EVIDENCE FOR POLICY DESIGN
Center for International Development
at Harvard University

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Identifying Delhi's Sources of Air Pollution for Effective Abatement Policies

Executive Summary

An effective air quality management programme requires reliable identification of pollution sources and their respective contributions to ambient pollution levels. The two approaches for source apportionment for particulate matter are: chemical analysis (receptor-based) and monitoring data (source-based).

We identify two shortcomings with use of these approaches in Delhi source apportionment studies:

(i) Inadequate source profiling, i.e. tracing of chemical elements in ambient PM2.5 and PM10 distinctly to specific sources.

(ii) Inadequate accounting for seasonal and spatial variation in source contribution.

We recommend Delhi government set clear standards for source apportionment studies:

For chemical analysis, this requires defining an adequate sample that covers different seasons and all dominant sources. In cases where budget is limited, priority should be given to source-based studies with high-quality data.

How are Source Apportionment Studies for Air Pollution Conducted?

Source apportionment studies—typically conducted at the city or airshed level—ask how specific pollution sources contribute to observed pollution levels, and are typically done in two ways:

1. Receptor-Based Modeling

Ambient samples are collected close to a polluting source and source-specific chemical elements are identified via comparison to source profile in lab. The chemical composition of ambient samples is expressed as a combination of contributions from each source.

Advantages	Disadvantages
❖ Based on direct pollution measurements	❖ Costly
❖ Identifies source contributions as shares of ambient concentration	❖ Differentiating sources with similar chemical signatures hard
❖ Step-by-step protocol with little margin for error	❖ Source profiles from secondary sources may be unreliable
	❖ Limited spatial coverage

2. Source-Based Modeling

An emissions inventory is built by collecting energy consumption data for each source. Emissions factors[1] are used to estimate *mass* emissions by sector. A dispersion model converts mass emissions to ambient concentration shares.

Advantages	Disadvantages
❖ Low-cost as most cities have emission inventories	❖ Data inaccuracies
❖ Common emissions factors across fuels (except for PM)	❖ Produces ambient mass contributions not concentration
❖ Accounts for meteorological features and local topography	❖ Difficult to estimate contributions from some sources (road dust, burning).
	❖ Sensitive to dispersion model assumptions

[1] Emissions=emissions factor*fuel use

International best practice is to use high quality receptor-based studies, based on direct pollution measurement, lab analysis, and use of sophisticated statistical techniques (European Commission, 2004; Pant and Harrison, 2012). However, if limited budget imply sparse pollution samples that cannot account for spatial and temporal variation in source contributions then emissions inventory studies dominate.

Source Apportionment Studies for Delhi

Since 2000, there have been 10 receptor-based and 5 source-based studies for Delhi (see Appendix Table 1). Main sources identified are: vehicles, manufacturing/power plants, construction, road dust, and waste burning. But, relative weights of different sources differ across studies. For example, vehicle source contributions range from 11%-62% for receptor-based studies and between 7%-34% for source-based studies; similar differences occur for other sources. We trace this divergence to two reasons:

1) ***Samples taken in different seasons and locations.*** Few studies create representative averages using samples collected throughout the year. The few that do differ in location coverage and so report different findings (Srivastava et al. (2009) uses six sites and find that vehicles and roadside dust make up 62% of ambient PM10 in winter, whereas Chowdhury et al. (2007) use single location data and report the equivalent share as 20%).

2) ***Emissions inventory data quality.*** Source contributions differ on whether source-based studies use primary or secondary data, and between PM2.5 and PM10. Guttikunda and Calori (2012) use an outdated emissions inventory with obsolete source activity data (such 4-year-old traffic data) and find road dust to be the dominant PM10 source (31%), while constituting a smaller fraction of PM2.5 (6%). CPCB (2010) construct an original emissions inventory and show that road dust, in addition to being the dominant source, is also a critical pollutant that makes up over half of ambient PM10 concentrations. This is not to say that source-based studies using primary data are always more reliable. For example, the latter study collects emissions data close to each receptor site and extrapolates to the municipal region using land use maps, which discounts important sub-urban sources such as brick kilns.

Recommendations

Delhi needs improved source apportionment studies that follow two guidelines:

1. For receptor-based methods, sampling should be large-scale enough to ensure adequate spatial and temporal variation for distinct PM2.5 and PM10 source profiles and representative conclusions about source apportionment. This will necessarily increase costs.
2. If the above is found too expensive, then emissions inventory studies—based on recent and high-quality activity data and emissions factors—should be commissioned.

References

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Appendix

Table 1—Delhi Source Apportionment Literature Review and Results

Sr. No.	Reference	Method	Results			
			Vehicle	Industry	Dust	Burning
1.	Balachandran et al. 2000	Receptor	59%	19%	15%	-
2	Khillare et al. 2004	Receptor*	60%**	-	22%	-
3	Chowdhury et al. 2007	Receptor***	Fossil fuels (coal, gas, diesel)-25-33%		20-36%	7-20%
4	Srivastava and Jain, 2007	Receptor*	11%	22%	50%	-
5	Srivastava and Jain, 2008	Receptor	62%	2%	35%	-
6	Chelani et al. 2010	Receptor*	10-44%	15-26%	10-42%	5-10%
7	CPCB, 2010	Receptor	14%	8%	45%	17%
8	Sridhar, 2010	Receptor	-	20%	25%	10%
9	Khillare and Sarkar, 2012	Receptor***	27-31%	4-21%	49-65%	-
10	Tiwari et al., 2013	Receptor*	-	-	-	-
11	Gurjar, 2004	Source-based	19%	80%	-	
12	CPCB, 2010	Source-Based	7%	22%	52%	-
13.	Mohan et al., 2007	Source-Based	-	-	-	-
14.	Guttikunda and Calori, 2012	Source-Based	25%	13%	9%	6%
15.	Guttikunda and Goel, 2013	Source-Based	16-34%	14-21%	5-6%	20-27%

*Factor analysis used to identify sources. **60% is for vehicles and industry combined. Authors could not separate. ***Result depends on season and/or location.