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ASSESSMENT OF METEOROLOGICAL PARAMETERS FROM THREE SELECTED LOCATIONS IN ELEME AND OBIO/AKPOR LOCAL GOVERNMENT AREAS OF RIVERS STATE, NIGERIA

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ABSTRACT: *Industrialisation and urbanisation have increased exponentially in the past decade, leading to a higher release of environmental pollutants into the environment. Anthropogenic activities have caused several changes in the activities of air quality. This work was aimed at assessing the levels of meteorological parameters: carbon dioxide (CO2), nitrogen dioxide (NO2), sulphur dioxide (SO2), hydrogen sulphide (H2S), carbon monoxide (CO), ammonia (NH3) and formaldehyde (HCHO) in selected parts of Eleme and Obio/Akpor Local Government Area of Rivers State. The concentrations of selected air quality parameters were measured in-situ using standard measurements. The samples were collected from sixteen stations of three locations in parts of Eleme and Port Harcourt Metropolis bimonthly for one year. Data obtained was statistically analysed with using one-way annova and Ducan for mean separation across stations. Meteorological parameters and their values ranged in all the stations as follows: HCHO (0.23±0.01 to 5.42±0.29 mg/m³), EO (0.57±0.14 to 2.53±0.17 mg/m³), NO (undetected to 0.45±0.03 mg/m³), SO2 (undetected to 0.90±0.13 mg/m³), VOC (1.53±0.14 to 18.04±3.03 mg/m³), H2S (undetected to 0.83±0.93 mg/m³), CO (undetected to 15.83±1.44 mg/m³), NH3 (undetected to 5.83±1.33mg/m³), CH4 (undetected to 5.17±1.60 mg/m³) and CO2 (0.08±0.01 to 0.85±0.02 mg/m³). All meteorological parameters showed a significant difference in the mean concentrations across the stations at $p<0.05$. All parameters assessed were within the recommended values to be present in the air.*

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INTRODUCTION

Abulude et al. (2019) emphasized that air pollution has become a serious environmental and human health challenge, both locally and internationally. Air quality parameters such as particulate matter (PM), greenhouse gases (GHG), carbon monoxide (CO), nitrogen oxides (NO), sulphur dioxide (SO_2), lead (Pb), black carbon (black soot) and ozone (O_3), to mention but a few, are products of anthropogenic activities, resulting in global warming, ozone layer depletion and acid rain. Particulate matter is a very critical air pollutant that results in death of living organisms across the world. The pollution by Particulate Matter (PM) has become both environmental and human health problem with resultant effects on the atmospheric conditions as well as terrestrial and aquatic ecosystems. Taiwo et al. (2015) opined that the increasing level of air quality parameters and pollution of PM could be mostly attributable to natural and anthropogenic processes, such as industrialization, urbanization and biomass burning.

Due to the global impact of air pollution, airborne PM is known as the most important marker for determining the quality of air. Singh and Sharma (2015) noted that the study of the sources of PM high levels is very important to contributing to knowledge on ambient air quality reduction strategy with the required data for local and international regulation. Farao et al. (2014) asserted that in developed countries such as Europe, PM is among the air quality parameters upsetting the quality of air. The report from a workshop organised by the World Health Organisation, on the health significance of PM that causes environmental and human health challenges from different sources, recommended that future studies, in addition to other concerns, should investigate the source points of emissions vis-a-vis exposure of the increasing population. According to WHO (2018), air pollution has become the leading distinct biota and human health risk globally, with four million two hundred untimely mortalities due to exposure to air quality parameters in ambient air.

Georginia et al. (2020) posited that the increasing human population in urban centres with associated growth in anthropogenic activities is influencing the air quality conditions. Anake et al. (2016a) noted that in recent years, a substantial concentration of air quality parameters has been produced in Nigerian urban centres due to rapid urbanization, industrialization, combustion of biomass, uncontrolled vehicular emissions, and illegitimate waste management. They assert that heightened concentrations of air quality parameters in industrial communities have enhanced air pollution risk exposure levels in such localities. Akuro (2014) observed that some of the automobiles used in Nigeria have older engines with the likelihood of emitting harmful gases into the atmosphere. Open air burning of waste in the neighbourhood is common in Nigeria and is causing the release of PM into the atmosphere. In Rivers State, illegal artisan crude oil refining is on the increase in recent times and is releasing PM into the environment and causing air pollution. Also, the use of coal and firewood to cook is very common even in the urban centres, thereby causing air pollution. There is also evidence of the presence of PM in air around industrial areas of Rivers State (Simeon, 2019). A report by the World Health Organisation indicated that about seven million people died from the outdoor and indoor air pollution in Lagos, Nigeria (WHO, 2012 cited in Akett, 2022). According to the report, air pollution across the continent of Africa is responsible for the death of over seven hundred thousand persons yearly, and Nigeria is among the countries with the highest statistics of harmful air quality in Africa. The report also indicated that the death due to air pollution disasters in Nigeria in the past 30 years has increased to 40 percent. It is an open secret that the existence of accessible real-time air quality data is one of the most effective ways to ensure the

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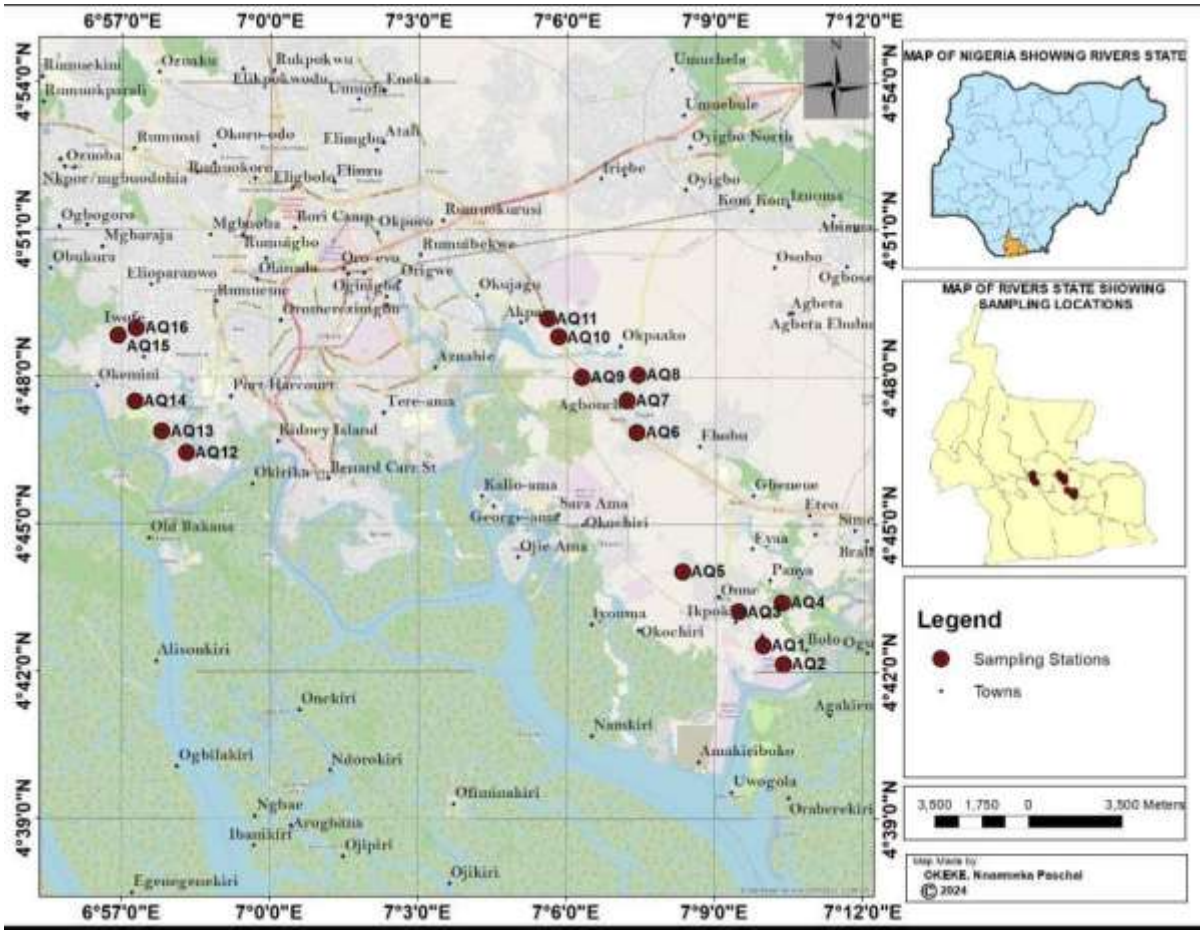
reduction of air pollution. However,access to these data is difficult in Nigeria and indeed Rivers State.

MATERIALS AND METHODS

This study was carried out in three locations in Rivers State, Nigeria. These areas are Onne, Aleto/Agbonichia and Rumuolumeni. Onne, also known as Onne-Eleme, is a town in Eleme, Rivers State, Nigeria. Rumuolumeni plays host to companies such as Saipem Contracting Nig. Ltd – a oil servicing company, Stock Gap – a petroleum product tank farm, Masters Energy – a petroleum product tank farm, the defunct Eagle Cement Company, Avion Oil and Gas Company, etc. The area had a recent experience of intense air pollution due to the high industrial activities going on in the area.

Fig. 2.1: Map Showing Meteorological Sampling Stations at Onne (five points), Aleto/Ogbonchia (six points) and Rumuolumeni (five points).



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Determination of Meteorological Parameters

Collection of Data

The levels of CH4, SO2, CO, CO2, H2S, HCHO, NH3, NO2, and TVOCs were instantly and directly monitored from the different sampling sites through the use of various portable controlled manual meters/monitors that measured and recorded the levels of air quality parameters instantaneously at the designated sampled locations.

Carbon Monoxide (CO), H2S, CH4, VOC

Drager 8000 x am environmental gas monitor equipped with an infrared sensor was used for the measurement of CO. The range of detection is between 1.0–1000 ppm with the alarm set at 2.00 and 20.00 ppm. Measurements were done by holding the sensor to a breathing height of about 1.5 meters in the direction of the prevailing wind; the reading was recorded when the monitor had warmed up (3 minutes) to burn off contaminants on the sensor and air sucked into the sensor. Reading is displayed after a few minutes.

Sulphur Oxides (SO_2) Measured as Sulphur Dioxide (SO2), Nitrogen Dioxide,

An Aeroquip environmental gas monitor equipped with an infrared sensor was used for the measurement of SO_2. The technique operates on the principle of dual wavelength IR Absorption; the range of detection is between 0.01–1000 mg/m^3 with the alarm set at 2.0 and 20.00 ug/m^3.

Ammonia (NH_3)

BW Honeywell Micro 5 PID Environmental gas Monitor equipped with an electrochemical sensor was used for the measurement. The equipment operates on the principle of dual wavelength IR Absorption, the range of detection is between 1–25 % with alarm set at 2.0 and 5.00 ppm.

Total Volatile Organic Compounds (TVOCs)

A drager X-am 8000 environmental gas monitor equipped with a PID sensor was used for the measurement of TVOCs. The equipment operates on the principle of photo ionization, the range of detection was between 0.1–1000 mg/m^3 with the alarm set at 0.20 and 5.00 mg/m^3.

Formaldehyde (HCHO) and Ethylene Oxide (EO)

Sample was taken by holding the sensor of Diemiern 106 particle mass monitor to the direction of the prevailing wind and the reading was recorded when stable.

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RESULTS AND DISCUSSION

The concentrations of formaldehyde (HCHO) in the air of sampled stations varied from 0.23±0.01 at Aker Base Station to 5.42±0.29 mg/m^3 at Eleme Petrochemical Station. The values of HCHO obtained from the different stations were statistically significant at $p<0.05$ as shown in Table 3.1. Mean monthly values of HCHO showed January values to be the highest, followed by March, September, November, July, and then May which had the lowest concentration. Station values indicated the highest values were observed in Eleme Petrochemical Company, followed by Nchia, while the lowest mean values were observed at Aker Base Stations and Rumuolumeni, as shown in Figures 3.1 and 3.2.

The concentrations of Ethylene oxide (EO) in the air from sampled stations varied from 0.57±0.14 at Naval Base Station to 2.53±0.17mg/m^3 at NAFCON and Onne/Eleme Station. The values of EO obtained from the different stations were statistically and significantly different at $p<0.05$, as shown in Table 3.1. Mean monthly values of EO showed January values to be the highest, followed by March, November, September, July, and then May which had the lowest concentration. Station values showed predominant values at NAFCON Gate and Onne/Eleme Road Station, followed by Eleme Petrochemical Company, FOT and IITA, while the lowest mean values were observed at Naval Base Stations (Figures 3.3 and 3.4).

Table 3.1 showed the concentrations of Nitrogen monoxide (NO) in the air from sampled stations varied from ND at Eleme/Oyigbo Station to 0.45±0.03 mg/m^3 at Eleme Petrochemical Station. The values of NO obtained from the different stations were statistically and significantly different at $p<0.05$. However, the highest concentration was observed in March, followed by July, May, January and November. September had the lowest concentration. Station values showed the most predominant values at Eleme Petrochemical, followed by Rumuolumeni, while the lowest mean values were observed at Eleme/Oyigbo Stations and Akpajo and Onne/Eleme (Figures 3.5 and 3.6).

The concentrations of Sulphur dioxide (SO_2) in the air from sampled stations varied from ND at Aker Base, Tank Farm and Naval Base Stations to 0.90±0.13 mg/m^3 at Petrol Tank Farm Station. The values of SO_2 obtained from the different stations showed statistically significant differences at $p<0.05$, as illustrated in Table 3.1. Mean monthly values of SO_2 showed January values to be the highest, followed by September, July and then March. May had the lowest concentration, followed by November. Station values showed the most predominant values at Petroleum Tank Farm, Onne Forest and FOT. However, values were not detected at Aker Base, Tank Farm and Naval Base (Figures 3.7 and 3.8).

The concentrations of volatile organic compounds (VOC) in the air from sampled stations varied from 0.60±1.15 at Rumuolumeni Station to 18.04±3.03 mg/m^3 at Tank Farm Station. The values of VOC obtained from the different stations were statistically and significantly different at $p<0.05$ in Table 3.1. The mean concentration of volatile organic compounds (VOC) during the months revealed that January had the highest concentration, followed by March and November, while the least values were observed in July, followed by May and then September. The mean stations concentrations of VOC showed Tank Farm to have the highest values, followed by Naval Base, Petroleum Tank farm, and Onne Forest. The lowest station values were observed at Rumuolumeni, followed by Akpajo and Eleme Petroleum Company Gate (Figures 3.9 and 3.10).

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The concentrations of Hydrogen sulphide (H_2S) in the air from sampled stations varied from ND at Onne Forest, IITA, Onne/Eleme, Akpajo and Naval Base Stations to 0.83±0.93 mg/m^3 at FOT Station. The values of H_2S obtained from the different stations showed statistically significant differences at $p<0.05$, as represented in Table 3.1. Mean monthly values of H_2S across the months of samplings showed that the highest concentration of H_2S was observed in January, followed by March and then November. The lowest values were observed in May and July, followed by September. Station values showed the most predominant values at FOT, followed by Petroleum tank farm and Rumuolumeni. However, values were not detected at Onne Forest, IITA, Onne/Eleme, Akpajo and Naval Base stations (Figures 3.11 and 3.12).

The concentrations of Carbon monoxide (CO) in the air from sampled stations varied from ND at IITA Station to 15.83±1.44 mg/m^3 at Onne/Eleme Station. The values of CO obtained from the different stations showed statistically significant differences at $p<0.05$, as illustrated in Table 3.1 The mean monthly concentrations of CO across the various stations showed that the highest concentration was observed in January, followed by November, September and then March. The lowest value was observed in July, which was followed by May. Station values of CO showed the most predominant values at Onne/Eleme Road, followed by NAFCON Gate, Akpajo and Tank Farm. No values were detected at IITA and the least value was found at Eleme/Oyigbo Road and Petroleum Tank Farm (Figures 3.13 and 3.14).

The concentrations of Ammonium ion (NH_4^+) in the air from the sampled stations varied from ND at IITA and JVC Stations to 5.83±1.33 mg/m^3 at Akpajo Station. The values of (NH_4) obtained from the different stations were statistically significant at $p<0.05$, as shown in Table 3.1. Mean monthly values of NH_4 showed January values to be the highest, followed by March, May and September. The lowest concentration was observed in the month of July, followed by November. Station values showed the most predominant values at Akpajo, followed by Nchia, NAFCON and Eleme Petrochemical Company Gate. However, values were not detected at IITA and JVC (Figures 3.15 and 3.16).

The concentrations of Methane (CH_4) in the air from the sampled stations varied from ND at NAFCON Station to 5.17±1.60 mg/m^3 at Petrol Tank Farm Station. The values of CH_4 obtained from the different stations were statistically significant at $p<0.0$, as shown in Table 3.1. The mean monthly concentrations of CH_4 across in the various stations showed that the highest concentration was observed in January, followed by March, September and then November. The lowest value was observed in July, followed by May. Station values of CH4 showed the most predominant values at Petroleum Tank Farm, followed by Nchia, Onne/Eleme Road. The lowest value was observed at IITA Station, followed by FOT (Figures 3.17 and 3.18).

The concentrations of Carbon dioxide (CO_2) in the air from the sampled stations varied from 0.08±0.01 at Aker Junction Station to 0.85±0.02 mg/m^3 at Akpajo. The values of CO_2 obtained from the different stations were statistically and significantly different at $p<0.05$, as illustrated in Table 3.1. The mean monthly concentrations of CO_2 across the various stations showed that the highest concentration was observed in November, followed September and then March. The lowest values were observed in July, followed by May. Station values of CO_2 showed the most predominant values at Akpajo while the least values were observed at Aker Junction and followed by Naval Base (Figures 3.19 and 3.20).

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Meteorological Parameters

Table 4.3: Mean and Standard Deviation of Some Meteorological Parameters

Station	HCHO	EO	NO	SO_2	VOC	H_2S	CO	NH_4	CH_4	CO_2
Petro. Tank farm	1.34±0.29 de	1.67±0.21 f	0.40±0.39 b	0.90±0.13 d	13.38±5.02 gh	0.50±0.55 ab	2.83±2.32 b	3.50±1.05 ef g	5.17±1.60 g	0.37 ± 0.34 b
Onne forest	1.28±0.05 de	1.43±0.29 ef	0.37±0.01 a	0.47±0.41 c	13.50±1.87 gh	0.00 a	3.17±3.43 b	3.00±1.41 ab c	2.67±1.03 def	0.68±0.10 cd
FOT	1.23±0.02 d	1.98±0.64 g	0.43±0.05 b	0.26±0.02 b	10.34±0.46 ef	0.83±0.93 b	7.50±2.17 c	1.33±1.63 ab	1.17±0.98 b c	0.84±0.03 d
IITA	1.23±0.02 a	1.98±0.64 a	0.12±0.04 a	0.02±0.01 a	5.63±1.53 c	0.00 a	0.00 a	0.00 a	0.85±0.02 ab	0.84±0.03 d
NAFCON	1.35±0.04 de	2.53±0.17 h	0.04±0.00 a	0.14±0.02 ab	8.25±0.85 d	0.17±0.41 a	12.33 ±1.37 f	4.83±0.75 gh	0.00 a	0.84±0.01 d
Onne/Eleme	1.36±0.05 de	2.53±0.17 f	0.03±0.01 a	0.06±0.01 a	3.34±0.58 b	0.00 a	15.83 ±1.44 g	1.50±0.55 ab c	3.67±0.52 f	0.82±0.02 d
Nchia	2.59±1.23 h	1.52±0.08 f	0.04±0.01 a	0.08±0.01 a	3.45±0.67 b	0.15±0.37 a	9.33±1.51 c de	5.67±1.63 h	5.00±1.67 g	0.82±0.02 cd
Eleme /Oyigbo	2.51±0.05 h	1.18±0.08 de	0.00 a	0.07±0.01 a	1.57±0.04 ab	0.33±0.51 ab	0.33±0.82 a	2.00±0.89 bc de	2.33±1.51 c de	0.59±0.39 c
JVC	2.53±0.05 h	1.75±0.10 fg	0.07±0.11 a	0.02 ±0.01 a	3.47±0.61 b	0.17±0.41 a	10.171.67 def	0.00 a	2.33±1.03 c de	0.83±0.03 d
Eleme Petro.	5.42±0.29 i	2.41±0.51 h	0.45±0.03 b	0.01±0.01 a	1.53±0.14 ab	0.17±0.41 a	3.67±0.82 b	4.0±1.26 fg	1.50±0.55 b cd	0.83±0.02 d
Akpajo	2.11±0.02 g	1.21±0.14 de	0.03±0.01 a	0.06±0.01 a	0.93±0.55 a	0.00 a	12.00±1.79 f	5.83±1.33 h	1.67±0.82 b cd	0.85±0.02 d

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Aker base	0.23±0.01 b	1.21±0.14 cd	0.04 ± 0.01 a	0.00 a	12.20±0.24 fg	0.17±0.41 a	7.67±1.03 c	1.82±2.04 bc d	1.67±0.52 b cd	0.73±0.03 cd
Tank Farm	1.92±0.17 f	0.96±0.13 cd	0.04±0.13 a	0.00 a	18.04±3.03 i	0.33±0.52 ab	12.00 ± 1.26 f	2.00±1.26 bc de	1.50±0.55 b cd	0.70±0.10 cd
Naval Base	1.29±0.09 de	0.57±0.14 ab	0.04±0.01 a	0.00 a	14.45±1.61 h	0.00 a	8.16±3.31 cd	2.50±1.05 bc de	2.00±0.89 b cd	0.25±0.03 ab
Aker Junction	1.42±0.05 b	0.82±0.26 bc	0.04±0.01 a	0.13±0.12 a	10.00±0.71 de	0.17±0.41 a	4.67±1.63b	1.50±0.55 ab c	2.33±1.03 c de	0.08±0.01 a
Rumuolumeni	0.62±0.02 c	0.88±1.66 cd	0.44±0.01 a	0.02±0.01 a	0.60±1.15 ef	0.50±0.55 a	10.83±2.48 ef	3.33±1.21 def	3.33±0.52 e f	0.64±0.43 cd
P value	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00

Superscripts with different letters across the column are significantly different.

Fig. 3.1: Mean Monthly Concentrations of HCHO

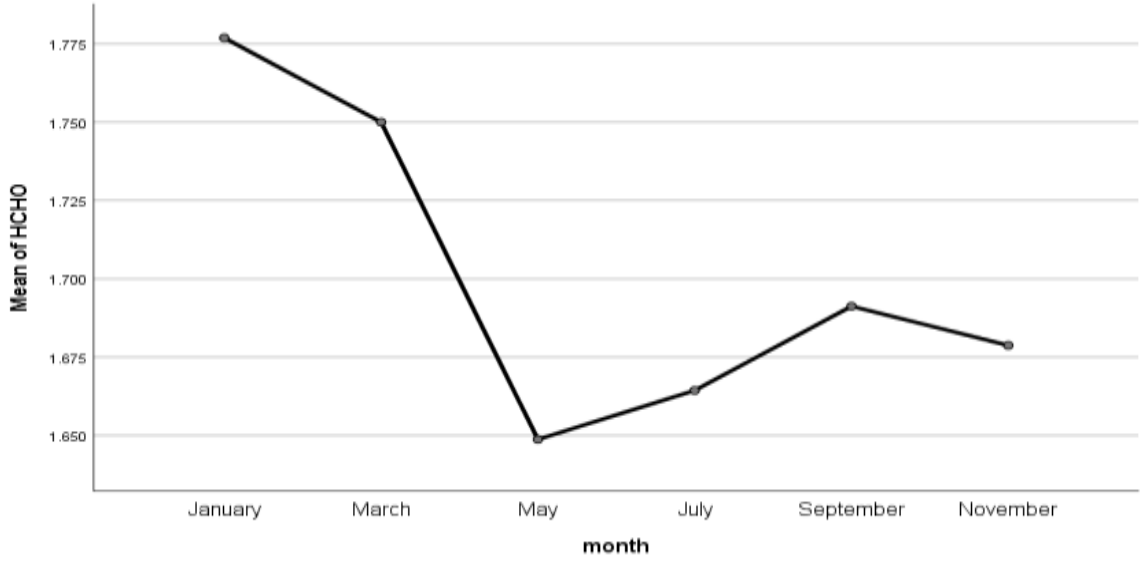

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Fig. 3.2

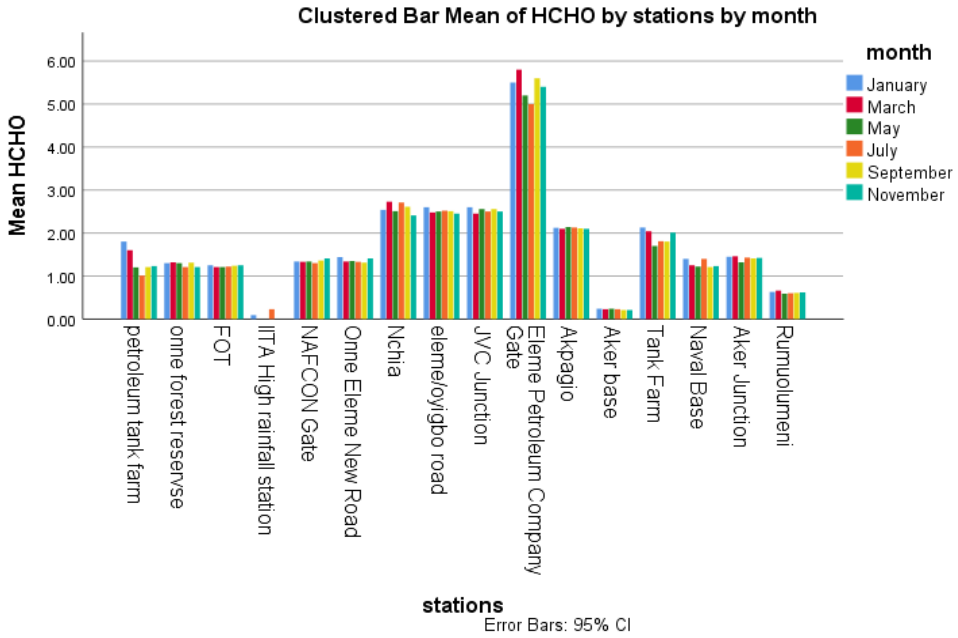

Fig. 3.3: Mean Monthly Concentrations of EO

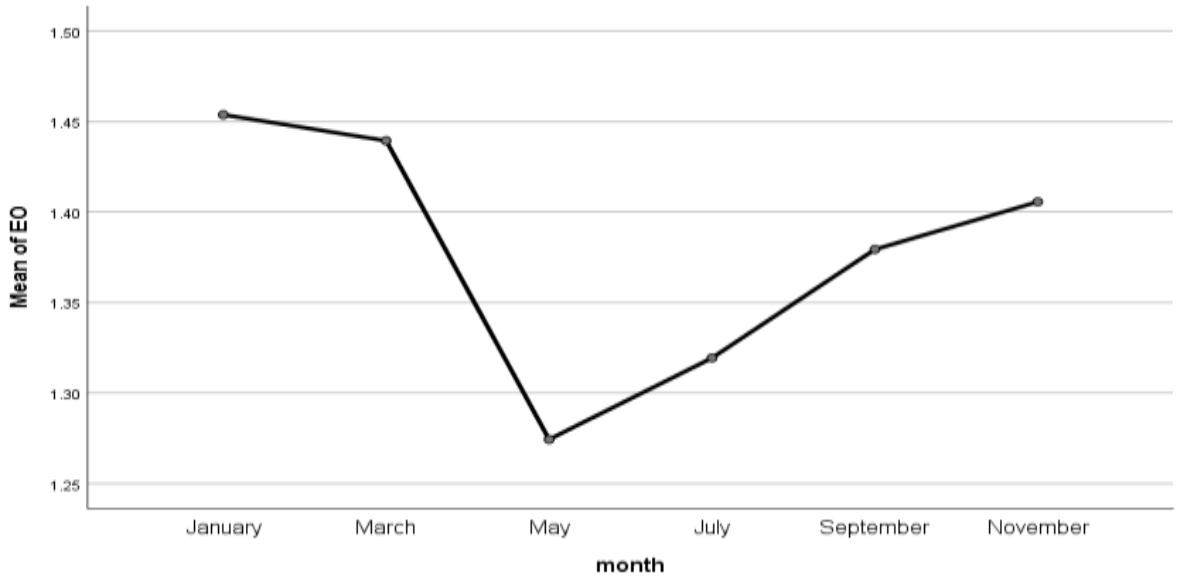

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Fig. 3.4

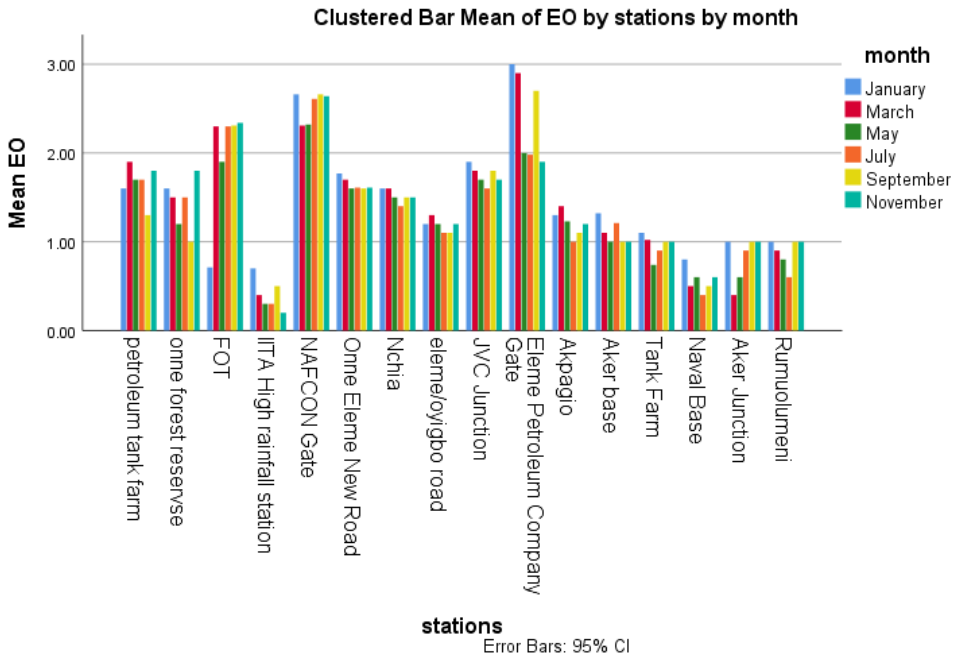

Fig. 3.5: Mean Concentrations of NO_2 by Months

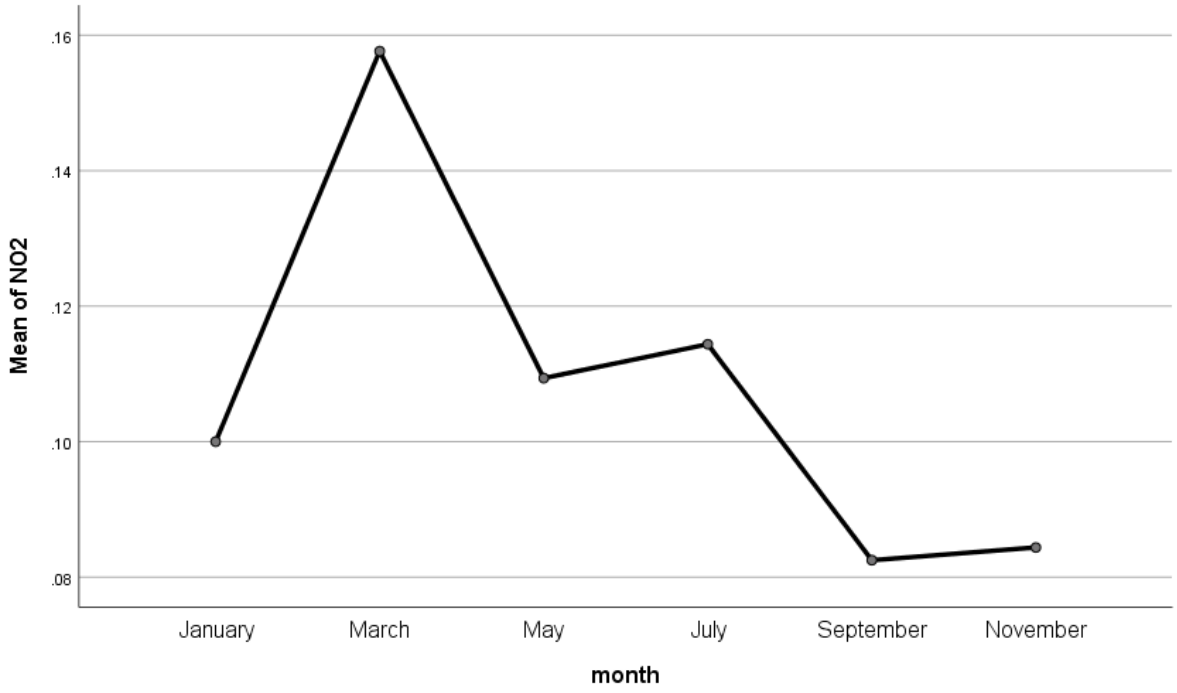

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Fig. 3.6

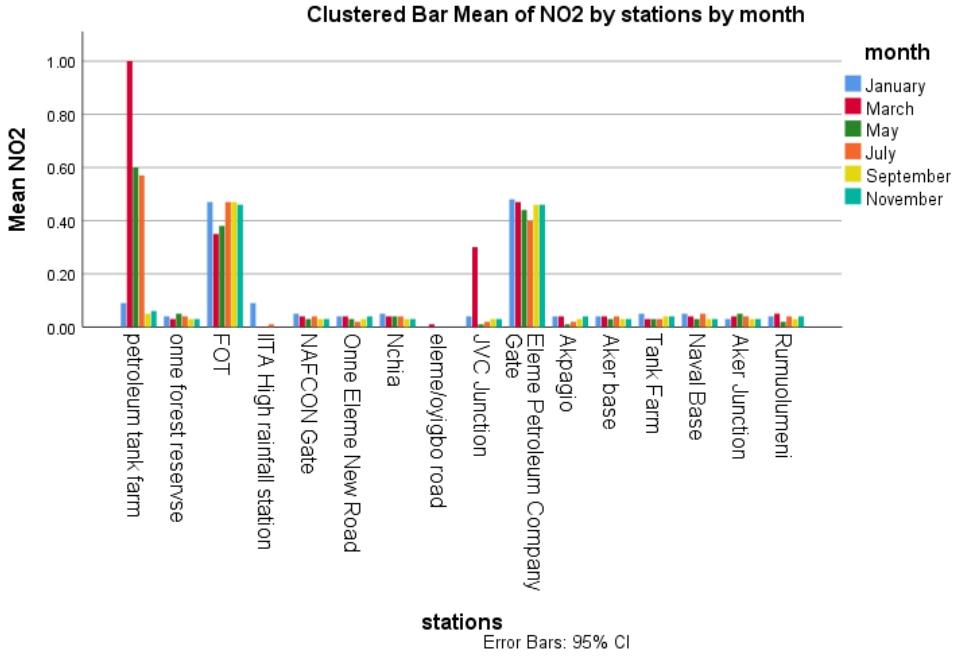

Fig. 3.7: Mean Concentrations of SO_2 by Months

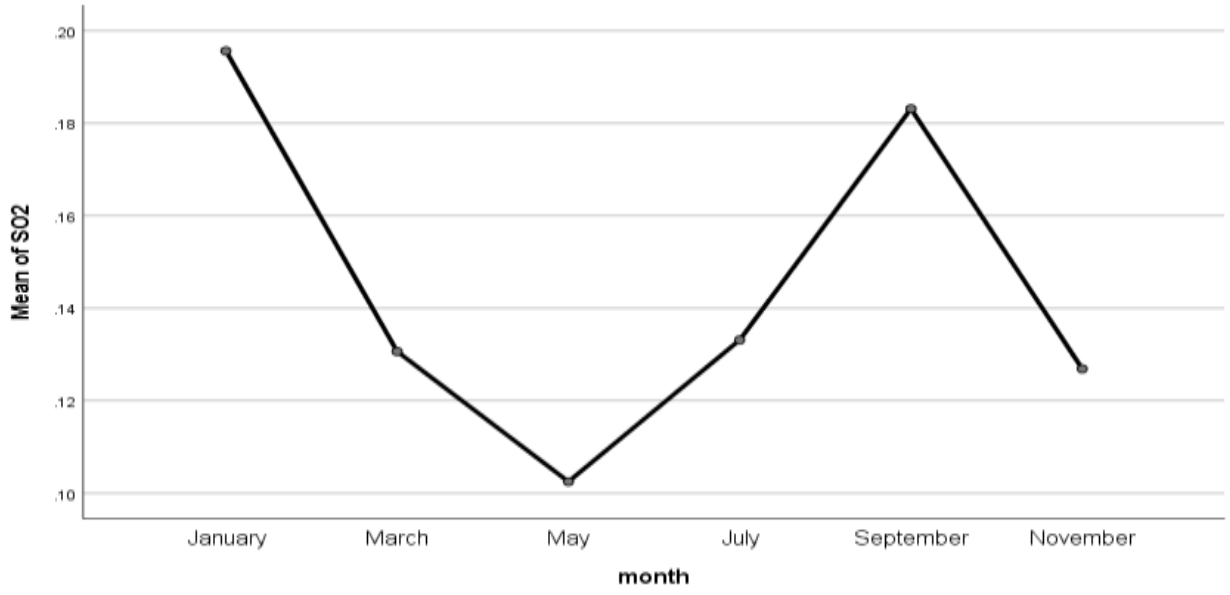

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Fig. 3.8

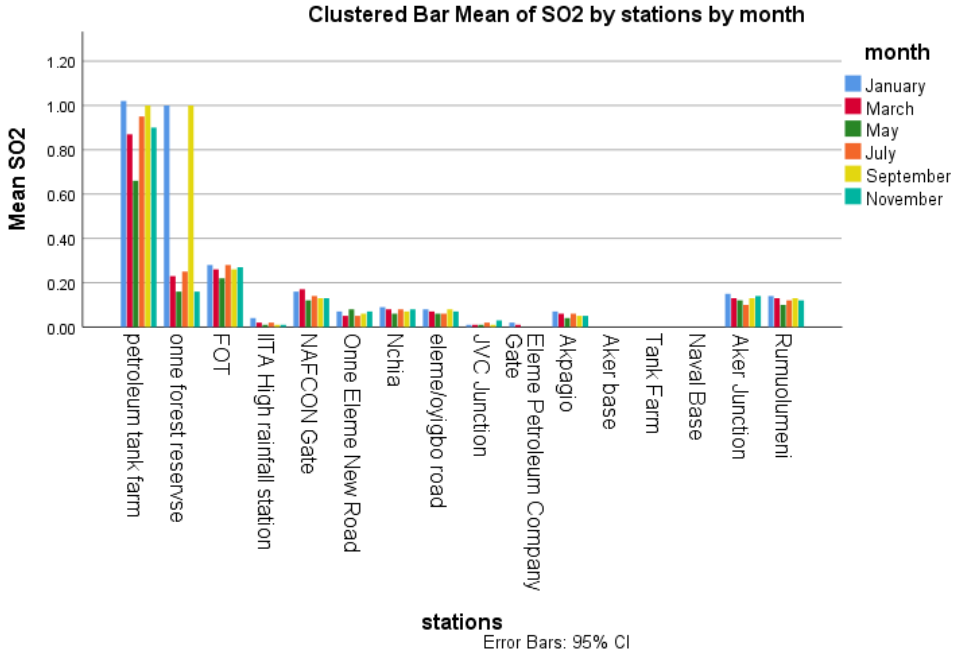

Fig. 3.9: Mean Concentrations of Volatile Organic Compounds (VOC) by Months

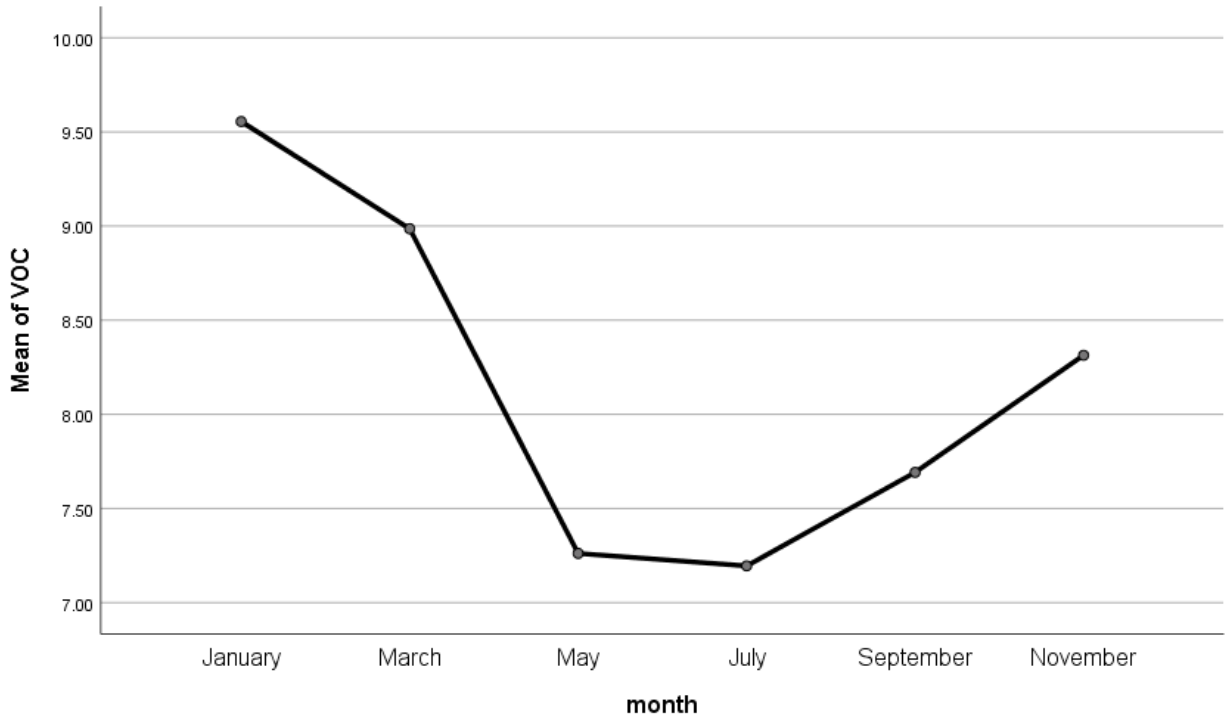

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Fig. 3.10:

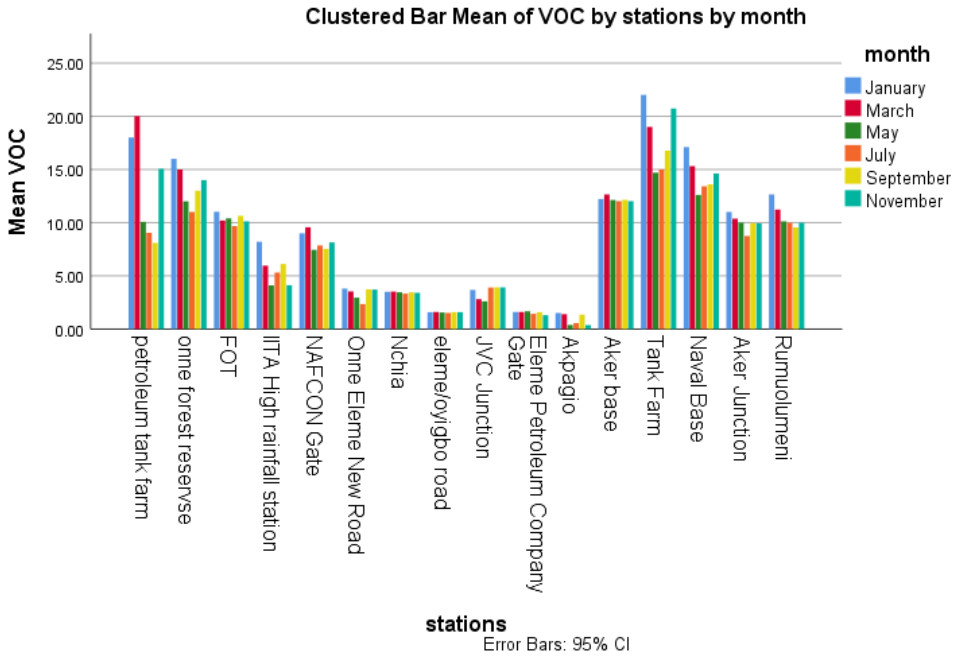

Fig. 3.11: Mean Concentrations of H_2S across the Months

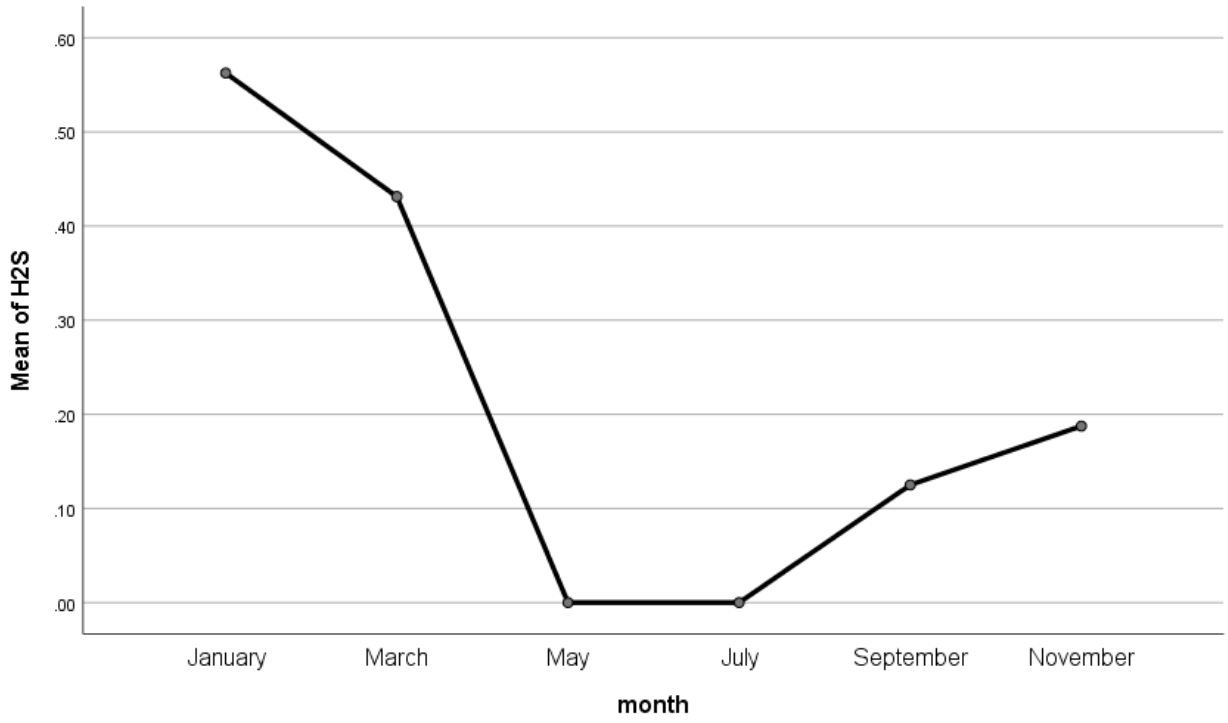

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Fig. 3.12: Mean

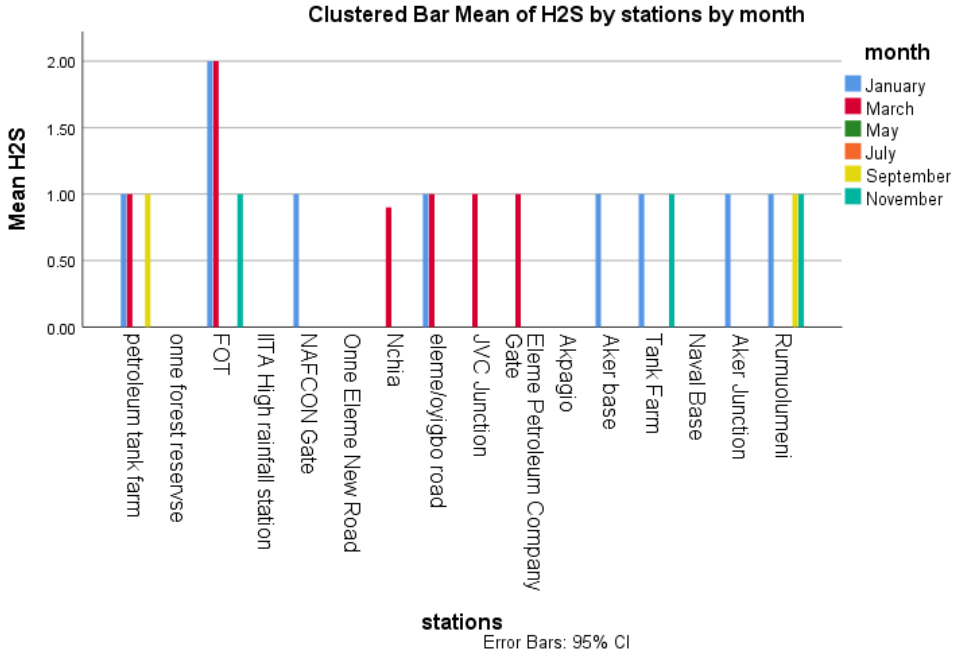

Fig. 3.13: Mean Concentrations of CO across the Months

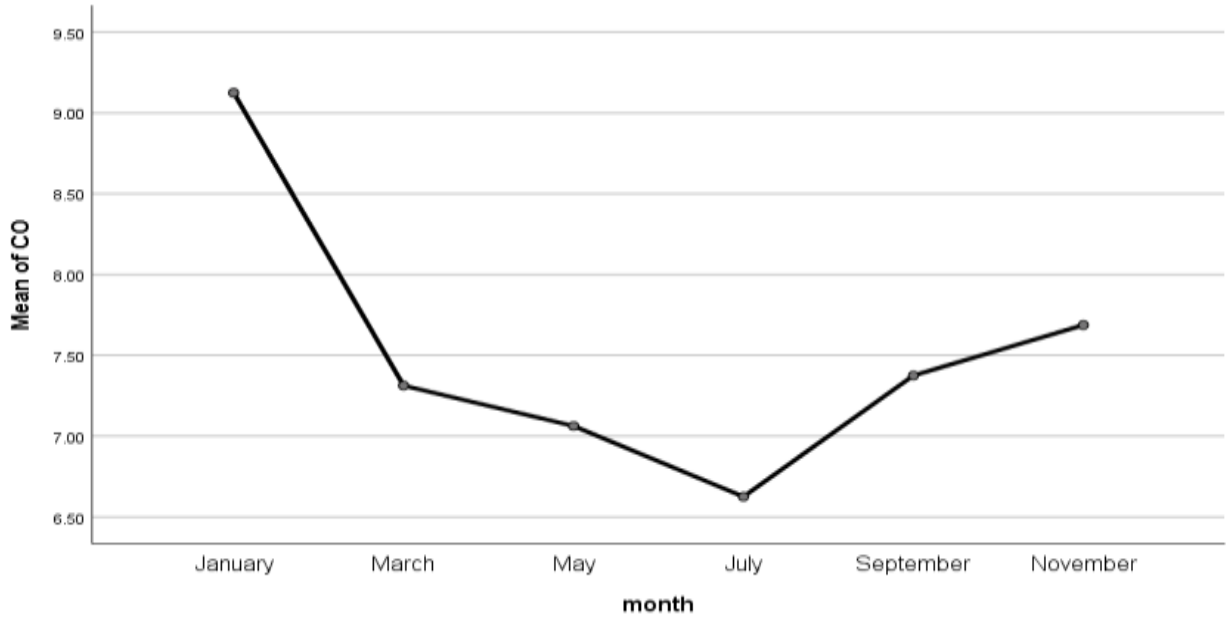

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Fig. 3.14

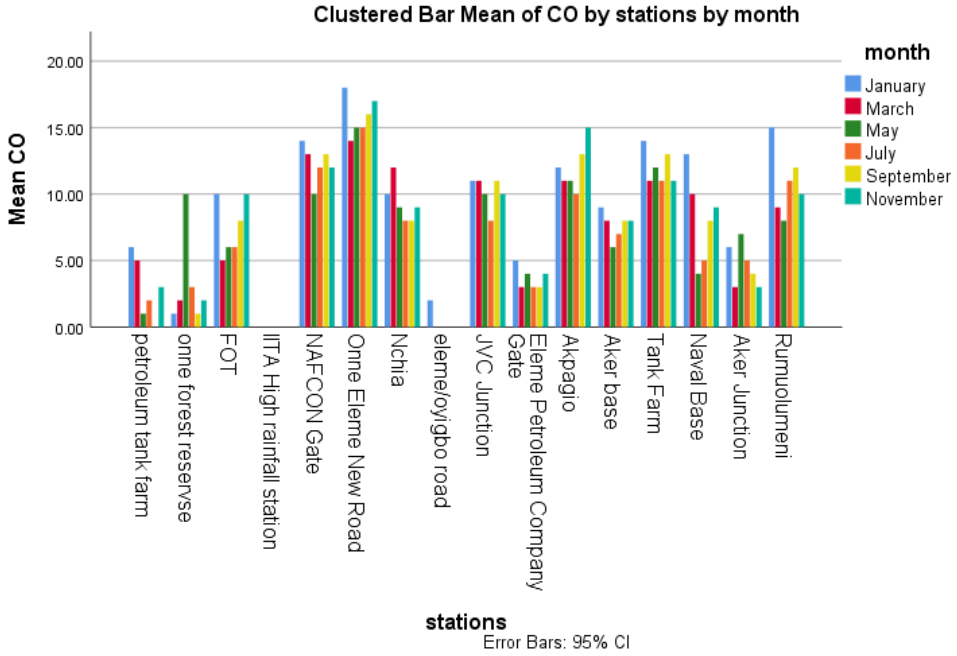

Fig. 3.15: Mean Concentrations of NH_4 by Months

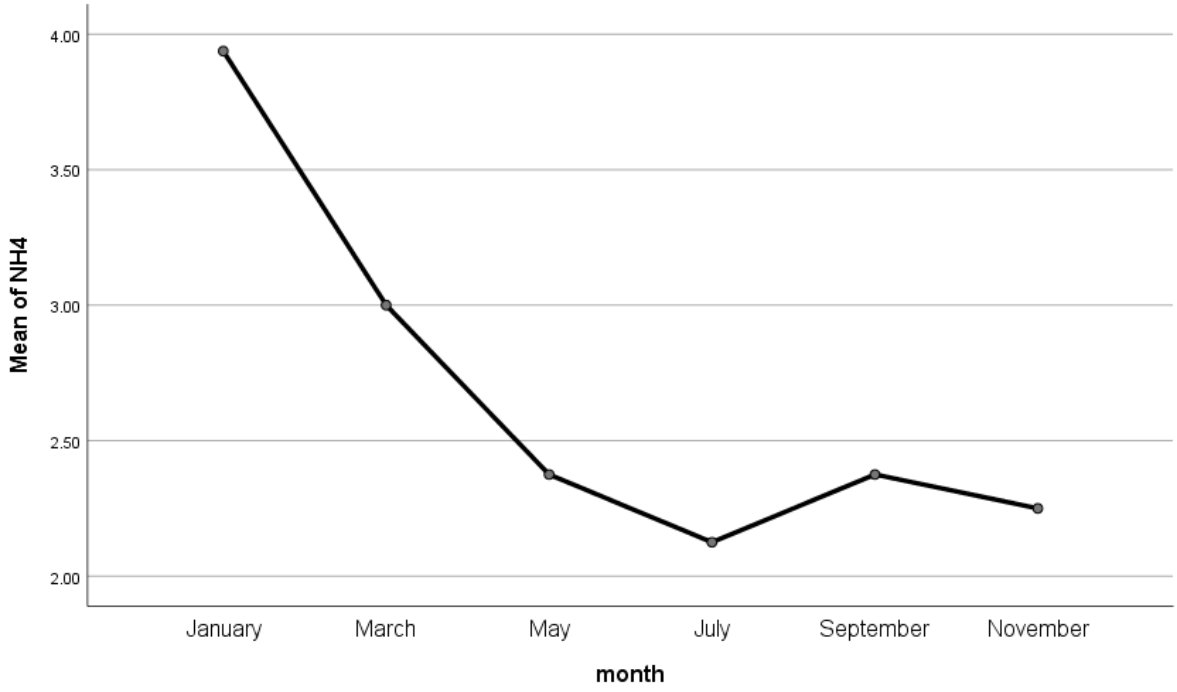

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Fig. 3.16

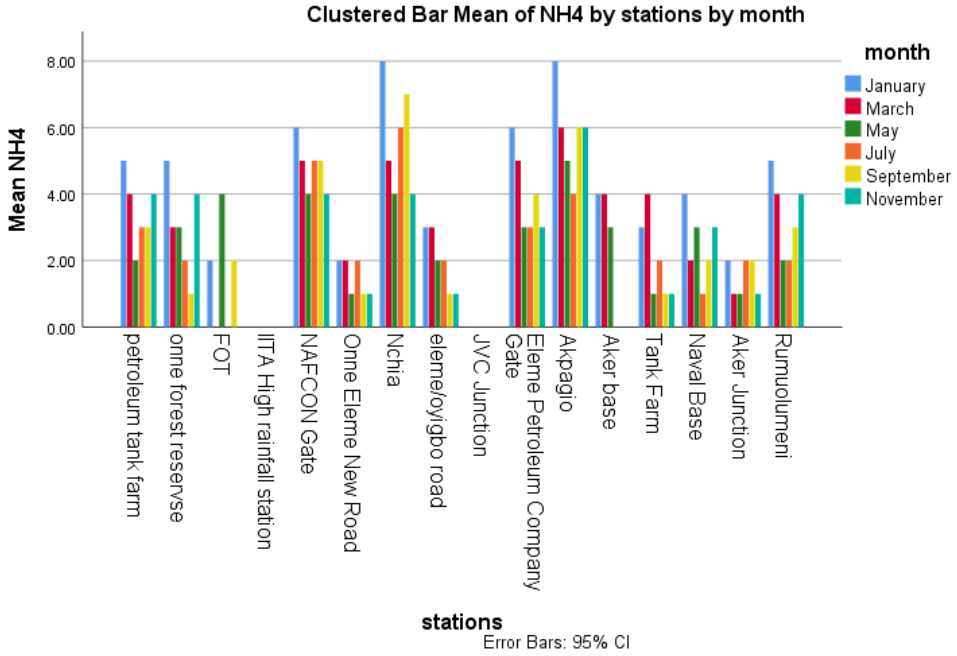

Fig. 3.17: Mean Concentrations of CH_4 by Months

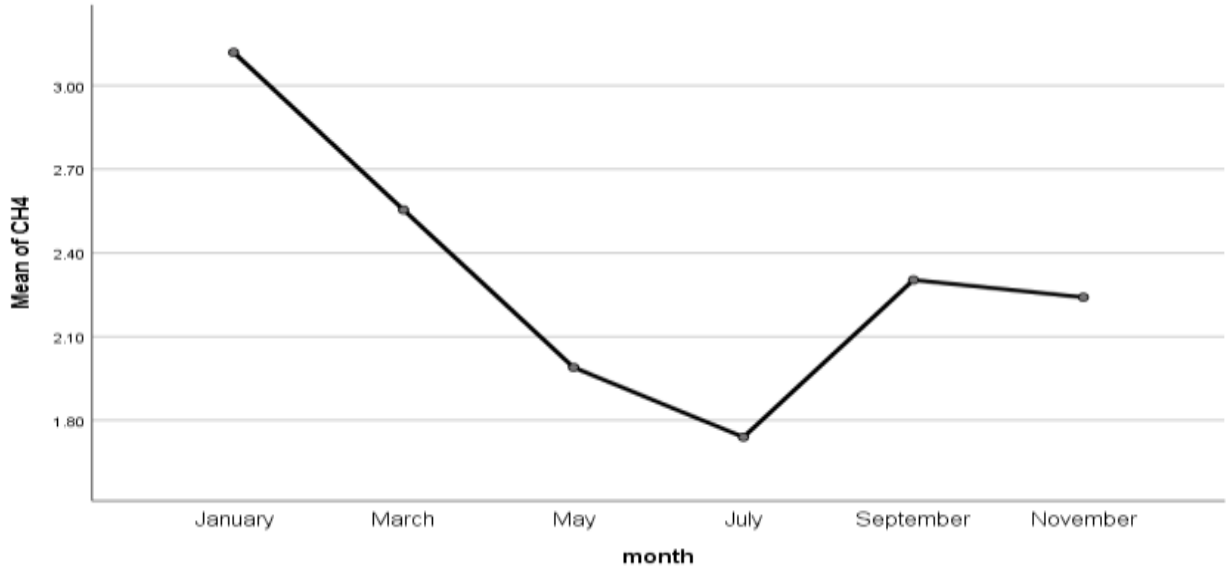

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Fig. 3.18

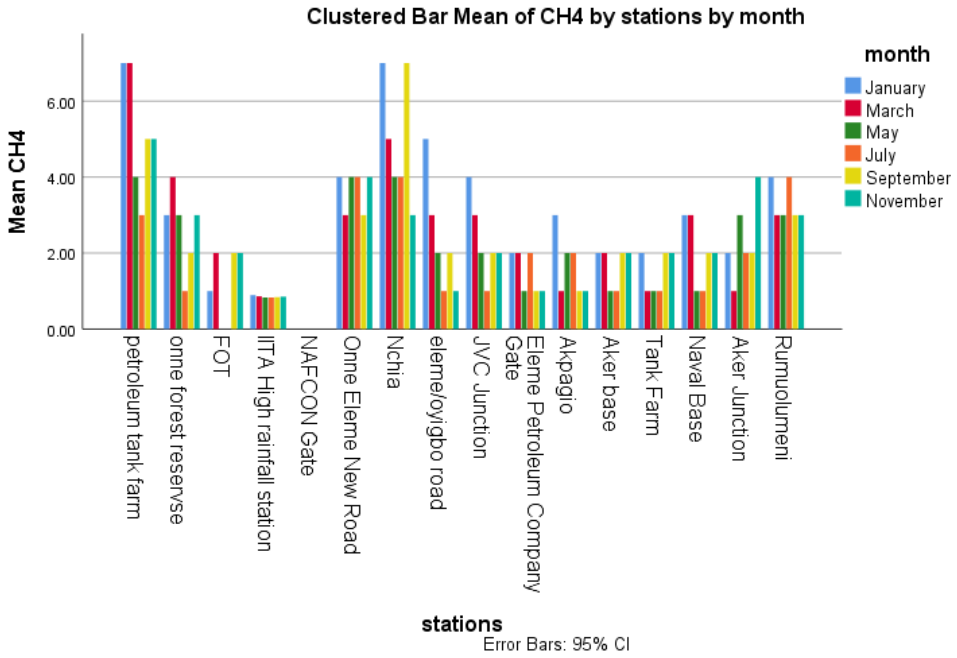

Fig. 3.19: Mean Concentrations of CO_2 across the Months

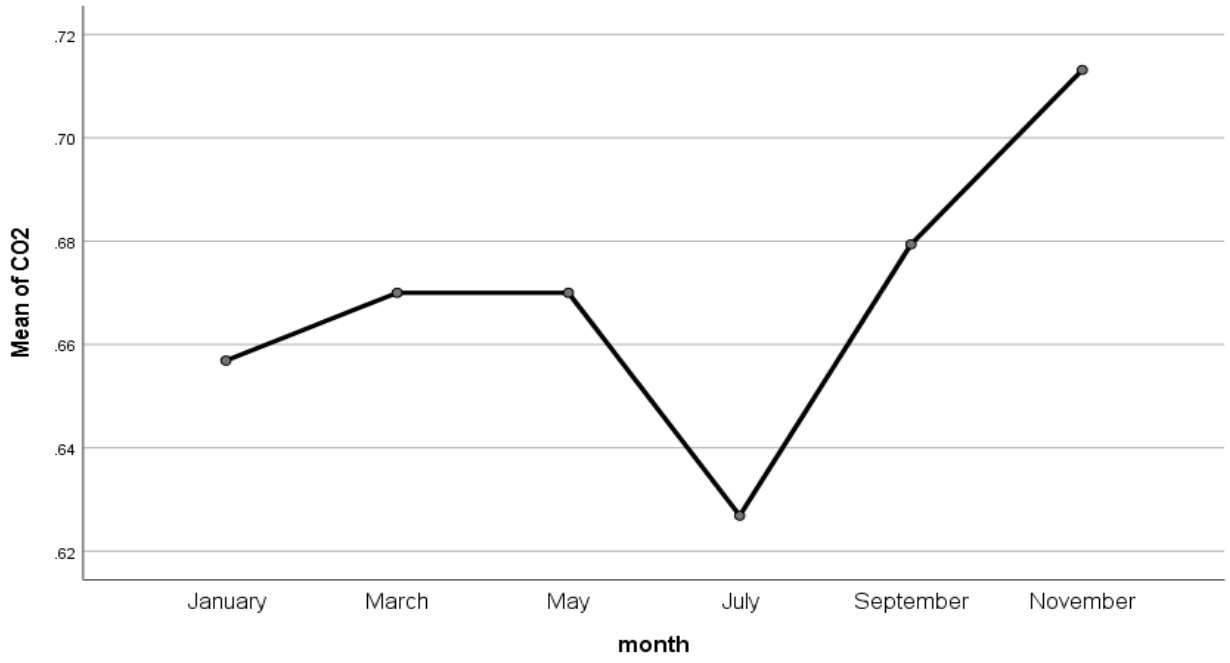

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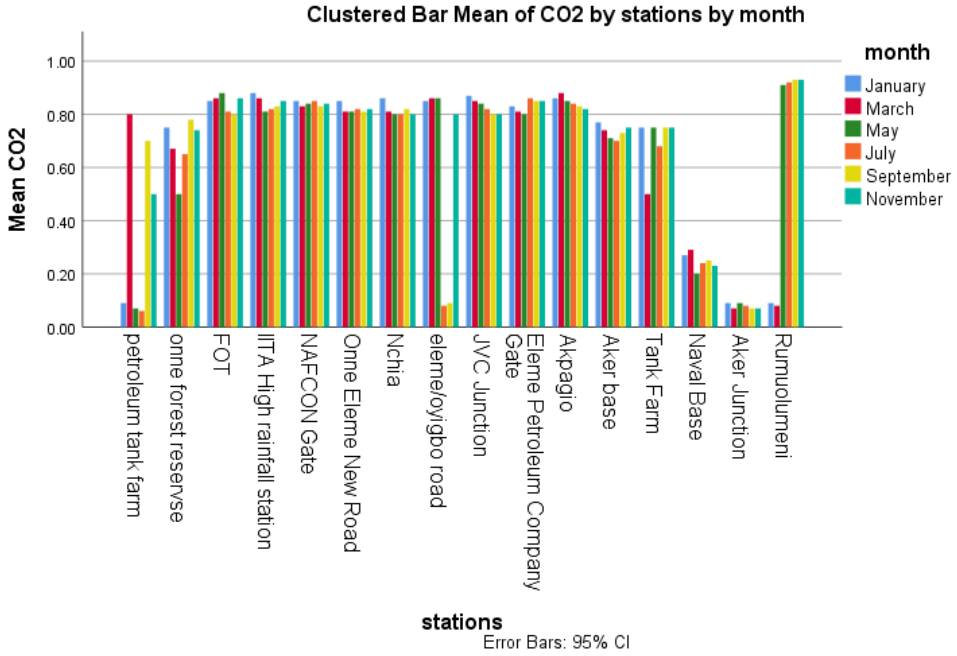
Fig. 3.20



Formaldehyde (HCHO)

The seasonal mean concentrations of HCHO across the sixteen sampled stations were less than the national permissible values of <30.00 to 100 µg/m^3 for the public places. Formaldehyde is recognised to induce acute poisoning and cause irritation, as well as other immune-toxic effects. As a result of its reactivity, inhaled formaldehyde is rapidly and almost entirely absorbed by the mucous tissues lining the upper respiratory tract. However, when supplied at low or medium concentrations, it cannot penetrate farther than the major bronchi of the respiratory tract (Bolt et al., 2010). Acute formaldehyde poisoning can result from inhaling its fumes or from swallowing its liquid phase. The severity of its poisoning depends on the inhaled or ingested amount (Ki-Hyun et al., 2011).

Volatile Organic Compounds (VOCs)

The seasonal mean concentration of VOCs across the sixteen sampling stations was less than the National permissible value of <600. 00 µg/m^3, classified as good air quality in the National air quality regulations (NESREA, 2014). The mean concentration values of VOCs at both seasons were less than the NESREA 2014 recommended limit. The effects of VOCs on human health include but are not limited to the irritation of nose, eye and throat (NESREA, 2014). Others are loss of coordination, nausea, headaches, as well as central nervous system, kidney and liver damage (Christine, 2018).

However, many have detectable odour at their source; formaldehyde is one of the most common VOC, a colourless gas with a sharp smell, common in building materials like plywood, particle boards and glue. VOCs are dangerous and inhaling them can be harmful to your health. The effects of VOCs will depend on their chemical makeup, the amount of exposure, and the surrounding ventilation (Christine, 2018).

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Carbon Monoxide (CO)

The seasonal mean concentrations of CO across the sixteen stations were high, except for IITA in which CO was not detected. The presence of relatively high concentrations of CO ranging from 0.33 to 15.83 could be attributed to the anthropogenic activities within and around the sampling stations.

Abam and Unachukwu (2009) compared the level of emissions of air quality parameters for CO (3.30–8.70 ppm) and the level of noise generated (58.50–72.40 dB) in the city of Calabar, Nigeria with the statutory requirements, and reported that the transport associated air pollution in Calabar was really substantial with a potential severe human health consequence. Carbon monoxide (CO) is produced from the combustion of natural and man-made products. Carbon monoxide influences the greenhouse gases that are severely associated with global warming. The effects of CO poisoning are loss of consciousness, weakness, vomiting, nausea, headache and dizziness (Emberson et al., 2018).

CO was reported to be within the safe range in Abuja, and 10 times below the value of 0.01 ppm (Shehu et al., 2019). The mean concentration of 1.87 ppm of CO was reported in Edo State (Goselle & Ibanga, 2019). CO is commonly produced in large concentrations from the combustion of fossil fuels in industries and transportation. Anthropogenic activities exert a substantial influence on the worldwide abundance of CO, and when CO is excessively inhaled, it lowers the amount of oxygen that enters the blood, slows down reflexes, and renders one confused and sleepy (USEPA, 2006). Carbon monoxide has been found to be responsible for more than half of the lethal poisonings that are documented every year, globally (National Safety Council, 1982).

Carbon Dioxide (CO_2)

The mean concentration values of CO_2 obtained in this study were more than the natural range of 0.04 %. The lowest was Aker Junction with 0.008%. There was no significant difference in mean concentration of CO_2 across the months of sampling and seasons. This may be attributed to climate change and increase in rainfall across all the months of sampling. The increase in CO_2 across the sampling points may be attributed to increase in industrialisation, urbanisation and population across the studied areas. The carbon dioxide (CO_2) concentrations of more than 10% may cause convulsions and coma, and CO_2 levels of more than 30% act rapidly, leading to loss of consciousness in seconds. Carbon dioxide, which is blamed for climate warming, has only a natural range volume share of 0.04% in the atmosphere.

Sulphur Oxides (SO) Measured as SO_2

The seasonal mean concentration values of sulphur dioxide (SO_2) obtained across the sixteen sampling stations were less than the National allowable limit of 350.00 µg/m^3 (0.35 mg/m^3). Atmospheric sulphur dioxide, a major oxide of sulphur, can be formed from both anthropogenic and natural sources. On a global scale, the total annual atmospheric flux of sulphur has been estimated to be 140–350 million tons (of which less than 30% is anthropogenic sulphur) in the form of sulphur dioxide, sulfuric acids, and sulphate. The primary and largest anthropogenic source of sulphur dioxide gas is fuel combustion from power generation and industrial processes (US EPA, 2019). Abam and Unachukwu (2009) compared the level of emissions of air quality parameters for SO_2 (0.04–0.15 ppm) and the level of noise generated (58.50–72.40 dB) in the city of Calabar, Nigeria with the statutory requirements, and reported that the

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transport associated air pollution in Calabar was really substantial with a potential severe human health consequence.

The emissions of SO_2 that result in high atmospheric SO_2 concentrations commonly lead to the formation of other sulphur oxides (SO), and SO could easily react with other compounds in the air to form fine particulates, which reduce visibility (US EPA, 2019). SO_2 and other forms of sulphur oxide also contribute to acid rain which is harmful to the ecosystems.

Nitrogen Dioxide (NO_2)

The seasonal mean concentration values of nitrogen dioxide (NO_2) across the sixteen stations were lower than the EGASPIN (2018) standard and the NESREA allowable limit of 200 µg/m^3. The sources of NO_2 include but are not limited to the combustion either from cooking or fires, vehicular sources, flaring and thunderstorms. As an air quality parameter, nitrogen dioxide (NO_2) has multiple roles, which are often difficult or sometimes impossible to separate from one another (Agency for Toxic Substances and Disease Registry [ATSDR], 2004). Abam and Unachukwu (2009) compared the level of emissions of air quality parameters in particulates for NO_2 (0.02–0.09 ppm) and the level of noise generated (58.50–72.40 dB) in the city of Calabar, Nigeria with the statutory requirements, and reported that the transport associated air pollution in Calabar was really substantial with a potential severe human health consequence.

Hydrogen Sulphide (H_2S)

The seasonal mean concentrations of hydrogen sulphide (H_2S) across the sixteen sampling stations were less than the National standard limit of 5.0 µg/m^3. Hydrogen sulphide (H_2S), as a colourless and flammable gas with a distinguishing odour of rotten eggs, is commonly formed naturally as well as from, or due to or as a result of, anthropogenic activities. The natural sources of H_2S are formed from crude oil, refined petroleum products, volcanic gases, natural gas, flaring and hot springs. From anthropogenic activities, such as the purification processes of natural and refinery gases, paper and pulp manufacturing and carbon, H_2S is easily released as emissions to the ambient air. Meanwhile, the respiratory tract is the main target organ of H_2S toxicity and, as a result, the elderly, children and people with asthmatic conditions are the most vulnerable. Following the severe noxious effects and risk exposure associated with high concentrations of H_2S for short times, all associated exposures should be consciously avoided (WHO, 2003).

CONCLUSION

The concentrations meteorological parameters (VOCs, SO_2, NO_2, CO, CO_2, H_2S, HCHO and NH_3) were instantly and directly determined and monitored from the sixteen sampled points. The mean concentrations of some air quality parameters were remarkably higher than the AQS, thereby raising potential environmental and human health risks across the stations. The high concentrations of some parameters above the permissible limits in the studied areas were attributed to the environmental activities caused by industrialization and urbanisation.

Prolonged exposure to air pollution in the studied areas may lead to health impact of metals, for carcinogenic and non-carcinogenic metals.

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