

Assessment of Soils and Some Atmospheric Gases Within the Vicinity of a Gas Flare Point

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Abstract:

The pollution of surface soils and some atmospheric gases around the vicinity of a Gas flare point has prompted researches aimed at considering geochemical investigation of the soil and atmospheric studies of the Gas flare point vicinity. This study investigated the surface soil pH and other physico-chemical properties. Soil nutrient indicators, Heavy metals within the vicinity of the Gas flare point, these include Fe, Zn, Cd, Cu, Ni, Pb, Mn, Cr, Available phosphorus, Exchangeable Potassium, Nitrate Nitrogen, Total Organic Carbon, Total Organic Matter, Soil Particle Size. Also 5 different atmospheric gases; H₂S, SO₂, VOC (Volatile Organic Carbon), NO₂ and CO were determined. Five samples were collected at different distances between the Port Harcourt Gas Flare point and KonoBoue community in Ogoni area of Rivers State. The range of Fe, Zn, Cd, Cu, Ni, Pb, Mn and Cr were 4170-8592mg/kg, 42-89mg/kg, 0.2-1.2mg/kg, 6.8-15.2 mg/kg, 0-46 mg/kg, 0.8-84 mg/kg, 238-3060mg/kg and 12.2-32.0 mg/kg respectively. Fe and Mn indicated high concentration. So also, Manganese appears consistent in all the soil sample apart from the control soil samples from Rivers State University. In terms of soil nutrient, KonoBoue soil samples were observed to have the lowest soil nutrient. Particle size distribution showed KonoBoue soil sample as silty clay while the rest soil samples showed Sandy texture. Among the atmospheric gases, VOC indicated high concentration with River State University indicating the least VOC concentration. Also, in terms of proximity, Particle Size Distribution, Nitrate Nitrogen, Available Phosphorus, Exchangeable Potassium, Total Organic Carbon, Total Organic Matter indicated decrease with increase in locational distance. On the contrary, the moisture content and the atmospheric gases distribution indicated increase in concentration distribution as the location distance increased, Heavy metals showed varied distribution for each Heavy metal. The correlation result showed strong correlation between the acidity and Heavy metals, this indicates the dependent effect of the atmospheric acidification effect on the Heavy metals and soil properties with Fe and Cr showing the strongest correlation coefficient.

Keywords —KonoBoue, Rivers State University, Gas Flare Point, atmospheric acidification, Acidity, Soil

I. INTRODUCTION

Gas Flaring is done by the upstream oil companies as a result of the burning of natural gas and petroleum hydrocarbons. Gas has been said to be flared in Nigeria, essentially due to lack of technical know-how, regulatory defects and economic constraints. Rather than reconverting the Gas Flare towards revolutionizing Nigeria economy and also lessening the environmental threat that Gas flaring poses, oil companies believe that the technology is expensive and see flaring as a cheaper option while enjoying the tacit consent of those in authorities. Ubani et al., (2013).

It has been found that Gas Flaring contributes to Climate change, Nigeria has been found to be one of the highest emitter of Green House Gas on African continent and among the highest emitter of CO₂ around the world (GGFR, 2002, Iyayi, 2004). Niger Delta region has been a location of global interest because it is not only a region identified with high massive oil exploration in Nigeria rather it is of Global focus. Niger Delta has a unifying feature with access to seas and rivers which include river Niger and river Benue and also it's a projected focus is for its marine biodiversity and food production from marine water and also Niger Delta offshore water in the world. E.C. (Ubani & Onyejekwe, 2013)

Nigeria has been found to have in operation over 200 gas flaring sites and also that about 22 billion standard flask is been explored daily and the disheartening fact is that about 75% of the quantity produced is flared. (Nwaugo et al., 2006). Studies have shown that the various impact of Gas flaring on microbial spectrum from soils around the Niger Delta area are also in various parts of the region. The activities of this microbial spectrum also affect the physicochemical parameters of the soil which in turn could impair with the fertility of the soil. (Nwaugo et al., 2006). Gas Flaring takes place in oil production platforms due to the need to get rid of associated gases. Low flare stacks employed leads to the flare getting into close proximity with nearby vegetation and soil. Studies revealed that Gas

flaring has high economic, social and health adverse effect both in Nigeria and the world at large (Ubani & Onyejekwe, 2013)

It has been found out that gas flaring activities affect the physicochemical properties of the soil as it does affect the Bacterial population, Fungi Population and also the population of plant in flaring vicinity. According to the finding of Isichei and Sanford, (1976) in their studies, Gas flaring decrease the chlorophyll content in the plants found near the area where the flare point is located.

According to a publication by Nigeria Liquefied Natural Gas in 2008, there is wide indication that gas flaring has resulted to widespread environmental damage in several regions through the release of greenhouse and other harmful gases that impairs the air quality, causes heat stress and also resulting to acid rain together with soil bacteria reduction (Akintoye et al., 2016)



Photograph of Gas Flare Stalk taken

Materials and Methods

The materials used for the analysis were Auto pipettes, Volumetric Flask, Filter paper, pH meter, Oven/ Hot plate, Polycarbonate tubes with caps, Analytical Balance, Mortar & Pestle, Sieve, Soil Hydrometer (ASTM 152H hydrometer), Sedimentation Cylinders, Internal timer, End-over-end Shaker, Internal timer, End-over-end Shaker, Polypropylene funnels, Dispenser, Polypropylene funnels, Dispenser, whatman filter paper.

Sample Sites

Five (5) composite samples were taken from different locations: 1km away from PortHarcourt

Gas Flare point, 2 Km away from Gas Flare point, the entry and the exit of KonoBoue, a community located at 34km away from the Gas Flare point and also control samples were taken from Rivers State University.

Sample Collection

Composite surface soil samples were taken at varied depth of 0-15cm, 15-30 cm and 30-45cm respectively(Uyigue& Enujekwu, 2017) due to possible migration of parameters of interest into the sub-soil level(Aghalino, 2009).

Three soil samples were taken from each depth making up nine soil samples from each location and transferred in labelled polyethylene sacs and transported to the Department of Chemistry Research Laboratory of Rivers State University, Port Harcourt Nigeria where the samples were homogenized.

Sample Preparation

The samples collected were spread on an uncontaminated plastic sheet placed on a plastic tray on a table in an open air in the laboratory for some days.

Thereafter, the air dried samples were sieved through a <250um stainless steel mesh screen.

Soil pH

About 10g of each sample was weighed and thereafter transferred into a bottle with screen cap and then 25ml of de-ionized water was added and the cap was put in place.

After the addition of the de-ionized water, the resulting suspension was mixed by shaking for about 15mins period after-which the resulting suspension was mixed by shaking for about 15 minsperiod ,it was then stirred and the pH measurement was taken with the insertion of the electrode probe. This whole process was also repeated with CaCl₂ solution in place of de - ionized water.

Heavy Metal Digestion (Aqua regia)

About 0.5g samples were weighed and then transferred into a burning test tubes and 20ml aqua regia (Hydrochloric acid and Nitric acid, ratio 3:1) was then added.

With the use of hot plate inside a fume cupboard, the resulting mixtures were digested for about 1 hour at 100⁰C. Thereafter, the resulting digests were allowed to cool and then filtered into a 100ml flask and then made to mark with de-ionized was, the digests were then labelled for AAS analysis.

Atomic absorption Spectrophotometer (AAS)

The filtrates were analyzed with Atomic Absorption Spectrophotometer after the equipment has been calibrated with different standard concentrations.

Then, the concentration of Fe, Zn, Cd, Cu, Ni, Pb, Mn, Cr were determined respectively and concentrations in soil were calculated in mg/kg.

Atmospheric Gases

Aeroqual series 500 Gas sensing device was used alongside the different sensors of the gases of interest. The different sensors used were Volatile Organic Carbon (VOC) sensor, Nitrogen dioxide sensor, Carbon monoxide sensor and Hydrogen sulphide sensor respectively.

The Atmospheric Gas Sensing of these different gases for the different locations was done.

Soil Moisture Content

The aluminum dishes were weighed prior to the startup of the moisture content determination. Thereafter, aliquot approximately 50g of the moist soil was placed into each aluminum dish and the dishes re-weighed.

Hence the moist weight of the soil sample is now known. Then the soil was dried overnight at 105⁰c in the oven and the dishes were removed from the oven and allowed to cool after which the dishes were reweighed and the soil was oven-dried to get the weight of the dry soil for the percentage moisture content.

Soil Total Organic Carbon

Soil Total Organic Carbon was determined using Walkley-Black Chronic acid wet oxidation method.

This was done by allowing the oxidisable matter in the soil to oxidize by 1N $K_2Cr_2O_7$ solution.

Thereafter, the reaction was assisted by the heat generated when two volumes of one volume of

Matter

The Soil Total Organic Matter is derived by using the expressional relationship between the Total Organic Matter (TOM) and Total Organic Carbon (TOC) as shown below:

Organic matter(%) = Total Organic Carbon(%) multiply by 1.72

Soil Particulate Size

Soil particle is made up of collection of different particles of diverse shapes and sizes. The method is designed to group the various diverse shapes and sizes and to determine the relative proportion by weight of each composition. Seiving and sedimentation is involved in this method, it sieves soil and water together with dispersant suspension in order to separate the particles. This method employs Stokes' law and the periodic measurement of the density of the suspension. Laker et al., (1982)

dichromate and two volumes of H_2SO_4 were mixed together. The remaining dichromate was then titrated with Ferroussulphate. The titration result is inversely related to the amount of Carbon present in the soil sample.

Soil	Total	Organic
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Results and Discussion

1 pH of the Different Soil Samples

Mean and standard deviation results of Moisture Content (%), pH, Nitrate Nitrogen(mg/kg), Exchangeable Potassium (mg/kg), Available Phosphorus (mg/kg), TOC (mg/kg), TOM (mg/kg) Kono- Boue soil samples, samples from 1km & 2Km away from Port Harcourt Gas Flare point and Rivers State University soil samples are provided below:

Table 4.1 : Mean and standard deviation results of Moisture Content (%), pH, Nitrate Nitrogen(mg/kg), Exchangeable Potassium (mg/kg), Available Phosphorus (mg/kg), TOC(mg/kg), TOM(mg/kg) Kono- Boue soil sample.

Table 4.2 : Mean and standard deviation results of Particle Size Distribution and Texture of Kono- Boue soil samples, samples from 1km& 2Km away from Port Harcourt Gas Flare point and Rivers State

Moisture Content (%)	pH (in water)	pH in CaCl2	Nitrate (mg/kg)	Exchangeable Potassium (mg/kg)	Phosphorus (mg/kg)	TOC (mg/kg)	TOM (mg/kg)
SURFACE							
0-15CM							
S1 3.91 ± 0.04	5.65 ± 0.03	3.45 ± 0.04	0.345 ± 0.003	0.321 ± 0.003	3.39 ± 0.06	1.07 ± 0.02	1.84 ± 0.01
S2 3.97 ± 0.08	5.22 ± 0.02	4.18 ± 0.02	0.198 ± 0.002	0.211 ± 0.002	2.65 ± 0.05	0.51 ± 0.00051	0.88 ± 0.02
S3 1.14 ± 0.01	6.08 ± 0.02	6.40 ± 0.04	0.254 ± 0.003	0.289 ± 0.005	3.24 ± 0.06	2.30 ± 0.05	3.96 ± 0.03
S4 1.29 ± 0.03	0.02	0.04	0.003	0.005	0.06	0.05	0.03
S5 1.13 ± 0.01	6.32 ± 0.02	6.07 ± 0.05	0.145 ± 0.002	0.254 ± 0.003	4.01 ± 0.012	2.77 ± 0.03	4.76 ± 0.05
	7.65 ± 0.04	5.02 ± 0.10	0.241 ± 0.002	0.291 ± 0.003	3.87 ± 0.08	2.11 ± 0.02	3.63 ± 0.05
SUBSURFACE SOIL							
15-30CM							
S1 4.85 ± 0.05	5.87 ± 0.05	3.45 ± 0.40	0.38 ± 0.004	0.22 ± 0.002	3.46 ± 0.03	1.11 ± 0.02	3.14 ± 0.02
S2 4.89 ± 0.03	5.52 ± 0.02	0.46	0.35 ± 0.003	0.24 ± 0.002	2.43 ± 0.02	0.45 ± 0.004	3.14 ± 0.03
S3 1.25 ± 0.02	6.35 ± 0.02	6.15 ± 0.08	0.32 ± 0.005	0.30 ± 0.003	± 0.03	1.11 ± 0.02	3.14 ± 0.01
S4 1.57 ± 0.02	0	5.80 ± 0.08	0.13 ± 0.001	0.29 ± 0.003	4.22 ± 0.008	2.73 ± 0.03	6.06 ± 0.02
S5 1.23 ± 0.01	6.42 ± 0.02	6.38 ± 0.22	0.21 ± 0.002	0.28 ± 0.0028	3.77 ± 0.04	1.66 ± 0.02	4.13 ± 0.02
SUBSTRATUM							
30-45CM							
S1 5.90 ± 0.05	5.92 ± 0.05	3.55 ± 0.04	0.25 ± 0.003	0.29 ± 0.003	3.02 ± 0.03	1.02 ± 0.01	2.08 ± 0.03
S2 6.01 ± 0.04	5.17 ± 0.06	3.67 ± 0.06	0.23 ± 0.002	0.27 ± 0.002	2.54 ± 0.05	0.89 ± 0.02	1.60 ± 0.01
S3 1.57 ± 0.03	6.20 ± 0.005	5.37 ± 0.20	0.33 ± 0.003	0.28 ± 0.003	3.76 ± 0.07	1.21 ± 0.02	± 0.02
S4 1.73 ± 0.03	0.005	0.20	0.003	0.003	0.07	0.02	6.13 ± 0.01
S5 1.82 ± 0.02	6.37 ± 0.06	5.56 ± 0.24	0.15 ± 0.0015	0.28 ± 0.003	4.23 ± 0.04	2.77 ± 0.03	0.01
	7.13 ± 0.12	5.63 ± 0.10	0.24 ± 0.0024	0.24 ± 0.002	3.65 ± 0.03	1.23 ± 0.01	0.02s

University soil samples.

	PARTICLE SIZE DISTRIBUTION						TEXTURE
SUFARCE0-15 cm	% Clay		% Silt		% Sand		
S1	45.23	± 0.4	43.104	± 0.45	11.66	± 0.11	SILTY
S2	50.215	± 0.50	45.156	± 0.35	4.63	±	CLAY
S3	0.05		7.241	± 0.07	0.418	±	SILTY
S4	0.004	92.341 ± 0.82		6.241	± 0.12		CLAY
S5	0.001	± 0.001	93.76	± 0.90	6.242	±	SAND
	0.06	0.092 ± 0.009	93.67	± 0.86			SANDSAND
							D
SUBSURFACE 15-30cm	50.215 ± 0.50		45.156 ± 0.40		4.629 ± 0.07		SILTY
S1	45.234 ± 0.45		43.104 ± 0.35		11.662 ± 0.06		CLAY
S2	5.241 ± 0.10		0.045 ± 0.0004		94.714 ±		SILTY
S3	0.70		6.241 ± 0.06		0.01 ± 0.0001		CLAY
S4	93.758 ± 0.82		7.202 ± 0.07		0.909		SAND
S5	± 0.009		9.889 ± 0.06				SANDSAND
							D
SUBSTRATUM 30-45cm	42.234 ± 0.42		41.104 ± 0.40		16.662 ± 0.2		SILTY
S1	50.22 ± 0.5		45.13 ± 0.42		4.66 ± 0.05		CLAY
S2	6.24 ± 0.06		2.82 ± 0.05		90.94 ± 0.8		SILTY
S3	7.24 ± 0.07		0.42 ± 0.004		92.34 ± 0.90		CLAY
S4	6.24 ± 0.05		2.81 ± 0.03		90.94 ± 0.75		SAND
S5							SANDSAND
							D

SURFACE HEAVY METAL	Fe(mg/kg)	Zn(mg/kg)	Cd(mg/kg)	Cu(mg/kg)	Ni(mg/kg)	Pb(mg/kg)	Mn(mg/kg)	Cr(mg/kg)
SURFACE SOIL								
0-15cm	3350 ±	53.8 ±	2.8 ±	15.8 ±	0.6 ±	6.2 ±	43 ±	34.8 ±
S1	10.05	2.7	0.11	0.63	0.02	0.24	0.41	0.5
S2	2485.8 ±	44.8 ±	0.2 ±	8.6 ±	0.8	4.4 ±	28.4 ±	17.8 ±
S3	74.6	1.34	0.01	0.34	±0.04	0.13	0.30	0.18
S4	2730 ±	128.2 ±	0	± 0.52	4	13.2	134.4 ±	15.8 ±
S5	81.9	5.13	± 0.2	11.2 ±	±0.2	±0.52	1.21	0.16
	12689 ±	68.4 ±	0.2	0.56	4	1	271.2 ±	14.8 ±
	253.78	2.05	± 0.02	9.4	±0.16	± 0.04	2.20	0.15
	7304 ±	91 ±	0	±0.47	2.8 ±	2.2	118.6	11.2 ±
	292.16	3.64	±0		0.11	±0.08	±1.19	0.11
SUBSURFACE SOIL								
15-30cm	4790	38	0.4 ±	13.6 ±	0.2 ±	6.6	27.8 ±	31.4 ±
S1	±143.7	±1.14	0.1	0.14	0.02	±0.07	0.3 20.6	0.03
S2	2318 ±	34	0.4 ±	6.4 ±	1.4 ±	4.8	± 0.2	15.6 ±
S3	69.54	±1.7	0.2	0.06	0.014	± 0.05	88.4	0.16
S4	10890 ±	66.4	0	8.6 ±	6	7.4	± 0.8	14.6 ±
S5	217.8	±2.66	0.6 ±	0.08	±0.06	±0.07	208.4	0.15
	9386 ±	39.2	0.12	8.4 ±	3.6	1.2	± 2.08	12.2 ±
	281.58	±1.57	0.2 ±	0.08	± 0.04	± 0.02	139.2	0.12
	9474	87	0.1	11.4 ±	3.4	1.8	± 1.4	12.6 ±
	±284.22	±4.35		0.15	± 0.03	± 0.04		0.10
DEEEP SUBSTRAC TUM SOIL								
30-45cm	4372	52.6	0.4	16.2 ±	4.6	6.6	31.4	32.4 ±
S1	±5.5	±2.3	± 0.005	0.16	±0.08	±0.08	± 0.08	0.30
S2	2666	50	0.4	9.2 ±	1.8	5.4	22.8	18.2 ±
S3	± 10.20	±2.0	± 0.008	0.09	±0.03	± 0.05	± 0.2	0.18
S4	12678	73.6	0.4	9.6 ±	4.6	4.8	78.2	16.2 ±
S5	±50.0	± 2.4	± 0.004	0.19	± 0.04	±0.08	± 0.4	0.32
	10364	60.6	0.2	13.8 ±	3.4	0	236.2	13.4 ±
	± 30.12	± 2.01	± 0.002	0.3	± 0.03	± 0	± 2.3	0.13
	9004	58.5	0.2	8.4 ±	4.4		97.4	13
	± 15.5	± 2.05	± 0.004	0.2	± 0.04		± 0.5	±H 0.26

Table 4.3 :Mean and standard deviation results of Fe, Zn, Cd, Cu, Ni, Pb, Mn, Cr concentration of Kono-Boue soil samples,samples from 1km& 2Km away from Port Harcourt Gas Flare point and Rivers State University soil sample.

Table 4.4 : Mean and standard deviation results of Atmospheric Gases from 1km& 2Km away from Port Harcourt Gas Flare point and Rivers State University atmospheric gases in ppm.

SAMPLE	H ₂ S	SO ₂	VOC	NO ₂	CO
KB1	0.06±0.03	0.78±0.75	374.67±137.49	0.030±0.01	0.23±0.3
1KA	0.00	0.00	219.33±19.74	0.012±0.01	0.03±0.39
2KA	0.70±0.58	0.02±0.00	335.3±79.16	0.008±0.00	0
RSU	0.00	0.00	115±22.2	0.119±0.08	0

Table 4.5: pH-metal Correlation

Metals	r (water)	r (CaCl ₂)	Square of coefficient (rsw)	Square of coefficient (rsCaCl)
Fe	0.58	0.93	34%	87%
Zn	0.01	0.51	0%	26%
Cd	-0.29	-0.71	-(8%)	-(50%)
Cu	-0.14	-0.22	-(2%)	-(5%)
Ni	-0.29	-0.72	-(8%)	-(52%)
Pb	-0.51	-0.29	-(26%)	-(8%)
Mn	0.50	0.76	-(25%)	58%
Cr	-0.49	-0.81	24%	66%

DISCUSSION

- The most abundant metals recorded were Fe, Mn and Zn.
- The distribution of various geochemical properties and acidity vary across the different locations S1-S5

DISCUSSION

- The most abundant metals recorded were Fe, Mn and Zn.
- The distribution of various geochemical properties and acidity vary across the different locations S1-S5
- Fe, Cr, Cd, Ni and Mn showed strong pH – Heavy metals correlation in the order of Fe > Cr > Mn > Cd.
- The acidity order follows the order of S2 > S1 > S3 > S4 > S5 respectively for acidity in water and S1 > S2 > S4 > S3 > S5 for acidity in CaCl₂
- Strong correlation of acidity & Heavy metals shows the dependent effect of the atmospheric acidification effect on the Heavy metals and the soil properties.
- The soils in Kono Boue were found to be most acidic compared to others, this may have been for the fact that the acidity is retained longer in a clay soil due to the structure.
- The moisture content of soils from Kono Boue is higher than 1KA, 2KA & RSU respectively, clay soil retains moisture longer than sandy.
- For Atmospheric gases, 1KA was found to have highest H₂S followed by KB1, VOC was found to be highest in KB 1 followed by 1KA, 2KA and RSU, for CO KB 1 has the highest concentration followed by 2KA, KB 1 has the highest concentration of

SO₂ followed by 1KA, for NO₂, RSU has the highest NO₂ followed by 1KA

- The inconsistent concentration of the atmospheric gases corroborate the atmospheric migration pattern.

VARIATION IN CONCENTRATIONS AT DIFFERENT PROXIMITY

In terms of proximity, Particle Size Distribution, Nitrate Nitrogen, Available Phosphorus, Exchangeable Potassium, Total Organic Carbon, Total Organic Matter indicated decrease with increase in locational distance. On the contrary, the moisture content and the atmospheric gases distribution indicated increase in concentration distribution as the location distance increased, Heavy metals showed varied distribution for each Heavy metal.

VARIATIONS IN CONCENTRATIONS AT DIFFERENT DEPTH

The moisture content trend of the soil was observed to increase from the surface soil samples, 0-15cm; subsurface soil samples, 15cm-30cm; and the in depth soil, 30-45cm; respectively. There is reduction in acidity observed across the depth from the surface soil to the in-depth. Also, Nitrate, Exchangeable Potassium, Available Phosphorus, Total Organic Carbon all reduced in concentration across the depth from the surface soil samples to in-depth. Fe, Cu, Ni and Pb increased in concentration down from the surface soil samples to the in-depth soil samples while Zn, Cd, Mn and Cr showed a decrease from the surface soil samples, subsurface down to the in-depth soil samples respectively.

CONCLUSION AND RECOMMENDATION

As seen that the acidification effect of the atmospheric gases affects the heavy metals distribution, periodic atmospheric check of every Gas flare environment should be put in place in order to check mate the safe limit of Heavy metals distribution and other geochemical parameters. Liming of the acidic soil is recommended.

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