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Ozone Level Study at Major Traffic Stalling Points in the Federal Capital City, Abuja, Nigeria

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Abstract
In the absence of a reference corpus on air pollution profiles at Nigeria's capital city of Abuja, this study was designed to be a pilot in the hope that its structure would form the basis for further suchlike air pollution studies such that a reference corpus may be created. The part of Abuja chosen for this pilot study was the heavily built-up Federal Capital City (FCC), the "heart" of the capital. Seventy-six major traffic stalling points were identified in the FCC: a traffic stalling point (TSP) is defined to be a road junction or node where all practical motor-mobiles (that is, cars, trucks, motor-cycles, motorized rickshaws, etc.) necessarily decelerate upon approaching the junction, for safety purposes, and accelerate to change velocity as they exit that junction; the process of acceleration involves revving of the engines of the motor-mobiles, with associated increase in the exhaust gaseous effluents. The first phase of this exercise involved the selection of appropriate stations to be occupied within the FCC; coordinate identification (plus corresponding elevation information) using a Global Positioning Systems (GPS) unit was incorporated in this phase. The second phase involved ozone (O_3) levels measurements at the major traffic stalling points that were identified and these were carried out over a spread of 10 hours (that is, 7 a.m. to 5 p.m.) at the quarterly hour-mark interval (that is, 15 minutes): the GasAlert EXTREME Single Gas Detector (Ozone Mode) equipment was employed in this phase; thirty-seven sequences of measurements were taken for each day at each of the major traffic stalling points over the three-day period, resulting in a total of 37 x 3 = 111 individual measurements. 111 individual measurements over a spread of 76 major junctions resulted in 8436 targeted measurements for the period of survey; the full-bodied data set of this study represented these 8436 targeted measurements as much as possible. For the third and final phase, the data-set thus built was processed and interpreted in order that deductions on the prevailing nature of the ground-level ozone (O_3) air pollution gas could be made. The targeted 111 individual measurements at the different major traffic stalling point were analysed to determine the number of "counts" of the time interval for ozone levels measurements greater than the acceptable threshold of 0.1 ppm. Below the threshold of 0.1 ppm, ozone levels are classified as "tolerable;" between 0.1 ppm and 9 ppm, ozone levels are classified as "hazardous;" above 9 ppm, ozone levels are classified as "critical." Thus, the "counts" frequency indicated in this analysis applies only to ozone levels above 0.1 ppm, with no descriptive bar on the upper limit of the ppm magnitude, even if this goes beyond 9 ppm, where possible. This result of this study shows that risk to ozone exposure for road users within the FCC is greatest in the hours after midday, beginning from just at lunch time to the early evening rush-hour of 5 p.m. (the timeframe of intense sunshine in Nigeria). Thus, this principal observation has corroborated the prevailing scientific notion that vehicular effluents released during periods of intense sunshine are the mechanism for the formation of ozone. A Geographic Information System (GIS) scheme was implemented for this study in order to have the results of this survey available to the general public: since the "mother ship" of a GIS already exists as the Abuja Geographic Information System (AGIS), the logical approach here was to create an ozone pollution layer that was a veritable subset of the AGIS.
Keywords: *Ozone; sunshine; effluent; pollution; motor-mobile; TSP; ppm; GIS*

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I. Introduction

Ozone. Ozone is a pale blue, highly poisonous gas with a strong odour. Ozone is considered a pollutant at ground level, but the ozone layer of the upper atmosphere protects life on Earth from the Sun's harmful ultraviolet radiation. Ozone is one of three forms, called allotropes, of the element oxygen. Ozone is triatomic, meaning that it has three atoms in each molecule (formula O_3). Ordinary, or diatomic, oxygen (O_2) is more stable than ozone and accounts for the bulk of oxygen in the atmosphere. Electrical sparks and ultraviolet light can cause ordinary oxygen to form ozone. The presence of ozone sometimes causes a detectable odor near electrical outlets. At normal temperatures and pressures ozone is a gas with a specific gravity of 2.144 (about 1.5

times the density of ordinary oxygen gas). Ozone accounts for only a tiny fraction of the atmosphere and is normally invisible, but high concentrations of ozone gas are pale blue. The gas condenses to a liquid at -111.9°C (-169.52°F) and freezes at -192.5°C (-314.5°F). Liquid ozone is deep blue, and is diamagnetic (repelled by magnetic fields). Solid ozone is dark purple. Ozone is much more active chemically than ordinary oxygen. It is used in purifying water, sterilizing air, and bleaching certain foods. Ozone at ground level is a health hazard, causing respiratory ailments such as bronchitis and asthma. It also damages vegetation and causes rubber and some plastics to deteriorate. Nitrogen oxides and volatile organic gases emitted by automobiles and industrial sources combine to form ozone. In 1998, the United States Environmental Protection Agency (EPA) implemented a new air rule designed to curb nitrogen oxides released by coal-fired electric power plants. Many cities issue public air quality warnings when ozone levels rise to dangerous levels. Ozone in the upper atmosphere, however, is vital to life. This ozone forms by the action of ultraviolet light from the Sun on molecules of ordinary oxygen. The ozone layer absorbs ultraviolet radiation so that much of it never reaches the ground. Certain industrial compounds cause ozone to break down, opening holes in the ozone layer and exposing life on the ground to dangerous levels of ultraviolet radiation. A single atom of chlorine, for example, floating about in the upper atmosphere, can destroy hundreds of thousands of molecules of ozone because the chlorine acts as a catalyst and is not itself altered in the process.

Environment and Environmental Pollution. Environment is the pysical and biotic habitat which surrounds us; that which we can see, hear, touch, smell and taste. Pollution can be defined as an undesirable change in the physical, chemical or biological characteristics of the air, water or land that can harmfully affect the health, survival or activities of humans or other living organisms (Henry and Heinke, 2004).Environmental pollution is the contamination of the earth's environment with materials that has an interference with the environment and are hazardous to human health or living organism. It has been classified into various categories that includes air pollution, water pollution, soil pollution, noise pollution and electromagnetic radiation. Electric motors, electric transmission lines, and appliances such as toasters, electric blankets and computers, all produce electromagnetic fields (EMFs) that are hazardous to human health. Nevertheless, several studies have concluded that children exposed to EMFs from power lines have an increased risk of contracting leukemia, lymphomas and nervous system cancers (Botkins and Keller, 1995). Pollution can also be defined the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. The major kinds of pollution are (classified by environment) air pollution, water pollution, and land pollution. Modern society is also concerned about specific types of pollutants, such as noise pollution, light pollution, and even plastic pollution. Although environmental pollution can be caused by natural events such as forest fires and active volcanoes, use of the word pollution generally implies that the contaminants have an anthropogenic source (that is, a source created by human activities). Pollution has accompanied humankind ever since groups of people first congregated and remained for a long time in any one place. Indeed, ancient human settlements are frequently recognized by their pollutants (shell mounds and rubble heaps, for instance). Pollution was not a serious problem as long as there was enough space available for each individual or group. However, with the establishment of permanent settlements by great numbers of people, pollution became a problem, and it has remained one ever since (Encyclopaedia Britannica, 2012). According to Encarta (2007), "environmental pollution is the contamination of the earth's environment with materials that interfere with human health, the quality of life, or the natural functioning of the ecosystem (living organisms and their physical surroundings). Whilst some environmental pollution is a result of natural causes (such as volcanic eruptions), most are caused by human activities. Environmental pollution has been classified into different categories that include air pollution, water pollution, solid pollution, hazardous pollution, and noise pollution."

Air Pollution at Traffic Stalling Points. Vehicle movements at traffic light junction are regulated by traffic signals. Vehicles will accelerate and enter the junction if the signal turns green. While the signal is green, incoming vehicles enter the intersection at cruising speed or average speed. Vehicles will decelerate and come to a complete stop when the signal turns red. The process is repeated for each cycle of traffic signal. All of the different level of vehicle movement at the junction contributes to fuel consumption and pollutant emissions. Along a stretch of road, the most critical places are considered to be road junction. Usually, traffic engineers will design a road junction based on the anticipated volume of traffic that will use the junction. Severe traffic congestion can occur as a result of designing road junctions according to inappropriate standards. Increase in congestion will certainly increase the amount of pollutions being emitted.

Traffic Stalling Point (TSP) and "Major" and "Minor" Categorisation. It is understood from Jonah and Bawa (2014), Jonah and Duromola (2014), Jonah *et al.* (2014) that a traffic stalling point is formed at the intersection of a road junction. Minor traffic stalling points are formed at intersections of minor road junctions and major traffic stalling points are formed at intersections of major road junctions. In the course of this survey, at the site selection and co-ordinate identification phase, on-site real-time decisions were made regarding junctions where low-traffic density minor roads meet and where high-traffic density major roads meet. Thus, "major" and "minor" classification of traffic stalling junctions was a product of on-site observations by the survey crew; seventy-six major traffic stalling junctions or points were identified at the area of this study.

Parts-Per-Million. The concept of a parts-per-million indicates the concentration of a substance (especially gas) in a medium whose volume in that medium is exactly $1/1{,}000{,}000^{th}$ of the total volume of the principal medium.

Geographic Information System (GIS). A GIS is a computer system for performing geographical analysis. GIS has four interactive components: an input subsystem for converting into digital form (digitising) maps and other spatial data; a storage and retrieval subsystem; an analysis subsystem; and an output subsystem for producing maps, tables, and answers to geographic queries. GIS is frequently used by environmental and urban planners, marketing researchers, retail site analysts, water resource specialists, and other professionals whose work relies on maps.GIS evolved in part from the work of cartographers, who produce two types of maps: general-purpose maps, which contain many different themes, and thematic maps, which focus on a single theme such as soil, vegetation, zoning, population density, or roads. These thematic maps are the backbone of the GIS because they provide a method of storing large quantities of fairly specific thematic content that can later be compared. In 1950, for example, British urban planner Jacqueline Tyrwhitt combined four such thematic maps (elevation, geology, hydrology, and farmland) in one map through the use of transparent overlays placed one on top of another. This relatively simple yet versatile technique allowed cartographers to create and simultaneously view several thematic maps of a single geographical area. The arrival of the computer in the 1950s brought another essential component of GIS. By 1959 the American geographer Waldo Tobler had developed a simple model to harness the computer for cartography. His MIMO ("map in–map out") system made it possible to convert maps into a computer-usable form, manipulate the files, and produce a new map as the output. This innovation and its earliest descendants are generally classified as computerised cartography, but they set the stage for GIS. In 1963 the English-born Canadian geographer Roger Tomlinson began developing what would eventually become the first true GIS in order to assist the Canadian government with monitoring and managing the country's natural resources. (Because of the importance of his contribution, Tomlinson became known as the "Father of GIS.") Tomlinson built on the work of Tobler and others who had produced the first cartographic digital input device (digitizer) and the computer code necessary to perform data retrieval and analysis; they had also developed the concept of explicitly linking geographic data (entities) and descriptions (attributes). The two most common computer graphic formats are vector and raster, both of which are used to store graphic map elements. Vector-based GIS represents the locations of point entities as coordinate pairs in geographic space, lines as multiple points, and areas as multiple lines. Topographic surfaces are frequently represented in vector format as a series of non-overlapping triangles, each representing a uniform slope. This representation is known as Triangulated Irregular Network (TIN). Map descriptions are stored as tabular data with pointers back to the entities. This allows the GIS to store more than one set of descriptions for each graphic map object. Raster-based GIS represents points as individual, uniform chunks of the Earth, usually squares, called grid cells. Collections of grid cells represent lines and areas. Surfaces are stored in raster format as a matrix of point elevation values, one for each grid cell, in a format known as a digital elevation model (DEM). DEM data can be converted to TIN models if needed. Whether raster or vector, the data are stored as a collection of thematic maps, variously referred to as layers, themes, or coverages. Computer algorithms enable the GIS operator to manipulate data within a single thematic map. The GIS user may also compare and overlay data from multiple thematic maps, just as planners used to do by hand in the mid-1900s. A GIS can also find optimal routes, locate the best sites for businesses, establish service areas, create line-of-sight maps called viewsheds, and perform a wide range of other statistical and cartographic manipulations. GIS operators often combine analytical operations into map-based models through a process called cartographic modeling. Experienced GIS users devise highly sophisticated models to simulate a wide range of geographic problem-solving tasks. Some of the most complex models represent flows, such as rush-hour traffic or moving water, that include a temporal element (Longley *et al.*, 2005; Heywood *et al.*, 2011; Maguire, 1989; Maguire *et al.*, 1991; Goodchild, 1997; Mark, 2003; Department of Environment, 1987; Aronoff, 1991; Bruce, 2008; Smith *et al.*, 1987; Jian and Philippa, 2009; Verma *et al.*, 2008; Jonah *et al.*, 2011; Jonah *et al.*, 2011A; Jonah *et al.*, 2011B; Jonah *et al.*, 2011). In the course of the 2012 suite of noise and air pollution studies at identified traffic stalling junctions or points in Minna town, Nigeria, Jonah and Ayofe (2014) created a GIS for this town and a purpose-specific building layer for the various urban built-up attributes like those of residential buildings, commercial buildings, administrative buildings, educational buildings, finance-institution buildings, as well as the best-route road network analysis from one part of town to the other.

Highly Ozogenic Sphere. This is the time interval or the time segments at defined major traffic stalling junctions where ozone counts are observed to be greater than the median determined for that particular traffic stalling junction. It is vital to point out here that for the "hazardous" category of ozone levels greater than 0.1 ppm encountered in the course of this study, time of exposure is a also a point to be considered. The published literature tells us that only a 15-minute exposure limit can be tolerated for this "hazardous" category in order to avoid the basic and primary symptoms of continuous headaches and shortness of breaths. Any time interval indicating a count is "*ozogenic sphere*" but any time interval indicating a preponderance of counts must be "*highly ozogenic sphere*" indeed. The introduction of the "median" concept is to enable the classification of these "*highly ozogenic spheres.*" These time segments are those that must be flagged for continuous monitoring.

On The "Median" Concept. The median concept is introduced for each of the major traffic stalling point in order to contrain the conclusion that is drawn with respect to which time interval is "*ozogenic*" and "*highly ozogenic*." It is desired that the "highly ozogenic" time segments be flagged for further real-time, continuous observations. The median value is the calculated middle-value of the set of amplitudes of ozone counts for each of the major traffic stalling point.

Area of Study. It is understood that the Federal Capital City (FCC) is the ringed-off core development of the Federal Capital Territory (FCT) encompassing the neigbourhoods of Maitama, Asokoro, Central Business District, Garki, and Wuse. The street guide map of the FCC is shown as Figure 1.

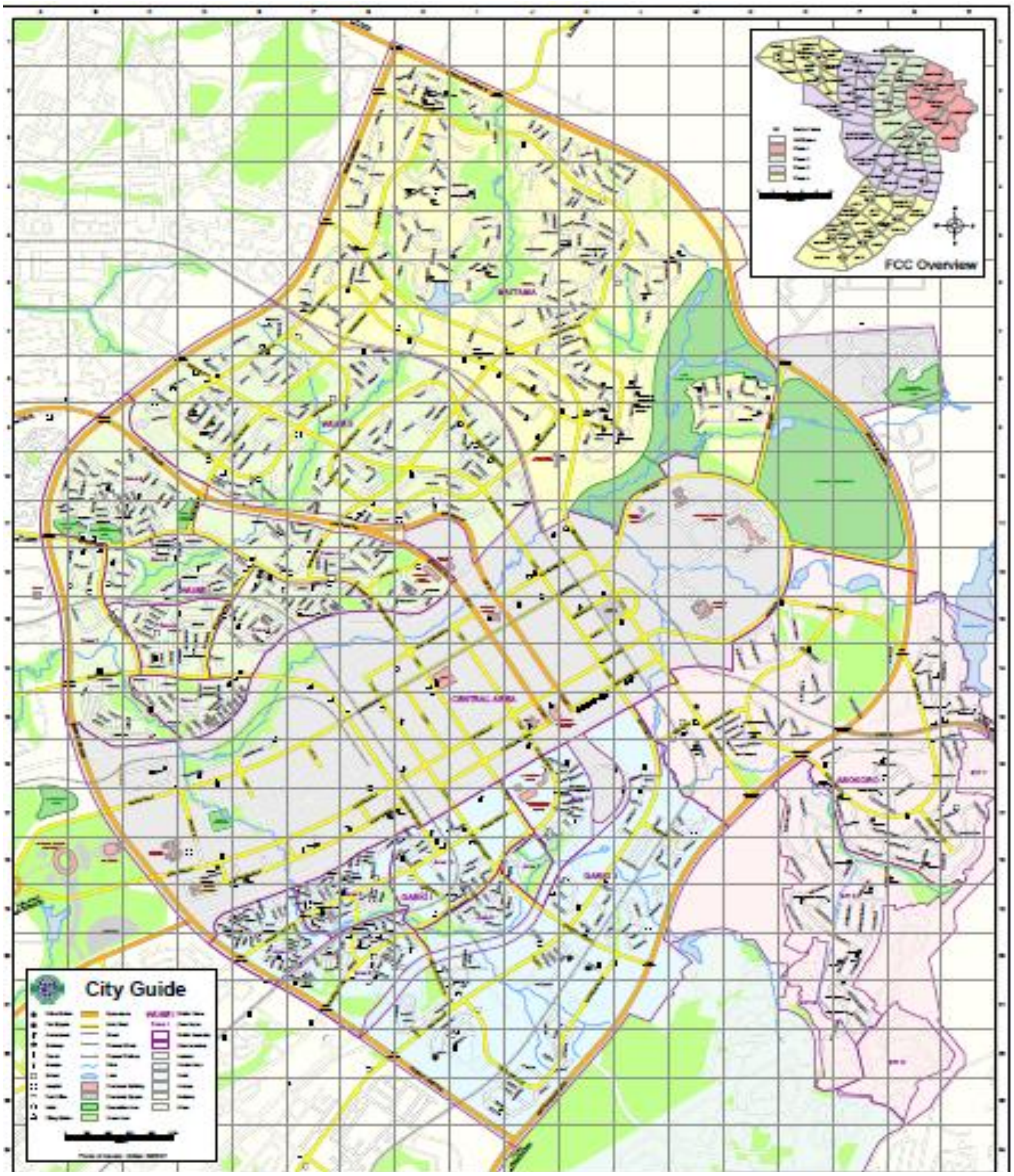

Figure 1. Street guide map of the FCC

The Federal Capital Territory (FCT) is part of the North Central geopolitical zone of Nigeria. It has interstate boundaries with Nasarawa State to the east and southeast, Niger State to the west and northwest, Kaduna State to the northeast and Kogi State to the southwest. Its capital, Abuja, is also the capital of Nigeria. The area of the Federal Capital Territory was originally part of Niger, Nasarawa and Kogi states. It was established in 1976 by the Federal Capital Territory Act of the military government of General Murtala Muhammed. Abuja is the first planned city in Nigeria and was built mainly in the 1980s. It officially became Nigeria's capital on December 12, 1991. Its main cities and towns are Abuja (capital city), Abaji, Bwari, Gwagwalada, Kuje, Kwali and Lugbe.The territory is currently made up of six Area Councils, and these are Abuja Municipal Area Council (AMAC), Abaji, Gwagwalada, Kuje, Bwari, and Kwali. The Federal Capital Territory covers an area of 7,753.9 square kilometres. It lies at latitude 09°05′ north and longitude 07°32′ east. It has a population of 1,406,239 (2006 census figures) and a population density of 192 people per square kilometre. It accounts for 1.3% of Nigeria's total population. The early settlers of the Federal Capital Territory were the Kwa-speaking people of Nigeria's middle belt region. The Kanuri people from Borno came to the area during the Fulani Jihad in the nineteenth century. The main ethnic groups in the Federal Capital Territory are the Gbabyi, Koro, Gade, Bassa, Gwandara and Ganagana. Nine languages are spoken in FCT. The Gbabyi people form the largest ethnic group and the Gbabyi language is the most widespread.

Problem Statement of the Ozone (O_3) Level Study. At the present, there exist a knowledge void of air pollution substances and noxious effluents that are emitted by motor-mobiles at traffic stalling points of the FCC.

Aim and Objectives of the Ozone (O_3) Levels Study. The aim of this study is to plug the knowledge void that exists of a particular air pollution substance at traffic stalling points of the FCC.The principal objectives of this study are the following:

i) To create a database of ozone that is emitted by motor-mobiles at traffic stalling points for the FCTA; such a database would be tailored toward general enlightenment whence the general populace would be made aware of the hazards of ozone air pollution problems at the various traffic stalling points in the FCC.

ii) To transform such a database of ozone to a reference document for the different points surveyed. This document would highlight the various ozone pollution indices for the locations surveyed.

Justification for the Ozone (O_3) Levels Study. Measurements of the indices of ozone at the various traffic stalling points of the FCC would contribute immensely to FCTA's repertoire of actionable data set that is most desirable for policy formulation in the near- and long-term.

Scope of the Ozone (O_3) Levels Study. All of the identified traffic stalling junctions at the FCC, minor and major categorizations, was occupied in the course of this survey. However, only the major traffic stalling junctions were earmarked for ozone level measurements.

Method

Phase I: Site Selection and Co-Ordinate Identification. The first phase of this exercise involved the selection of appropriate locations to be occupied within the FCC. Coordinate and elevation identifications were achieved by use of hand-held Global Positioning Systems (GPS) units. It is vital to point out here that a total of 103 traffic stalling points were identified; 76 of these were of the "major" classification whilst 27 were of the "minor" classification.

Phase II: Data Collection. Ozone levels in parts per million (ppm) were measured by means of hand-held ozone meters at the quarter-hourly mark from 7 a.m. through 5 p.m. at any one of the selected major traffic stalling points over a three-day period in order to create a large data field from which a fairly accurate deduction could be made. For this three-day survey-station life cycle, about seven junctions were usually occupied. The ozone meter employed for this survey is the GasAlert EXTREME Single Gas Detector by BW Technology of the Honeywell Group. For the gas ozone (O_3), the operating temperature is between -20^{o}C and +50^{o}C, operating humidity is between 15% and 95%, the detection range is between 0 to 1 ppm (at 0.01 ppm increments), the sensor types are the plug-in electrochemical cells, calibration mode is auto zero, typical audible alarm is of the 95 dB level, display is alpha-numeric liquid crystal display (LCD), self-test is initiated at activation. The device is classified to both U.S. and Canadian Standards as intrinsically safe for Class I, Division 1, Group A, B, C, D and Class II, Group E, F, G.

The Work Schedule:- In order to design a workable schedule, the FCC was gridded into eight sectors based on the existing structure as obtained from the street guide map of Figure 1. The sectors are the following, viz:

i. Maitama
ii. Wuse I
iii. Wuse II
iv. Central Business District (CBD)
v. Garki I
vi. Garki II
vii. Asokoro

viii. Ring Road I

A daily work-plan was drawn up for this survey, detailing crew activity, date of occupation of specified traffic stalling point, duration of occupation of specified traffic stalling point, and the week-lapse of survey. This schedule is as shown in the accompanying table.

Field Crew Distribution and Pattern-of-Survey:- The survey crew for this exercise composed of seven teams with two members each spread out over seven major junctions for each day of study; the crew occupies the next linear (adjustments are made if linearity is not defined) seven major junctions after the third day of measurements. The Pattern-of-Survey Progression Map is shown as Figure 2; this map is colour-coded for day-by-day station occupation for measurements purpose for the duration of the survey. Ten units of ozone monitors were acquired for this survey; one unit was assigned to each team and three units were designated as back-ups.

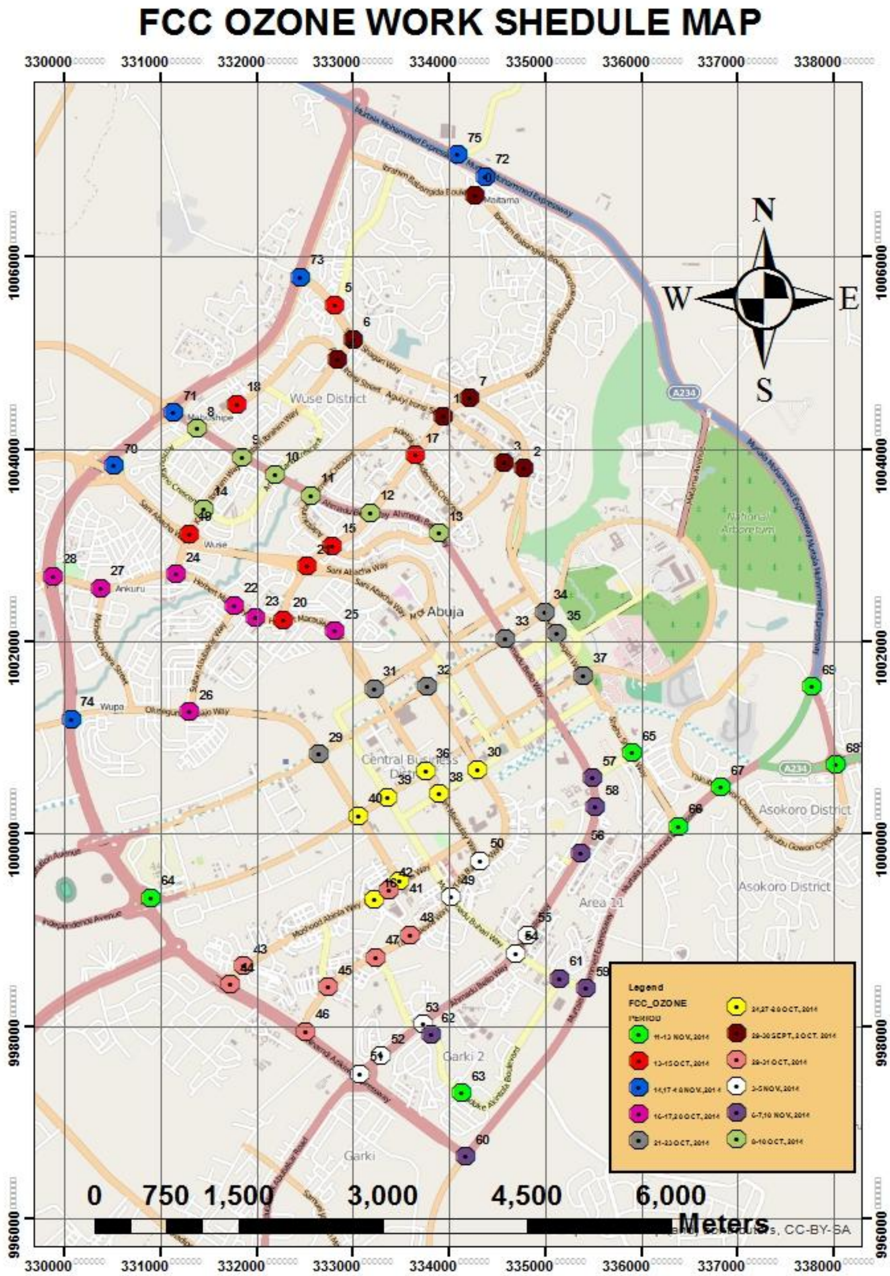

Figure 2. The Pattern-of-Survey Progression Map. (Note that this map is colour-coded for day-by-day station occupation for measurements purpose for the duration of the survey.)

II. Result

Thirty-seven sequences of measurements were taken for each day at each of the major traffic stalling points over the three-day period, resulting in a total of 37 x 3 = 111 individual measurements. Recall, also, that 111 individual measurements over a spread of 76 major junctions result in 8436 targeted measurements for the period of survey. The full-bodied data set of this study represented these 8436 targeted measurements as much as possible, except where extant circumstances precluded measurement at a particular location on a particular location. Where these extant circumstances exist, they have been duly noted; rainfall interruption, say; restricted location like the Presidential Villa Junction, say. Please refer to the full-bodied data set for this study that is presented in the complementary document.

III. Discussion

The targeted 111 individual measurements at the different major traffic stalling point were analysed to determine the number of "counts" of the time interval for ozone levels measurements greater than the acceptable threshold of 0.1 ppm. Below the threshold of 0.1 ppm, ozone levels are classified as "tolerable;" between 0.1 ppm and 9 ppm, ozone levels are classified as "hazardous;" above 9 ppm, ozone levels are classified as "critical." Thus, the "counts" frequency indicated in this analysis applies only to ozone levels above 0.1 ppm, with no descriptive bar on the upper limit of the ppm magnitude, even if this goes beyond 9 ppm, where possible. Summary tables of ozone levels prevalence regimes for days 1, 2, and 3 were generated from whence a cumulated summary table was produced. There are nine-hour time segments of survey; lunch break was between 12 noon and 1 p.m. The numerical values (0 through 15) associated with each time segment refer to particular count(s) above the threshold of 0.1 ppm. From the aforementioned cumulated summary table, highlights for just a couple of survey stations (from a total of 76 survey stations) are presented hence:

Traffic Stalling Point 1: IBB Boulevard/Osun Crescent. The highest count is observed between 2 p.m. to 3 p.m. See Figure 3 and Table 1.

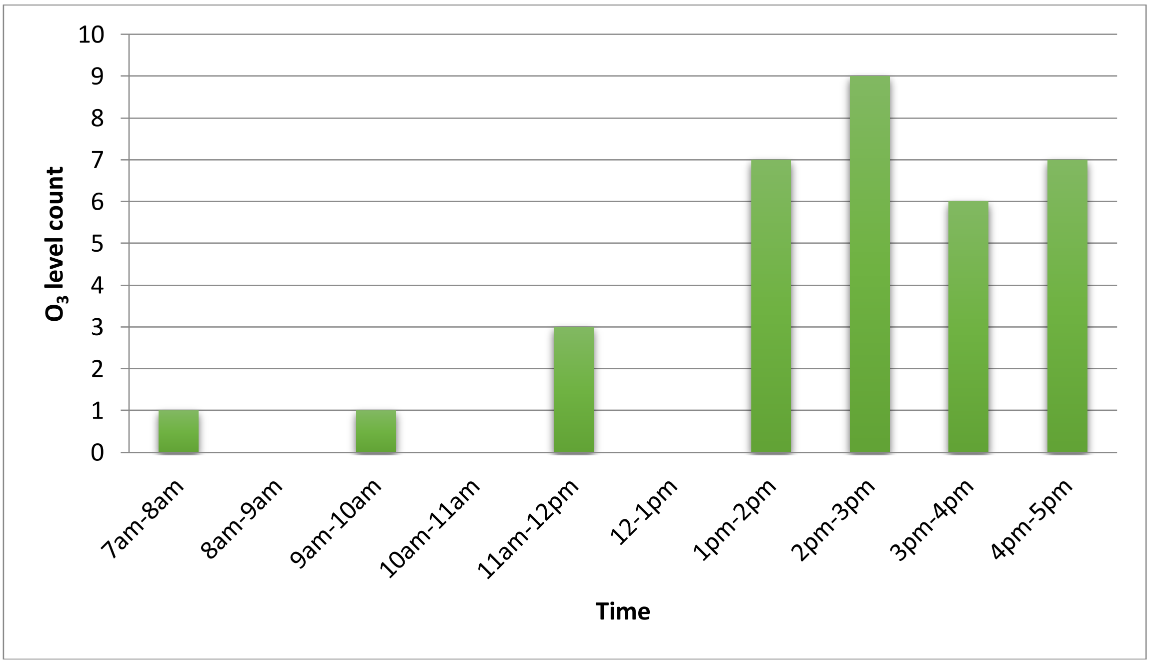

Figure 3. Bar chart representation of the count-density of ozone levels greater than 0.1ppm

Table 1. Statistical analysis information of TSP 1

Set of Amplitudes of Ozone Counts	Range	Median
7a.m. to 8a.m.: 1	0	
8a.m. to 9a.m.: 0	0	
9a.m. to 10a.m.: 1	1	
10a.m. to 11a.m.: 0	1	
11a.m. to 12noon: 3	3	**3**
1p.m. to 2p.m.: 7	6	
2p.m. to 3p.m.: 9	7	
3p.m. to 4p.m.: 6	7	
4p.m. to 5p.m.: 7	9	

Traffic Stalling Point 2: IBB Way/Aguiyi Ironsi Street. See Figure 4 and Table 2.

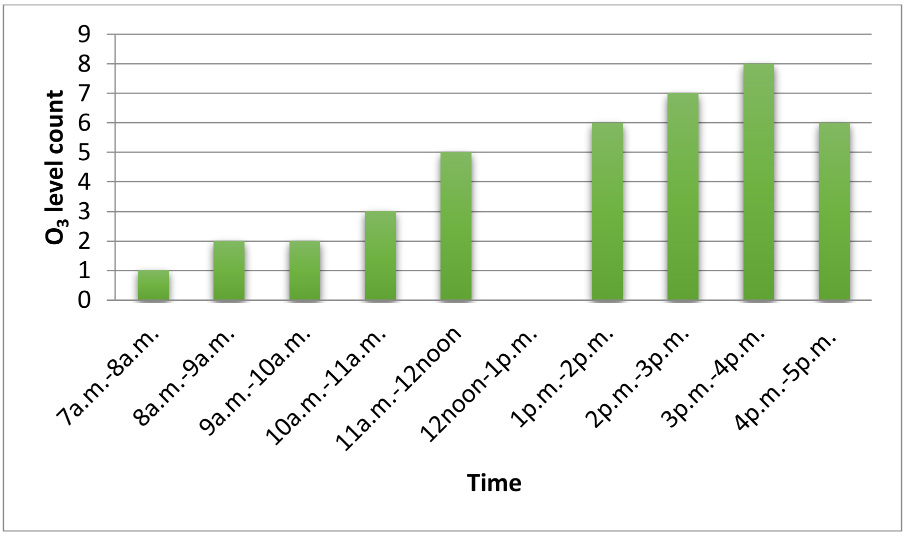

Figure 4. Bar chart representation of the count-density of ozone levels greater than 0.1ppm

Table 2. Statistical analysis information of TSP 2

Set of Amplitudes of Ozone Counts	**Range**	**Median**
7a.m. to 8a.m.: 1	1	
8a.m. to 9a.m.: 2	2	
9a.m. to 10a.m.: 2	2	
10a.m. to 11a.m.: 3	3	
11a.m. to 12noon: 5	5	**5**
1p.m. to 2p.m.: 6	6	
2p.m. to 3p.m.: 7	6	
3p.m. to 4p.m.: 8	7	
4p.m. to 5p.m.: 6	8	

Traffic Stalling Point 3: Aguiyi Ironsi Street/Ademola Adetokunbo Crescent. See Figure 5 and Table 3.

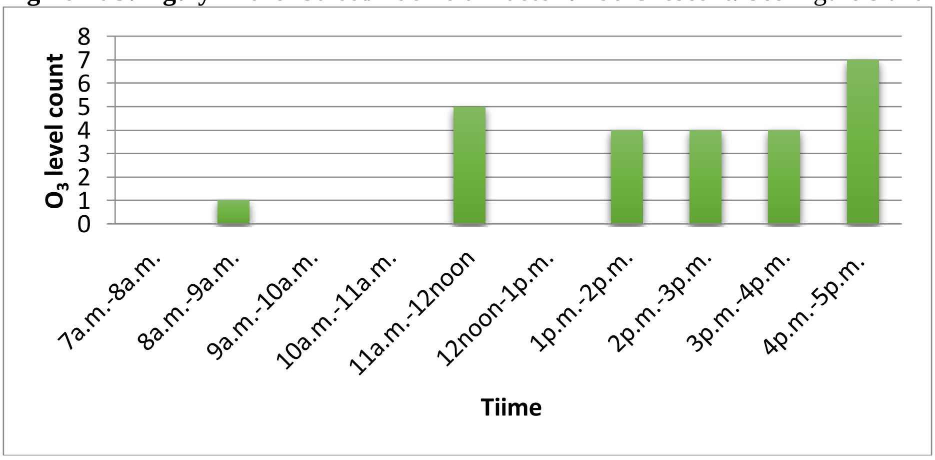

Figure 5. Bar chart representation of the count-density of ozone levels greater than 0.1ppm

Table 3. Statistical analysis information of TSP 3

Set of Amplitudes of Ozone Counts	**Range**	**Median**
7a.m. to 8a.m.: 0	0	
8a.m. to 9a.m.: 1	0	
9a.m. to 10a.m.: 0	0	
10a.m. to 11a.m.: 0	0	
11a.m. to 12noon: 5	4	**4**
1p.m. to 2p.m.: 4	4	
2p.m. to 3p.m.: 4	4	
3p.m. to 4p.m.: 4	5	
4p.m. to 5p.m.: 7	7	

Trend of Hourly Ozone Levels Count Across Major Traffic Stalling Points on the Geographic Information System (GIS). The trend of the hourly ozone levels count across major junctions on the

Geographic Information System (GIS) is shown in Figures 6 to 14. Each of the major traffic stalling junctions is represented by a dot that is coded for colour and size to represent the frequency of ozone level count greater than 0.1 ppm recorded for the time interval under consideration for the period of the survey.

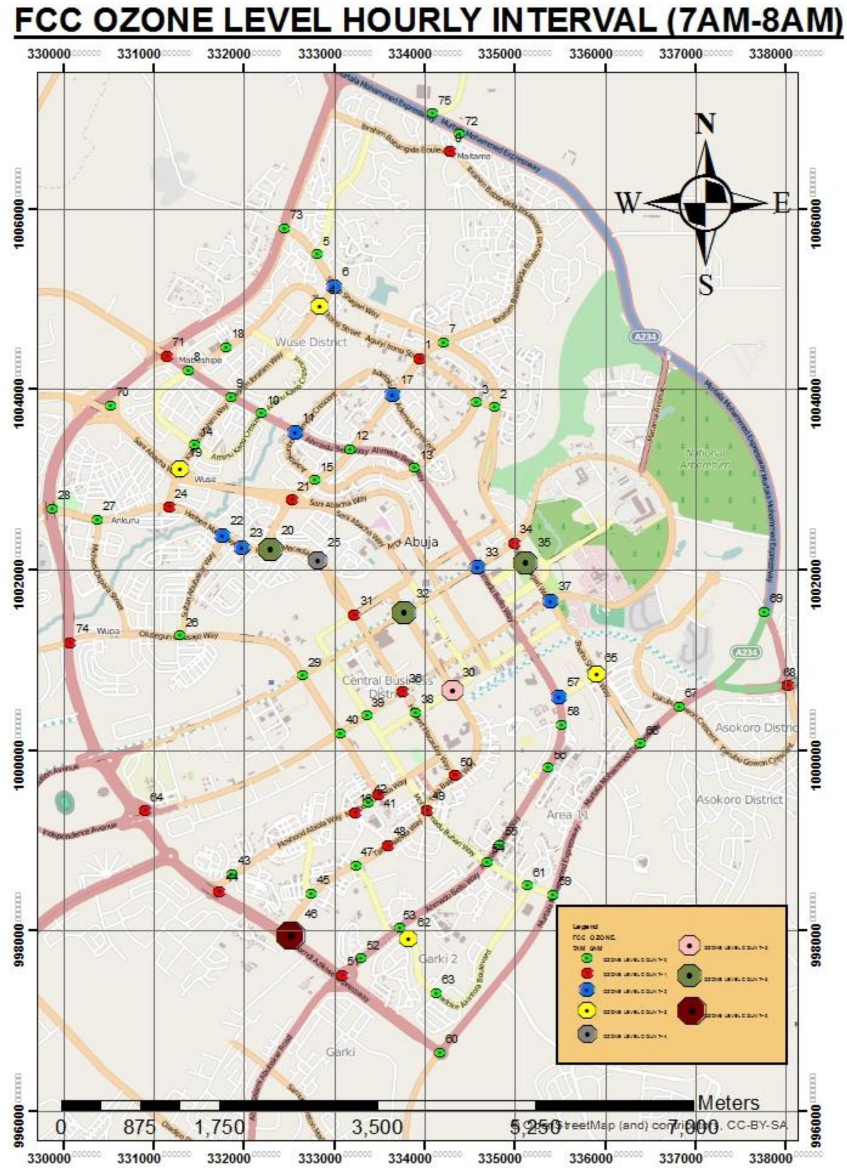

Figure 6. Hourly ozone levels count across major junctions on the GIS: 7 a.m. to 8 a.m.

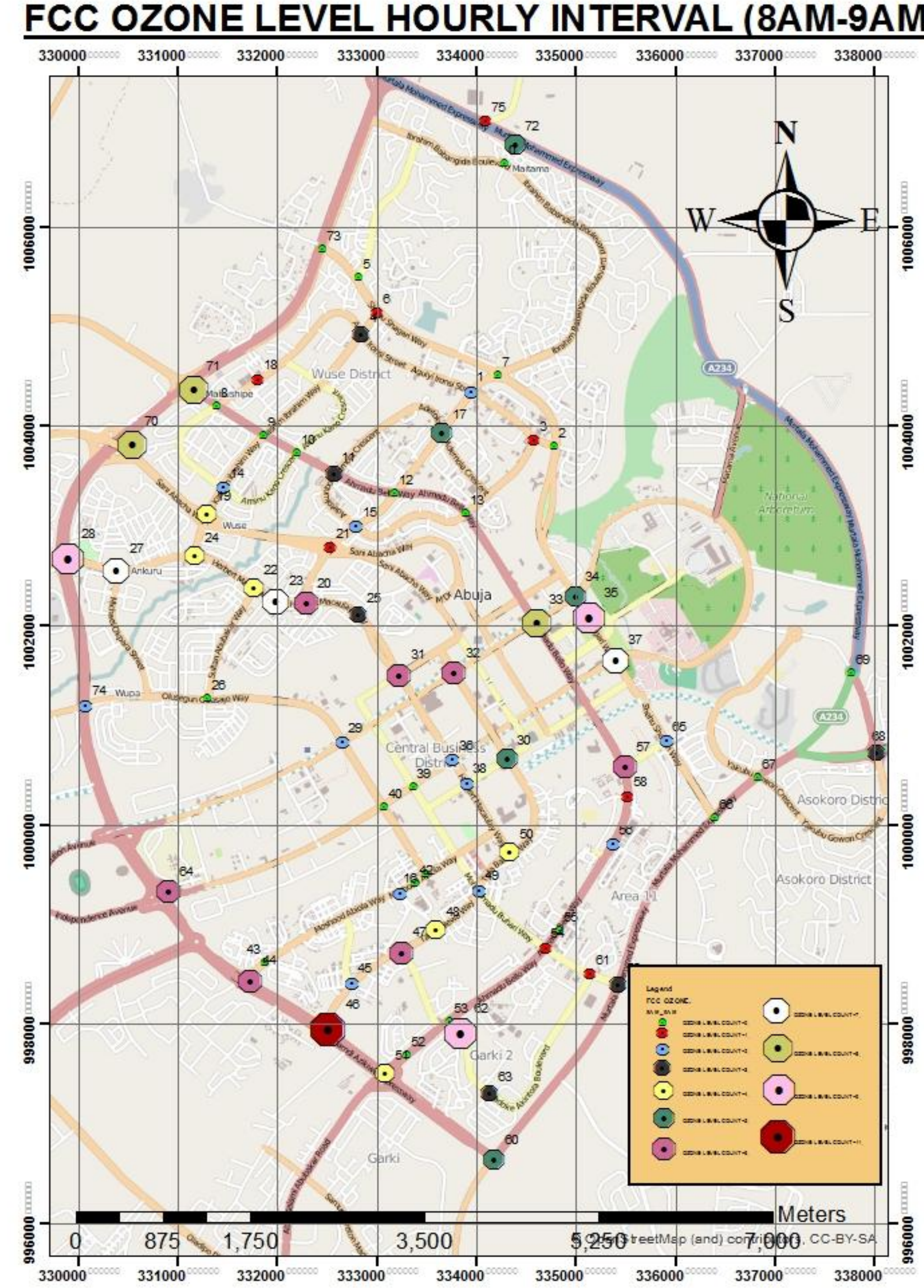

Figure 7. Hourly ozone levels count across major junctions on the GIS: 8 a.m. to 9 a.m.

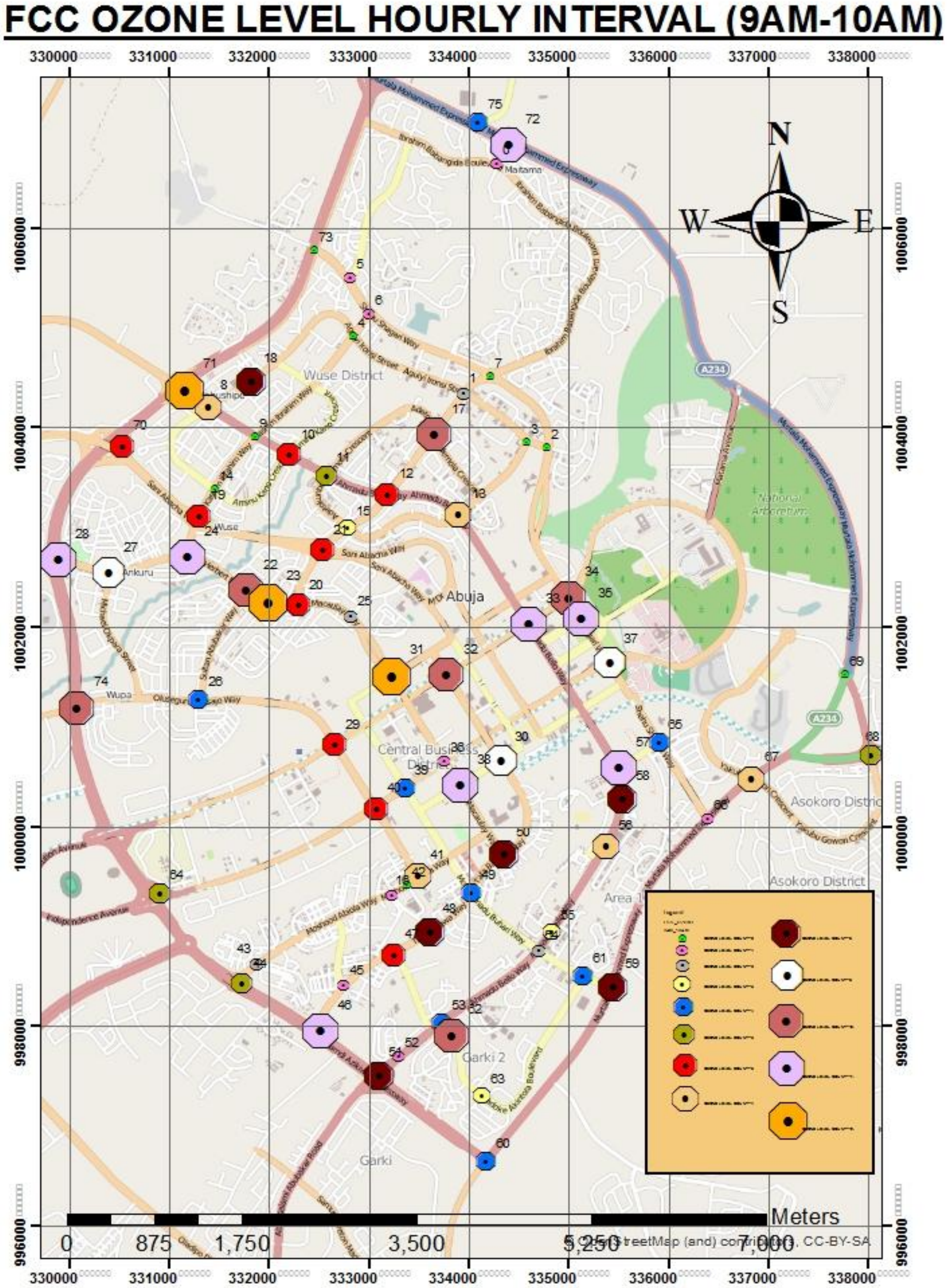

Figure 8. Hourly ozone levels count across major junctions on the GIS: 9 a.m. to 10 a.m.

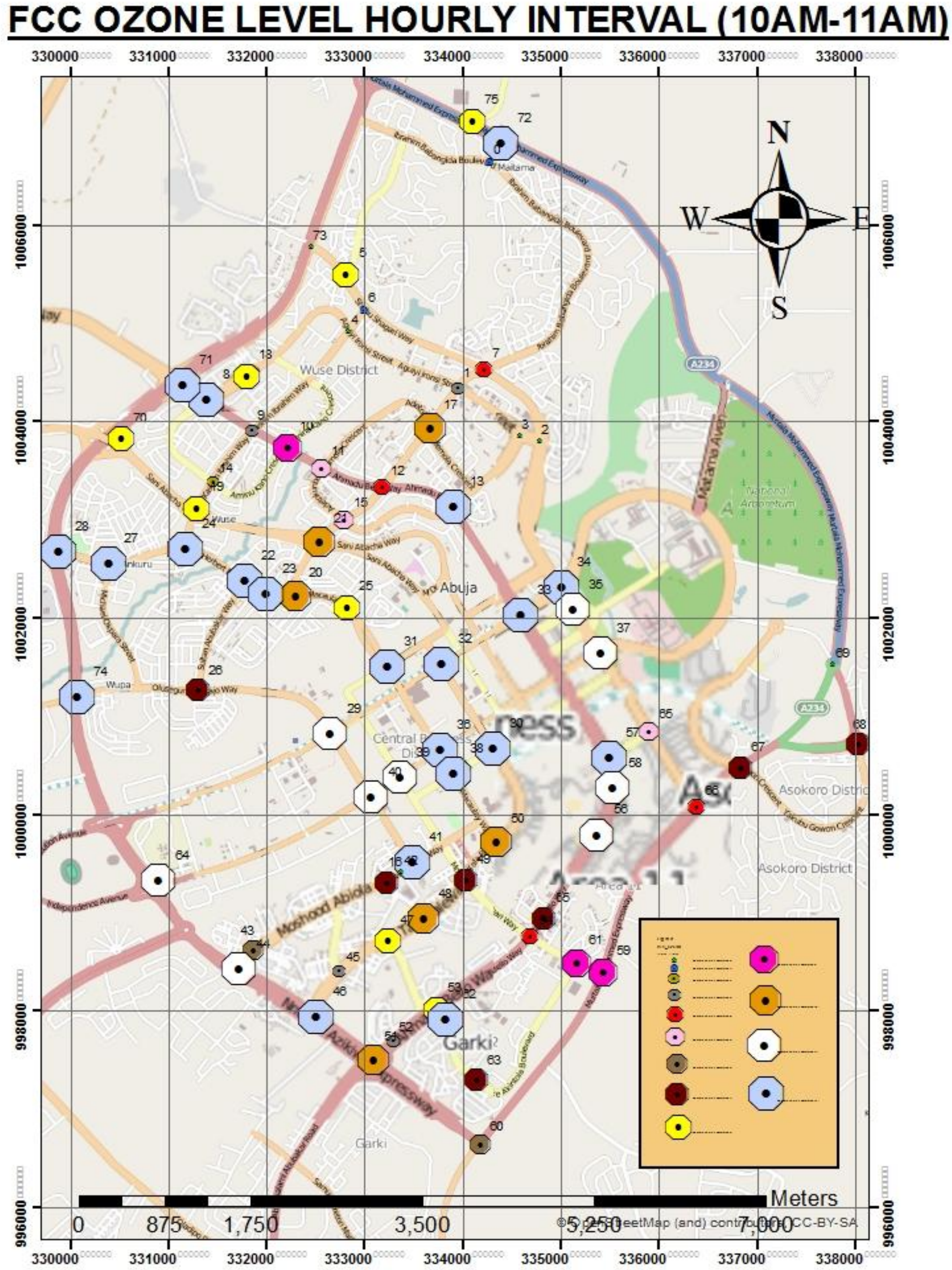

Figure 9. Hourly ozone levels count across major junctions on the GIS: 10 a.m. to 11 a.m.

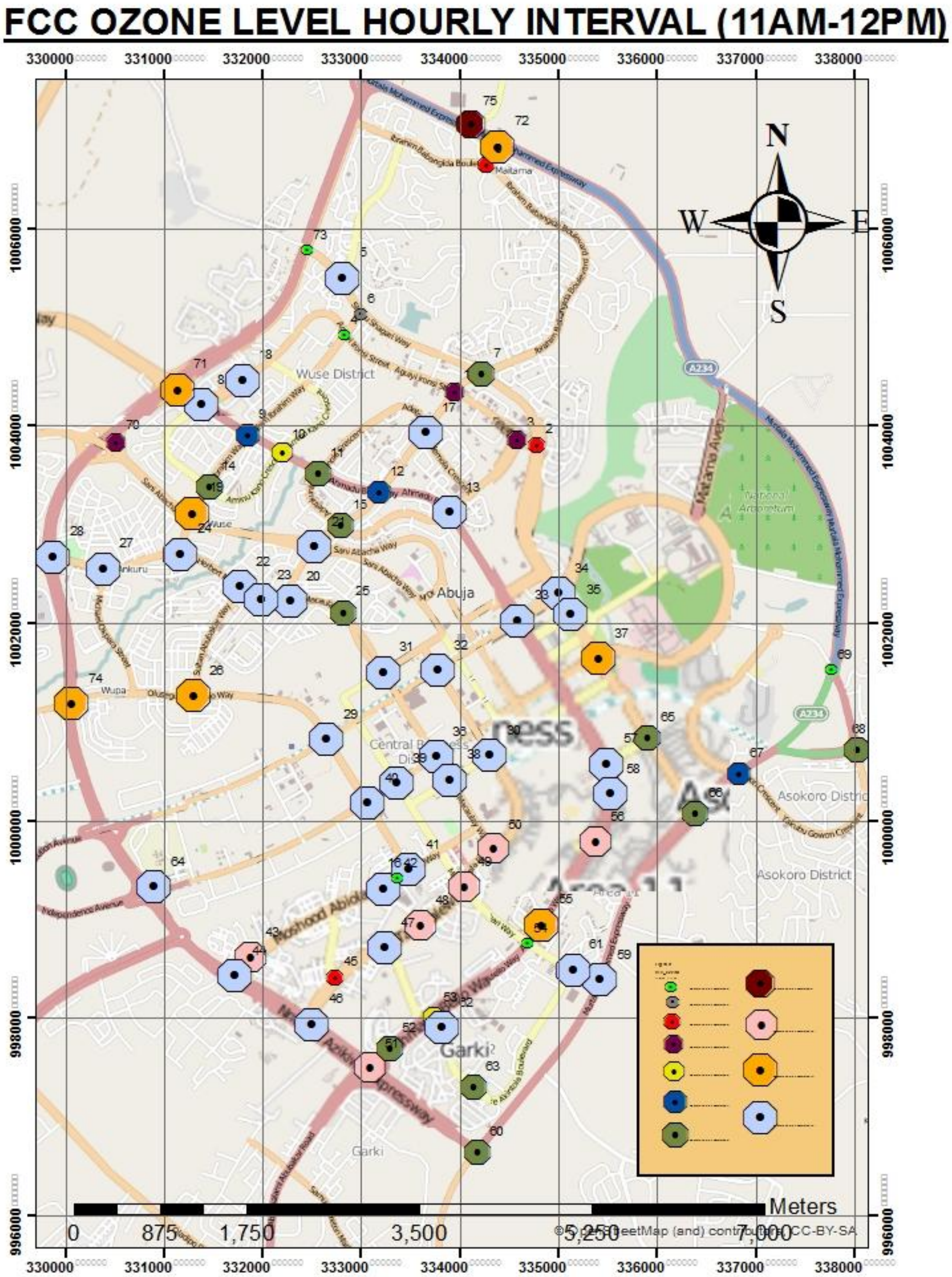

Figure 10. Hourly ozone levels count across major junctions on the GIS: 11 a.m. to 12 noon

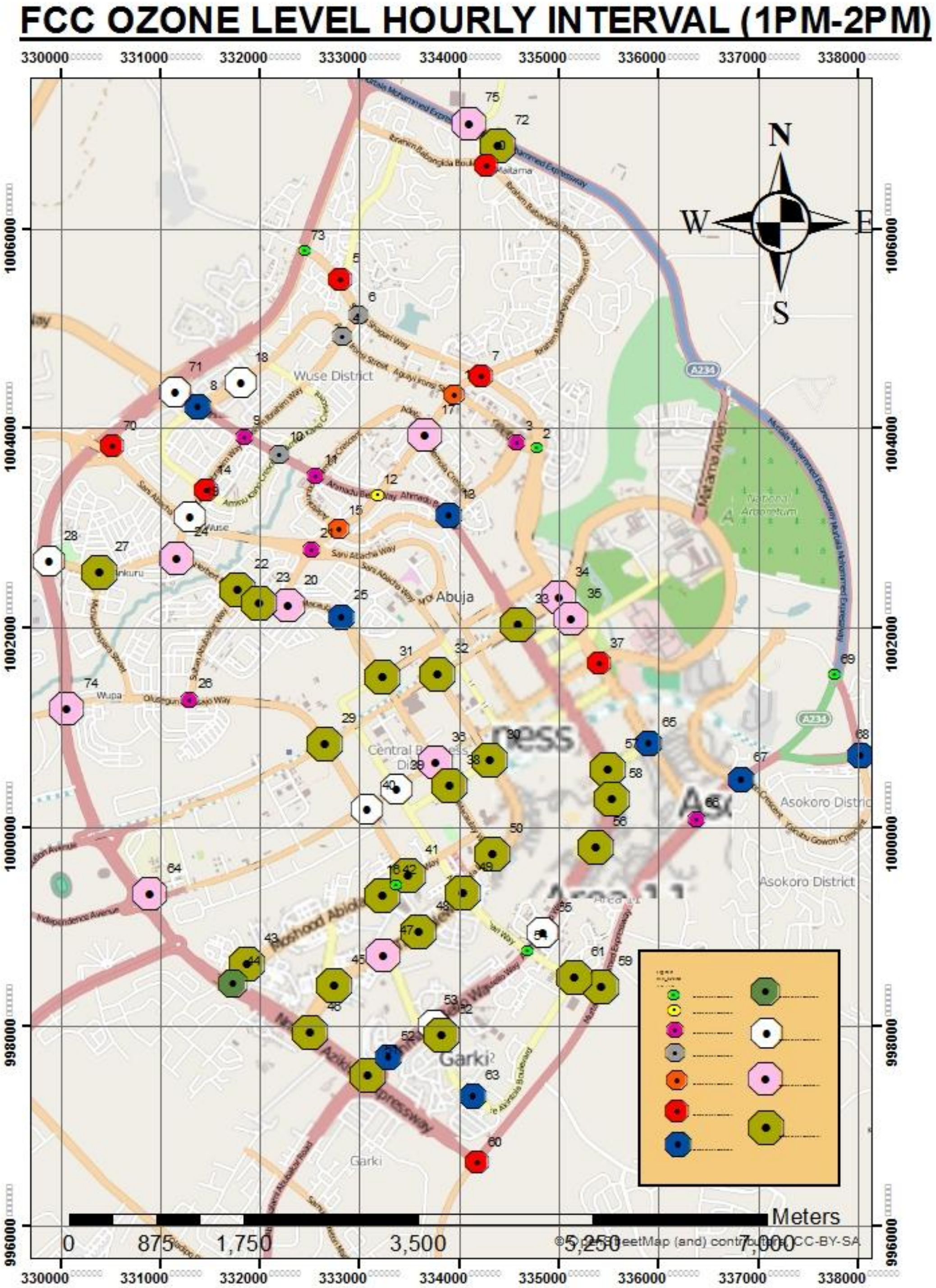

Figure 11. Hourly ozone levels count across major junctions on the GIS: 1 p.m. to 2 p.m.

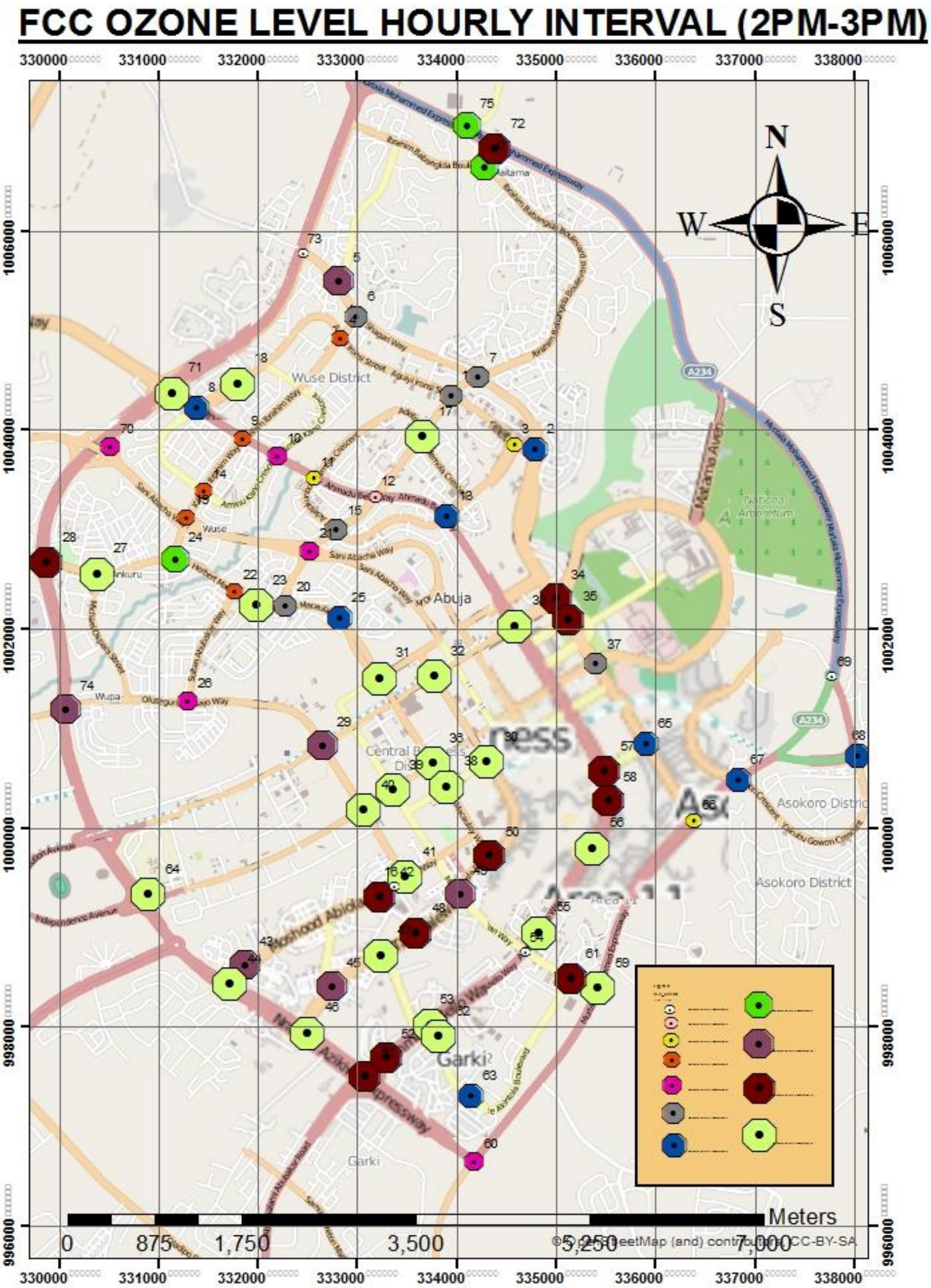

Figure 12. Hourly ozone levels count across major junctions on the GIS: 2 p.m. to 3 p.m.

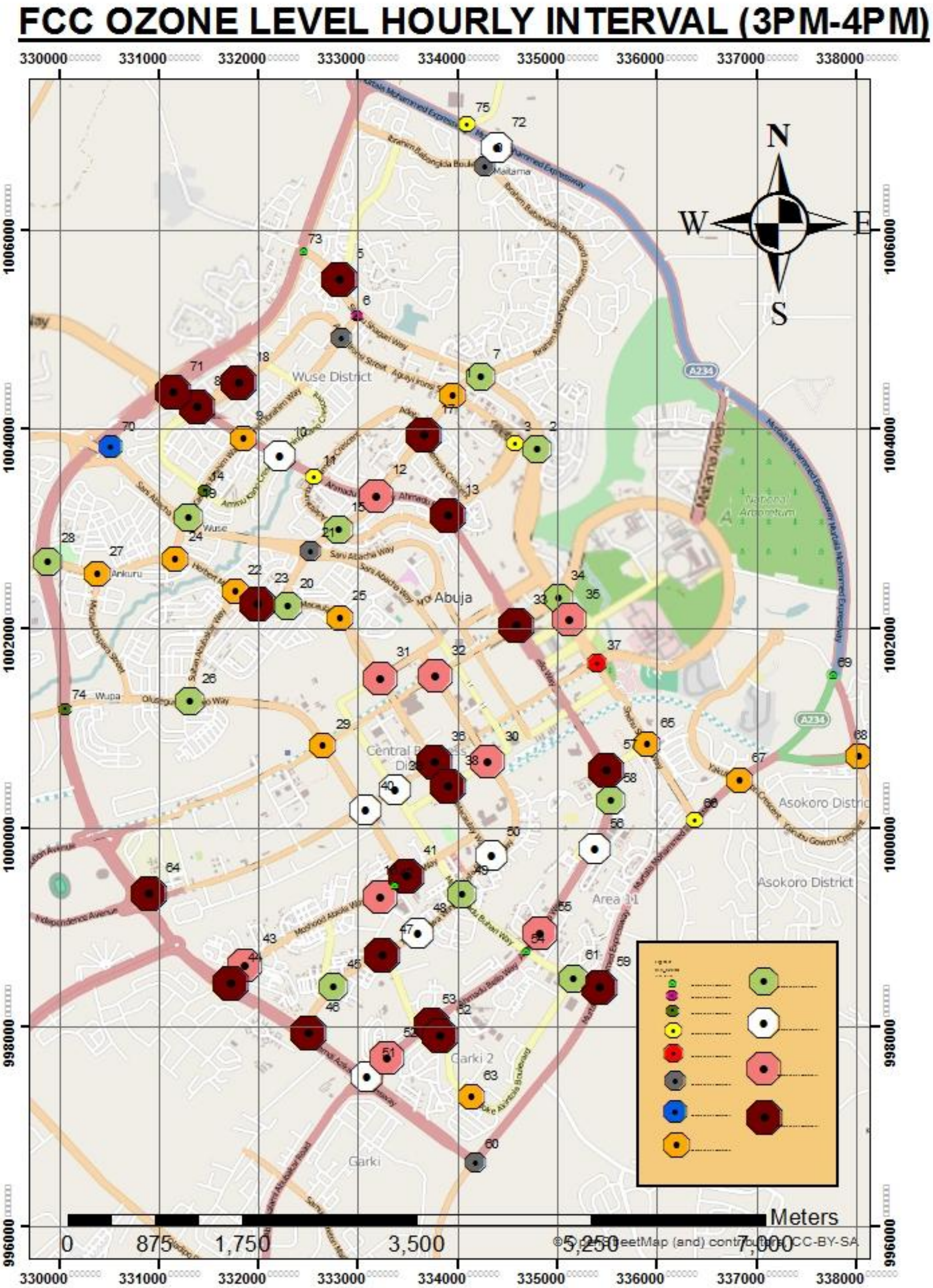

Figure 13. Hourly ozone levels count across major junctions on the GIS: 3 p.m. to 4 p.m.

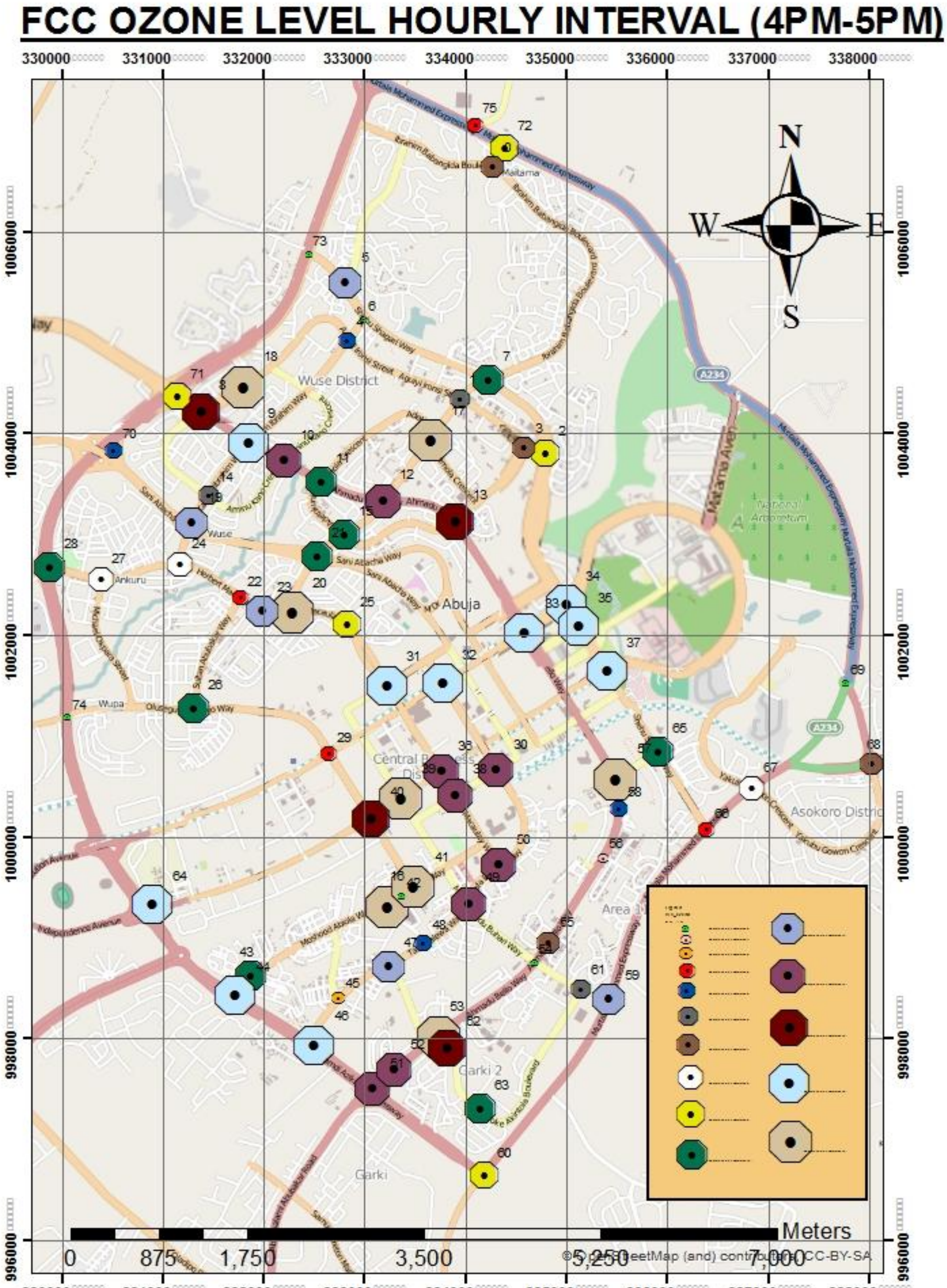

Figure 14. Hourly ozone levels count across major junctions on the GIS: 4 p.m. to 5 p.m.

On the Creation of a Geographic Information System (GIS) Layer of Ozone (O_3) Pollution at the Major Traffic Stalling Points of the Federal Capital City. It is most desirable to have the results of this survey available to the general public, and thus it was most fitting and proper to implement a Geographic Information System (GIS) scheme to achieve this purpose. Since the "mother ship" of a GIS already exists as the Abuja Geographic Information System (AGIS), the logical approach here was to create an ozone pollution layer that was a veritable subset of the AGIS; the ozone pollution indices layer thus created renders itself readily to queries and suchlike attributes. The ArcGIS®10 was the package utilized to create the desired ozone pollution layer for this study; this specialized application comes with its specialized features of graphic user interface which provides a route by which the XY attributes of the data set may be imputed. Corresponding attribute tables for the traffic stalling points were also imported into the ArcGIS®10 from whence a specified stalling traffic point is linked to its particular attribute of sector, longitude, latitude, date of survey, etc. Essentially, the ArcGIS®10 produces a composite map that renders itself to queries.

Conclusion

A table of conclusion (Table 4) of flags for time segments of ozone counts greater than the specific median across the major traffic stalling junctions was drawn up for the remarks generated in the formats for just a couple of survey stations (out of a total of 76) reproduced hence:

Traffic Stalling Point 1: IBB Boulevard/Osun Crescent. The time interval of *1 p.m. to 5 p.m.*at the IBB Boulevard/Osun Crescent major stalling traffic point is tagged as "*highly ozogenic sphere*," a term that is especially coined for this survey. The median count here is 3 and the time interval of *1 p.m. to 5 p.m.* has counts greater than 3.

Traffic Stalling Point 2: IBB Way/Aguiyi Ironsi Street.

Highly Ozogenic Sphere: *1 p.m. to 5 p.m.* for the median determined for this particular traffic stalling junction.

Traffic Stalling Point 3: Aguiyi Ironsi Street/Ademola Adetokunbo Crescent

Highly Ozogenic Sphere: *11 a.m. to 12 noon; 4 p.m. to 5 p.m.* for the median determined for this particular traffic stalling junction.

Table 4. Table of conclusion of flags for time segments of ozone counts greater than the specific median across the major traffic stalling junctions. (Codes for "flagged for continuous observation" ≡ ▲ and ▼.) Note: ▲ ≡ "highly ozogenic;" ▼≡ "ozogenic."

	7 to 8 a.m.	**8 to 9 a.m.**	**9 to 10 a.m.**	**10 to 11a.m.**	**11 to 12noon**	**1 to 2 p.m.**	**2 to 3 p.m.**	**3 to 4 p.m.**	**4 to 5 p.m.**
TSP 1						▲	▲	▲	▲
TSP 2						▲	▲	▲	▲
TSP 3					▲				▲
TSP 4					▲		▲	▲	▲
TSP 5						▲	▲	▲	▲
TSP 6					▲		▲	▲	▲
TSP 7						▲	▲		
TSP 8					▲			▲	▲
TSP 9				▲	▲			▲	▲
TSP 10					▲		▲	▲	▲
TSP 11				▲				▲	▲
TSP 12			▲	▲	▲				▲
TSP 13			▲		▲			▲	▲
TSP 14				▲	▲			▲	▲
TSP 15					▲	▲	▲		▲
TSP 16					▲		▲	▲	▲
TSP 17					▲		▲	▲	▲
TSP 18					▲		▲	▲	▲
TSP 19					▲	▲		▲	▲
TSP 20				▲	▲				▲
TSP 21				▲	▲	▲		▲	▲
TSP 22			▲	▲	▲	▲			
TSP 23				▲	▲	▲			
TSP 24			▼	▼	▼	▼	▼	▼	
TSP 25									▲
TSP 26				▲	▲			▲	▲
TSP 27				▲	▲	▲	▲		
TSP 28				▲	▲				
TSP 29				▲	▲	▲	▲		
TSP 30									▲
TSP 31									▲
TSP 32									▲
TSP 33				▲	▲				▲
TSP 34					▲				▲
TSP 35			▲	▲	▲				▲
TSP 36				▼	▼		▼	▼	▼
TSP 37				▲	▲		▲		▲
TSP 38				▼	▼	▼	▼	▼	▼

TSP 39				▼	▼	▼	▼		▼
TSP 40				▲	▲		▲		▲
TSP 41									▲
TSP 42					▲	▲			▲
TSP 43					▲	▲			▲
TSP 44						▲		▲	
TSP 45				▲	▲		▲	▲	▲
TSP 46						▲	▲	▲	
TSP 47									▲
TSP 48					▲		▲	▲	
TSP 49						▲	▲		
TSP 50					▲	▲	▲		▲
TSP 51						▲	▲		▲
TSP 52									▲
TSP 53							▲	▲	▲
TSP 54						▲	▲	▲	▲
TSP 55				▼					
TSP 56					▲	▲	▲	▲	
TSP 57				▲		▲	▲		
TSP 58									▲
TSP 59				▲	▲	▲	▲		
TSP 60					▲	▲	▲	▲	
TSP 61					▲	▲			▲
TSP 62					▲	▲	▲		
TSP 63									▲
TSP 64									▲
TSP 65				▲	▲		▲	▲	▲
TSP 66									▲
TSP 67					▲				
TSP 68						▲	▲	▲	▲
TSP 69					▲	▲	▲	▲	
TSP 70	Restricted Zone	Restricted Zone	Restricted Zone	Restricted Zone	Restricted Zone	Restricted Zone	Restricted Zone	Restricted Zone	Restricte d Zone
TSP 71			▲	▲			▲	▲	
TSP 72				▲	▲	▲	▲		
TSP 73				▲		▲			
TSP 74		▲		▲		▲		▲	
TSP 75				▲	▲	▲			
TSP 76				▲	▲	▲	▲		

IV. Recommendation

Now that the pattern and trend of ozone pollution has been established at the major traffic stalling junctions of the FCC, it is fitting and proper to initiate an environmental audit mechanism scheme to build on the substrate identified herein. This environmental audit mechanism scheme should be biannual surveys centred on those time segments that are flagged for the different major traffic stalling points. It is recommended, too, that particulate air matter pollution should also be carried out based on this ozone pollution format. In addition to, or exclusive of, other air pollution studies like those of carbon dioxide, noise, and suphur dioxide should be carried out in tandem, too. The result of this study and similar counterpart studies should form the background of a basic public-health enlightenment policy of the FCT TS/BRT&TR Department. The result of this study and similar counterpart studies should also form the background of a road worthiness collage of vehicle types that should be allowed to ply the urban roads of Nigeria's major cities.

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