INVESTIGATION OF NITROGEN DIOXIDE INDICES AND THE CREATION OF A UNIQUE GEOGRAPHICAL INFORMATION SYSTEM (GIS) LAYER MAP FOR NITROGEN DIOXIDE POLLUTION IN MINNA, NIGER STATE

Jonah, S.A.,* Okunlola, I.A., * Amadi, A.N., Baba-Kutigi A.N., and Umar, M.O.,
Department of Physics, Federal University of Technology, Minna
***Department of Geology, Federal University of Technology, Minna**

ABSTRACT
Environmental pollution is a nuisance that we have to put up with from day to day. This project was designed and executed such that an appropriate town-gown synergy advocacy could be evolved. The principal objective of this study is to help prepare the framework for a nitrogen dioxide pollution database for Minna. Stations of interest were identified, appropriately geo-referenced, and marked in the conventional way. The sample points(households) were re-visited with the nitrogen dioxide meter whence information about the sources of nitrogen dioxide and the corresponding values of nitrogen dioxide were logged progressively from one point to the next. All the stations used for this survey (about 5350 households and commercial centres) indicate nitrogen dioxide levels greater than the internationally-recommended safe threshold of 0.0002ppm. Nitrogen dioxide signatures over Maikunkele and Mobil neighbourhoods are quite high because a significant number of households and business locations own cars and use generators.

Keywords: Environmental pollution, environmental pollution, threshold value, GIS

Introduction

Environmental pollution is a nuisance that we have to put up with from day to day. Over the last couple of decades interest has been centred on environmental pollution and climate change issues all over the world. Thus, it is fitting and proper that, in fulfillment of one of its founding charters, the Federal University of Technology, Minna, should be able to make its contribution to the field of environmental pollution, especially as it affects the local communities. To this end, this project has been designed and executed such that an appropriate town-gown synergy advocacy could be evolved.

A 1999 study by Basu and Samet addressed the evidence on the health effects of exposure to emissions of NO_2 from gas stoves, covering findings of 45 epidemiological studies. These studies had addressed diverse outcome measures, including the risks of acute respiratory illness, decreased pulmonary function, respiratory symptoms and asthma exacerbation. According to Basu and Samet, most studies have focused on schoolchildren, studies of adults and more recently, prospective studies of infants have also been carried out. Basu and Samet also pointed out that the findings have not been consistent across all studies in showing adverse effects. They concluded that the evidence does not support a causal relationship between exposure to NO_2 or use of a gas stove and increased risk for respiratory morbidity at the levels of NO_2 typically associated with gas stoves. Some studies do show increased risk for respiratory health effects, however, and the evidence does not support the conclusion that NO_2 emitted by gas stoves is risk-free. Further research would be indicative if populations receiving exposures in a range of interests can be identified.

Brunekreef and Sunyer (2003), Sandoval, Ulriksen, and Escudero (1985), .published an article detailing the major pollutants from motor vehicle exhaust, mainly particulate matter, nitrogen dioxide and polycyclic aromatic hydrocarbons. The emphasis is on motor vehicle emissions from diesel powered engines, which have become a significant source of air pollution in urban areas. The impact of motor vehicle pollutants on respiratory health is explored, and the major studies relating asthma to high volume of traffic and proximity to major traffic arteries were reviewed.

Koo, Ho, and Ho (1990) pointed out that epidemiologic studies have demonstrated a strong link between increased concentrations of NO_2 in polluted environments and respiratory symptoms, including rhino rhea, cough, and infections of the lower respiratory tract. According to Koo et al (1990), more recent evidence suggests that exposure to pollutants may also contribute to the development of the sensitization of atopic individuals to aeroallergens. Unlike ozone, NO_2 is a primary pollutant that is found both indoors and in the outdoor atmosphere. During high-temperature combustion, oxygen reacts with nitrogen to generate oxides of nitrogen, which mainly include nitrogen oxide and NO_2. In the outdoors, motor vehicular emissions represent the major source of NO_2. According to Koo et al (1990), indoor levels can reach up to 4 ppm in power plants, refineries, and ice-skating rinks, outdoor levels usually do not exceed 0.5 ppm. Gas stove cooking and environmental tobacco smoke are other sources of indoor household exposure. The effects of NO_2 exposure on airway disease are beginning to be better appreciated. The authors also pointed out that animal studies have demonstrated that the terminal bronchiolar epithelium is particularly sensitive to NO_2-induced injury after brief exposures (i.e., 1 to 6 hours), the effects of which include epithelial flattening, loss of cilia and ciliated cells, epithelial cell hyperplasia, damage to surface membranes, and disruption of epithelial tight junctions. According to the authors, NO2 also leads to an increased inflammatory cell influx and may affect lung defense mechanisms through reduced mucociliary clearance and changes in alveolar macrophages and other immune cells. According to the authors, NO_2 also may induce an inflammatory cell influx and eosinophil activation in humans. NO_2 can potentiate responses to aeroallergens in mildly sensitive asthmatic persons. It has been shown that loratadine, 1415 an antihistamine, and fluticasone propionate, 16 an inhaled steroid, can each block the effects of NO_2, suggesting that atopic mechanisms (ie, eosinophil-mediated or mast cell-mediated mechanisms) may be altered by NO_2. On the other hand, in vitro studies have not shown that NO_2 significantly influences bronchial smooth muscles hyper responsiveness in wild-type guinea pigs17 or ovalbumin (OVA)-sensitized guinea pigs. The interactions between inhaled aeroallergens and NO_2 are not well understood. Thus, in the present study we decided to investigate the effect of relatively short-term exposure (24 hours) to NO_2 on antigen-induced hyper responsiveness, mucus production by epithelial cells, and airway inflammation in vivo in a murine model of allergic asthma.

Miliby and Milne (1969) conducted a study on the inhalation of nitrogen dioxide and bronchiolitis obliteras. It is now generally accepted that nitrogen dioxide is the main causative factor of the pulmonary changes following the inhalation of nitrogen fume. Nitrogen dioxide is an equilibrium mixture of NO_2 and N_2O_4 and possibly N_2O_3 maybe involved. Industrial usage of nitric acid, metal picking and silo filling may allow the liberation of dangerous qualities of nitrous fumes. In conficting spaces with poor ventilation, the concentration in the air may rise above the emergency tolerance with an eventual possibility of calamitous result to those exposed.

Methodology

Data Acquisition

Co-ordinate identification for this project exercise was facilitated by the use of hand-held Global Positioning System (GPS) units. A GPS unit measures the geographical location (and elevation) of a place in terms of its longitude and latitude in units of degrees, minutes and seconds as well as the Universal Traverse Mercator (UTM) protocol.

The data acquisition procedure was basically to identify stations of interest that were approximately geo-referenced and marked in the conventional way. The stations were re-visited with the NO_2 were logged progressively from one point to the next. The neighbourhoods covered in this investigation are Maikunkele, Tundun Fulani, Bosso Esatae, Bosso Low-cost Housing Estate, Bosso, F-layout, Government Reservation Area (G.R.A.), Zarumai Neigbourhood, Limawa, Dutsen Kura Hausa, Dutsen Kura Gwari, and Mobil Roundabout.

About 5350 (over a period of three months) stations were occupied for this study. These stations were the points of interest that where high levels of nitrogen dioxide are emitted. The dataset collected from the field are usually presented in conformance with the Geographic Information System (GIS) protocol in terms of single static source representing a point shape, their numerical identities (IDs), latitude, longitude, conventional locations on the ground noise emission sources, rated output of sources, and the presence or absence of nitrogen dioxide (determined from a comparison of the measured value with the threshold value). Table 1 shows the data collected over 100 households.

Table 1: Abridged form of dataset of study

Shape	ID	Cordinates		Location	Pollution Sources	Power Rating	Pollution Status
Point	1	9.6513	6.5123	Sabon gari	PETROL	2.0 kw/220v/50Hv	Present
Point	2	9.6513	6.5122	Sabon gari	YAMAHA	1.5 kw/220v/50Hv	Present
Point	3	9.6513	6.5121	Sabon gari	MAISUYA SPORT	2.0 kw/220v/50Hv	Present
Point	4	9.6514	6.512	Sabon gari	FIREWOOD	7.5 kw/220v/50Hv	Present
Point	5	9.6513	6.512	Sabon gari	CHARCOAL		Present
Point	6	9.6513	6.5119	Sabon gari	GENERATOR	11.5 kw/220v/50Hv	Present
Point	7	9.6633	6.5195	Sabon gari	YAMAHA		Present
Point	8	9.6632	6.5195	Sabon gari	TIGER GEN		Present
Point	9	9.6631	6.5193	Sabon gari	CHARCOAL	2.0 kw/220v/50Hv	Present
Point	10	9.6632	6.5193	Sabon gari	TIGER	7.5 kw/220v/50Hv	Present
Point	11	9.6632	6.5191	Sabon gari	FIREWOOD	11.5 kw/220v/50Hv	Present
Point	12	9.6632	6.5191	Sabon gari	DIESEL GEN	11.5 kw/220v/50Hv	Present
Point	13	9.6633	6.519	Sabon gari	YAMAHA	2.0 kw/220v/50Hv	Present
Point	14	9.6634	6.5191	Sabon gari	TIGER	2.0 kw/220v/50Hv	Present
Point	15	9.6636	6.5191	Sabon gari	TIGER		Present
Point	16	9.6637	6.5191	Sabon gari	CHARCOAL		Present
Point	17	9.6633	6.5189	Sabon gari	FIREWOOD		Present
Point	18	9.6634	6.5188	Sabon gari	TIGER		Present
Point	19	9.6637	6.5185	Sabon gari	GRINDING MACHINE	2.0 kw/220v/50Hv	Present
Point	20	9.6638	6.5184	Sabon gari	FIREWOOD		Present

Point	21	9.6631	6.5182	Sabon gari	CHARCOAL	7.5 kw/220v/50Hv	Present
Point	22	9.6632	6.5182	Sabon gari	FIREWOOD		Present
Point	23	9.6632	6.5183	Sabon gari	FIREWOOD	2.0 kw/220v/50Hv	Present
Point	24	9.6632	6.5181	Sabon gari	FIREWOOD		Present
Point	25	9.6633	6.5181	Sabon gari	TIGER	7.5 kw/220v/50Hv	Present
Point	26	9.6634	6.5179	Sabon gari	YAMAHA	7.5 kw/220v/50Hv	Present
Point	27	9.6641	6.5179	Sabon gari	TIGER	2.0 kw/220v/50Hv	Present
Point	28	9.664	6.5178	Sabon gari	YAMAHA		Present
Point	29	9.664	6.5178	Sabon gari	DIESEL	2.0w/220v/50Hv	Present
Point	30	9.6642	6.5179	Sabon gari	CHARCOAL	12.00w/220v/50Hv	Present
Point	31	9.6643	6.5177	Sabon gari	MAI SUYA SPOT	12.00w/220v/50Hv	Present
Point	32	9.6644	6.5176	Sabon gari	CHARCOAL		Present
Point	33	9.6645	6.5174	Sabon gari	MAI SHAYI	7.5 kw/220v/50Hv	Present
Point	34	9.6637	6.5182	Sabon gari	FIREWOOD	12.0 kw/220v/50Hv	Present
Point	35	9.6636	6.5182	Sabon gari	TIGER GEN	2.0 kw/220v/50Hv	Present
Point	36	9.6635	6.5181	Sabon gari	MAISUYA	2.0 kw/220v/50Hv	Present
Point	37	"	"	Sabon gari	CHARCOAL		Present
Point	38	"	"	Sabon gari	MAISAHAYI	12.00w/220v/50Hv	Present
Point	39	"	"	Sabon gari	OGARI	2.0 kw/220v/50Hv	Present
Point	40	9.6634	6.5182	Sabon gari	TIGER GEN		Present
Point	41	"	"	Sabon gari	CHARCOAL		Present
Point	42	9.6635	6.518	Sabon gari	TIGER GEN	11.5 kw/220v/50Hv	Present
Point	43	9.6633	6.518	Sabon gari	FIREWOOD	14.7 kw/220v/50Hv	Present
Point	44	9.6633	6.5179	Sabon gari	MOTORCYCLE	2.0 kw/220v/50Hv	Present
Point	45	"	"	Sabon gari	WORKSHOP		Present
Point	46	"	"	Sabon gari	VOLCANIZER	2.0 kw/220v/50Hv	Present
Point	47	"	"	Sabon gari	MACHINE		Present
Point	48	9.6632	6.5179	Sabon gari	TIGER GEN	7.5 kw/220v/50Hv	Present
Point	49	9.6632	6.5179	Sabon gari	TIGER GEN	2.0 kw/220v/50Hv	Present
Point	50	9.6632	6.5179	Sabon gari	TIGER GEN	2.0 kw/220v/50Hv	Present
Point	51	9.6631	6.5178	Sabon gari	YAMAHA GEN	1.5 kw/220v/50Hv	Present
Point	52	9.6631	6.518	Sabon gari	YAMAHA GENERATOR	1.5 kw/220v/50Hv	Present
Point	53	9.6631	6.5178	Sabon gari	TECH GENERATOR	2.0 kw/220v/50Hv	Present
Point	54	9.663	6.5177	Sabon gari	TIGER GENERATOR	2.0 kw/220v/50Hv	Present
Point	55	9.6629	6.5177	Sabon gari	YAMAHA GEN	2.0 kw/220v/50Hv	Present
Point	56	9.6629	6.5176	Sabon gari	TIGER GEN	2.0 kw/220v/50Hv	Present
Point	57	9.6628	6.5176	Sabon gari	TIGER GEN	2.0 kw/220v/50Hv	Present
Point	58	9.6628	6.5175	Sabon gari	YAMAHA GENERATOR	1.5 kw/220v/50Hv	Present
Point	59	9.6628	6.5174	Sabon gari	YAMAHA GENERATOR	1.5 kw/220v/50Hv	Present
Point	60	9.6628	6.5174	Sabon gari	MIKANO	2.0 kw/220v/50Hv	Present
Point	61	9.6627	6.5173	Sabon gari	MESHES	2.0kw/220v/50Hz	Present
Point	62	9.6627	6.5173	Sabon gari	MIKANO	11.5 kw/220v/50Hz	Present
Point	63	9.6627	6.5172	Sabon gari	FIRE WOOD	2.0 kw/220v/50Hz	Present
Point	64	9.6627	6.5172	Sabon gari	ZUZUKI GENERATOR	1.5 kw/220v/50Hz	Present
Point	65	9.6627	6.5171	Sabon gari	TIGER GENERATOR		Present
Point	66	9.6626	6.5171	Sabon gari	TIGER GENERATOR		Present
Point	67	9.6625	6.517	Sabon gari	YAMAHA		Present
Point	68	9.6624	6.5169	Sabon gari	TIGER GEN		Present
Point	69	9.6624	6.5168	Sabon gari	FIREWOOD	14.7 kw/220v/50Hv	Present
Point	70	9.6623	6.5167	Sabon gari	FIREWOOD	7.5 kw/220v/50Hv	Present
Point	71	9.6622	6.5165	Sabon gari	FIREWOOD	2.0 kw/220v/50Hv	Present
Point	72	9.6623	6.5164	Sabon gari	FIRE WOOD	7.5 kw/220v/50Hv	Present
Point	73	9.6624	6.5165	Sabon gari	FIREWOOD	11.5 kw/220v/50Hz	Present
Point	74	9.6624	6.5166	Sabon gari	FIREWOOD		Present
Point	75	9.6624	6.5158	Sabon gari	REFUSE DUMP		Present
Point	76	9.6623	6.5157	Sabon gari	FIREWOOD		Present
Point	77	9.663	6.5192	Sabon gari	FIREWOOD		Present
Point	78	9.6628	6.5192	Sabon gari	FIREWOOD	2.0 kw/220v/50Hv	Present
Point	79	9.6628	6.5192	Sabon gari	TIGER GEN	2.0 kw/220v/50Hv	Present
Point	80	9.6627	6.5192	Sabon gari	TIGER GEN	1.5 kw/220v/50Hz	Present
Point	81	"	"	Sabon gari	JINLING		Present

Point	82	"	"	Sabon gari	GRINDING MACHINE		Present
Point	83	"	"	Sabon gari	TIGER	2.0 kw/220v/50Hv	Present
Point	84	9.6626	6.5192	Sabon gari	TIGER	7.5 kw/220v/50Hv	Present
Point	85	"	"	Sabon gari	JINLING		Present
Point	86	"	"	Sabon gari	TIGER		Present
Point	87	9.6626	6.5193	Sabon gari	TIGER		Present
Point	88	9.6624	6.5193	Sabon gari	TIGER	7.5 kw/220v/50Hv	Present
Point	89	9.6622	6.5193	Sabon gari	TIGER	2.0 kw/220v/50Hv	Present
Point	90	9.6621	6.5194	Sabon gari	TIGER		Present
Point	91	9.662	6.5194	Sabon gari	JINLING	2.0 kw/220v/50Hv	Present
Point	92	"	"	Sabon gari	GRINDING MACHINE		Present
Point	93	"	"	Sabon gari	FIREWOOD	2.0 kw/220v/50Hv	Present
Point	94	9.6619	6.5194	Sabon gari	TIGER	2.0 kw/220v/50Hv	Present
Point	95	"	"	Sabon gari	JINLING		Present
Point	96	"	"	Sabon gari	YAMAHA	11.5 kw/220v/50Hv	Present
Point	97	"	"	Sabon gari	ZUZUKI	2.0 kw/220v/50Hv	Present
Point	98	"	"	Sabon gari	LISTER	2.0 kw/220v/50Hv	Present
Point	99	"	"	Sabon gari	LISTER	2.0 kw/220v/50Hv	Present
Point	100	9.6618	6.5193	Sabon gari	TECHNO GEN	2.0 kw/220v/50Hv	Present

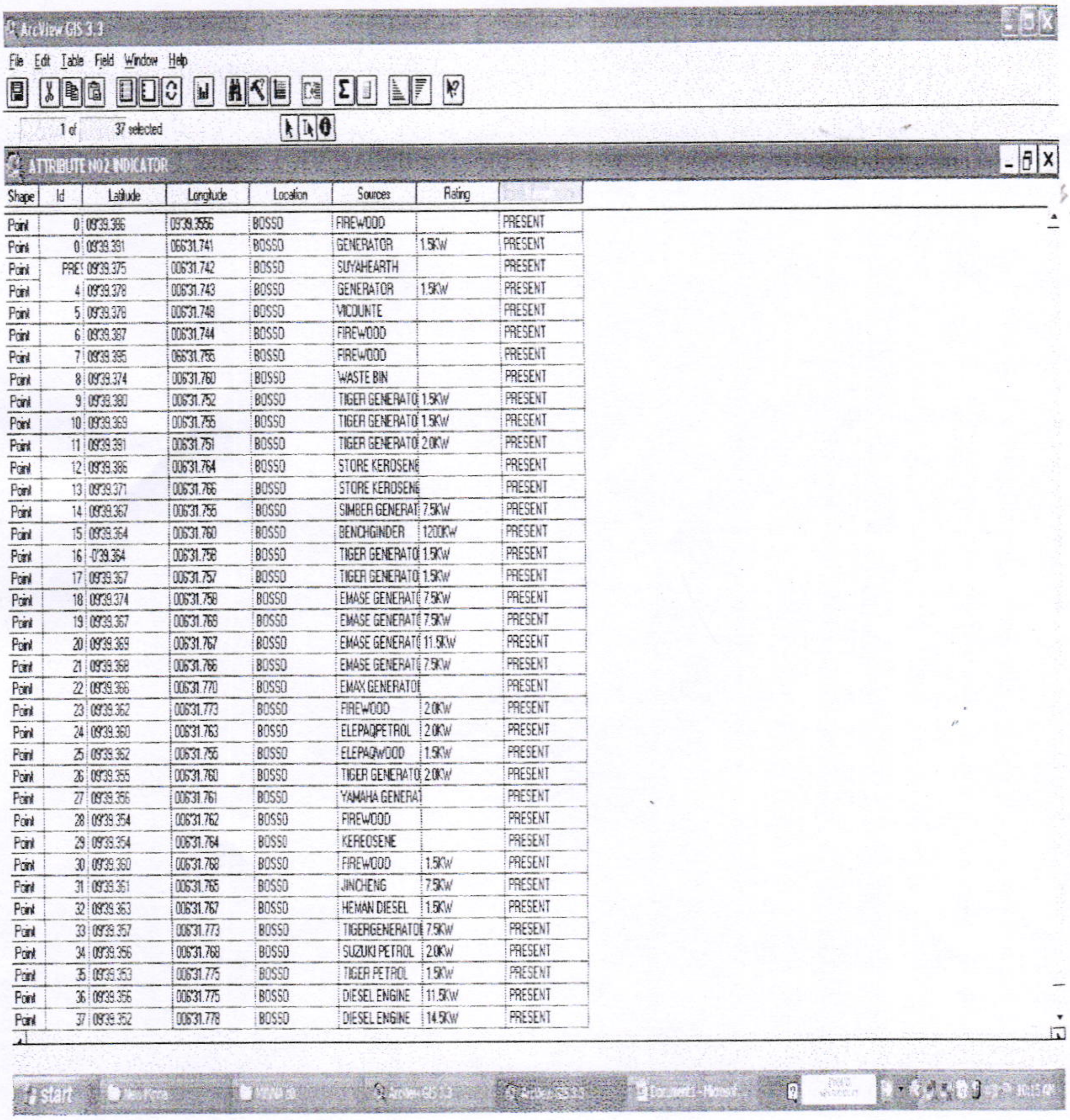
Naming of locations on digitised map, creation of a database on ArcView platform, query procedures, and presentation of pollution layer

The attributes were named using the text tools on the ArcView menu. From the theme and edit icons, the text mode was enabled in order that locations on the map could be named. The result for this procedure is shown in Fig.1.

Fig.1. Naming locations on map

On the map of Fig.1, the location of the Bosso Campus of the Federal University of Technology, Minna, is identified on the top left hand corner as "FUT" whilst the Women's Teachers College is identified as "WTC". Other principal neighbourhoods and streets of Minna town identified on the map are Maitunbi, Tunga, Kpakungu, David Mark Road and IBB Road.

The conventional database contains rows and columns, geographical coordinates of the locations of sources of nitrogen dioxide, sources of nitrogen dioxide, rating, nitrogen dioxide levels, and pollution status (present or absent, see Table 1). This same dataset on the ArcView3.3 is shown in Fig.2.


ArcView GIS 3.3
File Edit Table Field Window Help
1 of 37 selected
ATTRIBUTE NO2 INDICATOR

Shape	Id	Latitude	Longitude	Location	Sources	Rating	
Point	0	09'39.386	09'39.3556	BOSSO	FIREWOOD		PRESENT
Point	0	09'39.391	066'31.741	BOSSO	GENERATOR	1.5KW	PRESENT
Point	PRE!	09'39.375	006'31.742	BOSSO	SUYAHEARTH		PRESENT
Point	4	09'39.378	006'31.743	BOSSO	GENERATOR	1.5KW	PRESENT
Point	5	09'39.378	006'31.748	BOSSO	VICOUNTE		PRESENT
Point	6	09'39.387	006'31.744	BOSSO	FIREWOOD		PRESENT
Point	7	09'39.395	066'31.755	BOSSO	FIREWOOD		PRESENT
Point	8	09'39.374	006'31.760	BOSSO	WASTE BIN		PRESENT
Point	9	09'39.380	006'31.752	BOSSO	TIGER GENERATO	1.5KW	PRESENT
Point	10	09'39.369	006'31.755	BOSSO	TIGER GENERATO	1.5KW	PRESENT
Point	11	09'39.391	006'31.751	BOSSO	TIGER GENERATO	2.0KW	PRESENT
Point	12	09'39.386	006'31.764	BOSSO	STORE KEROSENE		PRESENT
Point	13	09'39.371	006'31.766	BOSSO	STORE KEROSENE		PRESENT
Point	14	09'39.367	006'31.755	BOSSO	SIMBER GENERAT	7.5KW	PRESENT
Point	15	09'39.364	006'31.760	BOSSO	BENCHGINDER	1200KW	PRESENT
Point	16	-'39.364	006'31.758	BOSSO	TIGER GENERATO	1.5KW	PRESENT
Point	17	09'39.367	006'31.757	BOSSO	TIGER GENERATO	1.5KW	PRESENT
Point	18	09'39.374	006'31.758	BOSSO	EMASE GENERATO	7.5KW	PRESENT
Point	19	09'39.367	006'31.769	BOSSO	EMASE GENERATO	7.5KW	PRESENT
Point	20	09'39.369	006'31.767	BOSSO	EMASE GENERATO	11.5KW	PRESENT
Point	21	09'39.368	006'31.766	BOSSO	EMASE GENERATO	7.5KW	PRESENT
Point	22	09'39.366	006'31.770	BOSSO	EMAX GENERATOR		PRESENT
Point	23	09'39.362	006'31.773	BOSSO	FIREWOOD	2.0KW	PRESENT
Point	24	09'39.360	006'31.763	BOSSO	ELEPAQPETROL	2.0KW	PRESENT
Point	25	09'39.362	006'31.755	BOSSO	ELEPAQWOOD	1.5KW	PRESENT
Point	26	09'39.355	006'31.760	BOSSO	TIGER GENERATO	2.0KW	PRESENT
Point	27	09'39.356	006'31.761	BOSSO	YAMAHA GENERAT		PRESENT
Point	28	09'39.354	006'31.762	BOSSO	FIREWOOD		PRESENT
Point	29	09'39.354	006'31.764	BOSSO	KEREOSENE		PRESENT
Point	30	09'39.360	006'31.768	BOSSO	FIREWOOD	1.5KW	PRESENT
Point	31	09'39.361	006'31.765	BOSSO	JINCHENG	7.5KW	PRESENT
Point	32	09'39.363	006'31.767	BOSSO	HEMAN DIESEL	1.5KW	PRESENT
Point	33	09'39.357	006'31.773	BOSSO	TIGERGENERATOR	7.5KW	PRESENT
Point	34	09'39.356	006'31.768	BOSSO	SUZUKI PETROL	2.0KW	PRESENT
Point	35	09'39.353	006'31.775	BOSSO	TIGER PETROL	1.5KW	PRESENT
Point	36	09'39.356	006'31.775	BOSSO	DIESEL ENGINE	11.5KW	PRESENT
Point	37	09'39.352	006'31.778	BOSSO	DIESEL ENGINE	14.5KW	PRESENT

Fig.2.Creation of database on ArcView3.3.

In Fig.2, it is seen that the conventional database of Table 1 has been modified in conformance with the ArcView 3.3 specification for easy input into the GIS database.

The database was inputted and hot-linked to the spatial data (map and coordinate). The NO_2 levels were identified with magenta dots based on the geographical location points. The areas where the points (magenta-coloured dots) are shown indicate that the NO_2 measured was higher than the standard threshold value (0.0002ppm). The NO_2 status on ArcView3.3 is shown in Fig.3.

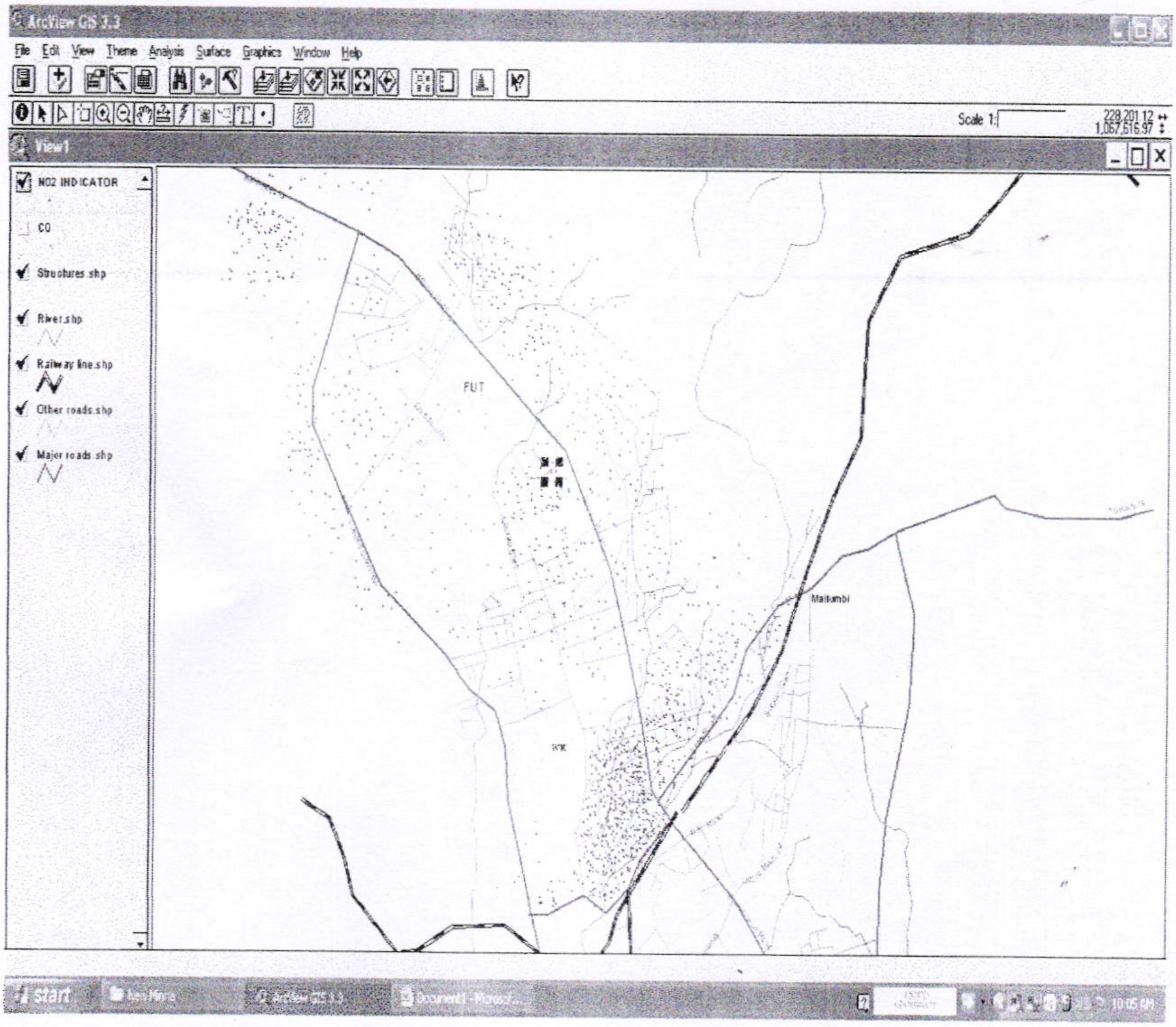


Fig.3. Query procedure on ArcView

The query was performed on ArcView3.3 by ensuring that the entire menu themes were active. The Query Builder allows for easy selection of features based on their attributes. Inside the dialog box, under Fields, the first step involved double-clicking on "Point". The points that comprised of geo-reference points, locations, sources, rating, and NO_2 levels as well as pollution status appeared in the box at the bottom of the dialog. To find specific attributes, the = sign was chosen by clicking on it once. An attribute name from the point list was selected by double-clicking to add it to the expression, and then "New Set" was selected. By default, ArcView highlighted the queried selection in magenta. The attributes that were queried were highlighted in magenta on the map. Fig.4 shows the pollution map of NO_2 on ArcView3.3.

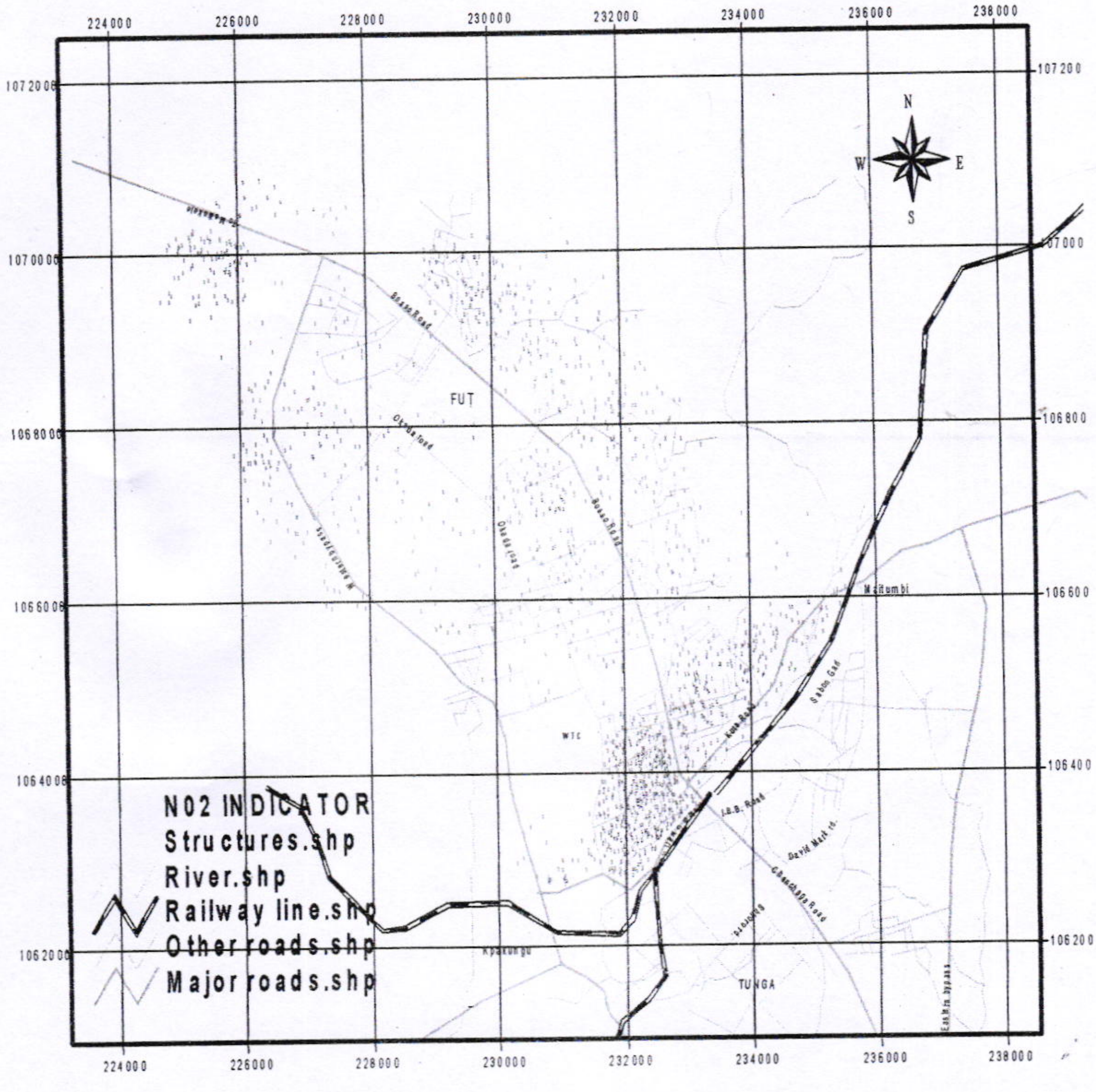


Fig.4. Pollution map of NO_2 over Minna.

Results

All the stations occupied for this survey (about 5350 households and commercial centers) indicate NO_2 levels greater than the internationally-recommended safe threshold of 0.0002ppm. The predominant sources of NO_2 were fossil fuel- burning units like vehicle engines and generators. Other sources were the charcoal hearths and firewood hearths. The GIS tool has been employed in the analysis of the full body of the dataset acquired for this project work with the core objective of producing an NO_2 pollution layer of a half segment of Minna town from Maikunkele to Mobil Roundabout Thus at the click of a mouse, information about the NO_2 pollution signature for the half segment of Minna town can readily be assessed. From the NO_2 pollution map of Fig.4 it is observed that Bosso, F-layout, and G.R.A. have sparsely distributed magenta dots whilst the dot densities for Maikunkele and Mobil area are high.

Conclusion

It can be deduced from the pollution map produced for this project work that, overall, the NO_2 level signatures over Maikunkele and Mobil neighbourhoods are quite high because a significant number of households and business locations own cars and use generators. The more developed a neighbourhood is, the greater the NO_2 magenta dot density. This GIS pollution layer map could now serve as a veritable urban development tool that would assist public health officials and town planners recommend appropriate actions to be taken to safeguard the health of the citizenry.

Recommendation

The study group members recommend that, as effective safeguard measures for the long term, the development and adoption of alternatives sources of energy on a large scale should be encouraged. For the short term the power supply situation in Minna should be improved in order to discourage the use of fuel-burning engines. The result of this study is actually futuristic in its outlook. Thus it is strongly recommended that a GIS host platform for Minna be created so that the interacti ve nature of the nitrogen dioxide pollution map of Fig.5 can be fully exploited.

It is also recommended that novelty studies of this kind be replicated in the major towns and cities of Nigeria.

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