Formaldehyde and Other Air Toxics: Risk and Exposure Assessment

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Introduction

Formaldehyde is listed as a probable human carcinogen¹ or a known human carcinogen², and acute and chronic exposure can lead to respiratory health effects, eye, nose, and throat irritation, and allergic sensitization³. Objectives of this research:

- Characterize population risk due to formaldehyde inhalation exposure both in the home and outdoors.
- Identify sources of formaldehyde and other air pollutants.

Studies

1. Lewiston-Clarkston Valley Air Toxics Study: A 2006 EPA study in the LCV showed above average formaldehyde and acetaldehyde concentrations for a rural area, recommending continued monitoring of the area. Data was collected using methods shown below from three sites in July 2016 and 2017: Hawai., Asotin, and Sunset Park.

2. EPA Indoor Air Quality Study: This study, focused in Pullman, WA, aims to collect more data about air quality in the home. Indoor and Outdoor PTR-MS data for a variety of compounds has been collected for six homes in both fall/winter and spring/summer months and air canister samples for houses 4,5,5, and 7 were obtained.

Risk Assessment Methods:

- Risk characterization based on the Environmental Protection Agency’s Integrated Risk Information System (IRIS) was performed for both studies:
  - Cancer: Excess cancer risk per million people was calculated using the IRIS Inhalation Unit Risk of 1.30E-5 µg/m³. The EPA predicts that a person inhaling air at this concentration over their lifetime would have < 1 E6 chance of cancer incidence due to formaldehyde. Multiplying by the observed concentration, this predicts the excess probability of cancer incidence per person. A pressure of 0.9 atm and a temperature of 23°C were used for outdoor summer calculations, 21°C for indoor calculations, and 4.5°C for outdoor winter calculations when converting between ppb and µg/m³.
  - Chronic: Non-cancer health endpoints were evaluated using the inhalation Reference Concentration (RfC) and Regional Screening Level (RSL) from the EPA. Using the RfC of 9.83E-3 mg/m³, screening levels for both residents and outdoor workers were used to compare the relative safety of conditions in the home and outdoors.

Air toxics Measurements:

- In addition to these air toxics measurements from 2016, 2017 analysis included SO2 event triggered samplers to collect 2 minute grab samples that may be linked to the sulfur-emitting Clearwater Pulp and Paper Mill in Lewiston.

Risk Assessment Results

- Figure 2 shows the 10th, 25th, 50th, 75th, and 90th percentile and average cancer risk per million people for each Lewiston-Clarkston Valley site, and Figure 3 does the same for each house in the IAQ study—both indoor and outdoor measurements in summer and winter months. Figure 4 shows the yearly indoor median for each house and each LCV site compared to EPA Regional Screening Levels. Indoor air concentrations of formaldehyde were consistently higher than outdoors, even in the relatively polluted sites in the LCV. No data was available for H3 or H5 in the winter.

- Figure 5 indicates that SO2 is a good tracer for pulp mill emissions. Known pulp tracers in the SO2 grab samples are generally higher than the 12-hour samples (Fig.7), while vehicle exhaust tracers are generally correlated diurnal variations in SO2 and HCHO, with peaks from 6-8 am.

- Figure 6. Quantitative GC-MS data of abundant tracers of vehicle exhaust, collected from Sunset site. SO2 grab samples have responses generally lower than 12-hr samples.

- Figure 7. Quantitative/quantitative GC-MS data of pulp mill tracer compounds, collected at Sunset site. SO2 grab samples have areas/responses generally higher than 12-hr samples.

Indoor Air Composition Source Analysis

<table>
<thead>
<tr>
<th>House 4</th>
<th>House 5</th>
<th>House 6</th>
<th>House 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>Isopentane</td>
<td>Ethanol</td>
<td>Tolune</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Acetone</td>
<td>1,2,3-trimethyl benzene</td>
<td>2-methanol</td>
</tr>
<tr>
<td>Di-isobutene</td>
<td>Isopropyl alcohol</td>
<td>Isopropyl alcohol</td>
<td>Butane</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>Hexanal</td>
<td>Acetone</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Hexanal</td>
<td>Styrene</td>
<td>Tolune</td>
<td>Acetone</td>
</tr>
<tr>
<td>Isopentane</td>
<td>A-pinene</td>
<td>1,3-difluorobenzene</td>
<td>Isopropyl alcohol</td>
</tr>
<tr>
<td>Methanol</td>
<td>P-xylene</td>
<td>Di-methyleo</td>
<td>Heptal</td>
</tr>
<tr>
<td>1,4-dioxybenzene</td>
<td>Tolune</td>
<td>Ethyl acetate</td>
<td>P-xylene</td>
</tr>
<tr>
<td>Benzaldehyde</td>
<td>Di-isobutene</td>
<td>Isopentane</td>
<td>Tolune</td>
</tr>
</tbody>
</table>

Figure 8. Qualitative results from GC-MS analysis of indoor canister samples, from most abundant (top row).

- Some compounds such as ethyl acetate, acetone, styrene, methanol, and trimethyl benzene have some sources in common with formaldehyde: adhesives and/or wood products.
- Other common sources of compounds above include cleaning products (d-limonene, o-pinene, eucalyptol), shave gels/body wash (isopentane, isobutane), and aerosols (butane, ethyl acetate, benzaldehyde).
- Formaldehyde is a secondary product of VOCs; this may explain a source in the home.

Discussion and Conclusions

- Overall, indoor risk of cancer and non-cancer endpoints due to formaldehyde inhalation is far higher than outdoor risk.
- In the LCV, the Clearwater Pulp and Paper Mill emits SO2, which is strongly correlated with formaldehyde and shows diurnal variations. This indicates the HCHO we measured came from the mill.
- Fig. 4 and 5 indicate that SO2 is a good tracer for pulp mill emissions. Known pulp tracers in the SO2 grab samples are generally higher than the 12-hour samples (Fig.7), while vehicle exhaust tracers are generally lower or varied in the SO2 grab samples (Fig. 6). This provides further evidence that SO2 grabs are coming from the pulp mill stack. These samples will help us characterize other pulp mill emissions in the future.
- As homes become more energy efficient, entrapment of air toxics may present a significant public health problem. Further research and regulation must be done to identify hazardous substances in the home and to mitigate their effects.

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