Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

Vol. 9	No. 1	pp. 43-48	2010

Original Research Paper

Monitoring of Particulate Air Pollution Due to Vehicular Emission in Coimbatore City Using GIS

Selvakumar Madhavan and T. Meenambal
Department of Civil Engineering, Government College of Technology, Coimbatore-641 013, T.N.

Nat. Env. Poll. Tech.
ISSN: 0972-6268
www.neptjournal.com

Key Words:
Particulate air pollution
Vehicular emission
Coimbatore city
Air quality index
GIS

ABSTRACT

Geographical Information System (GIS) enables us to integrate and analyse a number of environmental data from different sources to model the overall impact of air pollutants on environment. The objective of this paper is to design an air quality management system. Air quality data were collected from 25 stations in and around Coimbatore city. In this paper a number of spatial and statistical analysis were carried out. Spatial analysis such as overlay, buffering and zoning were performed to provide an environmental alarming system. Among the various environmental standards defined in the world, in this work AQI (air quality index) standard is used. Considering the standards used, good, moderate, unhealthy, very unhealthy and hazardous places were determined. Maps showing the spatial dispersion of TSPM (total suspended particulate matter) and RPM (respirable particulate matter) were prepared. It has been found that in some areas the levels of suspended particulate matter is higher than the prescribed limit of 140 $\mu g/m^3$ and respirable particulate matter of 60 $\mu g/m^3$. Based on the GIS output the suggestions have been made to improve better living condition in Coimbatore.

INTRODUCTION

Particulate matter is the term used to describe particles that are suspended in the air. Particles may be solid or liquid and are one of the most obvious forms of pollution as they are visible in the hazes that cover a city or region. Size is the main determinant of the behaviour of an atmospheric particle. Airborne particulate matter is an ensemble of solid particles suspended and dispersed in air. In ambient air dust particles has size range from a few nanometers to hundreds of micrometer.

Air Quality Management System (AQMS) can be defined as a regulation of the amount, location and time of pollutant emissions to achieve some clearly defined set of ambient air quality standards or goals. Data sets created and organized under a Geographical Information System (GIS) generate a comprehensive and accurate solution (Burrough & McDonnel 1998). Moreover, the combination of GIS and geographic imaging solutions is quickly becoming a good support tool for decision planners (Pulia et al. 2003). GIS is a computer based information system that enables capturing, modelling, manipulation, analysis and presentation of geographically referenced data. It is a facility for preparing, presenting and interpreting facts to identify the state of air pollution in the city (Rahmatizadeh et al. 2004).

All over the world, the air pollution issues are being discussed and measures to reduce the impact are also continuously taking place. New methods and techniques are tried nowadays to control the air pollution. The developments in the information technology are also utilized in all the fields of engineering. One such newer application to control and manage the air pollution is through GIS, since GIS has been used as decision support system in all fields. It also reduces considerably the time taken for analysis of large volume of data and retrieval of the same for decision making. In addition, for the

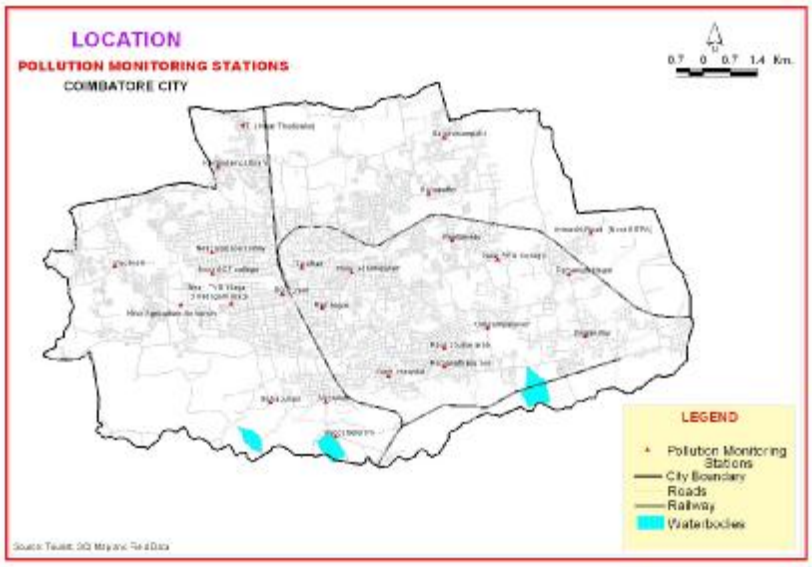

Fig. 1: Location of monitoring stations.

provision of performing queries GIS technology will be the best one. It is also to be noted that the engineering cost of GIS development for air quality management is less than that of other conventional methods.

In this paper 25 monitoring stations were selected covering the entire city. The stations were selected both in the heart of the city, residential areas, industrial areas and also in the outskirts of the city along the main intersections. High volume sampler was used for collecting the air particulates and analysed in the lab for TSPM and RPM.

STUDY AREA

Coimbatore is the second largest city in Tamilnadu. The city has six major arterial roads and three National Highways. Most of the textile industries are situated in Coimbatore. The population of the city is around 1.25 million. There are about 50,000 small, medium and large scale industries in the city. Due to industrialisation and urbanisation Coimbatore's air quality is worsening. The ambient air quality of Coimbatore has deteriorated with an increase in the number of vehicles and industrial pollution.

MATERIALS AND METHODS

The high volume sampler was used for sampling and monitoring. Around 25 stations were selected in and around Coimbatore city and the high volume air sampler was placed on tall buildings near to the intersection of roads and an average of 8 hours reading were recorded. The sampler uses a continuous duty blower to suck in an air stream. PM_{10} and TSPM were measured by passing air at flow rate of about 1.1 m^3/min through high efficiency cyclone which retains the dust particles greater then 10 micron size and allows only fines (less than 10 micron particles) to reach the glass micro fibre filter where these particles are retained. When fitted with a particle size classifier, it separates particles greater than 10μm size from the air stream. The air stream is then passed through a filter paper to

collect particles lesser than 10μm size (PM_{10}). Gravimetric measurements yield values of suspended particulate matter (TSPM), as the sum of the two fractions, and PM_{10} is the material retained on the filter paper. The sampler design is based on the method developed at National Environmental Engineering Research Institute (NEERI). The sampler is widely used in India in the National Air Quality Monitoring Programme (NAMP) of the country.

$$\text{RSPM} = \frac{\text{Final weight of filter paper} - \text{Initial weight of filter paper} \times 1000 \times 1000}{\text{Retention time} + \text{air flow}}$$

TSPM = Filter paper average + Pouch average

Table 1: Concentration of pollutants and AQI values.

S.No	Locations	Concentration in μg/m^3		AQI values	
		TSPM	RPM	TSPM	RPM
1.	ITI (Near Thudiyalur)	142.3	34.7	94	98
2.	Near Agriculture University	126.5	30.6	87	88
3.	Race course area	118.3	28.9	82	84
4.	Singanallur	112.0	26.0	79	77
5.	Near PSG College	140.7	34.7	94	98
6.	Near TVS Nagar (Thadagam Road)	125.8	30.6	86	88
7.	Near Saibaba colony	118.7	28.7	83	84
8.	Ramanathapuram	113.5	27.2	80	80
9.	Selvapuram	106.1	24.9	76	74
10.	Near Gandhipuram	176.0	43.2	111	114
11.	Avinashi Road (Near SITRA)	151.0	36.7	99	103
12.	Govt. Hospital	153.0	37.7	100	105
13.	Kavundampalayam	166.7	41.4	107	111
14.	Saravanampatti	145.2	35.5	96	101
15.	Ganapathy	169.3	41.8	108	111
16.	TataBad	169.0	41.8	108	111
17.	Ukkadam	168.1	41.5	107	111
18.	RS Puram	145.1	36.2	96	102
19.	Sundarapuram	154.3	38.4	100	106
20.	Ramnagar	163.5	37.8	105	105
21.	Peelamedu	159.8	35.9	103	102
22.	Udayampalayam	117.9	28.6	82	106
23.	Ramanuja Nagar	104.8	25.9	76	105
24.	Vadavalli	128.3	23.6	87	102
25.	Near GCT college	116.9	20.9	82	106

Table 2: Air Quality Index guidelines as given by EPA.

Break Points		AQI	Category	Colours
PM_{10} (μg/m^3)	PM_{25} (μg/m^3)			
0-54	0.0-15.4	0-50	Good	Green
55-154	15.5-40.4	51-100	Moderate	Yellow
155-254	40.5-65.4	101-150	Unhealthy for sensitive groups	Orange
255-354	65.5-150.4	151-200	Unhealthy	Red
355-424	150.5-250.4	201-300	Very unhealthy	Purple
425-504	250.5-350.4	301-400	Hazardous	Maroon
505-604	350.5-500.4	401-500	Hazardous	Maroon

Digitization is a process of converting raster data into vector data. Entry of graphical information into GIS is achieved by digitization. Regarding the various environmental standards defined in the world, in this paper the following AQI (Air Quality Index) standard has been used.

$$I_p = \frac{IH_i - IL_o}{BP_{Hi} - BP_{Lo}} \times [C_p - BP_{Lo}] + IL_o$$

I_p = Pollution index
C_p = The rounded concentration of pollutant P
BP_{Hi} = The breakpoint that is greater than or equal to C_p
BP_{Lo} = The breakpoint that is less than or equal to C_p
IH_i = The AQI value corresponding to BP_{Hi}
IL_o = The AQI value corresponding to BP_{Lo}

The data were structured and stored in the temporal database while Coimbatore's digital map at a scale of 1:20000 was uploaded and topologically structured using Arc view software. The location of stations on the map was georeferenced. Attribute data were assigned to spatial objects and the system was made ready for spatio-temporal analysis and management. The monitored raw air pollution data from the 25 different stations in Coimbatore for the year 2007 were stored as an attribute in the Arc view and then Air Quality Index (AQI) was calculated. The database was joined to digital map. Spatial analysis module was used for interpolation in three dimensions. Inverse distance interpolation is used for modelling between the monitoring stations. 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 set 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 grid point. Maps were produced for the pollutants. Considering the standards used, good, moderate, unhealthy, very unhealthy and hazardous places were determined.

RESULTS AND DISCUSSION

The data collected during the study are given in Table 1, and the air quality index guidelines in Table 2. The air pollution concentrations, collected from the monitoring stations, were analysed and their spatial distribution is shown in the form of maps. Fig. 2 shows the concentration of total suspended particulate matter (TSPM), and Fig. 3 the concentration of respirable particulate matter (RPM). The levels of the concentrations are differentiated using various shades. It is found that Gandhipuram has the maximum concentration. Then the places like Kavundampalayam, Saravanampatti, Ganapathy, TataBad, Ukkadam and Ramnagar have recorded higher concentration. Next high concentrations were recorded near Thudialur, SITRA, Government Hospital, RS puram, Sundarapuram and near PSG College. The places near GCT, Agri College, Vadavalli, Ramanujar Nagar, Udayampallayam, Singanallur, Race course area, near TVS Nagar (Thadagam Road), near Saibaba Colony, Ramanathapuram and Selvapuram have recorded low concentrations. The same trend is observed in the case of respirable particulate matter also.

Air quality index (AQI) for the recorded concentrations was calculated and depicted on the map shown in Figs. 4 and 5. It is found that AQI falls in two categories only. One is moderate level and the other is unhealthy for sensitive groups. The interior part which comprises Gandhipuram, RS puram, the commercial area of Ganapathy, residential areas like Saibaba Colony and in places near Ukkadam

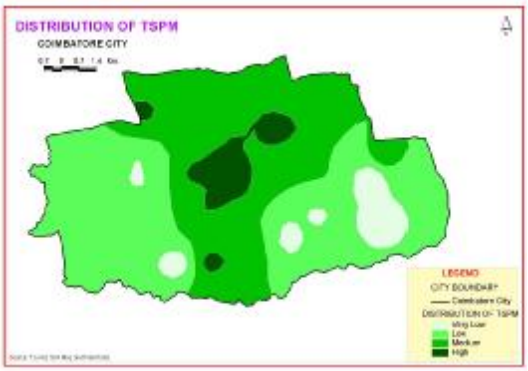

Fig. 2: Distribution of TSPM.

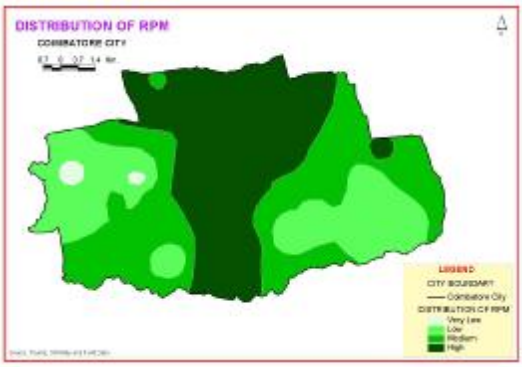

Fig. 3: Distribution of RPM.

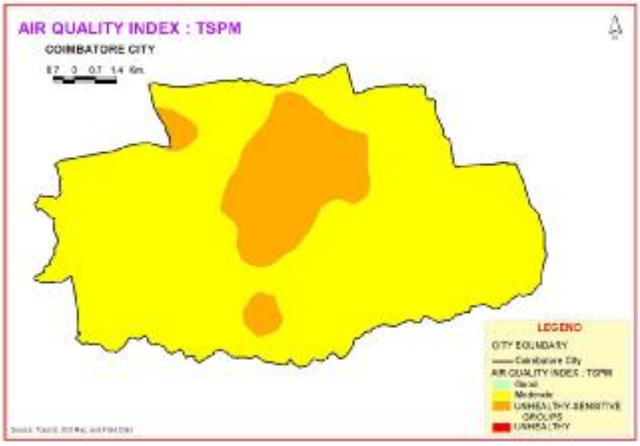

Fig. 4: Air quality index: TSPM.

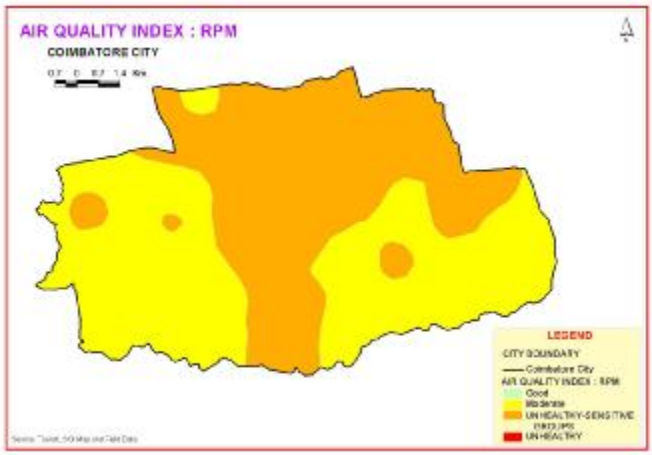

Fig. 5: Air quality index: RPM.

bus stand and Singanallur, the AQI value shows that it is unhealthy for sensitive groups of people. In other areas it is at moderate level.

CONCLUSION

Under normal conditions a human respiratory tract in good health is able to deal with inhaled particles without undue stress or long-term effects. In sensitive individuals, or when high levels of particles are present, particulate matter may contribute to increased rates of respiratory illnesses and symptoms. The air pollution problem originating due to particulate matter can be controlled by the development of air quality management system. The seasonal air pollution surfaces are useful for wide range of purposes, for health risk assessment of the population within the study area, to assist in establishing and monitoring air quality standards, and to evaluate transport policies. For high accuracy it is necessary to study the meteorological parameters like wind speed, temperature and altitude which affect pollution dispersion.

REFERENCES

Burrough, P.A. and McDonnel, R.A. 1998. Principles of Geographic Information Systems. Oxford.

Pulikesi, M., Baskaralingam, V., Elango, D., Rayuduc, V. N., Ramamurthi, V. and Sivanesan, S. 2006. Air quality monitoring in Chennai, India in the summer of 2005. Journal of Hazardous Materials, 136: 589-596.

Pulia, E., Guevara, M. and Pulia, C. 2003. Characterization of urban air quality using GIS as a management system. Environmental Pollution, 122: 105-117.

Rahmatizadeh, S.H., Delavar, M., Alsheik, R. and Motessadi, S. 2004. The use of spatio-temporal database for Air Quality Management. Geomatic, 83, NCC, Tehran, Iran.