HAP, PAH and Health

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Polycyclic Aromatic Hydrocarbons (PAH)

class 100+ chemicals composed of up to six fused benzene rings

EPA 16 Priority PAH

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benz[a]anthracene
- Benzo[b]fluoranthene
- Benzo[k]fluoranthene
- Benzo[g,h,i]perylene
- Benzo[a]pyrene
- Chrysene
- Dibenz[a]anthracene
- Fluoranthene
- Fluorene
- Indene[1,2,3 cd pyrene]
- Naphtalene
- Phenanthrene
- Pyrene
PAH and Soot Formation

A schematic of the Surface Shell Formation Model by Mohammad Reza Kholghy
Nitro and Oxy PAH

Formed during combustion and through atmospheric reactions processing

EFs of pPAHs, nPAHs, and oPAHs were positively correlated.

EFs of pPAHs, nPAHs, and oPAHs were significantly correlated with modified combustion efficiency and fuel moisture.

-Shen et al. 2013 ES&T
Sources of PAH

- Formed from combustion of carbon containing compounds
PAH Emissions and Solid Fuels

Emission factors of PAH vary by fuel type

• Onah et al. ES&T 1999
• Emission factor of PAH 2x wood vs coal briquettes – Lee et al EST 2005
• coal cake emissions as high or higher than wood and biomass fuels Shen et al. ES&T 2013, 2013
PAH emissions from cooking fuels

- Kerosene emission factor (mg/kg) similar to wood
- Kerosene emission factor 2x greater for MJ/kg
  - Onah et al. ES&T 2002
Route of Exposure

- Skin absorption
- Ingestion
- Inhalation
## WHO Guidelines for Indoor Air Quality

<table>
<thead>
<tr>
<th>Source</th>
<th>Concentration (μg/m³)</th>
<th>Comment</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETS</td>
<td>0.02–0.84</td>
<td>Pubs and restaurants (16 PAHs) (^a)</td>
<td>Harrison et al. (39); Bolte et al. (40)</td>
</tr>
<tr>
<td>Fuel</td>
<td>0.11</td>
<td>LPG for cooking</td>
<td>Raiyani et al. (36)</td>
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<tr>
<td></td>
<td>0.27–0.31</td>
<td>Kerosene for cooking</td>
<td>Raiyani et al. (36)</td>
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<td></td>
<td>1.22–1.9</td>
<td>Cattle dung and wood as cooking fuel</td>
<td>Raiyani et al. (36)</td>
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<tr>
<td></td>
<td>2.01</td>
<td>45–60 minutes, 16 PAHs, (^a) wood cooking fuel</td>
<td>Raiyani et al. (38)</td>
</tr>
<tr>
<td></td>
<td>3.46</td>
<td>45–60 minutes, 16 PAHs, (^a) dung cake cooking fuel</td>
<td>Raiyani et al. (38)</td>
</tr>
<tr>
<td></td>
<td>3.56</td>
<td>45–60 minutes, 16 PAHs, (^a) dung cake cooking fuel</td>
<td>Raiyani et al. (38)</td>
</tr>
<tr>
<td>Cooking</td>
<td>7.6</td>
<td>Chinese domestic cooking, 12 PAHs (^b)</td>
<td>Zhu &amp; Wang (41)</td>
</tr>
<tr>
<td>Heating</td>
<td>0.164</td>
<td>Kerosene stoves in Indian homes, 12 PAHs (^b)</td>
<td>Pandit et al. (37)</td>
</tr>
</tbody>
</table>
PAH Cooking Exposures

• daily mean (BaP) eq. exposure 0.2 μg/m³ in the winter vs 0.059 μg/m³ for control group—Ding et al Envr Poll 2012

• 1 μg/m³ BaP in kitchens cooking with biomass in North India – Ansar et al. 2009

Occupational Exposures

• 10 μg/m³ of BaP in air near coke ovens
PAH exposures and cookstoves

• 20-48% reduction of urinary PAH biomarkers from the use of improved Patsari stove in Mexico - Riojas-Rodriguez et al. EHP 2011

• 19%-52% reduction in urinary biomarkers after installation of improved biomass stove in Peru - Z et al. Environment International 2011
Health Impacts of PAH

- mutagenic and genotoxic, and induce DNA adduct formation
- B[\(a\)]P and a number of 4- to 7-ring PAHs are carcinogenic
- PAH exposures have led to PAH-DNA adducts
CVD and PAH

• PAHs, including B[\(\alpha\)] P and anthracene isomers have accelerated atherosclerosis plaque formation in animal studies \text{Penn et al. Carcinogenesis 1988}

• IHD 60% increased risk for 273 ng/m\(^3\)> among male European and Israeli asphalt workers – \text{Burstyn et al. Epidemiology 2005}

• CVD associated with phenanthrene biomarker using NHANES – \text{XU et al. 2010 S of the TE}
Prenatal PAH Exposures and Health Impacts

• high prenatal exposure to PAHs increased risk for LBW – Perera et al. EHP 2003
• prenatal exposure to PAH air pollutants contributes to behavioral problems from impacted brain development – Peterson et al. JAMA Psychiatry. 2015
  – slower processing speed,
  – ADHD symptoms, and
  – externalizing problems in urban youth
• Congenital heart defects and neural tube defects
Assessing Exposures

- Airborne
- Dietary assessment
- Urinary biomarkers
Assessing Exposures

• 100+ compounds
  – Oxygenated
  – Nitrogenated
  – Gas phase, particle phase, semivolutiles

• Cost

• Logistics
Black Carbon and PAH

Arnott et al. ES&T 2005
Thank You

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