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SPATIAL VARIATION OF NO_2 AND SO_2 IN THE AMBIENT ENVIRONMENT OF IMO STATE, NIGERIA

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Abstract: To investigate the spatial variation of Sulphur dioxides, (SO_2) and nitrogen dioxide, (NO_2), weekly air quality data of SO_2, and NO_2 concentrations from twenty two (22) air quality monitoring stations located at four (4) locations in Imo State were collected from November 2014 to June 2015. The average concentration of NO_2 and SO_2 in the locations ranged from 0.46 – 0.54 ppm and o.46 – 0.56 ppm respectively. The mean values of SO_2 and NO_2 exceeded both the US National Ambient Air Quality Standard and Nigerian National Ambient Air Quality Standard. The spatial distribution of the air pollutants as depicted with spatial variation and 3-D surface plots, and spatial variation maps indicates that elevated concentration of the air pollutants were observed in Owerri compare to other locations. Also on the basis of time, higher concentration of the pollutants were recorded in the afternoon and evening hours. The high concentrations of pollutants recorded in the study locations calls for concern and may pose environmental health challenges in the area.
Keywords: Spatial, variation, air, pollutants, ambient, environment.

Introduction

One of the basic requirements of human existence is clean air, but air pollution has continued to pose significant threat to this basic human need and environmental health worldwide (Hassan and Abdullahi, 2012). The problem of air pollution is a serious threat to environmental health in many cities of the world (Kan et al., 2009, Wong et al., 2008, McCarthy et al., 2007). Air pollution has been recognized as a major challenging environmental problem that has bedeviled both the developed and developing countries of the world, which has been linked to increased morbidity and mortality rates (Pope et al, 1995; Laden et al, 2000; Ngele and Onwu, 2015). The severity of air pollution problems in the cities reflects the level and speed of development (APMA, 2002; Molina et al., 2004; Grutter et al, 2014). The concentration of air pollutants vary spatially and temporarily causing the air pollution pattern to change with different locations and time due to changes in meteorological

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and topographical condition. This arises due to the concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions (Sengupta, 2003). Again, the spatial variation in air pollution concentration is hinged on the space variation of sources as well as atmospheric gradients which results in diffusion and transportation to areas outside the source of the air pollution (Ogba and Utang, 2009).

Fluctuations in time of the year or seasons have been reported to affect the observed air quality as this could influence dispersal of air pollutants by either decreasing or increasing their concentration in the atmosphere. Difference in the ambient temperature, relative humidity and wind speed including wind direction could also vary the concentration of atmospheric pollutants over the seasons (Kim et al 2015). It is important to note that low wind speed and high relative humidity do not facilitate rapid atmospheric pollutant dispersal and hence these pollutants may be trapped near the surface of earth. This effect could result in the increased concentration of air pollutants at a particular location depending on the elevation of the area. In this part of the world where there is two distinct seasons the atmospheric pollutants may vary spatially, for instance, during dry season when the relative humidity is moderately low with a higher wind velocity and the pollutants have higher tendency of being swiftly dispersed, as noted by Bhatia (2003) that air pollutants are disperse more in the dry season than in the wet season.

Study of the changes in the concentrations of SO_2 and NO_2 is an important environmental issue that calls for adequate concern. This has become necessary owning to the fact that both air pollutants contribute significantly to the formation of acid rain (Adachi et al, 1990; Akpan ,2003; Ideriah and Stanley, 2008; Ubouh, 2012). SO_2 is regarded as being the most important phytotoxic air pollutant emitted from industrial sources and NO_2 as the second most important (Fowler and Cape, 1982; Ashmore, 2005). Apart from NO_2 being a major gas that affects the atmospheric environment and indirectly causes climate change (Kim et al 2015). NO_2 plays a significant role in the formation of ground level ozone which involves photochemical oxidation reactions with CH_4 and CO (Aneja et al., 1996). It also reduces the lifetime of methane in the atmosphere which leads to disruption of radiation balance (IPCC, 2007). SO_2 is one of the major urban air pollutants and the main source of the pollutants is fossil fuel combustion and the use of sulphur laden coal (Pan et al, 2013). Sulphur dioxide is released into the atmosphere in large quantities by natural process. An important source is from the action of anaerobic bacteria in marshes, forming hydro-gen sulphide (H_2S), which is oxidized to sulphur dioxide (SO_2) and sulphur trioxide (SO_3) in the atmosphere (Akabueze et al 2012). Sulphur and sulphur gases are also emitted in large quantities as a result of volcanic activity and forest fire (Mohammed et al, 2013). The concentration of these atmospheric pollutants must have increased significantly due to the large influx of old and fairly used vehicles imported into the country following changes in government policy (Abam and Unachukwu, 2009). This is compounded by poor vehicle maintenance culture and presence of a class of vehicles known as "super emitters" that emits more harmful air pollutants which may elevate the level of these pollutants (USEPA, 2009). This is also supported by the fact that increases in SO2 emissions could be associated with increase in motor vehicle population (Gurjar et al., 2004). Also air pollution events such as dust storms, biomass combustion, and firework displays, which take place on many occasions in certain periods, may impact negatively to the air quality (Huang et al, 2015). Nigeria like many developing counties do not have continuous air quality monitoring stations and lack air quality data base, hence the need for regular quality report in this regard.

Materials and Methods

Study Area

Fig.1 is the map showing the study locations and sites, the research was conducted in Imo State (fig.1), which is located in the tropical rainforest zone climate, dominated by plains with elevation ranging from 50-200m above sea level. The annual rainfall is about 2400mm to 4000mm, which is concentrated almost entirely between April and October, with average relative humidity of about 80% and up to 90% occurring during the wet season. The maximum air temperature ranges from 28 to 38^0C, while the minimum air temperature range from 19^0C to 24^0C (Chiemeka, 2010; Ubuoh and Akhionbare, 2011; Okoro et al, 2014a, okoro et al 2014b).

Description of Study area

The state is rich in natural resources including crude oil and natural gas mainly within Ohaji, Egbema and Oguta, and the oil wells have taps to large quantities of natural gas, with an estimated reserve of about 1422 billion cubic meters (Odeyemi and Ogunseitan, 1985). Part of this gas has been continuously flared in the Niger Delta region since 1970 (NNPC, 1984). Also Orlu city is fast growing with a lot of commercial activities, use of power generators, high volume of vehicular traffic and presence of two stroke engine automobiles like motorcycles and tricycle. Owerri, the capital of Imo State has high population density (FR N Official Gazette 2007) with a lot of commercial activities, use of power generators, high volume of vehicular traffic and presence of two stroke engine automobiles like motorcycles and tricycles used for transportation which is known for incomplete combustion of fuel which could lead to the emission of noxious atmospheric air pollutants (Sengupta, 2003). The study therefore was conducted in Owerri, Orlu, Okigwe and Egbema area of Imo State, Nigeria.

2.3 Air quality sampling Procedure

The air pollutants SO_2 and NO_2 were sampled three times a day (morning, afternoon and evening) with Gasman hand held detector (Crowcon Instruments Ltd, England). Sampling was carried out for six months during dry and wet seasons, between November 2014 and June 2015. The sampling was carried out once a week at each of the 22 air monitoring locations, three times per day, four times a month for a period of six (6) months. The air quality sampling which was in two seasons, wet and dry season was carried out for a period of three months in each of the seasons. The concentration of the air pollutants were determined by the Gasman detector specific for the pollutants switch on and held at about 2m above ground level, then concentration recorded from the digital display when the reading becomes stabilized, and this was done in each of the 22 air quality sampling sites.

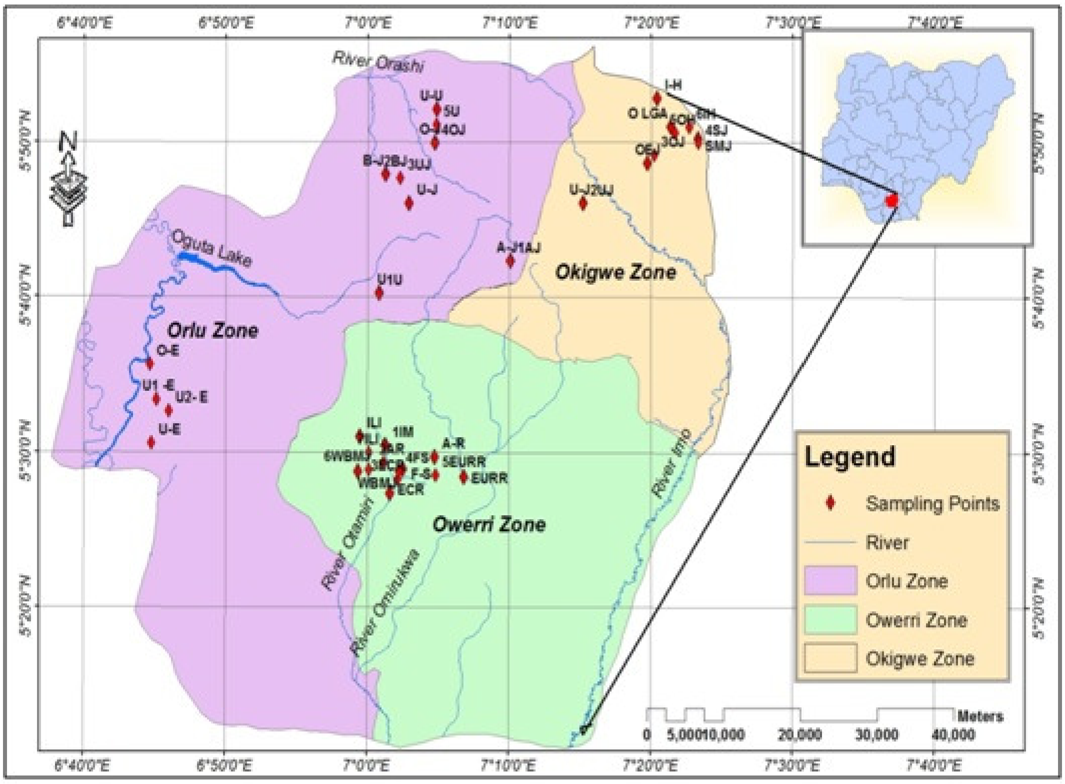


Fig 1: Map of Orlu showing air pollution monitoring locations

2.4 Method of Data Analysis

Data analysis was done using Microsoft excel 2007 and values of all the results from the 22 sampling points in the four locations were recorded as calculated mean values and standard deviation (SD) of the air pollutant concentrations in the morning, afternoon and evening hours. Spatial variation and 3-D surface plots of the air pollutant concentrations were modeled using Surfer 12 software, while spatial variation maps of the pollutants were modeled with Arc GIS 10.2 software and these were presented as choropleth maps to visualize the spatial distribution of the atmospheric pollutants concentrations associated with the geographical location of the areas sampled.

Results and Discussion

3.0 Results

Table 1 and 2 are the summary of the mean, minimum, maximum and standard deviation of NO_2 and SO_2 values obtained from the 22 sampling sites in the four locations, while fig. 2 to 5 are the wet and dry season spatial and 3-D plots of the air pollutants concentrations obtained from the 22 sampling sites. Also, fig.6 to 9 is NO_2 and SO_2 maps for dry and wet season showing their spatial distribution in the air quality monitoring locations.

Table 1: Summary of wet season mean concentration of the air pollutants

	NO_2 (ppm)			SO_2(ppm)		
	Morning	Afternoon	Evening	morning	Afternoon	Evening
Mean	0.46	0.54	0.53	0.46	0.54	0.56
Min	0.26	0.29	0.32	0.20	0.24	0.25
Max	0.59	0.71	0.95	0.71	0.87	0.85
SD	0.08	0.09	0.13	0.14	0.15	0.16

(where Min = minimum value, Max = maximum value, SD= Standard deviation)

Table 2: Summary of wet season mean concentration of the air pollutants

	NO_2 (ppm)			SO_2(ppm)		
	Morning	Afternoon	Evening	morning	Afternoon	Evening
Mean	0.44	0.48	0.45	0.37	0.43	0.45
Min	0.22	0.23	0.23	0.14	0.21	0.18
Max	0.65	0.66	0.62	0.60	0.65	0.82
SD	0.12	0.12	0.11	0.13	0.14	0.18

(where Min = minimum value, Max = maximum value, SD= Standard deviation)

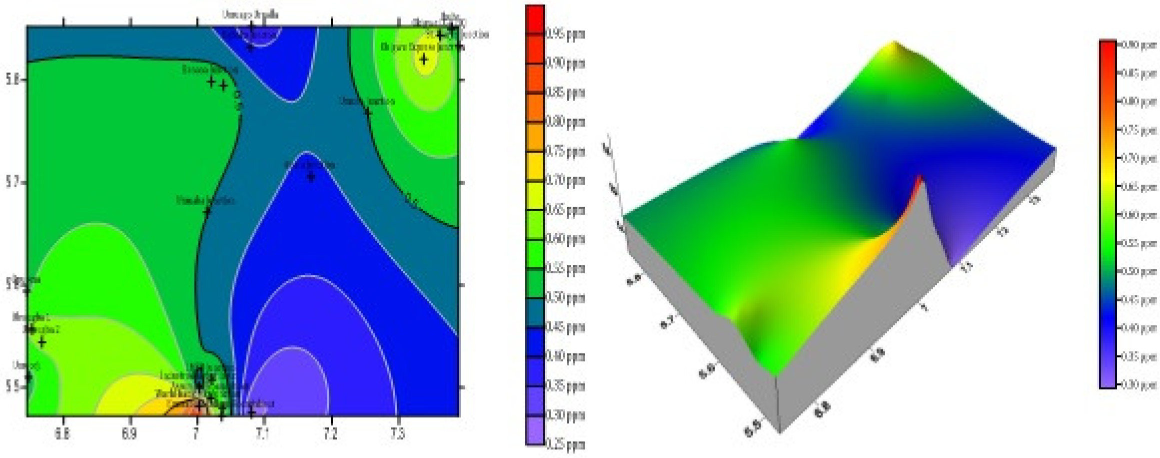


Fig.2: Spatial variation and 3-D plots NO_2 mean concentration (wet Season)

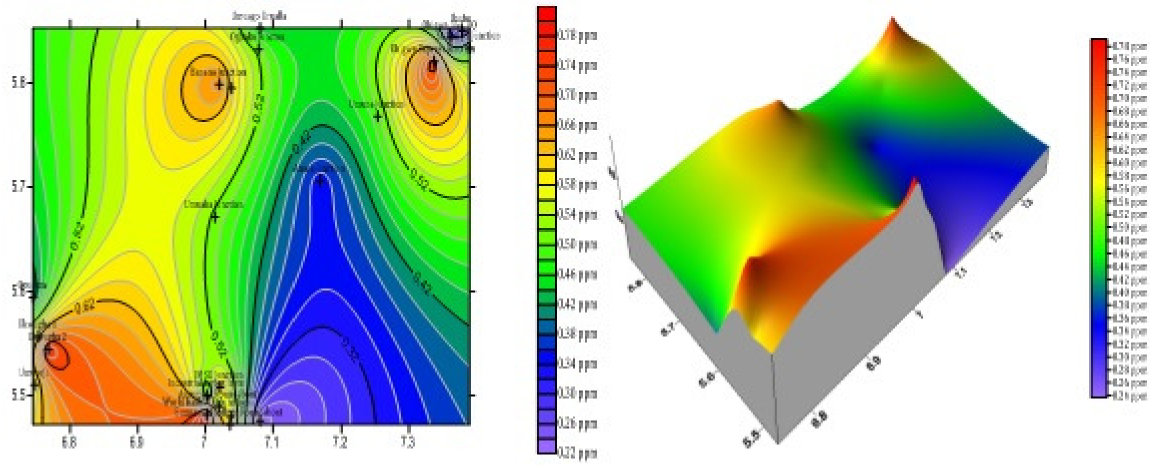


Fig.3: Spatial variation and 3-D plots of $S0_2$ mean concentration (wet season)

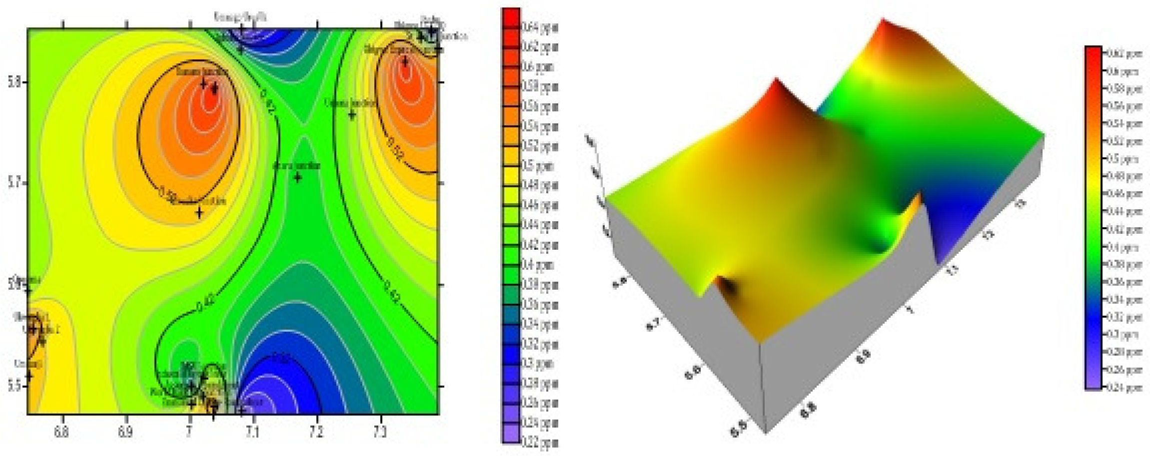


Fig.4: Spatial variation and 3 – D plots of NO_2 mean concentration (dry season)

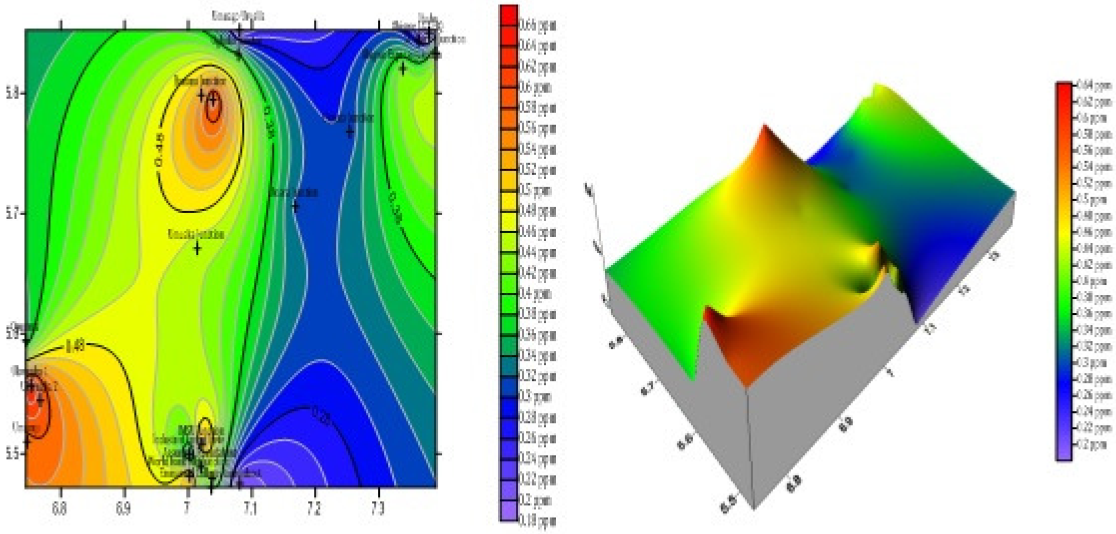


Fig. 5: Spatial variation and 3-D plots of SO_2 mean concentration (dry season)

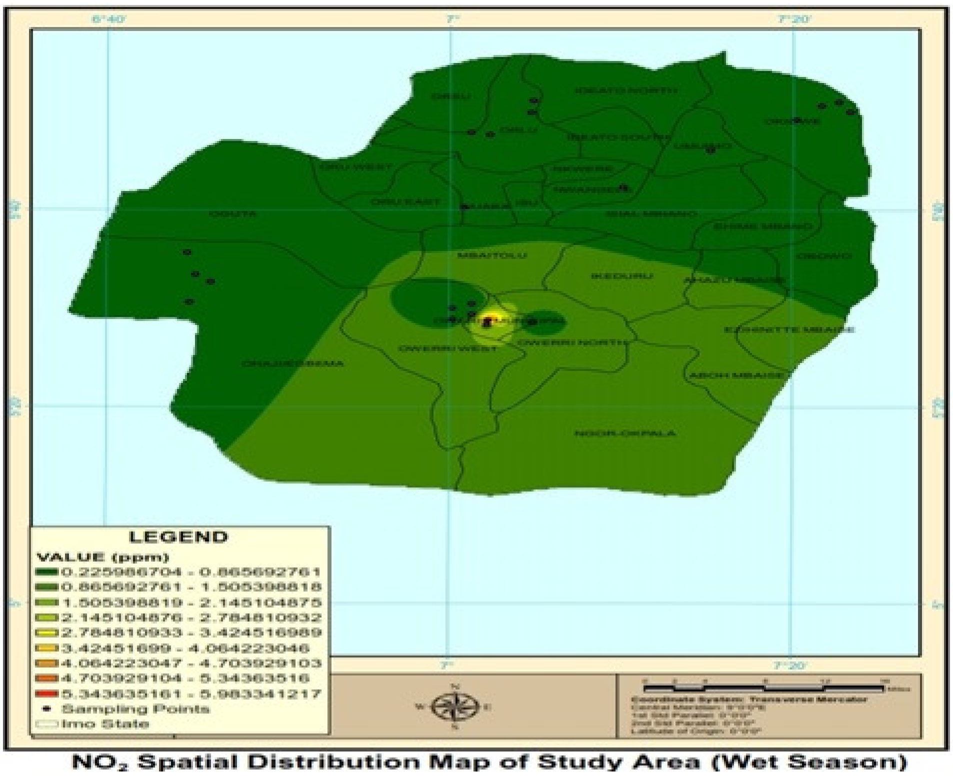


Fig. 6: Spatial distribution map of NO_2 in wet season

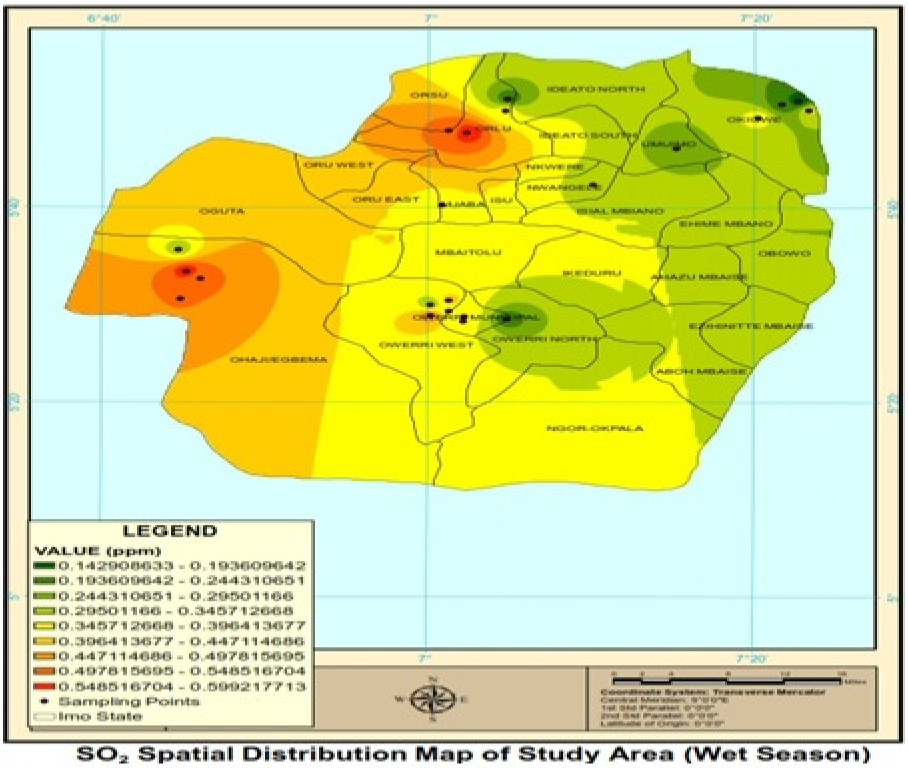


Fig.7: Spatial distribution map of SO_2 concentration in wet season

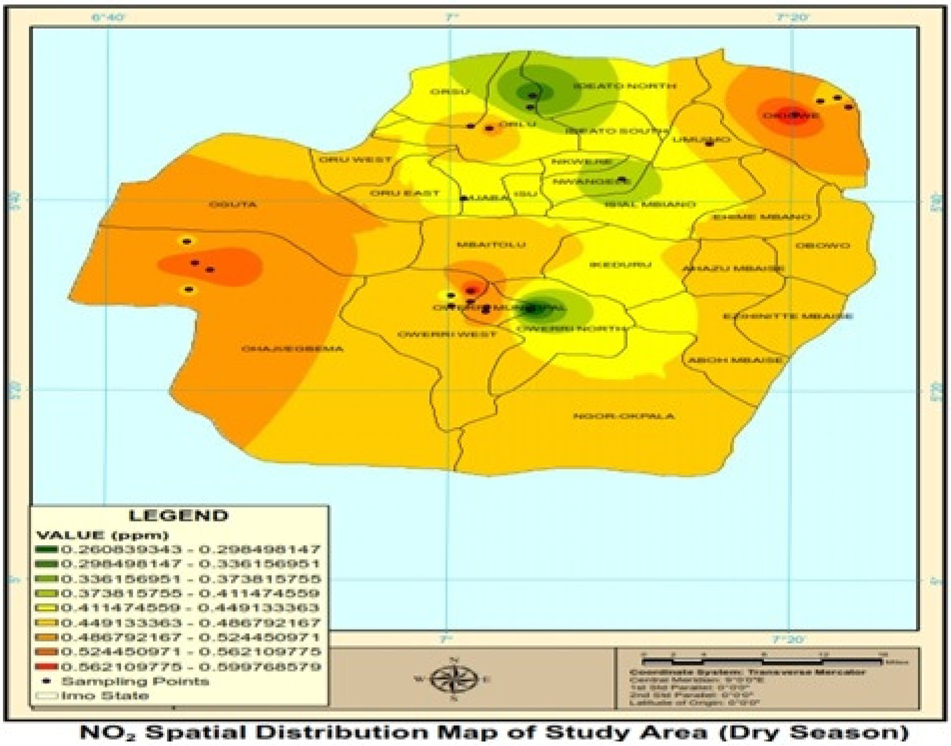
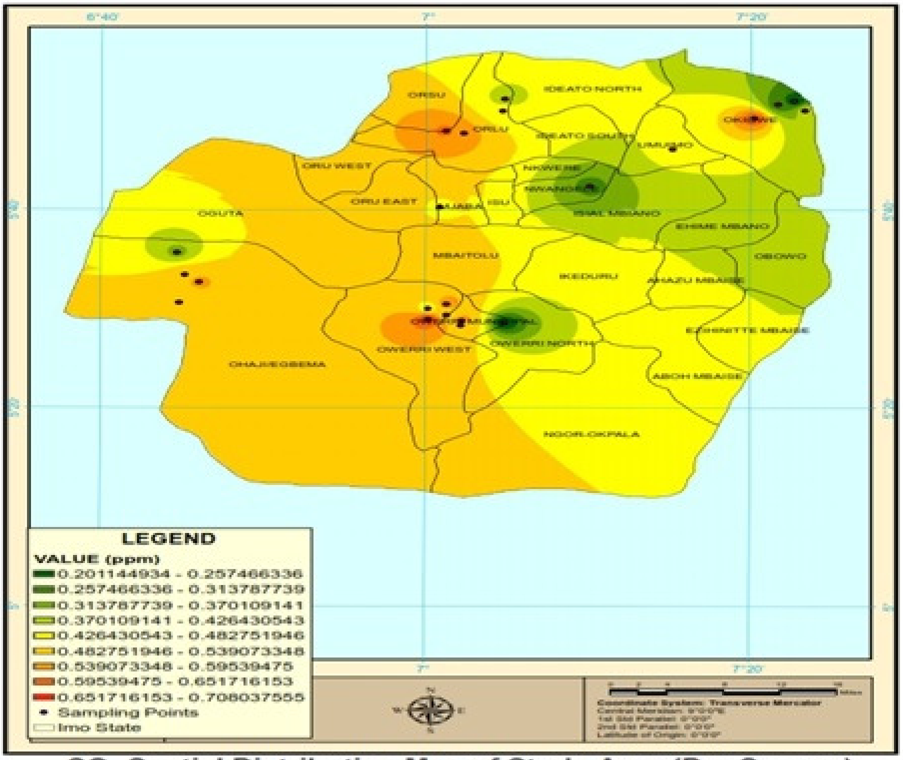


Fig. 8: Spatial distribution map of NO_2 concentration in dry season



SO_2 Spatial Distribution Map of Study Area (Dry Season)

Fig.9: Spatial distribution map of SO_2 concentration in wet season

3.1 Discussion

Table 1, Fig.2, fig. 3, fig.6 and fig.7 are the wet season results of NO_2 and SO_2. The result indicates that the mean values of NO_2 ranged from 0.26 – 0.59 ppm, 0.29 – 0.71 ppm and 0.32–0.95 ppm for morning, afternoon and evening respectively. The mean concentration of SO_2 ranged from 0.20–0.71ppm, 0.24–0.87ppm and 0.25–0.85ppm respectively for morning, afternoon and evening. The highest concentration of NO_2 was obtained in the evening while that of SO_2 was in the afternoon. Fig. 2 and 6 indicates that elevated concentration of NO_2 (0.95 ppm) was observed at Owerri and the peak is clearly seen in fig.2 (3- D plot of NO_2) when compared with other locations. The mean level of NO_2 in wet for the four locations are in the order Owerri > okigwe > Egbema > Orlu. In fig.3 and 7 the result indicates that SO_2 concentration were elevated in all the locations, but Owerri again has the highest peak (0.78ppm) as depicted in the 3-D plot of SO_2 (fig.3), and the order is Owerri > Egbema > Okigwe > Orlu. Also from table 1 it can be observed that higher concentration of NO_2 and SO_2 was obtained in the afternoon and evening which implies higher commercial and other anthropogenic activities responsible for the emission of these air pollutants.

In table 2, fig.4, fig.5, fig.8 and fig.9, the dry season results are presented. The results indicates that for NO_2, the mean values ranged from 0.22 - 0.65 ppm, 0.23 - 0.66 ppm and 0.23-0.62 ppm respectively for morning, afternoon and evening. In the case of SO_2, the mean concentration ranged from 0.14 – 0.60 ppm, 0.21 – 0.65 ppm and 0.18 – 0.82 ppm for morning, afternoon and evening respectively. Higher concentration of NO_2 was obtained in afternoon and evening, with afternoon showing the highest mean value of 0.48 ppm, while the highest mean value of SO_2 was observed in the evening. In fig. 4 and fig. 8 the spatial variation and 3-D surface plot and spatial map of NO_2 in dry season indicates that okigwe has the highest mean concentration of NO_2 followed by Owerri, Egbema and Orlu, and the spikes are clearly observed in fig. 4. On the other hand the mean level of SO_2 in dry season is in the order Egbema > Orlu >Owerri >Okigwe.

The elevated concentration of NO_2 and SO_2 observed in Owerri air sampling sites indicates that this may be due to higher vehicular traffic, presence of three stroke engine tricycles and higher commercial activities in the town. Owerri is the capital of the state with high population density (FRN Official gazette, 2007) and presence of an industrial layout which could contribute significantly to the emission of these pollutants. Slightly higher concentration of the air pollutants were obtained in the wet season than in the dry season. This is contrary to that reported by Gobo et al, 2012, where higher concentrations of air pollutants were obtained in the dry season. However, the result of the present study is in agreement with Mohammed and Caleb (2014) who reported elevated concentration of the air pollutants in the evening. The mean values of the air pollutants recorded in this study for SO_2 and NO_2 exceeded the US National Ambient Air Quality Standard and Nigerian National Ambient Air Quality Standard.

4. Conclusion

The concentrations of air pollutants recorded in this study varied from one location to the other and time of the day (ie morning, afternoon or evening). This observation is a reflection of the level population growth, urbanization, commercial activities, traffic flow, industrialization, time and season of the year. Though the observed levels of the gases were varied in the locations but one can conclude that higher values recorded in Owerri is expected of the town, being a metropolitan city and this calls concern. Hence there is need for serious awareness campaign on the effects of air pollution and regular air quality studies in the area.

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