CHAPTER-II

MATERIAL AND METHODS

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2.1 Introduction

In India, with rapid rise in population as well as changing lifestyles, in the last few decades there has been proportionally higher consumption of the natural as well as man made resources. This has not only resulted into increase in life standards and buying capacity for a few, but has also substantially increased in the number of automobiles, number of related industries, consumption of fossil fuels and resultant air pollution. This situation has been ignored for long, and now has come to stay as a major environmental problem in the country.

Cars, trucks and buses are known to emit significant quantities of carbon monoxide, hydrocarbons, nitrogen oxides, fine particles and lead. These pollutants impair health, destroy vegetation and inhibit the general quality of life. Especially with regard to health, their effects are most pronounced in the old and the very young. Many other sources also contribute and aggravate air pollution but the motor vehicle is the largest known source in terms of total load and the overall volume of air pollutants. The problem is compounded by the fact that vehicles emit pollutants in close proximity to the breathing zones of people, thus directly affecting their health.

Urban areas exhibit both the highest level of pollution and largest target of impacts on human health (Goyal and Sidhartha, 2003). In this developed and modern age, cities are rapidly turning into gas chambers with the advent of more and more technological innovations and Delhi is a good example of this phenomenon (Jes, 1999; CPCB, 2000). Delhi was ranked fourth among the most polluted 41 cities in the world, as there were over 2.2 million vehicles emitting 1280 tones of

pollutants daily. Diesel exhaust is considered to contain those substances, which are hazardous to human health (Agarwal, 1999).

The gaseous air pollutants like SO_2 enter the atmosphere mostly from combustion of coal and oil, rubber plants and chemical industries. Once in the atmosphere, sulphur dioxide can be oxidized to SO_3 (sulphur trioxide) and with water vapour, SO_3 is converted to sulphuric acid mist. Other basic oxides combine with SO_3 to form sulphate aerosols (Derek *et al.*, 2002; Fabio, 2004).

Carbon monoxide (CO) is not an irritant and has little or no effect on plants or materials; however, it reacts with haemoglobin in the bloodstream and deprives the heart and brain from oxygen. Moderate concentrations of it may significantly reduce brain function and high concentrations can be even lethal (Anonymous, Series-1998-2004).

Suspended particulate matter (SPM) in ambient air is a complex, multi-phase system consisting of particle sizes ranging from < 0.01 µm to >100 µm (Wan-Kuen *et al.*, 2006). When breathed in, these particles can reach the deepest regions of the lungs and lead to many significant health problems ranging from aggravated asthma to premature death (Freiman *et al.*, 2006; Benjamin *et al.*, 2006).

2.2 Significance of Present Work

With projected growth of vehicular population in the country, and particularly in the smaller cities like Kolhapur in the next decade, it is expected that air pollution due to the vehicular exhaust emission will became very serious and will need to be handled on top priority. This needs to be done with modern approaches and innovative techniques with emphasis on environmental protection in general.

However, this is possible only with better understanding of the causes and consequences of air pollution which could be very site specific and based on local climatic conditions and geo morphology. By

analyzing the air quality status of the city, as part of the long term monitoring, a strategy can be designed to deal with the air pollution situation today and in the future. Also for proper vehicular maintenance suitable guidelines need to be provided for vehicular users to reduce the emission levels. This would be very useful to maintain healthy ambient air quality of Kolhapur city. An attempt has therefore been made for the first time to monitor air pollutants in the city. Attempts are also made to review the two wheeler vehicular exhaust situation in Kolhapur.

2.2.1 Hypothesis

Due to the earlier experience there are certain assumptions related to air quality. Therefore the main hypotheses of the study are based on the following assumptions.

- The emission levels of vehicles in Kolhapur are much higher than that of standard limits.
- Kolhapur Municipal Transport (KMT) buses contribute for more emissions.
- The engine capacity of vehicles plays a major role in the pollution potential of an automobile.
- The number and types of auto vehicles in the city area is on increase.
- There is very low awareness about air pollution caused by vehicles.
- Working of PUC centres in the city is not as per the rule.
- The Ambient Air Quality of city can be increased substantially by maintaining auto vehicles.

2.2.2 Objectives

The study was undertaken to understand the present status of air pollution in Kolhapur city. It was also to understand the level of two wheeler vehicular pollution, rise in their number and possible

consequences of the same on city environment. The main objectives of the study therefore were as follows:

- To study present status of Ambient Air Quality at the identified sites
- To evaluate the awareness level in local people about air pollution.
- To check vehicular emissions from two wheeler vehicles.
- To asses air quality improvement potentials in the study area.
- To study overall trend of vehicular maintains.
- To suggest methods to bring down vehicular emissions.

2.3 Study Region

In order to assess the magnitude of vehicular emission, Kolhapur city was chosen as the study area. Kolhapur once a famous historical town is now a rapidly developing city nested in the southwest corner of Maharashtra. It is also known as Dakshin Kashi and is an important pilgrimage centre. It is located approximately at 16.7° N and 74.22° E. on banks of River Panchganga with average height of 545 meters above mean sea level on east of 'Sahyadri' range. The climate of Kolhapur is a blend of coastal and inland climate of Maharashtra. The temperature has a relatively narrow range between 12° C to 35° C. The city receives an average of 102.5 cm of annual rainfall from June to September through monsoon due to its proximity to the Western Ghats (Anonymous, 2004).

Kolhapur originally was a cluster of six villages namely Bramhapuri, Uttareshwar, Kholkhandoba, Rankala, Padmala and Ravaneshwar. River Panchganga is one of the major reasons of prosperity in Kolhapur. The river flows towards eastern northern side and meets River Krishna at Narsinhwadi and its entire catchment area lies in Kolhapur district. Many ancient temples are standing on the banks of River Panchganga. This site is one of the greatest antiquity and many

archaeological excavations have been made from time to time in this part.

Now Kolhapur is becoming a major industrial, educational and trade centre in Maharashtra. However, as a result of this transition the city is also facing new problems of pollution besides severe pollution of Panchaganga river. The ambient air quality of the city is changed in the recent years due to industrialization and related activities. Kolhapur with geographical area 6682 hectares has population of 4,85,183 (Census 2001) however according the recent estimate it is around 600,000. For sustaining their livelihood, people have adapted to trade and commercial activities. Metal, textile, mining, leather, milk and horticulture and cash crops like sugarcane are the important trade items of the city. Experts are of the opinion that Kolhapur is one of the cities of India, which has got one of the highest per capita income. The culture of Kolhapur is enriched and it is pinpointed in its treasures of varied items like cuisine, jaggery, footwears, jewelries etc. Table 2.1 indicate land use pattern in Kolhapur city. It must be noted that due to rapid urbanization as a result of growing number of education institutions, IT sector, five star MIDC, tourist destination and related developmental activities, the city is being transformed exponentially in the last two years. The traditional land use practices are therefore being changed drastically (Patil, 2007).

Table 2.1 Land Use Pattern of Kolhapur City

Sr. No.	Category	%
1	Residential	16.07
2	Commercial	2.40
3	Industrial	1.60
4	Social	13.52
5	Road transport	4.71
6	Open space	0.86
7	Social needs	0.67
8	Military	1.80
9	Barron land	19.32
10	Lakes	1.97
11	Agricultural (Fields)	37.10

Kolhapur city today acts as a hub for the economic and cultural development in south Maharashtra. Increasing trade and industrialization creates new job opportunities, which increases income and standard of living of the people. Also it attracts people from other urban areas as well as from rural and semi urban area. The major shift is in the work culture and attitudes of the work force. This is greatly influenced by the urban culture and practices and tries to adopt the modern, techno savvy way of life. This is evident from the craze among youth to posses mobile phones and two wheelers even if it may not be a priority or even a necessity.

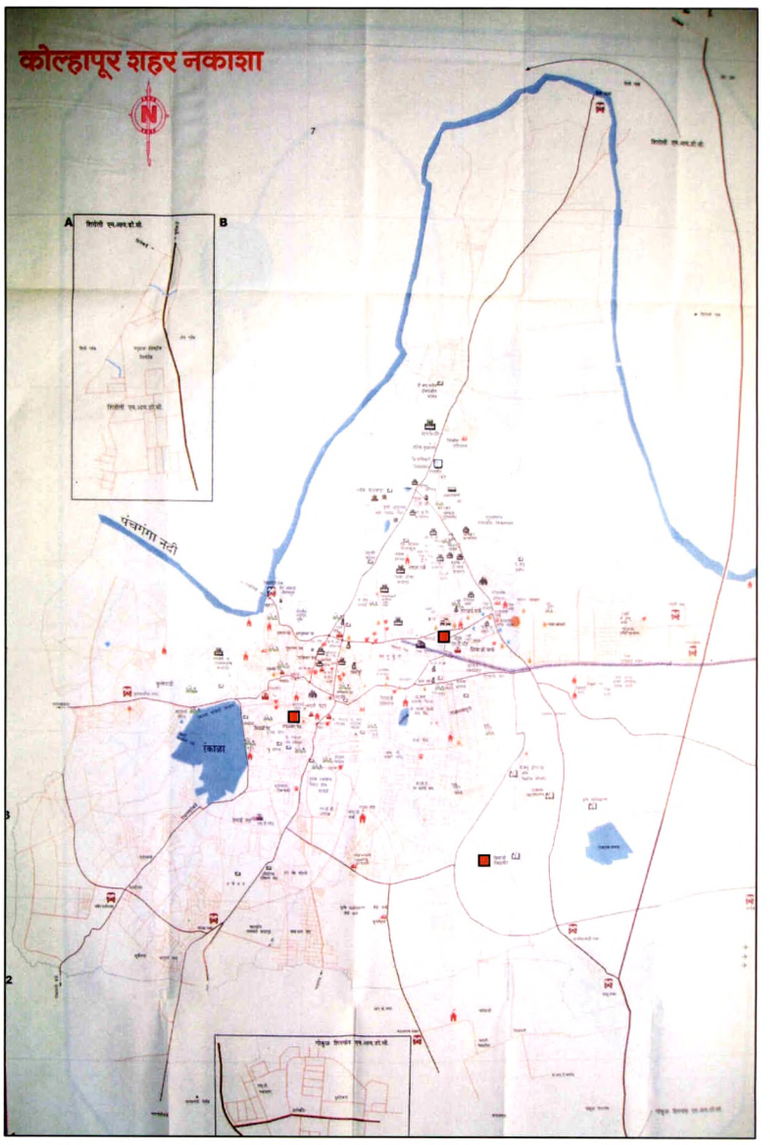
Quick and easy availability of loans from Cooperative and banking sector, increasing bike riding craze among young generation along with other reasons is responsible for tremendous increase in the number of autos in the region. Good fertile land, cash crop cultivation, increase in small and medium scale industries and commerce, modern cultivation practices etc. are some other reasons. Number of vehicles in Kolhapur district is increasing at the rate of 35 to 40 thousand new vehicles per year. As per one estimate at the end of July, 2007 for 30 lacks population in Kolhapur District the vehicular population was 5,23,367 vehicles (Mali, 2007), (Plate-III, c).

2.4 Methodology

The methodology adopted for study was as follows

1) Comprehensive review of the relevant literature.
2) Ambient Air Quality Monitoring with the help of Respirable Dust Sampler (RDS), and when it was not available with High Volume Sampler (HVS)
3) Checking of two wheeler emissions with the help of Auto Exhaust Analyser
4) Data regarding emissions levels checked by PUC centres and survey of vehicular maintenance from servicing centres.

Map-I



■ Study Sites in Kolhapur City.

5) Questionnaire survey of two wheeler owner's awareness of vehicular pollution.
6) Personal observations about the air quality in city.

2.4.1 Ambient Air Quality Studies

For ambient air quality monitoring, Site selection was done on the basis of CPCB guidelines (CPCB, 2003). Initially many potential sites in the city were visited. On the basis of accessibility, distance from ground, type of the area and its vehicular use a few sites were short listed. After approaching the owners of these sites for permission to install the monitoring instruments, availability of power supply, with out barriers of hoardings etc. the following three sites were selected in the east, west and south side of Kolhapur city. The other criterion considered was the nature of site such as control site, residential site and busy commercial site.

The study sites

Site 1:

The site was the Statistics department building, on Shivaji University campus. The site was considered as control site because the area is known to be free from any traffic or pollution, being in the green campus away from any thick human activity during daytime and calm at the other times (Plat-II, a).

Site 2:

This site was on Ruikar trusts building at Dabholkar corner. This location was one of the busiest traffic junctions in Kolhapur considering its proximity to the busy Central Bus Station (CBS), Railway Station and the major roads converging in this area (Plate-II, b).

Site 3:

Mahadwar road area is a hub of old Kolhapur. The site on Vaidhya building is at the road junction and entrance of Mahadwar of

famous Mahalaxmi Temple. The road is crowded through out the year by devotees, tourists and residents of the area alike (Plate-II, c).

All the three sites were inspected by the experts from MPCB and approved as they qualified the CPCB guidelines for air monitoring station. The parameters selected for the ambient air quality monitoring were also as per the CPCB guidelines. They were Nitrogen oxide (NO_x), Sulphur dioxide (SO_2), Respirable Suspended Particulate Matter (RSPM) and Suspended Particulate Matter (SPM).

Out of three stations selected each station was operated for two days per week for Twenty-four hours by using RDS instrument. After each four-hour time interval samples for NO_x and SO_2 were collected and analysed in the laboratory by using approved method on UV spectrophotometer. The methods of the analysis and instrument used are given in Table 2.2. (Plate-I,d).

Table 2.2 Details of Analysis for the four Parameters

Sr. No.	Parameters	Method of Analysis	Instrument used for sampling
1	SPM	APHA (Second Edition)	RDS/ HVS
2	RPM	APHA (Second Edition	Respirable dust Sampler (RDS)
3	SO_2	Improved West & Geake	HVS (through glass impinges
4	NO_x	Jacob & Hochheiser	HVS (through glass impinges

Thus from four-hour readings 24-hour weekly average was calculated and from these average readings monthly average was calculated. Thus total one year Ambient Air Quality Data was compiled for the period from September 2006 to August 2007. The instruments used for monitoring and their make are mentioned in Table 2.3 and Plate-I, a, b, c, d.

Plate - I

a) Respirable Dust Sampler (RDS)

b) High Volume Sampler (HVS)

c) Auto Exhaust Analyser

d) UV-Visible Spectrophotometer

Table 2.3 Ambient Air Sampling and Analysis Instruments

Instrument	Make
High Volume Sampler (HVS)	Netal India, Ltd, Thane.
Respirable Dust Sampler (RDS)	Envirotech Instruments Ltd, Delhi
UV-VIS Spectrophotometer	Elico India Ltd., India.

2.4.2 Statistical Analyses

a) Air Quality Index (AQI)

IIT Kanpur through a sponsored project from the Central Pollution Control Board, Delhi has proposed the Indian Air Quality Index (IND - AQI) in simple and lucid terms.

A segmented linear function is used relating the actual air pollution concentrations (of each pollutant) to a normalized number. The basis for these linear functions (for this study) is arrived after considering such functions adopted by other countries. The pollutants included for the proposed IND - AQI are SPM, SO_2, NO_2, PM_{10}, CO and O_3.

Since all the pollutants are not measured under the National Ambient Air Quality Monitoring Program, it is necessary that at least three pollutant concentrations must be available to calculate and report the index. The over all AQI is based on maximum operator system where the maximum value of sub-index becomes the AQI. To reflect the attainment of NAAQS, the AQI is referred to as Good between the ranges 0 - 100. For the second break point (at the standard of USEPA), the AQI takes the value of 200 and referred to as moderate. In absence of any other pollutant of any other pollutant health criteria in India, rest of categorization of Index is based on the USEPA Federal Episode criteria and Significant Harm Level.

IND-AQI is primarily a health related index with the following descriptor words: "Good (0 - 100)", "Moderate (101 - 200)", "Poor (201

- 300)", "Very poor (301 - 400)", "Severe (401 - 500)". On the basis of IIT Kanpur proposed the Indian Air Quality Index (IND - AQI), AQI is calculated for the three selected locations in Kolhapur city.

b) T-Test Analysis

Statistical analysis of the data was carried out using student 't' test The data were tested for four parameters to analyse pollution status of three selected sites. For analysis purpose of T-Test values like Average, Standard Deviation, T Calculated, T Table were calculated. The hypothesis is if T Calculated values are greater than T Table values then that particular parameter is said to be polluting.

2.4.3 Vehicular Exhaust Studies

During the study attempts were made to generate baseline data on vehicular exhaust from two wheeler petrol vehicles. The two wheelers of different vintage (year of manufacture) were studied for a period between 1980 till 2003 in three batches. Since the assumption was the old vehicles caused more pollution, new vehicles, with 2-3 year free maintenance were to not tested.

For vehicular exhaust analysis digital Auto Exhaust Analyser model NPM CH1, manufactured by Netal India Ltd. Thane was used. The instrument and the analysis procedures were approved by MPCB (Plate II, d).

Working principle

The instrument detects the CO /HC content in % and ppm respectively according to the principle by which the selective absorption of infrared radiation is measured for each gas. The gas sample is taken from the vehicle exhaust by means of the probe, free from moisture and is then conveyed to the measurement components and is measured as a certain wavelength by the gases in the cell.

Plate-II

a) Site 1: Shivaji University

b) Site 2: Dabholkar Corner

c) Site 3: Mahadwar Road

d) Testing of two wheeler exhaust with AEA

2.4.4 Questionnaire Survey

Questionnaire survey was conducted for auto mechanics and the owners of two wheelers from Kolhapur city. A total of 25 mechanics from different age groups were randomly selected and interviewed. A special questionnaire with 14 pertinent questions was designed and administered. A separate survey was conducted for 103 randomly selected two wheeler owners (Annexure II).

2.4.5 Observations of PUC centres and workshops

General personal observations of the traffic jams, air polluting vehicles, road congestions etc. were made through out the period of the study. Photo documentation was done whenever necessary. PUC centres were observed with more details for test of vehicle and to understand the process carried out with informal interactions with the operators.
