CHAPTER 6
VEHICLE TRAVEL SCENARIO IN HYDERABAD
AND ENVIRONMENTAL IMPACTS

This present chapter highlights development of a mobile pollution calculating tool for
the evaluation of transport-related air pollution situations in an urban environment.
Geographic information system (GIS) and Visual Basic platform is used to integrate
vehicle emission model, pollutant dispersion model (Caline 4) and related databases
to estimate the emissions and spatial distribution of traffic pollutants in Hyderabad.
The develop model not only can analyze the current pollution situations, but also can
predict the emissions influenced by changes in specific traffic conditions or under
vaying management policies.
The section 6.2 highlights the current vehicular travel scenario in Hyderabad, the
section deals with various vehicular categories and their growth rate over the years.
Section 6.3 presents the environmental consequences of vehicular travel in
Hyderabad. Section 6.4 highlights detailed methodology involved in the development
of emission load from road traffic. Section also presents the results on emission load
obtained from the model for different conditions such as peak time, daily average and
worst case wind angle air pollution concentration observed for carbon monoxide
using Caline 4 etc, Last section highlights the use of visual basic model the emission
load scenario from 1988 to 2003.
6.1. INTRODUCTION:
Many cities in India are experiencing rapid commercial, industrial and residential development accompanied by population explosion and growth in the total area of land developed. This has caused a multitude of problems including direct costs on the infrastructure needed to support development and the social and environmental side effects of developmental patterns. These problems have varying characteristics, which makes it difficult to find simple solutions. There have been many decades of interest in monitoring and modeling air pollution emissions from road traffic and in assessing the air pollution impacts of particular roadway projects through environmental impact assessments of new roadway proposals. However, there has been less attention given to environmental modeling of networks, particularly future flows on networks. The consequence is that much transport network planning to date still fails to consider environmental impacts of the future road network scenarios.

Now that few new roads or major expansions are planned in Hyderabad (Hyderabad 2020), it seems inevitable that such policies will have to be critically examined for the probable pollution load on those roads as well as their impact on the city centers in the years to come. The lack of information on emission loads raises few dangers, on the one hand good policies might appear ineffective, or might be poorly executed, because the studies do not account for all the channels by which these policies might work i.e. the proposed road networks are very sophisticated in certain ways, they have little to say about the effects on the usage of the modes by the vehicles, thus is the environmental pollution burden from these roads.

Keeping the above drawbacks into consideration it is designed in this chapter to develop emission quantity modeler for road traffic in Hyderabad so as to investigate the present and future pollution load from any proposed or existent road network. The traffic emission flow modeling system is based on a GIS based environmental modeling system designed to evaluate the environmental consequences of road traffic in Hyderabad. The system integrates information about traffic data carried out by HATS survey – 1998 (HATS (1998) and Road Transport Authority (Gandhi, CLN, 2003) year wise vehicular data to provide the input data to specially designed Visual Basic application models that estimates pollution from a road traffic system under test conditions. The present chapter initially discusses the growth scenario of road
transport in Hyderabad city, then brief methodological frame work for the calculation model in GIS environment is highlighted giving suitable references.

6.2. GROWTH SCENARIO OF ROAD TRANSPORT IN HYDERABAD CITY

Vehicle travel has increased substantially in Hyderabad during recent years (Gandhi, CLN 2003), with two wheelers contributing major share. Factors contributing to this trend are numerous, although some new travel can be attributed to shifting demographics and market characteristics, substantial evidence suggests that much of the increase is a direct result of changing developmental patterns.

As development becomes more dispersed, with increasing numbers of families living on large lots at the urban fringes, and as jobs and housing become increasingly segregated from one another, distances between destinations have increased and people are forced to make more trips by motor vehicles, since the distances between destinations are often too great to walkthrough.

The total number of vehicles in Hyderabad increased by 273.9% during 2003 compared to 1987. Figure 5.1 and Figure 5.2 shows the growth rate and relative increase of various vehicular categories in Hyderabad over the last 18 year. The analysis shows that the compound growth rate of all vehicles in Hyderabad stands at an average value of 10%. But the relative growth of all vehicles differs widely. The highest growth rate of 24.61 percent has been shown for motorcars for the whole period of 16 years even though its share in total vehicle population has increased only 0.79 percent (from 3.9 percent in 1987 – 88 to 4.69 in 2002 – 2003).

Similar is the trend in the case of school busses. The compound growth rate in case of school busses is 23.34 percent. But its share in total vehicle population is very much negligible. Its share in total vehicle population was 0.016 percent in 1984 – 85 to 2.3 percent in 2002 – 2003. The analysis also shows that the share of motorcycles, scooters and mopeds in total vehicle population is comparatively very high.

So far the Moped population is concerned its share stands at 37.6 percent in 1984 – 85. it fell to 35.44 percent in 1990 - 1992. Again it rose to 40.91 percent in 1987 – 88. But after 1987 – 88 its share has declined gradually and it stands at 21.23 percent in 1990 – 91. The compound growth rate of Moped population is 2.53 percent. The analysis also shows that the share of Motorcycles, scooters and Mopeds in total vehicle population is comparatively very high.
Scooter population showed an erratic movement, its share in total vehicle population stands at 23.32 percent in 1985 – 86. It rose to 27.26 percent in 1986 – 87. But in the next two years, its share fell to 23.33 percent in 1987 – 88 and 19.36 percent in 1988 – 89. During 1990 – 91 its share has declined to 15.40 percent. But the compound growth rate of scooter population stands at 8.96 percent. The motorcycle population has increased at the compound growth rate of 15.12 percent. Its share in total vehicle population also shows an erratic movement. From 20.33 percent in 1985 – 86 its share fell to 16.79 percent in 2002 – 2003.

Figure 6.1 Vehicular growth rates of different vehicular categories in Hyderabad

6.3. ENVIRONMENTAL CONSEQUENCES OF VEHICLE TRAVEL AND EMISSION MODELING:

Motor vehicles emit pollution through fuel combustion (exhaust) during operation and fuel evaporation during and between periods of operation. Motor vehicles emit air pollutants such as Oxides of Nitrogen, sulphur dioxide, and Lead and contribute a large portion of CO and ozone precursors in particular. Vehicle travel also kicks up
large quantities of particulate matter from roads (especially on unpaved roads in rural areas).

Since motor vehicles are the fastest growing source and contribute a significant portion of the emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOX) and particulate in urban areas (UNEP/WHO, 1992), emissions from automotive engines are considered as a major source of urban air pollution (Anu Kousa et al, 2002; Jenson, 1998; Moragues and Alcaide, 1996; Gualtieri and Tartaglia, 1998, Leorey O. Marquez and Nariida C. Smith, 1999, A. W. Reynolds and B. M. Broderick, 2000). It would therefore be useful to have a modeling tool able to weigh both of them at a time, enabling transportation policy-makers to find strategies bearable by the environment.

![Percentage growth rate of vehicular number in Hyderabad](image)

**Figure 6.2 Percentage growth rate of vehicular number in Hyderabad**

Several recent research works focused on the assessment of the effects of traffic pollution (Y. de Kluizenaar, J. Ahern and E. P. Farrell, 2001. Schmidt and Schaffer (1998), E. J. Kinnee et al, 2004) developed an integrated simulation system for traffic flow information, air pollution modeling and decision support in a distributed High Performance Computing Network to investigate the air quality in urban areas. Moragues and Alcaide (1996) used a geographic information system (GIS) to assess and locate traffic effects before and after a new traffic infrastructure enters services, and the results showed that GIS is an effective tool for carrying out environmental
impact assessment. Gualtieri and Tartaglia (1998, developed a comprehensive model for the evaluation of air pollution caused by road traffic in urban areas to help the decision making of local administrators. Rebolj and Sturm (1999) integrated existing emission calculation software with a graphical user interface to estimate traffic air pollution. The section below discusses the model description and results on various links in Hyderabad and the dispersion of the pollution to selected receptor positions.

6.4. EMISSIONS FROM ROAD NETWORK:

A coherent geo-coded road network with assigned road and road traffic data has been established. A technical map was obtained from HUDA, Hyderabad. The technical map included the road network among many other themes. However, the roads were not geo-coded and it was not possible to identify the individual road by the road code and further the road network included a few missing links that were digitized using Ground checks.

Road network was divided into road segments using GIS Software, ArcGIS (www.esri.com). Each road is defined by a polyline that can be identified with unique digit code and each road segment is a road section between two road intersections or between an intersection and dead end of the road. Segmentation of the road network is required because traffic loads usually differ between intersections.

Road segment is uniquely defined by its road code and the nearby road segments as shown in figure 6.3. The road network has 373 road codes and 1,907 road segments corresponding to an average of about nearly 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. (William Bachman et al., 2000) A close up of the geo-coded road network with street names is shown in figure 6.4.

The aim is to assign traffic data to the geo-coded road network. However, at present the road network map does not have traffic data linked to the digital road network, various traffic data sources and approaches were therefore considered. A spreadsheet containing details on different road intersections and links was obtained from the Hyderabad Urban Development Authority (HATS -1998). The traffic data was organized according to to –from nodes where nodes represent points as shown in figure 6.5. A simple but tedious approach was used to assign traffic data to the road network. A road intersection in the spread sheet is defined as the road section between
two major intersections name as to and from specific roads. These road sections were
given unique segment number. The digital road network was then manually edited to
match exactly the way the spreadsheet was organized.

Fig. 6.3 showing methodology adopted for the emission estimation from road
traffic

Figure 6.4. Process of the road grid-based road length calculation
The spreadsheet with road and traffic data included street width, travel speed and low traffic load of the various categories. The average distribution of traffic performance according to vehicle categories on the road network was also calculated for passenger cars, vans, Lorries and buses. Road segments with missing street width were assigned the average width of 8 meters. The length of the road segment was calculated using a GIS feature.

![Diagram showing the relationship between Road attribute Database, Emission Coefficient Database, Traffic Flow Database, Monitoring Air Quality Database, Emission Estimator, Dispersion Model, Air pollution database, Total Pollutant Emission, Distribution of pollutants, Correlation study.]

**Fig. 6.5 Emission calculation methodology adopted in the present work**

**6.4.1. Emission estimation methodology:**

The air pollutants considered for calculation of emission are carbon monoxide, hydrocarbons, nitrogen oxides, sulfur dioxide and particulate matter. The emission factors (APPCB, 2003) for each pollutant are produced as link based emission levels emitted by traffic on the modeled road network and can either be used and presented for each link or transformed as grid based emissions. The air pollution emission factors are adopted for the present work. Table 6.1 shows the emission factors adopted for the estimation of major pollutants from transportation sector. Pollutant emissions levels from in service vehicles vary depending on vehicular characteristics, operating conditions, level of maintenance, fuel quality and ambient conditions such
as temperature, humidity speed and altitude. However, such detailed analysis is not
dealt in this thesis work.

Table 6.1 Emission factors for the estimation of pollution load from road traffic (g/km)

<table>
<thead>
<tr>
<th>Vehicular type</th>
<th>CO</th>
<th>NOx</th>
<th>HIC</th>
<th>SO2</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two wheelers - 4s</td>
<td>2.2</td>
<td>0.3</td>
<td>0.7</td>
<td>0.023</td>
<td>0.05</td>
</tr>
<tr>
<td>-2s</td>
<td>2.2</td>
<td>0.06</td>
<td>2.13</td>
<td>0.023</td>
<td>0.05</td>
</tr>
<tr>
<td>3 wheelers (cars, taxi, Jeeps and others)</td>
<td>5.1</td>
<td>1.28</td>
<td>0.14</td>
<td>0.053</td>
<td>0.2</td>
</tr>
<tr>
<td>Buses and goods carrier</td>
<td>3.6</td>
<td>12.6</td>
<td>0.87</td>
<td>0.075</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Source: APPCB-2003

The emission factor is defined as the estimated average emission rate for a given pollutant for a given class of vehicles. Estimates of vehicle emissions are obtained by multiplying an estimate of the distance traveled by a given class of vehicles by an appropriate factor (Min Der Lin and Yung-Chang Lin, 2003). The basic formula for estimating emissions using obtained emission factors is

\[ E_{\text{emission}} = ef \times \text{VKT} \]

For a given segment of an artery with a length of \( L \), the traffic characteristics are assumed to be constant, the emission intensity of line sources are calculated by

\[ E_p = L \times N_i \times F_{P_i} \]

Where \( L \) is the length of the road researched, \( N_i \) = traffic flow, number of vehicles of type \( i \), passing through the road segment (vehicle/hour), \( F_{P_i} \) = emission factor of vehicle type \( i \) (g/km), \( I = \) vehicle types (1 to \( n \)), \( F_{P_i} = \) Emission factor of vehicle type \( i \), \( E = \) Total vehicle emission in the city.

Roadway facilities are divided into zones and lines corresponding to different emission modes of running exhaust only and no attempts were made to model different vehicular conditions such as idling, acceleration, cursing, deceleration etc. Facility activity estimates are used to allocate emission production to those vector spatial data structures used by transportation planners.

Line facilities are the major roads that are used in the present emission inventory. On road fleet distributions and calculated traffic flow parameters are used to generate
road segment specific estimates of carbon monoxide, hydrocarbons, and oxides of nitrogen. For each road segment 8, 1, 24 hr variables are determined and are combined to develop the fraction of activity occurring with each specific emission rate (g/km). Total hourly, 24, 12 combined running exhaust emissions from minor and major roads provide total on-road running exhaust emissions. Figure 6.5a to 6.5d shows the model data input parameters for calculation of emission load in Visual Basic environment. The output file is stored as database (*.dbf) format which is imported to GIS environment using join table command, available (ESRI (2002).

In computing the grid based emissions the study area is divided into cells of sizes of 1km² and the emission levels for each grid cell for each pollutant are computed as sum of the emissions from the individual links within the cells. The emission inventory is carried out by converting the facility based emission estimates into grided estimates, procedurally 1km² grid cell size is used to create a polygon database of grid cell boundaries, allocating each line to its corresponding grid, summing all emissions for each cell and converting the results to raster data structures. Emissions at each facility are converted to a rate based on the area or length.

Figure 6.5a Visual Basic based emission load and dispersion model for calculation of mobile pollution in load in Hyderabad
Figure 6.5b Grid ed emission model for calculation of pollution load in Hyderabad
The role of emission inventory module is to prepare the facility based emission estimates for input into dispersion models particularly Caline 4 (Caltrans, 1989). An important component of the entire modeling process is the ability to aggregate estimates to a user defined grid cell size. The most efficient technique for accomplishing this task is to convert the emission load due to running exhaust emission estimates to raster data structure. Once in raster data structure, developing gridded estimates for inventory reporting are fairly easy. Conversion of the data from vector to raster tool available in many of the larger GIS software’s tools. After conversion, total mobile source emission estimates are calculated for the entire area.

The tools available in the GIS for conversion make some assumptions about the vector data that may not be desired. Problems occur with direct conversion especially for linear structure. Straight conversion is possible but grid cells take on the value of the largest feature or largest portion within its boundaries. For linear features, this means that all cells represent the same emission value or rate. However, the line can bisect the cell at any point resulting in variations in the cells ability to properly identify the portion of the road that falls within its boundaries (Bachmann, 2003).
The spatial environment consists of the GIS input coverage. The spatial environment is transforming and removing manual, 2003) the databases are all distributed in different formats, requiring conversion. Numerous other steps were needed to fully prepare data for model running (e.g., individual link was selected corresponding output cells). The GIS database was used in the personal study (e.g., 1998). Model spatial coverage such as type of used in the previous study (e.g., 1998). The vehicle inventory was created during 1998, in the availability systems and vehicle inventory data. The vehicle inventory database used for the road network 6.4.2 GIS-Based model for auto-mobile exhaust emissions: 6.4.2 GIS-Based model for auto-mobile exhaust emissions: conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type conversion and local identification type. However, the model does not consider non-auto-mobiles, evapo-solvent emissions, calibration, vehicle deterioration effects and impacts of grade on load, and capacity. The results regarding model activity of the vehicle, number of vehicles and type of vehicle, pollution by hour and emission mode. The emission inventory model makes use of the equivalent to the vector grid size. The grid raster datasets are individual layers of each cell. The resulting vector grid data is then combined to raster cells with cell sizes and values falling within the grid cell boundaries can be weighted by area or length and intersect the zoning and internal structures with a vector grid. Once intersected all emissions much larger than the anticipated internal structures. One way around the problem is to lower the problem. However, exiting internal structures and small as large as 1-3 km² similar issues occur with polygons above their boundaries. The smaller the grid cell, the
exhaust lines consist of conflated travel network segments and the polygons represent the roads that have road specific estimates result of travel activity.

6.4.2.2. Fleet characteristics:
Fleet characteristics were studied from the files of the HATS - Survey 2000. Different vehicular characteristics were studied and the model into files created distribution of vehicular fleet. The fleet characteristics studied includes type of the vehicle, name of the link, number hours traffic is monitored, 16hr 24hr average vehicular numbers and average speed on the road and major connecting links.

6.4.2.3 Running exhaust activity:
Running exhaust activity was determined for major roads and traffic junctions for different time periods. Minor roads consisted of all roads not explicitly modeled in the present model. Major roads were explicitly modeled, for whose database was available on number of vehicles and peak time vehicular count etc.

6.4.2.4. Facility and grided emissions:
The emission estimates for the sample area were developed for engine running exhaust activity. Engine running emissions were developed for each Land use and vehicular inventory combined database. The grided estimates were aggregated from the facility entities at 100, 250, 500, 1000 meter grid cells. The various sizes were developed to explore and demonstrate the impact of grid cell size on the emissions estimate.

6.4.3. Emission model results:
Figures 6.6 through 6.15 represent the modeled link wise pollution load in Hyderabad. Table 6.2 shows the pollution load changes from 2000 to year 2004 calculated using business as usual conditions. The mean present day pollution load from the vehicular fleet is observed to be 49, 1.211, 43, 33 and 67 gm/day for Nitrogen oxides, Sulphur dioxide, particulate matter, Hydrocarbons and Carbon monoxide respectively for the selected major links. It is observed that the areas most emission load being released are Chaderghat – Nalgonda X roads and Tank bund. Whereas the least emission loads are generating areas are of outskirts of the city and include areas like Nadargul, Kompally and Gandlapocharam. It is interesting to note that few major projects are being carried out these areas the future emission scenario may change with more induced travel in years to come.
### Table 6.2 Summary emission statistics for different pollutants in kg/day during 2000 - 2020

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Min</th>
<th>Max</th>
<th>Average</th>
<th>Min link</th>
<th>Max link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen oxides</td>
<td>1.75</td>
<td>178</td>
<td>49</td>
<td>Mangalghat – Puranapool</td>
<td>Chanderghat – Nalgonda X road</td>
</tr>
<tr>
<td>Sulphur dioxide</td>
<td>0.381</td>
<td>4.627</td>
<td>1.211</td>
<td>Injapur – Hyatnagar</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>0.1660</td>
<td>16.11</td>
<td>4.3</td>
<td>Injapur – Hyatnagar</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>0.680</td>
<td>133</td>
<td>33.659</td>
<td>Gandlapocharam – Kompally</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>0.00376</td>
<td>453</td>
<td>67</td>
<td>N Pedargul – Adibatla</td>
<td>Nalgonda X roads</td>
</tr>
</tbody>
</table>

#### 2004

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Min</th>
<th>Max</th>
<th>Average</th>
<th>Min link</th>
<th>Max link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen oxides</td>
<td>1.0</td>
<td>1660</td>
<td>92</td>
<td>Sabji mandi – Alapatinagar</td>
<td>BHEL Patancheru</td>
</tr>
<tr>
<td>Sulphur dioxide</td>
<td>0.02</td>
<td>54</td>
<td>1.904</td>
<td>N Pedargul – Adibatla</td>
<td>Tank bund</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>0.08</td>
<td>174.13</td>
<td>7.261</td>
<td>Injapur – Hyatnagar</td>
<td>Tank bund</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>0.38</td>
<td>1468</td>
<td>49.35</td>
<td>Gandlapocharam – Kompally</td>
<td>Tankbund</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>0.01</td>
<td>1492</td>
<td>93</td>
<td>Yajmal – Saneerpet</td>
<td>Lak di ka pool</td>
</tr>
</tbody>
</table>

#### 2020

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Min</th>
<th>Max</th>
<th>Average</th>
<th>Min link</th>
<th>Max link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen oxides</td>
<td>3.1</td>
<td>5240</td>
<td>275</td>
<td>Gandlapocharam – Kompally</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
<tr>
<td>Sulphur dioxide</td>
<td>0.05</td>
<td>1401</td>
<td>50</td>
<td>Gandlapocharam – Kompally</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>0.21</td>
<td>4468</td>
<td>194</td>
<td>Injapur – Hyatnagar</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>1.01</td>
<td>4220</td>
<td>145</td>
<td>Gandlapocharam – Kompally</td>
<td>Chanderghat – Nalgonda X roads</td>
</tr>
</tbody>
</table>
Map showing sulphur dioxide emissions from major road links in Hyderabad

Figure 6.6 Modeled Sulfur dioxide emission in different road links in Hyderabad
Map showing Particulate matter emissions from major road links in Hyderabad

Figure 6.7 Modeled Particulate matter emission in different road links in Hyderabad
Figure 6.8 Modeled Oxides of Nitrogen emission in different road links in Hyderabad
Map showing Hydrocarbons emissions from major road links in Hyderabad

LEGEND gm/day
  0 - 43.06
  43.06 - 110.32
  110.32 - 240.76
  240.76 - 544.84
  544.04 - 1468.83

Road Network

Prepared by:
Centre for Environment,
JNTU, Kukatpally, Hyderabad - 72

Sources: HATS Survey 2000 - 2001

Figure 6.9 Modeled Hydrocarbons emission in different road links in Hyderabad
Map showing Carbon Monoxide emissions from major road links in Hyderabad

LEGEND

Source: HT 2000 - 2004

Figure 6.10 Modeled carbon monoxide emissions from major road links in Hyderabad
Modeled Total Carbon monoxide emissions using 1Sq.Km grid in Hyderabad

Figure 6.11. Map showing carbon monoxide emissions from major road links in Hyderabad
Modeled Total Oxides of Nitrogen emissions using 1 Sq.Km grid in Hyderabad

Figure 6.12 Modeled Total oxides of Nitrogen emission using 1 Sq. Km Grid in Hyderabad
Modeled Total Suspended Particulate Matter emissions using 1 Sq.Km grid in Hyderabad

Figure 6.13 Modeled Total Suspended Particulate matter emissions using 1 Sq. Km grid in Hyderabad
Modeled Total Hydrocarbons emissions using 1 Sq.Km grid in Hyderabad

Figure 6.14 Modeled Total Hydrocarbon emission using 1 Sq. Km Grid in Hyderabad
Modeled Total Sulphur dioxide emissions using 1 Sq. Km grid in Hyderabad

Figure 6.15 Modeled Total Sulphur dioxide emission using 1 Sq. Km Grid in Hyderabad
Modeled Carbon Monoxide emission using 1 Sq.Km grid during 2003 - 2004 in Hyderabad

Figure 6.16 Modeled carbon monoxide emission in different road links in Hyderabad
Modeled Hydrocarbons emissions for 2003 - 2004 using 1 Sq.Km grid in Hyderabad

Figure 6.17 Modeled Hydrocarbons emission in different road links in Hyderabad
Modeled Oxides of Nitrogen emission using 1 Sq.Km grid during 2003 - 2004 in Hyderabad

Legend Kg/day
- 1.752 - 35.683
- 35.683 - 69.613
- 69.613 - 103.543
- 103.543 - 137.474
- 137.474 - 171.404

Figure 6.18 Modeled Oxides of Nitrogen emission in different road links in Hyderabad
Figure 6.19 Modeled Particulate matter emission in different road links in Hyderabad
Modeled Sulphur Dioxide emission using 1 Sq.Km grid during 2003 - 2004 in Hyderabad

Figure 6.20 Modeled Sulfur dioxide emission in different road links in Hyderabad
The major road total running exhausts CO, sulfur dioxide; Oxides of Nitrogen, Hydrocarbons and Particulate matter were estimated to be 40340, 429, 20349, 20349, 11080 and 1628 gm/day. The total estimated HC is 734,000 grams, and the total estimated NOX is 811,000 grams. The total emissions estimates were developed by adding the 1km² meter aggregations of major road running exhaust (aggregate modal) total emissions for the study area are represented in figures 6.16 to 6.20. The results obtained from the emission load experiments has clearly shown that the predominant pollution load contributed by major road links in Hyderabad such as Chaderghat, Tankbund, Begumpet, Secunderabad etc.

6.4.4. Peak time pollution loads:
Figures 5.21 to 5.22 show the temporal variability found in the peak hour traffic volume estimates occurring between 9 AM and 11 AM. The CO and HC estimates are characterized by the major road emissions and the spikes of engine start emissions. The NOX estimates are characterized by emissions on the major roads. The results revealed that the integrated system can provide decision-makers with up-to-date emission information and give additional visualization and analysis possibilities. The results clearly suggest that management measures are required to reduce peak hour traffic pollution at as many as seven links are required, which are giving an average emission load of 35gm/hour.

The average peak time pollution generated at various links is given in figure 5.24. It is observed that the Chaderghat, Tankbund, Punjagutta, Abids, Secunderabad and Dilsukhnagar areas are showing high peak time emission loads. Figure 5.28 shows the different pollutants and their emission loads generated at different links. Chaderghat – Nalgonda X roads, Chaderghat – Amberpet, Lakdikapool, and Begumpet areas are observed to release high amounts of peak flow emission loads. The maximum peak hour emission load of 85 gm/hour during morning hours is observed for Chaderghat – Amberpet link.

6.4.5. Carbon monoxide pollution concentration prediction using Caline4 model:
In air pollution problems the air quality models are used to predict concentrations of one or more species in space and time as related to the dependent variables. They form one of the most important components of an urban air quality management plan (Elsom, 1994,
Langhust et al. 2004). The dispersion model used here is Caline-4, a simple line source Gaussian plume dispersion model which was originally used to predict the impacts of CO near road-ways (Caltrans, 1989).

Gauss solution for linear sources is based on the principle of overlaying, which assumes the concentrations of emitted substances at the receiving point equal the sum of dispersions of all infinitesimal point sources which together add up to the linear source (Rebolj and Sturm, 1999). Caline-4 divides individual road segments into a series of elements from which incremental concentrations are computed and then summed to form a total concentration estimate for a particular receptor. Each element is modeled as an "equivalent" finite line source (FLS) positioned normal to the wind direction and centered at the element midpoint, and the dispersion concentration at the downwind receptors can be expressed by Gaussian formulation. The receptor concentration attributable to an infinitesimal FLS segment, \( dy \), can be calculated as (Caltrans, 1989):

\[
dC = \frac{qd_y}{2\pi u \sigma_x \sigma_y} \left[ \exp \left( -\frac{y^2}{2\sigma_y^2} \right) + \exp \left( -\frac{(z-H)^2}{2\sigma_z^2} \right) \right] + \exp \left[ -\frac{(z+H)^2}{2\sigma_z^2} \right]
\]

Where \( dC \) incremental concentration; \( C \) receptor concentration; \( q \) lineal source strength; \( u \) wind speed; \( H \) source height; \( \sigma_x, \sigma_y \) horizontal and vertical dispersion parameters.

The integral of the whole FLS becomes (Caltrans, 1989):

\[
C = \frac{q}{2\pi u \sigma_x \sigma_y} \left[ \exp \left( -\frac{(z-H)^2}{2\sigma_z^2} \right) \right] + \exp \left[ -\frac{(z+H)^2}{2\sigma_z^2} \right] \left[ \exp \left( -\frac{y^2}{2\sigma_y^2} \right) \right]
\]

Caline-4 computes receptor concentration as a series of incremental contributions from each element FLS. The source strength for each segment needs to be modified by a weighting factor, then the emission contribution from a given road segment to the
Peak Hour Carbon monoxide emission at selected links during 2000 in Hyderabad

Legend

- 3.63 - 5.44
- 5.44 - 7.57
- 7.57 - 23.29
- 23.29 - 34.05
- 34.05 - 83.18

Road Network

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Figure 6.21 Modeled peak hour carbon monoxide emission selected road links in Hyderabad
Figure 6.22 Peak Hour pollution load from major links in Hyderabad
receptor can be calculated (M D Lin, Y C Lin, 2002). Detailed meteorological information is required for accurate predictions of air pollution concentration levels near roadways but, for planning at the network level, the required meteorological details would not be readily available. To accommodate trade-off between accurate predictions using detailed data and the planning purposes worst-case concentration approach is used. The area background concentration level for the pollutant, generally available from APPCB operated monitoring stations, is added to the concentration levels computed from the Caline 4 model to obtain the total concentration levels at each receptor location. Figure 5.23a and 5.23b shows the emission modeler developed using Visual Basic environment for calculation of receptor concentrations in Hyderabad. Fig. 5.23 shows the worst case carbon monoxide concentration at different receptor positions during 2000 and during 2004 due to increased vehicular fleet.

Figure 6.23a Model showing the receptor characteristics for calculation of dispersion concentration from mobile pollution load in Hyderabad
The model assumption is based on the arithmetic average traffic growth in Hyderabad and ‘worst-case’ conditions would need to be determined for any particular geographical location, the highest ambient concentration would be expected to occur during peak traffic flow accompanied by the poorer dispersion conditions of the morning. Figure 6.26 shows the modeled worst case carbon monoxide emission for different study periods. (The predicted concentration for year 2020 was based on the results of attractive index carried out by the author described in chapter 7).

It is observed that with the increasing vehicular fleet by year 2020 the worst case carbon monoxide concentrations are modeled to reach 27ppm maximum and a minimum of 2ppm at Kompally and zoo park region. The results revealed that the integrated system can provide decision-makers with up-to-date emission information and give additional visualization and analysis possibilities.
Figure 6.24 Modeled worst case carbon monoxide concentration levels in different road links in Hyderabad
Worst case carbon monoxide concentration during 1999 - 2020

Figure 6.25 Worst case carbon monoxide concentration changes during 1999 - 2020
6.5 EMISSION LOADS FROM 1988 – 2003 IN HYDERABAD URBAN DEVELOPMENT AUTHORITY:

The developed model was used to study the emission load from road traffic generated over the years. Figure 6.26 shows the total pollution load generated for 1km during 1988 – 2003. During 2003 the pollution load was observed to be high when compared to other modal years. The total pollution load for all the pollutants was observed to increase over the years, with the contribution of carbon monoxide to pollution load being more when compared to other pollutants over the years.

The total pollution load for carbon monoxide is observed to be 10.07 tons/km by the 2003 it stood at 105.75 with an increase of 100 times over the span of 16 years or less same over the years. The concentrations of hydrocarbons were observed to increase from 18.62 to 68.50, increase by 4 times over the years. The oxides of nitrogen are observed to increase from 3.76 during 1988 to 14.01 by the years 2003, an increase by 4 times over the years. Figure 6.26 to 6.34 shows the modal split wise emission load and total quantities of generated over the years. It is observed that the total emission load contribution from two wheelers sectors was more during 2003, when compared to other vehicular classes.

It is observed from the study that the contribution of two wheelers to carbon monoxide is high when compared to other vehicular categories. During the year 1988, the carbon monoxide emission from two wheelers was observed to be 1.80 and has reached to 65.49 by the year 2003. The major contributing factor for this rise in pollution load being the increasing number personalized wheeler population.

It is also observed that during 1988 the major contributor of carbon monoxide pollution load was cars and vans however, by the year 2003 the load from these vehicular class is observed to be nearly ½ the value contributed by two wheelers i.e. 30.73. With the present trend of growth in two wheelers and cars in Hyderabad, in coming few years period the contribution from this vehicular category may pose significant problem warranting an immediate action.
Figure 6.26 Emission loads of Nitrogen oxides in Hyderabad 1986 – 2003

Figure 6.27 Emission load of Carbon monoxide in Hyderabad 1986 – 2003
Figure 6.28 Emission load of Sulphur dioxide from different vehicular categories during 1986 – 2003 in Hyderabad

Figure 6.29 Emission load of Hydrocarbons from different vehicular categories during 1986 – 2003 in Hyderabad
Figure 6.30 Particulate matter emission load during 1986 – 2003 in Hyderabad

Figure 6.31 Emission from truck over the years 1986 – 2003
Figure 6.32 Emission load from buses during 1986 – 2003 in Hyderabad

Figure 6.33 Emission load from cars/vans during 1986 – 2004 in Hyderabad
Figure 6.34 Emission load from three wheelers in Hyderabad 1986 – 2003

Figure 6.35 Emission load from two wheelers in Hyderabad 1986 – 2003
The two wheelers are also observed to be contributing more of particulate matter emissions when compared to other pollution categories. It is concluded from the emission studies that the predominant source of pollution in Hyderabad mobile sector being the two wheeler population. Consequently a suitable management needs to be under taken for reducing pollution from two wheelers, such as widening the roads, encouraging more public transit systems.

6.6. CONCLUSION:

This chapter presented a preliminary study on the evaluation of transport-related air pollution situations in Hyderabad. Emission calculation models used in this study are integrated in a GIS, which is able to utilize the spatial information and describe the urban road network and the distribution of the pollutants in the atmosphere. A methodology for estimating air pollution levels of both whole and all component parts of road transport network has been described. The model has applied to network scales varying from local plans to the city wide scale. The use of GIS based system has advantages of permitting the computation and the analysis to be performed rapidly. The GIS also generates high quality display outputs, which are easy to understand.

As an important part of environmental assessment involves predicting future changes in relation to the existing conditions, the present thesis work has highlighted the changes in pollution load under different traffic conditions to estimate future pollution loads. The intention is that the planners will have, at their disposal, on-the-spot feedback on the environmental effects of the transport system being considered and the facility to ascertain how to manipulate it to achieve better air pollution outcomes.
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