

Air Quality Network Development in Addis Ababa

Considerations for Siting Air Quality Monitor Stations



Picture credit: OrgangeSmile.com

Presentation created by
David Pfothauer,
University of Colorado
Boulder

Outline of Topics

- I. General Objectives for Air Quality Monitoring Networks
- II. Macroscale Siting Considerations
 - I. Data vs. Resources
 - II. Monitoring Station Specific Data Purposes
- III. Microscale Siting Considerations
 - I. Air Inlets and their Surroundings
 - II. Nearby Obstacles to Consider
 - III. Practical Considerations for Monitoring Stations
- IV. Long Term Goals of Setting Up a Monitoring Network

General Objectives and Considerations for Air Quality Monitoring

A. Public Reporting of Air Quality

Ensuring citizens have open access to interpretable data on pollution and air quality

B. Support Compliance with Ambient Air Quality Standards

Upon implementation of regulations and standards, monitors serve to ensure air quality benchmarks are met and maintained

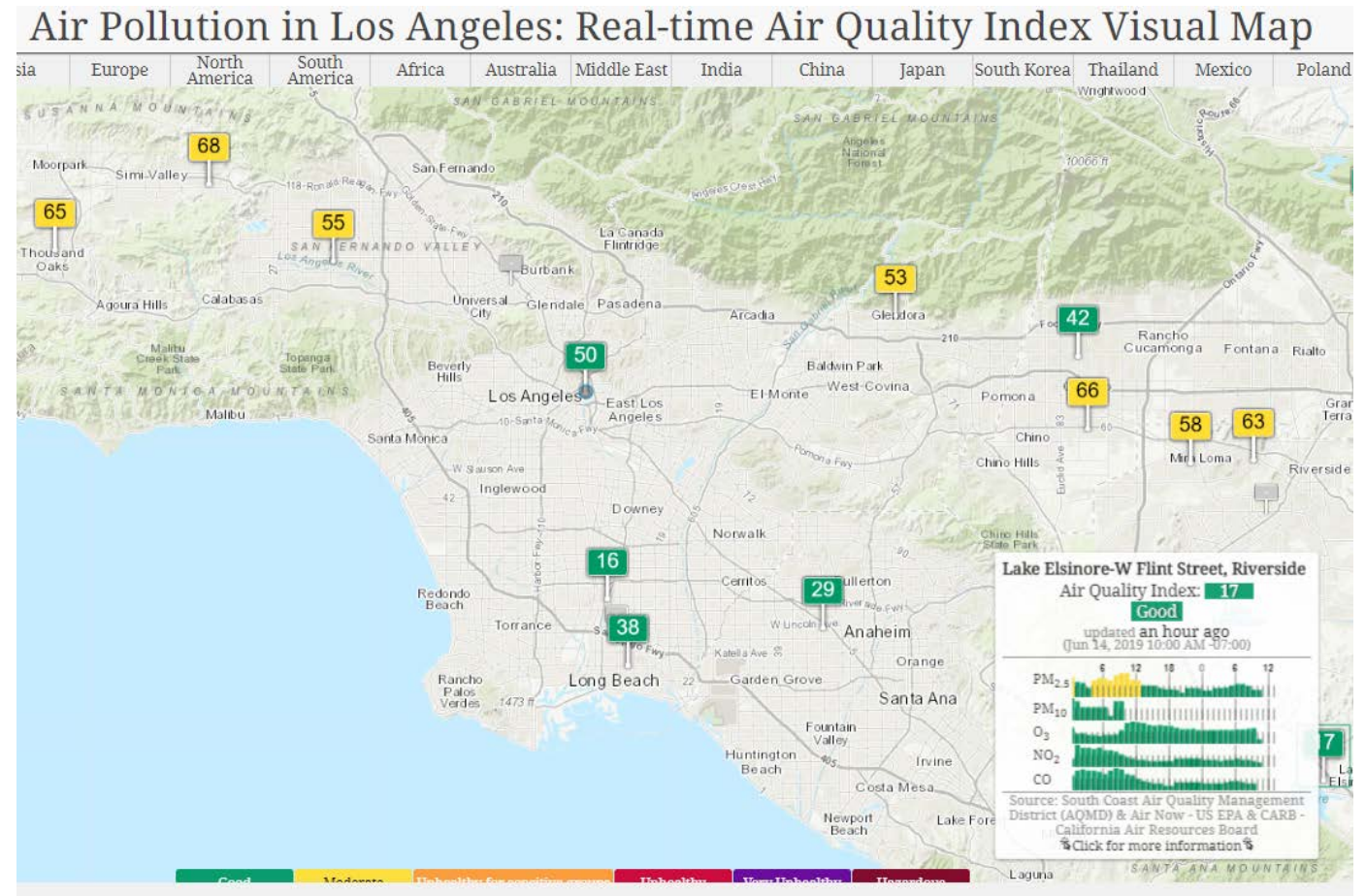
C. Support Air Pollution Research Studies

Provision of constant monitoring and sensing can create robust datasets with which research can be conducted, leading to better understanding of pollution and air quality trends.

Data vs. Resources: More Sites Provide More Data

Air Pollution concentrations can change on **very** small scales. Having more sites provides better understanding of air quality trends across cities and populations

As an example: California has over 62 continuous PM_{2.5} monitors – many in Los Angeles – allowing for measurement of pollution differences across cities, neighborhoods, and suburbs



<https://aqicn.org/map/los-angeles/>

Data vs. Resources: The Unavoidable Trade-off - Strategically Choosing Data Goals to Fit Budget Constraints

Comprehensive Monitoring is Expensive:

Costs for single stations can range from \$100,000-\$200,000 USD depending on how many species are measured

Monitoring multiple species at a single site is more cost-efficient to operate than scattering monitors across multiple sites

Establish priorities for air quality monitoring early

Determining realistic end goals early will simplify network planning

Project Title: Near Road NO2 Air Monitoring Station

▼ Grant Information

Grant ID Number:	XA - 96313701-0	AAShip:	R03 - Region 3
EPA Region:	EPA R3	Lab/Office:	
Division/Office:	Air Protection Division 3AP00	Media:	Air
CFDA:	66.034		
Grant Program:			
Authority:			
Recipient Name:	Allegheny County Health Department		
City:		Recipient Type:	County
State:	PA	Cong District:	14
		DUNS:	174669184
Competition Status:			
Award Date:	06/07/2012	Cum Award:	\$200,000
Project Start:	03/01/2012	Project End:	02/28/2014

▼ Project Title & Description

Yosemite.epa.gov/oarm

GRIMM PM Monitor
~ \$100,000 USD



BAM-1020
PM Monitor
~ \$20,000 USD



Station Purpose – Geographical Placement Determines How the Data are Used

Air Quality Monitoring sites can fit many data needs

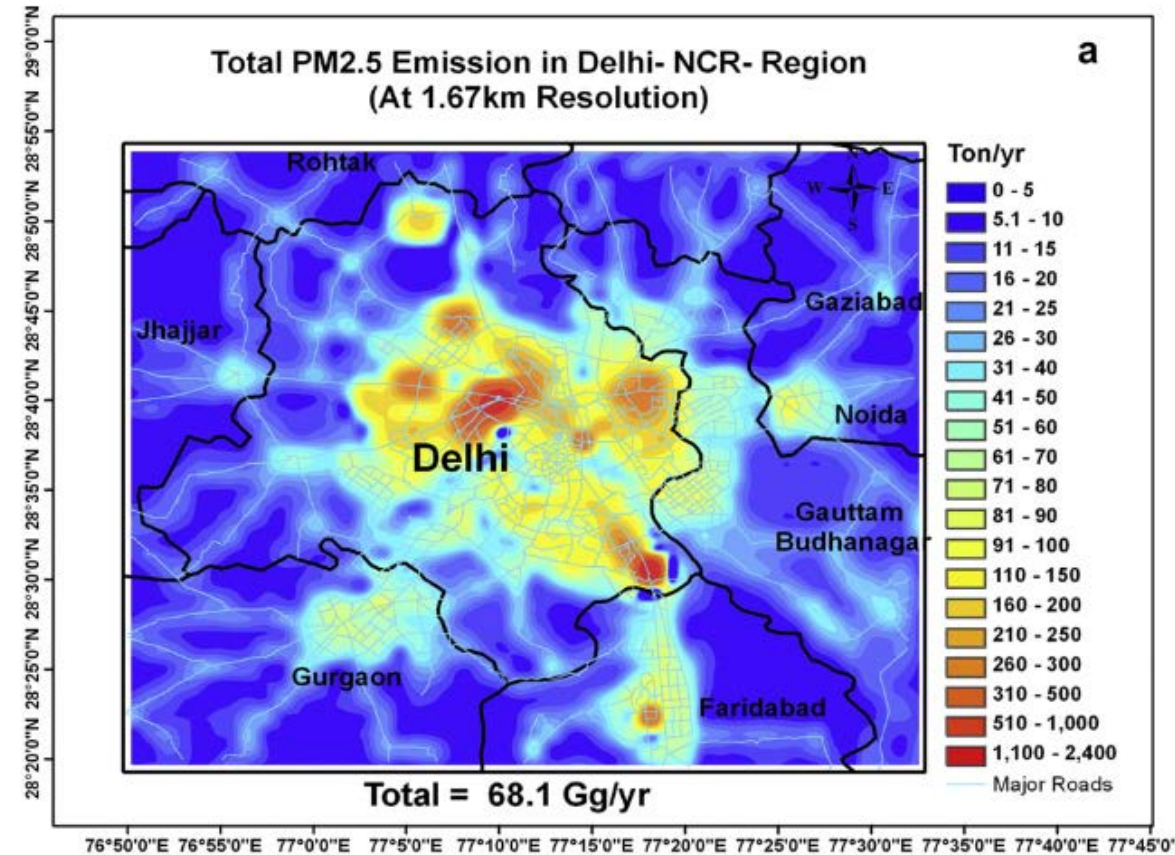
Code of US Federal Regulations – Title 40 offers
6 categories of monitoring station purpose:

- (1) Assess Highly Polluted Areas**
- (2) Monitor Densely Populated Areas**
- (3) Monitor Large Emission Contributors**
- (4) Conduct Research and Modeling Efforts on Pollution Transport**
- (5) Determine and Maintain Background levels**
- (6) Evaluate and Monitor Environmental Impacts Pollution has on Crops and Visibility**

Monitoring in Highly Polluted Areas

(1) Sites located to determine the highest concentrations expected to occur in the area covered by the network. (*Regulate Hot Spots*)

- Hot spots can form as result of multiple major source contributors.
- Geography and weather trends can also lead to major elevations in pollutant concentrations.
- Useful to monitor for regulatory purposes, also to ensure dangerous and life-threatening pollution levels are not reached



Sahu, Saroj Kumar, Gufran Beig, and Neha S. Parkhi. "Emissions inventory of anthropogenic PM_{2.5} and PM₁₀ in Delhi during Commonwealth Games 2010." *Atmospheric Environment* 45.34 (2011): 6180-6190.

Monitoring in Highly Populated Areas

(2) Sites located to measure typical concentrations in areas of high population density. (*Span the Most People*)

- Monitoring Stations in densely populated areas can offer air quality information to large numbers of citizens
- Useful for collecting data that can be used for epidemiological and health effects studies
- Many Management Plans use Population Density data as preliminary criteria for Station Citing

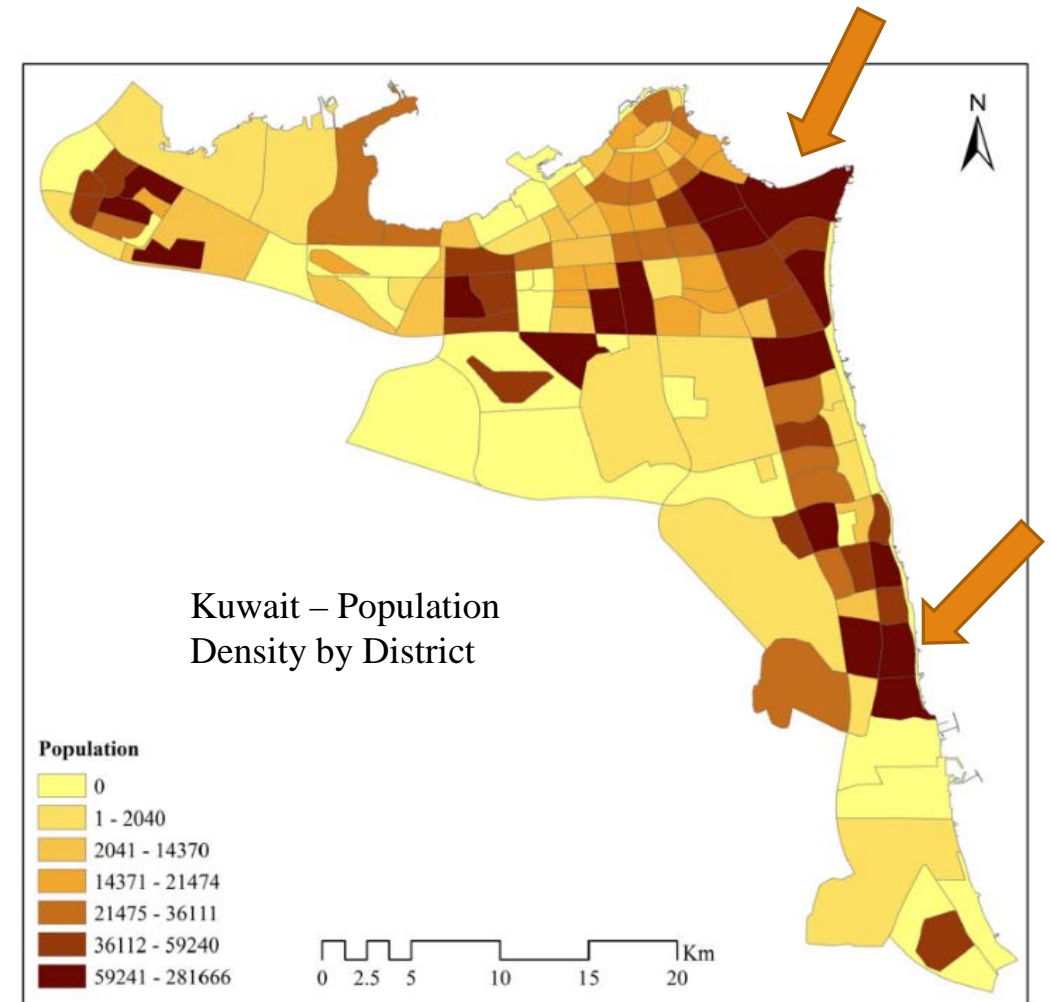


Fig. 2. Spatial distributions of Kuwait populations in 2011 at the district level (ASA, 2011).

Alsahli, Mohammad M., and Meshari Al-Harbi. "Allocating optimum sites for air quality monitoring stations using GIS suitability analysis." *Urban climate* 24 (2018): 875-886.

Monitoring Near Major Emission Sources

(3) Sites located to determine the impact of significant sources or source categories on air quality. (*Investigate Large Emissions Contributors*)

- Monitoring stations near specific source contributors can help in determining specific contributions from a particular area.
- Also useful in source apportionment to confirm chemical profile for a specific source

Major Emission Sources:

- Power Plants
- Factories or Industrial Processing Plants
 - Major Roadways or Highways
- Landfills or Waste Treatment Plants

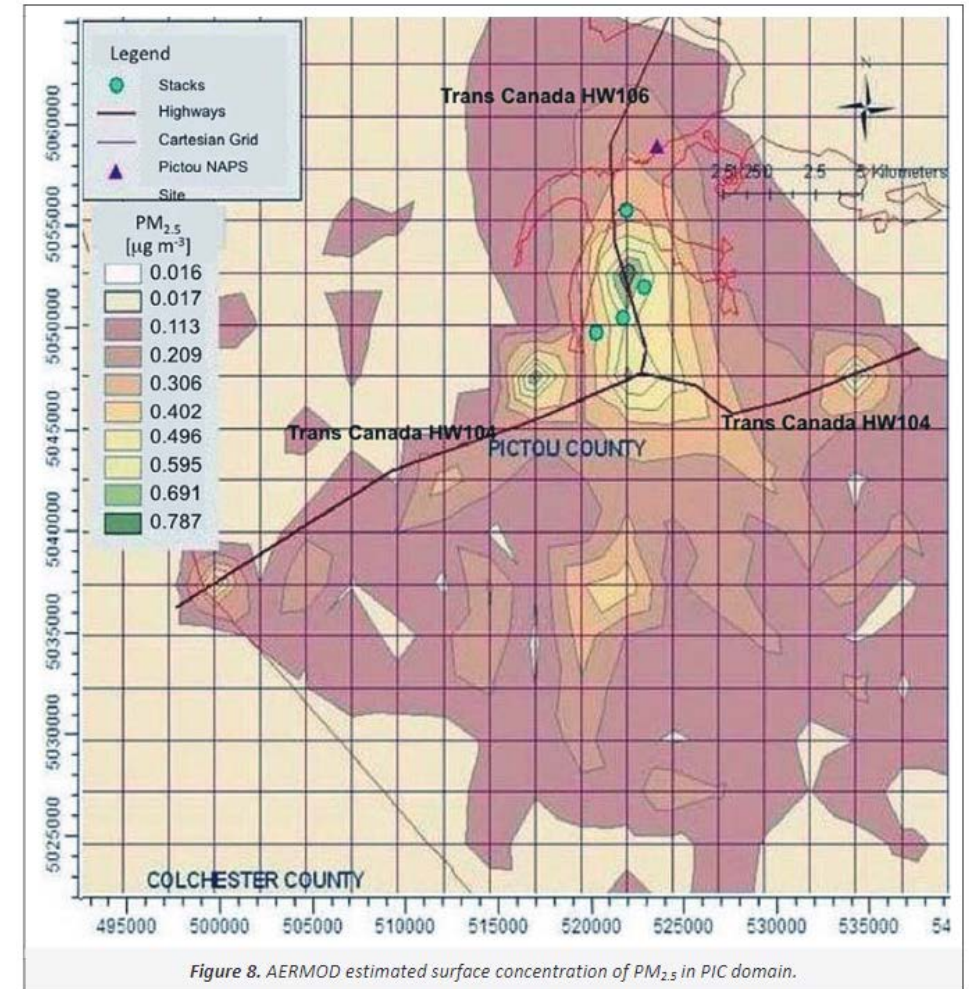


Picture credit: www.hies.nih.gov

Stations for Research, Transport Modeling, and Predication

(4) Sites located to determine the extent of regional pollutant transport among populated areas; and in support of secondary standards. (*Research Transport and Chemistry*)

- Stations can be used to validate pollution transport and dispersion models
- Generally placed downwind of major sources
- Also used for modeling chemical transport and secondary aerosol formation



Gibson, Mark D., Soumita Kundu, and Mysore Satish. "Dispersion model evaluation of PM_{2.5}, NO_x and SO₂ from point and major line sources in Nova Scotia, Canada using AERMOD Gaussian plume air dispersion model." *Atmospheric Pollution Research* 4.2 (2013): 157-167.

Monitoring Ambient Concentrations and Environmental Impact

(5) Sites located to determine general background concentration levels. (*Determine Background*)

- Away from major sources of emissions
- Assess how all sources and major emitters contribute to background levels outside of city
- Related to assessing pollution health effects for broader population



<https://dissolve.com> – Boston, MA suburbs

(6) Sites located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts. (*Assess Environmental Effects*)

- Monitoring sites in areas with agriculture or livestock can provide insight into air pollution effects on crops, produce, and farmland



WikiEducator – Air Pollution

Site Specific Considerations –Providing Accurate Measurements

Once a general location is determined for an air quality monitoring site – small scale precautions need to be taken into account to ensure equipment and sensors are accurately measuring air pollutants and the site is representative of analogous areas around the city.

At Site Considerations:

- Air Inlet Location
- Surrounding obstacles
- Air Flow
- Accessibility



www.fondriest.com

Air Inlet Dimensions and Height

- At least a 270 degree arc of air access – with no obstructions affecting airflow near sampler
- Inlet should be 2- 8 meters above the ground – this is considered to be the breathing zone.

Avoid sampling near rooftop fans, air conditioners, or sampler exhaust

- Ensure the sampler pump or fan exhaust is not near sampler inlet
- Can cause misrepresentative circulation of recycled air



www.fondriest.com

Nearby Buildings and Trees Can Affect Air Measurements

- Trees too close to monitors can scavenge pollutants and cause misrepresentation of air quality
- Trees higher than the inlet of a monitor should be more than **10-20 meters** away



<https://www.buncombecounty.org>



media.wired.com

- Unless measuring specific sources, inlet should be away from possible emission sources that may skew measurements
- Nearby buildings or walls should be at least 5 meters away from inlet
- 10 – 25m away from major roadways

Practical Considerations for Operating and Maintaining Sites

- Ease of Access for Filter Exchange and/or Maintenance
 - If monitoring site involves filter sampling – regular filter exchanges will require an easy to access sampler
- Security
 - Sampling equipment is expensive – a secure site will prevent vandalism and/or theft of devices
- Availability of Reliable Electricity
 - Easy access to power outlets is necessary unless sensors can run reliably on solar panels



Recommended Monitoring Stations for Early Air Quality Management

For early development of air monitoring networks site purpose (1) and (2) are most important:

- (1) Assess hot spot pollution areas – determines how air quality compares to worldwide regulations and recommendations (WHO, USEPA, EU)
- (2) Monitor in highly populated areas – provides data for assessing how pollution levels affect public health and citizen wellbeing



Picture credit: OrgangeSmile.com

Future Efforts and Monitoring Networks

Future funding and investment can start to unpack to air pollution's sources and provide justification for environmental policy

- (3) Monitor Large Emission Contributors
- (4) Conduct Research and Modeling Efforts on Pollution Transport
- (5) Determine and Maintain Background levels
- (6) Evaluate and Monitor Environmental Impacts Pollution has on Crops and Visibility



Picture credit: OrgangeSmile.com

Conclusions and Summary

- Monitoring Network Objectives
 - Public Reporting and Education
 - Maintaining Pollution Regulation
 - Research and Air Quality Trend Analysis

- Monitoring Station Specific Data Objectives
 - (1) Assess Highly Polluted Areas
 - (2) Monitor Densely Population Areas
 - (3) Monitor Large Emission Contributors
 - (4) Conduct Research and Modeling Efforts on Pollution Transport
 - (5) Determine and Maintain Background levels
 - (6) Evaluate and Monitor Environmental Impacts Pollution has on Crops and Visibility

- Resources vs. Data – Unavoidable trade-off
 - Make realistic data goals early in network development to fit budget constraints

- Site Specific Considerations
 - Unobstructed Air Inlets
 - Distance away from contaminating sources (exhaust vents, roadways)
 - Security and Accessibility
 - Electricity to power equipment

Citations and Additional Resources

Publications

Alsahli, Mohammad M., and Meshari Al-Harbi. "Allocating optimum sites for air quality monitoring stations using GIS suitability analysis." *Urban climate* 24 (2018): 875-886.

Duyzer, Jan, et al. "Representativeness of air quality monitoring networks." *Atmospheric Environment* 104 (2015): 88-101.

Gibson, Mark D., Soumita Kundu, and Mysore Satish. "Dispersion model evaluation of PM_{2.5}, NO_x and SO₂ from point and major line sources in Nova Scotia, Canada using AERMOD Gaussian plume air dispersion model." *Atmospheric Pollution Research* 4.2 (2013): 157-167.

Sahu, Saroj Kumar, Gufran Beig, and Neha S. Parkhi. "Emissions inventory of anthropogenic PM_{2.5} and PM₁₀ in Delhi during Commonwealth Games 2010." *Atmospheric Environment* 45.34 (2011): 6180-6190.

Government Resources

California Air Resources Board. "Particulate Matter Program"
<https://www.arb.ca.gov/pm/pm.htm>

Code of Federal Regulations, Title 40 Part 58: "Ambient Air Quality Surveillance"
40 C.F.R. § 58.10 2018.

Ambient Air Monitoring Network Assessment Guidance –
USEPA 454/D-07-001, February 2007

"Sampling Methods" EPA QA Handbook Volume II, Section 7.0

Directive 2008/50/EC of the European Parliament and of the Council of
21 May 2008 on Ambient Air Quality and Cleaner Air for Europe