Source Characterization from Indoor Air Concentration Data – Quinoline Example

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AIHCE
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Quinoline

CAS: 91-22-5
MW: 129.16
VP: 1 mmHg @ 60°C
Chronic rat LOAEL = 25 mg/kg/day
Questions Under Study

- Are there indoor sources of quinoline contributing to indoor air levels?
- What is their magnitude?
- Are the known sources sufficient to explain reported indoor air levels?
- If not, what sources could be responsible for the indoor air findings?
EXPOSURE Analysis

• The data show that indoor air is a significant source of exposure.
• Composite sample from 757 Canadian homes of 22 g/m³ (Otson, et al, 1994).
• Ohio study found 16 g/m³ indoors while there was 3.3 g/m³ outdoors. (Hawthorne and Seivers, 1984).
Using 3.3 g/m³ as the estimated outdoor quinoline concentrations and 22 g/m³ as the mean level in indoor air allows for an analysis of the indoor sources that caused this airborne concentration.
Technical Rationale

- Air in residences typically undergoes an exchange rate with outdoor air in the approximate range of 0.3 to 3 mixing changes per hour (Murray, D.M. and Burmaster, D.E., 1995; Wallace, L. et al, 2002; Wilson A.L., 1996),

- Thus, measurements of indoor air concentrations represent a record of the contemporary input and outflow of the measured agent.
• Consider a room with an initial fixed level of airborne concentration \( C_0 = 100 \) and no new material entering the room air. This is described as:

\[
C = C_0 \ e^{-\left(\frac{\text{ventilation rate}}{\text{volume}}\right)(\text{time})}
\]

• When \( \text{(ventilation rate)(time)} \) equals the room volume, a single mixing air change has occurred and \( C = C_0 \ e^{-1} \) or \( C/ C_0 = .368. \) (i.e., 63% has been removed)
Rationale (con’t)

• Assuming 22 g/m$^3$ indoors and an outdoor concentration of 3.3 g/m$^3$, the concentration of quinoline indoors is being caused by dynamic sources inside the house.

• Since measured airborne concentration is a time-weighted average value of the concentration exiting the room, then it follows that there was a similar input of material mass to the room air during that period of time.
In short, measured airborne concentrations indoors can be used to infer information about the strength of the indoor sources of quinoline that caused these concentrations.
\[ V dC = G dt - QC dt \]

- \( V \) = volume of the home or room (for room-specific sources).
- \( C \) = concentration of air contaminant (mass/unit volume).
- \( G \) = source or generation rate of contaminant (mass/time).
- \( Q \) = ventilation rate (mixing volume of air/unit time).
- \( t \) = time
At Equilibrium with $G$, $Q$ and $V$ constant.

\[ C = \frac{G}{Q} \]

\[ G = CQ \]
Back Calculation of Quinoline Indoor Source Strength using the following:

- Concentration in indoor air = 22 g/m³
- Concentration in outdoor air = 3.3 g/m³
- Home floor area = 2500 ft²
- Home volume (8 ft ceiling) = 20000 ft³
- Home volume (m³) = 566 m³
- ACH = 0.6 /hr
Source Strength (Mass Released to Indoor Air)

- Approximately 6 milligrams per hour of quinoline are entering the interior air space of the home under consideration;
- This corresponds to 1 gram/week;
- Are the known sources sufficient to explain this finding?
### Amount of Consumer Product Needed Each day
to Explain Source Strength of Quinoline

<table>
<thead>
<tr>
<th>Product</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarettes @ 0.020 mg/cig</td>
<td>7200</td>
</tr>
<tr>
<td>Powdered Laundry detergent</td>
<td>3359</td>
</tr>
<tr>
<td>Liquid Laundry detergent</td>
<td>3427622</td>
</tr>
<tr>
<td>Drier-added fabric softener</td>
<td>305</td>
</tr>
<tr>
<td>Liquid Fabric Softener</td>
<td>5872</td>
</tr>
<tr>
<td>Liquid Dishwashing Detergent</td>
<td>1312137</td>
</tr>
<tr>
<td>Household cleaner</td>
<td>55984</td>
</tr>
</tbody>
</table>
Conclusions

• Assuming **all** the quinoline in each of the various consumer products considered in the supporting working document is released into the air in a single day would require thousands of cigarettes or hundreds of pounds-to-tons of these products to be in the home in order to approximate this source strength.

• Thus, the primary source of the quinoline found in the indoor air of Canadian homes is **not** from these consumer products and remains unaccounted for in the indoor environment.
What Source of Quinoline Could Explain This level

- A puddle of pure quinoline with an area of 50-150 cm² vaporizing into the home (about ¼ of the area of a single sheet of paper).
- A puddle of a mixture of quinoline (with a molar fraction of 1%) of 0.5-1.5 m² (about the size of a table top of a small table).
- Such a vaporizing area must be constantly renewed.
- This suggests that some type of forced introduction an aerosolized liquid or vapors from a heated liquid.
Where is the Quinoline Coming From?

- A testable hypothesis is that the quinoline may be coming from indoors sources of incomplete combustion.
- The reasoning behind this supposition is that fossil fuel typically contains 0.3-2% nitrogen mostly in the form of heterocyclic compounds of which quinoline is believed to be an important component.
What it could mean for Non-inhalation Exposure & Risk

• Relatively high indoor air concentrations of quinoline could mean significant dislodgeable concentrations of this compound on smooth surfaces from the air-to-surface deposition of this semi-volatile compound and thus the potential for dermal and oral (hand-to-mouth) exposure.

• Air-to-food deposition and subsequent ingestion in this near-field environment is also a distinct possibility.
Mean Air Exposure

- Sample of 22 g/m³ from a composite of 757 samples
- Hypothesis 1 –
  - Quinoline levels follow a log normal distribution
  - Assuming a geometric standard deviation (GSD) of 2 (a value that could be expected based just on the variation in air exchange rates)
  - The 95th percentile will be 3.2 times higher than the median
- Hypothesis 2 –
  - Home with certain heating sources (oil) will be higher than those with natural gas or electric
  - There are homes with levels 2-3 times higher
Risk Implications

- Limited Toxicity data
- MOE (chronic rat LOAEL) using mean level
  \[ = \frac{25\text{mg/kg/day}}{0.019 \text{mg/kg/day}} \]
  \[ = 2,100 \]
- MOE using 95th percentile
  \[ = \frac{25\text{mg/kg/day}}{0.464 \text{mg/kg/day}} \]
  \[ = 540 \]
Conclusion

• Health Canada was justified in concluding that (absent further data) the Ministers consider this compound to be “toxic”
• Indoor air levels present a concern for quinoline both directly and by suggestion from indirect pathways
• The source of the indoor air levels is not clear
• Suggests the need for additional monitoring