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# Investigation of Nitrogen Dioxide Indices and the Creation of a Unique Geographic Information System (GIS) Layer Map for Nitrogen Dioxide Pollution in Minna, Niger State

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## 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 project work 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 stations 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 occupied 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.

**The Problem:** The absence of a nitrogen dioxide database for Minna was a source of embarrassment for the Niger State Government when an international development agency requested to be granted access to that type of dataset. Representatives from the Niger State Ministry of Environment duly contacted the Federal University of Technology, Minna, in order to help solve what was obviously a pressing problem.

**Project Objectives:** The principal objectives of this project work are as follows:

i. To help prepare the framework for a nitrogen dioxide pollution database for Minna; this project will be the substratum upon which subsequent studies would be laid.
ii. To help build the nucleus for an environmental awareness advocacy programme to be funded and executed by the Niger State Government.

**Justification of Project Work:** This study is predicated on one of the founding charters of the Federal University of Technology, Minna, i.e. the deployment of academic resources to solve pressing community needs (the town-gown synergy concept).

**Scope of Study:** The study was designed to cover all of the developed areal extent of Minna town, more of a house-to-house coverage scheme.

A 1999 study by Basu and Samet addresses 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. Although most studies have focused on schoolchildren, studies of adults and more recently, prospective studies of infants have also been carried out. 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 indicated if populations receiving exposures in a range of interest can be identified.

Brunekreef and Sunyer (2003), Sandoval *et al.* (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 are reviewed.

Koo *et al.* (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. 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 $NO_2$. While 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. 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 h), 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. $NO_2$ 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. $NO_2$ 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 h) 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.

Bauer and co-workers (ursulavbauer@dcf.state.fl.us) undertook a study of the health effects of the release of nitrogen dioxide, measuring the association between acute low level exposure and pulmonary symptoms. The authors reviewed the records of three emergency departments, surveyed 80 emergency department patients, 552 community residents, 21 chemical plant workers, and 29 emergency workers, and conducted a case-control study. Pulmonary case status was defined as having an objective pulmonary finding noted on the emergency department record, reporting that the onset of symptoms was subsequent to the release, and being within the city limits at the time of the release. Self-reported case status was defined as reporting one or more symptoms consistent with exposure to nitrogen dioxide in the week after the release and having been within the city limits at the time of the release. Control subjects were survey respondents who reported no symptoms in the week after the release and had been within the city limits at the time of the release. Chemical exposure was characterised by proximity to, direction from, and being outdoors within one hour after the release. Duration of potential exposure was not measured. Logistic regression was used to estimate odds ratios and 95% confidence interval for symptoms by exposure level, adjusted for age, sex, smoking, and preexisting pulmonary conditions. Local emergency department visits increased fivefold in the week after the release. The most common complaints recorded in a systematic sample of 528 visits in the first 30 hours after the release were headache (31%), burning eyes (30%), and sore throat (24%). Objective pulmonary findings were recorded for 41 (5%) patients in the week before and 165 (4%) in the week after the release. The odds of being a pulmonary case increased by 40% for each quarter-mile increment in proximity to the release (odds ratio [OR] 1.4; 95% confidence interval [CI] 1.1, 1.7), while the odds of being a self-reported case increased by 20% for each quarter-mile increment in proximity (OR 1.2, 95% CI 1.1, 1.4). People who met the pulmonary case definition were 2.5 times (CI 1.3, 4.8) more likely than control subjects to have been outdoors and 6.4 times (CI 3.2, 12.6) more likely to report a preexisting pulmonary condition. Self-reported cases were 2.6 times (95% CI 1.8, 3.8) more likely than control subjects to have been outdoors and 1.9 times (95% CI 1.1, 3.1) more likely to report a preexisting pulmonary condition. Conclusions: Emergency department visits increased five-fold,

but serious acute health effects were uncommon. People who met the pulmonary case definition were six times more likely to report pulmonary symptoms than those without preexisting conditions. This study was not designed to determine any potential long-term effects of exposure.

Smith and co-workers (krksmith@uclink4.berkeley.edu) conducted a critical review of the quantitative literature linking indoor air pollution from household use of biomass fuels with acute respiratory infections in young children, which is focused on, but not confined to, acute lower respiratory infection and pneumonia in children under two years in less developed countries. Biomass in the form of wood, crop residues, and animal dung is used in more than two fifths of the world's households as the principal fuel. Medline and other electronic databases were used, but it was also necessary to secure literature from colleagues in less developed countries where not all publications are yet internationally indexed. The studies of indoor air pollution from household biomass fuels are reasonably consistent and, as a group, show a strong significant increase in risk for exposed young children compared with those living in households using cleaner fuels or being otherwise less exposed. Not all studies were able to adjust for confounders, but most of those that did so found that strong and significant risks remained.

Miliby *et al.* (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 $N_2O_3$ may be involved. Industrial usage of nitric acid, metal picking and silo filling may allow the liberation of dangerous qualities of nitrous fumes. In confining 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.

Coggon *et al.* (www.dnc@mrc.soton.ac.uk) conducted a study in January 2000 to investigate the relation between fluctuations in personal exposure to nitrogen dioxide ($NO_2$). One hundred and fourteen (114) asthmatic school children within the ages of 7-12 were recruited from the Southampton area of England. Exposures of $NO_2$ were measured weekly over a 13-month period

with passive diffusion tubes. The result of the weekly mean personal $NO_2$ exposures were generally low and range from 0.7 to 496 g/m$^3$ with a geometric mean of 17 g/m$^3$. Finally, at low outdoor $NO_2$ concentrations, fluctuation in $NO_2$ in outdoor air as measured at a central monitoring station do not contribute importantly to variation in personal exposures when averaged over a week.

**Data Acquisition**

**Co-ordinate Identification:** 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. A typical GPS device is shown in Fig.1.

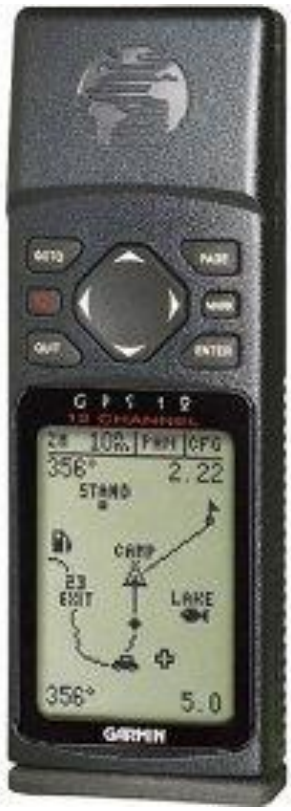


Fig. 1. Typical GPS device

**Data Collection Procedure:** Stations of interest that were identified as for this study were appropriately geo-referenced and marked in the conventional way. The stations were re-visited with the $NO_2$ meter whence information about the sources of $NO_2$ and the corresponding values of $NO_2$ were logged progressively from one point to the next. The neighbourhoods covered in this investigation are Maikunkele, Tudun Fulani, Bosso Estate, Bosso Low-Cost, Bosso, F-layout, G.R.A., Zarumai, Limawa, Dutsen Kura Hausa, Dtsen Kura Gwari, and Mobil.

**Dataset of Study:** About 5350 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 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). An abridged form of the dataset is presented as Table 1.

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 |

**Creation of a Unique GIS Layer of Nitrogen Dioxide Pollution Level Map for Minna**

**Concept of GIS:** A geographic information system (GIS) is a computer-based tool for mapping and analysing geographic phenomenon that exist, and events that occur, on Earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualisation and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. Map making and geographic analysis are not new, but a GIS performs these tasks faster and with more sophistication than do traditional manual methods. Today, GIS is a multi-billion-dollar industry employing hundreds of thousands of people worldwide. GIS is taught in schools, colleges, and universities throughout the world. Professionals and domain specialists in every discipline are become increasingly aware of the advantages of using GIS technology for addressing their unique spatial problems. We commonly think of a GIS as a single, well-defined, integrated computer system. However, this is not always the case. A GIS can be made up of a variety of software and hardware tools. The important factor is the level of integration of these tools to provide a smoothly operating, fully functional geographic data processing environment. In general, a GIS provides facilities for data capture, data management, data manipulation and analysis, and the presentation of results in both graphic and report form, with a particular emphasis upon preserving and utilising inherent characteristics of spatial data. The ability to incorporate spatial data, manage it, analyse it, and answer spatial questions is the distinctive characteristic of geographic information systems.

**Digitisation of Analogue Map of Study Area**

Digitisation is a simplification process that converts all spatial data to a point (e.g., a well), a line (e.g., a stream), a polygon formed by a closed, complex line (e.g., a lake), or a grid cell. Digitisation reduces all spatial entities to these simple forms because they were easy to store in the computer. A GIS database cannot readily recognize features or entities as human map users do. For example, we cannot enter the entity "lake" into a GIS. Rather, we entered the spatial data coordinates for the lake's shoreline as a polygon. Later, the attributes of the lake will be entered into the GIS database and will be associated with the polygon. Following the digitization of map features, the user completes the compilation phase by relating all spatial features to their respective attributes, and by cleaning up and correcting errors introduced as a result of the data conversion process. The end

results of compilation were a set of digital files, each accurately representing all of the spatial and attribute data of interest contained on the original map manuscripts. These digital files contained geographic coordinates for spatial objects (points, lines, polygons, and cells) that represent mapped features. Although we conceptualize the GIS as a set of registered map layers, the GIS actually stores these data at a much more primitive level.

**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 Fig.2.

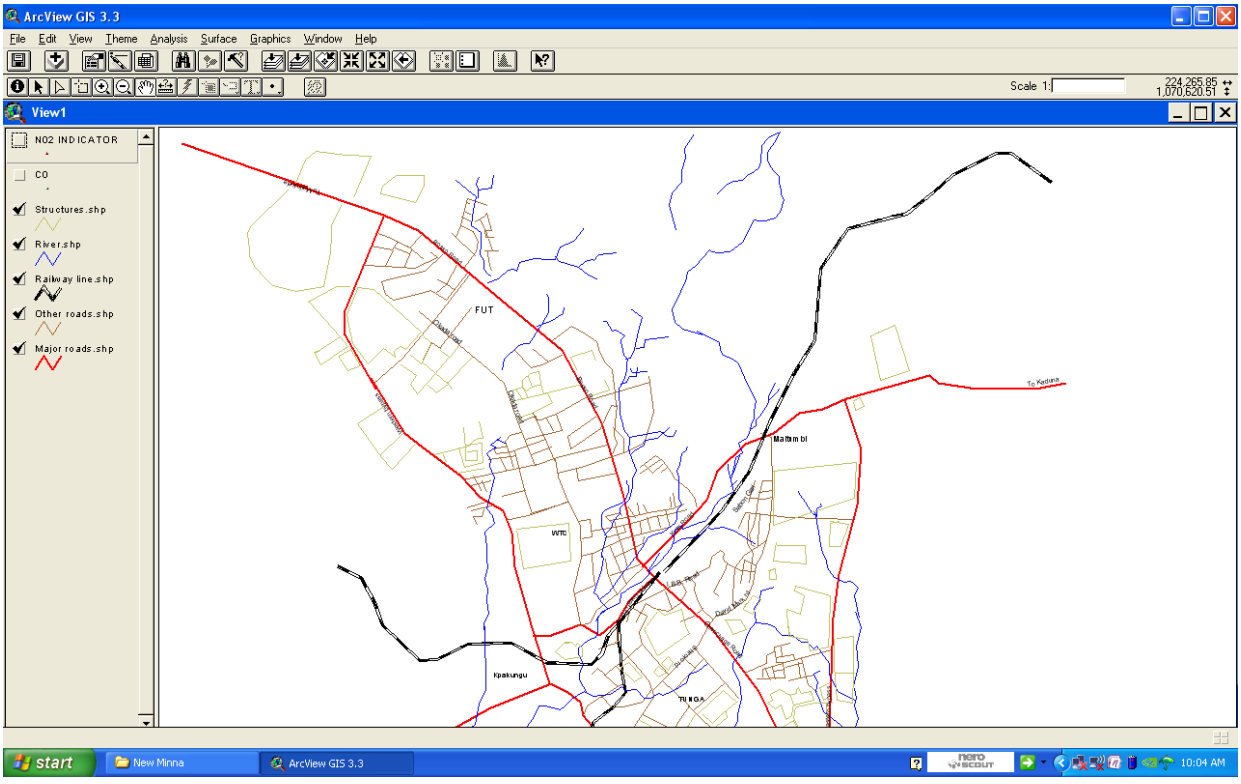


Fig.2. Naming locations on map

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.3.

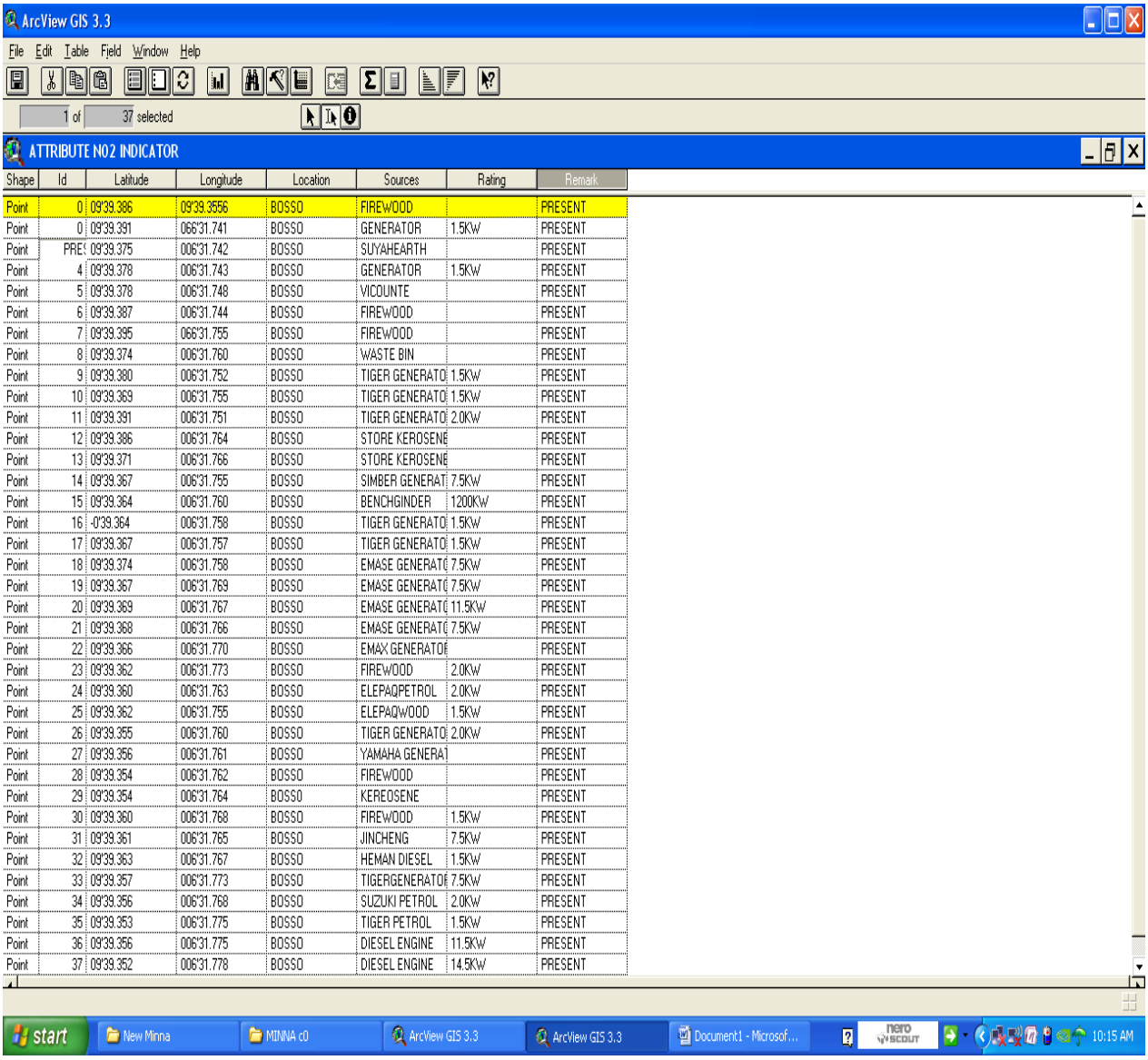


Fig.3.Creation of database on ArcView3.3.

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.4.

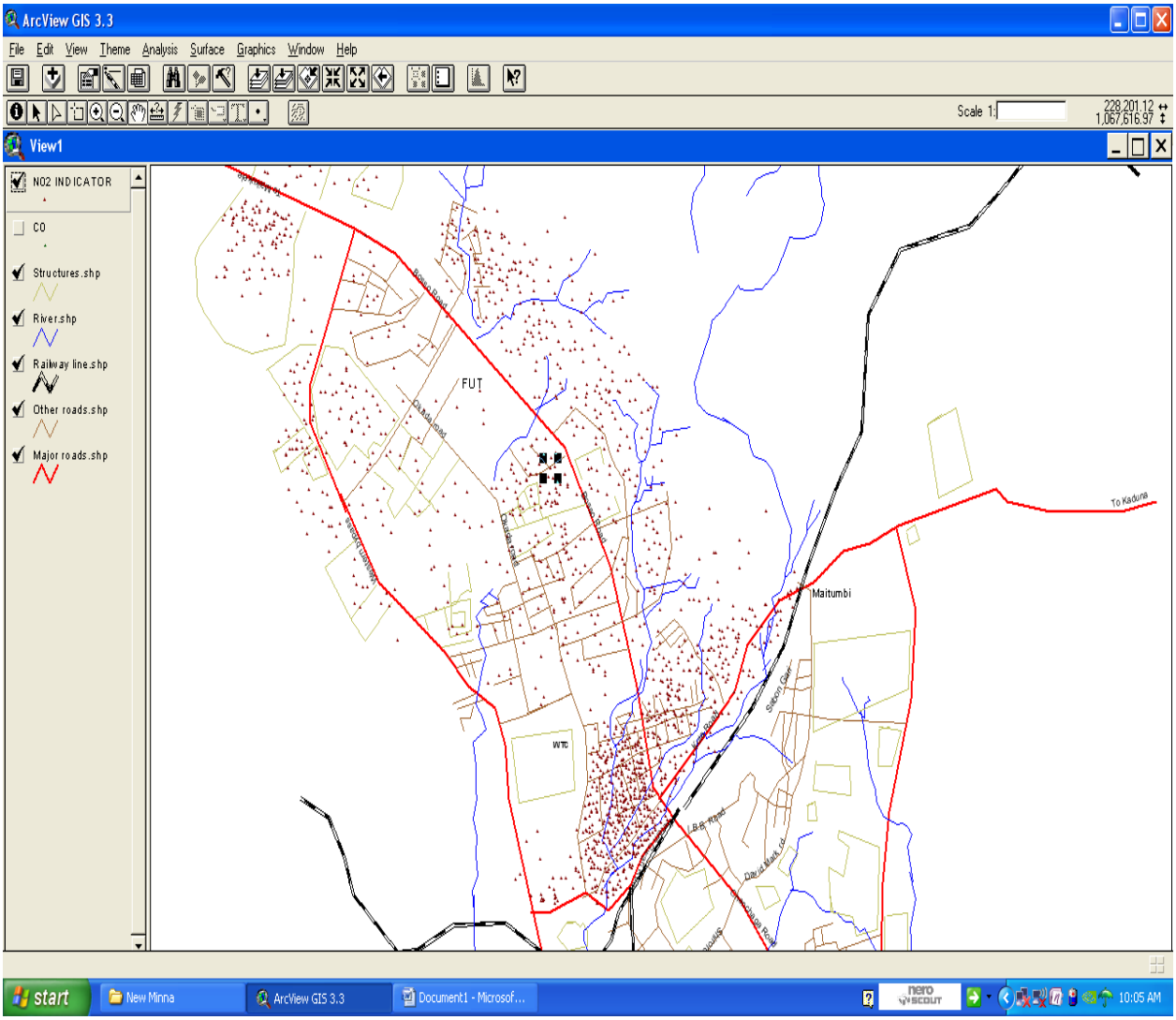


Fig.4. Query procedure on ArcView

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.5 shows the pollution map of $NO_2$ on ArcView3.3.

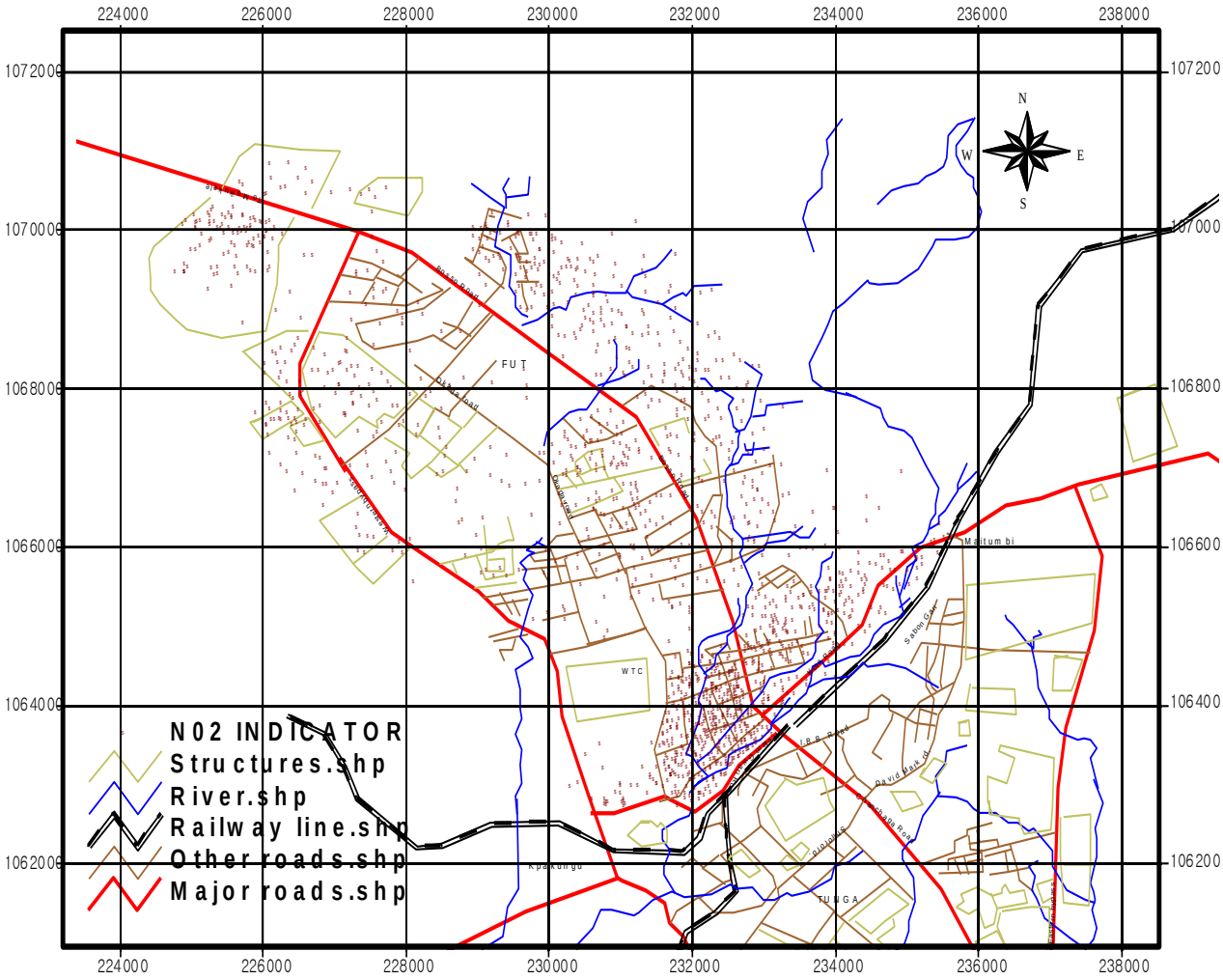


Fig.5. Pollution map of $NO_2$ over Minna

**Results and Conclusion**

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. This unique GIS layer is the first of its kind anywhere in Nigeria. 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.5 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. 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. A radical measure that should be adopted to reduce overall $NO_2$ pollution is the adoption of a best-practice scheme like the use of bicycles for short haul light trips. 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 interactive 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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