VARIABILITY IN SELENIUM:MERCURY MOLAR RATIOS IN FISH IN FRESHWATER ECOSYSTEMS

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ABSTRACT

Mercury is an important remediation issue in freshwater ecosystems. Because of the hazard mercury presents to biota and to people consuming fish, it is important to understand the factors influencing uptake and effects on receptors. Recent work has suggested that selenium might ameliorate the toxic effects of mercury, and a molar excess of selenium may be protective although the protective level is unknown. We examined the selenium:mercury molar ratios in fish near Oak Ridge and in the Savannah River. There was considerable inter-individual variation in molar ratios such that these ratios may not be useful for risk communication. However, where there are high levels of selenium, the toxicokinetics of mercury in fish may be altered. This will be examined for Poplar Creek and the Savannah River. This work will aid DOE and EPA because it will allow managers and scientists to understand another aspect of the fate and transport of mercury in fish and organisms higher on the food chain.

RATIONALE

1. Mercury is an environmental contaminant of concern for biota and humans
2. All forms of mercury are toxic, and its methylmercury that bioaccumulates in fish
3. Fish are an important part of the food chain, often leading to human exposure
4. Relatively high levels of mercury have been reported in fish from the Oak Ridge area.

BACKGROUND

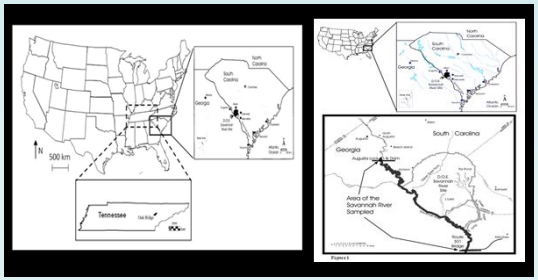
1. Some fish contain mercury in sufficient quantities to cause adverse effects in people who consume them frequently
2. Some state agencies issue consumption advisories
3. There are consumption advisories for fish from many rivers
4. Selenium offers some protective effect againt mercury, although the mechanisms are unclear
5. It has been suggested that a molar excess of Se to Hg may be protective against Hg toxicity

OBJECTIVE

1. To examine selenium:mercury molar ratios in fish from Oak Ridge and Savannah River as models for freshwater systems
2. To examine variation within and among fish species, and sites
3. To consider whether selenium:mercury molar ratios are useful for risk managers

USEFULNESS TO EPA AND OTHERS

1. Understand variations in both selenium and mercury in different species of fish
2. Understand variations in the selenium:mercury molar ratios in these fish and whether they may be protective of mercury toxicity



METHODS

1.Use already collected fish from Oak Ridge and the Savannah River
2. Analyze mercury and selenium levels in muscle
3. Determine Selenium:Mercury molar ratios
4. Examine variation in ratios by fish species, and site.

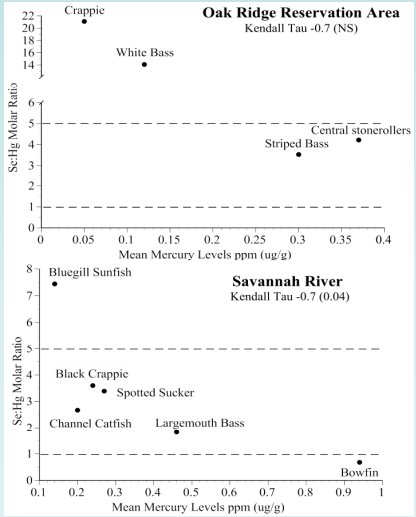
RESULTS

Table I. Mercury and selemium levels (ppm wet weight) (ug/g), selenium-mercury molar ratios, and relationship of these ratios to fish size for fish from Oak Ridge and the Savannah River. Given are arithmetic means ± SE.

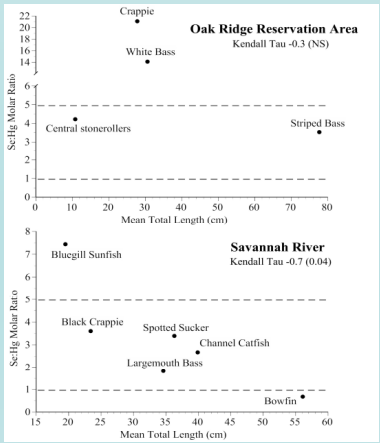
Common Name (Scientific Name)	n	Mercury Mean ± SE	Selenium Mean ± SE	Hg nmol/g wet wt.	Se nmol/g wet wt.	Se:Hg Ratio (Means)[a]	Se:Hg Ratio Correlation with Hg tau (p)	Se:Hg Ratio Correlation with Length tau (p)
Savannah River Site								
Bowfin (*Amia calva*)	58	0.94 ± 0.05	0.25 ± 0.01	4.69	3.17	0.68	-0.57 (<0.0001)	-0.24 (0.007)
Largemouth Bass (*Micropterus salmoides*)	48	0.46 ± 0.04	0.33 ± 0.02	2.29	4.18	1.82	-0.65 (<0.0001)	-0.39 (0.0001)
Spotted Sucker (*Minytrema melanops*)	35	0.27 ± 0.04	0.36 ± 0.05	1.35	4.56	3.39	-0.57 (<0.0001)	-0.34 (0.005)
Black Crappie (*Pomoxis nigromaculatus*)	53	0.24 ± 0.02	0.34 ± 0.03	1.20	4.31	3.60	-0.53 (<0.0001)	-0.24 (0.01)
Channel Catfish (*Ictalurus punctatus*)	45	0.20 ± 0.02	0.21 ± 0.01	1.00	2.66	2.67	-0.69 (<0.0001)	-0.30 (0.004)
Bluegill Sunfish (*Lepomis macrochirus*)	30	0.14 ± 0.02	0.41 ± 0.03	0.70	5.19	7.44	0.60 (<0.0001)	-0.04 (NS)
Kruskal Wallis X^2 (p)		141 (<0.0001)	56.1 (<0.0001)			120 (<0.0001)		
Oak Ridge Reservation								
Central stonerollers (*Campostoma anomalum*)	20	0.37 ± 0.05	0.61 ± 0.05	1.84	7.76	4.22	-0.53 (0.001)	0.42 (0.009)
Striped Bass (*Morone saxatilis*)	15	0.30 ± 0.04	0.41 ± 0.03	1.48	5.21	3.53	-0.49 (0.01)	-0.02 (NS)
White Bass (*Morone chrysops*)	29	0.12 ± 0.02	0.65 ± 0.04	0.58	8.23	14.11	-0.69 (<0.0001)	0.26 (0.05)
Crappie (*Pomoxis spp.*)	14	0.05 ± 0.02	0.42 ± 0.03	0.25	5.26	21.09	-0.62 (0.002)	-0.06 (NS)
Kruskal Wallis X^2 (p)		46.8 (<0.0001)	25.6 (<0.0001)			46.1 (<0.0001)		

a. The Se/Hg molar ratios are calculated on unrounded mean Hg and Se values.

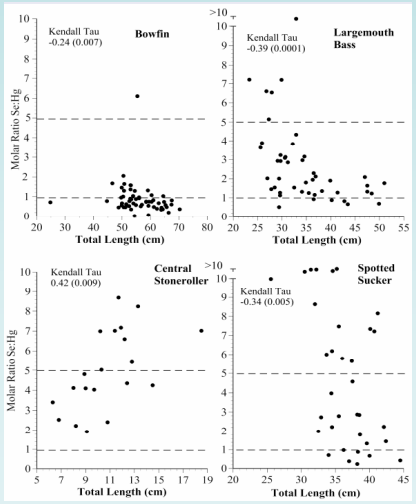
Selenium:Mercury Molar Ratios by Mean Mercury Levels



Selenium:Mercury Molar Ratios by Fish Size



Selenium: mercury ratio by total length for individual fish of four different species



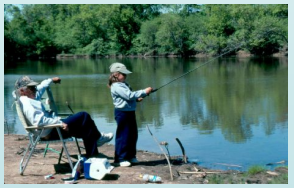


Table II. Variation in Selenium-Mercury Ratios within fish that might be useful in risk assessment or risk management.

Common Name	Se:Hg Ratio (Means)[a]	Se:Hg Mean ± SE (Individual fish)	% of Fish with Molar Ratios < 0.99	1.0-5.0	>5.0
Savannah River					
Bowfin	0.7	0.9 ± 0.1	74.1%	24.2%	1.7%
Largemouth Bass	1.8	2.7 ± 0.4	12.5%	75.0%	12.5%
Spotted Sucker	3.4	9.7 ± 3.2	20.0%	37.1%	42.9%
Black Crappie	3.6	4.3 ± 0.3	7.6%	56.5%	35.9%
Channel Catfish	2.7	4.1 ± 0.6	10.7%	63.8%	25.5%
Bluegill Sunfish	7.4	15.3 ± 3.5	0.0%	30.0%	70.0%
Oak Ridge Reservation Area					
Central stonerollers	4.2	5.0 ± 0.5	0.0%	55.0%	45.0%
Striped Bass	3.5	4.3 ± 0.5	0.0%	71.4%	28.6%
White Bass	14.1	21.4 ± 2.4	0.0%	10.3%	89.7%
Crappie	21.1	38.4 ± 11.5	0.0%	0.0%	100.0%

a. The Se/Hg molar ratios are calculated on unrounded mean Hg and Se values.

DISCUSSION: Main findings

1. Selenium:Mercury ratios showed great variation within fish species
2. The ratios for Bowfin (and some Spotted Sucker) were in the range to suggest NO protective effect of selenium
3. For most other fish, ratios exceed 2:1, but are less than 5:1.

DISCUSSION: Implications for Managing Mercury Fluxes

1. The mercury environment in EFPC is complex
2. Considerable monitoring occurs
3. Selenium levels should be examined in key fish over time to determine variations
4. Selenium levels might be high enough to provide some protection for mercury toxicity, but data are required to understand variations.
5. In the absence of information on protective molar ratios, advisories should be based on mercury levels.

CONCLUSIONS

1. There is a great deal of variation in Selenium:Mercury Molar Ratios within and among freshwater fish
2. These ratio are not yet useful for risk management
3. Selenium should be measured in more fish at Oak Ridge to determine if ,over time, levels of selenium are sufficient to general provide some protection from mercury toxicity.

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