

HEALTH CONSULTATION

Brandy Branch Reservoir

Harrison County, Texas

Prepared by

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

BACKGROUND AND STATEMENT OF ISSUES

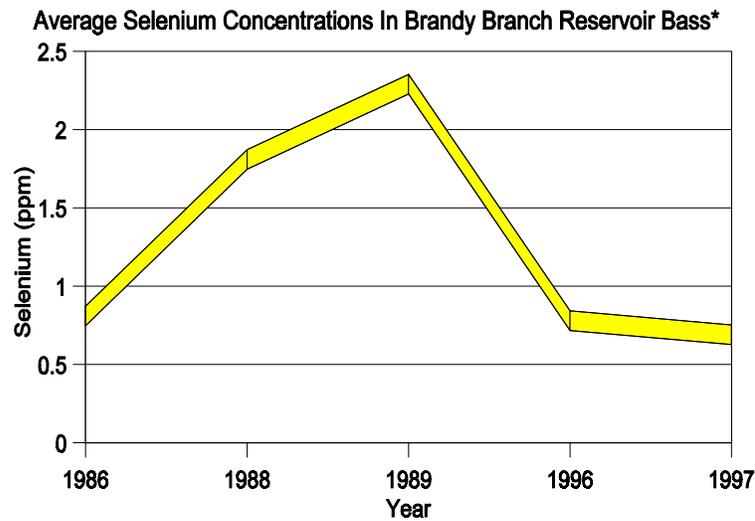
The Texas Department of Health Seafood Safety Division (SSD) requested that the Health Risk Assessment and Toxicology Program evaluate the potential health risks associated with consumption of fish taken from Brandy Branch Reservoir, a 1,200 acre cooling reservoir for Pirkey Power Plant and operated by Southwestern Electric Power Company (SWEPCO). Brandy Branch Reservoir is located 10 miles southwest of Marshall in Harrison County, Texas. During the late 1970's, several power plant cooling reservoirs in Texas received discharges from ash ponds containing elevated selenium levels, resulting in increased selenium concentrations in fish. An investigation of a series of fish kills in waterbodies near power plants in the early 1980's implicated elevated levels of selenium in fish tissue and water. The Texas Parks and Wildlife Department (TPWD) reported elevated levels of selenium in Brandy Branch fish during this time. From 1986-1989, TPWD reported that average selenium concentrations in Brandy Branch fish increased from 0.81 to 2.29 ppm. The reasons for this increase are unknown but may include sampling variations, seasonal variations in selenium concentrations, or continued input of selenium into the reservoir during this period.

Since the fish kills, the Texas Department of Health (TDH), TPWD, and SWEPCO have worked cooperatively to monitor selenium levels in fish tissue. In 1992, TDH issued a fish consumption advisory for the reservoir after it was determined that the levels of selenium in fish 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 17 fish (13 largemouth bass, 1 white bass, and 3 white crappie) for a re-evaluation of the present fish consumption advisory. The concentration of selenium in the fish ranged from 0.46 to 1.79 ppm with an overall average concentration of 0.87 ppm (Table 1).

| Table 1. Selenium in Brandy Branch Reservoir Fish | | | | |
|--|--------------------|-------------|-----------------------------|-------------------------------|
| November 1996 | | | | |
| Species | # collected | Size | Selenium Range (ppm) | Selenium Average (ppm) |
| Largemouth Bass | 10 | 14-16.3" | 0.46-1.0 | 0.78 |
| White Crappie | 2 | 11.8-12.2" | 1.01-1.1 | 1.05 |
| All Fish (1996) | | | | 0.83 |
| March 1997 | | | | |
| Largemouth Bass | 3 | 15.4-17.3" | 0.519-0.926 | 0.69 |
| White Crappie | 1 | 13.7" | 1.04 | 1.04 |
| White Bass | 1 | 15.7" | 1.79 | 1.79 |
| All Fish (1997) | | | | 0.98 |
| All Fish (1996-97) | | | | 0.87 |

Figure 1



*1986-89 data collected by TPWD, 1996-97 data collected by TDH

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 [1]. The estimated bioaccumulation factor for selenium in fish ranges from 485 to 1,746, depending on the species [2]. In general the more soluble and mobile forms of selenium (selenite and selenate) dominate under aerobic (high oxygen concentrations) and alkaline (high pH) conditions [1].

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 [1]. Welsh et al. reported that about three percent of Maryland residents consumed diets which contained over 200 µg of selenium per day [3]. 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 [4]. However, when eaten in amounts that are not much higher than required for good nutrition, selenium becomes harmful to humans and animals [1] (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 [5]. 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 [6].

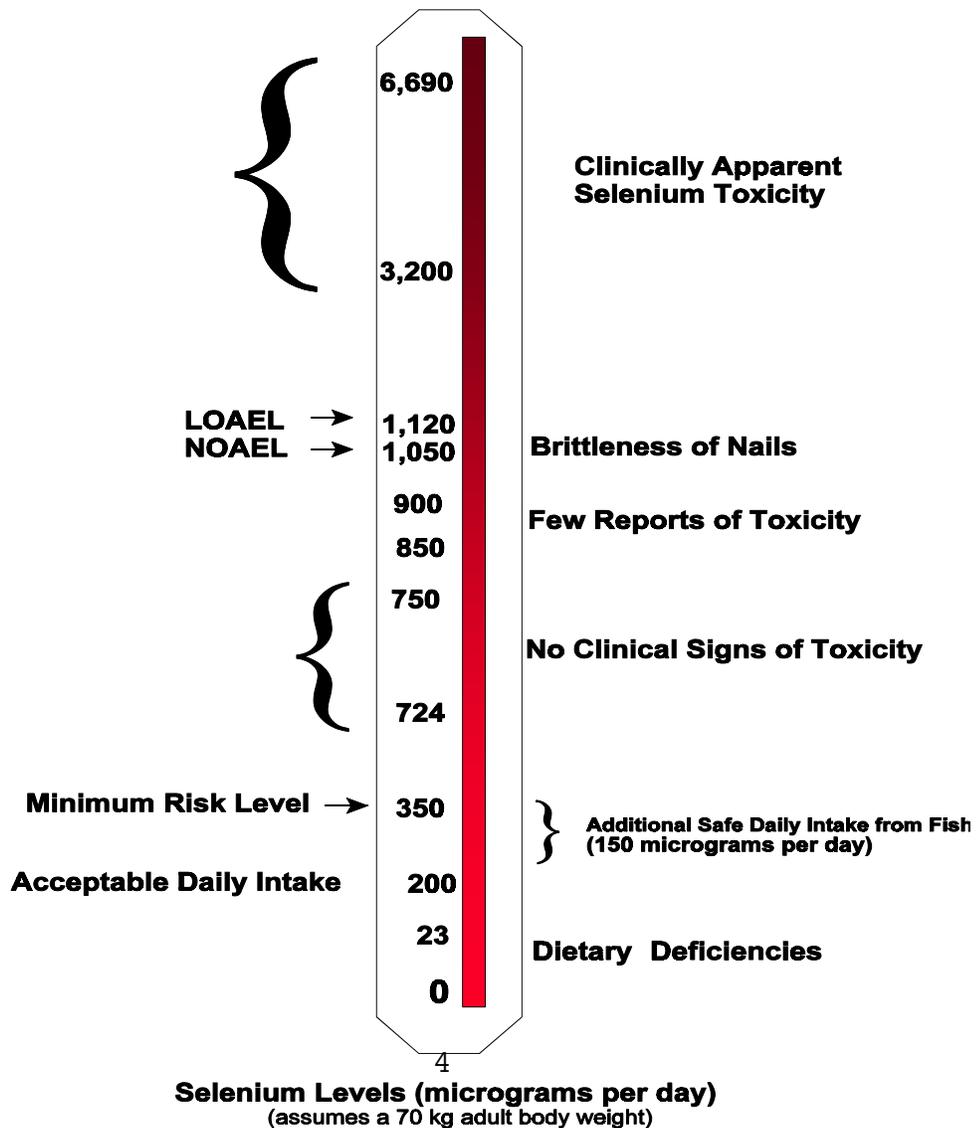
The Agency for Toxic Substances and Disease Registry (ATSDR) recently has established a chronic oral Minimum Risk Level (MRL) for selenium of 5 µg/kg/day [1]. For a 70 kg adult this is equivalent to an intake of 350 µg/day. The MRL is an estimate of the daily human exposure to a hazardous substance that 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 [1].

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 µg/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 Brandy Branch Reservoir, we used the same paradigm used in the previous 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.

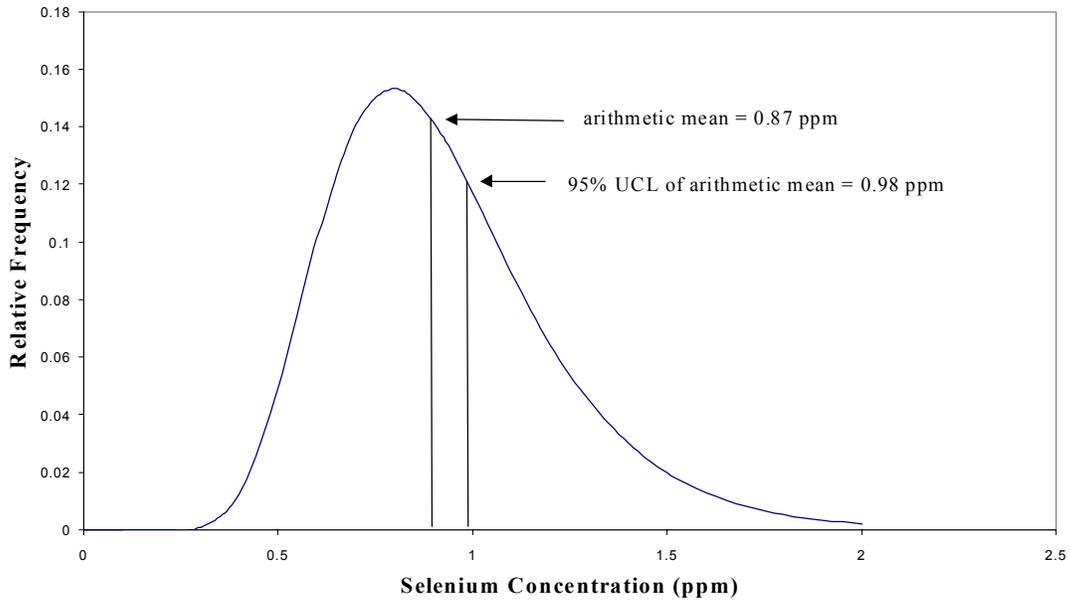
To determine the actual number of meals that could be consumed without exceeding the MRL, we used two values for the concentration term; the arithmetic average and the 95th percent upper confidence interval (95% UCL) of the arithmetic average. The 95% UCL is defined as a value that when calculated repeatedly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

We estimated the 95% UCL by defining the distribution of selenium in fish tissue from Brandy Branch Reservoir using the 1996-97 data and then randomly drawing 1,000 samples of 17 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. Figure 3 provides a graphical representation of the relationship between the sample distribution, the arithmetic average, and the 95% UCL of the arithmetic average.

Using these assumptions we estimate that adults (70 kg) could consume between five and six (eight ounce) meals per week and children (body weight 10-30 kg) could consume approximately one to five (four ounce) meals per week of Brandy Branch 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

Relative Frequency of Selenium Concentrations in Brandy Branch Fish



| Table 2. Recommended Limitations on Long-Term Fish Consumption by body weight | | | | | | |
|---|------|--|--------------------------------|--|---|-----------------------|
| Body Weight | | Estimates Based on Average and Upper 95% UCL Selenium Levels for the 17 fish samples collected | | | | |
| (kg) | (lb) | (a) | (b) | Acceptable Daily Intake of Selenium From Fish (ug/day) | Quantity of fish that can be consumed without exceeding MRL | |
| | | Baseline exposure (µg/day) | Minimum Risk Level (µg/day) | | Meals per week | |
| | | (BW x 2.86 ug/kg/day) | (BW x 5 ug/kg/day) | | Average (0.87 ppm) | 95% UCL (0.98 ppm) |
| Assumes a child body weight and an average meal size of 4 ounces each | | | | | | |
| 10 | 22 | 29 | 50 | 21 | 1.6 | 1.5 |
| 20 | 44 | 57 | 100 | 43 | 3.3 | 2.9 |
| 30 | 66 | 86 | 150 | 64 | 4.9 | 4.4 |
| Assumes an adult body weight and an average meal size of 8 ounces each | | | | | | |
| 40 | 88 | 114 | 200 | 86 | 3.3 | 2.9 |
| 50 | 110 | 143 | 250 | 107 | 4.1 | 3.7 |
| 60 | 132 | 172 | 300 | 128 | 4.9 | 4.4 |
| 70 | 154 | 200 | 350 | 150 | 5.8 | 5.1 |
| 80 | 176 | 229 | 400 | 171 | 6.6 | 5.8 |
| 90 | 198 | 257 | 450 | 193 | 7.4 | 6.6 |
| 100 | 220 | 286 | 500 | 214 | 8.2 | 7.3 |

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 five meals per week (4 ounces each) would not exceed minimal risk levels for adverse health effects from selenium in fish.

CONCLUSIONS

1. Based on the 1996 and 1997 sampling data, levels of selenium in Brandy Branch Reservoir fish are lower than they were during the late 1980s.
2. Depending on body weight (10-30 kg), children could consume approximately one to five (four ounce) meals of Brandy Branch fish per week before exceeding the MRL. Adults (70 kg) consuming five to six (eight ounce) meals of Brandy Branch fish per week would not be expected to exceed the MRL. Approximately three times these amounts would be required to exceed the lowest levels reasonably expected to result in signs and symptoms of toxicity, therefore, ingestion of fish from Brandy Branch poses no apparent public health hazard.

RECOMMENDATIONS

1. The fish consumption advisory issued for Brandy Branch Reservoir in 1992 should be re-evaluated based on the current recommended limitations on long-term fish consumption.

REFERENCES

1. ATSDR, 1996. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Selenium. Atlanta: ATSDR, Aug. 1996.

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CERTIFICATION

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

Chief, SPS, SSAB, DHAC, ATSDR