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Satellite Sensor-Based Evaluation of Air Pollutants Concentration: A Case Study of Abuja, Nigeria

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ABSTRACT

This study investigated air pollution high risk zones with hot spot map of air quality status in Abuja, the Federal Capital Territory of Nigeria. The study period was 2013. The research utilized satellite imagery from NigeriaSat-X 2011 with spectral ranges 0.7-0.9 µm, 0.63-0.69 µm and 0.52-0.62 µm of band 2, 3, 4. Using a geographic information system (GIS), the study developed a relationship between air pollutants and the land use/ land cover of Abuja city. These pollutants include carbon (ii) oxide (CO), and sulphur (iv) oxide (SO_2), nitrogen (iv) oxide (NO_2) and ozone (O_3). The concentrations of the pollutants were obtained from satellite sensors for six (6) measuring locations classified into industrial, commercial, residential and traffic point, distributed within the city of Abuja. The results indicated that the most polluted area was identified as Idu. Using statistical analysis, the study also established a relationship between the concentration of air pollutants and the land use/ land cover classification (industrial, commercial, residential and traffic point) for Abuja city. The result obtained from this study provided substantial evidence to suggest a strong link between air pollutants derived from satellite sensor and land use/land cover (LU/LC).

1. Introduction

1.1 Background of Study

Air quality has increasingly become a great concern to the public, researchers and policy-makers, as extensive research has demonstrated that air pollutants affect the health of humans and animals, damage vegetation and materials, reduce visibility, affect weather and climate. Therefore, accurate mapping of air quality, identification of hotspot area and likely key pollutants is important for the evaluation of the current spatial distribution of air pollutants concentration, air pollution control regulations, and other environmental and seasonal variation related activities. Air monitoring is of a greater importance to urban populations, because urban areas have been a source of major pollutants in the past and they support a vast number of people in concentrated areas.

1.1.1 Satellite Based for Air Quality Monitoring

Air quality monitoring has typically been done using ground based instrumentation, which has severely restricted the area of land that can be monitored. The ground instruments are designed to monitor specific pollutants (e.g. carbon dioxide) and many of these instruments cannot provide an accurate description of the total concentration of all pollutants at a citywide level. For these reasons, remote sensing satellites have been used to assist in air quality monitoring of urban areas. Remote sensing satellites have many advantages of monitoring air quality on a citywide scale. Satellite observations can provide a complete survey of the city; show the major sources of pollution and the distribution pattern; assist in determining where the effort should be focused to decrease the level of pollution and determine any relationship between the city features and air pollution distribution [1]. One factor that signifies whether a city has an advanced understanding of the importance of air quality monitoring is if it has passed regulations to help mitigate pollution levels. Satellite observations can ensure that these regulations are necessary and effective; assist in timely enforcement of these regulations and help in creating public awareness and participation [2]. Another advantage of satellite remote sensing technology is that it can monitor many pollutants simultaneously, it has the capability to in near real-time and provides continuously rapid monitoring. However, there are some limitations associated with satellite remote sensing technology. One of chief limitations is spectral interference cause by other atmospheric inhabitances that are not pollution. Satellite observations are restricted to wavelength ranges of atmospheric windows; the results of the observations are subject to atmospheric conditions. Therefore, any pollutant with a low concentration will not be detected.

1.1.2 Earth Observation Satellite for Mapping Air Pollution

Earth observation (EO) by very low spatial resolution satellite sensors (e.g. TOMS) has been a powerful addition to the array of techniques available for detecting and tracking atmospheric pollution on a global scale. Recently, researcher is focusing on the use of Earth observation satellite (e.g. NigeriaSat-2) to evaluate and map atmospheric pollution in Abuja city. A variety of techniques have been developed [3, 4]. Such techniques may be applicable to Earth observation data with resolutions varying from low (e.g. Meteosat, AVHRR) to high (e.g. SPOT, Landsat) [5, 6]. High-resolution satellites allow mapping urban air quality indicators such as the Aerosol Optical Thickness (AOT), which is indicative of the Particulate Matter (PM) loading in the atmosphere, particularly in photochemical pollution conditions [7-12]. The goal of this paper is to use satellite sensors to evaluate the spatial distribution of air pollutants concentration, remote sensing and GIS for monitoring and mapping air pollution in the lower troposphere at urban scale.

1.2 Problem's Statement

Abuja in Nigeria has been experiencing ambient air pollution, with little or no real solutions to alleviate many of these problems. The environmental consequences of rapid industrialization have resulted in countless incidents of land, air and water resources sites being contaminated with toxic materials and other pollutants, threatening humans and ecosystems with serious health risks. The need for remediation was recognized, by exception, in instances where damage was determined to be unacceptable. As the pace of industrial activity intensified and the understanding of cumulative effects grew, a pollution control paradigm became the dominant approach to environmental management.

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1.3 Justification

Remote sensing represents a powerful technology for providing input data for measurement, mapping, monitoring and modelling of air pollution within the GIS context. There are many ways of integrating the techniques of satellite remote sensing and GIS for air quality monitoring. One method adopted for this work is to use remotely sensed data and GIS to generate hot spot maps for air quality.

1.4 Aim and Objectives of the Study

The aim of this study is to evaluate the spatial distribution of air pollutants concentration in Abuja.

The specific objectives are:

1. To estimate air pollutants concentration from satellite sensor measurement over the FCT.
2. To determine the land use/land cover and their contribution to air pollutants concentration in the study area.
3. To determine the relationship between air quality data obtained from satellite sensor and land use/land cover impact.

1.5 The Study Area

Abuja, Nigeria's new capital city is located at the centre of the country (Fig. 1). With a total population of 1,402,201 (2006 population census) the Federal Capital Territory (FCT) has a land area of 923,768 square kilometres, which is two and halftimes the size of Lagos, the former capital of Nigeria. The FCT is bounded on the north by Kaduna State, on the west by Niger State, on the east and south-east by Plateau State, and on the south-west by Kogi State. It falls within latitude 8.922° N and 9.187° N of the Equator and longitudes 7.233° E and 7.555° E with Elevation of 536 m and total population of 1,402,201 (2006) population censuses. A scene that cannot be missed about Abuja is the coming together of the savannah grassland of the north and middle belt with the richness of the tropical rain forests of the south. This marriage of the nature has ensured that Nigeria's capital is endowed with fertile land for agriculture.

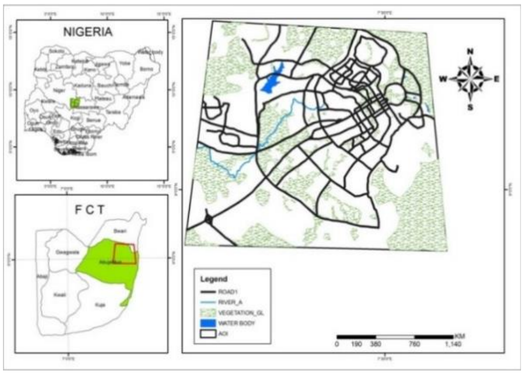

Fig. 1 The study area map

1.5.1 Weather and Climate

The FCT experiences two seasons annually, the rainy season from April to October, characterized by moderate temperatures and high levels of precipitation, and the dry season, from November to March, characterized by extreme temperatures and low levels of precipitation. Between seasons, there is a brief Harmattan caused by the North East Trade Wind, with intensified coldness and dryness creating dust and haze.

1.5.2 Soil and Land Capability

The two main types of soils in FCT are the sedimentary belt in the southern and south-western extremities of the territory and the pre-Cambrian Basement complex rock country which accounts for more than 80 per cent of the territory.

1.5.3 Vegetation

The Federal Capital Territory falls within the Savannah zone vegetation of the West African sub-region but patches of rain forest, however, occur in the Gwagwa plains that form one of the surviving northern-most occurrences of the mature forest vegetation in Nigeria. The vegetation of the FCT is divided into three Savannah types of park or grassy that occupies about 53 per cent of the total area and where the vegetation is annually; the Savannah woodland that occurs mostly in the rugged and less accessible parts on the Gurara, Robo and Rubochi plains and surrounding hills. They cover 12.8 percent and the Shrub Savannah that occurs extensively in rough terrain close to hills and ridges in all parts of the FCT and covers about 12.9 percent of the land area.

2. Experimental Methods

2.1 Materials

The materials used for the mapping and monitoring of air pollutants in Abuja, Federal Capital Territory research include; NigeriaSat-X imagery, NigeriaSat-X used for this project was captured on the 8th December, 2011 and was obtained in National Space Research and Development Agency (NASRDA). The satellite image NigeriaSat-X was used to map roads infrastructures and also used to classify land use/land covers into commercial; industrial, residential area and traffic point in such a way the analysis can be well defined. The NigeriaSat-X is an Earth observation satellite with spectral ranges 0.7-0.9 µm, 0.63-0.69 µm and 0.52-0.62 µm. The three bands (i.e. near infra-red, Red and Green are closely related to those of bands 2, 3 and 4 of Landsat-7. The sensor employs the push broom imaging technology using two cameras per band (mounted in a double-barrel cross-track configuration) thus providing a dual (slightly overlapping) swath with a combined swath width of > 600 km with a spatial resolution 22 m GSD (Ground Sampling Distance) at nadir.

2.1.1 Data Set: Google Earth

This imagery was used for the validation of classification of the results into different classes (i.e. commercial, residential, industrial and traffic area).

2.1.2 Air Quality Data Satellite sensor

Air quality data comprises of SO_2, CO, NO_2, and O_3 are the parameter obtained from the satellite sensor-based used for mapping and modeling of air pollution in Abuja. The Sensors used for the monitoring include; OMI and Atmospheric Infrared Sounder (AIRS) are the various sensors where air quality data were obtained. OMI was the sensor used for obtaining the values of nitrogen (iv) oxide, sulphur (iv) oxide and ozone respectively and AIRS sensor was used for obtaining values of carbon (ii) oxide pollutants concentration for the purpose of this work.

2.1.3 Software and Hardware

Arc GIS software: This Software is software developed and sold by Environmental Systems Research Institute (ESRI), Inc. it has undergone developmental changes overtime, from different versions, a system based on typed commands to a graphical user interface. Is a comprehensive system that allows people to collect, organize, manage, analyze, communicate, and distribute geographic information. The system is available everywhere using web browsers, mobile devices such as smartphones, and desktop computers among others. ArcGIS version 10.1 was used for this project. Its advantage of being user friendly was considered.

2.1.4 Excel Software

This software was used to convert the values obtained from satellite sensor and linked to land use/land cover of the area to spatial reference. ERDAS imagine software: This software was used for the analysis of classification of the area into commercial, industrial, residential and traffic point area. Coordinate point of monitoring Locations: Coordinate point of monitoring Location includes; Apo, Asokoro, Idu, Lugbe, Maitama and Wuse. These are the areas in which their coordinate point were linked to satellite sensor and obtained air quality parameter in Abuja.

2.2 Method

The methodology adopted for this study (Fig. 2) is divided into four main stages. These stages include data acquisition, preliminary data processing, data analysis and the generation of air quality maps. The primary data for this research is the air quality data and the satellite image (NigeriaSat-X) within near infra-red, Red and Green with spectral ranges 0.7-0.9, 0.63-0.69 and0.52-0.62 respectively, the three bands come closely to those of landsat-7 bands 2, 3 and 4. Air quality data of six (6) Continuous Air Quality Monitoring (CAQM) stations located at the following location i.e. Maitama, Asokoro, Wuse, Lugbe, Apo and Idu. Although the data for the components of pollutants i.e. Sulphur Dioxide [SO_2], Nitrogen Dioxide [NO_2], Ozone [0_3], Carbon Monoxide [CO] as concern in Abuja Air Pollution Index (API) are obtained only Abuja is of main concern in this study. The air quality data of air pollutants concentration values of Abuja was collected from satellite sensor-based (e.g. OMI, AIRS, and MODIE-TERRA (source: my NASA data and Giovanni)). The method of obtaining data from

NASA data is as follow: Type my NASA data website on the internet, load it, and click Explore NASA DATA then, Live Access Server-Advance. Here, you see data set click to open atmosphere and click air quality to record any air quality you want, below there is Longitude and Line plot to compute coordinate point and year to access your measurement. Under line plot click Time to display Start date/time and End date/time here there is cardinal point to compute the coordinate, as far as pollutant, particular year(s) and coordinate have been properly fixed then click update plot. The results appear in graph then, click show values to display results from January to December. ERDAS is used to classified image into land use/land cover but Google earth was used to validate the classification. Geostatistical analyst tool available in ARC GIS 10.1 was used to assess the statistical properties of satellite data. Secondly, the selected images and data layers of air pollutants concentration which was collected from satellite sensor-based for study was processed and added to excel and import to ArcGIS. Abuja roads network were digitized from NigeriaSat-X image in order to assess pollution from traffic point. Although the data undergo geo-referencing in order to become geometrically coherent for proper interpretation. All data's were geo-referenced according to UTM WGS (Zone 31° N) coordinate system. For the purpose of use of the possibilities offered by (ArcGIS 10.1)/ERDAS imagine program as well NigeriaSat-X image, and air quality data from satellite sensor-based was used (one of the spatial analyst tools i.e. ordinary Kriging) to view and analyze the concentration of air pollutants and link with (Land used/Land cover) of Abuja city (The pollutants concentrations in residential areas, industrial and commercial areas, as well as increased vehicles and traffic congestion in Abuja city, in order to identify pollution hot spot and key pollutant in FCT).

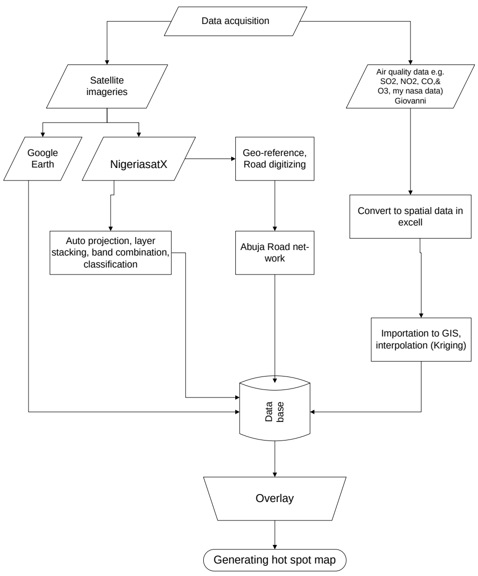

Fig. 2 Methodology flow chart

2.3 Data Analysis

The interpolation criteria applied for the data provided in this study was ordinary Kriging method. In statistics, originally in Spatial Analyst Tools, Kriging or overlay (weighted sum) and reclassify is a method of interpolation for which the interpolated values are modeled by a Kriging process governed by prior covariance, as opposed to a piecewise-polynomial spline chosen to optimize smoothness of the fitted values. Ordinary kriging was selected for this study based on how well it has performed on prior years data and because the statistical characteristics of the data in 2000 and 2003 make Ordinary Kriging the appropriate choice of estimator. The data displayed no trend at the scale of the modeling; thus, Ordinary Kriging was the appropriate technique to use. This research has used ordinary kriging to make satellite-based CO, SO_2, NO_2 and O_3 models for the years 2013.

3. Results and Discussion

Results of air pollutants recorded from satellite sensors measurement for four different types of pollutants parameters over Abuja include; SO_2, NO_2, CO and O_3 obtained from satellite sensor-based (i.e. OMI and AIRS). Different continuous air quality monitoring (CAQM) locations classified into; industrial, residential, commercial and traffic coordinate point's configuration were used. Table 1 shows the result of carbon (ii) oxide pollutant concentration in various locations based on land use/ land cover of the area of Abuja from January to December 2013 season. Table 2 shows the result of Nitrogen (IV) oxide pollutant concentration in different locations in Abuja from January to December 2013 season as well. Table 3 shows the Ozone pollutant concentration for various locations in Abuja 2013 season from January to December. Table 4 in the other hand shows the concentration of Sulphur (iv) oxide pollutant concentration in various areas bases on land use/land cover of Abuja from January to December 2013 to ascertain the months and places where the concentrations is high, so as to address the situation.

Analysis carried out from Table 1 using ordinary kriging interpolation method based on six CAQM locations located within Abuja municipal from month of January to December, 2013. Reports showed high concentration value of 316 was recorded in January in Idu area and low concentration of 174 was recorded in September in Maitama area of Abuja.

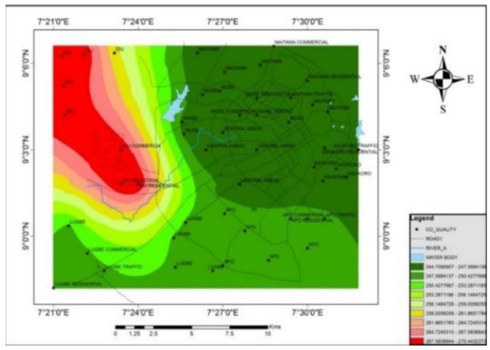

Fig. 3a Concentration hot spot map of carbon monoxide (CO)

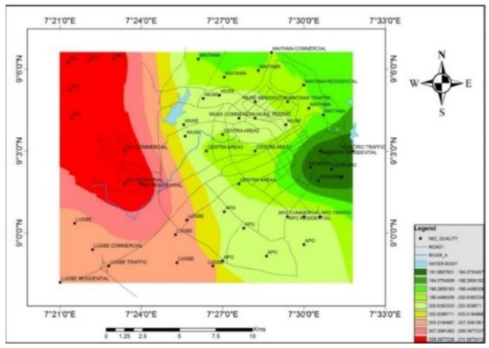

Fig. 3b Concentration hot spot map of nitrogen dioxide (NO_2)

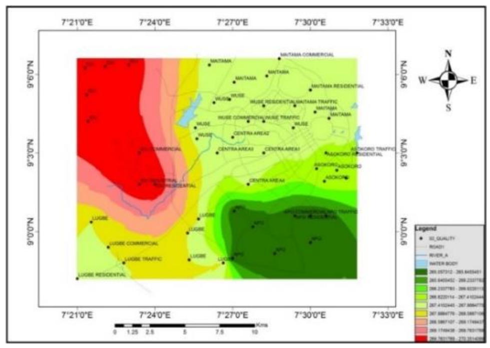

Fig. 3c Concentration hot spot map of ozone (O_3)

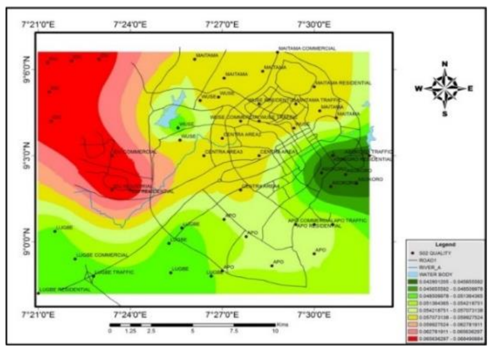

Fig. 3d Concentration hot spot map of sulphur dioxide (SO_2)

Analysis carried out from Table 2 using ordinary kriging interpolation method for six CAQM locations within Abuja municipal from month of January to December 2013. It shows that high concentration of nitrogen (iv) oxide recorded to be 402 in January and low concentration of 102 was recorded in August 2013.

Analysis carried out from Table 3 using ordinary kriging interpolation method based on six CAQM locations located within Abuja municipal from month of January to December 2013. Reports showed that, low concentration of 236 recorded in January and high concentration of 287 recorded in September.

Analysis carried out from Table 4 using ordinary kriging interpolation method based on six CAQM locations located within Abuja municipal from month of January to December 2013 shown that high concentration of 0.154 was recorded in the month of December and low concentration of 0.015 recorded in September month in 2013.

Concentration of carbon monoxide (CO) Fig. 3a and nitrogen dioxide (NO_2) Fig. 3b generated from interpolation using ordinary kriging method showed that concentration level is low in Wuse, Maitama and Asokoro areas. Low level concentration of CO and NO_2 may be as a planning structure of these areas like planting of trees and some other natural phenomena that can sink pollutants. Also, NO_2 concentration reduces due to the photo-dissociation process, in which the gas is broken down to form ozone in the troposphere; as a result satellite may capture small amounts of Nitrogen concentration.

Ozone (0_3) concentration level Fig. 3c is high in all the locations except Apo but higher in Idu area, suspected to be key pollutant in Abuja. Prevalent high concentration may be as a result emission of nitrogen oxide and volatile organic compound emitted from motor vehicles in heavy traffic jam during sunny day can react in atmosphere to form high level concentration of ozone (0_3).

Sulphur (iv) oxide ($S0_2$): Pollutant concentration of sulphur dioxide Fig. 3d is high in Idu area of Abuja which can be as a result of on-road vehicles: Vehicles operated on highways, streets and roads. Non-road sources: Off-road vehicles and portable equipment powered by internal combustion engines. Includes; lawn and garden equipment, recreational equipment, construction equipment, metal smelting and other industrial processes.

Table 1 Results of carbon (ii) oxide monthly concentration

Carbon (ii) oxide monthly concentration (mol/cm^2)														
Locations	X(E)	Y(N)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lugbe Residential	7.35	8.97	290	280	248	248	210	195	182	203	184	182	201	242
Lugbe Commercial	7.37	8.99	289	290	250	247	210	195	182	200	184	182	205	242
Lugbe Traffic	7.38	8.98	290	290	250	248	210	195	184	204	184	184	204	250
Idu Indusrial	7.39	9.03	316	310	270	240	220	210	184	204	181	184	212	252
Idu Residential	7.4	9.03	310	300	260	240	240	210	184	200	180	184	212	250
Idu Commercial	7.39	9.05	310	305	260	240	240	212	184	200	180	184	212	252
Maitama Residential	7.5	9.09	274	270	245	242	210	194	180	200	179	180	205	240
Maitama Commercial	7.48	9.11	284	280	250	240	210	194	180	200	180	182	214	241
Maitama Traffic	7.49	9.08	285	280	245	240	220	195	182	196	174	182	214	241
Wuse Commercial	7.46	9.07	284	281	246	240	212	192	182	202	178	180	206	230
Wuse Residential	7.47	9.08	284	280	246	240	212	192	182	202	178	180	206	229
Wuse Traffic	7.47	9.07	284	280	246	240	212	192	182	202	178	180	206	230
Asokoro Residential	7.51	9.05	282	280	246	234	212	192	182	202	178	179	204	232
Asokoro Traffic	7.53	9.05	282	280	246	234	212	192	182	202	178	179	204	232
Apo Residential	7.49	9.01	285	285	248	240	212	198	182	224	178	180	205	232
Apo Commercial	7.5	9.01	285	285	248	240	212	198	182	224	178	180	205	234
Apo Traffic	7.51	9.01	285	285	248	240	212	198	184	224	178	181	207	234
Central Area 1	7.47	9.05	284	283	246	240	210	195	182	204	180	181	206	229
Central Area 2	7.45	9.06	282	280	247	240	212	194	182	204	179	180	206	229
Central Area 3	7.44	9.05	282	280	245	240	210	194	182	202	179	180	206	230
Central Area 4	7.46	9.03	284	281	247	242	210	192	184	200	178	180	205	231

Table 2 Results of nitrogen (iv) oxide monthly concentration

Nitrogen (iv) Oxide Monthly concentration (10 mol/cm^2)														
Locations	X(E)	Y(N)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lugbe Residential	7.35	8.97	342	317	268	218	178	159	146	107	110	159	218	240
Lugbe Commercial	7.37	8.99	358	318	270	218	180	159	148	107	110	164	220	242
Lugbe Traffic	7.38	8.98	348	318	270	221	180	159	148	110	114	164	224	242
Idu Industrial	7.39	9.03	400	318	272	224	180	161	148	110	117	168	234	250
Idu Residential	7.4	9.03	400	318	270	221	180	160	147	108	110	160	224	248
Idu Commercial	7.39	9.05	402	318	272	222	180	159	147	107	114	164	224	248
Maitama Residential	7.5	9.09	334	312	261	208	174	150	138	103	113	154	200	234
Maitama Commercial	7.48	9.11	336	314	262	220	174	152	139	104	113	154	200	234
Maitama Traffic	7.49	9.08	341	314	262	218	176	152	139	104	114	154	218	234
Wuse Commercial	7.46	9.07	340	314	266	220	178	150	142	105	114	154	216	236
Wuse Residential	7.47	9.08	337	313	262	216	174	152	140	104	113	158	218	234
Wuse Traffic	7.47	9.07	340	316	264	224	176	154	143	106	113	156	218	234
Asokoro Residential	7.51	9.05	316	309	260	209	168	150	139	102	110	159	188	230
Asokoro Traffic	7.53	9.05	316	312	264	217	169	152	142	103	110	144	188	230
Apo Residential	7.49	9.01	316	316	266	208	170	153	140	104	111	144	188	240
Apo Commercial	7.5	9.01	328	318	264	208	178	156	140	106	112	149	210	240
Apo Traffic	7.51	9.01	328	318	268	220	178	158	142	106	113	154	210	242
Central Area1	7.47	9.05	340	316	266	218	178	157	143	105	114	152	214	234
Central Area2	7.45	9.06	340	312	264	216	174	154	139	104	114	154	216	236
Central Area3	7.44	9.05	338	314	264	219	176	156	139	104	114	154	216	236
Central Area4	7.46	9.03	337	316	263	216	178	156	144	103	113	156	218	240

Table 3 Results of ozone (0_3) monthly concentration

Ozone (O_3) Total ozone column (Day time/Ascending) [DU]														
Locations	X(E)	Y(N)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lugbe Residential	7.35	8.97	242	249	256	264	275	283	287	284	281	277	268	257
Lugbe Commercial	7.37	8.99	242	249	256	264	275	283	287	284	281	277	268	257
Lugbe Traffic	7.38	8.98	242	250	256	265	275	283	287	284	281	277	268	257
Idu Industrial	7.39	9.03	242	250	256	265	275	284	287	285	282	277	269	258
Idu Res	7.4	9.03	240	250	256	265	275	284	287	285	282	277	269	258

Idu Com	7.39	9.05	242	250	256	265	275	284	287	285	282	277	269	258
Maitama Res	7.5	9.09	242	247	255	263	273	281	285	281	279	277	268	257
Maitama Com	7.48	9.11	242	247	255	263	273	281	285	281	279	277	268	257
Maitama Traffic	7.49	9.08	242	247	255	263	273	281	285	281	279	277	268	257
Wuse Com	7.46	9.07	242	247	255	263	273	281	285	281	279	277	268	257
Wuse Residential	7.47	9.08	242	247	255	263	273	281	285	281	279	277	268	257
Wuse Traffic	7.47	9.07	242	247	255	263	273	281	285	281	279	277	268	257
Asokoro Res	7.51	9.05	242	246	255	263	273	281	285	281	278	277	268	257
Asokoro Traffic	7.53	9.05	242	247	255	263	273	281	285	281	278	277	268	257
Apo Residential	7.49	9.01	236	245	250	261	272	281	284	278	274	276	267	255
Apo Commercial	7.5	9.01	236	245	250	261	272	281	284	278	274	276	267	255
Apo Traffic	7.51	9.01	236	245	250	261	272	281	284	278	274	276	267	255
Central Area 1	7.47	9.05	242	247	255	263	273	281	285	281	280	277	268	256
Central Area 2	7.45	9.06	242	247	255	263	273	281	285	281	279	277	267	257
Central Area 3	7.44	9.05	242	247	255	263	273	281	285	281	280	277	268	257
Central Area 4	7.46	9.03	242	247	255	263	273	281	285	281	279	277	268	257

Table 4 Results of sulphur (iv) oxide monthly concentration

Monthly concentration of $S0_2$ (Dobson unit)														
Locations	X(E)	Y(N)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lugbe Residential	7.35	8.97	-	-	-	0.01	0.02	-	0.21	0.057	0.015	-	0.152	0.14
Lugbe Commercial	7.37	8.99	-	-	-	0.01	0.02	-	0.21	0.057	0.015	-	0.152	0.14
Lugbe Traffic	7.38	8.98	-	0.09	-	0.01	0.12	-	0.21	0.057	0.015	-	0.152	0.14
Idu Indusrial	7.39	9.03	-	0.09	-	0.03	0.12	-	0.22	0.038	0.02	-	0.144	0.154
Idu Residential	7.4	9.03	-	0.09	-	0.03	0.12	-	0.22	0.038	0.02	-	0.144	0.154
Idu Commercial	7.39	9.05	-	0.09	-	0.03	0.12	-	0.22	0.038	0.02	-	0.144	0.154
Maitama Residential	7.5	9.09	-	0.08	-	0.01	0.11	-	0.18	0.038	0.01	-	0.14	0.134
Maitama Commercial	7.48	9.11	-	0.08	-	0.01	0.11	-	0.18	0.038	0.01	-	0.14	0.134
Maitama Traffic	7.49	9.08	-	0.08	-	0.01	0.11	-	0.18	0.038	0.01	-	0.14	0.134
Wuse Commercial	7.46	9.07	-	0.08	-	-	0.11	-	0.18	0.038	0.01	-	0.14	0.136
Wuse Residential	7.47	9.08	-	0.08	-	-	0.11	-	0.18	0.038	0.01	-	0.14	0.136
Wuse Traffic	7.47	9.07	-	0.08	-	-	0.11	-	0.18	0.038	0.01	-	0.14	0.136
Asokoro Residential	7.51	9.05	-	-	-	0.02	-	-	0.23	0.032	-	-	0.12	0.112
Asokoro Traffic	7.53	9.05	-	-	-	0.02	-	-	0.23	0.032	-	-	0.12	0.112
Apo Residential	7.49	9.01	-	0.09	-	0.02	0.04	-	0.23	0.02	-	-	0.12	0.112
Apo Commercial	7.5	9.01	-	0.09	-	0.02	0.04	-	0.23	0.032	-	-	0.12	0.112
Apo Traffic	7.51	9.01	-	0.09	-	0.02	0.04	-	0.23	0.032	-	-	0.12	0.112
Central Area 1	7.47	9.05	-	0.082	-	0.01	0.11	-	0.18	0.038	0.01	-	0.141	0.134
Central Area 2	7.45	9.06	-	0.082	-	0.01	0.11	-	0.08	0.038	0.01	-	0.141	0.134
Central Area 3	7.44	9.05	-	0.082	-	0.01	0.11	-	0.18	0.038	0.01	-	0.141	0.134
Central Area 4	7.46	9.03	-	0.082	-	0.01	0.11	-	0.18	0.08	0.01	-	0.141	0.134

4. Conclusion

The results of study have shown that data from NigeriaSat-x can be used to produce detailed air pollution map. Therefore, Earth observations made by satellite sensors are likely to be a valuable tool for monitoring and mapping air pollution due to their major benefit of providing complete and synoptic views of large areas in one snap-shot. Blending together with remote sensing and GIS, pollutants concentration values can be derived over a large area of interest systematically.

The results showed significant key pollutants of Abuja. This is as a result of statistic in geostatistical analysis of hotspot map concentration of C0, $N0_2$, 0_3, and $S0_2$. It also shown a relationship between the concentration of air pollutants and land use/ land cover classification (industrial, commercial, residential and traffic point) for Abuja city. Gaseous emissions of pollutants from industries, building demolition, population explosion and auto exhaust can responsible for increasing concentration of the pollutants which can cause rising discomfort, increasing airborne diseases, decreasing productivity and deterioration of artistic and cultural patrimony in Abuja.

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