Health Implications of Mercury (Hg) in East Texas Lakes

Larry K. Lowry, PhD
The University of Texas Health Center at Tyler
Background

- There is increasing concern about Hg contamination in East Texas lakes.
- Hg has potential health impacts on susceptible populations (children, pregnant women, subsistence fisherman, fishing communities, and public health agencies).
- Some lakes have been posted or have had health advisories issued by State agencies.
The press releases

Texas releases most mercury to air
State also No. 1 in emissions of chemicals from manufacturing
05/24/2002

EPA: Texas plants are major mercury polluters
Government data show coal-fired power plants in state lead the nation in emissions of toxic metals
Friday, May 24, 2002
By Kevin Carmody
AMERICAN-STATESMAN STAFF
Power plants are Texas

Mercury Threat to Kids Rising, Unreleased
EPA Report Warns
February 20, 2003
By JOHN J. FIALKA
Staff Reporter of THE WALL STREET JOURNAL
Washington -- A report warning that emissions of mercury by coal-fired power plants and other industrial sources poses an increasing health danger to young children has been delayed for nine months, while the Bush administration struggles with how to handle an increasingly contentious environmental problem.

The Environmental Protection Agency report is to be released soon, officials said, to young children's health. The report is seen as a key to the White House's Office of Science and Technology's efforts to settle the mercury question. Among the hurdles that the report faces is the high level of scrutiny by the media and the public.
Fish advisories for Hg in Texas waters

**Mercury Advisories**

- **B.A. Steinhagen Reservoir** - largemouth bass, freshwater drum, white bass, hybrid white/striped bass
- **Big Cypress Creek** - largemouth bass, freshwater drum
- **Caddo Lake** - largemouth bass, freshwater drum
- **Lake Daingerfield** - largemouth bass
- **Lake Kimball** - all fish
- **Lake Meredith** - walleye
- **Lake Pruitt (Black Cypress Bayou)** - all fish
- **Lake Ratcliff** - largemouth bass
- **Sam Rayburn Reservoir** - largemouth bass, freshwater drum
- **The Gulf of Mexico** - king mackerel
- **Toledo Bend Reservoir** - largemouth bass, freshwater drum
- **Upper Lavaca Bay** - illegal to possess any species of fish or crabs from this area

NW TX

Gulf area
Caddo Lake
The newspapers, Caddo Lake

Editorial ... 5-14-03

Caddo Lake: Do more extensive testing

After more than eight years, retesting of Caddo Lake fish for mercury contamination is overdue. The failure of the Texas Legislature and the state Department of Health to plan and fund an appropriate public health safety program is reprehensible.

In 1995, the state health department issued advisories warning people not to eat largemouth bass and freshwater drum from Caddo. Fish that contain high levels of mercury can cause a variety of ailments, including damage to the nervous system, birth defects and, in high doses, death. The advisories specifically caution women who are pregnant to limit their intake of fish from the lake.

That’s the last we’ve seen of state health officials in regard to this problem. We don’t know if the levels of mercury have gone up or down. We don’t know if any people have experienced health problems as a result of this contamination.

Dwight Shellman, the executive director of the Caddo Lake Institute, wants to hold a health fair this fall that would test residents’ blood for cancer, diabetes and, for the first time, take hair samples to test for mercury. He says he has been asking the state for years to do the screening.

That seems like a reasonable request, given the health dangers of mercury poisoning.

5-31, State: Despite mercury alerts, Caddo Lake residents still relish their catches

UNCERTAIN — Mayor Betty Holder just loves fishing for bass and will tell you, from across the counter of her grocery store, that nothing — not even the mercury in Uncertain’s Caddo Lake — keeps her from throwing in her line.

“I have eaten many bass and I think I’m just about as healthy as anyone,” said Holder, a well-tanned wisp of a woman. “And if I wanted, I’d have bass tonight and I wouldn’t be afraid to.”

In fact, many folks in Uncertain — a resort town where, if you show up without a rod and reel, people will wonder why you are here at all — are fearless about eating what they pull from the lake’s murky, cypress-covered coves and meandering bayous.

Dwight Shellman wants to do something about that.

Shellman, a part-time resident who heads the nonprofit Caddo Lake Institute dedicated to studying the lake, wants to have people living around Caddo Lake tested for mercury. At the very least, the testing would make them more aware of the dangers, he said.
What to believe?

Something is Fishy
Mercury Pollution in Texas

Mercury: A toxic heavy metal that causes learning disabilities, tremors, birth defects, attention deficits, mental retardation and even death.

The Awful Truth

Mercury Advisories
Outline of presentation

- The Hg cycle - how Hg enters our food chain
- Sources of Hg in local lakes
- Methods for exposure assessment
- Mercury concentrations in lakes, fish
  - Reference values
Other topics

- Factors affecting Hg accumulation in fish
- TDH risk assessments-fish advisories
- Assessment of exposure in humans
- Risks to susceptible populations
The Hg cycle
Description, Hg cycle

- Mercury enters the atmosphere as Hg vapor
  - Incineration, power plants, natural sources
  - Evaporation from soil, lakes
- Mercury is photo-oxidized to inorganic Hg
- Inorganic Hg deposited in lakes and soil from rain
  - Other agents such as oxides of Nitrogen and Sulfur lead to acid rain
The cycling of Hg in lakes

- Inorganic Hg cycles in lake and sediment
- Microflora convert inorganic Hg to methyl Hg (organic Hg)
- Methyl Hg accumulates up the food chain concentrating in the biggest game fish
- Fisherman catches fish, eats fish
Sources of mercury in local lakes

- Widespread mercury contamination in most East Texas lakes
- Not tied to any point source or direct discharge
- Most likely:
  - Coal burning power plants
  - Incineration
- Seems to be associated with acidic lakes
  - Is this related to acid rain?
Exposure assessment methods

- The dose makes the poison - Paraselsus

Assess exposure by

- Measurement of Hg in water
  - Where in lake?
  - How deep?

- Measurement of Hg in fish
  - Whole fish: dilutes value
  - Edible filet: represents human consumption
Total mercury data in East Texas lakes
Human health reference value: 0.0122 µg/L (Twidwell, TCEQ, 2000)
Reference values, Hg in water

- **TCEQ**
  - 0.0122 μg/L

- **WHO**
  - 0.001 mg/L (1 μg/L)

- **EPA MCL for drinking water**
  - 0.002 mg/L (2 μg/L)
Mercury data in fish from lakes

■ Prior to 1993, total fish Hg – no problem found
■ 1993 – elevated fish Hg in edible portions in LA, AR lakes
■ Testing in TX using edible portions reveal widespread Hg in fish above advisory levels
Reference values for fish

- **TCEQ**
  - 0.65 mg/kg (ppm) total Hg in large predator fish (game fish) (0.7 sometimes listed)

- **FDA action level**
  - 1 ppm (mg/kg) methylmercury
    - Limit fish consumption to 7 oz per week
  - 0.5 ppm
    - Limit fish consumption to 14 oz per week
Fish data
(Twidwell, TCEQ, 2000)

- Only eatable fish tissue analyzed
- Hg detected in 13 East Texas lake, mostly in large mouth bass.
- Levels exceeded reference levels in Pruitt lake and Kimball reservoir.
- Hg levels higher in larger predator fish
Fish data by size
(Reference value: 0.65 mg/kg, Twidwell, TCEQ 2000)

Figure 21. Mercury in Muscle Tissue of Largemouth Bass From Pruitt Lake (Black Cypress Bayou)

Figure 18. Mercury in Muscle Tissue of Largemouth Bass From Kimball Reservoir
## Caddo Lake fish data
(Ref value: 0.65 mg/kg, TDH Risk Assessment, 1995)

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Size, in</th>
<th>Total Hg, mg/kg (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Largemouth bass</td>
<td>14-18 (illegal)</td>
<td>0.67 (0.526-0.883)</td>
</tr>
<tr>
<td>Largemouth bass</td>
<td>&gt; 18 (legal)</td>
<td>1.11 (0.61 –1.63)</td>
</tr>
<tr>
<td>Freshwater drum</td>
<td>17-27</td>
<td>1.27 (0.92 –1.53)</td>
</tr>
<tr>
<td>Chain pickerel</td>
<td>19-21</td>
<td>0.96 (0.75-1.16)</td>
</tr>
<tr>
<td>Channel catfish</td>
<td>14-21</td>
<td>0.21 (0.10 – 0.36)</td>
</tr>
</tbody>
</table>
Effect of pH on Hg accumulation in fish (Twidwell, TCEQ, 2000)

When expected Hg concentration in fish is modeled, major factor is lake with acid pH

- Based on expected Hg concentration in fish, pH explains 51% of fish Hg levels
- Correlation of pH with fish Hg shown at right

Figure 30. Relationship Between Expected Mercury Concentrations (EHg) and Ambient pH in 13 East Texas Reservoir and Lakes. The Regression Equation is EHg = 2.39 - 0.291(pH); r² = 0.51.
Other contributing factors
(Twidwell, TCEQ, 2000)

- Total organic carbon (organic matter)
- Other water chemistry factors
- Combination of pH and TOC explains 61% of fish Hg levels
No correlation of Hg in lake with Hg in fish (Twidwell, TCEQ, 2000)

- **Examples**
  - Pruitt and Kimball lakes
    - Moderate Hg in water
    - Highest pH, TOC, highest levels of Hg in fish
  - Other lakes
    - Moderate Hg in water
    - Normal pH, lower TOC, lower levels of Hg in fish
Fish advisories and bans

Mercury shown by (x)
TDH fish advisories

Based on risk assessments prepared by TDH

B.A. STEINHAGEN RESERVOIR, SAM RAYBURN RESERVOIR, BIG CYPRUS CREEK, TOLEDO BEND RESERVOIR AND CADDIO LAKE

ADV-12 Issued November 2, 1995

SABINE, SHELBY, PANOLA, JASPER, ANGELINA, SAN AUGUSTINE, MARION, HARRISON, NEWTON, AND TYLER COUNTIES

ADVISORY AREA:
All waters of the B.A. Steinhagen Reservoir, Sam Rayburn Reservoir, and Big Cypress Creek. All Texas waters of Toledo Bend Reservoir and Caddo Lake

CHEMICAL OF CONCERN:
Mercury (Hg)

SPECIES AFFECTED:
Largemouth bass and freshwater drum in the above mentioned reservoirs, creek and lake. White bass and hybrid white/striped bass taken from B.A. Steinhagen Reservoir

CONSUMPTION ADVICE:
1) Adults should consume no more than two meals, not to exceed 8 ounces of fish per meal, per month combined of largemouth bass and freshwater drum from the following waterbodies: B.A. Steinhagen Reservoir, Sam Rayburn Reservoir, Big Cypress Creek, Toledo Bend Reservoir and Caddo Lake.

2) Children should consume no more than two meals, not to exceed 4 ounces of fish per meal, per month combined of largemouth bass and freshwater drum from the following waterbodies: B.A. Steinhagen Reservoir, Sam Rayburn Reservoir, Big Cypress Creek, Toledo Bend Reservoir and Caddo Lake.

3) Of the meals recommended above, adults should consume no more than one meal, not to exceed 8 ounces of fish per meal, per month of white bass or hybrid/striped bass from B.A. Steinhagen Reservoir.

4) Of the meals recommended above, children should consume no more than one meal, not to exceed 4 ounces of fish per meal, per month of white bass or hybrid white/striped bass from B.A. Steinhagen Reservoir.
What is the basis or reference value?

- Older risk assessments (like Caddo Lake)
  - Based on EPA reference dose of 0.0003 mg/kg/day with a 10 x margin of safety
  - Screening value is 0.65 mg/kg (ppm) for women of childbearing age consuming 30 grams per day.

- Newer risk assessments
  - Based on human exposure data and observed health effect. Same number
Exposure assessment in humans

- Baseline data from NHANES study
- Body burden measurements
  - Blood
  - Urine
  - Hair
Reference values, Hg in blood

### Table 8. Mercury

Geometric mean and selected percentiles of blood concentrations (in µg/L) for males and females aged 1 to 5 years and females aged 16 to 49 years in the U.S. population, National Health and Nutrition Examination Survey, 1999-2000.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Geometric mean</th>
<th></th>
<th>10th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
<th>90th</th>
<th>95th</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(95% conf. interval)</td>
<td>Selected percentiles</td>
<td>(95% confidence interval)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5 years (males and females)</td>
<td>.343 (.299-.393)</td>
<td>&lt; LOD &lt; LOD</td>
<td>.300 (.200-.300)</td>
<td>.500 (.500-.600)</td>
<td>1.40 (1.10-2.00)</td>
<td>2.30 (1.40-3.20)</td>
<td>705</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>.317 (.270-.372)</td>
<td>&lt; LOD &lt; LOD</td>
<td>.200 (.200-.300)</td>
<td>.500 (.500-.600)</td>
<td>1.10 (0.80-1.50)</td>
<td>2.10 (1.10-3.50)</td>
<td>387</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>.377 (.311-.457)</td>
<td>&lt; LOD &lt; LOD</td>
<td>.200 (.200-.300)</td>
<td>.800 (.500-1.00)</td>
<td>1.60 (1.20-2.30)</td>
<td>2.70 (1.80-4.80)</td>
<td>318</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-49 years (females)</td>
<td>1.02 (.860-1.22)</td>
<td>.200 (.200-400)</td>
<td>.900 (.800-1.20)</td>
<td>2.00 (1.60-2.70)</td>
<td>4.90 (4.00-6.10)</td>
<td>7.10 (5.60-9.90)</td>
<td>1709</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(females, 16-49 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican Americans</td>
<td>.820 (.691-.974)</td>
<td>.200 (&lt;LOD-200)</td>
<td>.400 (.300-.500)</td>
<td>.900 (.700-1.00)</td>
<td>1.40 (1.20-1.90)</td>
<td>2.60 (2.10-3.40)</td>
<td>4.00 (2.70-5.50)</td>
<td>579</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic blacks</td>
<td>.330 (.111-.164)</td>
<td>.300 (200-500)</td>
<td>.600 (.500-900)</td>
<td>1.30 (1.10-1.60)</td>
<td>2.60 (1.90-3.30)</td>
<td>4.80 (3.30-6.60)</td>
<td>5.90 (4.40-10.9)</td>
<td>370</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic whites</td>
<td>.944 (.765-1.17)</td>
<td>&lt; LOD &lt; LOD</td>
<td>.400 (.300-.400)</td>
<td>.900 (.700-1.10)</td>
<td>1.90 (1.40-2.90)</td>
<td>5.00 (3.40-6.50)</td>
<td>6.90 (5.40-10.6)</td>
<td>588</td>
<td></td>
</tr>
</tbody>
</table>

< LOD means less than the limit of detection, which is 0.14 µg/L.
# Reference values, Hg in urine

## Table 9. Mercury

Geometric mean and selected percentiles of urine concentrations (in μg/L) for females aged 16 to 49 years in the U.S. population, National Health and Nutrition Examination Survey, 1999-2000.

<table>
<thead>
<tr>
<th>Age group (females)</th>
<th>Geometric mean (95% conf. interval)</th>
<th>Selected percentiles (95% confidence interval)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-49 years</td>
<td>.720 (.642-.808)</td>
<td>&lt; LOD (.260-.370)  .310 (.650-.880)  .770 (1.46-1.84)  1.62 (2.68-3.58)  3.15 (3.86-5.55)  5.00</td>
<td>1748</td>
</tr>
<tr>
<td>Race/ethnicity (females, 16-49 years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexican Americans</td>
<td>.724 (.607-.864)</td>
<td>&lt; LOD (.240-.350)  .280 (.520-.890)  .650 (1.33-2.35)  1.69 (3.10-4.45)  3.68 (4.68-7.51)  5.62</td>
<td>595</td>
</tr>
<tr>
<td>Non-Hispanic blacks</td>
<td>1.07 (.888-1.29)</td>
<td>&lt; LOD (.360-.650)  .450 (.870-1.34)  1.03 (1.85-2.89)  2.30 (3.41-6.08)  4.81 (5.13-9.64)  6.98</td>
<td>381</td>
</tr>
<tr>
<td>Non-Hispanic whites</td>
<td>.657 (.576-.748)</td>
<td>&lt; LOD (.210-.340)  .280 (.560-.810)  .710 (1.31-1.77)  1.50 (2.35-3.32)  2.84 (3.26-5.24)  4.05</td>
<td>594</td>
</tr>
</tbody>
</table>

< LOD means less than the limit of detection, which is 0.14 μg/L.
Reference values, Hg in hair

- No established values from NHANES
- Values from literature
  - Drasch, 1997 (Germany) median 0.25 µg/g
    - From 150 cadavers with no known exposure to Hg.
  - Grandjean, 1992 (Faroe Islands) median 0.8 µg/g
    - From 18 islanders with no fish consumption
  - Japanese studies – less than 2 µg/g
    - Known to be higher in metals than other populations
Health effects from consumption of Hg in the diet

- Neurotoxic effects most common in adults.
  - Tremor, paresthesia (numbness), ataxia (unstable), malaise, visual disturbances

- Prenatal exposures, infants
  - Developmental delays
  - Neurobehavioral changes
Effects from fish consumption

Three studies with inconclusive results

- **Faroe Islands**
  - High Hg in fish and whale food
  - Some developmental delays, failed to account for other chemical exposures

- **Seychelles**
  - No effects seen at hair Hg levels seen above

- **New Zealand**
  - Some effects on psychological and developmental tests, no effects if eliminate one outlier
Health effects in susceptible populations

- Pregnant women
  - Concerns are for developmental disorders in the fetus

- Children, infant to teen
  - Children are more susceptible to developmental disorders and behavioral changes as their systems are developing
Subsistence fishermen

Fish advisories are for casual fish eaters
- Example: Caddo Lake, 2 fish meals a month at 2 week intervals for adults (8 oz), children (4 oz)

What about a subsistence fisherman that eats an 8 ounce serving every day?
- Possibility of substantial dose of Hg and more chronic conditions associated with Hg poisoning
- Fish studies above not conclusive
What about others?

- What about the pregnant spouse of the subsistence fisherman?
- What about the risks to children of these families?
- What about risks to native Americans?
Conclusions

- Hg in fish pose little risk to most casual eaters of fish, even in those lakes with fish advisories.
- Hg in fish may pose a significant risk to children and to subsistence fisherman and their families.
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The SW-CPEH is an education and consultation service for Texas and the surrounding states.

Contact us at:
- 1-888-901-5665
- E-mail: swcpeh@uthct.edu
- URL: http://research.uthct.edu/swcpeh