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MONITORING AIR POLLUTANTS DUE TO GAS FLARING USING RAIN WATER

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ABSTRACT

The paper assessed major air pollutants resulting from gas flaring using rainwater. Rainwater samples were collected during the dry and wet seasons (2002/2003) and analyzed for physico-chemical characteristics such as, pH, TDS, conductivity, NO_3^-, CO_3^{2-} and SO_4^{2-}. The mean values for the studied parameters during the dry season were pH (5.3) conductivity (20.50 µs/cm), TDS (17.13 mg/L), NO_3 (23 mg/L), SO_4^{2-} (1.41/ mg/L) and CO_3^{2-} (16.97 mg/L) and that for wet season were; pH (6.1), conductivity (19.60µs/cm), TDS (16.56mg/L), NO_3 (24mg/L), CO_3^{2-} (16.13mg/L) SO_4^{2-} (1.29mg/L). The mean levels of conductivity, TDS, and SO_4^{2-} were within statutory safe limits, while that of pH, CO_3^{2-} and NO_3^- were above the safe limits specified by the Federal Ministry of Environment guidelines and standards for drinking water quality.

KEYWORDS: Rainwater, Gas flare, pollutants, monitoring, Water quality.

INTRODUCTION

Oil and gas are Nigeria's economic determinant and majority of this natural resource comes from a small geographical area called the Niger Delta (Fig. 1). Nigeria is blessed with abundant natural gas (about 3,500 billion cubic metre) and almost 50 percent of these are associated (Heide, 1997).

Nigeria produces more natural gas than its uses. This is because most of the natural gas produced is mainly from oil wells, which cannot be avoided as a result of oil production. The gas is then flared. The burning process which is known as combustion is a rapid oxidation or burning of gas with simultaneous evolution of heat, and light (Dryden, 1995). Gas flaring is carried out in stacks, which may be vertical, horizontal or angular.

Gas flaring emits carbon IV oxide (CO_2) carbon II oxide (CO), methane (CH_4) hydrogen sulphide (H_2S), nitrogen IV oxide (NO_2), nitrogen II oxide (NO), nitrogen I oxide (N_2O), sulphur IV oxide (SO_2) sulphur VI oxide (SO_3) and heat.

Other pollutants released in the course of gas flaring are smoke and soot. The composition of flared gas is a function of the origin of the gas. A typical composition of natural gas is presented in Table 1.

Table 1: Composition of Natural Gas in Bonny Field

Composition	Mole Percentage
Carbon dioxide (CO_2)	1.54
Nitrogen (N_2)	0.29
Methane (CH_4)	70/91
Ethane (C_2H_6)	6.13
Propane (C2H8)	6.56
Hydrogen sulphide (H_2S)	Variable
Iso-butane (C_4H_{10})	3.72
n-butane (C_4H_{10})	3.62
Iso-pentane (C_5H_{12})	1.87
Pentane (C_5H_{12})	1.35
Hexane (C_6H_{14})	1.53
Heptane (C_7H_{16})	1.56

Source: Irikefe (2001)

The products released by combustion of natural gas have the potential of altering the natural state of the environment (Nwankwo and Ifeadi, 1988). Carbon IV Oxide for example can upset the natural CO_2 cycle and it has been implicated in global warming (Folland and Nicrebra, 1995). The effects of acid rain on soil and water bodies are well documented (Adeyinka, 1993). The presence of smoke and soot can result to the formation of photochemical smog, which has the potential of reducing visibility (Croft, 1978).

Carbon II oxide is extremely poisonous. It has a high affinity for haemoglobin (Hb) in red blood cells so preventing the carriage of oxygen by the Hb to essential parts or the body cells (Ndu, et al., 1991).

Gas flaring retards plant growth (Isichei and Sanford, 1976) and cause depressed flowering and fruiting (Oluwatimlehin, 1981). Excessive heat released during gas flaring has a lot of far-reaching effects. It can lead to skin discolouration, increased enzymatic activities resulting in death and decreasing the breeding potential of animals (Isichei and Sanford, 1976).

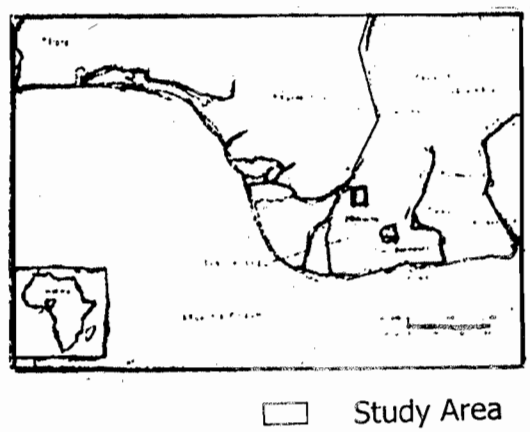

Fig.1: Location of the Niger Delta Basin in Southern Nigeria where gas flaring stacks exist. Also shown is the approximate location of the study area.

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Water in its natural state may not be pure because it is a universal solvent with the ability to dissolve numerous chemicals and to carry a lot of impurities in suspension. Rainwater can be used to ascertain the atmospheric pollution. This paper presents a study on the application of rain water in monitoring potential air pollutants resulting from gas flaring.

EXPERIMENTAL PROCEDURE

The study area was Kwale gas plant located in Beniku village in Ndokwa-East Local Government Area of Delta State (Fig. 1). The plant has two 15m high vertical flare stacks that burn continuously with a lot of soot, an indication of incomplete combustion (Fig. 2). The plant receives about 75mm scf/d of gas from the fields and utilizes only 20 percent to generate electricity and the excess 80 percent flared.

METHODOLOGY

Rainwater samples were collected several times throughout the season: early rain in April, regular rain period (May – June), peak rains (July – September) and irregular and less frequent period of (November – March). Rainwater samples were collected with a clean 42cm diameter plastic basins placed on stands on metre high above the ground. To reduce the effect of wind, four basins were placed in the direction of North, South, East and West. After each rain, rainwater in the plastic basins were bulked and transferred into 250ml plastic can, which were filled, to the brim to exclude air, stoppered and taken to the laboratory for analysis. The samples were analyzed for pH, conductivity, total dissolved solids (TDS), nitrate (NO_3^-) sulphate (SO_4^{2-}) and carbonate (CO_3^{2-}). These parameters were chosen because they are good impact indicators. pH, conductivity and TDS were determined using Bench-Top multi-parameter water quality instrument (Orion 1260). At determination of any parameter, the instrument was properly checked and calibrated before and after use. Nitrate concentration of samples was determined using Brucine colourimetric technique. To 50ml of filtered sample was added

Table 2: Physico-chemical Characteristics of Rainwater from Kwale Gas plant Area.

S/N	Date of Sample Collection	Parameters/Units					
		Ph	Cond. (µs/cm)	TDS Mg/L	NO_3^- Mg/L	SO_4^{2-} Mg/L	CO_3^{2-} Mg/L
1	17/4/2002	5.4	23	18	27	1.50	18.6
2	21/4/2002	5.6	17	17	30	1.40	17.4
3	22/4/2002	5.4	25	21	36	1.30	18.0
4	27/4/2002	5.5	19	24	28	1.43	19.0
5	29/4/2002	6.1	21	27	23	1.40	18.0
6	6/5/2002	5.9	23	16	21	1.37	14.6
7	11/5/2002	5.7	17	18	32	1.38	17.0
8	13/5/2002	5.8	18	21	31	0.91	16.6
9	17/5/2002	5.6	17	18	32	0.92	17.0
10	24/5/2002	5.6	19	21	32	1.40	16.4
11	27/5/2002	5.7	19	22	27	1.20	17.0
12	4/6/2002	5.8	19	18	24	1.20	18.0
13	7/6/2002	5.7	24	19	25	1.40	18.4
14	12/6/2002	5.6	18	14	26	1.40	14.8
15	17/6/2002	5.5	19	14	27	1.30	14.5
16	24/6/2002	5.4	22	17	25	1.40	14.8
17	26/6/2002	5.7	26	15	25	1.30	18.0
18	29/6/2002	5.8	17	20	27	1.40	18.6
19	17/7/2002	6.7	21	12	27	1.60	15.7
20	13/7/2002	6.6	22	11	24	1.45	16.4
21	16/7/2002	6.7	19	14	25	1.40	15.8
22	24/7/2002	6.5	17	15	21	1.52	17.2
23	27/7/2002	6.3	26	16	26	1.50	16.4
24	4/8/2002	6.8	22	14	27	1.60	16.0
25	7/8/2002	6.7	16	14	12	1.40	15.4
26	14/8/2002	6.8	16	15	14	0.90	16.7
27	17/8/2002	6.7	16	14	17	0.97	16.7
28	24/8/2002	6.7	17	12	18	1.00	18.2
29	5/9/2002	6.6	17	17	15	1.20	17.6
30	11/9/2002	6.4	18	14	17	1.30	18.0
31	16/9/2002	6.3	16	15	18	1.40	18.0
32	20/9/2002	6.3	22	14	19	1.50	17.4
33	23/9/2002	6.5	20	11	21	1.40	16.0
34	29/9/2002	6.6	19	12	20	1.45	16.4
35	6/10/2002	5.6	22	13	21	1.50	15.8
36	21/10/2002	5.0	17	15	19	1.30	16.0
37	23/10/2002	6.1	18	13	18	1.30	17.1
38	24/10/2002	6.2	19	14	19	1.40	17.4
39	26/10/2002	5.5	21	15	21	1.40	14.5
40	29/10/2002	5.4	26	14	23	1.50	14.7
41	31/10/2002	5.7	22	21	24	1.40	13.9
42	1/11/2002	5.6	25	22	27	1.60	13.7
43	7/11/2002	5.4	18	20	23	1.30	14.0
44	8/11/2002	5.2	17	21	24	1.40	13.8
45	16/11/2002	5.3	22	20	21	1.50	18.6
46	17/11/2002	5.4	19	21	27	1.40	17.4
47	22/12/2002	5.4	20	20	26	1.40	17.8
48	28/12/2002	5.0	22	21	27	1.30	17.6
49	4/1/2003	4.9	19	22	25	1.50	17.8
50	18/2/2002	5.0	21	20	26	1.40	17.9

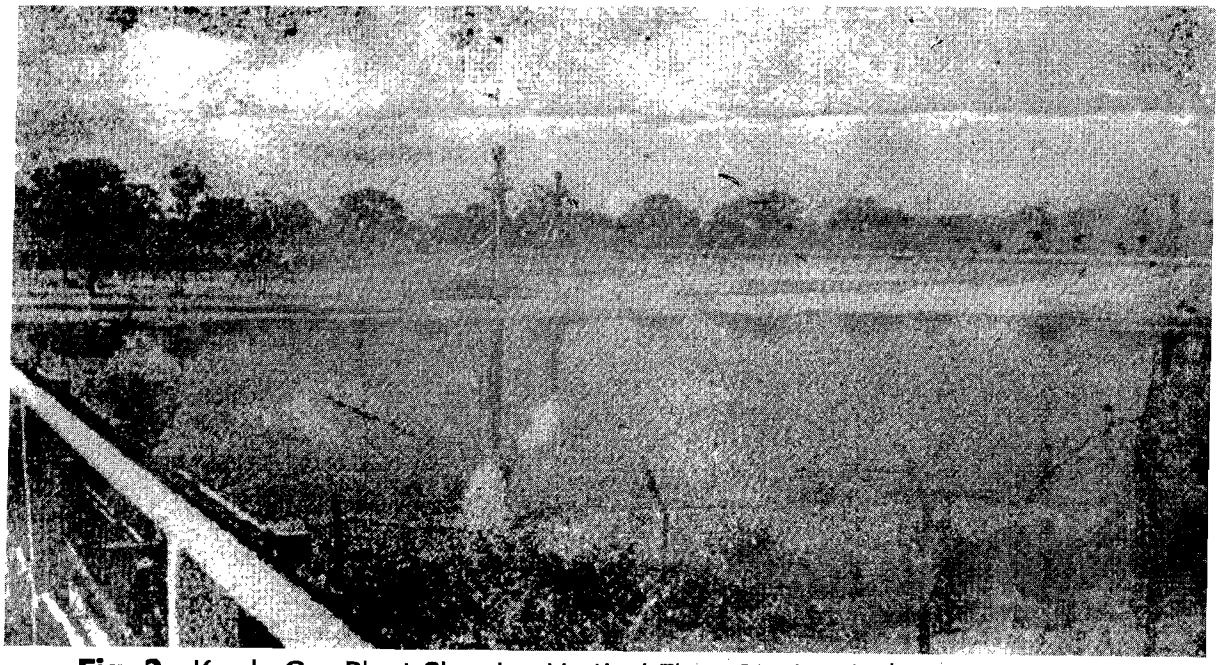

Fig. 2: Kwale Gas Plant Showing Vertical Flare Stacks study area.

1ml HCL solution and thoroughly mixed. Calibration standards were prepared for nitrate in the range of 0 to 7 mg/l by diluting to 50ml. The following volumes of intermediate nitrate solution were used (1,2,4,7.....35ml). Absorbance was read against distilled water set at zero absorbance using unicam UV/visible spectrophotometer. A wavelength of 220nm was used for nitrate reading. A standard curve was constructed by plotting absorbance due to nitrate against standard nitrate concentration. Nitrate concentration of sample was obtained directly from the standard curve.

Carbonate concentration in the sample was determined titrimetrically. 10ml of sample was introduced into a conical flask and 2 drops of phenolphthalein indicator added. The amount of carbonate was calculated by titrating the pink coloured water sample against 0.02M sulphuric acid until a colorless neutralization point was obtained. The amount of sulphate in the sample was determined using turbidimetric method. 100ml of sample was poured into a clean glass cell of a spectrophotometer (HACH DR 2000) absorbance (concentration) read with a calibration curve. All methods of sample analyses are consistent with the standard method APHA (1990), ASTM (1986) and DPR (2002).

RESULTS AND DISCUSSION

The results of physico-chemical analyes carried out on the rainwater samples over the period (April, 2002 to March, 2003) are presented in Table 2.

From the values in Table 2, the mean values of studies parameters were computed for dry season of (October, 2002 to March, 2003) and wet season of (April, 2002 to September, 2002). The computed mean ($\bar{x}$), and standard deviation (± SD), are present in Table 3.

The mean values obtain in Table 3 were compared against that of the Federal Ministry of Environment guidelines and standards for drinking water quality (FME, 2002) as shown in Table 4.

From the results, the mean pH values of the samples were 5.30 and 6.10 for dry and wet season respectively. This depicts that the rainwater studied is an acidic medium. The acidity of the rainwater may have resulted from substances such as oxides of sulphur, nitrogen and carbon that entered the atmosphere via gas flaring, which were converted to sulphuric acid, nitric acid and carbonic acid. Statistically, the mean values showed a significant seasonal variation as deduced from standard deviation (SD= ± 0.37) for dry and (SD = ± 0.48) for wet seasons. This can be attributed to increased rainfall. The results obtained in this study agreed with an earlier report that pH of rainwater in a gas-flared community are acidic (Ebeniro and Avwiri, 1996)

Nitrate concentration in the studied samples shows seasonal variation of 23 mg/L and 24 mg/L for dry and wet seasons respectively. There is a significant difference of (SD ± 3.06) and (SD ± 5.77) for dry and wet seasons respectively. The levels were generally higher (about two-fold) than the standard quality for drinking water (FME, 2002). The contribution of nitrates formed naturally by photochemical

Table 3: Mean ($\bar{x}$) and Standard deviation (± SD) of the physico-chemical parameters of rainwater.

Parameters/Units	Sampling Periods	
	Dry Season $\bar{x}$ (± SD)	Wet season $\bar{x}$ (±SD)
Ph	5.3 (± 0.37)	6.1(± 0.48)
Cond (µs/cm)	20.50(± 2.63)	19.60 (± 3.18)
TDS(mg/L)	17.13 (± 3.46)	16.56 (± 5.29)
NO_3(mg/L)	23(± 3.06)	24(± 5.77)
SO_4^{2-} (mg/L)	1.41 (± 0.09)	1.29 (±
Co_3^{2-}(mg/L)	16.97 (± 1.77)	16.13 (± 1.29)

Table 4: Water characteristics of drinking water quality (FME, 2002).

Parameter	RESULT		FME (2002)
	Dry Season	Wet Season	
pH	5.30	6.10	6.5-8.5
Cond (µs/cm)	20.50	19.60	4000
TDS (mg/L)	17.13	16.56	400
NO_3 (mg/L)	23	24	10
SO_4^{2-} (mg/L)	1.41	1.29	500
CO_3^{2-} (mg/L)	16.97	16.13	< 10

oxidation of nitrogen to give oxides of nitrogen during lightening and thunder storms may have accounted for the high values of nitrate obtained in all samples especially during the wet season.

The mean sulphate values obtained for the study are 1.41 mg/L and 1.29 mg/L for dry and wet seasons respectively. Sulphate values showed no significant seasonal variation (SD ± 0.09) and (SD ± 0.23) for dry and wet season respectively. The mean TDS values are 17.13 mg/L and 16.15 mg/L for dry and wet seasons respectively. The mean conductivity values are 20.50 µs/cm and 19.60 µs/cm for dry and wet seasons respectively. The levels of sulphate, TDS and conductivity are mostly below the safe limits specified for drinking water quality (FME, 2002). These values were consistent with values reported for the same area in previous studies by the Research Planning institute (RPI, 1995).

The carbonate values obtained in the samples analysed showed a significant seasonal variation deduced from standard deviation (± 1.77) for dry season and (SD± 1.29) for wet season. For the dry season rainwater sample, the obtained carbonate mean value was 16.97 mg/L and that for wet season was 16.13mg/L. The maximum allowable CO_3^{2-} in drinking water is 5mg/L. This is excess and will definitely make water corrosive because it is acidic. Awiri and Tay (1999) confirmed the corrosiveness of rainwater collected from gas flared location.

CONCLUSION

This study shows that rainwater collected from Kwale Gas plant area is unsafe for human consumption with mean values of pH, nitrate and carbonate for both dry and wet seasons exceeding limits specified for drinking water quality. We therefore suggest that the Federal Ministry of Environment should pursue the zero-flare down program to ensure its success before 2008.

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