Health Effects of Shipping Related Air Pollutants

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Overview
With the South California Coast Air Basin as an example

• Contribution of Marine Vessels to potential health problem
• Lung - the major organ affected
• Health and Environmental Effects of different classes of air pollutants
• Summary and Current Studies
Marine Vessels are a Major Source of Air Pollution
South Coast Air Quality Management District
News 7/8/98

“Ocean going ships, harbor tugs and commercial boats emit TWICE as many smog forming emissions as all of the South coast Air Quality Management District’s power plants”

SCAQMD Estimated Annual Average Emissions 2000 Tons / Day

<table>
<thead>
<tr>
<th>Source</th>
<th>ROG</th>
<th>CO</th>
<th>NOx</th>
<th>SOx</th>
<th>PM10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total SC Air Basin</td>
<td>1094</td>
<td>7286</td>
<td>1212</td>
<td>90.3</td>
<td>374.3</td>
</tr>
<tr>
<td>Marine: Total</td>
<td>54.3</td>
<td>312.6</td>
<td>54.4</td>
<td>27.2</td>
<td>5.20</td>
</tr>
<tr>
<td>&quot; : Commercial</td>
<td>4.29</td>
<td>5.26</td>
<td>43.7</td>
<td>27.1</td>
<td>3.14</td>
</tr>
<tr>
<td>&quot; : Recreation</td>
<td>50.0</td>
<td>307.3</td>
<td>10.7</td>
<td>0.17</td>
<td>2.06</td>
</tr>
<tr>
<td>% of SC Basin:  Percentages</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comm. Marine</td>
<td>0.39</td>
<td>0.07</td>
<td>3.61</td>
<td>30.0</td>
<td>0.84</td>
</tr>
<tr>
<td>Total Marine</td>
<td>4.96</td>
<td>4.29</td>
<td>4.49</td>
<td>30.2</td>
<td>1.39</td>
</tr>
<tr>
<td>Tot. Marine as % Total Mobile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.96</td>
<td>4.57</td>
<td>5.11</td>
<td>42.2</td>
<td>12.4</td>
</tr>
</tbody>
</table>
Exposure to Airborne Materials

Average Adult breathes about 11,000 liters / day.

The Respiratory Tract and Lung are the sites of primary exposure to air pollutants.
Lower Respiratory Tract

Alveolar / Capillary Interface
Health Effects of Oxidant Air Pollutants

OXIDANTS  Ozone (O3) and Nitrogen dioxide (NO₂)

\[ \text{NOx} + \text{Reactive Organic Gases (ROG)} + \]
\[ \downarrow \]
\[ \text{OZONE} \]
\[ \downarrow \]
\[ \text{SMOG} \]

Health Effects of Oxidants

- Both Ozone and NO2 are strong oxidizing agents and will damage lung tissue, causing inflammation.
- Lung damage, and reduced lung function
- Increased Respiratory Illness
- Aggravates breathing problems, cough, chest pain and Asthma
Environmental Effects of Oxidants
\( \text{NO}_2 \) and \( \text{O}_3 \)

- Oxidant damage to leaves
- Crop loss
  
  (in CA = $300 - 700 million / year)
- Damage to rubber and plastics
- Damage to Ecosystems
Sulfur Dioxide Health Effects

Short Term Exposure:
- Irritates and Restricts Airways
- Chest Tightness
- Reduces Mucus Clearance

Long Term Exposure, few studies, but suggest:
- Bronchitis
- Suppresses Immune System
Sulfur Dioxide in the Environment

- Effective restrictions on sulfur content of fuels -
- Ambient $\text{SO}_2$ in CA $\downarrow$ by > 60% over 20 years
- Shipping produces considerable percent of total $\text{SO}_2$ in CA.
- $\text{SO}_2$ Remains problem in Eastern USA
  - Acid Rain, deposition $\rightarrow$ degradation of crops, water, environment
What are PM10 and PM2.5?

PM 10: Particulate material with a diameter of 10 microns or less

PM 2.5: Particulate material with a diameter of 2.5 microns or less
What particles are of concern?

- Particles 10 microns or less (PM10) bypass body's defenses and enter lung
- **Coarse** fraction (>2.5-10 µm) deposits in the airways, the deep lung
- **Fine** fraction (<2.5 µ m) easily penetrates to deep lung
- **Ultrafine** fraction (<0.1 µ m) like gases--spread throughout lung

What are the health effects of particles?

Studies show particles damage lungs:
- Increase asthma attacks
- Aggravate bronchitis
- Reduce lung function growth in children
- Contribute to premature death and hospital visits of people with respiratory and cardiac problems
Health Effects of Diesel and Heavy Fuel Oils

- **Ultrafine PM** \(< 0.1\mu m\) associated with:
  - Respiratory Illness, Cancer,
  - Asthma (bound allergens)
  - Cardiovascular Disease
  - Decreased lung function
- **Toxic Air Contaminants** - Lung and Bladder cancer
- **Pollutant gases** - Respiratory, Cardiopulmonary and ecological effects

2/1/01

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Diesel PM’s Contribution to Potential Cancer Risk from Ambient Air in California

<table>
<thead>
<tr>
<th>Component</th>
<th>Cancer Risk * Excess Cancers / million people</th>
<th>Contribution to total Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cancer Risk</td>
<td>758</td>
<td></td>
</tr>
<tr>
<td>Diesel Exhaust PM</td>
<td>540</td>
<td>71.2%</td>
</tr>
<tr>
<td>1,3 Butadiene</td>
<td>74</td>
<td>9.8%</td>
</tr>
<tr>
<td>Benzene</td>
<td>57</td>
<td>7.5%</td>
</tr>
<tr>
<td>Other VOCs **</td>
<td>78</td>
<td>10.4%</td>
</tr>
</tbody>
</table>

Based on the 2000 Emission Inventory, assuming exposed for 70 years, inhalation route only.

** Carbon tetrachloride, polycyclic aromatic hydrocarbons, e.t.c.

ARB October 2000

2/1/01
Health Effects - Summary

Urban Ambient Air Quality is still not acceptable
- Oxidant levels (smog)
- PM
- Toxic Air Contaminants (TACs)

Marine Vessels contribute to Air Pollution on land
- major problems NOx and ROG (form Ozone)
- PM (Ultrafines from Diesel) and TACs
- SOx

What we still need to know:
Current Studies (ARB)

Long term Effects of Air Pollution
Children’s Health Study (USC)
Fresno Asthmatic Children’s Environment Study (UCB)

Mechanism of Effect of PM especially Ultrafines
Ambient Aerosol Concentrator / Toxicology
(UCLA / USC)

Investigation of Complex Mixes
Ozone, NO₂ and CO / Controlled Exposures (UCSF)