EFFECTS OF GAS FLARE FROM UTOROGU GAS PLANT ON BIOCHEMICAL VARIABLES OF CASSAVA LEAVES (*Manihot esculentum*), DELTA STATE.

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ABSTRACT

Gas flaring is a major contributor to the emission of toxic gases and other gaseous pollutants into the atmosphere. This study investigated the impact of gas flare on leaves of cassava around Utorogu gas plant, Delta State. Three sampling locations were chosen at 1 km , 2km and 3km distance from the gas flare stack and a control location at Orerokpe 10km away. Ambient air quality was determined for methane ($CH_{4)}$ (ppm), oxides of sulphur ($SO_{x)}$ (ppm) oxides of nitrogen ($NO_{x)}$ (ppm), carbon monoxide (CO) (ppm), and hydrogen sulphide (H_2S) (ppm). Leaves collected were taken to the laboratory for analysis. Relative Leaf Water Content (RLWC)(%), Total Chlorophyll Content (TCC)(mg/m3), Leaf Extract pH(LEP)(mol/litre) and Ascobic Acid Content (AAC) (mg) were determined under standard laboratory methods. Ensuing data were subjected to standard statistical analysis. Results showed that CH4 varied from 38.00-92.00ppm, H_2S from 0.05-1.20ppm, CO from 11.00-26.40ppm, SOx from 252.00-340.00ppm and NO_X from 82.00-190.00ppm. RLWC varied from 30.50-56.33, TCC varied from 1.98-4.66, LEP varied from 4.50-7.00mol/litre and AAC varied from 0.03-0.15. It was revealed that NOx, SOx and CO exceeded NESREA's short-term tolerance limits for ambient air pollutants of (40-60) ppm, 100 ppm, and 10ppm respectively. This showed that these air pollutants exerted significant inhibitory influence on biochemical activities of the leaf studied. Environmental regulatory agencies and oil exploration companies should help reduce gas flaring to avoid damages to crop production.

KEYWORDS: **Air pollutants, Biochemical variables, cassava leaves, Crop growth.**

INTRODUCTION

- Gas flaring, a major source of air pollution of public and environmental concern (Mokhatab *et al.*, 2006)
- In recent past, air pollutants which have direct effect on vegetation and crop yield are causing increasing concern (Joshi and Swami, 2007).
- Increasing number of industries and automobile vehicles are continuously adding toxic gases and other substances to the environment (Seyyednejad *et al*.,2001)
- These toxic pollutants include sulphur and nitrogen oxides, carbon (II) oxide and soot particles, as well as smaller quantities of toxic metals, organic molecules and radioactive isotopes (Agbaire and Esiefarienrhe, 2009).
- Effect of air pollutants on vegetation is the best and more direct determination of toxic effects of air pollution. [Rai *et al*.,2010 ; Joshi and Swami, 2007) .

INTRODUCTION

- Associated gases, a mix of smoke, precisely referred to as particulate matter are routinely flared in the course of producing and processing oil. However, the Niger Delta case attracts more attention given the volume of gas flared since the beginning of commercial oil production in the country (Whittle et al., 1998)

- According to Oghenejoboh (2005) Like the combustion of other carbonaceous fuels, gas flaring produces oxides of carbon (CO_X), sulphur (SO_x) and nitrogen (NO_x), water vapor, volatile and non-volatile forms of trace metals e.g. Pb, Hg, Cd, As, Cr, Cobalt, Zn and Nickel.
- Incomplete combustion of the flared gas produces greenhouse gases such as methane Carbonmonoxide and water vapour Ogwejiofor (2000).
- Manahan(2009) posited that flaring is typically incomplete releasing of substantial amount of soot and CO, Polyclic Aromatic Hydrocarbons (PAHs), small quantities of sulphur compounds like sulphur dioxide (SO_2), hydrogen sulphide(H_2S), carbon disulphide(CS_2), carbonyl sulphide(COS) and volatile organic compounds (VOCs) into the atmosphere.

INTRODUCTION

- Royles (2010) in his work concluded that the flared gas is composed of natural gas, Methane, Propane, Ethylene, propylene, butadiene and butane to a tune of 95% and above.

Common effects of gas flaring on crops incude

- **CHLOROSIS:** SO_2 destroys plant tissues and produces gradual yellowing of leaves as chlorophyll production is impeded (Ahkionbare, 2009),
- **NECROSIS:** Bhatia (2009) observed that plant organs are impacted by air pollutants leading to necrosis (dead areas on leaves)
- **Epinasty:** (downward curvature of leaves and abscission (dropping of leaves), reduction in growth rate and eventual death of plant.
- **Reduction in soil moisture content,** in extension reducing its fertility and crop yeild. Flare pollutants such as SO_x and NO_x form acids in the presence of rain water. As inhabitants are agrarians and their farmlands located in the vicinity of the flow station, this research therefore targeted the effect of these pollutants on the biochemical variables of cassava (*Manihot esculentum*) leaf.

METHODOLOGY

Fig. 1. Aerial photograph of Utorogu, the study area

METHODOLOGY

STUDY AREA

- Utorugo is situated in Ugheli south local government area of Delta State
- Located between longitude 060° 01’ 34.72’’E and latitude 050° 31’ 19.59’’N.
- Annual rainfall of 2,650mm.
- Temperature is high throughout the year with an annual mean of 26.3^{0}C monthly.
- Relative humidity range from 60-80% with peak value > 80% recorded in July and August .
- Surface wind is calm (1.6 – 2.1m/s) with moderate potentials for dispersing air pollutants introduced to them and is predominantly southwest during the wet season and northeast during the dry season (SPDC, 2002).
- Vegetation is typical rainforest in nature.
- The inhabitants are predominantly farmers and estimated total population figure is projected at 311,970 (NPC, 2006).

METHODOLOGY

Plate 1. An open gas flare near one of the sampling locations

SAMPLE COLLECTION

- **Leaf sample collection**

With the aid of a stainless knife, leaves of cassava (*Manihot esculentum*) were randomly collected in three different locations at a distance of 1km, 2km, and 3km apart (L1, L2 and L3) and a control sample L4 at 10km away. Samples were carefully taken to the laboratory in a stainless container under a space of 1hour.

- **Air Quality Monitoring**

The sampling equipment used include High Volume Sampler (HVS) (testo 350 Flue gas Analyzer) and Digital automatic gas monitors (DAGMs)

- **High Volume Sampler (HVS):** **The modified EPA gravimetric high volume method was used. This technique involved drawing a known volume of air through a pre-weighted glass fiber filter (20 X 25cm) by means of heavy duty turbine blower at flow rate of 1.3 m^3/min (SPDC, 2002). This collected suspended particulate matter within the size range of 100-0.1µm diameters.**

- **Digital Automatic Gas Monitors (DAGMs).** **The Crowcon Gasman Air Monitor that had been pre-calibrated using air cylinder standard (SPDC, 2002) was used in the direct detection of CH_4, CO, NO_x, SO_x, H_2S and Temperature (0^{oC}) while the Haze dust 10 µm Particulate Monitor was used for the detection of particulate matter (SPM_{10}).**

Determination Of Variables

Determination of Biochemical variables

- **Relative Water Content (RLWC):**

With the method as described by Singh (1997), leaf relative water content was determined and calculated with the formula:

$$RLWC = \frac{FW - DW * 100}{TW - DW}$$

Where FW = Fresh weight, DW = Dry weight, TW = Turgid weight

- **Total Chlorophyll Content (TCC)**

This was carried out according to the method described by Rao (2006).

- **Leaf Extract pH**

5g of the fresh leaves was homogenized in 10ml deionized water. This was filtered and the pH of the leaf extract determined after calibrating pH meter with buffer solution of pH 4 and 9 (Aremu *et al*., 2010)

- **Ascorbic Acid Content (AAC)**

Spectrophotometric method (Aremu *et al*., 2010).

Statistical Analysis

- Descriptive statistics (with graphical illustrations)
- Pearson Product Moment Correlation Coefficient (r)
- ANOVA
- Linear regression

RESULTS

Ambient air Quality

Wide variations were observed in some of the air pollutants measured (CH_4, H_2S, $SO_{X,}$ $_{CO}$ and NO_X) across the sampling locations. Methane varied from 38.00-92.00 (65.83±6.20), hydrogen sulphide varied from 0.05-1.20(0.52±0.13), carbon monoxide varied from 11.00-26.40(21.12 ±1.62), oxides of sulphur varied from 252.00-340.00(278.33±8.82) and oxides of nitrogen varied from 82.00-190.00(127.42±13.01), while Temperature ranged from 26.5^{0}C- 35.6^{0}C (30.2±0.40)

Table 1. **Descriptive statistics of Air Pollutants around Utorogu gas plants (ppm)**

Parameters	Minimum	Maximum	Range	Mean	SE	FEPA (1991)
CH_4	38.00	92.00	54.00	65.83	6.20	NS
H_2S	0.05	1.20	1.15	0.52	0.13	NS
CO	11.00	26.40	15.40	21.12	1.62	10
SO_X	252.00	340.00	88.00	278.33	8.82	100.
NO_X	82.00	190.00	108.00	127.42	13.01	40-60
Temp.(0^{0}C)	26.5	35.6	9.1	30.2	0.40	NS

SE = standard error, NS = not specified

Oxides of nitrogen(82-190) ppm, oxide of sulphur (252-340) ppm, and Carbon (11) oxide (11-26.40) ppm. Variables measured exceeded FEPA (1991) short-term tolerance limits for ambient air pollutants of (40-60) ppm 100 ppm, and 10ppm respectively.

RESULTS

Biochemical Parameter of Cassava (*Manihot esculentum*) leaves

Slight variations were observed in the biochemical variables measured across the sampling locations. RLWC varied from 30.50-56.33 (42.65±2.08), TCC varied from 1.98-4.66(3.49±0.28), LEP varied from 4.50-7.00(5.39±0.20) and AAC varied from 0.03-0.15(0.99±0.11)

Table 2. **Variation in biochemical parameters of cassava leaves around Utorogu gas plant (ppm)**

Parameters	Minimum	Maximum	Range	Mean	SE
RLWC	30.50	56.33	25.83	42.65	2.08
TCC	1.98	4.66	2.68	3.49	0.28
LEP	4.50	7.00	2.50	5.39	0.20
AAC	0.03	0.15	0.12	0.99	0.11

SE=standard error, RLWC = relative leaf water content, TCC = total chlorophyll content, LEP = leaf extract pH, AAC= ascorbic acid content.

Of the biochemical variables, RLWC exhibited the highest range of 25.83 ppm, while AAC recorded the least range of 0.12 ppm. However, TCC and LEP exhibited comparatively moderate ranges of 2.68 and 2.50ppm respectively.

RESULTS

Relationships between air pollutants and biochemical variables of crop.

At $P<0.05$, CH_4 and SO_X correlated negatively with TCC (r=-0.683) and RLWC (r=-0.652) respectively. At $P<0.01$ CH_4 correlated negative with RLWC (r=-0.815), H_2S correlated negatively with RLWC (r=-0.823) and TCC (r=-0.776). However, CO correlated negatively with RLWC(r=-0.740), LEP (r=-0.833), AAC (r=-0.810), while SO_X correlated negatively with TCC (r=-0.841). NO_X correlated negatively with RLWC (r=-0.808) and TCC (r=-0.733) at $P<0.01$.

RESULTS

Table 3. Correlation coefficients (r) between the air pollutants and crop leave variables

Parameters	CH_4	H_2S	CO	SOx	NOx
RLWC	-0.815**	-0.823**	-0.740*	-0.652*	-0.808
TCC	-0.683*	- 0.776**	-0.482	-0.841**	-0.733**
LEP	-0.522	0.387	-0.83	-0.09	-0.418
AAC	-0.245	0.188	-0.810*	-0.106	0.101

* = significant at P<0.05, **= significant at P<0.01, RLWC = relative leaf water content, TCC = total chlorophyll content, LEP = leaf extract pH, AAC= ascorbic acid content. RLWC and Methane Regression between Biochemical variables and Air pollutants

- The regression scatter plot showed that relative leaf water content (RLWC) decreased with increasing methane concentration (Fig. 2).

- **The coefficients table shows that the expected RLWC = - 0.274 X CH4 + 60.70 ………… i,**

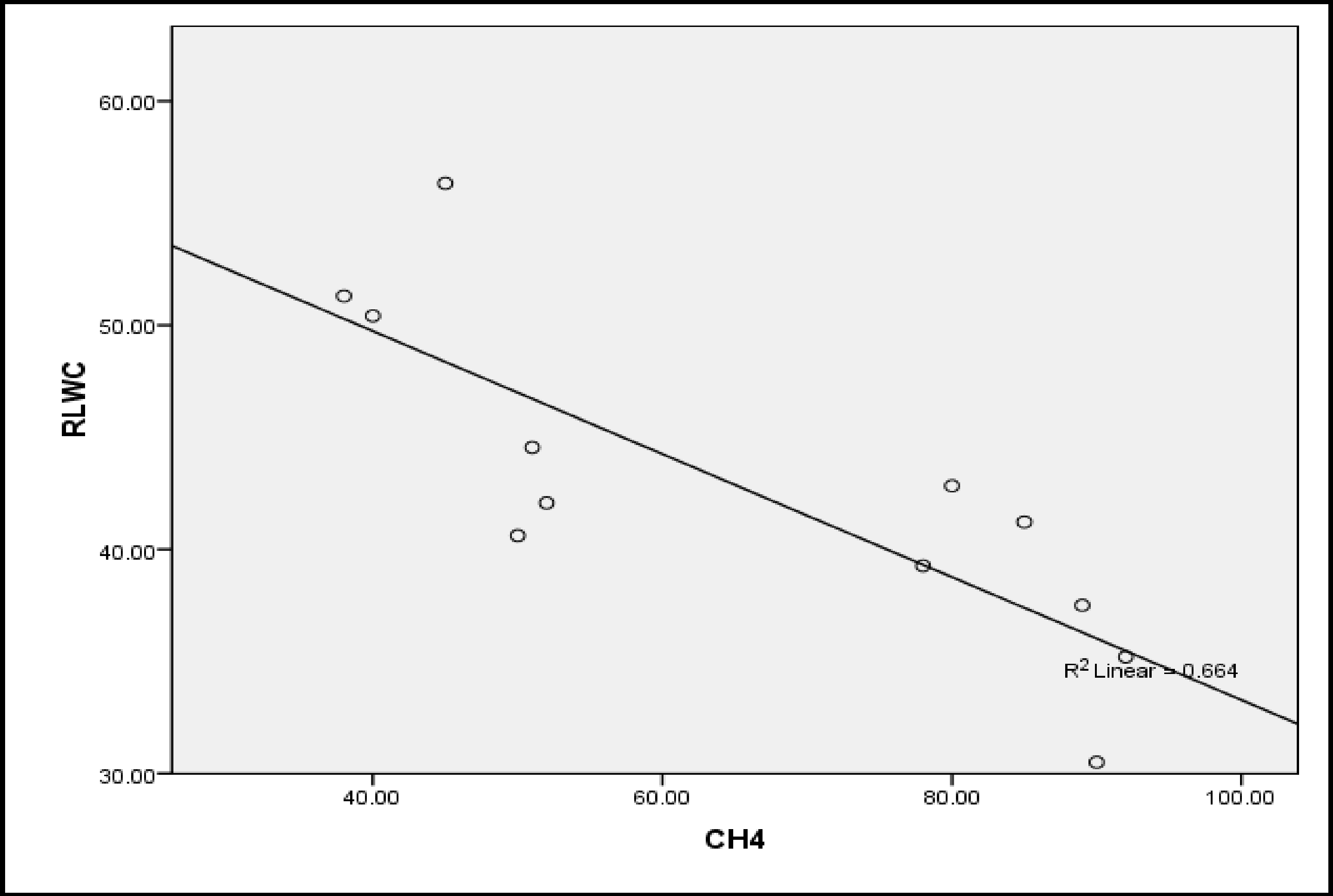

Fig. 2. Regression plot between relative leaf water content and methane concentration.

- **The regression scatter plot revealed that Total Chlorophyll Content (TCC) decreased with increasing methane concentration (Fig. 3).**

- **The coefficients table shows that**

  the expected TCC = - 0.031 X CH4 + 5.521 ………..ii,

TCC and Methane

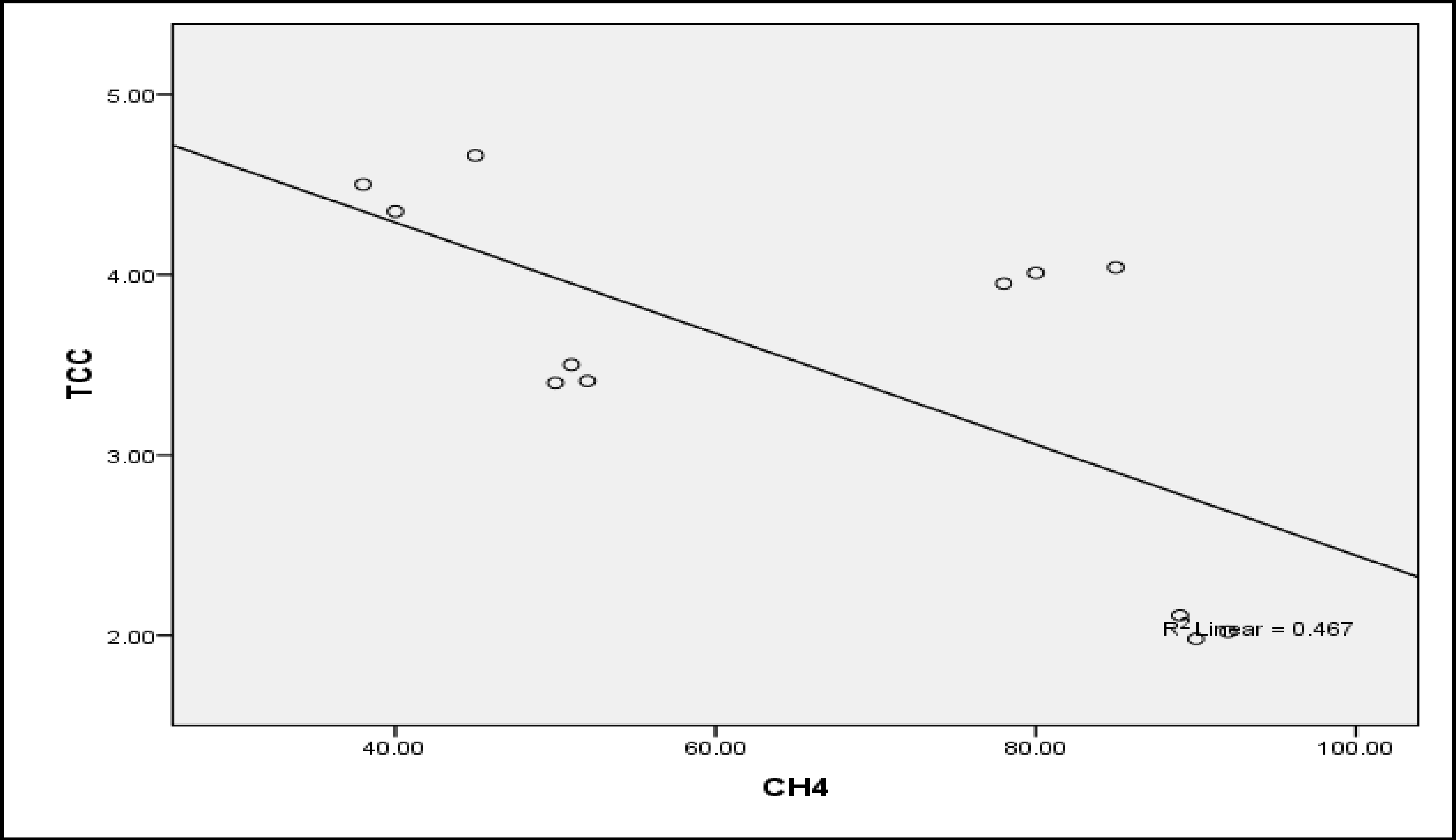

Fig. 3. Regression graph of Total Chlorophyll Content and Methane

Spatial Variation in biochemical variables and air pollutants

- Relative Leaf Water Content (RLWC), Total Chlorophyll Content (TCC), and Ascorbic Acid Content (AAC) were highest in L 3, L 2, and L 1, respectively from the flare stack. CH_4, CO, SO_x and NO_x were highest in cassava leaves in L 1, L 2, and L 3 respectively.

- The test of homogeneity in mean variances across the sampling locations from the flare stack revealed significant differences in the air pollutants [$F_{(16.59)} > F_{crit\ (4.10)}$] and in the biochemical variables measured [$F_{(5.23)} > F_{crit\ (4.17)}$] at $P<0.05$.

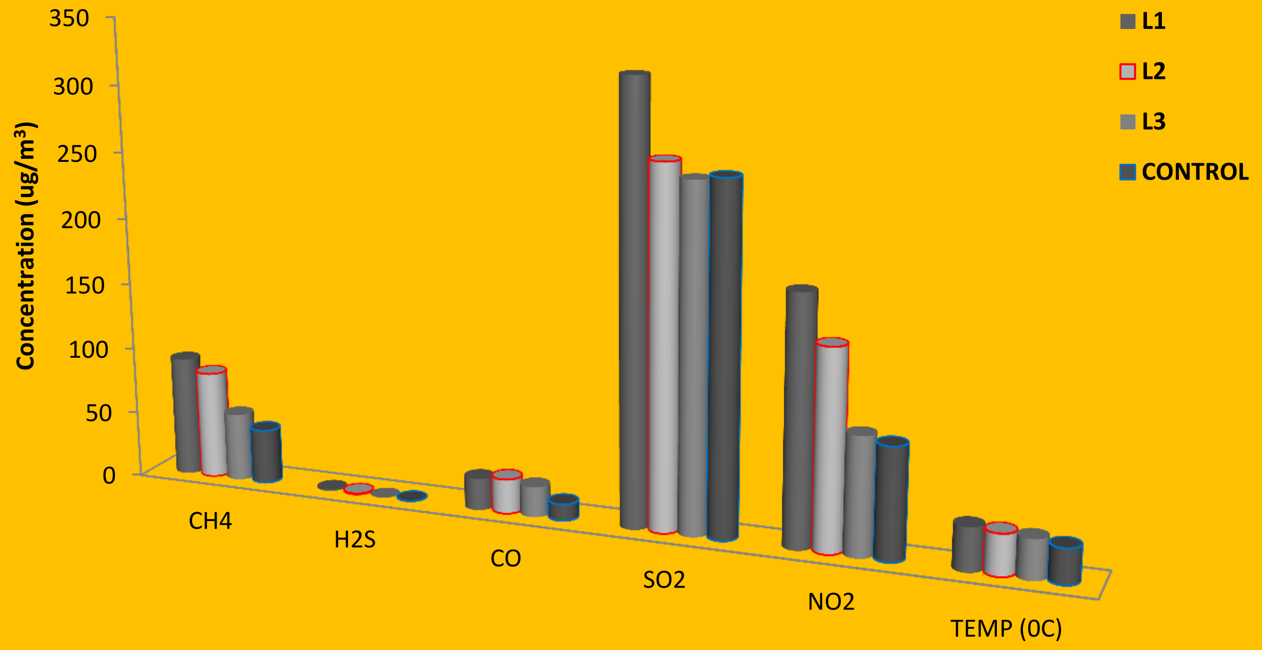

Fig. 7. Longitude variations in air pollutants around Utorogu gas plant

Fig. 4. Longitudinal variations in air pollutants around Utorogu Gas Plant

Longitudinal variations of air pollutants .

SO_2 exhibited maximum concentration, while H_2S was least at all the sampling locations (Figure 4). Highest concentration of SO_2 (340 ppm) was recorded in L 1, while the least concentration (257 ppm) was recorded in L 3.

Longitudinal variation of biochemical variables of *Manihot esculentum* around Utorogu gas plant.

The control location recorded comparatively higher concentrations in RLWC (56.33ppm), TCC (4.66 ppm) and LEP (7.00ppm). (Figure 5). However, RLWC in cassava leaves revealed maximum concentrations at all the locations while AAC revealed least concentrations.

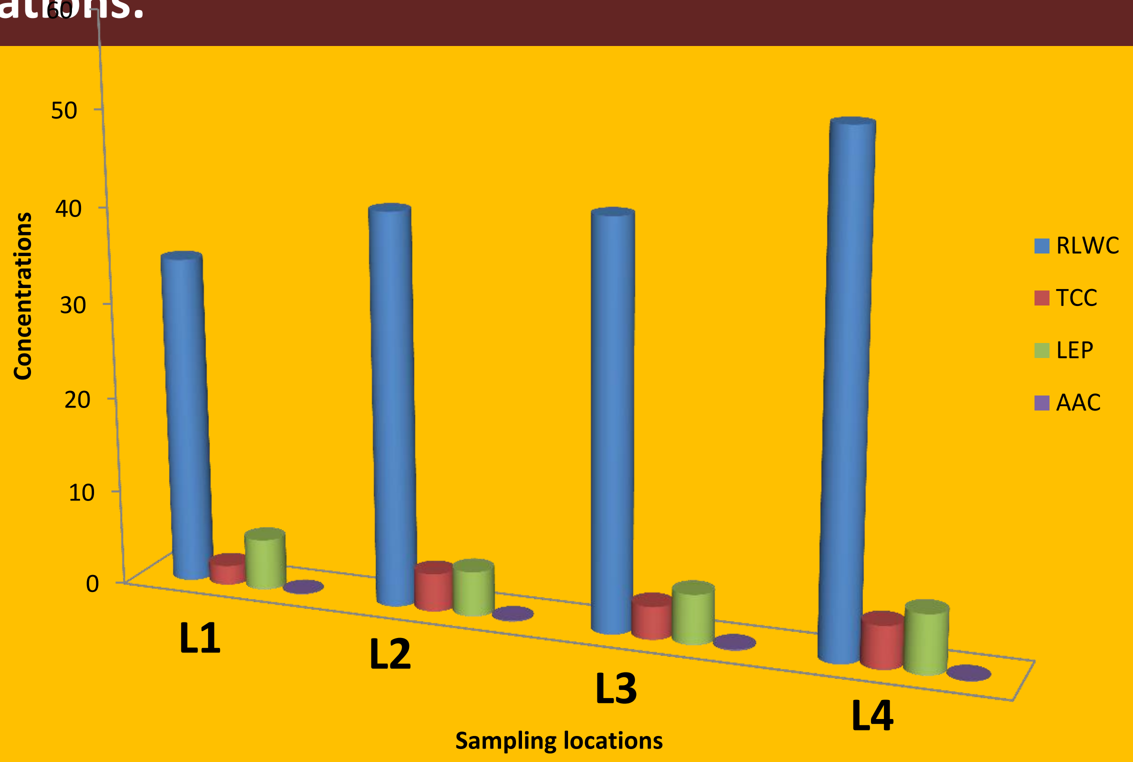

Fig. 5. Longitudinal variations in biochemical variables of *Manihot esculenta* leaves.

DISCUSSION

- Elevated concentrations of pollutants above natural ambient levels (FEPA, 1991; SPDC, 2007) was recorded.
- Values slightly lower than those recorded by Oghenejoboh (2005) in ambient air samples around a gas flare station at a community in the Niger Delta. This elevation was obviously contributed by the gas flare source point of pollution. This collaborates the work of (Ogwejifor, 2000; Oghenejoboh, 2005) that gas flare fallouts contribute pollutants to the air (Hart, 2010; Adekola *et al*., 2010).
- Polluted air could actually lead to loses in essential nutrient as well as contribute to toxic components of crop in most agricultural villages.
- Rainwater containing various metals (such as Cd, Pb and Hg) had been identified as a major cause of serious health problems in the Niger Delta area (WHO, 1987). Some of these health problems include anemia, renal dysfunction, lung cancer and other neo-behavioral effects.
- Acidified water in the range of pH 1-3.5 damages plant leaves(Narayanan, 2009). Other negative effects are corrosion and tarnishing of metals (including building roofs), erosion and soiling of buildings, as well as discoloration and peeling of paints (Oghenejoboh, 2005).

DISCUSSION

- **The negative effects of air pollutants on plants have been reviewed by (Seyyednejad, 2011). Mean CH_4, SOx, NOx & CO concentrations in the current study were higher than values recorded by Aremu (2012) in gas flare around Sapele gas plant in Delta State (Liu, 2008).**

- **Values recorded for H_2S by Singh (1977) (0.54-2.33 µg/kg) were higher than the current study's (0.05-1.20µg/kg). However, values of the air quality variables were comparable to their own, except for CO and Methane which were higher in the current study.**

- **The negative regression relationship between biochemical variables and air pollutants indicates decrease in RLWC and TCC with increase in air pollutants which explains the shrinkage observed in cassava and other plants in the area.**

DISCUSSION

- **The observed spatial variation in the biochemical variables measured in plants has also been documented by other researchers (Oghenejoboh, 2005; Hart, 2010; Onyedika, 2008; Zhuang, 2009; Aremu, 2010; Seyyednejad, 2011). The consistency in lowest concentrations in Ascorbic Acid Content across the sampling locations indicates common pollutant source as well as ecological mobility and bioavailability in biotic tissues.**
- **Pollutant concentrations were generally highest in sampling location 1, 2, and 3 horizontally from the flare stack and least in location 4 spatially, from the stack. This confirms the dispersal of aerial materials from point sources of pollution to distances in and around its vicinity. Dispersal of pollutants has been stated to be controlled by wind speed, direction as well as topography, and its concentrations affected by dilution effects over distances (Narayanan, 2007; Adesiyan, 2005).**

CONCLUSION

- CH_4 & SOx showed significant negative influences on TCC and RLWC.
- H_2S exerted significant negative influence on RLWC & TCC, while CO showed a significant negative influence on RLWC, LEP & AAC.
- NOx exerted significant negative influence on RLWC and TCC.
- Vegetation is therefore an effective indicator of the overall impact of air pollution and the effects observed is a time averaged result that is more reliable than the one obtained from direct determination of the pollutant in air over a short period
- The air pollutants exerted significant inhibitory influences on biochemical variables of the crop studied.

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THANK YOU

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