STUDIES ON INNOVATIVE APPROACHES FOR ASSESSMENT OF AMBIENT AIR QUALITY IN FAST GROWING URBAN CENTERS;
Application of Online Air Quality Monitoring & GIS tools

EXECUTIVE SUMMARY

In recent years, research on the assessment of ambient air quality has increasingly become an issue of critical importance in view of the accumulating evidence revealing the adverse effects of pollution on human health, agricultural crops, man-made environments (damage to building materials) and ecosystems. Urban and regional planning is regarded as a possible tool for a limited but precious resource use control, and as a means to assure a better environmental air quality. It now refers to new problems involved in the concept of sustainability. Actually, it's a common practice to find planning on a strong sense of responsibility towards the natural environment to avoid a further crisis of the settlement system. Consequently, an integrated study of identification of appropriate sites for representative evaluation of air pollution, novel means of monitoring air quality, assessment of air quality, identifying the predominant sources of pollution, and evaluation of different management strategies become essential for the development of a healthy and habitable region.

In this PhD programme the author has taken up systematic and detailed studies on the design and development of advanced electrochemical sensors based online pollution monitoring system and development of a Traffic emission evaluation and scenario testing tools using GIS and Map Objects based data processing framework to continuously monitor air pollution, quantify the emissions and predict various test scenario emissions caused by vehicular traffic in Urban environments.

The first task in this programme is development of precise methodology for the identification of the multi-objective air quality monitoring network using site selection criterion. The second task is the development of online air pollution monitoring system for continuously assessing the ambient air quality and integration of monitoring data with meteorological information to assess the dispersion potential and studies, which can inform air quality. The third task is the development of emission tool and reconstruction of the entire mobility pattern in Hyderabad and the
quantification of generated or attracted trips by the year 2020 and its pollution potential.

The multi-objective air pollution monitoring sites are selected using evaluation of general and site-specific criteria for each proposed site in GIS environment that may affect the representativeness of the data collected. Local features that may affect either the chemical or meteorological parameters are also evaluated to assure a minimum of interference.

The online air pollution monitoring system is developed using electrochemical sensors for sulphur dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, mercaptans, hydrogen sulfide, hydrocarbons and ozone. The system is designed also to continuously monitors PM$_{10}$ / PM$_{2.5}$, sound level and meteorological parameters such temperature, wind speed, wind direction, rainfall, humidity and barometric pressure. The system is designed to deliver real time data on various pollution ½ hr intervals during peak hours and 1hr during normal hours.

Emission load estimations from the mobile source in Hyderabad is carried out on the basis of traffic inventory carried out during 1999 – 2000 (HATS – II). The model emission calculation system developed in Visual Basic environment is useful both for diagnostic information and for the possibility to envisage in terms of relative changes - the effects of various management measures.

The network data consisting of traffic loads, the traffic flows during different time frames is established. In accordance with (Hyderabad Area Transportation Study – II) HATS –II traffic surveys and extrapolations, vehicles have been divided into different classes taking account of categories of emission factors. For each vehicle category, the emission factors for SO$_2$, CO, NO$_X$, particulate matter, hydrocarbons are considered. The model considers the running emission load arising due to vehicle movements only and it does not considers emission load arising from idle, acceleration, and deceleration of vehicle conditions. The model outputs emission rates for each network, for each pollutant (in g/(km/h)), and for each vehicle class, and the total emissions (in kg/day).

The maps represent a steadily increasing situation: the motorization rate has almost doubled in ten years in the Hyderabad region, in spite of a substantially stable population growth. This means that corrective actions are necessary to modify the
traffic modal split and to give a specific function to public transport. If this process does not take place, this enormous automobile number pressure can cause serious damage in terms of air pollution load, congestion and circulation danger, and living conditions especially in the most central part of the city.

It is therefore imperative to study the impact of each proposed alternative on the nature and magnitude of air pollution emission load in the city. The vehicular travel assessment tool is developed to test different scenarios for the various travel management options for the evaluation of projected emission levels for the year 2020 in the context of HUDA master plan for the year 2020 that includes development of road network infrastructure in the form of express ways, inner and outer ring roads.

The suggested strategies critically examined in GIS environment include intersection geometry improvement (c) Road widening (d) grade separations (e) parallel roads (f) Bus bay relocations and (g) Work rescheduling.

The whole PhD programme is carried out with the following detailed objectives.

**OBJECTIVES:**

1) Assessment of existing Ambient Air Quality Monitoring network in Hyderabad.

2) Design a multi-objective air pollution monitoring network to determine compliance with National Ambient Air Quality Standards for gaseous and particulate matter.

3) Design and development of a novel online air quality monitoring system, consisting of existing electrochemical sensor systems for sulphur dioxide, oxides of nitrogen, carbon monoxide, Mercaptans, ozone, Hydrogen sulfide, Hydrocarbons, particulate matter.

4) Development of procedures and protocols for the preliminary data validation and data archival and data transmission to internet via a file transfer protocol (FTP) protocol.

5) Assessment of vehicular travel scenario in Hyderabad and the development of a vehicular emission assessment system based on a GIS based environmental modeling and Dispersion to different source locations using Caline 4.

6) Preliminary assessment of travel dimensions- trip origin and trip attraction in Hyderabad using Attractive index and extrapolating the future travel using the
developed index. Evaluation of projected emission levels for the year 2020 in the context of (Hyderabad Urban Development Authority) HUDA master plan for 2020 that includes development of road network infrastructure in the form of express ways, inner and outer ring roads.

However the following are the limitations in the execution and interpretation of data.

1) The development of the electronic and other hardware components are custom made by outside sources.

2) The long-term assessment of online air pollution monitoring system further need to be assessed and the detailed calibration procedures are not incorporated in the present thesis work.

3) The secondary data sources for travel inventory and emission factors and fuel consumption were collected from State Pollution Control Board, Road Transport Authority, HATS (Hyderabad Area Transportation study) survey data, HPCL (Hindustan Petrochemicals Limited) and are used for the development of the model without any validations, and the emission model calculates total running emissions and is not corrected for speed changes of the vehicle, type of the road etc, as such data is not available for Indian conditions.

4) The pollution load changes due to the existent Multimodal transportation system (MMTS) is not carried out as the availability of information on the traffic changes are not available.

5) Due to non-availability of projected vehicular modal split data for the year 2020 the author has assumed that model split to remain same which may not hold true with the changing economic trends. However the model can predict the emission levels once the original split is available.

Organization of the thesis:
The entire work carried out in this PhD programme is presented in this thesis in 8 chapters.
Chapter 1 briefly discusses the concepts of ambient air quality and the pollution scenario in few Asian countries and outlines approaches for attaining clean air, finally
introduces the topic of research area with the broad objectives and organization of the thesis.

In Chapter 2 the history of ambient air quality monitoring strategies i.e. National Ambient Air quality Monitoring in India, and the need for the continuous online atmospheric monitoring is discussed. There are a number of ambient air quality monitoring programmes currently being carried out in India. However they are not without limitations, the major limitations are representativeness of the air pollution sampling locations, the lack of skilled manpower, financial support, and availability of appropriate data validation protocols, and choice of analytical methods being followed, which are discussed in detail.

Chapter 3 provides a method and rationale for designing a multi-objective ambient air quality monitoring network in Hyderabad to determine compliance with National Ambient Air Quality Standards (NAAQS) for gaseous and particulate matter. Proper selection of the appropriate air pollution sampling sites for the online and manual air pollution and meteorological monitoring is of utmost importance to assure that the data generated is representative of the regime to be investigated.

The integrated methodology used for assessing the spatial distribution of primary pollutants includes the numerical models of atmospheric pollutants dispersion, and spatial interpolation using Inverse distance weighting method of ground-based point measurements. The objectives of monitoring network design include 1) Reliable representation of air pollution spatial-temporal patterns 2) Detection of pollution exceedances over National Ambient Air Quality Standards 3) Monitoring air pollution in areas where it represents the major human health risk 4) finally to take care of logistics such as shelters, protection against vandalism etc. All these points are discussed in this chapter.

Chapter 4 discusses the design and development of advanced electrochemical sensor based online air pollution monitoring system consisting of such as sulphur dioxide, oxides of nitrogen, carbon monoxide, hydrocarbons, ozone, mercaptans and hydrogen sulphide sensors. The chapter presents the design architecture of online pollution monitoring system, the environmental control of the monitoring station and the placement of various manifolds for representative sampling.
The Chapter also discusses the need for and design of meteorological data acquisition system incorporated in to the online air pollution monitoring. The meteorological systems such temperature, humidity, barometric pressure, rainfall, wind speed and wind direction are also discussed in the chapter.

In Chapter 5 various aspects of data acquisition, data archival and data presentation of online air pollution monitoring system are discussed. Initially a brief discussion on the hardware and software components necessary for a data acquisition and processing system are highlighted, then the issue of data archival and retrieval of real-time data and data presentation using various advanced information technologies is described.

Chapter 6 of this thesis presents the traffic scenario in Hyderabad and the changing growth rate over the years. This chapter also discusses about the traffic emission flow modeling system. A vehicular emission assessment system based on a GIS is designed for scenario testing to evaluate the environmental consequences of road traffic in Hyderabad. The system integration details on the traffic – base data and results on the modal results are presented in the chapter.

In Chapter 7 various transportation management strategies for controlling vehicular emission load are presented. The proposed vision 2020 document suggestions are critically examined for the probable impact on the emission load. Attempt has been made to develop a travel demand forecasting model for assessing the traffic and trip attraction. A cumulative index representing the overall employment centers, residential and recreational centers are identified and an index has been developed. The regression equation correlating the attractive index and observed traffic volume at various junctions is also studied. Chapter 7 discusses different alternative options and how each option will help in reducing the emissions.

Finally in Chapter 8 the summary of the entire work done in this PhD programme and major conclusions drawn and future scope of the work are discussed.