1. Introduction

A team of air monitoring experts from USEPA Region 5 Chicago traveled to Pune in September 2003. The purpose of this visit was twofold: to present an introductory course in air quality monitoring and to evaluate the existing respirable particulate matter (PM_{10}) monitoring program in Pune. The three-day course was delivered on September 10-12 by Dr. Peter Scheff (University of Illinois at Chicago), Ms. Motria Caudill and Mr. Steve Rothblatt (USEPA Region 5).

The team spent two days, September 15 and 16, in the field evaluating the five existing PM_{10} sites operated by Pune Municipal Corporation (PMC), Maharashthra Pollution Control Board (MPCB) and University of Pune (UP). The team also visited the laboratories operated by PMC and MPCB. Representatives of PMC, MPCB, and UP took part in the field visits and provided information about the objectives and operation of the PM_{10} network.

This report contains the results of the USEPA network review (Section 2) and recommendations for improving the Pune PM_{10} monitoring network (Section 3).

2.0 Pune PM_{10} Network Review

The USEPA team reviewed the Pune PM_{10} network using the same criteria used to evaluate monitoring sites in the U.S. The application of U.S. criteria to review a network in India was deemed appropriate, despite the fact that the two countries have differing regulatory systems, because the objective of monitoring in both nations is the same, i.e. characterize community exposure and determine whether established ambient air quality standards are being met.

2.1 General

To conduct an effective review of the PM_{10} monitoring network, the USEPA team attempted to obtain information about Pune's monitoring program and the city itself in advance of their visit.

Information of interest:

- existing PM_{10} monitor locations - siting rationale, prior monitoring data
- local meteorological data, prevailing winds
- topographic map of Pune, preferably in electronic GIS form
- identification of major PM emitting point sources - type of industry, address, GIS coordinates, approximate amount of annual emissions
- identification of mobile sources - road map (pref. in GIS), data on traffic density
- identification of area sources - population density map, location of PM area sources

PMC provided USEPA with general data on Pune's population distribution, population growth, land use, vehicle density, and primary roadways. This information is summarized in a series of figures in Appendix A. The figures show that the central zones of Pune have the greatest population density and most congested roadways. Registration of 2-wheel vehicles has sharply increased in recent years. The population has been steadily growing for decades. Residential areas prevail in outlying zones, combined with commercial properties in the southwest, and

recreational parks in the eastern zones. Industrial parks are concentrated in the northern portion of the city and suburbs. Lands south of Pune are mainly agricultural.

USEPA did not receive meteorological data collected in Pune. PMC advised USEPA that the prevailing winds are either from the east or west, depending on season. North/south winds are less frequent. A detailed topographic map has also not been provided. It is apparent that Pune is situated in a depression, surrounded by low mountains. A list of Pune's industrial sites and addressed was provided to USEPA, although facility emission data was not obtained.

2.2 Existing monitoring data

PMC provided PM_{10} data collected at their two sites, Yeshwantrao and Swargate (Majur Adda), in 2001-2002. USEPA was able to incorporate these data into the training session by using them in examples of basic data presentation, statistics, and analysis. These figures are included in Appendix B.

Ambient PM_{10} concentrations are apparently higher at the Swargate site, which is situated in a high-density traffic area as compared with Yeshwantrao. The two PMC sites are weakly correlated with one another, suggesting that their measurements are reflecting air quality on a very local scale and do not indicate broader community exposure. A review of PMC data indicated that samples were collected on an unusual schedule - two consecutive days per week, usually Thursday and Friday. Analysis of paired consecutive samples (Thursday versus Friday of the same week) show that the two sampling days are highly correlated with each other, which is to be expected due to effects of auto-correlation, i.e. two consecutive samples are not independent of one another. Monitoring data were not provided for sites operated by MPCB and UP.

2.3 Monitor Siting

The locations of PMC, MPCB, and UP monitoring sites are shown on Figure 1. Photographs taken by USEPA and rough site drawings are presented in Appendix C. The most appropriately sited monitor is the University of Pune sampler in Pimpri-Chinchwad, an industrial area north of the city. This sampler is located on the rooftop of a low-rise building, i.e. within the "breathing zone" air strata (2-15 meters above ground), with no major obstructions from trees or buildings.

Other monitors operated by UP, PMC and MPCB are situated in or near roadways and are unduly influenced by local traffic patterns. Airflow around these monitors is also blocked to varying degrees by billboards, trees, and buildings. A detailed review of PM_{10} sampler placement versus U.S. siting requirements is shown in Table 1. USEPA siting requirements are taken from the Quality Assurance Handbook for Air Pollution Measurement Systems, USEPA, Office of Air Quality Planning and Standards, EPA-454/R-98-004, August 1998, available online at: http://www.epa.gov/ttn/amtic/files/ambient/qaqc/redbook.pdf .

Figure 1. Pune tourist map showing PM_{10} monitor sites. Not to scale.

Table 1. PM_{10} monitoring site evaluation in comparison to U.S. siting requirements.

	U.S. siting requirement*	Yeshwantrao	Swargate	Nalstop	Jog Center	Pimpri-Chinchwad
Operating Agency	-	PMC	PMC	U of Pune	MPCB	U of Pune
Address	-	Karve Road Karvenagar, Kothrub	Shankar sheth, Satara, Shivaji Rds	Karve Rd & Law College Rd.	Mumbai-Pune Hwy.	Bhosari; Old Pune-Mumbai Hwy.
Latitude	-	18.5025	18.5005	18.5086	18.5404	18.6334
Longitude	-	73.8126	73.8583	73.8315	73.8511	73.8289
Vertical	2-15 M	5 M	5 M	5 M	1 M	5 M
Spacing from Trees	≥10 M	10 M	> 20 M	10M	< 10 M	> 20M
Obstacle Distance	2x height differential	Height of nearby bldg. unknown	Nearby bldgs not 2x height away	Nearby bldgs not 2x height away	Nearby bldgs not 2x height away	OK
Unrestricted Airflow	≥ 270 degrees; no obstruction between monitor and source	Platform cage blocks inflow; tent blocks one side	Billboard and street signal blocks	Billboard and street signal blocks	Billboard directly above sampler	OK
Distance to Road	> 5 M; see figure	5 M	None	None	< 5 M	>20 M
Paving	Paved	Paved	Paved	Paved	Under construction	Paved
Comment	-	Muddy, dusty shoulder	Road is crumbling	Dirty, dusty road	Very dusty	Dusty road

* Source: Quality Assurance Handbook for Air Pollution Measurement Systems, USEPA, Office of Air Quality Planning and Standards, EPA-454/R-98-004, August 1998.

2.4 Sampling equipment and laboratory procedures

The two types of PM_{10} samplers in use at the Pune stations were on display for USEPA and workshop participants at the PMC laboratory. The device used at the two PMC sites is the PEM-HVF-10 model produced by Polltech Instruments, Mumbai. University of Pune and MPCB both use the Envirotech APM 460 model recommended by NEERI. Additionally, PM_{10} is measured using a continuous Thermo-Environmental beta gauge.

The PM_{10} sampler used by UP and MPCB has a cyclone design with no flow control. This model design makes it difficult to know the actual flow rate throughout the 24-hour sampling period, thus putting the calculated ambient concentrations in question.

Current laboratory procedures in Pune include folding sample filters when they are weighed and conditioning at 110 degrees centigrade prior to use in the field. The folding will break the fibers in the filter and may cause underestimation of the true concentration. A modification to the balance where the filters will not have to be folded was discussed. We also suggested that conditioning be done at room temperature and that the effect of heating the collected PM to 110 degrees be studied.

2.5 Quality Control

The three monitoring agencies in Pune do not coordinate their activities and do not appear to be following the national quality control requirements. We recommend that the three groups adopt India's recommended quality control practices to ensure consistency in procedures. A program where one Pune agency audits another group's monitors and field/laboratory procedures would also be beneficial.

Given the performance issues associated with some of the PM_{10} monitors used in Pune, we recommend that the different monitoring devices be checked against one another. We suggest an experiment where one of each type of device should be co-located at the same site and operated for a period of one month of daily sampling. We suggested that the monitors be installed at the industrial site where there is a large open roof and operated together for a minimum of 12 days to define the equivalence between these methods. The results would quanitify the degree of agreement between monitors and suggest a possible correction factor that could be applied to future monitoring data collected at different sites.

2.6 Summary of recommendations

1. Four of the 5 monitoring sites are adjacent to high traffic roadways or inside busy traffic intersections. These measurements are not appropriate for determining broader population exposure. We recommend that 3 of the 5 stations be located in residential communities to better represent city-wide concentrations.

2. We recommend that continuous meteorological monitoring be started in Pune. This data will be essential for detailed data analysis as well as to support dispersion modeling for air quality strategy development.

3. We recommend that the sampling schedule be reevaluated. The current schedule collects samples on two consecutive days once per week. A more efficient sampling schedule that meets the 114 measurements-per-year required in India would be to collect samples every 3 days. The same schedule should be followed at all sites in the network.

4. We recommend that sampler inter-comparison studies be carried out to assess the equivalence of the different sampling methods used in India.

5. We suggest a modification to the balance where the filters will not have to be folded. We also suggested that conditioning be done at room temperature and that the effect of heating the collected PM to 110 degrees be studied.