Evaluation of the Spatial Distribution and Retention of Criteria Pollutant (Carbon monoxide) using Geographic Information System. A case study of Ikeja Local Government Area, Lagos

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Abstract

Every urban metropolitan area is mainly characterised by industrial settings and traffic related activities. These cities are degraded by considerable amounts of pollution in different forms: air, water, noise or any other form of environmental degrading agent. Many of the polluting agents are detrimental to human health, properties and the environment at large, but constant monitoring programs for these pollutants are rarely put in place or taken with levity until the effects of pollutants become very obvious. Knowing the type and amount of concentration of the pollutants is necessary in the determination of hazardous nature of the environment. This work is aimed at studying the spatial distribution of carbon monoxide which is referred to as Criteria Pollutant by the World Health Organisation (WHO). The concentration of the criteria pollutant is sampled and quantified using digital air samplers, while the spatial distribution of the pollutant is modelled on continuous surface using spatial interpolation techniques such as Kriging and Inverse Distance Weighting (IDW) methods. The concentration and retention ability of the local air was modelled in a Geomantic environment using ArcMap GIS so that the spatial autocorrelation of climatic factors and the air borne pollutant could be understood. From the results obtained, Alausa secretariat and Caleb International School area showed very high carbon monoxide concentration and retentivity, while the Anthony village area showed very low carbon monoxide concentration and retentivity.

Keywords: criteria pollutant, mapping, spatial distribution and spatial interpolation techniques.

1.0 Introduction

Air pollution is the introduction of chemicals, particulate matter, or biological materials into the atmosphere that cause harm or discomfort to humans or other

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living organisms, or damage the natural environment. An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as either primary or secondary. Usually, primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone - one of the many secondary pollutants that make up photochemical smog. According to World Health Organisation **(WHO, 1992)** standard, a specific amount of these contaminants are to be tolerated in the environment as a significant quantity of the air pollutants in the local air is detrimental to human health, properties and the environment at large. In order to monitor and be able to manage the level of these pollutants in the ambient air, several countries of the world had designed various standards such as Pollutant Standard Index **(PSI)** for monitoring the degree of "cleanliness" of the atmosphere, for ensuring safer environment. In addition to these, WHO (1992), released an Air Quality Guideline and emission standard which can serve as a guide for countries, especially the developing countries that are yet to develop any form of Air Quality Standard and emission policy.

1.1 Effects of Air Pollution

Air pollution is generated from a number of different sources. The concentrations of air pollutants that are being measured in the ambient air will always be the sum of the interactions from different sources. It is therefore important to have some basic knowledge about the characteristics of the sources in the different areas. The sources of pollution can be categorised into

- Point (or stationary) sources e.g. Industrial stacks
- Linear (or mobile) sources e.g. traffic related emitters
- Polygonal sources e.g. conglomerate of point sources such as Industrial Estate

Emissions of air pollutants are related to socio-economic activities such as:

- Combustion of fossil fuels (power production),
- Industrial processes of various kinds,
- Road transport,
- Waste burning, open air and incinerators,
- Solvent use,
- Agricultural activities.

Substances emitted into the atmosphere by human and natural activities are the cause of many current and potential environmental problems, including:

- Acidification
- Air quality degradation
- Global warming/climate change,
- Damage and soiling of buildings and other structures
- Stratospheric ozone depletion,
- Human and ecosystem exposure to hazardous substances such as carbon monoxide.

Carbon monoxide is a significantly toxic gas and has no odour or colour. It is the most common type of fatal poisoning in many countries. Symptoms of mild poisoning include headaches, dizziness and a long-term squeals of pain often occur at concentrations less than 100 ppm. Exposures can lead to significant toxicity of the central nervous system and the heart. Carbon monoxide can also have severe effects on the foetus of a pregnant woman. Carbon monoxide with concentration as low as 667 ppm, can cause up to 50% of the body's haemoglobin to be converted to carboxy-haemoglobin (HbCO). Carboxy-haemoglobin is quite stable but this change is reversible. Carboxy-haemoglobin is ineffective for delivering oxygen, resulting in some body parts not receiving oxygen needed. As a result, exposures of this level can be life-threatening. When Carbon monoxide combines with haemoglobin in the blood can prevent binding of oxygen, which causes anaemia. In this also, myoglobin and mitochondrial cytochrome oxides are thought to be compromised. Treatment largely consists of administering 100% oxygen or hyperbaric oxygen therapy, although the optimum treatment remains controversial.

It is necessary to have quantitative information on these emissions and their sources in order to help:

- Inform the policy makers and the public,
- Define environmental priorities and identify the activities and actors responsible for the problems,
- Set explicit objectives and constraints,
- Assess the potential environmental impacts and implications of different strategies and plans
- Evaluate the environmental costs and benefits of different policies,
- Monitor the state of the environment to check that targets are being achieved,
- Monitor policy action to ensure that it is having the desired effects,
- Ensure that those responsible for implementing the policies are complying with their obligations.

1.2 Mapping and Spatial Distribution of Criteria Air Pollutants

Air pollution survey is a critical study of a specified geographical area for the principal purpose of determining the nature, sources, extent and effects of the air pollution that either exists within the area or that exerts a significant influence upon it. Several different purposes may be served by an air pollution survey. Among these are the evaluations of highly localized problems, urban and land-use planning, development or improvement of a community air pollution control program, and research. In the context of this work, air pollution survey is restricted to air sampling using digital air sampler, mapping of air pollutant sources and interpolation for determining unsampled location for air pollutant concentration. Criteria air pollutant is a term used internationally to describe air pollutants that have been regulated and are used as indicators of air quality. The regulations or standards are based on criteria that relate to health and/or environmental effects. Criteria air pollutants are:

- Carbon monoxide (CO_2),
- Lead (Pb),

- Nitrogen dioxide (NO_2),
- Ozone (O_3),
- Particulate Matters (PM),
- Sulfur dioxide (So_2),

For the purpose of this work, the only criteria pollutant of concern is Carbon monoxide (CO) which is the one that is usually present in the environment due to high industrialisation, high traffic and other sources of pollution that release pollutants of carbon contents.

1.3 Air Quality Monitoring System Design

Air Quality Monitoring System (AQMS) can be defined as the regulation of the amount, location and time of pollutant emissions to achieve some clearly defined ambient air quality standards or goals. For an efficient AQMS definition a decision support system is needed [Hussein, 2003]. AQMS should be used for detecting the pattern of each pollutant in space and time dimensions. The ultimate purpose of monitoring is not merely to collect data, but to provide the information necessary for scientists, policy makers and planners to make informed decisions on managing and improving the environment. Monitoring fulfils a central role in this process, providing the necessary sound scientific basis for policy and strategy development, objective setting, compliance measurement against targets and enforcement action (Fig. 1)

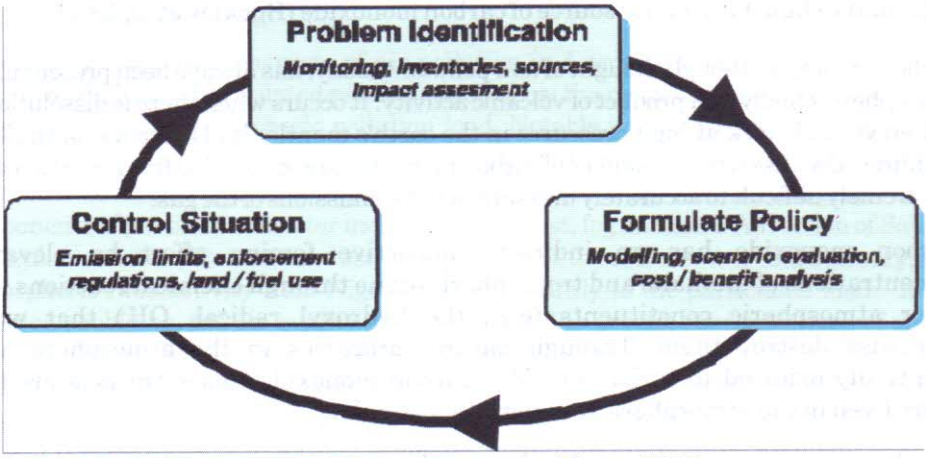

Fig.: The Role of Monitoring in Air Quality Management (Bjarne, 2002).

However, the limitations of monitoring should be recognized. In many circumstances, measurements alone may be insufficient or impractical for the purpose of fully defining population exposure in a city or country. No monitoring program, however well funded and designed, can hope to comprehensively quantify patterns of air pollution in both space and time. At best, monitoring provides an incomplete - but useful - picture of current environmental quality. Monitoring, therefore, often needs to be used in conjunction with other objective assessment techniques, including modelling, emission measurement and inventories, interpolation and mapping and these can be optimally achieved with the aid of GIS.