Health risk assessment related to mercury exposure from consumption of fish from a proposed hydroelectric complex

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Mercury and Reservoirs

- Reservoir impoundment causes temporary increases of mercury levels in fish (10 to 30 years)
- Maximum levels in new reservoirs reach 0.5 mg kg\(^{-1}\) (ww) in non-piscivorous species and 2.0 to 4.0 mg kg\(^{-1}\) (ww) in piscivorous species
- Potential health risk to fish consumers
- A reduction of fish consumption is also a public health concern
Mercury and Reservoir Projects

- Hydroelectric projects subjected to EIAs and public hearings
- Building permits are awarded with the condition that mercury health risk management and communication programs for fish consumers be established
- Need for a Health Risk Assessment Method
Health Risk Assessment related to fish consumption

- Total Installed capacity: 1,500 MW
- Terrestrial flooded area: 220 km²

Romaine Complex Project

- 4 Power houses
- 4 Reservoirs
Health Risk Assessment

- **Approach**
  - Determine current Hg exposure of local populations
    - Current sources of Hg in diet of local populations
    - Current Hg levels in main sources of mercury
  - Determine future exposure of local populations
    - Future mercury levels in sources of mercury affected by the project
    - Fish consumption scenarios
    -Declared intention of fishing in reservoirs
  - Determine additional health risk by comparing future exposure with recognized health effect thresholds
Health Risk Assessment

» Current mercury exposure

- Mercury in hair analysis
  - 3 local populations
    - Havre-Saint-Pierre (N = 94)
    - Longue-pointe-de-Mingan (N = 60)
    - Mingan (Innu) (N = 36)
  - Targeted groups
    - General population, Fishers, Non fishers
    - Men, women, women (18-39 years old)
Health Risk Assessment

- Current sources of mercury in diet
  - Questionnaire
    - Store-bought food
    - Consumption of local fish and wildlife
    - Harvest area
    - Proportion of project-affected Hg sources

- Current Hg levels in diet
  - Sport or subsistence fishing and hunting
  - Store-bought (Restaurant and grocery)
### Current Proportion of Mercury Sources in the Diet of the 3 Local Populations

<table>
<thead>
<tr>
<th>Current sources of Hg</th>
<th>Ekuanitshit (%)</th>
<th>Havre-Saint-Pierre (%)</th>
<th>Longue-Pointe-de-Mingan (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Non-piscivorous fish from affected areas</td>
<td>1.1</td>
<td>0.6</td>
<td>0.0</td>
</tr>
<tr>
<td>B Non-piscivorous fish from unaffected areas</td>
<td>24.1</td>
<td>9.5</td>
<td>16.9</td>
</tr>
<tr>
<td>C Piscivorous fish from affected areas</td>
<td>2.0</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>D Piscivorous fish from unaffected areas</td>
<td>5.1</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>E Local marine fish and seafood (unaffected)</td>
<td>5.3</td>
<td>3.8</td>
<td>3.4</td>
</tr>
<tr>
<td>F Waterfowl from affected areas</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>G Waterfowl from unaffected areas</td>
<td>39.6</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>H Marine mammals (unaffected)</td>
<td>3.2</td>
<td>24.4</td>
<td>5.8</td>
</tr>
<tr>
<td>I Store or restaurant fish and seafood (unaffected)</td>
<td>19.3</td>
<td>59.4</td>
<td>72.0</td>
</tr>
</tbody>
</table>

**Total sources**

|                | 100             | 100                    | 100                        |

**Proportion of affected sources (1)**

|                | 3.3             | 0.8                    | 0                           |

1: Only sources A, C and F are affected by the project
Mercury Exposure of Local Populations

- **Future mercury exposure**

  \[
  \text{Future Hg Exposure} = \frac{\text{Current Hg Exposure} \times \text{Future avg [Hg] in diet (µg/g)}}{\text{Current avg [Hg] in diet (µg/g)}}
  \]

- **Considering:**
  - Future mercury levels in affected mercury sources *(reservoir Hg in fish model)*
  - 3 consumption scenarios
**Current Exposure**

Current average [Hg] in diet

\[
[Hg_{avg}]_{Diet} = \left( \sum_{i=A}^{I} \sum_{j=1}^{n} [Hg_{xy}] \right) \div Nb_{meals}
\]

Where:
- for \( i \) = A to I significant sources of Hg
- for \( j \) = 1 to n meals consumed by each participant
- \( Hg_{xy} \) = Hg concentration in x species from y location consumed (µg/g)
- \( Nb_{meals} \) = Total number of meals of each participant
Future Mercury Exposure

Consumption scenarios

- No change in consumption habits
  - Only [Hg] of affected sources (A,C,F) change in

\[
[Hg_{avg}]_{Diet} = \left( \sum_{i=A}^{1} \sum_{j=1}^{n} [Hg_{xy}]_{ij} \right) \div Nb_{meals}
\]

- Realistic scenario
  - 10% of trout meals from natural lakes replaced by reservoir fish (70% piscivorous – 30% non-piscivorous)

- Worst case scenario
  - 25% of trout meals from natural lakes replaced by reservoir fish (70% piscivorous – 30% non-piscivorous)

- Calculated for each participant of study
## Comparison of current and future mercury exposures (mg g⁻¹ in hair) Worst-case scenario

<table>
<thead>
<tr>
<th>Target group</th>
<th>Innu of Ekuanitshit</th>
<th>Havre-Saint-Pierre</th>
<th>Longue-Pointe-de-Mingan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Exposure</td>
<td>Future Exposure</td>
<td>Current Exposure</td>
</tr>
<tr>
<td><strong>General population</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average value</td>
<td>0.48</td>
<td>0.81</td>
<td>0.85</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.00</td>
<td>5.00</td>
<td>4.10</td>
</tr>
<tr>
<td><strong>Fishers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average value</td>
<td>0.51</td>
<td>0.75</td>
<td>0.99</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.10</td>
<td>2.10</td>
<td>4.10</td>
</tr>
<tr>
<td><strong>Women (18 – 39 years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average value</td>
<td>0.28</td>
<td>0.44</td>
<td>0.63</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.10</td>
<td>0.10</td>
<td>0.13</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.57</td>
<td>1.30</td>
<td>2.30</td>
</tr>
</tbody>
</table>
Conclusions

- **Approach takes into account:**
  - Current Hg exposure of local populations
  - Main sources of mercury in diet
  - Predicted mercury levels in affected sources in diet
  - Realistic future consumption scenarios

- **For Romaine Hydroelectric complex:**
  - Estimated future exposures remain well below recognised thresholds of potential health effects
  - No additional health risk foreseen, even for worst-case scenario
  - Health risk communication program to be discussed with local Public Health Institutions
Health Risk Assessment related to fish consumption

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