International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

Spatial Analysis of Impacts of Fugitive Emission Concentration using GIS and Remote Sensing Techniques: A Case Study of Onitsha Metropolis, Anambra State, Nigeria.

Ejikeme, J.O.; Igbokwe, J.I. and Emengini, E.J.

Department of Surveying and Geoinformatics, Nnamdi Azikiwe University,P.M.B. 5025, Awka, Anambra State, Nigeria

ABSTRACT

Air is considered safe when it contains no harmful chemicals and only low levels of other chemicals that become harmful in higher concentration to human, animals, plants or their ecosystem. Air pollution sources tend to be concentrated in urban cities like Onitsha. Onitsha metropolis is characterized with high population densities, industries and transportation network. Thus, it is adversely affected by emission of this harmful chemical. Air pollutants emanate from a source; therefore, they have situational relevance and hence have a positional element attached to them. Geographic Information System (GIS) and satellite remote sensing data were used to display and apply spatial analysis to data which reside in large database in order to obtain a strong visual appreciation of the concentration of the air pollutants as well as model its impact on the land use and land cover of Onitsha metropolis. The study area was segregated into eight zones and the result shows that zone 1has the highest total concentration of fugitive air pollutants combined as 20.248ppm, zone 2 with 15.262ppm and zone 3 having 13.936ppm. This could be attributed to heavy transportation network, high population densities and industries in zone 1. Zone 3 has the least total concentration of fugitive air pollutant. This may be attributed to the high vegetation cover and less concentration of buildings existing in the zone.

Keywords: *Air, Pollution, GIS, Remote Sensing, Database*

ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

1. Introduction

Air pollution can be defined as any atmospheric condition in which certain substances are present in such concentration that they can produce undesirable effects on man and his environment (Rao, 2006). These substances are considered air pollutants only when its concentration is relatively high compared to a given standard. The adverse effects of air pollutants in the environment and on human health in particular cannot be over-emphasized. Studies had been carried out on the effect of air pollution on man and his environment. The most notorious pollutant responsible for metallic corrosion is sulphur dioxide. At level of 0.09-1ppm, SO_2 affects fabric, leather and paint (Obiekezie et al, 2000; Rao 2006; Xian 2007). The effect is more pronounced in cities since human activity is concentrated into relatively small space. As cities multiply in number and size, the quantity of pollutants spewed into the air increases.

The variety of matter emitted into the atmosphere by natural and anthropogenic sources is so diverse that it is difficult to clearly classify air pollutants (Rao, 2006). However, they are divided into two categories, namely: primary and secondary pollutants. The primary pollutants are those that are emitted directly from the sources. Example of pollutants under this category are particulate matter such as ash, smoke, dust, fumes, mist and spray, inorganic gases such as sulphur dioxide (SO_2), hydrogen sulphide (HS), nitric oxide(NO), ammonia(NH_3), carbon monoxide (CO), carbon dioxide (CO_2), and hydrogen fluoride(HF), olefinic and aromatic hydrocarbons; and radioactive compounds. The secondary pollutants are those that are formed in the atmosphere by chemical interactions among primary pollutants and normal atmospheric constituents. Examples are Sulphur trioxide, Nitrogen dioxide, Peroxyacetyl nitrate (PAN), aldehydes, ketones and various sulphate and nitrate salts. Among the large number of primary pollutants emitted into the atmosphere, only few are present in sufficient concentration to be of immediate concern. These include: particulate matter, sulphur oxides, oxides of nitrogen, carbon monoxide and hydrocarbon. They are also referred to as fugitive emissions and are critical due to their potential harmful effects on human health.

These pollutants are released from anthropogenic sources and thus have geographic location. The sources of air pollutants can be grouped according to a variety of methods, including type of source, number and spatial distribution of sources and type of emissions. Thus, for a meaningful control of air pollution in the environment, there is the need to have accurate and up-to-date information about the spatial distribution and types of emission of the pollutants. Fortunately, Geographic Information System (GIS) technique has the potential as it is an effective tool for spatial analyses and modeling of concentrations of air pollutants. This is also possible because of its three basic key functions; database management, spatial analysis and visualization. With these three components, this system provides the capabilities of linking the concentration of the air pollutants with their geographic location. GIS technology can effectively represent the spatial relationships between sources and receptors. GIS, if integrated with satellite remote sensing data can be used to spatially analyze the relationship between the geographic location of air pollutants and the land use/land cover classes of the area. Hence, the primary objective of this study was to demonstrate the capability of GIS and Remote sensing techniques for analyzing the impact of fugitive emission concentration in Onitsha metropolis.

1.1 The Study Area

The study area (Onitsha metropolis) is located between Latitudes $06^{0}05^{1}$N and $06^{0}16^{1}$N and Longitude $06^{0}42^{1}$E and $06^{0}53^{1}$E (see figure 1). It covers Onitsha North and South Local Government Area and part of Obosi, Nkpor and Iyiowa Odekpe of Anambra State. It is bounded by Anambra West/East L.G.A. and Oyi in the North, Idemili-North/South in the East, Ogbaru L.G.A in the South and in the West by the River Niger. Onitsha is the largest urban center in Anambra state. It is also a major commercial town east of the Niger. Onitsha has a main market which is considered the largest market in West Africa. With her ever-increasing commercial activities, environmental problems like air pollution tend to be on the increase. The study area witnesses two distinctive climatic changes in a year, the dry season and rainy season. The dry season takes place from the month of October to March while the rainy season starts from March to September.

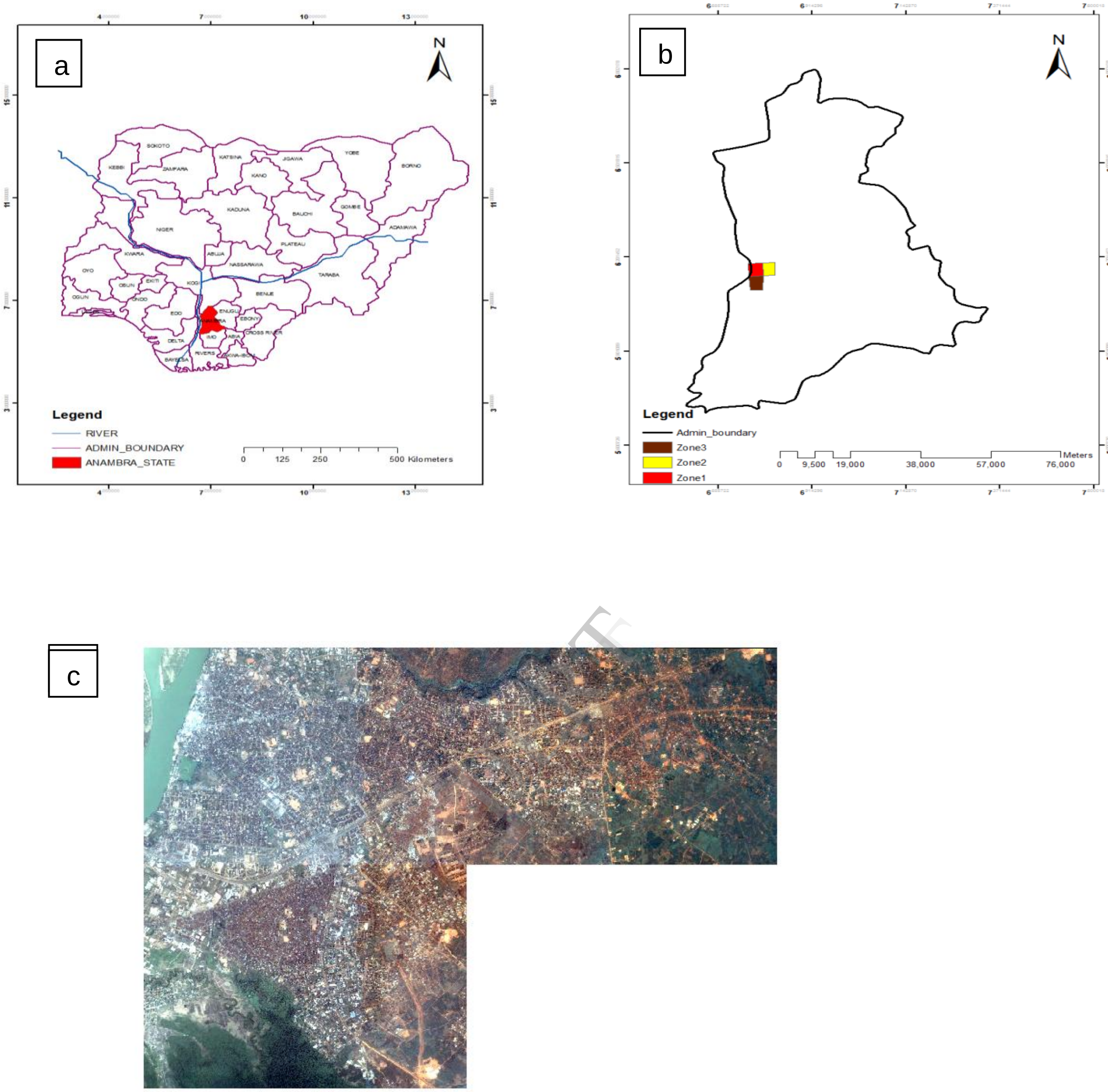

Figure 1(a) Map of Nigeria showing Anambra State; (b) Map of Anambra State showing Onitsha metropolis; (c) Ikonos image window of Onitsha metropolis.

Adapted from the Ministry of Lands, Survey and Town Planning, Awka and Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka, Anambra State, Nigeria.

2. Materials and Methods

The Ikonos image was segregated into 3 zones and each zone digitized as a polygon. The sampling points were located using handheld GPS and their locations plotted into the polygonized zone layers. The fugitive concentration of the air pollutants were assessed in both dry and wet season using Atomic Absorption Spectrophotometer (AAS) over a period of time from November 2010 to October 2011. Clean white basin of 0.8m diameter was placed at a height of 10m in each of the grid zones. A total number of twelve basins were used and basin harvested for dust deposits and analyzed using standard procedure of AAS. The measurement result of the pollution sources in each zone was compared, and analyzed vis-à-vis their contribution to the land use and land cover classification of the zone. The values of the fugitive concentration in the zone were embedded over the digital map created for the zone. Data base of the fugitive concentration was created and Inverse Distance Weighted (IDW) raster interpolation of spatial analyst extension in ArcGIS 9.3 software was used to delineate the locational distribution of various fugitive emission pollutants. The interpolated result of each of the pollutant in each zone was compared to that of the other zones and analysis performed.

The Ikonos image which had already been georeferenced in UTM Zone 32, WGS 84 ellipsoid was sub mapped into three zones and each zone classified into Built-up Area, Open Space, Water bodies and Vegetation depending on the class that was identified on the zone using ILWIS 3.3 software. These land use classes were adopted because of their impact on the concentration and dispersal of air pollutants (Xian, 2007; Civerolo et al, 2000).

3. Results and Discussions

The classified map of each zone was generated as shown in figures 2.1-2.3

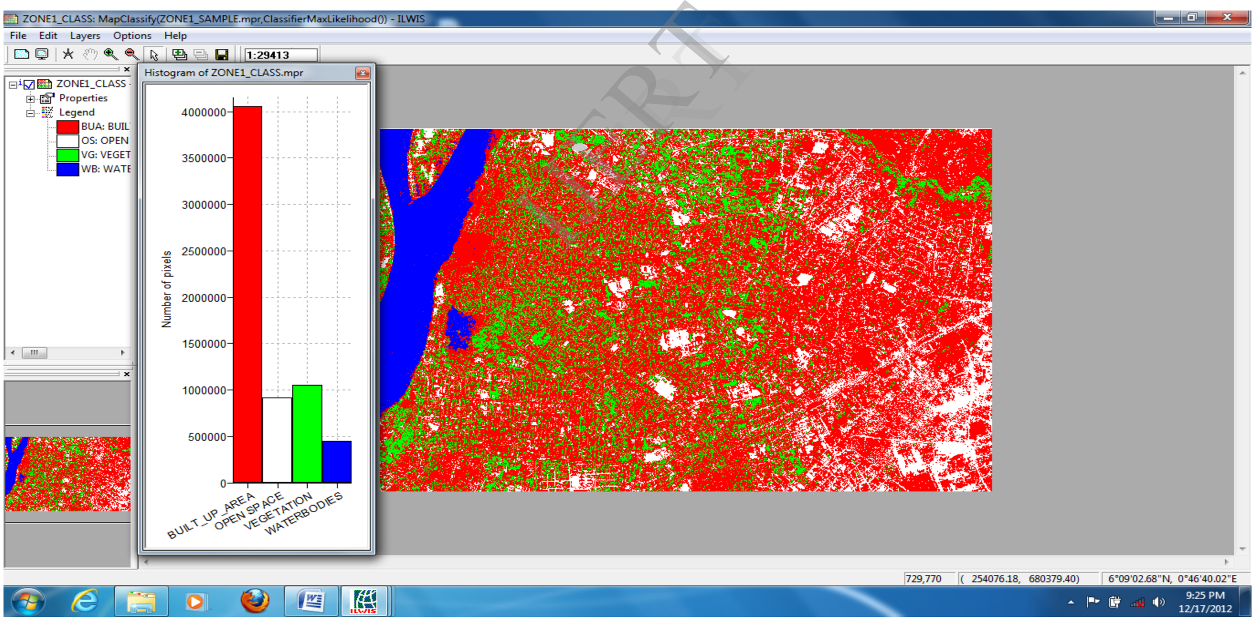

Figure 2.1: Classified map of Zone 1 using Ikonos image

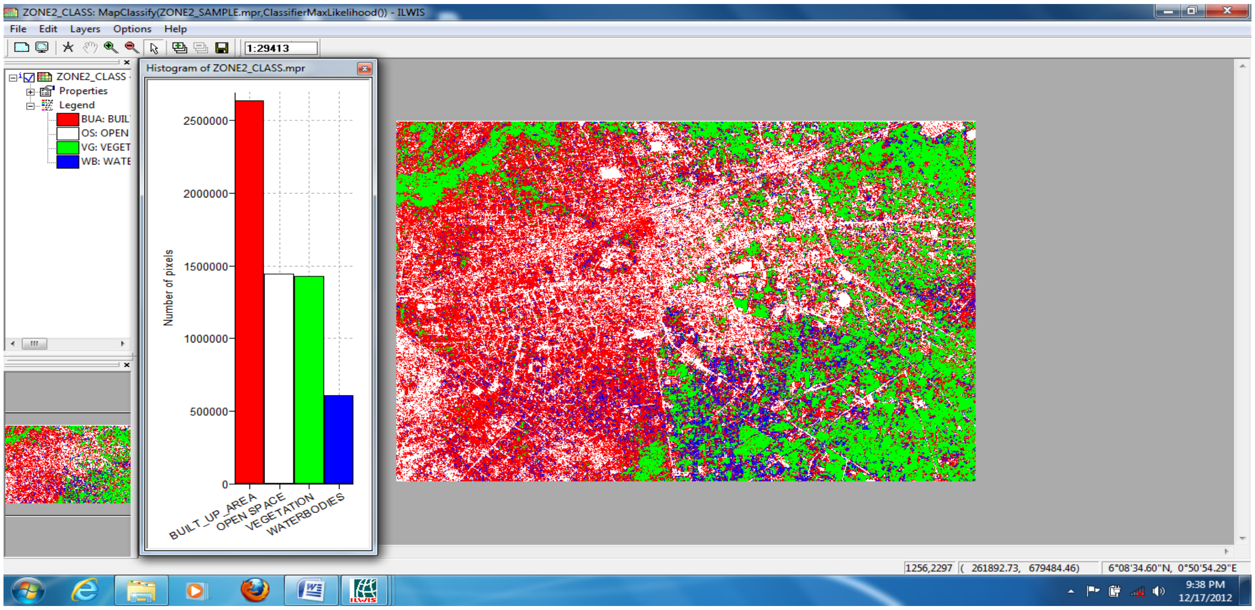

Figure 2.2: Classified map of Zone 2 using Ikonos image

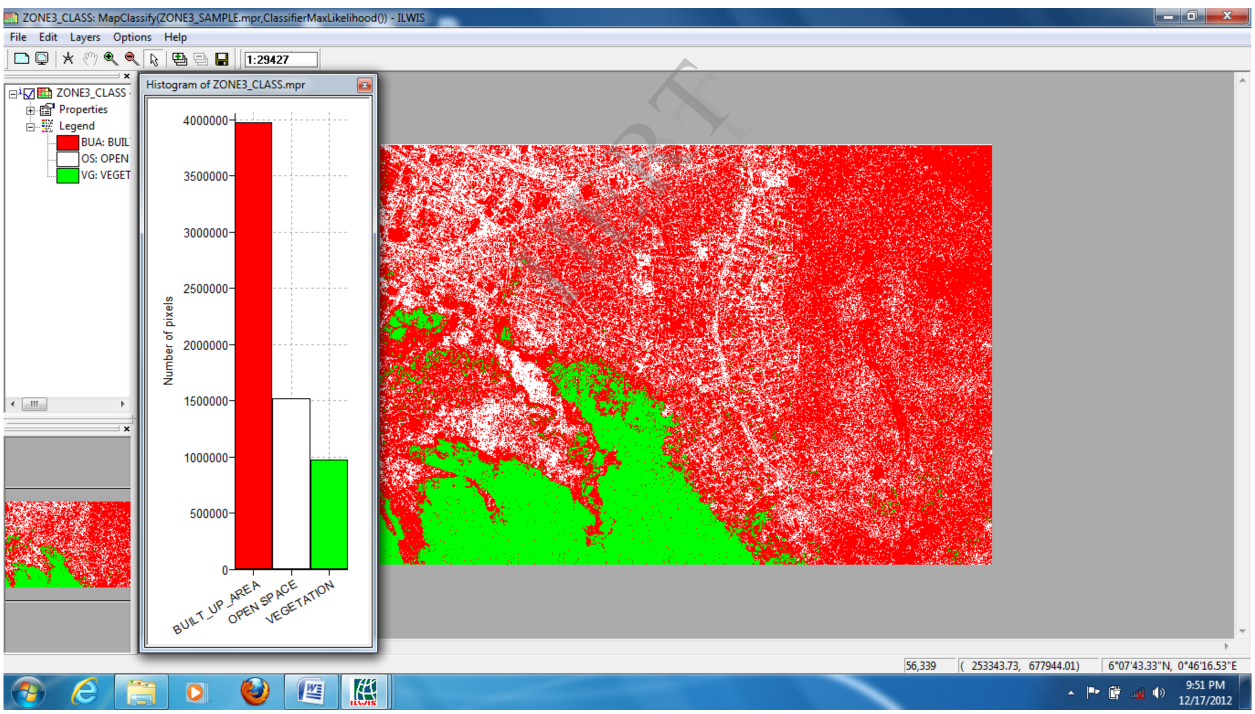

Figure 2.3: Classified map of Zone 3 using Ikonos image

The overall classification accuracy for zone 1, zone 2 and zone 3 are 93.52%, 74.03% and 90.66% respectively. This suggests that they are reliable for modeling land cover change analysis. Civerolo *et al.* (2000) suggested that additional vegetation cover in urban areas could affect pollutant concentration and their dispersal by reducing energy demand and biogenic emissions in surrounding areas. Xian (2007) used spatial and temporal urban development

ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

information derived from satellite remote sensing data in 2002 to explore urban land use/ land cover impact on O_3, NO_X and $PM_{2.5}$ concentrations and distributions in the Las Vegas Valley.

The IDW interpolation for zone 1, zone 2 and zone 3 is shown in figures 2.4, 2.5 and 2.6 respectively.

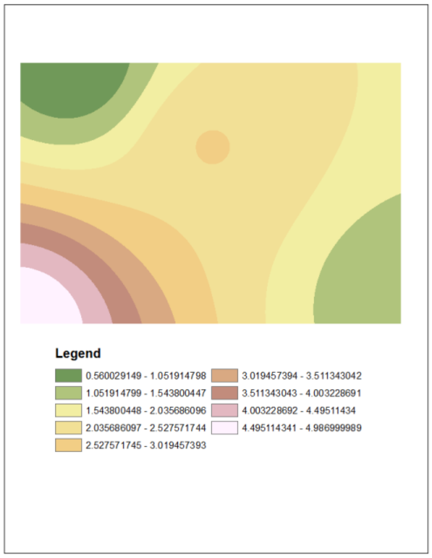

Figure 2.4: IDW interpolation of Zone 1

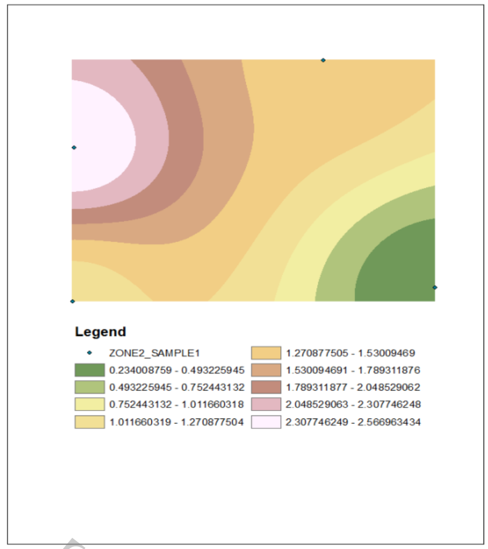

Figure 2.5: IDW interpolation of Zone 2

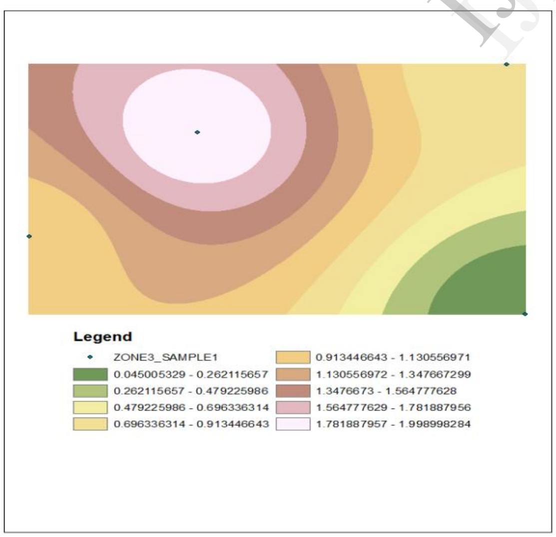

Figure 2.6: IDW interpolation for Zone 3

ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

The sample query was performed in order to determine the sample point that has the highest number of CO in Zone 1. The result (see figure 2.7) shows that the sample point highlighted has the highest concentration of CO. This may be attributed to the high concentration of commercial activities, buildings and a major highway around the sampling point in zone 1. The same analysis was performed for Zone 3 and the result is shown in figure 2.8.

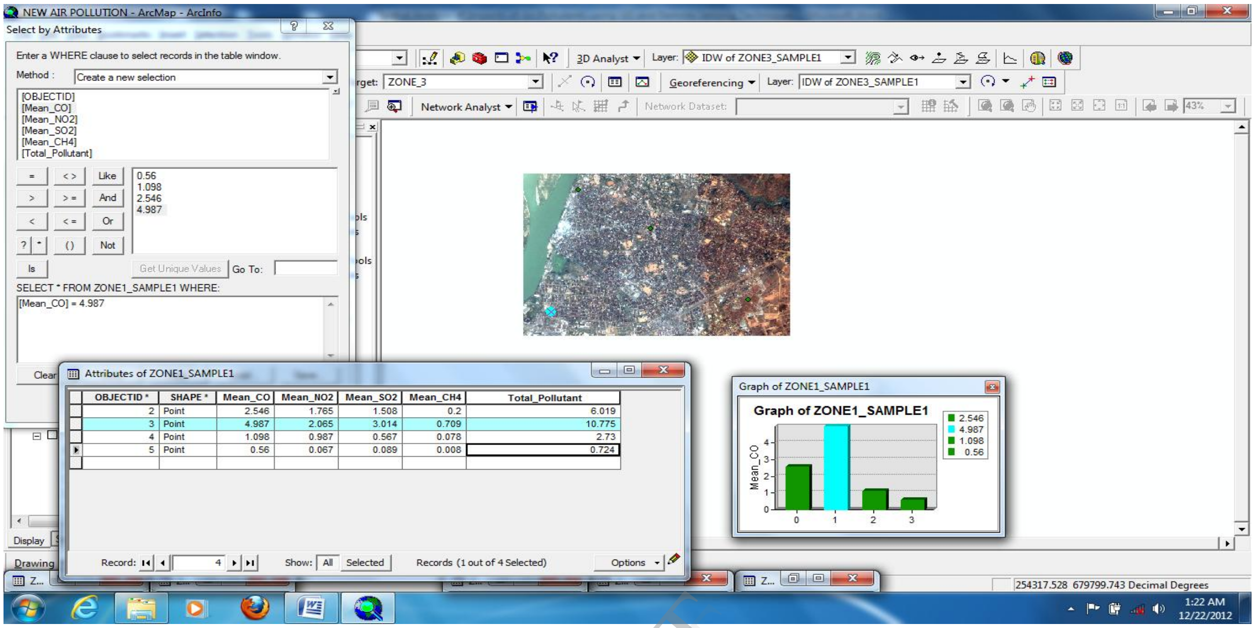

Figure 2.7: Query showing the sample point with the highest concentration of CO in Zone1

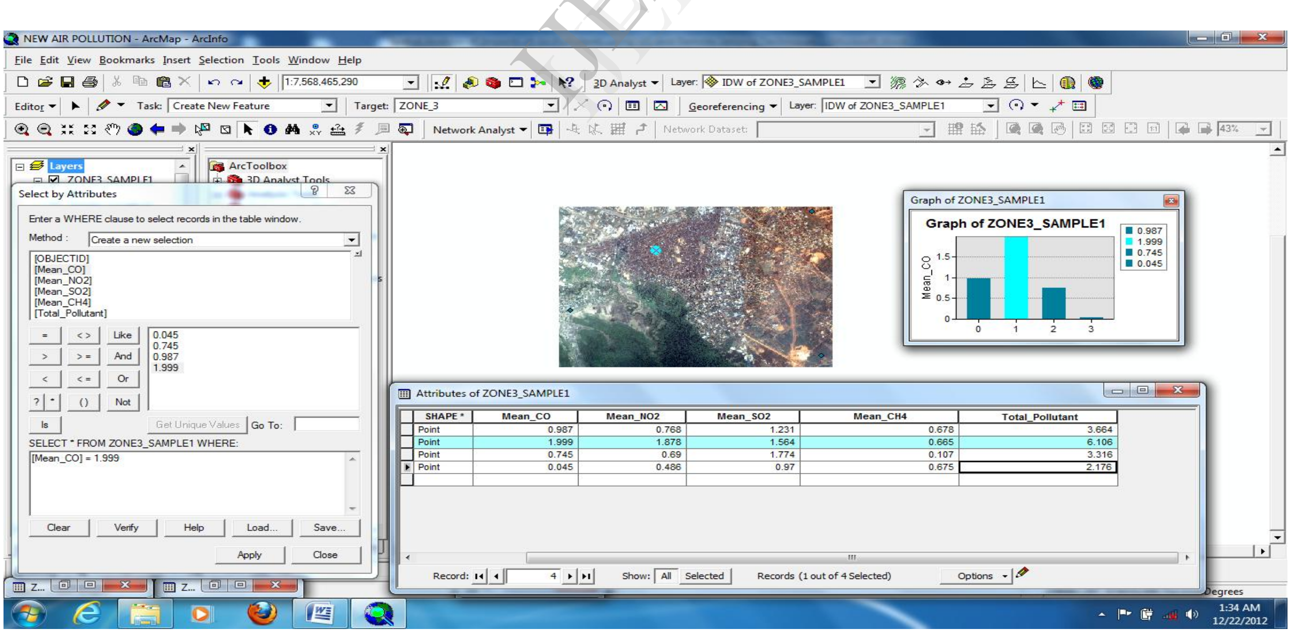

Figure 2.8: Query showing the sample point with the highest concentration of CO in Zone3

Concentration of air pollutants vary considerably depending on the proximity of the pollution, the source strength, meteorological conditions and the reactivity of the atmosphere. The nature and orientation of buildings contributed significantly in either the dispersion or concentration of emitted gases. High concentration of buildings blocked free circulation of gases at ground level thereby limiting their dispersion and dilution. The result of the classification shows that zone 1has the highest number of built-up area and population. The poor turbulent mixing of the pollutants in the built-up areas especially during the dry season characterized by gentle breeze may have led to the high concentration of pollutants at ground levels. This could be attested from the high concentration value recorded at the zone. The result of the sample queries obtained in figure 2.7 was compared with that obtained from figure 2.8 and the results shows that zone 1 has the highest total concentration of CO (9.191%) while zone 3 has the least with total concentration of 3.776% for CO.

4. Conclusion

This study shows the capability of using remote sensing and GIS to analyze the locational distribution of air pollutants. Air pollutants usually originate from a source and thus, have geographic element attached to them. Integrating GIS data with remote sensing image provides a better understanding of the impact of air pollutant on the land use/ land cover analysis of the study area. The study area was segregated into zones and each zone analyzed vis-à-vis the amount of fugitive pollutant being emitted in the zone. Using the zones as unit of study was considered better and more effective in understanding the problem of air pollution in Onitsha. Using the data derived, it was possible to distinguish the characteristics of air pollutants in each zone together with its dimension. It was also possible to differentiate the degree of pollution in each zone. This will build up the image of each zone in the minds of the citizen in having to choose the zones for their residential, industrial and commercial purposes.

References

Civerolo, K; Sistla, G; Rao, S.T; Nowak, D.J (2000). The effects of land use in meteorological modeling: implication for assessment of future air quality scenarios. Atmospheric Environment, 39, pp. 1615-1621.

Obiekezie, S.O; Ono, M.N and Igbokwe, J.I (2000). Monitoring and Auditing of Impacts of Environmental Degradation. Environmental Review, Vol. 3, No.2, pp. 309-321.

Rao, C.S (2006). Environmental Pollution Control Engineering. Newage International (P) Limited Publishers, New Delhi, (ISBN: 81-224-1835-X).

Xian, G (2007). Analysis of impacts of urban land use and land cover on air quality in the Las Vegas region using remote sensing information and ground observations.