DECISION MAKING THROUGH INTEGRATED SYSTEM FOR AIR QUALITY ASSESSMENT

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Abstract: *To provide scientifically sound and decision relevant information to overcome the problems of air pollution, an integrated system for air quality management need to be developed. This strategy of air pollution control can be achieved within four phases. First phase includes monitoring, second modelling, third implementation of GIS and last phase includes development of system for decision support. Further, a GIS based decision making is expected to make air quality management system more efficacious and may be adopted as an efficient and cost effective approach for continuous improvement of air quality status. These advanced capabilities of such integrated system are expected to be beneficial for environmentalists, planners and decision makers so that they can reliably generate, simulate and analyse more information in the decision making process about environmental parameters.*
KEYWORDS*: INTEGRATED SYSTEM, AIR QUALITY ASSESSMENT, DECISION SUPPORT SYSTEM*

1. Introduction

High air pollution load in urban cities has been a major contributing factor towards degrading the ambient air quality day by day.[1] Urban air pollution remains as a serious environmental problem, whose solutions must have priority, but also an adequate approach.

Air quality assessment faces new and continuing challenges, because of the growth of urban conglomerates, population growth and rapid urbanization. Therefore, to analyse urban traffic impacts on air quality, an interdisciplinary approach is needed. An integrated system consisting of monitoring activities, dispersion models, GIS and decision support system may be created to assess the status of air quality, but also to support decision making towards continuous improvements of air quality status.

The main purpose of this research paper is description of the structural components of such integrated system, designed to give support in decision making connected with forecasting and managing urban air quality. Assessment of air pollution is required to predict the air quality in different urban situations, but also to evolve certain traffic management measures to maintain the air quality levels within the tolerable limits. In the following, integration of validated tools, which will support environmental management decision-making associated with air quality problem is described.

2. Structural components of integrated system for air quality management

The integrated system for management of urban air quality includes a number of closely related components that can be grouped into:

- monitoring measurements and on-line monitoring systems
- dispersion models for correlation of emission with ground ambient concentrations in order to understand the contribution of sources
- GIS and impact assessment, together with
- related reporting and public information.

To provide scientifically sound and decision relevant information supporting planning and management, these components are integrated in a system for air quality management (AQMS), whose purpose is scenario analysis and optimisation tasks.[2] The integrated air quality management system has been needed in order to select the right decisions for protection of human health and the ecosystem from an increasing impact of air pollution.

Basic method for assessment of air pollution are dispersion models supported with GIS. Integration with monitoring data from observation networks as a element that is both spatially referenced and at the same time dynamic and with a real-time nature, adds an additional dimension that also needs to be integrated.[3]

2.1. Monitoring of air pollution

In integrated system for air quality management, monitoring is the first operation. Today, GIS makes this operation easy. The monitoring stations are major sources to assess the accurate air quality status for the desired area. These stations may be chosen by first developing an integrated geographic database and then applying suitable selection criteria under GIS environment.

Monitoring is essential to assessing the effectiveness of air pollution control actions. The goal of an Air Quality Information System (AQIS) is, through monitoring, to keep authorities, major polluters and the public informed on the short- and long-term changes in air quality, thereby helping to raise awareness.

Monitoring, as a part of integrated system for air quality management include institutional building and training in order to assure sustainability in the system established in the area or region.[4]

Next, to translate emission under given meteorological conditions into ambient air quality (immissions), dispersion models are used.

2.2. Dispersion modelling of air pollution

Air dispersion modelling is an essential step in the air quality assessment process as it is the only way to evaluate the impact of future changes in air pollutant emission sources.[5] Dispersion modelling is computer tool that use mathematical equations to simulate how air pollutants disperse in the atmosphere. The model takes emissions from a source, estimates how high into the atmosphere they will go, how widely they will spread and how far they will travel based on hourly meteorological data. The model then outputs the concentrations that will occur at the selected receptors.

2.2.1. Dispersion model requirements

There are several competing requirements in the design of an air pollution model. A model must capture the essential physics of the dispersion process and provide reasonable and repeatable estimates of downwind concentrations.

Dispersion models can be set up to estimate downwind concentrations of contaminants over varying averaging periods – either short term (three minutes) or long term (annual). Most modern air pollution models calculate the pollutant concentration downwind of a source using information on the:[6]

- contaminant emission rate
- characteristics of the emission source
- ambient or background concentrations of pollutant
- topographic complexities of the area source configuration
- meteorological variables such as wind speed, wind direction, ambient temperature, atmospheric stability, atmospheric turbulence and thermodynamic effects.

A generic overview of how this input information is used in a computer-based air pollution model is shown in figure 2.1.

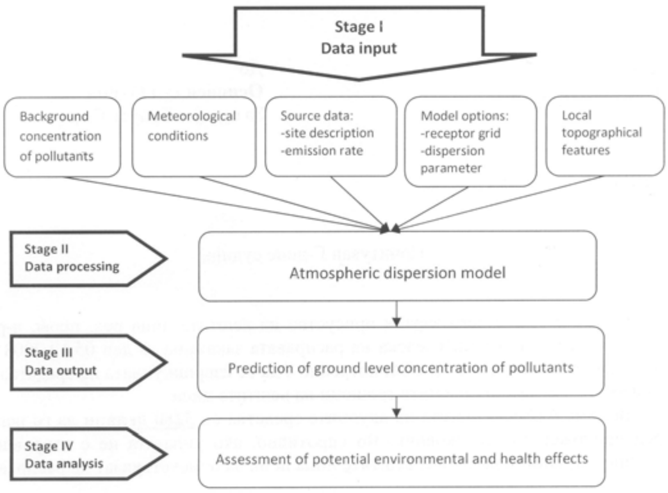

Figure 2.1: *Overview of the air pollution modelling procedure*
Source: [6]

The process of air pollution modelling contains four stages (data input, dispersion calculations, deriving concentrations, and analysis). The accuracy and uncertainty of each stage must be known and evaluated to ensure a reliable assessment of the significance of any potential adverse effects.

Computer models are highly specialized tools. A model applied improperly, or with inappropriately chosen data, can lead to serious misjudgements regarding the source impact or the effectiveness of a control strategy. As modelling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology.

In general, the more parameters a model includes, the more accurately the result will represent the real situation. If the parameters necessary for a particular model are unknown, that model should not be used.

Even the most sophisticated atmospheric dispersion model cannot predict the precise location, magnitude and timing of ground-level concentrations with 100% accuracy. However, most models used today have affirmed model evaluation process and the modelling results are reasonably accurate, provided when appropriate model and input data are used.[6]

2.2.2. Selection of appropriate dispersion models

While all dispersion models are developed to provide accurate pollutant concentration estimates under specified conditions, it is important to select a model that most accurately simulates the existing or future emissions source, even though it is often difficult to replicate project site characteristics exactly.

The most significant factors that determine the quality and accuracy of the results are:[5]

- the suitability of the model for the task
- technical competence of those undertaking such modelling
- the availability of accurate source information
- level of detail and accuracy needed for the analysis
- the availability of accurate meteorological data
- detail and accuracy of the database emissions inventory and air quality data.

Currently, the most commonly used dispersion models are steady-state Gaussian-plume models, providing an analytical solution to the dispersion equations. These are based on mathematical approximation of plume behaviour and are the easiest models to use. They incorporate a simplistic description of the dispersion process and can provide reasonable results when used appropriately.[6]

The *new generation* dispersion models adopt a more sophisticated approach to describing diffusion and dispersion using the fundamental properties of the atmosphere rather than relying on general mathematical approximation. This enables better treatment of difficult situations such as complex terrain and long-distance transport.[6]

2.3. Application of GIS in air pollution modelling

Geographic Information System (GIS) is tool for collecting, storing, transforming and displaying spatial data for a particular set of purposes. Most urban environmental problems of air pollution do have an obvious spatial dimension that can be addressed by GIS.[3]

GIS is a modern technological tool and may be used for the development of geospatial air quality models. As dispersion models have become more numerous, complex, and diverse, the powerful techniques available in GIS have been increasingly used for spatial data management, visualization, user interface, analysis of impacts, and, sometimes, the modelling itself. The combined use of air quality models and GIS has become standard procedure and an indispensable tool to assess potential air quality impacts.[9]

GIS can have a wide application in all stages of integrated system for air quality management, acting as an integrative framework for the entire process, from the generation, storage, and display of the information relative to the sensitivity of the affected resources, to impact prediction and finally their evaluation for decision support.

The GIS integrated in such system is designed to offer several possibilities for understanding the problems of air pollution:[7]

- the GIS makes it easier to place the air pollution sources at the correct location, for example by making it easy to display and edit the total network of road links in a city
- gives a good overview of where to expect high impact of air pollution
- viewing the measurement stations on a map with the pollution sources will give an idea of what concentrations may be expected to find at the stations for a given meteorological conditions
- the GIS makes it possible to search for geographically linked data in the database.

Various capabilities of GIS may be utilized for air pollution modelling, which may include locating monitoring stations, developing air quality models and development of spatial decision support system. By doing air quality modelling under GIS environment, the output of the pollutant records can be obtained in the form of spatial records.

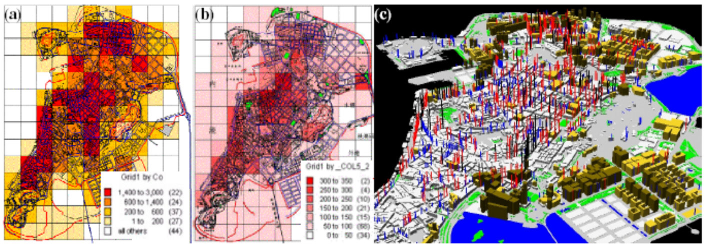

Figure 2. 2*: (a) Distribution of CO_2 emission by 300x300 m grids; (b) CO concentrations by 300x300 m grids; (c) Modelled CO concentrations by different approach in traffic scenario (columns represent CO concentrations; blue 0-1,5 ppm; red 1.5-2.5 ppm; and black 2,5-5,6 ppm).*
Source: [8]

The implementation of dispersion models based on a GIS offers various advantages to handle spatial and temporal data. A wide range of data collected by monitoring systems and by mathematical dispersion modelling can be managed in the frame of spatial models developed in GIS. Therefore, the scale of urban air pollution problems make GIS a powerful tool for management of spatial and temporal data, complex analyses, and visualization.[9]

The advanced modelling capabilities of GIS as a decision support tool are expected to be beneficial for environmentalists, planners and decision makers so that they can reliably generate, simulate and analyse more information about air pollution parameters.

2.4. Decision making process

A final level of integration in AQMS is between the information system and the human end user, or in more abstract terms, the decision making process that uses the management information system as an input. Despite different dispersion models, and quite different user group and their specific requirements, this system needs a flexible client-server implementation for distributed and decentralized use of information resources.[3] To facilitate easy access to complex technical information and tools of analysis to the broad group in the environmental policy and decision making process, an understandable user interface is required. Interactive multimedia technology, in particular the Internet, provide a number of interesting opportunities including public participation.[10] Internet technology also is an essential technical element not only to disseminate the air quality forecasting information but also to access to the produced data in real-time in an efficient way.

The GIS based decision support system (DSS) provides an advanced modelling and analysis system for environmentalists so that they can reliably generate and simulate more information about environmental parameters.[1] One of key components in spatial DSS is the data warehousing and analysis. For air quality monitoring, numerous records of meteorology, pollution and other related data for last several years are needed to be analyzed which may be done efficiently by developing decision support system under GIS environment.

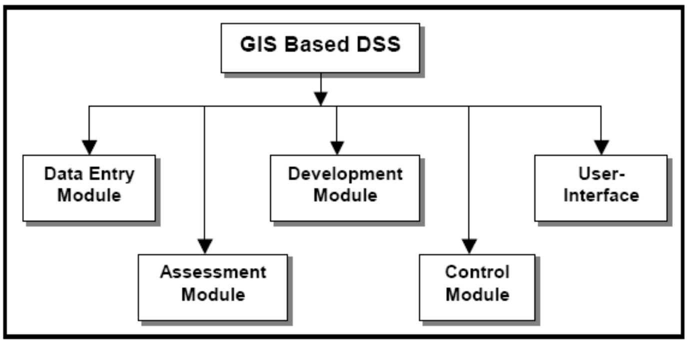

Figure 2. 3: *The structure of proposed GIS-based decision support system*

Source: [1]

Data Entry Module - this module is for entering basic geographic and attribute data. Data for control module is also entered using this module.
Assessment Module - the main objective of this module is to assess the variations of meteorological, air pollution and related data at each monitoring stations.
Development Module - for developing predictive models for any pollutant at any location. For each pollutant, a separate mathematical equation may be developed based on statistics of the pollutant records of previous years.
Control Module - this module is important to the decision-makers and it is used to control the pollution level of criteria pollutant. Various regulations and policies are a part of this module. This module helps the planners/environmentalists to identify the required decisions which must be taken to achieve the goal.
User-Interface - it consists of menu-based interface to help various planners and decision makers in efficient usage of the developed decision support system. All the modules should be well linked together within a GIS-based user interface and should provide graphics, dialog boxes, spatial analysis and other required functions.

3. Conclusion

Decision making process is based on integrated system for air quality management. This system combines monitoring, data presentation and dispersion modelling in one package, together with GIS, which enable the user not only to present and evaluate the present situation, but also to undertake environmental planning for a sustainable future. All these features are designed to address difficult analytical problems with large volumes of data, and at the same time provide a convenient and easy to use user interface.[11]

To provide decision making relevant information, integration of GIS with data bases, monitoring results from observation networks, and spatially explicit dispersion modelling must be provided.

The GIS platform, on which the system is operated and in which maps are developed and integrated, provides easy access to the data and gives a perfect and easily understandable data presentation. [7]

Such information helps decision makers to optimize urban design and traffic management. Modelling of the pollution dispersion with a GIS is a powerful way of making the modelled results user-friendly and easily understandable for local authorities as well as the public.[3] Therefore, the general idea of such integrated system is to improve the decision making process for policy makers by providing a professional tool to assist air quality planning.

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