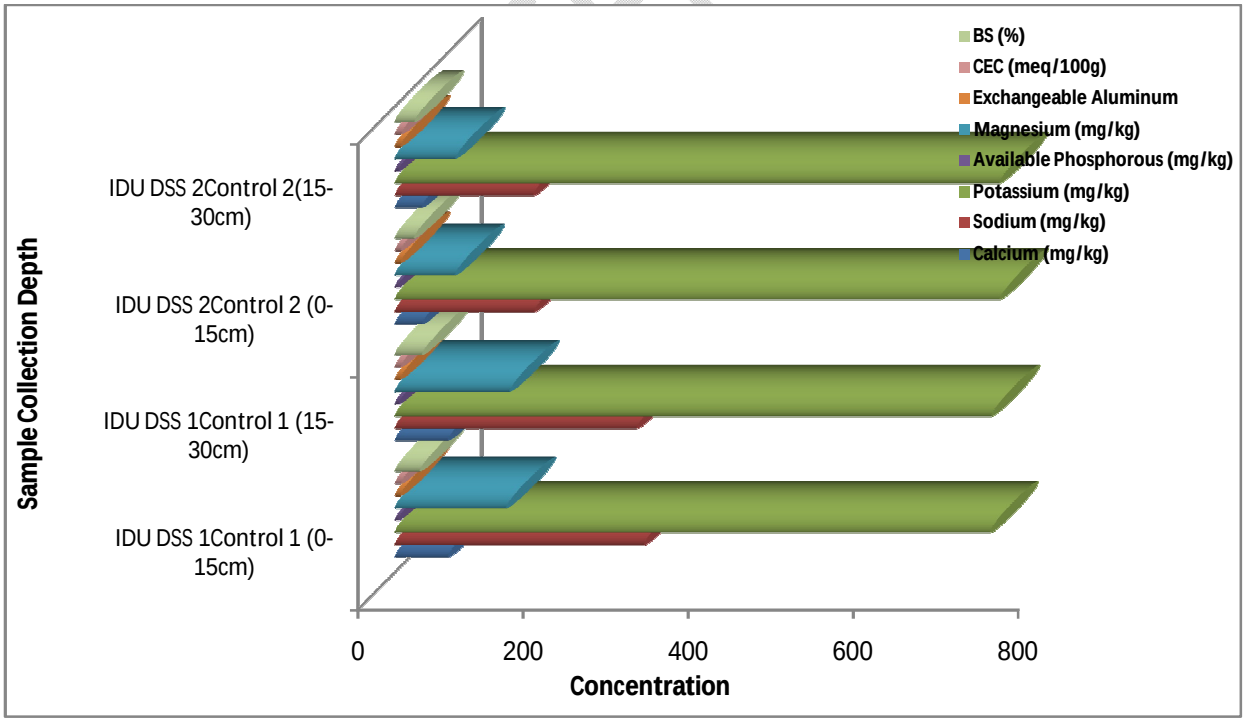

Figure 7: Soil Physicochemical Properties at Udu (Control Site) from Flare Point

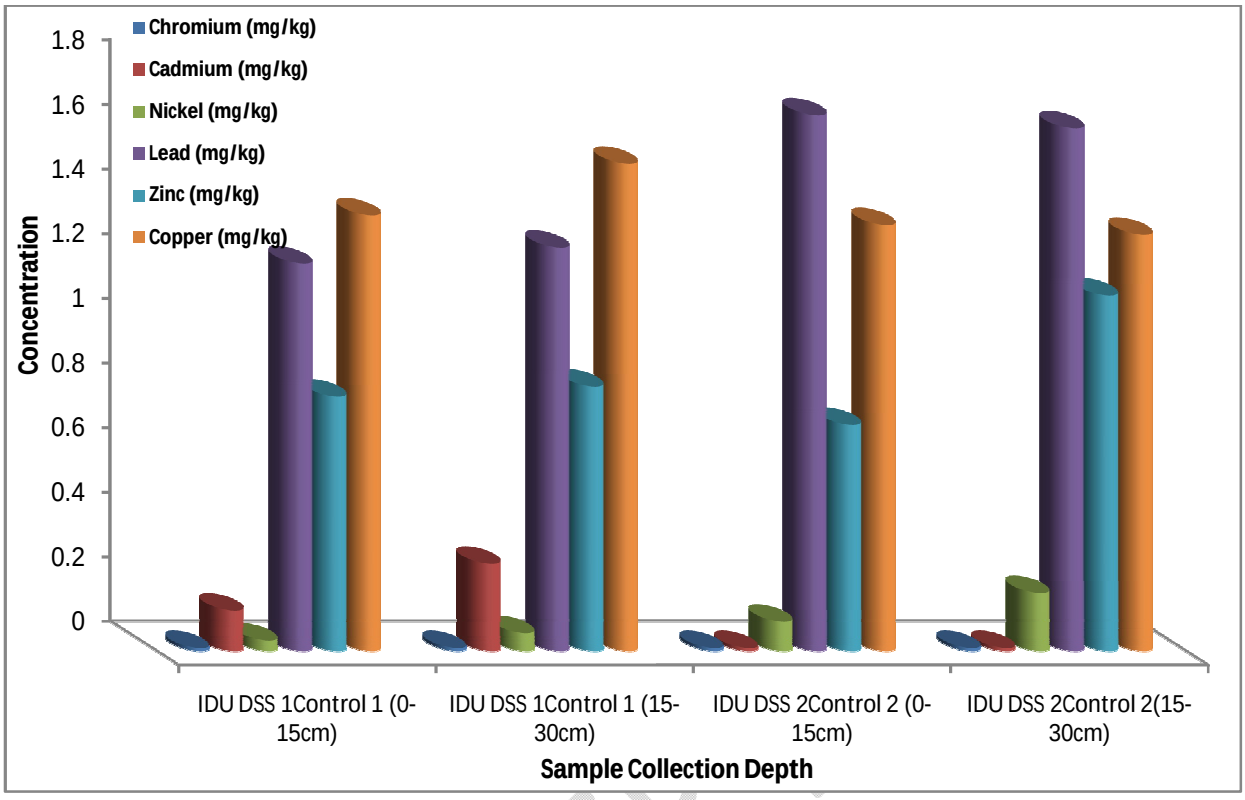

Figure 8: Heavy Metals Properties at Control site with no Flare Points

The increase in pH trend was widely shown EB ASS1 0-15 and EB ASS1 15-30cm (5.73 and 5.55) as compared with control station at Idu community with a pH value of 6.12 and 6.02 respectively. This shows that the further the distance, the wider the dispersion of gas in respect to rate of wind and its direction of flow; while the trace metals; Cr, Cd, Ni, Pb, Zn, Cu, Mn and Fe shows similar trend in respect to quantity of hydrocarbon emission generated which is dependent on the degree of combustion.

The pH values in this study were lower than those values reported by [10] [11]. Low pH from these anthropogenic sites could be as a result of the decomposition of organic matter that releases carbon (iv) oxide which reacts with water to form carbonic acid which eventually reduces soil pH. This low pH enhances solubility and mobility of heavy metals [12] and the presence of humic acid which is the major acid in soil organic matter.

There is a high build-up of heavy metal concentration in soil samples from all the sampled locations closer to the flare stations, which drastically reduced as the distance of sampling from flare stations increased.

3.2 Data Presentation of Sampled Soil Properties at Varying Distances

From Tables 1-3, it was observed that soil closer to flare sites has relative high acidic content than other soils and reduction in total organic content of the soil and its trace metals also increases. The studied Soils are fast losing their fertility and capacity for sustainable agriculture due to the acidification of the soils by the various pollutants associated with gas flaring in the area.

The effects of gas flaring on soil properties at various distances shows from the preliminary monitoring that there is heavy pollution of gases within (10-40m) from the flare sites. However soil organic and physicochemical properties were relatively normal at the control site (Idu site) as shown in Table 4.

Table 1: Analysis of Physiochemical Properties of Soil Sample at 20m from Flare Point

ENVIRONMENTAL SOIL SAMPLES ANALYSIS REPORT AT 20M									
S/N		**Ebocha Soil Sample Identification and Result**						**DPR Limits**	
		EB SS1 A		**EB SS1 B**		**EB SS1 C**			
		0-15	15 -30	0 - 15	15-30	0-15	15-30	**Target**	**Interv.**
	Parameter								
Physico-chemical:									
1	pH	4.68	4.60	5.01	4.75	4.80	4.79	NA	NA
2	TOC	1.50	0.84	3.78	2.70	3.18	3.00	NA	NA
Petroleum Hydrocarbons:									
3	THC (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Exchangeable Anions/Nutrients:									
4	Total Nitrogen (mg/kg)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
5	Phosphate (mg/kg)	5.00	4.92	54.16	53.00	13.00	12.50	NA	NA
Exchangeable Cations & Others									
6	Calcium (mg/kg)	178.40	178.42	134.60	135.62	238.02	238.04	NA	NA
7	Sodium (mg/kg)	6.90	7.10	16.01	16.30	25.11	25.01	NA	NA
8	Potassium (mg/kg)	19.25	19.26	59.60	59.64	30.02	30.06	NA	NA
9	Available Phosphorous (mg/kg)	1.63	1.60	17.66	17.28	4.24	4.08	NA	NA
10	Magnesium (mg/kg)	40.00	40.02	41.62	41.63	42.80	42.84	NA	NA
11	Exchangeable Aluminum	4.16	5.89	14.09	14.26	23.34	23.00	NA	NA
12	Exchangeable Acidity (meq/100g)	0.060	0.051	0.075	0.098	0.096	0.052	NA	NA
13	CEC (meq/100g)	11.140	10.313	16.754	20.612	18.676	11.086	NA	NA
14	BS (%)	5.855	6.331	22.165	18.014	11.332	19.090	NA	NA
Heavy Metals:									
15	Chromium (mg/kg)	4.890	4.120	3.021	3.241	3.152	3.580	100	380
16	Cadmium (mg/kg)	2.458	3.116	2.583	2.050	2.440	2.709	0.80	12
17	Nickel (mg/kg)	2.046	2.718	2.782	2.551	1.989	2.761	35	210
18	Lead (mg/kg)	6.152	5.892	9.161	7.281	5.118	5.061	85	530
19	Zinc (mg/kg)	171.310	163.067	148.911	149.900	110.520	95.460	140	720
20	Copper (mg/kg)	49.560	40.390	36.739	30.562	29.562	30.290	36	190
21	Manganese (mg/kg)	2.618	2.900	3.351	3.110	2.945	3.710	--	--
22	Iron (mg/kg)	434.123	420.560	407.011	415.670	410.012	415.033	NA	NA

Note: BS (Base Saturation), CEC (Cation Exchange Capacity), TOC (Total Organic Carbon), THC (Total Hydrocarbon)

Table 2: Analysis of Physiochemical Properties of Soil Sample at 50m from Flare Point

ENVIRONMENTAL SOIL SAMPLES ANALYSIS REPORT AT 50m									
S/N		Soil Sample Identification and Result						DPR Limits	
		EB SS2 A		EB SS2 B		EB SS2 C		Target	Interv.
		0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm		
	GPS Location								
	Parameter								
Physico-chemical:									
1	pH	5.80	5.98	5.75	5.40	5.61	5.98	NA	NA
2	TOC	1.91	1.62	3.20	2.70	1.08	1.80	NA	NA
Petroleum Hydrocarbons:									
3	THC (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Exchangeable Anions/Nutrients:									
4	Total Nitrogen (mg/kg)	1.83	0.89	1.03	2.11	0.90	1.02	NA	NA
5	Phosphate (mg/kg)	5.20	4.50	8.80	7.90	5.50	6.03	NA	NA
Exchangeable Cations & Others									
6	Calcium (mg/kg)	85.00	85.02	91.02	98.12	97.02	79.22	NA	NA
7	Sodium (mg/kg)	22.91	22.99	54.98	54.99	32.08	32.11	NA	NA
8	Potassium (mg/kg)	49.40	49.42	83.40	83.42	18.82	18.84	NA	NA
9	Available Phosphorous (mg/kg)	1.69	1.47	8.09	7.99	1.79	1.98	NA	NA
10	Magnesium (mg/kg)	41.83	41.85	47.80	47.85	47.80	47.83	NA	NA
11	Exchangeable Aluminum	19.01	19.00	51.10	51.08	29.01	29.27	NA	NA
12	Exchangeable Acidity (meq/100g)	0.084	0.092	0.048	0;.056	0.055	0.053	NA	NA
13	CEC (meq/100g)	15.989	17.301	12.411	13.979	12.255	11.842	NA	NA
14	BS (%)	9.379	8.670	33.285	29.661	22.304	23.085	NA	NA
Heavy Metals:									
15	Chromium (mg/kg)	3.051	2.719	2.550	2.164	3.011	2.004	100	380
16	Cadmium (mg/kg)	1.710	1.901	1.650	1.410	1.330	1.623	0.80	12
17	Nickel (mg/kg)	1.301	1.76	1.560	0.917	1.791	1.189	35	210
18	Lead (mg/kg)	3.751	2.671	3.013	3.903	2.617	1.860	85	530
19	Zinc (mg/kg)	73.118	70.490	65.501	55.722	37.840	34.820	140	720
20	Copper (mg/kg)	23.372	26.310	19.862	16.483	20.631	21.112	36	190
21	Manganese (mg/kg)	1.250	1.100	1.748	1.829	1.125	1.330	--	--
22	Iron (mg/kg)	121.524	113.280	143.165	132.700	130.625	125.809	NA	NA

Note: BS (Base Saturation), CEC (Cation Exchange Capacity), TOC (Total Organic Carbon), THC (Total Hydrocarbon)

Table 3: Analysis of Physiochemical Properties of Soil Sample at 100m from Flare Point

ENVIRONMENTAL SOIL SAMPLES ANALYSIS REPORT AT 100m									
S/N		**Soil Sample Identification and Result**						**DPR Limits**	
		EB SS3 A		**EB SS3 B**		**EB SS3 C**		**Target**	**Interv.**
		0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm		
	GPS Location								
	Parameter								
Physico-chemical:									
1	pH	6.21	5.99	6.09	6.12	6.06	5.94	NA	NA
2	TOC	0.90	1.12	1.23	0.87	1.02	0.98	NA	NA
Petroleum Hydrocarbons:									
3	THC (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA	NA
Exchangeable Anions/Nutrients:									
4	Total Nitrogen (mg/kg)	2.32	1.81	1.25	1.02	1.06	1.10	NA	NA
5	Phosphate (mg/kg)	5.89	7.11	6.90	5.70	7.12	6.70	NA	NA
Exchangeable Cations & Others									
6	Calcium (mg/kg)	147.60	163.90	149.02	149.12	56.90	59.22	NA	NA
7	Sodium (mg/kg)	13.451	14.871	34.98	25.89	17.10	18.69	NA	NA
8	Potassium (mg/kg)	23.69	25.10	34.67	39.04	23.83	21.09	NA	NA
9	Available Phosphorous (mg/kg)	3.00	2.50	3.12	3.50	2.56	3.01	NA	NA
10	Magnesium (mg/kg)	52.34	53.09	37.40	51.44	39.50	42.190	NA	NA
11	Exchangeable Aluminum	22.01	26.17	65.78	66.70	33.12	36.42	NA	NA
12	Exchangeable Acidity (meq/100g)	1.238	0.892	0.072	0.062	0.097	0.061	NA	NA
13	CEC (meq/100g)	18.772	18.096	13.182	12.750	14.110	14.290	NA	NA
14	BS (%)	7.309	7.109	28.901`	26.774	23.390	24.108	NA	NA
Heavy Metals:									
15	Chromium (mg/kg)	1.510	1.254	1.350	1.210	1.611	1.056	100	380
16	Cadmium (mg/kg)	0.910	1.001	1.150	0.810	0.650	0.550	0.80	12
17	Nickel (mg/kg)	0.070	0.067	0.080	0.072	0.065	0.060	35	210
18	Lead (mg/kg)	0.020	0.055	0.040	0.068	0.061	0.051	85	530
19	Zinc (mg/kg)	22.110	20.745	20.200	16.410	16.551	10.950	140	720
20	Copper (mg/kg)	15.510	16.000	15.251	14.910	12.750	12.500	36	190
21	Manganese (mg/kg)	<0.01	<0.01	0.050	0.052	<0.01	<0.01	--	--
22	Iron (mg/kg)	40.250	49.105	38.550	32.650	29.250	28.150	NA	NA

Note: BS (Base Saturation), CEC (Cation Exchange Capacity), TOC (Total Organic Carbon), THC (Total Hydrocarbon)

Table 4: Analysis of Physiochemical Properties of Soil Sample at Idu from Flare Point

ENVIRONMENTAL SOIL SAMPLES ANALYSIS REPORT							
S/N		**Soil Sample Identification and Result**				**DPR Limits**	
		IDU DSS 1 Control 1		**IDU DSS 2 Control 2**		**Target**	**Interv.**
		0-15	**15-30**	**0-15**	**15-30**		
	Parameter						
Physico-chemical:							
1	pH	6.23	6.21	5.89	5.93	NA	NA
2	TOC	1.30	1.60	2.10	2.40	NA	NA
Petroleum Hydrocarbons:							
3	THC (mg/l)	<0.01	<0.01	<0.01	<0.01	NA	NA
Exchangeable Anions/Nutrients:							
4	Total Nitrogen (mg/kg)	<0.01	<0.01	<0.01	<0.01	NA	NA
5	Phosphate (mg/kg)	12.50	14.90	11.30	14.00	NA	NA
Exchangeable Cations & Others							
6	Calcium (mg/kg)	63.30	63.50	33.02	32.10	NA	NA
7	Sodium (mg/kg)	301.10	292.10	167.90	166.92	NA	NA
8	Potassium (mg/kg)	720.12	722.01	732.01	731.7	NA	NA
9	Available Phosphorous (mg/kg)	4.08	4.86	3.68	4.56	NA	NA
10	Magnesium (mg/kg)	134.89	139.11	73.01	73.50	NA	NA
11	Exchangeable Aluminum	6.70	6.55	7.02	7.10	NA	NA
12	Exchangeable Acidity (meq/100g)	0.064	0.077	0.0523	0.0812	NA	NA
13	CEC (meq/100g)	7.596	7.510	7.277	8.210	NA	NA
14	BS (%)	30.223	33.012	23.192	23.892	NA	NA
Heavy Metals:							
15	Chromium (mg/kg)	<0.01	<0.01	<0.01	<0.01	100	380
16	Cadmium (mg/kg)	0.126	0.271	<0.01	<0.01	0.80	12
17	Nickel (mg/kg)	0.033	0.056	0.091	0.180	35	210
18	Lead (mg/kg)	1.201	1.250	1.660	1.620	85	530
19	Zinc (mg/kg)	0.789	0.820	0.701	1.102	140	720
20	Copper (mg/kg)	1.350	1.510	1.320	1.290	36	190
21	Manganese (mg/kg)	<0.001	<0.001	<0.001	<0.001	--	--
22	Iron (mg/kg)	2.361	2.561	3.101	2.901	NA	NA

Note: BS (Base Saturation), CEC (Cation Exchange Capacity), TOC (Total Organic Carbon), THC (Total Hydrocarbon)

3.3 Soil Parameters Summary Discussion

The result from data Tables and Figures shows that the closer a sampling point was to the flare, the higher the soil temperature. This high temperature affects the survival of microbes and germination of plants. Beyond 100m from the fare tip, the soil temperature was more strongly influenced by vegetation cover and the moisture content, rather than the presence of the flare or even insulation. The soil temperature taken in the morning was approximately $1^{o}C$ lower than that taken in the late afternoon or evening. Effect of vegetation cover was found to lower the soil temperature by as much as $4^{o}C$.

Sampled stations at varying distances showed that pH values, changed from acidic (4.0 – 4.2) to near neutral (6.4 – 6.6) away from the flare point. The low pH values at the flare points could be attributed to the acidic oxides produced by the flaring. Both the lower pH and higher aluminum concentrations in surface water that occur as a result of acid rain can cause damage to fish and other aquatic animals. At pH lower than 5, most fish eggs will not hatch and lower pHs can kill adult fish. As lakes and rivers become more acidic, biodiversity is reduced. Acid rain has eliminated insect life and some fish species over the years due to these gas flaring and dangerous gaseous emissions.

Although, from the figures shown above the mean value of Pb (9.161mg/kg – 5.061mg/kg) shows a relative high value as compared to the control points at Idu community with (1.660mg/kg – 1.201 mg/kg) respectively, Cu content shows a good reduction as the distance increases from 280m to 840m with 10.621mk.kg at EB ASS1 0-15 and 11.081mg/kg at the bottom soil (15-30cm) to 2.753mg/kg at EB CSS1 top soil (0-15cm) and 2.803 mg/kg at EB CSS1 bottom soil (15-30cm). The Metal analysis results shows that if crop samples were sampled at a closer range of 100m to 250m to the flare stack, high trace metals will be recorded.

4.0 CONCLUSION

Theoretically, the combustion processes with complete combustion create relatively innocuous pollutants such as; gases (carbon dioxide and water) and metals. It is safe to conclude that gas flaring not only produces excessive heat which alters the temperature of the environment, but also causes gaseous pollutants to be present in the environment which may have adverse effects on the inhabitants and thus on the socio-economic activities of Ebocha community.

Results from this study has shown that gas flaring does not just cause air pollution but also impact the physicochemical properties of surrounding soil environs. Also, soils closer to the stack had more metal immobilization than soil further away due to dispersion of pollutants by wind. This is because the flaring efficiency depends on wind speed, stack exit velocity, stoichiometric mixing ratios and heating value; the flaring in reality is rarely successful in the achievement of complete combustion. It is therefore very imperative to control gas flaring in the Niger Delta, as the impact on the food chain, ecosystem and human health is significant.

REFERENCES

1. Fagbeja, M.A.; Hill, J.; Chatterton, T.; Longhurst, J.; Akinyede, J. Residential-Source Emission Inventory for the Niger Delta—A Methodological Approach. J. Sustain. Dev. 2013, 6, 98–120. [CrossRef]

2. Adoki, A. Air Quality Survey of some locations in the Niger Delta Area. J. Appl. Sci. Environ. Manag. 2012, 16, 125–134.

3. Nwachukwu, A.N.; Chukwuocha, E.O.; Igbudu, O. A Survey on the Effects of Air Pollution on Diseases of the People of Rivers State, Nigeria. Afr. J. Environ. Sci. Technol. 2012, 6, 371–379. [CrossRef]

4. The World Bank. Little Green Data Book 2015. Available:https://openknowledge.worldbank.org/bitstream/handle/10986/22025/97814 64805608.pdf (accessed on 26 July 2017).

5. Uyigue, E.; Agho, M. Coping with Climate Change and Environmental Degradation in the Niger Delta of Southern Nigeria. Community Research and Development, Centre Benin City. Availableonline:http://priceofoil.org/content/uploads/2007/06/07.06.11%20-%20Climate_Niger_Delta.pdf (accessed on 26 August 2017).

6. Ubong, I.U.; Ubong, U.U.; Ubong, U.E.; Ukonta, R.; Ishmael, D. Distribution of Particulate Matter in Cawthorne Channels Air Basin in Nigeria. Environ. Pollut. 2015, 4, 19–26. [CrossRef]

7. Ogbebor D, Ugbebor N.J, Momoh O.L.Y, Ndekwu B.O. Land pollution assessment from slaughterhouses waste discharge in Port Harcourt. Journal of Engineering Research and Reports. 2021;21(6):10-28, 2582-2926.

8. Ehumadu C.O., Uyigue .L. and Ndekwu .B.O. Air Pollution Assessment of a Gas Flare Site in the Niger Delta Region. Journal of Engineering Research and Reports 2021;20(8): 116-126, 2582-2926.

9. Gobo, A.; Richard, G.; Ubong, I. Health Impact of Gas Flares on Igwuruta/Umuechem Communities in Rivers State. J. Appl. Sci. Environ. Manag. 2010, 13, 27–33. [CrossRef]

10. Osakwe S. A. Heavy metal contamination and physicochemical characteristics of soils from automobile workshops in Abraka, Delta State, Nigeria. International Journal of Natural Science Resources. 2014;2(4): 48-58.

11. Ogbebor D, Ugbebor N.J, Momoh O.L.Y, Ndekwu B.O. Modelling of Soil Profile Pollutant Yield on Slaughterhouse Wastes Deposited Land. Journal of Engineering Research and Reports. 2021;21(8):16-29, 2582-2926.

12. Akan J.C, Audu S.I, Mohammed Z, Ogugbuaja V.O. Assessment of heavy metals, pH, organic matter and organic carbon in roadside soils in Makurdi metropolis, Benue State, Nigeria. Journal of Environmental Protection. 2013;4:618- 628.

13. Ampofo EA, Awortwe D. Heavy metal (Cu, Fe and Zn) pollution in soils: pig waste contribution in the Central Region of Ghana. Adv Appl Sci Res. 2017;8:1- 10.