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SPATIAL AND TEMPORAL DISTRIBUTION OF THE CONCENTRATION OF GASEOUS AIR POLLUTANTS: A CASE STUDY OF TRANS-AMADI INDUSTRIAL LAYOUT PORT-HARCOURT

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Abstract: **In this study, spatial and temporal distribution of the concentration of gaseous air pollutants (CO, NO_2, and SO_2 O_3) was carried out using ArcGIS in the wet season of 2016. The study was aimed at assessing the pattern of pollutants distribution in the atmosphere using GIS in the study area. Twelve sampling stations were identified, and calibrated air quality meters were used to measure air quality data during the morning, afternoon, and evening hours respectively for five days. The average concentration of the air pollutants in the morning hours ranged from 25.73 to 4.97 ppm for CO, 0.430 to 0.063 ppm for SO_2, 0.275 to 0.021 ppm for NO_2 and 0.011 to 0.019 ppm for O_3, in the afternoon hours from: 0.257 to 0.040 ppm, 0.492 to 0.027 ppm, 27.60 to 9.57 ppm and 0.069 to 0.012 ppm for SO_2, NO_2, CO and O_3 respectively and in the evening hours. The average evening concentrations of the pollutants ranged from 0.497 to 0.087ppm, 0.305 to 0.064 ppm, 32.27 to 4.60ppm and 0.021 to 0.011ppm for SO_2, NO_2, CO and O_3 respectively. However, higher concentrations of the pollutants were mostly observed in the evening period followed by the morning period then the afternoon period. Mapping of different concentration of air pollutants was carried out using kriging and inverse distance weighting type of interpolation method in GIS environment. This study has established that the quality of air in the study area is very poor and polluted with CO, NO_2, O_3. The deterioration in air quality could be attributed to the heavy presence of industries within the area, high volume of traffic and slow traffic flow experienced in the area and other anthropogenic activities like meat processing using tire in the slaughter area etc. going on within the Trans-Amadi area. Many residents in this area are exposed to dangerous level of air pollution by pollutants such as NO_2, SO_2, O_3 and CO which has a tremendous effect on health.**

Keywords: **Trans-Amadi, spatial and temporal distribution of the concentration of gaseous air pollutants, air pollution, Port-Harcourt.**

I. INTRODUCTION

Air pollution has continued to dominate global conversations not just because of its prevalence and criticality to human health but also, its impact on the environment [2] [9] [5] [19]. Air pollution is described as a global "public health emergency," one that will not only affect the health of many humans living in urban areas and environment, but also economies as public spending on health will be on the increase [10] [16] [27].

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According to [28] air pollution is the adulteration of the indoor or ambient (outside) air quality by any chemical, physical or biological substance (air pollutants) that changes the original and natural composition of the atmosphere [3] [11] [13] [27]. Several studies [6] [15] [21] [26] [12] have attributed the increasing prevalence of these air pollutants to uncontrolled anthropogenic activities such as urbanization, industrialization, and vehicular emissions.

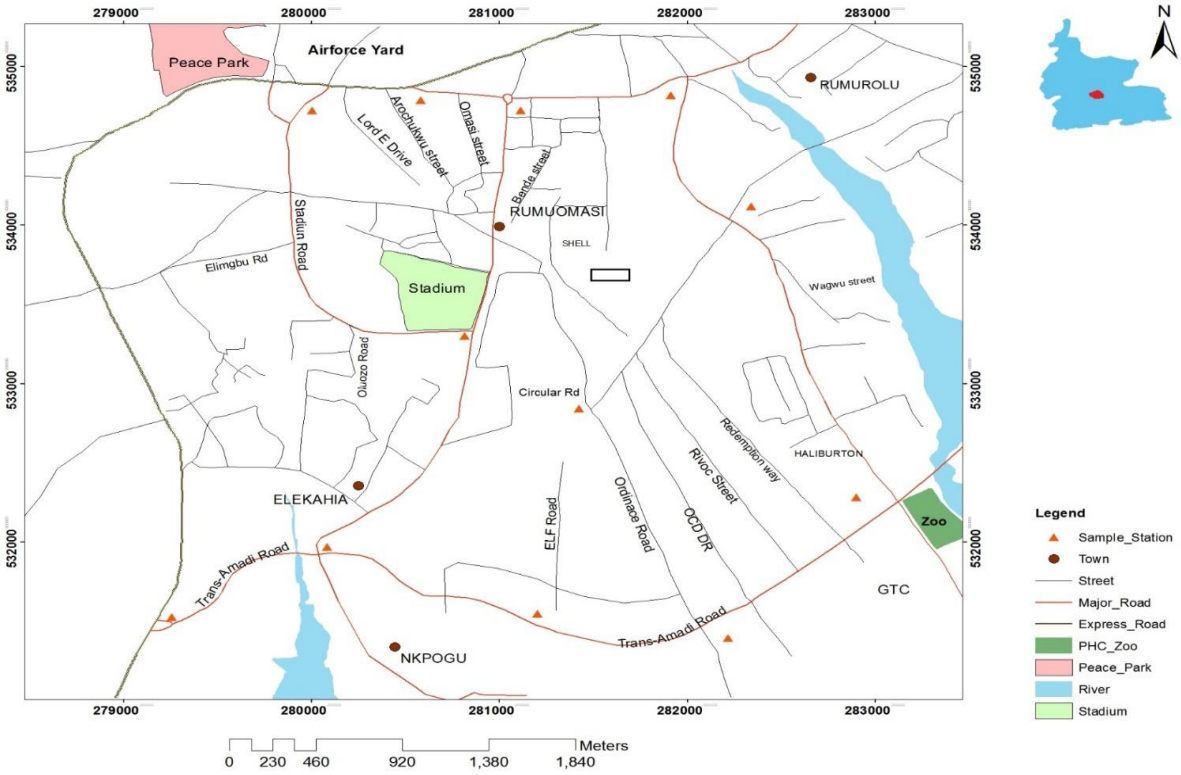
Consequent upon the wide-ranging and deleterious effects of air pollutants on human health and the environment [25] [23] [20] [14]. It has become imperative to constantly monitor the concentration of air pollutants to take appropriate decisions to mitigate the pollutants and protect human health and share such information in a simplified manner using maps that are easy to understand by the public [6] [21] [26] [12].

Geographic information system (GIS) is therefore, an efficient tool which can be deployed for gathering, storing, manipulating, managing, and analyzing various types of geographical data and represent graphically for easy understanding [22] [18] [16] [4] [9] [24].

This study, therefore, focuses on assessing the pattern of pollutants (NO_2, SO_2, CO and O_3) distribution using GIS in Trans-Amadi industrial layout, Port-Harcourt.

II. MATERIALS AND METHOD

Ambient air monitoring of pollutants (CO, SO_2, NO_2 and O_3) was carried out three times a day (morning, afternoon, and evening hours) for five days consecutively during the wet season of September 2016. The survey was carried out to assess and mapping the concentration of these pollutants in the study area. The study was carried out in Trans-Amadi industrial layout, Port Harcourt (Figure 1). Trans-Amadi is an industrial area which is in the heart of the capital of in the oil rich Rivers State River Port Harcourt (Fig 1). The area is heavily populated with both industrial and residential buildings of many national and multi-national companies. It lies geographically between latitude 004°48'53" N & 004°38'03" N and longitude 007°2'14" E & 006°50'51" E. Port Harcourt is a petroleum city and a major business hub with a population of about 1,382,592 [28].



Source: Authors field work.

Fig. 1: Map of study area showing sampling points.

Real time insitu measurement of air pollutants were carried out using Aeroqual series 200 instruments to measure the concentrations of selected pollutants while coordinates (longitude and latitude were captured using Global Positioning System (GPS). The distance of the monitoring station from the major roads was 20m. The measurements were taken at a height of 1.50 m above ground level. Collected air quality data were arranged and averaged using Microsoft excel 2013 for each pollutant.

Aerial map of Port Harcourt obtained from NARSDA was imported into the ArcGIS environment; georeferenced and digitized. The arranged average concentration of the pollutants for the morning, afternoon and evening hours were imported into the digitized aerial map of the study area where kriging and inverse distance weighting techniques were used to interpolate the concentration.

A. AIR QUALITY INDEX MODEL

The Air Quality Index (AQI) was calculated for all sampling locations using the daily average concentration of the measured parameters. The AQI is an index for reporting daily air quality. It tells us how clean or polluted the air is, and corresponding health effects. The AQI scale is divided into six categories and a specific color assigned to each to appreciate at first glance whether air pollutants are reaching unhealthy levels in the area or not.

Table 1: The Air Quality Index values.

Air Quality Index (AQI) Values	Levels of Health Concern	Color
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for sensitive group	Orange
151-200	Unhealthy	Red
201-300	Very Unhealthy	Purple
301-500	Hazardous	Maroon

Source: [1]

The Air Quality Index values for every pollutant monitored were calculated using.

$$I = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} (BP_{Hi} - BP_{Lo}) + I_O \qquad 3.1$$

Where

I_p = the index for pollutant p

C_p = the rounded concentration of pollutant p

BP_{Lo} = the breakpoint that is less than or equal to C_p

BP_{Hi} = the breakpoint that is greater than or equal to C_p

I_{Hi} = the AQI value corresponding to B_PHi

I_{Lo} = the AQI value corresponding to B_PL_o

Sources: [7]

B. RESULTS AND DISCUSSION

i. result of morning concentration of pollutants

The mean concentration of Sulphur dioxide (SO_2) in the morning period ranged from 0.060ppm at Old Aba Road junction to 0.392ppm at Garrison junction.

The mean concentration of Nitrogen dioxide (NO_2) in the morning period varied from 0.02ppm at First bank to 0.27ppm at slaughter.

The average concentration of Carbon Monoxide (CO) during the morning hours ranged from 4.48ppm at First bank to 20.50 at Stadium Road junction.

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The mean concentration of Ozone (O_3) varied between 0.11ppm at Stadium Road junction to 0.19ppm at market junction.

ii. result of afternoon concentration of pollutants

The mean concentration of Sulphur dioxide (SO_2) in the afternoon period ranged from 0.010ppm at Old Aba Road junction to 0.40ppm at Slaughter junction.

The mean concentration of Nitrogen dioxide (NO_2) in the afternoon period varied from 0.01ppm at End of Ordinance junction to 0.49ppm at Nkopgu junction.

The average concentration of Carbon Monoxide (CO) during the afternoon hours ranged from 4.98ppm at First bank to 28.80 at Slaughter.

The mean concentration of Ozone (O_3) varied between 0.12ppm at End of Ordinance junction to 0.21ppm at market junction.

iii. result of evening concentration of pollutants

The mean concentration of Sulphur dioxide (SO_2) in the evening period ranged from 0.08ppm at Oginigba to 0.64ppm at Slaughter junction.

The mean concentration of Nitrogen dioxide (NO_2) in the evening period varied from 0.02ppm at End of Ordinance junction to 0.30ppm at Slaughter.

The average concentration of Carbon Monoxide (CO) during the evening hours ranged from 7.45ppm at Oginigba to 40.88 at Slaughter.

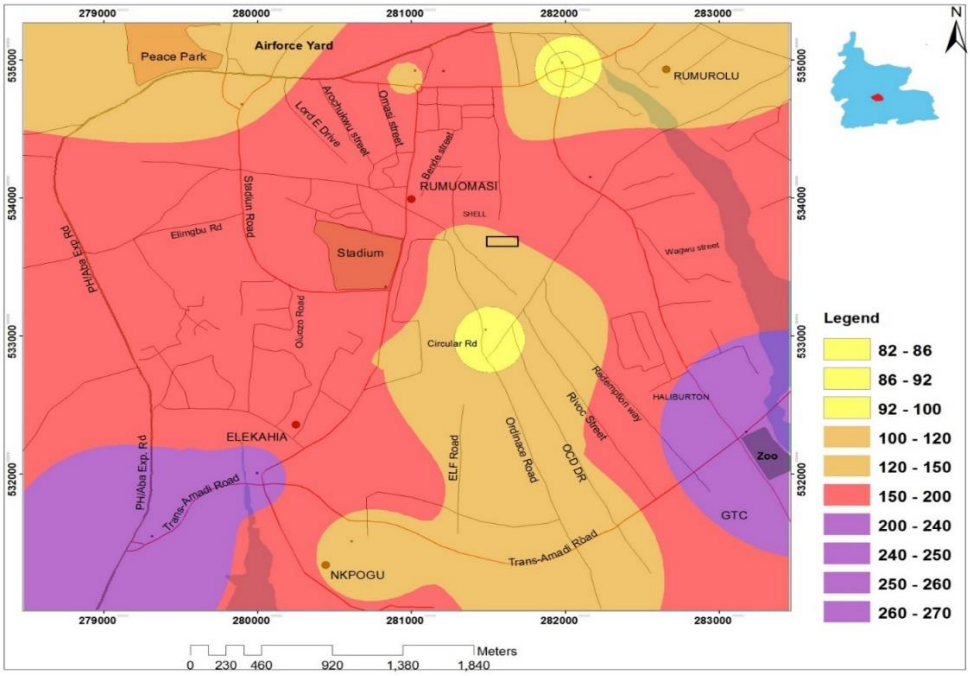
The mean concentration of Ozone (O_3) varied between 0.11ppm at Garission junction to 0.21ppm at Oginigba.

C. DISCUSSION

Figure 2, 3 and 4 shows the AQI map and the color code used to categorize the state of the environment (air) during the morning period, the afternoon period and evening periods in all the air quality sampling stations throughout the study area. AQI of the pollutants were determined to evaluate the health risk which the public are exposed due to atmospheric pollution.

i. quality of air in the morning hours

Figure 2 shows the AQI map which shows the quality of air in the study area during the morning period.



Source: Authors field work.

Fig. 2: AQI map for the morning hours

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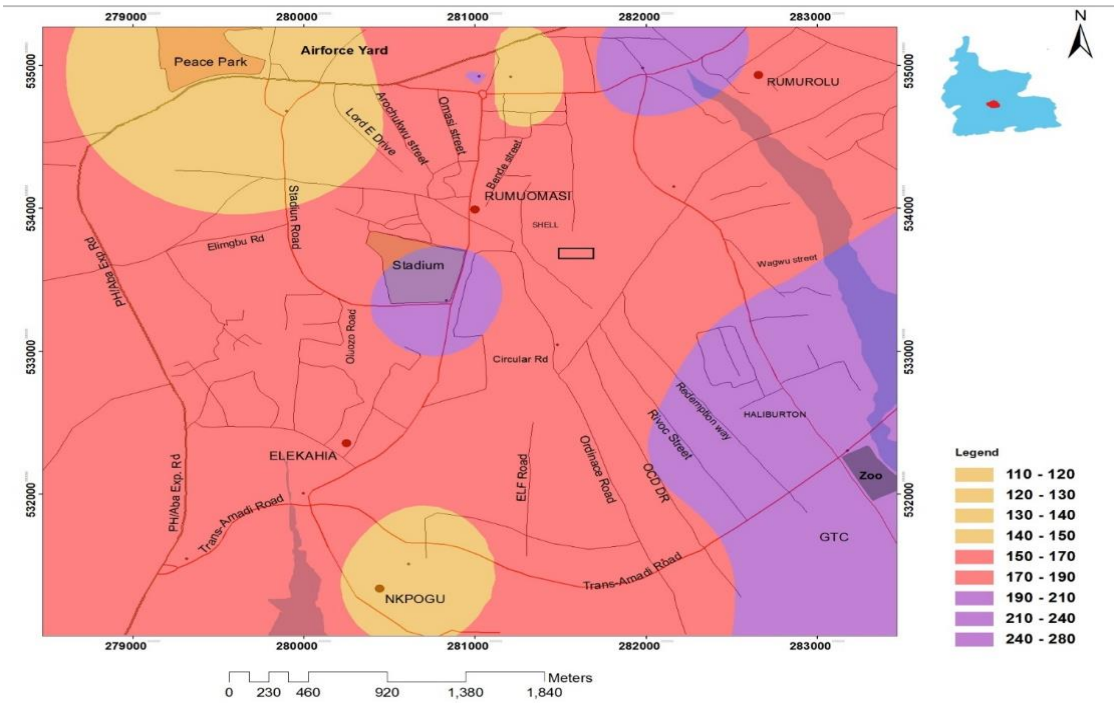
The state of air in the morning period in the study location as shown in figure 10, shows that Slaughter and Garrison areas are heavily polluted with CO (271) and SO_2 (242) respectively. This could be ascribed to high industrial activity going on the Slaughter area, high traffic volume, slow traffic flow and the activities of an abattoir in the area where vehicle tire are used to process meat expired and the Garrison area as a result of industrial generators, high traffic and slow flow of traffic in the morning hours. The quality of air in these areas is very unhealthy according to AQI classification and everyone (sensitive and insensitive group) within this area may experience serious health effects. Air quality around Airforce junction, Stadium Road junction, First bank junction, Market junction is unhealthy (Red color) according to AQI classification and everyone in these areas might begin to experience some severe adverse health effects, and members of the sensitive groups might experience more severe health effects. The deterioration in the natural quality of the location could be due to the high traffic volume and industrial activities. The state of air in the sampled location colored orange is unhealthy for the sensitive group, though the large population is unlikely to be impacted at this AQI values, the very sensitive group (people with heart and lung disorder, older adults and children) are at the highest risk from prolonged contact to ground-level ozone.

Air quality in the areas colored yellow according to AQI classification is acceptable; however, for some pollutants but there could be health concern for a very small fraction of people who are unusually sensitive to polluted or contaminated air.

ii. quality of air in the afternoon hours

Indicated in Figure 3 is the quality of air in the study area during the afternoon period.



Source: Authors field work.

Fig. 3: AQI map for afternoon air quality in the study area.

The purple-colored areas: Slaughter, Old aba road and Stadium Road junction were heavily polluted with CO (284, 211 and 204 respectively). The quality of air in these locations is at an unhealthy level for everyone. The air quality might create a health alert notifying that the whole population may experience more serious health effects. The elevated afternoon concentration in the slaughter area could be because of traffic, industries within the area, and abattoirs. While in Old aba road and Stadium junction area is because of traffic. The quality of air in the orange-colored areas (Airforce and Mother Cat area) is unhealthy for sensitive groups (people with lung disease, older adult, and children). The Red colored areas have unhealthy air quality according to AQI classification and the general population in this area may experience adverse health effect on short exposure, and members of the sensitive groups of people would experience more severe health effects. The degradation in the quality of air in these areas may be attributed to traffic and industrial activities.

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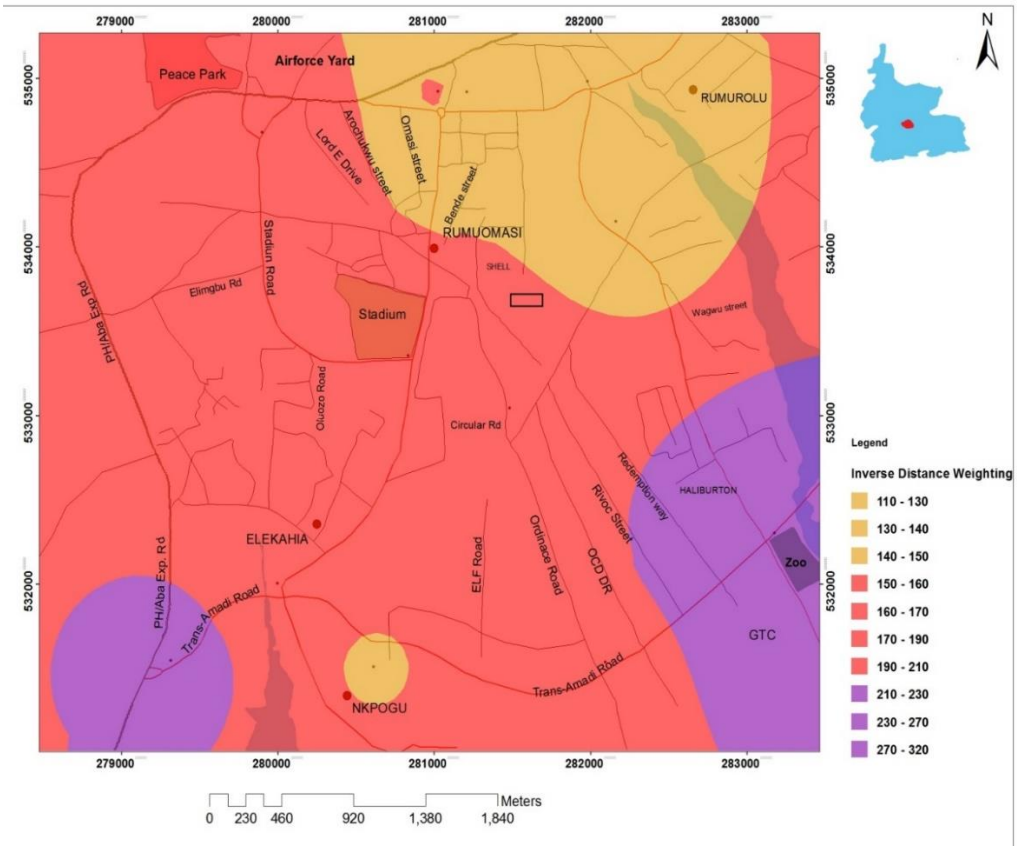
iii. quality of air in the evening hours

Figure 4 indicates the quality of air in the evening period throughout the study area.



Source: Authors field work.

Figure 4: AQI map for afternoon air quality in the study area.

The pollution level in the purple-colored areas is very unhealthy (AQI range 201 to 300) according to AQI classification. The air quality in these locations could trigger very serious health alert because every occupant of these locations is at risk both sensitive and insensitive group of experiencing very serious adverse health effects. The air quality in the red colored areas according to the AQI category is unhealthy for people. Everyone in this area for about 8 hours is likely to may being to notice and experience some serious health changes and the sensitive groups (people with heart and lung diseases) may begin to experience very severe and life-threatening health effects. The state of the environment (air) in the orange-colored areas for sensitive people is unhealthy. However, the public at large may not likely be affected or will not be at risk within this AQI value, the sensitive group of people (people with lung disease, older adults and children) are at a higher risk of experiencing and feel severe health effects from prolong contact and inhalation of ground-level ozone.

III. CONCLUSION

Air is a vital resource needed for the survival of humans as such conscious effort needs to be made to conserve and safeguard the natural quality and state air from deterioration due to anthropogenic activities and man's quest in the use of technology and man's economic activities.

The findings of the study showed that quality of air in the Trans-Amadi area of Port Harcourt is poor. The deterioration in air quality could be ascribed and attributed to the heavy presence of industries within the area, high volume of traffic and slow traffic flow experienced in the area and other anthropogenic activities like meat processing using tire in the slaughter area etc. going on within the Trans-Amadi area. Many residents in this area are exposed to dangerous level of air pollution by pollutants such as NO_2, SO_2, O_3 and CO which has a tremendous effect on health. The concentration of the pollutants obtained in most of the sampling areas varied above regulatory limits except for few areas during the afternoon hours.

This study therefore recommends that air quality monitoring station be stationed at strategic location within Port Harcourt and its environs in cooperated with geographical information system (GIS) for real time air quality data relay, there is an urgent need to put in place, implement and strengthen air pollution standards especially as it relates to health. The standard will not only help protect public health, including the health of sensitive populations (people with lungs disease, children, and the elderly.

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