HEALTH CONSULTATION

Martin Creek Lake

Rusk and Panola Counties, Texas

Prepared by

Texas Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

BACKGROUND AND STATEMENT OF ISSUES

The Texas Department of Health Seafood Safety Division (SSD) requested that the Health Risk Assessment and Toxicology Program evaluate the potential health risks associated with consumption of fish taken from Martin Creek Lake, a 5,000 acre cooling reservoir operated by Texas Utilities Electric Service Company (TU Electric). Martin Creek Lake is located 17 miles northeast of Henderson, on the border of Rusk and Panola Counties. During the late 1970's, Martin Creek Lake received discharges from ash ponds containing elevated selenium levels, resulting in increased selenium concentrations in fish. In 1979, selenium concentrations in bass ranged from 7.1 to 8.3 ppm. Elevated levels of selenium in water and fish tissue were implicated in a series of fish kills during this time.

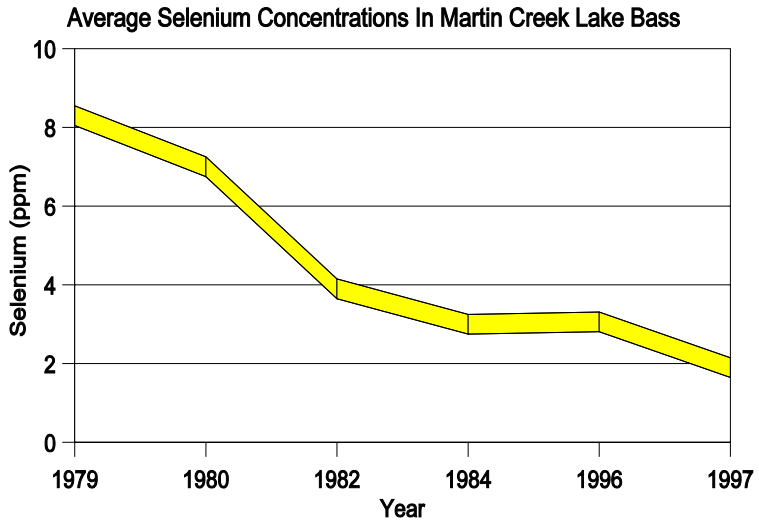
Since the fish kills, TDH, the Texas Parks and Wildlife Department (TPWD), and TU Electric have worked cooperatively to monitor selenium levels in fish tissue. In 1992, TDH issued a fish consumption advisory for the lake after it was determined that the levels of selenium in fish from the lake could pose a potential health risk. The advisory recommended that adults consume no more than one eight-ounce meal each week and children seven years of age and older consume no more than one four-ounce meal each week. Children six and under, pregnant women, or women who may soon become pregnant were advised not to consume the fish. Additionally, persons consuming fish from the reservoir were advised not to consume mineral dietary supplements with selenium exceeding 50 micrograms per day.

In 1996 and 1997, TDH collected 34 fish (17 bass, 10 channel catfish, 4 black crappie, 1 white crappie, and 2 flathead catfish) for a re-evaluation of the present fish consumption advisory. The concentration of selenium in the fish ranged from 0.7 to 4.0 ppm with an overall average concentration of 2.3 ppm (Table 1). Although selenium levels in fish from Martin Creek Lake continue to be above reported national averages (0.1 to 1.5 ppm [1]), the concentration of selenium in fish from Martin Creek Lake has been decreasing over the 19 years of investigation (Figure 1).

Table 1. Selenium in Martin Creek Lake Fish

Species	# collected	Size	Selenium Range (ppm)	Selenium Average (ppm)
November 1996				
Largemouth Bass	13	15-21"	2.17 - 4.0	3.06
Channel Catfish	8	15-26"	0.996 - 1.79	1.35
White Crappie	1	16"	2.74	2.74
Black Crappie	2	12-14"	4.18 - 4.23	4.2
All Fish (1996)				2.6
March 1997				
Largemouth Bass	4	15-21"	1.67 - 2.42	1.9
Black Crappie	2	14"	2.28 - 2.77	2.5
Channel Catfish	2	22"	0.743 - 0.839	0.79
Flathead Catfish	2	23-25"	1.11 - 1.17	1.14
All Fish (1997)				1.6
All Fish (1996-97)				2.3

Figure 1



DISCUSSION

Selenium

Selenium is a naturally occurring substance that is widely, but unevenly distributed in rocks and soils of the earth's crust. It is rarely found in pure form in the environment. When rocks decompose into soils, selenium often combines with sodium and oxygen to form sodium selenate, or with water to form sodium selenite, both of which are water soluble. Plants easily take up inorganic selenium compounds from water and change them to organic selenium compounds such as selenomethionine. The major man-made source of selenium in the environment is coal burning, especially the fly ash that results from burning coal. Persons living near industrial sites may be exposed through ingesting the soil or water, breathing the dust, eating plants that may have taken up selenium from soil, or ingesting fish that may have taken up selenium from high concentrations in water [2]. The estimated bioaccumulation factor for selenium in fish ranges from 485 to 1,746, depending on the species [3]. In general the more soluble and mobile forms of selenium (selenite and selenate) dominate under aerobic (high oxygen concentrations) and alkaline (high pH) conditions [2].

Humans and animals are both capable of absorbing and utilizing both organic or inorganic forms of selenium from food or water sources. Most of the selenium that enters the body is excreted in the urine within 24 hours. Selenium can build up in the body if exposure is high and occurs over a long period of time. Body burdens of selenium primarily occur in the liver, kidneys, hair, and nails. Selenium is an essential dietary element for both human and animals in either the inorganic or organic form. Selenium has antioxidant effects which help prevent damage to tissues caused by oxygen. A selenium deficient diet can result in Keshan disease, the signs and symptoms of which may include muscle pain, cardiomyopathy, enlargement of the heart,

increased red blood cell fragility, and pancreatic degeneration.

The human recommended daily allowance (RDA) of selenium for maintenance of good health is 55 micrograms per day (ug/day) for women and 70 micrograms per day for men. Estimates of the average intake of selenium from food for the U.S. population range from 71 to 152 micrograms of selenium per person per day [2]. Welsh et al. reported that about three percent of Maryland residents consumed diets which contained over 200 μg of selenium per day [4]. The Food and Nutrition Board of the National Research Council has estimated the safe and adequate daily dietary intake of selenium in adults to be 50 to 200 μg [5]. However, when eaten in amounts that are not much higher than required for good nutrition, selenium becomes harmful to humans and animals [2] (Figure 2). Signs and symptoms of sub-acute and chronic toxicity in humans include brittleness and loss of hair and nails; blisters, eruptions and skin mottling; pitting and excessive decay of the teeth; a garlic or sour-milk breath odor; periodic episodes of nausea and vomiting; and increasing fatigue.

No human populations in the U.S. have been reported to have chronic selenium toxicity, including populations in the western part of the country with naturally high levels of selenium in the soil and water. In a study of 142 subjects living in a seleniferous area of South Dakota and Wyoming, there was no evidence of toxicity from selenium in subjects whose intake was as high as 724 ug per day [6]. There have been a limited number of case reports of individuals who developed minimal signs of selenium toxicity following chronic dietary intakes of 850-900 ug per day. In areas of China with selenium intakes of 3,200 to 6,690 ug per day, clinically apparent selenium toxicity was observed, while persons with daily intakes in the range of 42-750 ug per day did not produce any signs of toxicity or other adverse health effects [7].

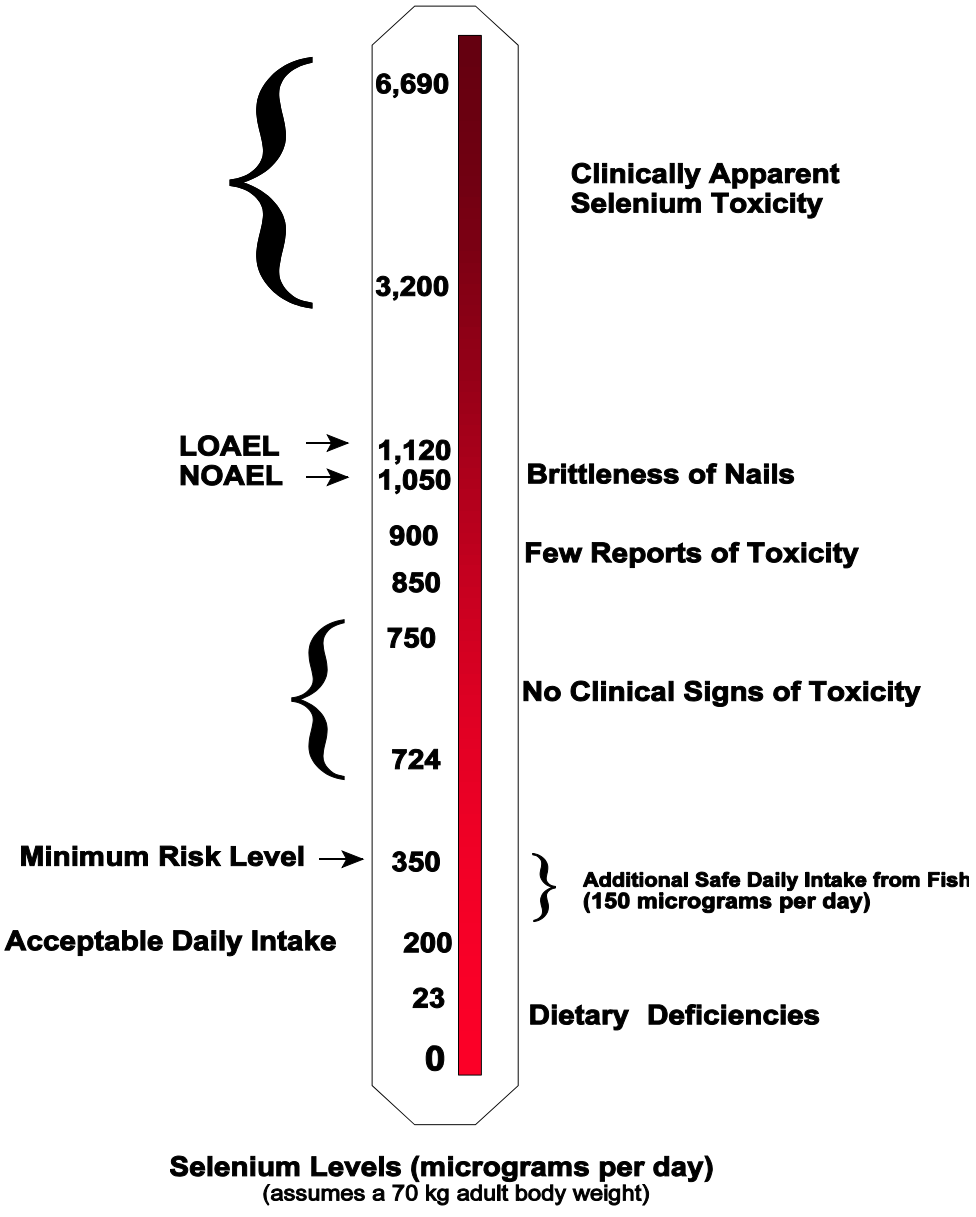
The Agency for Toxic Substances and Disease Registry (ATSDR) recently has established a chronic oral Minimum Risk Level (MRL) for selenium of 5 μg/kg/day [2]. For a 70 kg adult this is equivalent to an intake of 350 μg/day. The MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of noncancer health effects over a specified duration of exposure. The MRL was derived from a study involving a Chinese population with high selenium intake. Blood selenium concentrations and degree of selenosis were determined for 349 adults. The endpoint used to derive the MRL was nail disease, specifically brittleness of nails. By regression analysis the corresponding selenium dietary intakes were determined. A "no observable adverse effects level" (NOAEL) of 15 ug/kg/day, was determined. The NOAEL is the highest dose at which no statistically or biologically significant adverse effects were observed. For a 70 kg adult this dose is equivalent to a selenium intake of 1,050 μg/day. To establish the MRL, ATSDR divided the NOAEL by a factor of three to account for human variability. It is important to note that the MRL based on the Chinese study may be conservative because only dietary exposure was considered and it has been suggested that inhalation exposure to selenium in smoke was significant. The population studied cooked their meals on open fires of coal containing high concentrations of selenium.

Carcinogenicity

The EPA and the National Toxicology Program have determined that selenium is not classifiable as a carcinogen and it is rated as a Group D chemical. In fact, studies of cancer in humans

suggest that lower than normal selenium levels in the diet may increase the risk of cancer. This may be due to the fact that selenium is used in the body in enzymes that protect against oxidative damage to tissues which may be responsible for cancer promotion. One specific form of selenium, called selenium sulfide, is a probable human carcinogen. Selenium sulfide is not found in foods, and is a very different chemical from the organic and inorganic selenium commonly found in the environment. Because it is not absorbed through the skin, its primary use in the anti-dandruff shampoo Selsun Blue, is considered safe [2].

Figure 2. Health Effects of Selenium



Toxicological Evaluation

In 1992, when TDH estimated the risks associated with eating selenium contaminated fish, an MRL for this contaminant was not available. Using available information, TDH estimated 400 µg/day (5.71 µg/kg/day assuming a 70 kg adult) to be a safe and acceptable dietary selenium intake. This estimated safe daily intake is remarkably similar to the MRL (5 µg/kg/day) established by ATSDR and provided approximately a 2.6-fold safety factor below the current NOAEL of 1,050 ug/day, or the lowest level reasonably expected to result in signs or symptoms of toxicity. In performing the risk assessment, TDH determined the acceptable daily intake of selenium from fish by subtracting an assumed daily intake of selenium from other sources (200 µg/day [2.86 µg/kg/day assuming a 70 kg adult]) from the estimated safe and acceptable daily intake. Thus, for a 70 kg adult, TDH estimated that 200 µg (2.86 µg/kg/day) was an acceptable daily intake of selenium from fish.

To evaluate the current risks associated with eating fish from Martin Creek Lake we used the same paradigm used in the previously risk assessment except that we used the MRL established by ATSDR. Assuming a background daily intake of selenium from other sources of 200 µg, we estimate that approximately 150 µg/day (2.14 µg/kg/day assuming a 70 kg adult) is an acceptable daily intake of selenium from fish.

To determine the actual number of meals that could be consumed without exceeding the MRL we used two values for the concentration term; the arithmetic average and the 95th percent upper confidence interval (95% UCL) of the arithmetic average. The 95% UCL is defined as a value that when calculated repeatedly for randomly drawn subsets of site specific data, equals or exceeds the true average 95 percent of the time.

We estimated the 95% UCL by defining the distribution of selenium in fish tissue from Martin Creek Lake using the 1996-97 data and then randomly drawing 1,000 samples of 34 fish from that distribution. Averages were obtained for each of the 1,000 samples and the 950th rank ordered average was defined as the 95th percentile. The arithmetic average should be most representative of the concentration that would be contacted over time; however, the 95% UCL of the average provides a conservative estimate of the average concentration and is useful to account for sampling variations and suspected seasonal variations in fish tissue concentrations. Figure 3 provides a graphical representation of the relationship between the sample distribution and the 95% UCL of the arithmetic average.

Using these assumptions we estimate that adults could consume approximately two (eight ounce) meals per week and children (body weight 10-30 kg) could consume approximately one to two (four ounce) meals per week of Martin Lake fish before exceeding the MRL (Table 2). Individuals would have to consume approximately three times these amounts before exceeding the lowest level reasonably expected to result in signs or symptoms of toxicity.

Figure 3
Probability Density Distribution for Selenium Concentration in Fish from Martin Lake

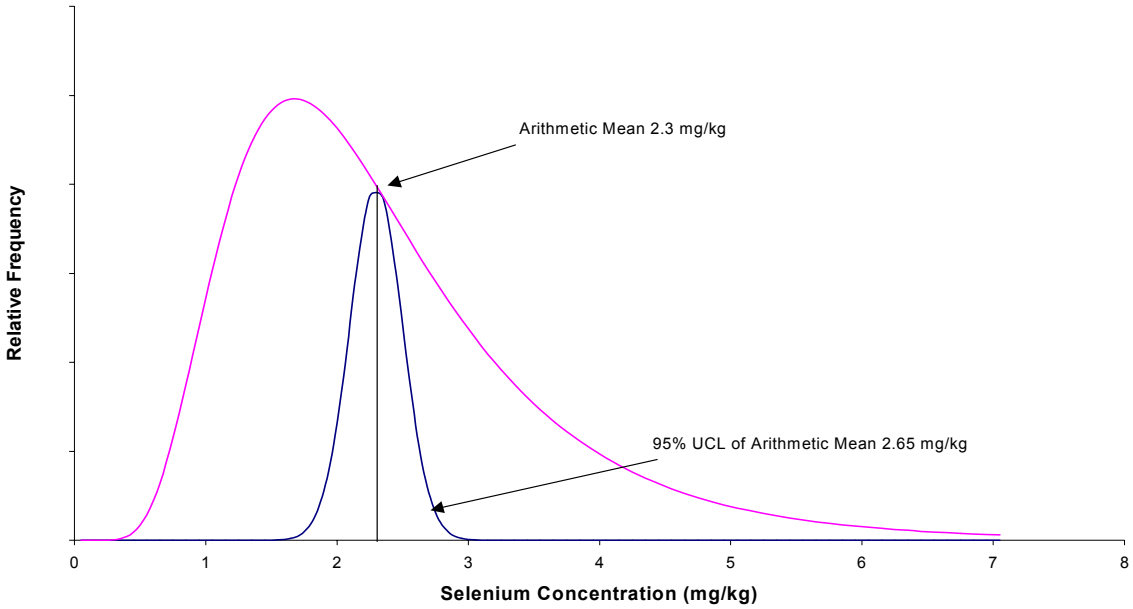


Table 2. Recommended Limitations on Long-Term Fish Consumption by body weight

Body Weight		Estimates Based on Average Selenium Level of 2.3 ppm for the 34 fish samples collected				
(kg)	(lb)	(a) Baseline exposure (µg/day) (BW x 2.86 ug/kg/day)	(b) Minimum Risk Level (µg/day) (BW x 5 ug/kg/day)	Acceptable Daily Intake From Fish (ug/day) ((b) - (a))	Quantity of fish that can be consumed without exceeding MRL — Meals per week	
					Average (2.3 ppm)	95% UCL (2.65 ppm)
Assumes a child body weight and an average meal size of 4 ounces each						
10	22	29	50	21	0.6	0.54
20	44	57	100	43	1.2	1.1
30	66	86	150	64	1.9	1.6
Assumes an adult body weight and an average meal size of 8 ounces each						
40	88	114	200	86	1.2	1.1
50	110	143	250	107	1.6	1.3
60	132	172	300	128	1.9	1.6
70	154	200	350	150	2.2	1.9
80	176	229	400	171	2.5	2.2
90	198	257	450	193	2.8	2.4
100	22	286	500	214	3.1	2.7

ATSDR's CHILD HEALTH INITIATIVE

The TDH has prepared this consult under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). TDH has included the following information in accordance with ATSDR's Child Health Initiative.

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances emitted from waste sites and emergency events. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are shorter than adults, which means they breathe dust, soil, and heavy vapors close to the ground. Children are also smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

Special consideration was given to children's health in this consultation. Children consuming one to two meals per week (8 ounces each) would not exceed minimal risk levels for adverse health effects from selenium in fish.

CONCLUSIONS

1. The levels of selenium in Martin Creek Reservoir have decreased significantly during the period of investigation (1979 - 1998).

2. Estimated exposures to selenium from eating fish from Martin Creek do not exceed minimum risk levels for adverse health effects for children consuming one to two meals per week (4 ounces each) or for adults consuming approximately two meals per week (8 ounces each). Approximately three times these amounts would be required to exceed the lowest levels reasonably expected to result in signs and symptoms of toxicity.

RECOMMENDATIONS

1. The fish consumption advisory issued for Martin Creek Lake in 1992 should be re-evaluated based on the current recommended limitations on long-term fish consumption.

REFERENCES

1. IRIS, 1998. Integrated Risk Information System. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office. Cincinnati, Ohio.

2. ATSDR, 1996. Agency for Toxic Substances and Disease Registry. Toxicological

Profile for Selenium. Atlanta: ATSDR, Aug. 1996.

3. Lemly, 1985. Toxicology of selenium in a freshwater reservoir: Implications for environmental hazard evaluation and safety. Ecotoxicol. Environ. Safety 10:314-338.

4. Welsh, et al., 1981. Selenium in self-selected diets of Maryland residents. J. Am. Diet Assoc. 79-277-85.

5. FNB, NRC, 1980. Food and Nutrition Board, National Research Council: Recommended dietary allowances, 9th ed. Washington, D.C: National Academy of Sciences.

6. Longnecker, et.al., 1991. Selenium in diet, blood, and toenails in relation to human health in a seleniferous area. Am. J. Clin. Nutr. 53:1288-94.

7. Yang, et.al., 1983. Endemic selenium intoxication of humans in China. Am. J. Clin. Nutr. 37:872-81.

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CERTIFICATION

The Martin Creek Lake Health Consultation was prepared by the Texas Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the Health Consultation was initiated.

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Technical Project Officer, SPS, RPB, DHAC

The Division of Health Assessment and Consultation, ATSDR, has reviewed this Health Consultation and concurs with its findings.

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Chief, SPS, SSAB, DHAC, ATSDR