Tropospheric Concentrations of Methane Around A Quarry Site in Uturu, Abia State, Nigeria

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Abstract: *Measurement of methane (CH_4) concentration in ambient air at Setraco quarry site, Abia State (latitude 05º33 N and 06º03 N, and longitude 10ºE and 07º29 E) was carried out in this work. The gas was measured using an automatic air sampler (EM-4 Type Multi-P detector). The measurements were made at three sampling points; the engine house, petrol/gas dispense station and crushing site for 12 weeks (7th August – 6th November, 2018) at one (1) hour interval per session for three sessions (morning, afternoon and evening) in a day. The results obtained indicated that concentrations of methane were higher in the quarrying sites than in the control and exhibited highest concentrations of methane in the petrol stations and in the crushing site of the quarry. Therefore, future risk of continuous engagement in the quarrying activities is advocated in this work and it is recommended that continuous monitoring of levels of methane around the quarry should be embarked upon.*

Key Words: Quarry site, Uturu, Green house emission, methane.

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1.0 Introduction

Greenhouse gases are known for their ability to regulate global temperature through the absorption and emission of radiation within the infra-red region. These gases include water vapour, carbon (IV) oxide, methane, sulphur (IV) oxide, nitrous oxide and fourinated gases (Karl and Trenberth, 2003). Among all the green Methane is a significant organic gas in the atmosphere because methane is a greenhouse gas with global warming potential of 26 to 36 over 100 years and is also a precursor to ozone. It is the most abundant and effective greenhouse gas compared to carbon (IV) oxide. Several sources have been identified as contributors to atmospheric methane including mining and transportation of coal, flaring of natural gas, oil exploration activities, combustion engines, livestock emission, decay of organic waste and decay of organic waste, etc (Hinrich, 2016)

According to Mohajan (2012), excessive concentration of methane in the atmosphere is dangerous because of its high global warming potentials and yet much concentration on atmospheric researches is on carbon (IV) oxide. Lelieveld et al., (1998) also stated that the current climate forcing by CH4 (excluding indirect chemical effects) is 26 times that of CO2. As at 1998, the rate of increase of methane concentration was estimated at 0.8 % per year. Alvarez et al. (2018) also predicted methane concentration in the atmosphere to be 11.5 ppb in 2018.Due to increase urbanization and industrialization, this concentration is increasing. In spite of its established impact, less attention is concentrated on methane emission. The International energy agency (2020) observed that fossil-fuel methane emissions are the most easily addressed source of emissions and therefore suggested that industries can reduce its worldwide emissions by 75% in order to achieve 40-50% reduction of total methane emissions.

Occurence of methane in mining sites is not strange but it can constitute health risk especially to the workers and the entire ecosystem at a long range.

Individual exposed to excessive concentration of methane can experience fatigue, dizziness and headaches, progressing to more severe symptoms of nausea, agitation and displaced speech. In high concentrations, Methane deposes oxygen causing asphyxiation. Tutak and Brodny (2019) noted that methane emission from some Polish coal mines were very high and use the data obtained from methane monitoring between 1993–2018 to predict future danger if the emission rate is not control. Bonettiet al., (2019), investigated methane and carbon (IV) oxide concentrations in the ventilation systems of two coal mines (A and B) in the Santa Catarina coal deposit in southern Brazil (Paraná Basin, Bonito Formation), and estimate their greenhouse gas (GHG) emissions. The highest CH4 levels (1.8%) were recorded in strong methane emanation areas in mine A, below the lower explosive limit (5%).

Although literature is scanty on the concentration of methane in sandstone quarry sites, comprehensive information from various quarry sites compiled by Benham *et al*., (2005) indicated that recent and abandoned quarries are significant source of methane. Arising from lack of continuous monitoring of concentration of methane in the atmosphere around quarries in Nigeria, the present study is designed to measure levels of concentrations of methane in a quarry site in Abia state.

The process of getting useful stone from a quarry is known as quarrying. The methods and equipment used in quarry depend on the purpose for which the stone is extracted. Different quarrying activities have different impacts on air quality (Babatunde *et al,* 2013). Mineral exploration, mining and processing have resulted in environmental damages including ecological disturbance; destruction of natural flora; pollution of air, land and water; instability of soil and rock masses; land-scape degradation and radiation hazards due to the emissions of greenhouse gases. Work has been done on the levels of heavy metals in soil and vegetation of this quarry site (Bada & Fagbayibgo, 2009) and on the level of suspended particulates in the ambient air and around selected quarry sites (Oguntoke *et al*., 2009) but much work has not been done on the effect of quarry activities in relation to the emission of air pollutants and greenhouse gases and hence this underscores the importance of this study.

Proper identification and quantification of GHG is a significant factor needed for the assessment of the potential consequences on humans and the environment (Berman, 2012).

2.0 Materials and Methods

2.1 The study area

This research was conducted at Setraco Nigeria Ltd located at Uturu, Abia State (See Fig. 1). Uturu is one of the communities that make up settlements in Isuikwuato Local Government Area of Abia State

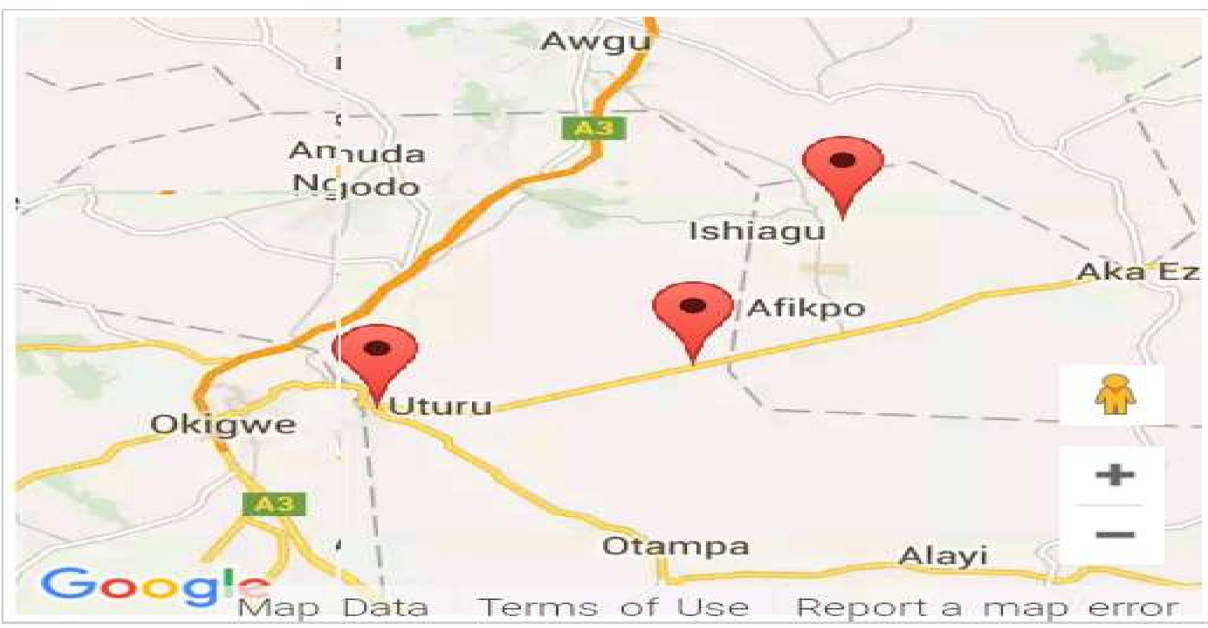

Fig. 1: Map of Uturu showing neighbouring towns

It is located within latitude 05.33°N and 06.03°N, and longitude of 10°E and 07.29°E and is bounded on the West and South by highlands (as high as 24m above sea level). The climate of Uturu is seasonal. The wet season in the community generally commences in March with rainfall of about 1367 – 1672.4mm and a minimum of 97 rain days a year. The mean annual temperature in Uturu ranges from 25.23°C - 27.2°C (Chiemeka, 2011) and humidity is 94%.

Concentration of methane was measured using the EM – 4type pocket multi-Pdetector (Fig. 2).

The instrument measures concentration of methane in percentage by volume of air and has a high degree of precision with ±0.01 error.It also measures CH_4 by catalytic combustion and can be used widely in measurement of CH_4 gas in ambient air. The response time of the instrument is less than 60 seconds. Other features of the instrument are working temperature range which is between 0-40°C, rated operating voltage is 3.6volts and the equipment can work continuously for more than 10 hours under non-alarm condition. The presence of the alarm is also an added advantage to indicate when the concentration of the sampling gas is above detection limit.

Fig. 2: The EM – 4Type Pocket Multi-P Detector

3.0 Results and Discussion

Figs. 3 and 4 are plots showing weekly mean concentration of methane gas in the atmosphere around the quarry sites. Analysis of variance (ANOVA) was used to compare the mean values of the three sampling points within the three sessions of measurements (morning, afternoon, evening) at 95% confidence level. The alpha (α) value was calculated using equation 1

$$\alpha = \frac{100-9}{100} = 0.05 \qquad (1)$$

The significance (p-value) of the test should be less than the alpha (α) value for a certainty in the test.The p-values obtained from the comparism are represented in Table 1a-c.

CH_4 weekly mean concentration represented on Fig. 3 showed a highest concentration of 0.23% in the morning, afternoon and evening sessions in week 7 and at the Engine house while lowest concentration of 0.04% in the morning, afternoon and evening sessions respectively at the Engine house. From Fig. 4, it is seen that weekly mean concentration of CH_4 had the highest value of 3.14% in the afternoon sessions of week 4 and lowest value of 0.39% in the afternoon session of week 1 at the Fuel Station. This implies that the fuel station contributed uniquely to the measured concentration of methane because it is a major hydrocarbon content in petroleum products (Lundegard *et al*., 2000).

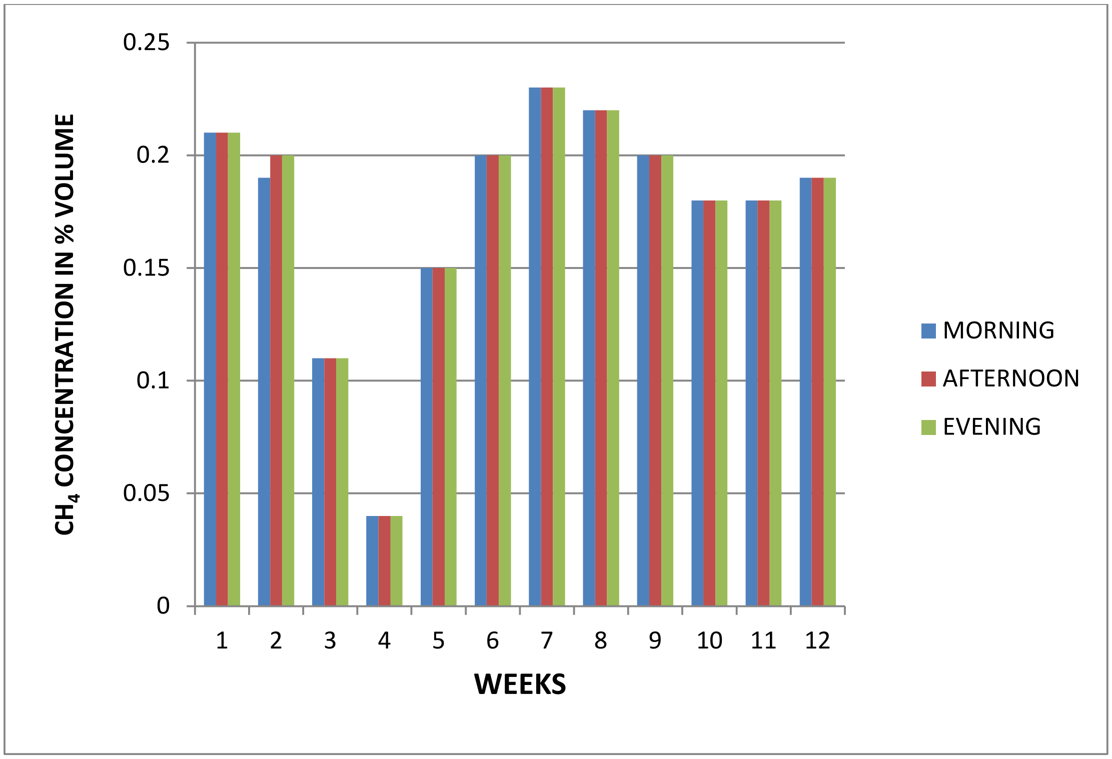

Fig. 3: The weekly mean CH_4 concentrations (morning, afternoon and evening sessions) at Engine House, Setraco

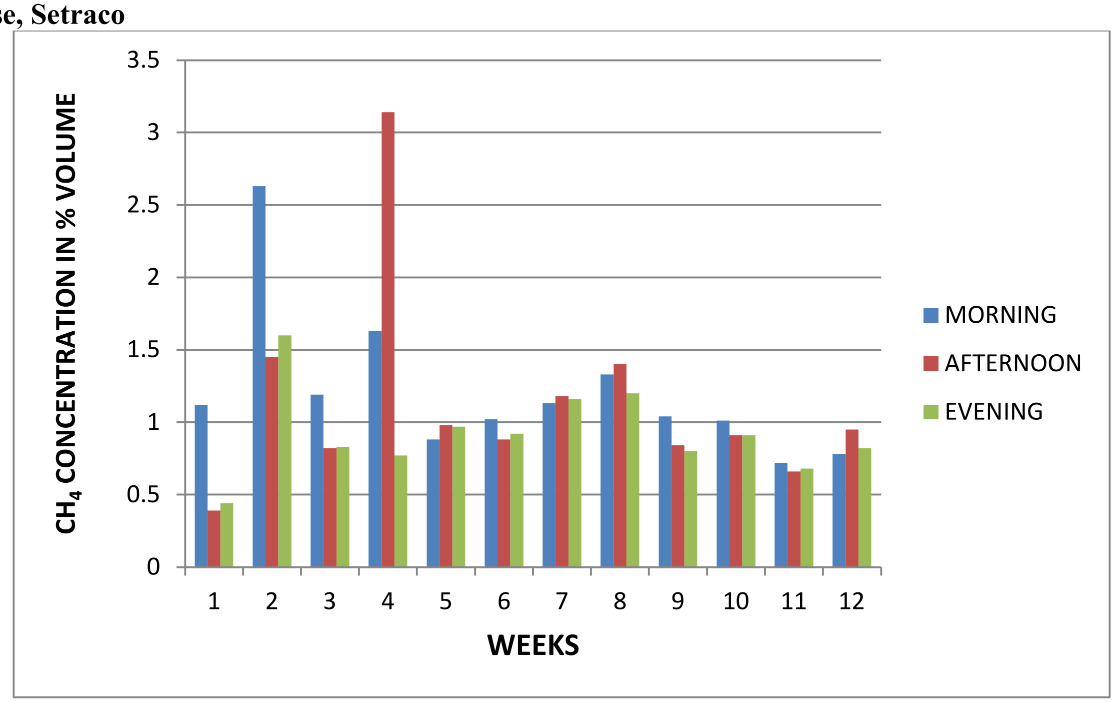

Fig. 4: The weekly mean CH_4 concentrations (morning, afternoon and evening sessions) at the petrol/gas dispense Station, Setraco

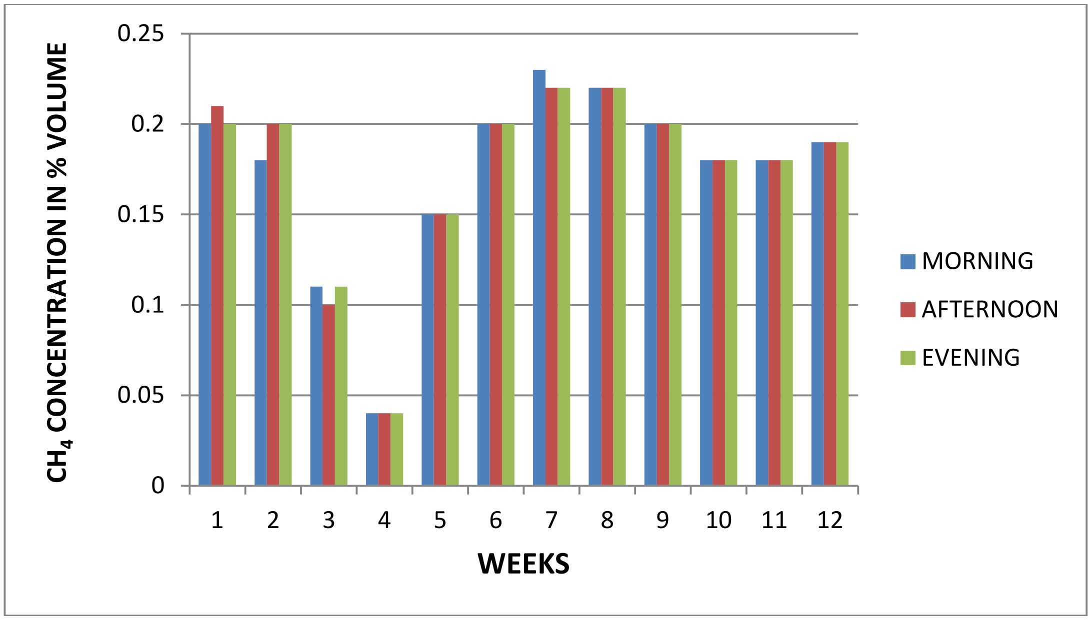

Fig. 5: The weekly mean CH_4 concentrations (morning, afternoon and evening sessions) at the Crushing site, Setraco.

According to study conducted by Okonkwo *et al*. (2014) in Umuahia, Abia state, prominent gas pollutants present in the ambient air around some petrol and gas filling stations were volatile organic compounds followed by methane before carbon monoxide. Their results indicated significant differences between the concentration of these gases in the studied and control sites. Weekly mean concentration of methane was highest at the crushing site of the quarry. Measured concentration in the morning section of the 7th week was 0.23 %. However, lowest concentration of 0.04% were recorded during the morning, afternoon and evening sessions respectively of the 4th week. Reported studies conducted the mining and quarrying sectors of 12 European countries including hard coal and lignite mining, crude petroleum and natural gas extraction, mining of metal ores, and other service activities in the mining sector revealed significant emission of greenhouse gases including methane (Agata *et al*., 2016). Literature is relatively scanty in levels of concentration of methane gas around mining sites.

The observed concentration of methane CH_4 recorded at the petrol/gas dispense station of Setraco quarry also confirm that fuel station is a known contributor of methane emission. The pipelines used to transmit and distribute natural gas constitute an important source of methane to the atmosphere. Continuous emissions may also result from leaking components such as valves and seals.

Table 2: ANOVA of CH_4 weekly mean concentration for the threesampling point, Setraco

	(a) Morning	
Sampling point	**Sampling point**	**p-value**
Engine house	Fuel station	0.000
Engine house	Crushing site	0.989
Fuel station	Crushing site	0.000
	Afternoon	
Sampling point	**Sampling point**	**p-value**
Engine house	Fuel station	0.000
Engine house	Crushing site	0.992
Fuel station	Crushing site	0.000
	Evening	
Sampling point	**Sampling point**	**p-value**
Engine house	Fuel station	0.000
Engine house	Crushing site	0.981
Fuel station	Crushing site	0.000

In Table **1a-c**, the p-value ANOVA between Engine house and Crushing site shows a very minimal significance having a p-value of 0.989, 0.992 and 0.981 in the morning, afternoon and evening sessions while there was a strong p-value of 0.000 between the CH_4 concentrations at fuel station-engine house and fuel station-crushing site respectively.

The atmospheric abundance of CH_4 is about a factor 200 smaller than that of CO2. Still it contributes significantly to the enhanced greenhouse effect owing to a relatively high warming efficiency (Houwlling, 1999).

The World Health Organization (WHO) acceptable limit of 0.1% for 8-hour working period for emission of the gas is 0.1% but CH_4 weekly mean of 0.19% was calculated from the measured concentration during the morning, afternoon and evening sessions respectively; although this result is slightly above the WHO recommendation of 0.1% exposure limit for 8hours. This also shows that it is significant to state from this study that workers in the quarry site might also be exposed to health risk from emissions of CH_4.

The control station was situated at a distance 200m away from the quarry. Results obtained from the control sites are recorded in Table 2.

Table 1: Concentration of methane in the control stations

S/N	DAYS	CH_4 (%vol)
1	Morning	0.18
	Afternoon	0.18
	Evening	0.18
2	Morning	0.20
	Afternoon	0.20
	Evening	0.20
3	Morning	0.19
	Afternoon	0.19
	Evening	0.19
4	Morning	0.19
	Afternoon	0.20
	Evening	0.19
5	Morning	0.18
	Afternoon	0.18
	Evening	0.18

4.0 Conclusion

The measurement and analyses of the concentration of CH_4 gas in ambient air at Setraco quarry site, Abia State (latitude 05^o33 N and 06^o03 N, and longitude 10^oE and 07^o29 E) was carried out in this work. The gas was measured using an automatic air sampler (EM-4 Type Multi-P detector). The measurements were made at three sampling points; the engine house, fuel station and crushing site for 12 weeks (7^{th} August – 6^{th} November, 2018) at one (1) hour interval per session for three sessions (morning, afternoon and evening) in a day. Three measurements were made at each sampling point in a day and weekly mean concentrations of the gas calculated for each of the sampling points. The results obtained indicated that the major sources of atmospheric methane are petrol station and the crushing site. Therefore, quarrying activities have great potential to increase atmospheric methane and requires continuous monitoring in order to protect the health of the workers and the global environment.

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