Air Pollution and Health: An Integrated Agenda

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Summary

• How air pollution can be better controlled by taking a total exposure approach
• The example of India
Estimated Burden of Disease for South Korea - 2016
Estimated Burden of Disease for India - 2016
Trend over time: South Korea
Trend over time: India
%PM$_{2.5}$ from “Residential” Emissions: NASA

~30% of primary particle pollution in India is from household fuels

Household Air Pollution from Solid Cooking Fuels in India

- Biggest impact in adults ~0.6-1.0 million premature deaths (two-thirds the DALYs)
- Still important for children ~40-60 thousand deaths (one-third the DALYs)
- Biggest single risk factor of any examined for Indian women and girls
- Important source of outdoor air pollution - ~30% in India
State-wise estimates of 24-h kitchen concentrations of PM2.5 in India

Solid-fuel using households

GBD
Ambient Air Pollution in India

• Largest environmental risk factor: 0.8-1.2 million deaths
• Largest health impact per capita in the world
• Many sources, both traditional and modern
• Many polluted cities, but rural areas also dirty
REGION: Urban Built-up Area of NCR Delhi
Modeled PM2.5 Source Contributions in μg/m3

WRF-CAMx forecasts; average of ~1600 1kmx1km urban grids of NCR. System details @ http://www.delhiairquality.info
Delhi’s pollution in 2016 – note effects of
1) the holiday (Diwali) and
2) crop residue burning
Ministry of Health and Family Welfare
Air Pollution Task Force

• First Ministry of Health in world to treat AP as one of its major priorities and consider along with other risk factors in its mission

• First government agency in the world not to address AP by location, but by total exposure – a true health focus

• Thus, not indoor/household, not outdoor, but by what will give the most health benefit
MoHFW AP Task Force

• One way of utilizing the total exposure approach is to estimate intake fraction by source category.
• Broken into “near field” and “ambient” intake fractions
• Emissions weighted essentially by proximity to population
• Goal is to change source apportionment to exposure apportionment
Introduction to Intake Fraction:

The quantification for policy of total exposure assessment
The Environmental Health Pathway
Environmental Pathway is different for different emission sources

Where are the people?
• How many, where, when, and for how long?
• Which kind of people (age, sex, health status) doing what (resting, working)
Much of the essence of exposure assessment can be captured by the concept of *Intake Fraction (IF)*

- *IF* is the fraction of material emitted that crosses some person’s physiological barriers (skin, GI tract, Resp. tract, etc.)

- For air pollution, *IF* is the fraction breathed in by the exposed population.
Intake Fraction Varies as Much as Toxicity (these are rough calculations for typical examples of sources in each class)

<table>
<thead>
<tr>
<th>Source</th>
<th>Grams Inhaled per Tonne Emitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Coal Power Plant</td>
<td>0.1</td>
</tr>
<tr>
<td>LDC Power Plant</td>
<td>1</td>
</tr>
<tr>
<td>Vehicles</td>
<td>10</td>
</tr>
<tr>
<td>Neighborhood Sources</td>
<td>100</td>
</tr>
<tr>
<td>Stove Vented Outdoors</td>
<td>1000</td>
</tr>
<tr>
<td>Stove Vented Indoors</td>
<td>10000</td>
</tr>
<tr>
<td>ETS</td>
<td>100000</td>
</tr>
<tr>
<td>Cigarette - mainstream</td>
<td>1000000</td>
</tr>
</tbody>
</table>

Smith, 1993

Grams Inhaled per Tonne Emitted
Power of Intake Fraction

- “Rule of One Thousand” = Pollutants released indoors are 1000 times more likely to reach someone’s lungs than if released outdoors.

- Sample comparison: U.S. power plant versus cigarettes
  - Source:
    - 1 ton coal = 1 million cigarettes (1 g each)
  - Emissions of particles
    - 1 ton coal = 24,000 cigarettes
  - Approximate particle intake equivalence
    - 1 ton coal = 24 cigarettes (ETS)

- Thus, even though there are more than 40 times more primary particles released from coal power plants in the US than from cigarettes, less than a 2-5% reduction in passive smoking (ETS exposures) would be equivalent to eliminating all the power plants in the country in terms of particle exposure.

Smith, 1988
Comparisons of Annual Population Intakes in California Based on IF Calculations

- **Vehicles**
  - 140 t CO
  - 12-40 kg benzene
  - 400 kg PM

- **ETS**
  - 8 t CO
  - 35 kg benzene
  - 1300 kg PM

Nazaroff & Lai, 2000
Emissions – PM$_{2.5}$

Draft MOHFW Report estimates by Guttikunda
## Ambient Intake Fractions in Hyderabad

ppm – grams inhaled per tonne emitted

<table>
<thead>
<tr>
<th>Category</th>
<th>Average</th>
<th>SD</th>
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<tbody>
<tr>
<td>Households</td>
<td>175</td>
<td>97</td>
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<tr>
<td>Construction</td>
<td>175</td>
<td>93</td>
</tr>
<tr>
<td>Waste.burn</td>
<td>140</td>
<td>74</td>
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<td>Veh.exhaust</td>
<td>130</td>
<td>64</td>
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<tr>
<td>Gen.sets</td>
<td>123</td>
<td>53</td>
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<tr>
<td>Industries</td>
<td>65</td>
<td>17</td>
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<tr>
<td>Dust</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Power plants</td>
<td>7.4</td>
<td>7.0</td>
</tr>
<tr>
<td>Brick.kilns</td>
<td>6.8</td>
<td>1.9</td>
</tr>
</tbody>
</table>
Hyderabad-2012

Ambient Exposures – PM$_{2.5}$

Emissions – PM$_{2.5}$

Draft MOHFW Report estimates by Guttikunda
MoHFW AP Task Force, cont.

• Nearfield intake fractions not as well developed but important for local sources
  – Vehicles
  – Neighborhood waste burning
  – Gen sets
  – Households

• Preliminary estimates of household nearfield intake fractions are about 5x those from ambient (downwind exposures) in Hyderabad (850 vrs 175 ppm)
MoHFW AP Task Force, cont.

- There are other ways of using total exposure in policy: without intake fraction
- Monitoring of carefully selected and representative populations using small personal monitors, e.g. on cell phones
- Measuring carefully selected microenvironments and combine with regular surveys of time use
- Others also
Heath versus Environment

- Health sector has vast resources not available to environment ministries
- In India, 1 million local health workers
- Hospitals, public health clinics, health science schools, professional associations,
- Also much public credibility
- And a focus on health, not environmental quality.
Collaborative Clean Air Policy Centre

Many thanks

Publications and presentations on website – easiest to just “google” Kirk R. Smith

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Paracelsus Updated

• Not only does
  The Dose Make the Poison
• But also,
  The Place Makes the Dose
And thus,
  The Place Makes the Poison