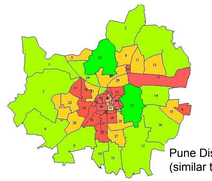
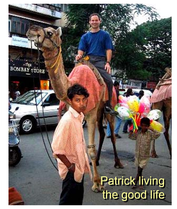
The Pune, India Experience: Developing a PM_{10} Emission Inventory and Database in Seven Days with Forty People

Patrick Gaffney and Michael Benjamin – California Air Resources Board
Ted MacDonald and John Mooney – U.S. EPA



Pune District Talukas (similar to Precincts)



Pune PM10 Inventory Project Team

Name, Affiliation, Location	Project Area of Work	Photo
Ms. Elizabeth Abbs Project Assistant Indian Environmental Engineering Research Institute, NEERI, Nagpur	Emissions: Commercial cooking (hotels, restaurants, bakeries)	
Jerome Boxerel Motor Vehicle Department	Emissions	
Dr. Michael Benjamin Emissions Database Specialist Project Facilitator, Sacramento, USA	Facilitator Database development team planning and coordination, QA oversight, GIS evaluation oversight	
Suresh Bhosale Jr. Scientific Officer Maharashtra Pollution Control Board, MPCB, Pune	Emissions: Stationary Sources, Biomedical waste, brick kilns, various industry sources, dry cleaning, stone pulverization, food industry, metal industry	
Mr. Yogesh Chemjet Sr. Software Engineer Vinzavidha Software Exp. Pvt. Ltd, VISEPL, Pune	Database: Mapping structure, reports, transactions, etc.	
S.R. Chaudhari Maharashtra Pollution Control Board, MPCB, Pune	Emissions Policy Stationary sources: Biomedical waste, brick kilns, various industry sources, dry cleaning, stone pulverization, food industry, metal industry	
Mr. M.K. Chaudhari Senior Deputy Director Automotive Research Association of India, ARAI, Pune	Emissions Policy	
Nenad K. Chaudhary M. Tech. Student CESE, Indra Institute of Technology, Bombay, CESE, IIT-BOMBAY, Mumbai	Emissions: Stationary Sources, Biomedical waste, brick kilns, various industry sources, dry cleaning, stone pulverization, food industry, metal industry	
Padmini Das MSC. Env Sc. Pune University Pune University, Environmental Sciences Department, PU, ES, Pune	Database: Evaluation of available GIS resources and preparation of summary report Emissions – Cremation (wood, dung, diesel)	
Mr. Mikkel Denk Meteken Weather Group Centre for Development of Advanced Computing, CDAC, Pune	Database: Design and development Emissions: Trains (diesel)	
R Fadnis Assistant Engineer Central Pollution Control Board, CPCB, New Delhi	Database: Programming & Liaison to CPCB, Delhi	
Dr. Sunil Gharpure Regional Transit Office, RTO, PUNE, Pune	Emissions: Stationary Sources	
Harshavardhan Ghorpade MSC. Env Sc. Pune University Pune University, Environmental Sciences Department, PU, ES, Pune	Database: Evaluate GIS resources; collect and scan available maps Emissions: Agricultural sources, diesel operations & ag pumps	
Mr. M.S. Gupta Pune Municipal Corporation, PMC, Pune	Overall Project Assistance Emissions Data weekend and facilitator, presentations, trains, etc., Official project collaborator	
Mr. Patrick Gaffney Emission Inventory Specialist Project Facilitator, Sacramento, USA	Emissions estimation team planning and coordination, emission estimation technical assistance and guidance	
Mr. Somnath Gaikwad Engineer (Roads) Pune Municipal Corporation, PMC, Pune	Emissions: Residential & commercial construction, concrete & bitumen road construction, bridge construction, hot mix plants	
Ms. Vanessa Gokhale MSc Geography Pune University, Geography Department, PU, G, Pune	Database: Development of source coding system Emissions: Fire & Fireworks Emissions: Provide assistance preparing emissions source and other data for upload to database	
Ms. Gaurav Hade Research Scholar CESE, Indra Institute of Technology, Bombay, CESE, IIT-BOMBAY, Mumbai	Emissions: Cooking in stoves using biofuels (firewood, cowdung), agricultural burning, forest fires (accidental & land clearing)	
Mr. N.V. Iyer Technical Advisor Bajaj Auto Limited, BAJAJ, Pune	Emissions policy and quality assurance. Wise direction and guidance on emission projects	
Mr. Dwijesh Kapoor M. Tech. Student CESE, Indra Institute of Technology, Bombay, CESE, IIT-BOMBAY, Mumbai	Database: GIS Group Emissions: Paved road dust, unpaved road dust, cooking in stoves (firewood, LPG, kerosene), street vendor emissions	
Mr. Vikrants Kapse Jr. Engineer (Civil) Road Dept. Pune Municipal Corporation, PMC, Pune	Emissions: Trash burning (city & dump site), city street sweeping	
Mr. Ravi R. Kanzarkar Deputy Director The Automotive Research Association of India, ARAI, Pune	Emissions Policy	
Mr. Jatin Kukkarni Director, Vinzavidha Software Exports Pvt. Ltd., VISEPL, Pune	Database: GIS, maps	
Mr. Aneesa Mahajan MSc Student Pune University, Environmental Sciences Department, PU, ES, Pune	Database – Develop source coding system and general assistance Website design and development co-leader Emissions: Diesel operations & agricultural burning	
Ms. Smadha Mehta M. Tech. Student CESE, Indra Institute of Technology, Bombay, CESE, IIT-BOMBAY, Mumbai	Emissions: Diesel Mobile source exhaust emissions	
Mr. Yogesh Mittal MSc Student Pune University, Environmental Sciences Department, PU, ES, Pune	Database – Develop source coding system Emissions: Residential & commercial construction Website design and development co-leader and implementation	
Mr. John Mooney United States Environmental Protection Agency, USEPA, Chicago, USA	Facilitator & Logistics Emissions: On-road mobile sources	
Dr. Utpal Mukherjee Director Central Pollution Control Board Synergy House II, Subhopanara CPCB, Vadodara 390023	Emissions: Stationary Sources, Biomedical waste, brick kilns, various industry sources, dry cleaning, stone pulverization, food industry, metal industry	
Ajoy Oza National Environmental Engineering Research Institute, NEERI, Nagpur	Emissions: Paved & unpaved road dust, cooking in stoves (firewood & LPG), cooking in slums (firewood, LPG, kerosene), on-road vehicle exhaust emissions	
Mr. Sagar Patil Jr. Software Engineer Vinzavidha Software Exp. Pvt. Ltd, VISEPL, Pune	Database: Application development	
Anil Pardhi Assistant Transit Office, RTO, PUNE, Pune	Emissions	
Hemlata Patel Pune University, Geography Department, PU, G, Pune	Database	
Mr. Uday Patil GIS Professional Centre for Development of Advanced Computing, CDAC, Pune	Database: GIS	
Mr. P.N. Pawar Project Engineer The Automotive Research Association of India, ARAI, Pune	Emissions: Paved & unpaved road dust, mobile, agricultural sources, diesel & agricultural dust emissions, agricultural unpaved roads & wasteland dust	
Mr.K. Pawale M. SC (Math) Pune University, PU, Pune	Database: Application development	
Thiess Pawarova M. SC Env. Sciences Pune University, Environmental Sciences Department, PU, ES, Pune	Database: Evaluation of available GIS resources and preparation of summary report Emissions – Cremation (wood, dung, diesel)	
Mr. R.A. Rajput Field Officer-I/ P.C.B. Pune Maharashtra Pollution Control Board, MPCB, Pune	Emissions: Stationary Sources: Biomedical waste, brick kilns, various industry sources, dry cleaning, food industry, metal industry	
Mr. M.S. Ratnaparkhe Rao Assistant Director AP Pollution Control Board, APPCB, Hyderabad	Emissions: Commercial cooking (hotels, restaurants, bakeries)	
A. Sahoo The Automotive Research Association of India, ARAI, Pune	Emissions	
Mr. Khanind Rao Project Engineer The Automotive Research Association of India, ARAI, Pune	Database: Team leader in database application development	
Mr. Brooks Sawyer Development Engineer (Traffic) Pune Municipal Corporation, PMC, Pune	Emissions Policy Overall Project Support	
P. Vanarase Jr. Scientific Officer AP Pollution Control Board, APPCB, Hyderabad	Emissions: Cooking in stoves using biofuels (wood, dung, ag waste), agricultural burning, forest fires (accidental & land clearing) Population forecasts, vehicle activity forecasts	

OBJECTIVE

Recruit and guide a team team of 40 participants from several of India's governmental and educational institutions to develop the first comprehensive PM10 emissions inventory and database for the region of Pune, India (population approximately 3.5 million). Complete the project within seven working days at a minimum of cost.

APPROACH

Prior to arriving in India, detailed project schedules and plans for developing the inventory system were developed to ensure sustained and measurable progress. The facilities for developing the emission inventory included two meeting rooms in a local Pune hotel (including the sweltering "Ming Suite"), six rented computers with slow dial-up internet access, and one inkjet printer that sometimes actually worked.

The majority of the participants, both university students and professionals, had little or no prior emission inventory experience. Participants were recruited with the help of the Mumbai (Bombay) office of the U.S. Agency for International Development and the U.S.-Asia Environmental Partnership (USAID/USAEP).

Following a half-day introduction to what an emission inventory is and inventory development methods, each participant selected their area of work: emissions estimation or emissions database.

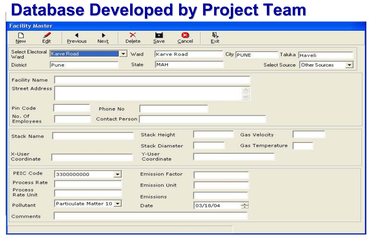
Each member was then assigned very specific and measurable tasks. For example, the table below shows the tasks for preparing the paved road dust estimates.

Emission Estimation Development Overview Schedule

Daily Schedule Overview	TUES	WED	THURS	FRI	WEEKEND	MON	TUES	WED
Emissions Inventory								
Case Study		□•						
Identification of Sources		□•						
Category Assignments		□•						
Planning Document		□•						
Inventory Source Worksheets		□•						
Methods & Data Sources Discussion		□•						
Identify Methods & Data				□				
Review Source Worksheets		□						
Problems & Issues		□						
Full Group Input on Problems			□					
Example Spreadsheets			□•					
Emission Factory & Activity Data Collection			□					
Staff Begin Spreadsheets			□					
Begin Populating Spreadsheets			□					
Rating Data Quality				□•				
Ongoing Emissions Work				□				
Group Assistance on Key Sources				□				
Presentation of Draft Emissions					□•			
Reasonableness Evaluation					□			
Identify Quick Fixes					□			
Finalize Emissions					□			
Document Methods					□			
Resolve Remaining Issues						□		
Assist With Date Loading						□		
Resolve QA & Other Issues						□		
Complete Documentation						□		
Finalize & Document Spreadsheets						□		
Compile All Documentation						□		

Note: Boxes marked with "□•" indicate that there will be a presentation and discussion lead by the facilitator.

Database Developed by Project Team



Preparing Emission Estimates

Areawide Sources	TUES	WED	THURS	FRI	WEEK END	MON	TUES	WED	Primary Responsibility
Paved Road Dust									Ajay Ojha, Prashant Pawar, Deepak Kapoor
Identify Staff		▣							
Evaluate Methodologies			▣						
Select Methodology			▣						
Evaluate Emission Factors				▣					
Calculate Emission Factors				▣					
Evaluate Available Activity Data				▣					
Develop Activity Data				▣					
Develop Spreadsheet				▣					
Calculate Emissions						▣			
Check Assumptions & Calcs							▣		
Format Emissions for Database							▣		
Load & Validate Data							▣		
Document Methodology & Assumptions							▣		
Identify Areas for Improvement (spatial, temporal, EFs, activity, etc.)							▣	▣	

WHAT HAPPENED?

The participants were extremely dedicated, focused, and resourceful. The work was frenzied and intense. The days were long. We all had an amazing time (usually).

The emission estimation team, lead by Gaffney, initially dispersed throughout the city of Pune, scouring local agencies for needed activity information such the quantity of wood burned in slums for cooking, the number of people sweeping streets with brooms, the production of regional brick kilns, and trash generation rates.

These activity data were then incorporated into existing U.S. EPA, California Air Resources Board, or other emission estimation methods that were modified to reasonably reflect Pune conditions.

The database team, lead by Benjamin, subdivided into groups to tackle database design and implementation, database coding systems, project web design and development, and evaluation of geographic information system (GIS) and global positioning system (GPS) tools.

RESULTS

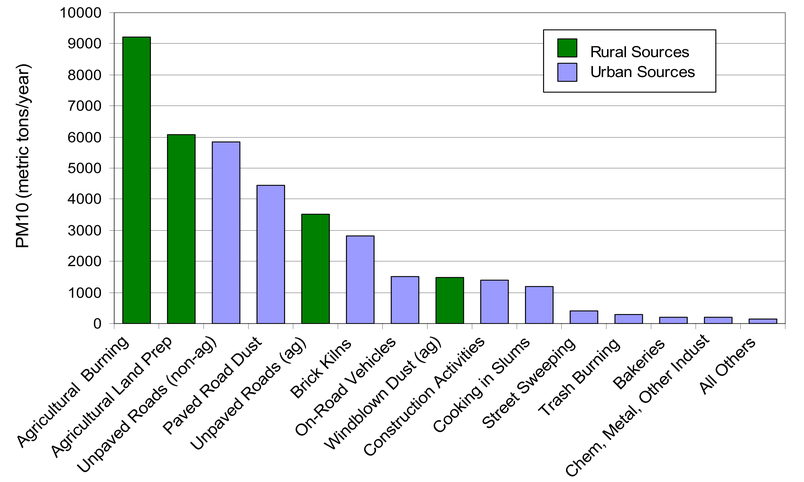
The Pune emission inventory team successfully developed a complete PM10 emission inventory for Pune city and the surrounding rural area. Emission estimates were based on local inputs and Pune conditions. The results are shown graphically above.

The team also completed development of a relational database system in Microsoft Access, an automated data loader, emissions reports, and the project website. **A full final report for the project is available at the project website at:** http://www.unipune.ernet.in/dept/env/pei/index.html

Some of the Pune Team

Michael sweats it out in the Ming Suite

Pune Regional Annual PM10 Emission Estimates

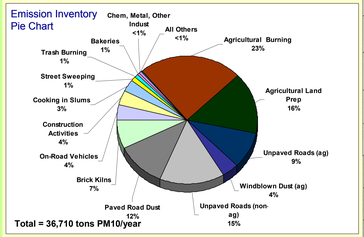


DISCUSSION

Prior to developing the inventory it was expected that the largest PM10 contributors in Pune would be on-road mobile sources and industry. The current results throw that assumption into question. Based on the inventory, open agricultural burning, fugitive dust, and other sources appear to also be significant regional PM10 emission sources.

Speciated PM10 monitoring data and increased spatial and temporal refinement are needed to evaluate the reasonableness of the initial emission estimates.

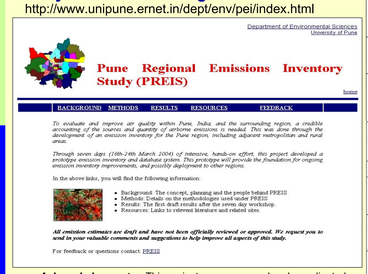
Emission Inventory Pie Chart



Total = 36,710 tons PM10/year

Study Website Home Page

http://www.unipune.ernet.in/dept/env/pei/index.html



CONCLUSIONS

Through the combination of outstanding logistical support, a clear and complete plan of attack, and extremely capable and enthusiastic participants, the Pune team built the first comprehensive PM10 emissions inventory and database system for the region.

This emissions inventory provides critical block in the foundation needed to improve air quality.

The participants now have real-world, hands-on experience in performing emission estimates and developing an emissions database system in a fast paced, team environment.

This knowledge is invaluable as India continues its proactive efforts to better understand their sources of air pollution, and to develop innovative solutions to improve air quality and health throughout the country.

Acknowledgements: This project was sponsored and coordinated by the U.S. EPA's Office of International Affairs under a Memorandum of Understanding (MOU) with the Indian Ministry of the Environment and Forests. Invaluable support was also provided by the U.S. Agency for International Development and the U.S.-Asia Environmental Partnership (USAID/USAEP) in Mumbai and New Delhi. Thanks also to the generous and dedicated participants, who made it all happen.