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Determining The Concentration of Criteria Pollutants in Bonny Island from Industrial Activities

E. E. AUSTIN[1], M. J. AYOTAMUNO[2], D. D. DAVIES[3]
[1]*Department Of Industrial Safety and Environmental Engineering Technology, Federal Polytechnic of Oil And Gas, Bonny Island, Rivers State.*
[2,3]*Department Of Agric/Environmental Engineering, Rivers State University (Rsu) Port Harcourt, Rivers State.*

Abstract- ***This research paper presented the investigation of the concentration of selected criteria pollutants from Industrial activities in Bonny Island. The research was carried out for a total of two months, each both at the rainy and dry seasons. Readings were taken at a distance of 100meters from the stack emitting gaseous pollutants from the NLNG plant. Air pollutant parameters measured were $PM_{2.5}$, PM_{10}, CO, NO_X, O_3 and SO_2 in line with international standards. The determination of selected criteria pollutants [CO, NO_X, O_3, SO_2, $PM_{2.5}$ and PM_{10}] content of Bonny Island environments during dry and wet seasons at selected sampling point for 2 months each in the studied environment showed concentrations ranging from 0.142 to 0.599, 0.005 to 0.013, 0.011 to 0.023, 0.002 to 0.004, 5.80 to 43.45 and 6.32 to 47.25ug/m^3 for dry seasons of CO, NO_X, O_3, SO_2, $PM_{2.5}$, and PM_{10}; and 0.458 to 0.821, 0.002 to 0.013, 0.011 to 0.027, 0.002 to 0.004, 5.0 to 38.29, and 4.84 to 19.76ug/m^3 for wet season of CO, NO_X, O_3, SO_2, $PM_{2.5}$, and PM_{10} respectively. Results of the analysis conducted showed that CO, NO_X, O_3, SO_2, $PM_{2.5}$, and PM_{10} concentration were below World Health Organizations [WHO] allowable limits and are acceptable for human.***

Keywords: Criteria pollutants, Industrial activities, Air pollution.

I. INTRODUCTION

According to Ukpere et al. (2018), environmental pollution is the introduction, release, or addition of any biological, chemical, physical, or radiological substance into any of the environment's component parts (air, water, land, or soil) at a rate faster than the rate at which the environment can naturally accommodate it through the process of absorption, dispersion, or decomposition (breaking down); and which threaten the quality of life. Environmental pollution, then, is any unfavorable alteration to the earth's biogeochemical cycles that could endanger human health and the existence of other living things (Leera & Isetima, 2017).

In light of this, Nanyelulgo and Godwin (2012) assert with particularity that "environmental pollution, that causes significant harm to the earth, is one of the greatest problems facing the Niger Delta region in Nigeria. Ukpere et al (2018) claim that the Niger Delta region has been engaged in oil exploration and exploitation for many years. It has had terrible effects on the local ecosystem. In the world, despite the fact that the oil industry located in this region has significantly contribute to the growth and development of the nation, its impacts on the environment is overwhelming (Mark, 2015).

Leera et al. (2017) noted that against this backdrop, "the negative impact of these multi-national oil companies and allied oil related activities (e.g., bunkering and illegal refining of crude oil) on environmental media constitutes a serious threat to the entire Niger Delta environment and renders the entire ecosystem unsustainable.

Environmental contamination brought on by oil drilling and related operation is one of the dangerous environmental issues that plague Bonny Island of Rivers State in Nigeria's Niger Delta (Ede et al, 2011). Oil spills continue to be one of the most notable causes of water and soil pollution in areas that produce oil, whereas gas flaring, industrial effluents, and equipment utilized in oil industry operations are the main sources of air pollution (Edopka & Ede, 2013). These include NLNG facilities. Electric gas turbines, boilers, incinerators, oxidizers and other equipment in the natural gas processing chain. Nnanyelugo and Godwin (2012), reported that air pollution resulted to ecological degradation, environmental contamination, related violations of human rights, excessive inflation, and loss of livelihood.

According to the World Health Organization (2014), exposure to outdoor and indoor air pollution will

cause roughly 7 million fatalities year, or 3.7 or 3.3 million, respectively, of all deaths worldwide. Major urban cities in the developing countries are faced with the peculiar problem of poor air quality, which has resulted into millions of untimely death as well as other adverse environmental impacts including climate change (Salani et al, 2021, Marais et al, 2014).

To prevent health effects from acute occurrences, it is crucial to implement short-term forecasts of peak pollutant concentrations in addition to annual average air quality assessments for health implications (Okunola et al, 2012). Many nations have real-time air quality forecasting (AQF) programs in place to forecast the concentrations of pollutants that pose particular health risks, such as ozone (O_3), nitrogen dioxide (NO_2), and particulate matter with diameters less than and equal to 2.5 mm ($PM_{2.5}$, and PM_{10}, respectively) (Manins 1999; US EPA, 2019; Pudykiewicz & Koziol, 2001; Baklanov and Kukkonen 2007). In order to reduce air pollution and limit exposure to unhealthy levels of air pollution, such information has been used to issue early air quality alerts that allow the government and the public to take precautionary measures like temporarily banning major emission sources, encouraging carpooling, or taking public transportation (Wayland et al., 2002).

Many scholars have researched on the concentration of air pollutants including criteria pollutants.

Assessment of air pollution concentrations near major roads in residential, commercial and industrial areas in urban cities in Nigeria were carried out (Ayodele & Dayo, 2017, Njoku et al, 2016; Obanya et al, 2018, Ojo et al, 2012).

Adepolu et al (2018) estimated the emissions of gaseous Criteria Air Pollutants (CAP) from the road transport system in the Lagos Metropolis.

Salami et al (2021) estimated the emission rates of criteria air pollutants (CAPs) generated from an industrial setting as well as the associated environmental impact on local air quality, using emission inventory methodology and air dispersion model.

Sonibare and Ede (2009) researched on the potential impacts of integrated Oil & Gas plant on Ambient Air Quality. The air quality implications of the SPDC-Bomu Manifold Fire explosion in K-Dere was investigated by Weli and Kobah (2014).

Olamide et al (2015) modelled criteria air pollutant emissions from selected Nigeria Petroleum Refineries.
This research paper is aimed at determining the concentration of criteria pollutants in Bonny Island from Industrial Activities.

Table 1: Air Pollutants in Bonny Island during Dry Season

	Parameters ($\mu g/m^3$)					
Period, day	CO	NO_X	O_3	SO_2	$PM_{2.5}$	PM_{10}
Day 1	0.311	0.008	0.014	0.002	26.89	30.35
Day 2	0.496	0.011	0.011	0.003	43.45	47.25
Day 3	0.142	0.011	0.019	0.002	13.3	14.84
Day 4	0.163	0.013	0.022	0.002	8.52	10.02
Day 5	0.302	0.009	0.023	0.002	10.1	10.93
Day 6	0.599	0.008	0.009	0.003	34	36.61
Day 7	0.544	0.011	0.011	0.002	34.8	37.67
Day 8	0.711	0.005	0.017	0.002	24.14	25.61
Day 9	0.543	0.006	0.019	0.002	13.49	14.65
Day 10	0.589	0.008	0.019	0.003	19.4	20.83
Day 11	0.399	0.007	0.021	0.004	8.38	9.02
Day 12	0.262	0.007	0.016	0.002	9.66	10.49
Day 13	0.25	0.01	0.02	0.002	6.25	6.84
Day 14	0.251	0.007	0.022	0.002	10.18	10.94

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Day 15	0.3	0.006	0.023	0.002	11.1	11.93
Day 16	0.269	0.008	0.015	0.003	16.76	18.29
Day 17	0.305	0.004	0.016	0.002	6.96	7.99
Day 18	0.392	0.006	0.011	0.002	25.61	28.04
Day 19	0.23	0.006	0.015	0.002	5.49	6.32
Day 20	0.202	0.011	0.015	0.002	5.8	6.77
WHO	2	200	50	125	40	50

Table 2: Air Pollutants in Bonny Island during Wet Season

	Parameters ($\mu g/m^3$)					
Period, day	CO	NO_X	O_3	SO_2	$PM_{2.5}$	PM_{10}
Day 1	0.458	0.011	0.02	0.003	4.37	4.84
Day 2	0.51	0.013	0.02	0.004	5.45	5.81
Day 3	0.592	0.006	0.019	0.003	18.55	19.76
Day 4	0.51	0.005	0.027	0.003	3.08	3.34
Day 5	0.643	0.006	0.012	0.002	17.37	18.31
Day 6	0.524	0.004	0.018	0.002	11.2	11.9
Day 7	0.57	0.005	0.017	0.003	6.4	6.82
Day 8	0.766	0.003	0.016	0.002	12.1	12.76
Day 9	0.541	0.005	0.027	0.002	5	5.31
Day 10	0.596	0.006	0.019	0.004	11.76	12.39
Day 11	0.821	0.003	0.011	0.003	38.29	40.3
Day 12	0.597	0.008	0.016	0.002	8.13	8.42
Day 13	0.77	0.005	0.012	0.003	16.54	17.35
Day 14	0.652	0.002	0.012	0.003	20.62	21.82
Day 15	0.569	0.007	0.017	0.002	5.9	6.18
Day 16	0.523	0.003	0.024	0.002	5.84	6.13
Day 17	0.52	0.002	0.017	0.002	9.6	10.07
Day 18	0.531	0.003	0.02	0.002	9.21	9.76
Day 19	0.758	0.004	0.018	0.004	11.86	12.32
Day 20	0.599	0.005	0.027	0.002	11.19	11.49
WHO	2	200	50	125	40	50

II. MATERIAL AND METHODS

2.1 Materials

2.1.1 Description of Study Area

The study area is Bonny local governments area in Rivers State with the heavy presence of multinational companies' operation. Bonny Island lies on apart of 40 kilometers south of Port Harcourt (Figure 3.1), with latitudes 4°52'N and 5°02'N, and longitudes 6°56'E and 7°04'E, with an estimated population of 309,200 people (Population Density, 2022). The Island has a rather flat topography, with an elevation of 3.05 atmospheric mean sea level and a total land area of 214.52m^2, with tidal floods and land subsidence affecting 70% of its size (NLNG, 2005). The island is directly connected to the Atlantic Ocean, where giant oil tankers export crude oil. The rainfall in the Bonny Island ranges from 2301 to 3670 mm during the wet season (March to November) and 43 to 97 mm during the dry season (December to March) (Adejuwon, 2012).

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Figure 2.1: Map of Bonny Island

2.1.2 Sampling Design

The design has 20 sampling points with 3 replicates consisting of 60 sampling points for air pollutants. These were carried out during dry and wet seasons for two different months, respectively. The sample were collected at a distance of 100 m away from the discharging point.

2.1.3 Sample Collection

Air sample were collected from twenty sampling points using digital gas monitor, giving an instantaneous reading/recording of data. The digital gas monitor is a high-volume sampler (Environed HVS APM – 410/451). The sampler has attachment APM – 411 for gas analysis. It was set at a height of 3 meters from the ground at the designated sampling points.

Air samples were collected for dry and wet seasons. Samples were collected during the time of active release of the pollutants. Sampling was done during the day time at regular intervals for a period of 8 hours according to Rao and WHO guidelines.

High grade high filter paper (GF/A) was used in the HVS for SPM. SOx and NOx were measure after the collected air was passed through the absorbent solutions. The absorbent solution is then analysed by UV/VIS spectrophotometer. A potable toxic gas monitor was used to measure the parameters.

In order to have effective sampling, some factors were taking into consideration. They include: meteorological, pollution sources and processes. The meteorological factors of interest are wind speed, wind direction, temperature, and humidity. Pollution sources such as gas plants and other industrial equipment use for oil and gas activities.

III. RESULTS AND DISCUSSION

3.1 Concentration of Criteria Pollutants (CO, NO_x, O_3, SO_2, PM $_{2.5}$, and PM_{10}) of Bonny Island Environment

Table 1 and 2 showed the results of the criteria pollutants including (CO, NO_x, O_3, SO_2, PM $_{2.5}$, and PM_{10}). The results for the various pollutants are discussed as below:

3.1.1 Carbon Monoxide (CO)

Figures 3.1 and 3.2 showed the CO results of the sampling point during dry and wet seasons in Bonny Island environment. These analytical results are presented in tables A1 and A2 according to the location and the days in which the samples were collected. The results showed discrepancies in the days of collections. This might be due to the rate at which emissions were released from the stack to the atmosphere. The release of emissions varies as there was increased and decreased of the concentration of CO in the Bonny Island environment thereby fluctuating the contamination level of the air.

From the experimental results, the CO concentrations in the Bonny Island atmosphere were below the permissive value of 2.0µg/m^3, respectively for both

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dry and wet seasons of 20 days of the experiment. This revealed that the air is suitable for human inhalation, which means it does not possess threat to the inhabitants of the Bonny Island. It also showed that the studied area is not polluted with CO in the atmosphere; hence inhaling the air will not be harmful to the inhabitant of Bonny Island due to its low content in the air. This supports the finding of Nnanyelugo and Godwin (2012), which is used to demonstrate that no element of the physical environment can be considered to be polluted until it has undergone a change in form or function that has the capacity to immediately or indirectly harm humans.

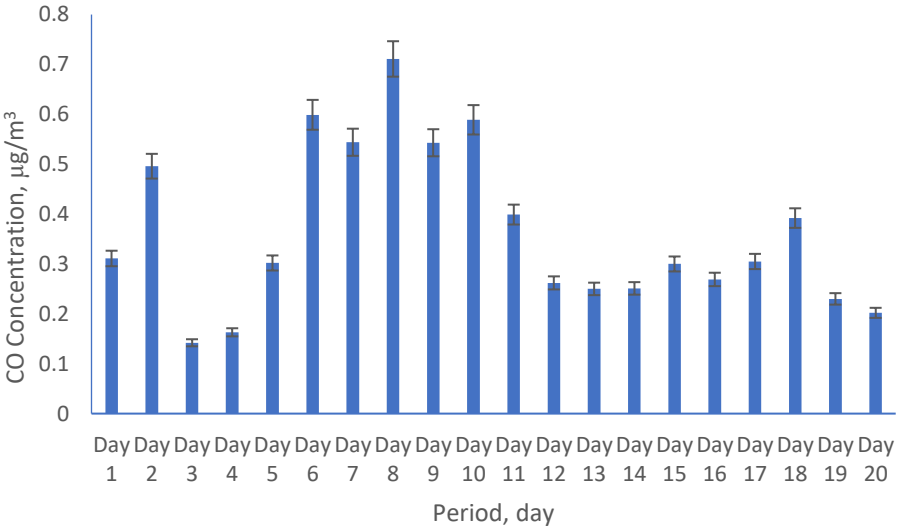

Figure 3.1: Plot of CO in Bonny Island during Dry Season with Percent Error Bar

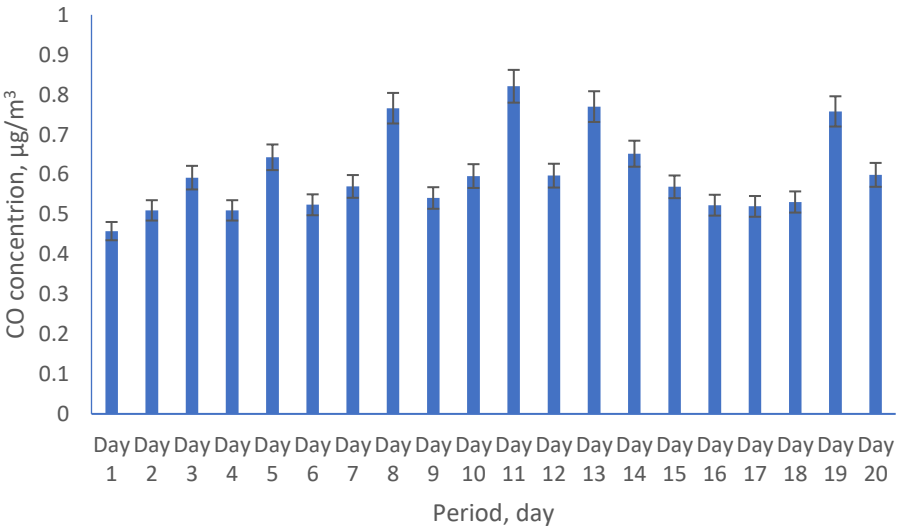

Figure 3.2: Plot of CO in Bonny Island during Wet Season with Percent Error Bar

3.1.2 Nitrogen Oxide (NOx)

Figure 3.3 and 3.4 showed the NOx results of the sampling point during dry and wet seasons in Bonny Island.

These analytics results are presented in tables 1 and 2 according to the location and the days in which the samples varies the increased and decreased of the concentration of NOx in Bonny Island. Thereby fluctuating the contamination level of the air.

From the experimental results, the CO concentrations in the Bonny Island atmosphere were below the permissive value of 200µg/m^3, respectively for both dry and wet seasons of 20 experiment. This revealed

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that the air is suitable for human inhalation, which means it does not possess threat to the inhabitants of the Bonny Island.

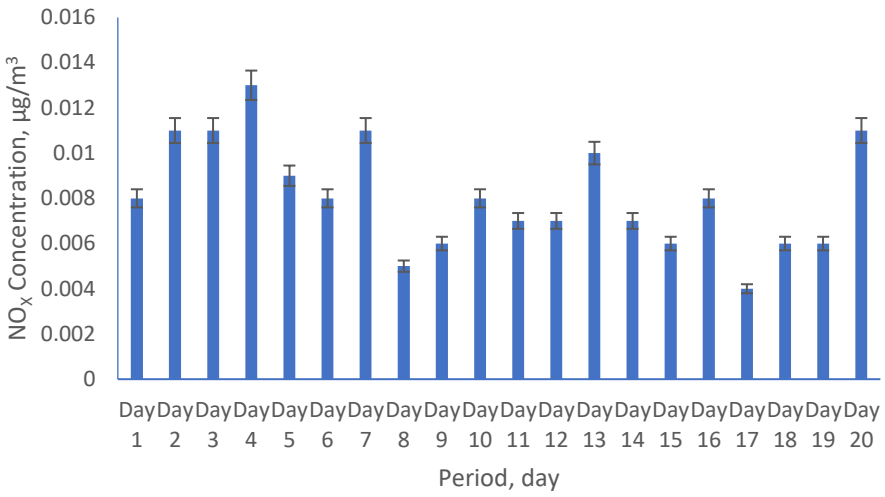

Figure 3.3: Plot of NO_X in Bonny Island during Dry Season with Percent Error Bar

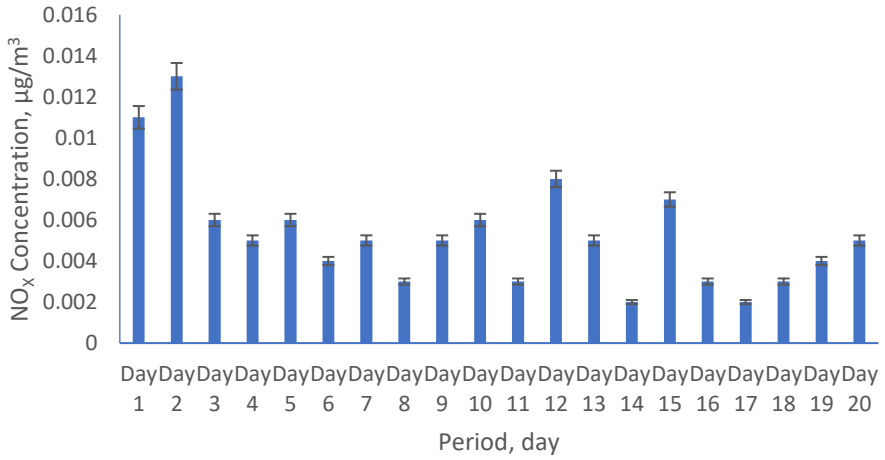

Figure 3.4: Plot of NO_X in Bonny Island during Wet Season with Percent Error Bar

3.1.3 Ozone (O_3)

Figures 3.5 and 3.6 showed the O_3 results of the sampling point during dry and wet seasons in Bonny Island environs. These analytical results are presented in tables A1 and A2 according to the location and the days in which the samples were collected. The results showed discrepancies in the days of collections. This might be caused by the rate at which emissions were released from the stack to the atmosphere. The release of emissions varies as there was increased and decreased of the concentration of O_3 in the Bonny Island environment thereby fluctuating the contamination level of the air. From the experimental results, the O_3 concentrations in the Bonny Island atmosphere were below the permissive value of 50µg/m^3, respectively for both dry and wet seasons of 20 days experiment. This revealed that the air is suitable for human inhalation.

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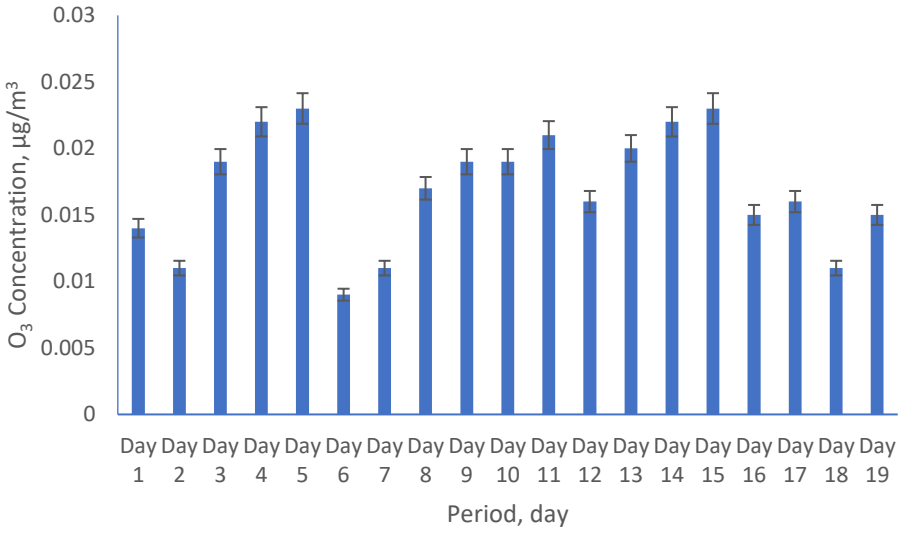

Figure 3.5: Plot of O_3 in Bonny Island during Dry Season with Percent Error Bar

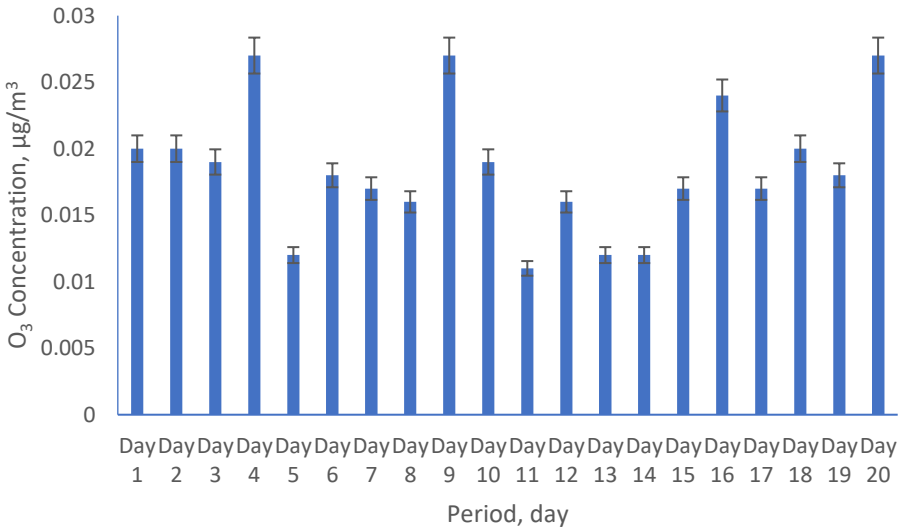

Figure 3.6: Plot of CO in Bonny Island during Dry Season with Percent Error Bar

3.1.4 Sulphur dioxide (SO_2)

Figures 3.7 and 3.8 showed the SO_2 results of the sampling point during dry and wet seasons in Bonny Island environs. These analytical results are presented in tables A1 and A2 according to the location and the days in which the samples were collected. The results showed discrepancies in the days of collections. This might be caused by the rate at which emissions were released from the stack to the atmosphere. The release of emissions varies as there was increased and decreased of the concentration of SO_2 in the Bonny Island environment thereby fluctuating the contamination level of the air.

From the experimental results, the SO_2 concentrations in the Bonny Island atmosphere were below the permissive value of 125µg/m^3, respectively for both dry and wet seasons of 20 days experiment. This revealed that the air is suitable for human inhalation, which means it does not possess threat to the inhabitants of the Bonny Island. It also showed that the studied area is not polluted with SO_2 in the atmosphere; hence inhaling the air will not be harmful to the inhabitant of Bonny Island due to its low content in the air.

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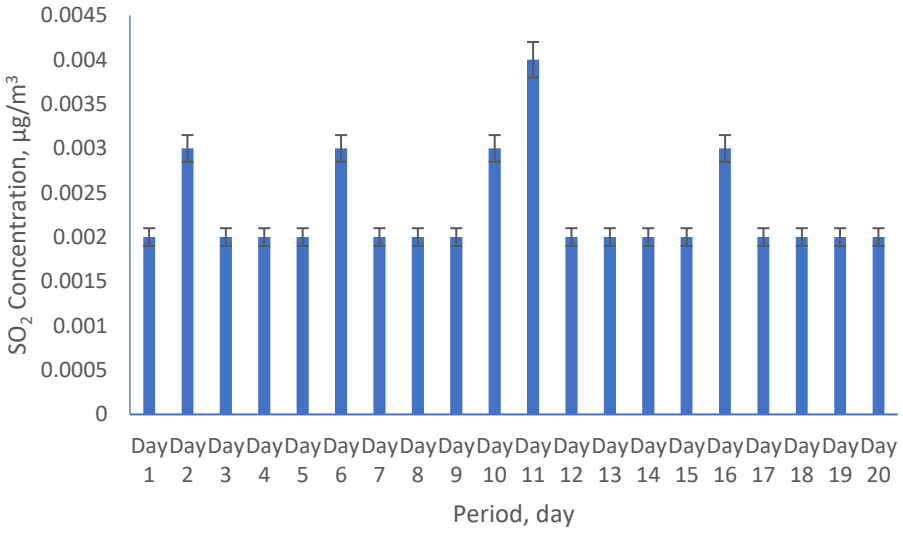

Figure 3.7: Plot of SO_2 in Bonny Island during Dry Season with Percent Error Bar

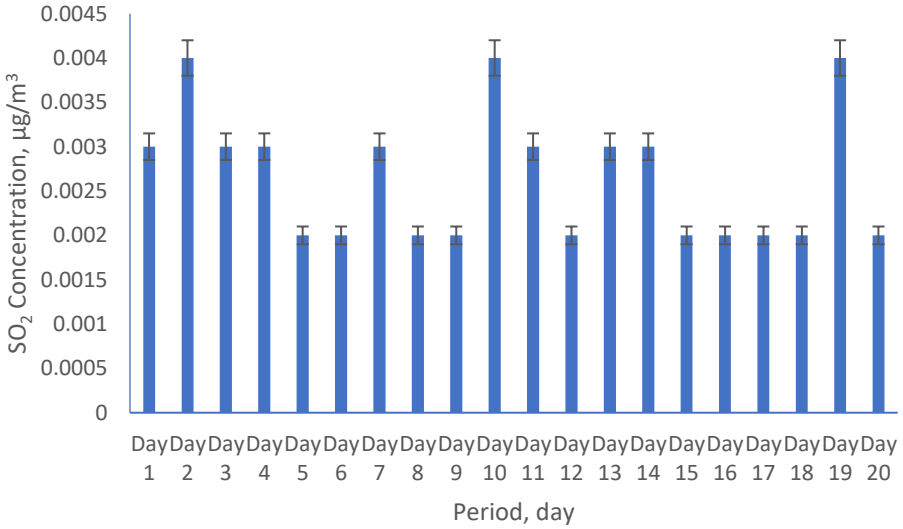

Figure 3.8: Plot of SO_2 in Bonny Island during Wet Season with Percent Error Bar

Figures 3.9 and 3.10 showed the $PM_{2.5}$ results of the sampling point during dry and wet seasons in Bonny Island environment. These analytical results are presented in tables A1 and A2 according to the location and the days in which the samples were collected. The results showed discrepancies in the days of collections. This might be caused by the rate at which emissions were released from the stack to the atmosphere. The release of emissions varies as there was increased and decreased of the concentration of $PM_{2.5}$ in the Bonny Island environment thereby fluctuating the contamination level of the air during dry and wet seasons.

From the experimental results, it indicates that the $PM_{2.5}$ concentrations in the Bonny Island atmosphere were below the permissive value of 40µg/m^3, respectively for both dry and wet seasons of the 20 days of the experiment. This revealed that the air is suitable for human inhalation, which means it does not pose threat to the inhabitants of the Bonny Island. It also showed the studied area is not polluted with $PM_{2.5}$ in the atmosphere; hence inhaling the air will not be harmful to the inhabitant of Bonny Island.

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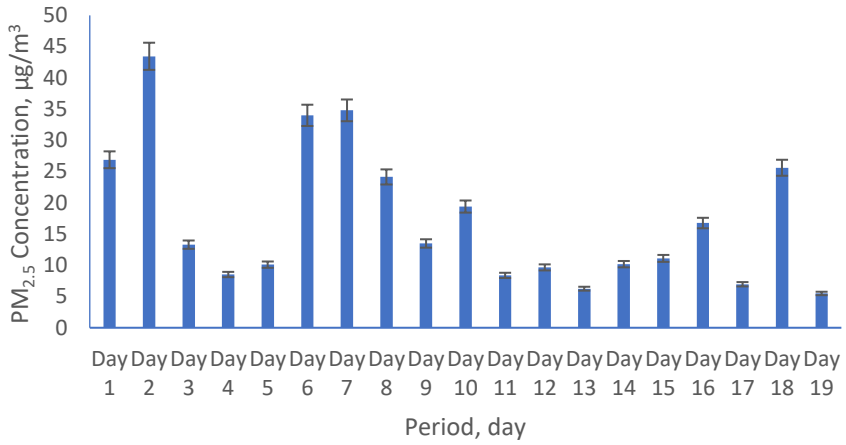

Figure 3.9: Plot of $PM_{2.5}$ in Bonny Island during Dry Season with Percent Error Bar

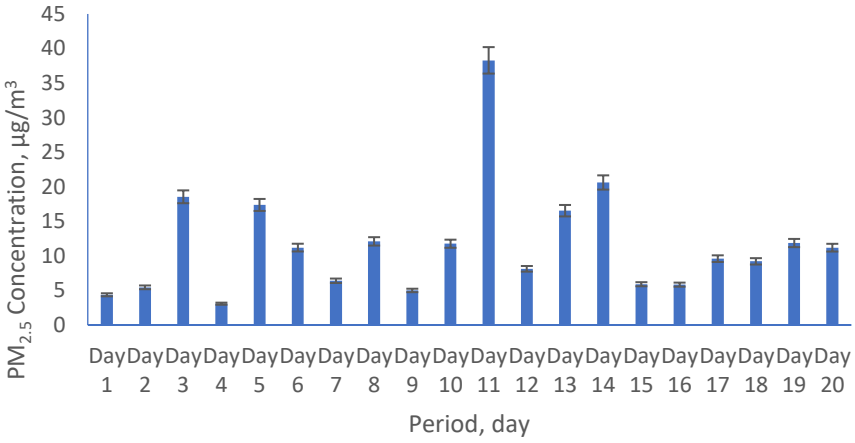

Figure 3.10: Plot of $PM_{2.5}$ in Bonny Island during Wet Season with Percent Error Bar

3.1.6 Particulate Matter (PM_{10})

Figures 3.11 and 3.12 showed the PM_{10} results of the sampling point during dry and wet seasons in Bonny Island environment. These analytical results are presented in table A1 and A2 according to the sampling location and the days in the samples were collected. The results showed discrepancies in the days of collections. This might be caused by the rate at which emissions were released from the stack to the atmosphere. The release of emissions varies as there was increased and decreased of the concentration of PM_{10} in the Bonny Island environment thereby fluctuating the contamination level of the air. According to Zhang et al. (2019), an exposure error (Berkson error) seems to be produced as PM_{10} concentrations vary spatially, and the relative magnitudes of the short- and long-term effects are still not fully understood. Nnanyelugo and Godwin (2012) stated that "the environment is polluted when there is substantial alteration in form and function of the components of the physical environment that in turn produces harmful effects on humans.

From the experimental results, the PM_{10} concentrations in the Bonny Island atmosphere were below the permissive value of 50µg/m^3, respectively for both dry and wet seasons of the 20 days of the experiment. This revealed that the air is suitable for human inhalation, which means it does not pose threat to the inhabitants of the Bonny Island. It also showed the studied area is not polluted with PM_{10} in the atmosphere; hence inhaling the air will not be harmful to the inhabitant of Bonny Island due to its low content in the air. This supports the finding of Nnanyelugo and Godwin (2012), which is used to demonstrate that no element of the physical environment can be considered to be polluted until it has undergone a change in form or function that has the capacity to immediately or indirectly harm humans.

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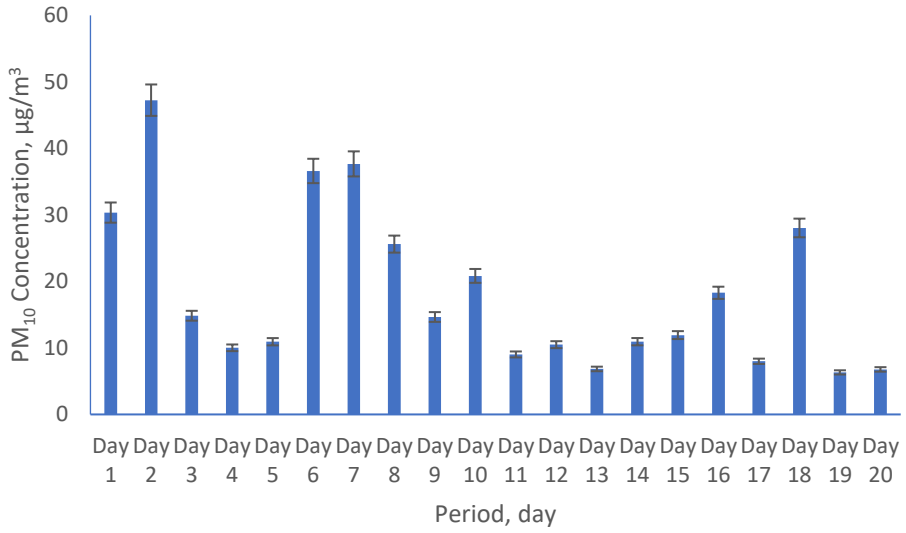

Figure 3.11: Plot of PM_{10} in Bonny Island during Dry Season with Percent Error Bar

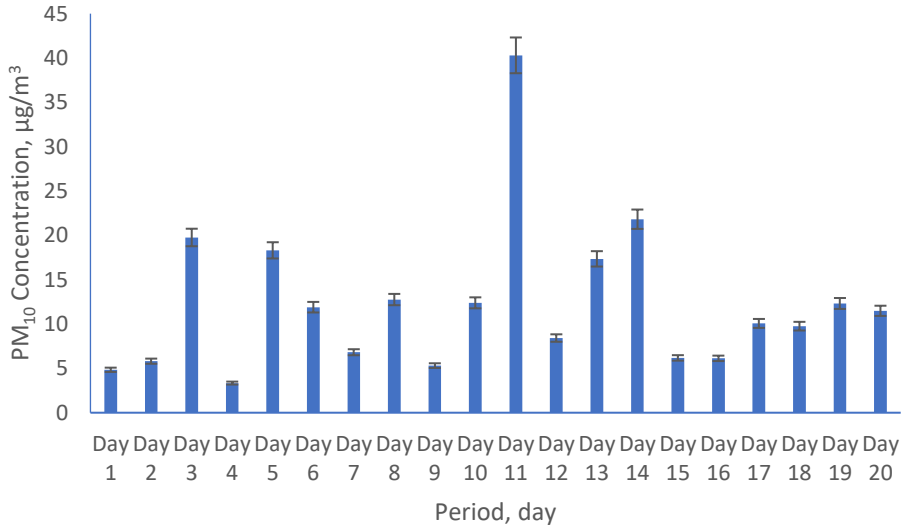

Figure 3.12: Plot of PM_{10} in Bonny Island during Wet Season with Percent Error Bar

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The study was based on investigative studies of air pollutants emission from industrial activities in Bonny Island, Rivers State. Analysis of the test results supports the following conclusions:

The determination of gaseous pollutants (CO, NOx, O_3, SO_2, $PM_{2.5}$, and PM_{10}) content of Bonny Island environs during dry and wet seasons at selected sampling point for 28 days each in the studied environment showed concentrations ranging from 0.142 to 0.599, 0.005 to 0.013, 0.011 to 0.023, 0.002 to 0.004, 5.80 to 43.45, and 6.32 to 47.25 µg/m^3 for dry season, and 0.458 to 0.821, 0.002 to 0.013, 0.011 to 0.027, 0.002 to 0.004, 5.0 to 38.29, and 4.84 to 19.76 µg/m^3 for wet season of CO, NO_X, O_3,and SO_2, respectively, in the air were below WHO standard and acceptable for human usage.

4.2 Recommendations

The recommendations drawn from this study are as follows:

i. Further research should be carried out on the effects of air dispersion on particulate matter, and gaseous pollutants.

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