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Air Quality Assessment in Petroleum Flow Station: A Case Study of Oredo Flow Station

[1]Bukar S.B; [2]Okonkwo H.N.; [3]Nwaezeapu O. A.
[1,2]Department of Environmental Science and Management Technology,
[3]Industrial Safety and Environmental Technology Department,
Petroleum Training Institute, P.M.B 20, Effurun, Delta State, Nigeria.

Abstract:- Air quality is a vital aspect of environmental health and a key determinant of human wellbeing. This study was carried out to assess air quality parameters and noise levels around Oredo Flow Station in Edo State, Nigeria. Parameters measured during the study were temperature, suspended particulate matter (SPM), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and noise. Each parameter was measured using appropriate equipment. Measurements were done at three points: Point A (300m from the flare site), Point B (200m from the flare site) and Point C (100m from the flare site) and in triplicates with mean values recorded. The result showed that temperature ranged from 28.60±0.3°C to 29.22±0.3°C; SPM ranged from 17.16±3.9 µg/m^3 to 60.74±14.6 µg/m^3; SO_2 ranged from 0.01±0.0 ppm to 0.03±0.0 ppm; CO concentrations ranged from 0.03±0.0 ppm to 4.45±1.3 ppm; and VOC concentrations ranged from 0.01±0.0 ppm to 1.87±0.2 ppm. The mean noise levels ranged from 56.24±2.8dB to 87.78±2.8dB. Time-weighted average noise level ranged from 56.2dB to 87.8dB. For all parameters, there was a general decreasing trend in values as distance to the flare site increased indicating that air quality parameters in the area were influenced by gas flaring activities. Recommendations made include routine air quality monitoring, alternative use of natural gas and implementing noise control measures.

***Keywords**:- Air Quality, Time-Weighted Average, Flow Station, Particulate Matter, Gas Flare.*

I. INTRODUCTION

Around the world and in Nigeria, the hydrocarbon industry is strategic and makes valuable contributions to economic growth. It is highly essential in filling the energy needs of countries, and, as such, there are a wide range of techniques and processes which are required for exploration and exploitation within the oil and gas industry (Nwagbara and Onwudiwe, 2020). While the industry comes with immense benefits, there is also the issue of environmental degradation, pollution and devastation which is associated with the activities of the industry. Nwokocha *et al.* (2015) reports that the environmental impacts of these activities are a threat to the survival of humans, and other living organisms. Within the Niger Delta region in Southern Nigeria, the quality of air has been greatly decreased due to the presence of oil production facilities. At present, conducting oil production activities without regulations had placed the country as having the world's fourth deadliest air environment worldwide with a recorded 150 deaths per 100,000 people resulting from air pollution (Ogundipe, 2018).

The World Health Organisation (2019) states that air pollution has become a major health risk from the environment in addition to its contributions to global warming. Health risks linked to poor air quality include lung cancers, respiratory and heart diseases, and irritation of the respiratory tract (Abulude *et al.*, 2019). Gas flare sites are the most common locations around which these risks are highest. Studies have shown that operation facilities consist of flow stations which have both flaring and venting systems that emit a wide range of air pollutants (Nwokocha *et al.*, 2015). The pollutants which are released in the process of combustion are determined by the chemical makeup of the gas being combusted, the method used in disposal and the efficiency of the combustion process (Simbi-Wellington and Ideriah, 2020). Common pollutants include CO_2 (carbon dioxide), CO (carbon monoxide), SOx (oxides of sulphur), NOx (oxides of nitrogen), VOCs (volatile organic compounds), heavy metals and carbon black (soot), which have all been reported to be the reasons for various health problems which workers in these facilities and members of nearby communities experience (Akpoghelie *et al.*, 2016). Local communities which are home to gas flaring sites often feature bad odours, high temperatures and loud noises which result from venting and flaring activities, making these causes for concern (Ojukwu and Somerville, 2020).

The National Environmental Standards Regulations and Enforcement Agency (NESREA) has taken steps to ensure that members of the general public are protected against poor air quality by setting air quality standards for pollutants such as SO_2, NO_2, H_2S and particulate matter, especially in areas where crude oil exploration activities take place (Abulude *et al.*, 2019). Yet, doubts remain concerning the enforcement of these standards. Therefore, this study aims to assess the air quality and noise levels around Oredo Flow Station.

II. METHODOLOGY

A. Study Area

Oredo flow station is located at Ologbo Edo State. The flow station consists of three transfer pumps. It is located at latitude 6.0643797 and longitude 5.583812.

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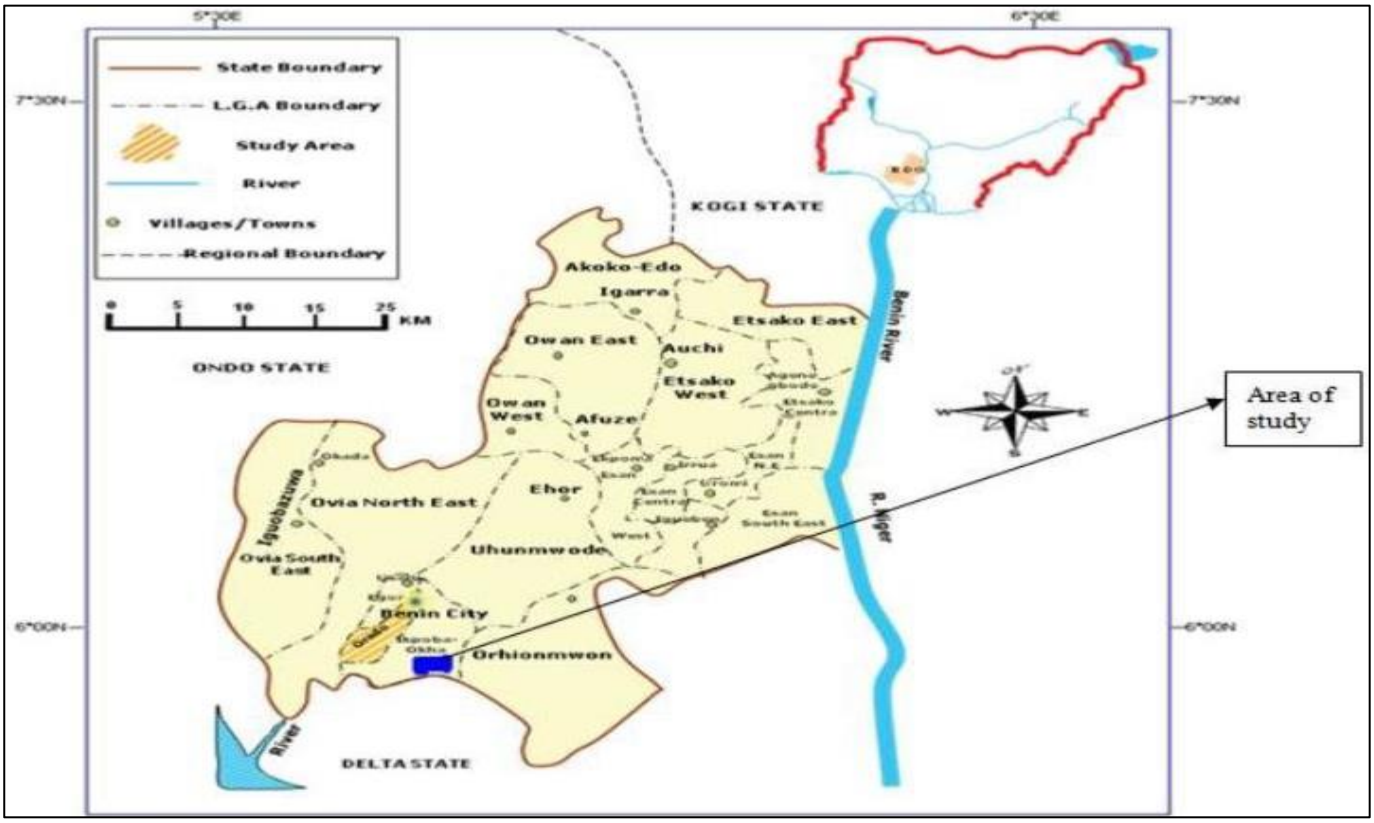

Fig 1: Geographical Location of Oredo Flow Station

B. *Air Pollutant Measurements*

The values for air quality parameters were determined using various air quality devices. These measurements were done at three (3) designated sampling locations within the flow/compressor station. These sampling locations were Point A (300m from the flare site), Point B (200m from the flare site) and Point C (100m from the flare site). Measurements were done three times at every location and a mean calculated to reflect the average level of exposure for each day.

The air quality detector was used to determine particle count, volatile organic compound, carbon monoxide and temperature. The Bacharach SO_2 meter monitor was used to measure the concentrations of SO_2 in the study area.

C. *Noise Measurement*

To measure the noise levels in the allocated region, the research used a digital Sound Level Metre (Model 407730). It was estimated that the metre was placed 1.5 metres above the floor. Readings were taken for a minute in order to obtain a consistent noise level. Three noise level readings were taken at each sample point by the device, and the average of these readings was recorded.

The time-weighted average noise level was determined using the formula below:

$$Time\ Weighed\ Average\ (TWA) = 16.61 Log10\left(\frac{D}{100}\right) + 90$$

Where D = Dose %

$$Dose\ \% = \frac{800}{T}$$

Where T = corresponding duration to a weighted sound level

$$T = \left(\frac{8}{2^{\frac{L-90}{5}}}\right)$$

Where L = average daily measured sound level.

D. *Statistical Analysis*

All analysis and calculations of the data collected were done using Microsoft Excel 2017 sheets. Mean and standard deviation of the values were derived. Data was presented in tables and charts which were appropriately labelled.

III. RESULTS

- *Temperature and Air Pollutants*

The results obtained for temperature and air pollutants in the study area are shown in Table 1. The trends in the values over the sampling period are shown in figures 1 to 5. Across the three sampling points, it is seen that temperature ranged from 28.60±0.3°C to 29.22±0.3°C. Suspended particulate matter ranged from 17.16±3.9 µg/m^3 to 60.74±14.6 µg/m^3. Oxides of sulphur ranged from 0.01±0.0 ppm to 0.03±0.0 ppm. CO concentrations ranged from 0.03±0.0 ppm to 4.45±1.3 ppm. VOC concentrations ranged from 0.01±0.0 ppm to 1.87±0.2 ppm.

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Table 1: Mean Values for Temperature and Air Pollutants in the Study Area

Parameter	Point A	Point B	Point C	Limits (WHO)
Temperature (°C)	28.60±0.3	28.64±0.5	29.22±0.3	NS
SPM (µg/m³)	17.16±3.9	33.34±11.9	60.74±14.6	260
SOx (ppm)	0.01±0.0	0.01±0.0	0.03±0.0	0.01 - 0.06
CO (ppm)	0.03±0.0	1.22±0.2	4.45±1.3	11.4
VOC (ppm)	0.01±0.0	0.31±0.1	1.87±0.2	160

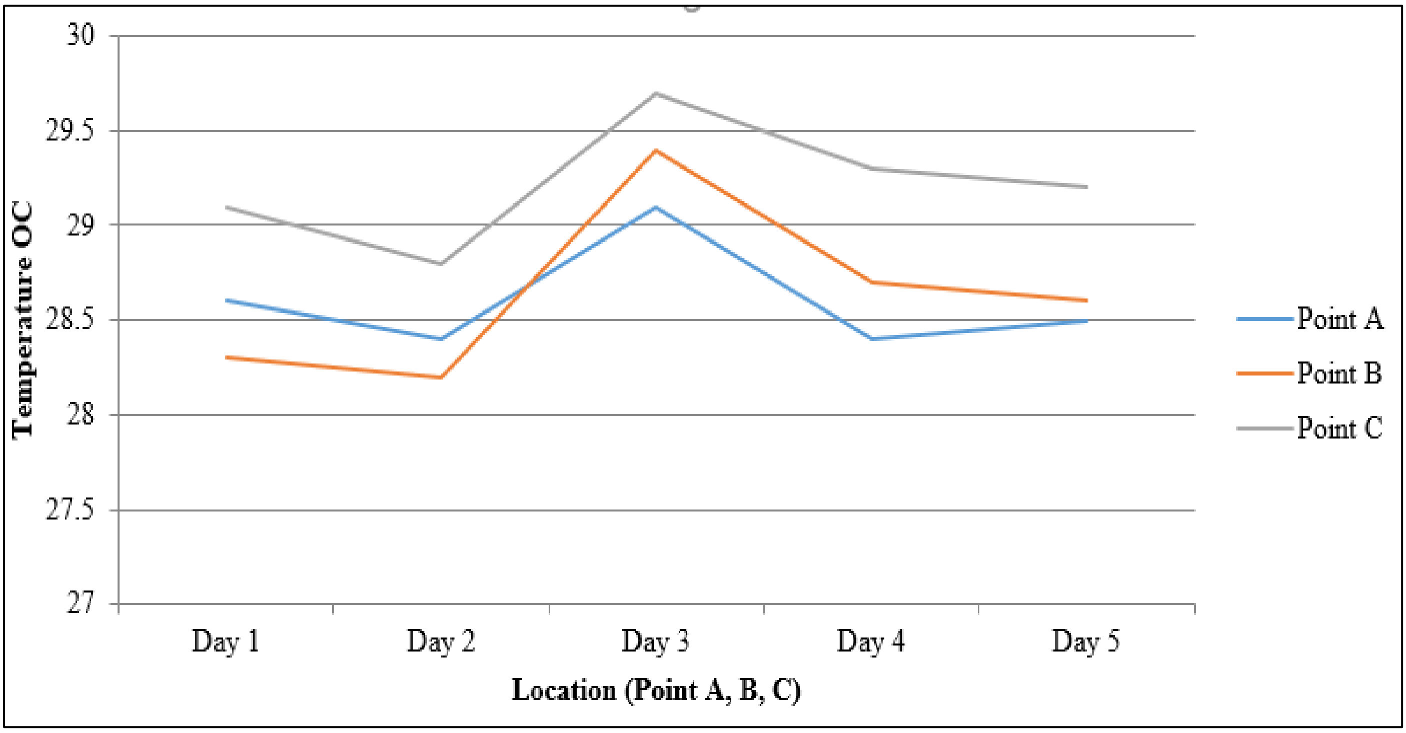

Fig 2: Temperature Trends Over the Measurement Period

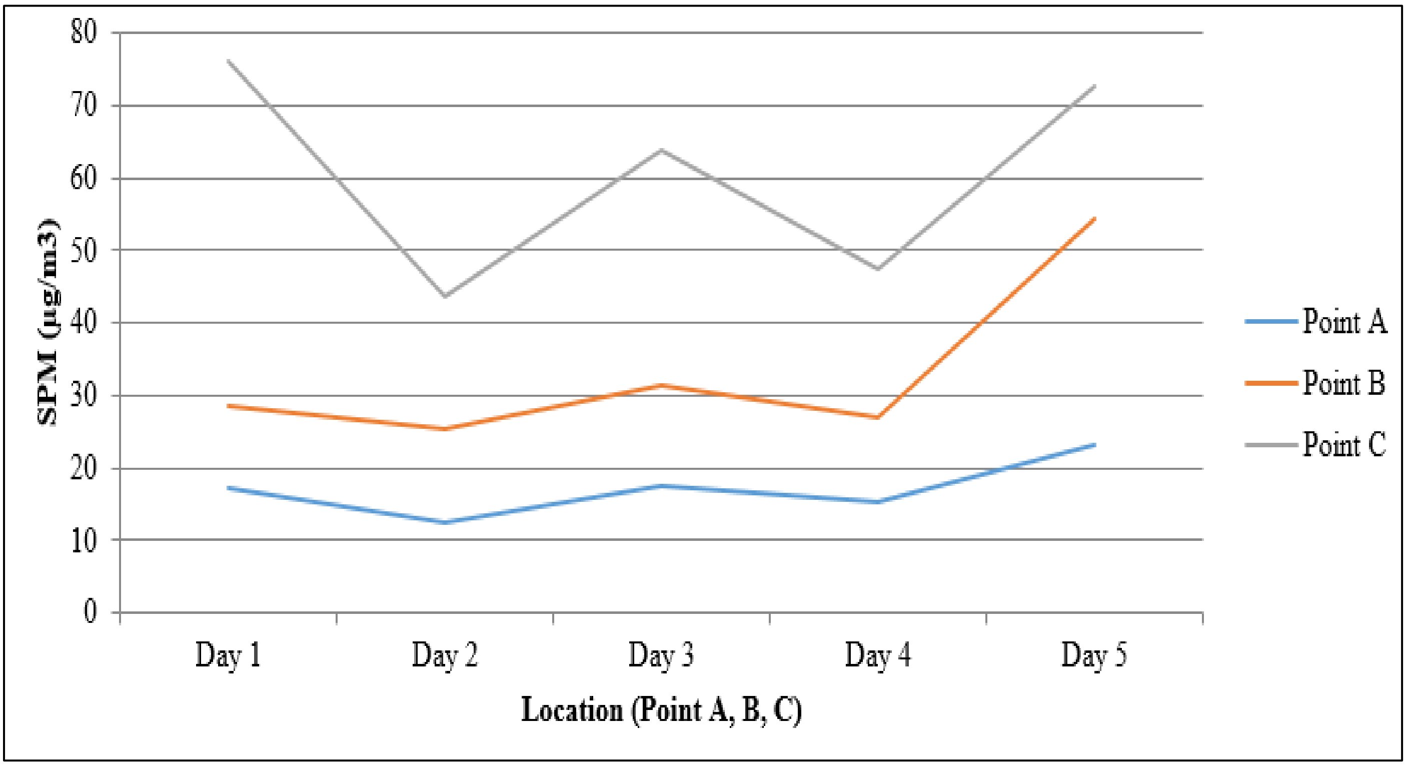

Fig 3: SPM trends Over the Measurement Period

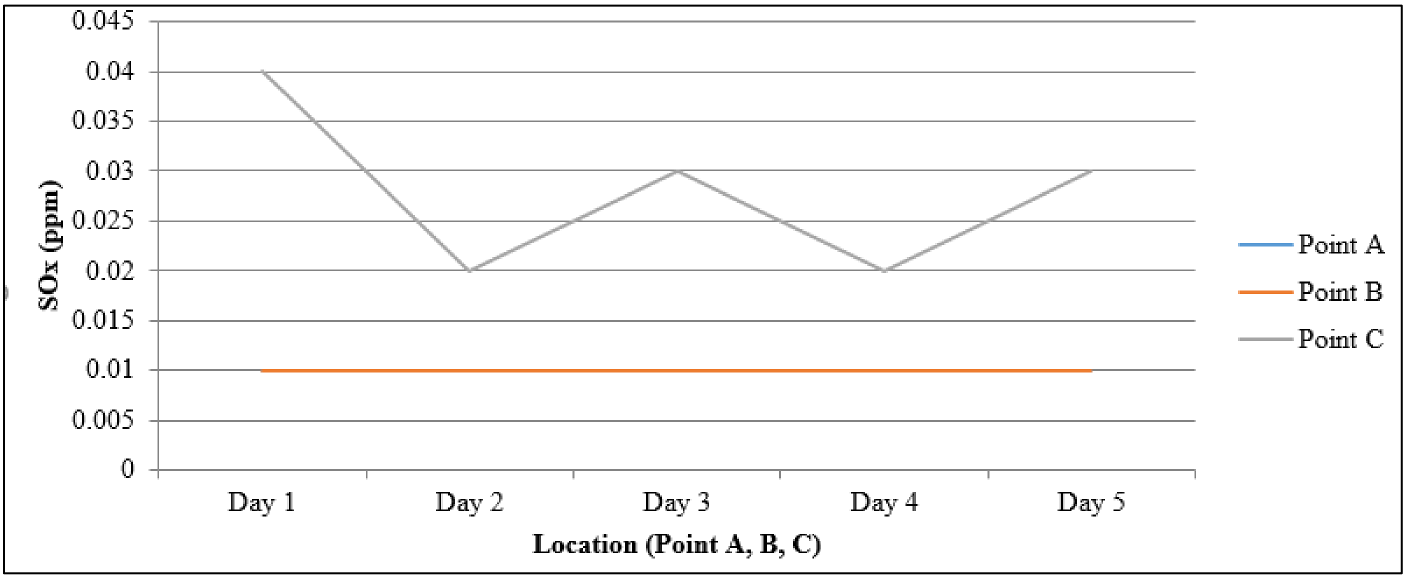

Fig 4: SOx Trends Over the Measurement Period

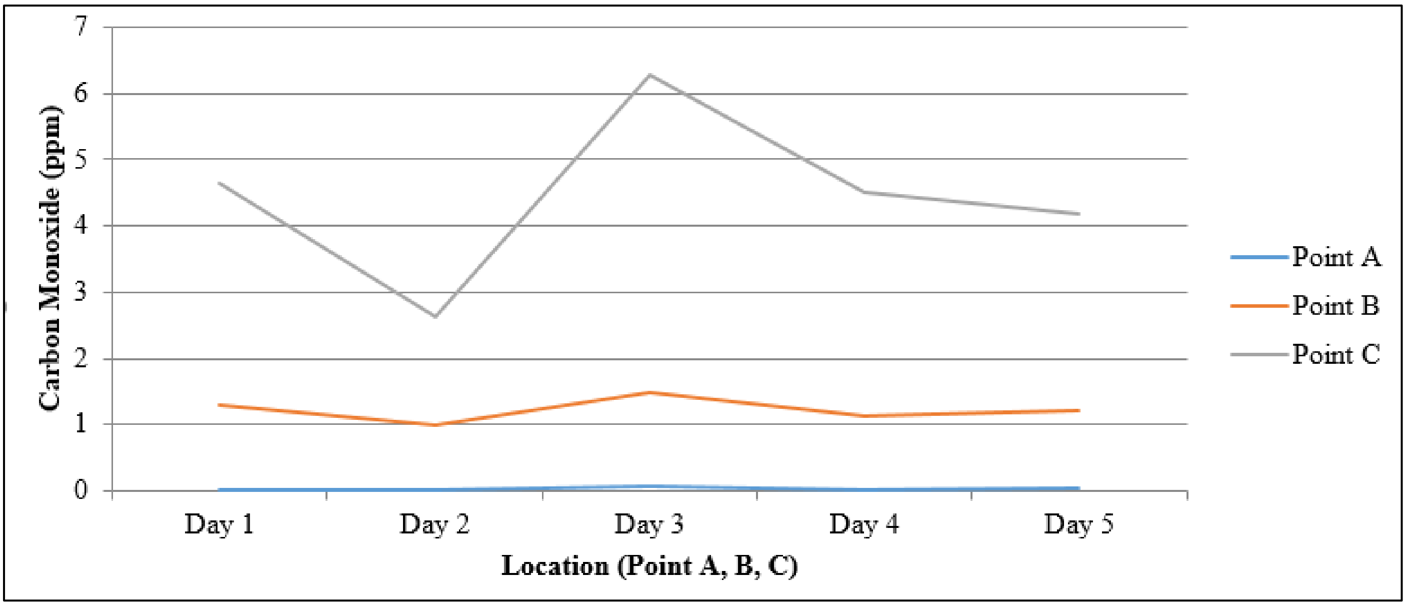

Fig 5: CO Trends Over the Measurement Period

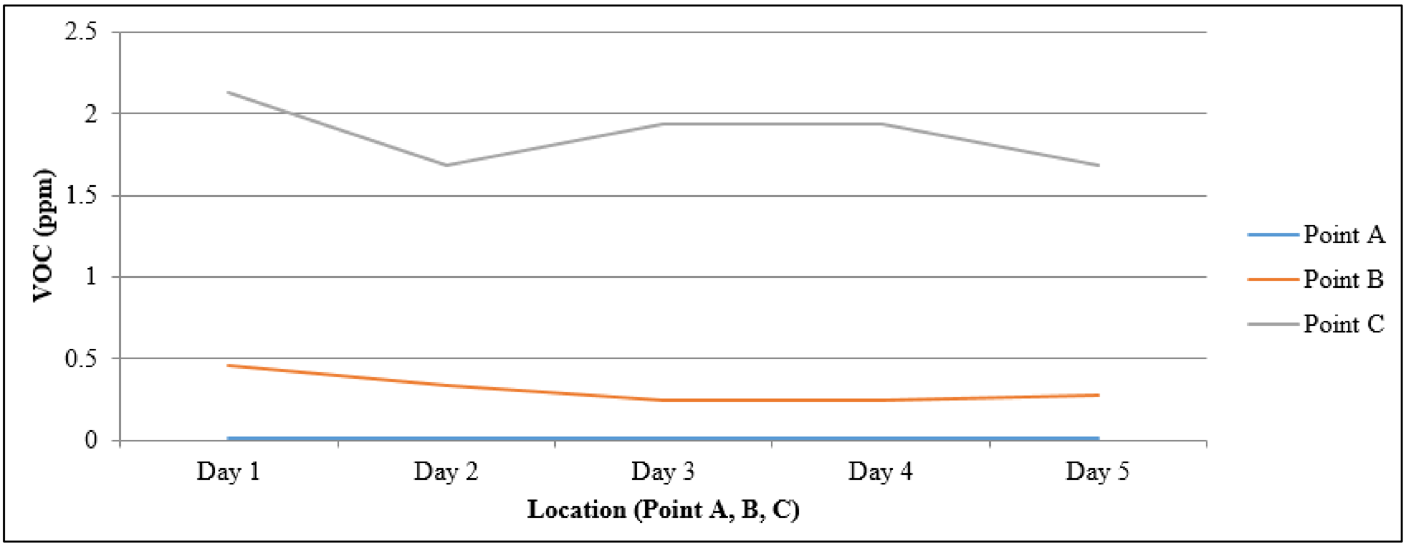

Fig 6: VOC Trends Over the Measurement Period

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➢ *Noise Values*

The noise levels recorded in the study area are presented in Table 2. The mean noise levels ranged from 56.24±2.8dB to 87.78±2.8dB. Time-weighted average noise level ranged from 56.2dB to 87.8dB.

Table 2: Noise Levels in the Study Area

Location	dB	
	Mean	**Time-Weighted Average**
Point A	56.24±2.8	56.2
Point B	87.78±2.8	87.8
Point C	65.70±2.6	65.7

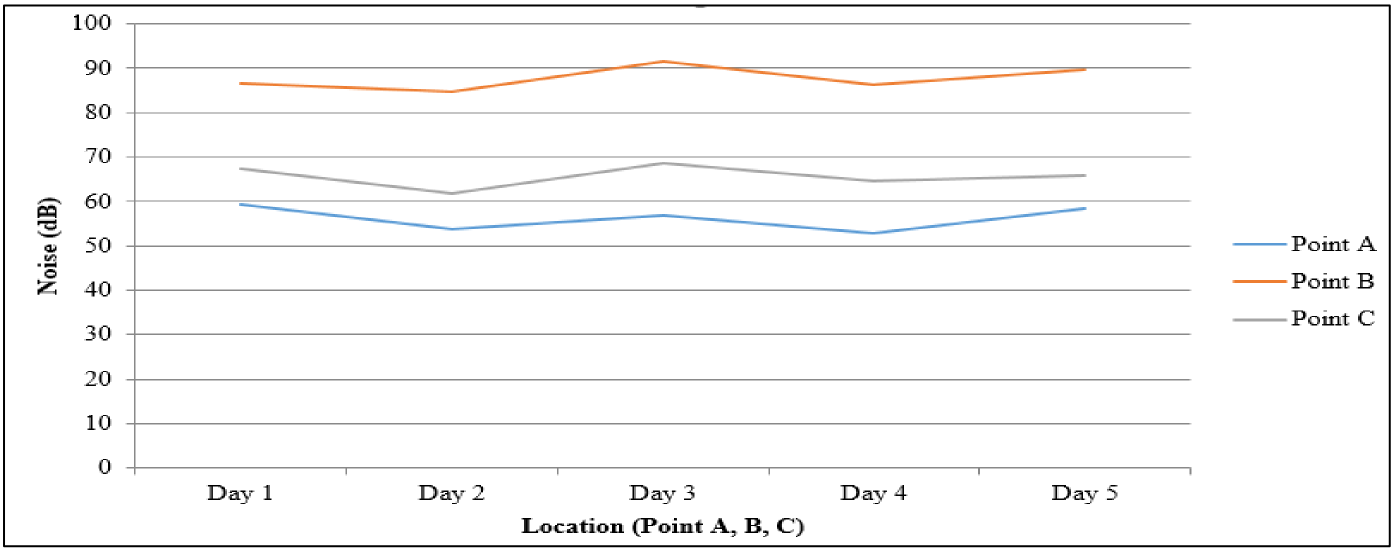

Fig 6: Noise Level Trends over the Measurement Period

IV. DISCUSSION

The recorded temperatures show a slightly decreasing trend as distance to the flare site increased. Previous studies have recorded similar findings (Akpomedaye and Okposo, 2021; Chukwu, 2022). While environmental agencies in Nigeria do not specify a standard for ambient temperature levels, it is vital to note that an ambient temperature of 30°C is needed for healthy living. The temperatures in the study area were below this value indicating that temperatures were not hazardous to health (Song *et al.,* 2017).

Atmospheric particulate matter is a result of chemical reactions involving emitted gases within the atmosphere. Particulate matter of various sizes can infiltrate the defence mechanisms of the respiratory tract causing damages (Mukherjee and Agrawal, 2017). The results obtained show that the concentration of particulate matter in the study area was less than the maximum permissible limit of 260μg/m^3. However, they exceed those of Nwagbara and Onwudiwe (2020) who recorded SPM values of 100m = 10.71μg/m^3, 200m = 8.51μg/m^3 and 300 = 4.69μg/m^3. This indicates that gas flaring in the area is a contributor to particulate matter concentrations as stated by Giwa *et al.* (2019).

Sulphur dioxide concentrations also showed a decreasing trend with increasing distance from the flare site. The concentrations recorded are similar to those in Chukwu (2022) where the mean recorded concentration of SO_2 was 0.01ppm. The values obtained all fell within the permissible limits for SO_2 in air and are not a health threat.

Incomplete combustion is a major source of carbon monoxide in the environment. In humans, CO combines with haemoglobin, decreasing the capacity of blood to carry oxygen and causing death (Kleinman, 2020). The decreasing trend in concentrations with increasing distance can be attributed to distance to combustion site and air transportation. The concentrations obtained were below permissible limits and, hence, not a health threat. The results are similar to those of Ojukwu and Somerville (2020) where CO fell within the WHO acceptable limits for air quality and <5ppm.

Building materials and paints are among the sources of volatile organic compounds, while they are also produced during oil exploration activities (Montero-Montoya *et al.*, 2018). Low concentrations of VOCs are recorded in this study and reflect the use of proper infrastructure that prevent leakages which may result to fire outbreaks. All concentrations were below maximum permissible limits.

Noise level measured during the study did not exceed the maximum permissible limit of 100dB for industrial areas. However, the increased with proximity to the site which can be attributed to the use of heavy machinery in operations (Uchegbulam *et al.,* 2022). The noise levels are not considered to be a health threat.

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V. CONCLUSION

This study evaluated air quality parameters and noise levels around Oredo Flow Station, Nigeria. Air quality assessment of the flow station made use of air quality parameters including temperature, suspended particulate matter, sulphur oxide, carbon monoxide, volatile organic compounds and noise. The observed values for each parameter were within permissible limits as recommended by the NESREA and the WHO. The observed trends in concentrations of air pollutants can be attributed to gas flaring activities and other operations carried out within the flow station. It can therefore be concluded that flow station activity contributes to increase in the concentration of air pollutants. Recommendations to improve air quality in the area include routine air quality monitoring, finding alternative uses for natural gas and implementing noise control measures.

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