INTRODUCTION

Urban growth is inevitable and the systems are becoming ever larger and increasingly complex as urban economies, social and political structures and norms, and transportation and other infrastructure systems and technologies evolve (Sadik, 1999). Urban air quality is a major concern throughout the world (Karen Bickerstaff, 2001). The pace of urban development, together with the type of social and economic forces that drive it, can have profound implications for the population in and outside of urban areas (Fenger, 1999 and Baldasano, 2003).

While urbanization can bring improvement to people’s income and lifestyles, it also comes with negative environmental and social impacts. These...
negative impacts threaten our quality of life at every level, from the health of the individual citizen, to the stability of the global economy, to the long-term survival of humans and natural systems around the world (Devas & Radkodi, 1993). Some of the major environmental issues associated with urbanization and the corresponding increases in population density are those related to water quality, waste management, and air quality (Scholorling, 2000).

The Hyderabad urban system depends primarily for its operation upon the consumption of fossil fuels. Hyderabad city is under significant influence of anthropogenic emissions, the levels of concentration of components were very similar to those at other Indian sites (Kulshrestha et al. 2003). The city’s systems which have also evolved particular land use and transportation patterns, which are far from optimal in their economic efficiency, social equity and environmental performance. As well as benefits, the continuing growth of city also brings disbenefits including congestion and pollution (Reddy and Chari, 2001). Pollution brings damage to health, degradation of the built and natural environment and loss of amenity.

The desirable path for future city development in any country is one which seeks to provide sustainable city in terms of minimizing the resource inputs, such as energy, and reduce waste outputs, such as air pollution and greenhouse gases, while optimizing land use, transport systems and infrastructure (Paul Ekins, 2001). The prime objective of the assessment study is to determine the need for and to propose actions that will maintain or improve air quality in Hyderabad for our ongoing project on Impact assessment of land use and air quality.

DESCRIPTION OF THE STUDY AREA

Hyderabad city, the capital of the state of Andhra Pradesh is located at the heart of the Deccan plateau of the Indian sub-continent. The total study area of Municipal Corporation of Hyderabad (MCH) is 179 Km² and divided into 11 planning zones. The study area is situated between 17° 18' 26" and 17° 27' 40" North latitudes and 78° 22' 26" and 78° 33' 26" East longitudes and is at an altitude of 536 m above Mean Sea Level (MSL). The climate is fairly equable with a daily mean maximum temperature varying from a minimum of 11.6°C during the month of December to a maximum of 40.56°C in April. Hyderabad gets its rainfall mainly from southwest monsoon with the total annual average rainfall of about 73.55 cm. It is located at an altitude of 570m above mean sea level.

METHODOLOGY

Developments in computer hardware and software have made possible electronic mapping with dynamic connections between maps and database information. These developments make it possible to manipulate maps and information to analyze spatial aspects of data (Ranger et al. 2002). In evaluation of impacts of land use/land cover changes on air quality, broadly two types of data products are generated, spatial data and non-spatial attribute data. The spatial data is comprised of land use/land cover, point sources. The non-spatial or attribute data is comprised of air quality parameters, and air quality index.

Description of sampling sites

The 44 sites were chosen to be representative for the typical Landuse category in the study area. They differed mainly with respect to the road traffic density and predominant landuse and population densities. Five sites were typical industrial locations, whereas fifteen were residential sites with low, medium and heavy traffic density and the remaining sites were allocated to be commercial and heavy traffic zones.

Analytical procedures

The air pollution measurements were carried out for 1 yr, starting from April 2005 to May 2006, with a frequency of one week at one location sampling. Each sample represents a continuous TSPM, RSPM, NOx and SO2 collection of 24 h duration. Rains in India are limited to four months of monsoon period with intense and continuous rainfalls. Hence, during this season, the samples were collected only during dry spell days. SPM were collected on glass fiber filter paper (size 20.3 - 25.4 cm), using a Respirable Dust sampler, operated at a flow rate of 1.0m³/min. NOx and SO2 were collected by aspirating ambient air through absorbent solutions; sodium tetrachloromercurate for SO2 and a mixture of sodium hydroxide and sodium arsenate for NOx, with an aspiration rate of 1.0m³/min Sample processing and analysis SO2 and NOx were analyzed colorimetrically using the method of West and Gaeke and modified method of Jacob and Hochheiser, respectively.

Information of land use/land cover

The spatial data is derived from satellite sensing sys-
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The satellite sensors are panchromatic and LISS-III sensors of IRS-ID satellite. Survey of India toposheets are 56K/7 and 56K/11 on 1:50,000 scale. In this study, the remote sensing data in the digital mode is used and is obtained by LISS III and PAN of IRS ID. Figure 1 shows the raw satellite imagery for Hyderabad city. LISS III sensor operates in four spectral bands; there are separate optics and detector arrays for each band. Map of 1:50,000 scale obtained from SOI covering the entire study area is used to extract the Ground Control Points (GCPs) and to demarcate the boundary of study area. This information is then used for image registration of LISS III and PAN digitally using EASI/PACE software.

Road segments are uniquely defined by its road code and the nearby road segments. The road network has 373 road codes and 1,907 road segments corresponding to an average of about 5 road segments per road code. In order to display street names, a database with road codes and street names was established based on the address database as suggested by Bachmann et al (Bachmann, 2002). The spreadsheet with road and traffic data included street width, travel speed and traffic load of the various categories such as passenger cars, vans, Lorries and buses.

Air quality index calculation

Vast amount of data that are generated as a result of air quality monitoring programmes complicates the meaningful interpretation (of data) and demands extensive statistical and computational efforts. In this research, adaptability of some of the existing AQIs that have been used by various agencies is examined. There are several types of AQIs cited in the literature having different criteria and mathematical functions, at times, leading to confusion. There is no single universal AQI (Anjaneyulu et al. 2001). The Pollution Standards Index (USEPA, 1998) (PSI) that is based on additive function of sub indices was examined for city of Hyderabad.

The air quality index is calculated using the following equation. The mathematical functions for calculating sub indices are proposed after considering health criteria and sub index values from the literature particularly from the website of USEPA (USEPA, 1976; Sharma et.al (2001)). The pollutants included in the index are:

\[ S_{0.2}, S_{PM}, O_3, N_0.2, PM_{10}, CO \text{ and } SO_2 \]

The quality of air in the study area can be estimated from the air quality index. The air quality index was calculated from the observed TSPM, RSPM, NOx and SO2 values using the formula:

\[ AQI = \frac{1}{4} \left( \frac{I_{SPM}}{S_{SPM}} + \frac{I_{RSPM}}{S_{RSPM}} + \frac{I_{SO2}}{S_{SO2}} + \frac{I_{NOX}}{S_{NOX}} \right) * 100 \]

Where,

\[ I_{SPM}, I_{RSPM}, I_{SO2} \text{ and } I_{NOX} = \text{ Individual values of suspended particulate matter, respirable particulate matter, sulfur dioxide and oxides of nitrogen respectively.} \]

\[ S_{SPM}, S_{RSPM}, S_{SO2} \text{ and } S_{NOX} = \text{ Standards of ambient air quality.} \]

The air quality index was individually calculated for all the sampling stations, and the quality of air was estimated. The index is classified in five categories i.e. 0-25 Clean air; 26 - 50 Light air pollution; 51-75 as moderate air pollution; 76- 100 as heavy air pollution and greater than 100 as severely polluted. Statistical analysis of the data was performed with the statistical software Origin 6.

Pollution interpolation studies

Arc/Info GIS spatial analyst module was used for interpolation in three dimensions. Inverse distance interpolation is used for modeling between the monitoring stations. Arc View is a computer software package that stores information about points, lines, and polygons, as well as the spatial relations between these features (Ian Masser, 2001).

This method of interpolation combines the idea of Thiessen polygon with the gradual change of trend surface. It considers weighted moving average. Weights are computed from a linear function of distance between sites of points and the points to be predicted. In this method the size of the starting radius is specified, which defines the starting search area for interpolation points around the grid point. The general theory underlying inverse distance weighing interpolation is that points closer to the estimation location are more influential than points farther away (Watson, 1992).

Identifying the impact of land use/land cover on air quality

GIS software such as ArcView can associate databases of attribute information (pollution information, point source data etc) with associated spatial objects. One database might contain information about streets names and ambient air quality information; another might have Landuse category, pollution sources in-
formation. Data can be displayed as thematic maps. For example, population information in a census database can be displayed as a dot-density map or by shading the census tracts according to their population. In addition to feature/object attribution (air quality index), the notion of topology is critical in GIS—each feature (point/line/polygon (location type) in GIS can “answer” three additional questions—“What is the air quality index,” “what the land use/land cover status,” and “which type of point sources are surrounding the region?”

RESULT AND DISCUSSION

Land use/land cover of Hyderabad

Two striking factors of Hyderabad’s urban growth are low density scattered development of urban fringe and absence of any identifiable visual character. The growth of the city of Hyderabad got an impetus from industrialization after 1961. There was a speculative growth pattern from 1964 to 1974. The area occupied by built up land in 1964 was 17092 hectares. During the late 70’s and 80’s the extension of urban sprawl of Hyderabad has been inhibited. The hitherto unoccupied areas of places were occupied. The boulders and tars, which were lying protected, were broken to be used for foundation stones of buildings coming up on the same sites. The sprawl area of Hyderabad between 1975 and 1991 is estimated to 19238 hectares, which accounts for 8.67% of the total geographical area. Figure 2 shows the land use/land cover classification map for the Hyderabad city.

Air pollution characteristics

City average pollution characteristics for all the pollutants reveal that the excepting sulfur dioxide all pollutants frequently exceed the NAAQS standards for 24 hr average and are below 8hr average values. Table 1 presents statistical data on the concentrations of the measured air pollutant concentrations at 44 selected locations in Hyderabad during the sampling period. Arithmetic averages for different places and comparison of the concentration levels among the sites are given in terms of arithmetic and geometric mean, median and range of the values. Figure 3 to

<table>
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<th>Parameter</th>
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**Spatial variation**

The ambient concentrations of air pollutants at a specific location are largely dependent on the point source emissions, predominant land use practices and transport atmospheric scavenging processes. Figure 8 to Figure 12 shows the statistical character-

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**Figure 1** Fused satellite data of IRS-1D and LISS-III satellite imagery

**Figure 2** Land use/land cover map of the study area

**Figure 3** Spatial distribution of oxides of nitrogen

**Figure 4** Spatial distribution of respirable suspended particulate matter

**Figure 5** Spatial distribution of total suspended particulate matter

**Figure 6** Spatial distribution of air quality index

Figure 7 shows the interpolated air pollution maps for Hyderabad city during the study period.
The total number of sampling stations from residential back ground is 14. The average pollution levels are 184, 96, 30 and 3 μg/m³ for TSPM, RSPM, Oxides of nitrogen and sulfur dioxide respectively. The recorded values were observed to exceed the National Ambient Air Quality Standards (NAAQS) for 13 sites.
for TSPM 12 sites for RSPM and 12 for oxides of nitrogen whereas the oxides of sulfur are found to be within the limits at all places.

Out of the 44 sampling stations 5 locations were observed to be with industrial background. The average pollution levels are recorded from a minimum of 286 μg/m³ to a maximum of 429 μg/m³ for TSPM, RSPM ranged from a minimum of 125 μg/m³ to a maximum of 207 μg/m³. NOx ranged from 44 μg/m³ to 129 μg/m³ at. SO2 varied from a minimum of 4 μg/m³ to a maximum of 8 μg/m³. The locations are found to exceed the National Ambient Air quality Standards on a regular basis.

TSPM, RSPM, SO2, NOx are the parameters which have been analyzed in the 25 sampling stations categorized under traffic / commercial areas respectively. The TSPM in these stations recorded a minimum of 212 μg/m³ and a maximum of 560 μg/m³. The RSPM varied from a minimum of 83 μg/m³ and a maximum of 299 μg/m³. The gaseous pollutants were found to be within the permissible limits. Impact of land use on air quality was assessed by carrying out the correlation studies, the results indicate the significant relation between type of the land use and number of vehicles plying and the corresponding land use. Figure 13 shows the correlation between land use and air quality in Hyderabad. The correlation studies carried out indicate the impact of land use on air quality is significant with places of commercial and industrial locations the pollution levels are high.

CONCLUSION

The study carried out on impact of land use on air quality has suggested that the Hyderabad city is facing air pollution problems because of unplanned city roads. Hyderabad city can be seen as representative of air pollution and envi- ronmental issues that affect most cities in develop- ing countries. Given the present favorable eco- nomic conditions, a further increase in air pollution vehicular mobility, industries, and urban activities can be expected in the next few years. Deterioration in air quality and the corresponding urban issues are not considered in land- use planning and zoning and in the further urban design of the city, it would not be possible to improve the environmental situation and its negative effects on health of the ecosystems.

REFERENCES


