

Exposure Investigation

**SERUM PCB AND BLOOD MERCURY LEVELS
IN CONSUMERS OF FISH AND TURTLES
FROM WATTS BAR RESERVOIR**

**WATTS BAR RESERVOIR/CLINCH RIVER OPERABLE UNIT
U. S. DOE OAK RIDGE RESERVATION**

OAK RIDGE, ANDERSON COUNTY, TENNESSEE

CERCLIS # TN1890090003

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Abstract

Previous investigations of the Watts Bar Reservoir have looked at many contaminants, but identified only polychlorinated biphenyls (PCBs) in reservoir fish as a possible contaminant of current public health concern. The purpose of this exposure investigation was to determine whether people consuming moderate to large amounts of fish and turtles from the Watts Bar Reservoir are being exposed to high levels of PCBs, or mercury--a historical contaminant of concern. The exposure investigation results are applicable only to the exposure investigation participants. This investigation is not a research study and the results cannot be extended to the general population or be used to evaluate the need for, or efficacy of, public health measures already in place.

After screening approximately 550 individuals, 116 individuals met the exposure investigation criteria and volunteered to participate in the exposure investigation. These participants were interviewed for demographic and consumption information, and blood was drawn for PCBs and mercury analyses. The average daily consumption rate of Watts Bar Reservoir fish, based on self-estimated consumption frequency and meal size for fish or turtles, was 66.5 grams per day (g/day). (Average consumption of fish in U.S. adults ranges between 13 and 25 g/day. Turtle consumption is not well characterized.)

Serum PCBs levels in the participants ranged from non-detectable levels to 103.8 micrograms per liter (mcg/L or parts per billion [ppb]). The detection limit was 3 mcg/L (ppb) and 46 individuals had non-detectable levels of PCBs in their serum. The median value was 4.25 mcg/L and the 95th percentile was 16.8 mcg/L. Persons were considered to have elevated values if their total serum levels were ≥ 20 mcg/L. Only 5 of the 116 individuals tested were above 20 mcg/L, and only one of these was above 30 mcg/L.

Total mercury levels in blood ranged from non-detectable levels to 20.0 mcg/L (ppb). The detection limit was 3 mcg/L (ppb), and 89 individuals had non-detectable levels of mercury in their blood. The median value was below the detection limit, and the arithmetic mean of the detections was 5.2 mcg/L. Organic mercury levels in blood ranged from 112 non-detects [detection limit 3 mcg/L (ppb)] to 11.0 mcg/L (ppb). The median value was below the detection limit, and the arithmetic mean of the detections was 6.0 mcg/L. Persons were considered to have elevated values if their total blood mercury was ≥ 10 mcg/L. Only 1 of the 116 individuals tested was above 10 mcg/L total mercury.

The exposure investigation participants= serum PCBs levels and blood mercury levels are very similar to levels found in the general population. In addition, the PCBs and mercury levels of the participants were lower than ATSDR health scientists expected to find in persons who consume moderate to large amounts of certain fish or turtles from Watts Bar Reservoir. Follow-up interviews with participants whose PCBs or mercury levels were considered elevated did not reveal other occupational or environmental factors that might have contributed to the higher levels. Additional information was provided to the participants to help them to reduce possible future exposures to PCBs or mercury. In addition, these participants were encouraged to inform their primary health care providers of their results.

Background

Over the past 50 years waterborne contaminants (radionuclides, metals, and organic compounds) have been released from the U. S. Department of Energy (DOE) Oak Ridge Reservation, into tributaries of the Clinch River and were transported into the Watts Bar Reservoir. Contaminants from the Oak Ridge Reservation, and other industrial sites in the Tennessee River watershed, have been found in the reservoir suspended in water, bioconcentrated in fish, and bound to particles suspended in the water or settled out in the sediment.

In 1989 the Oak Ridge Reservation was placed on the Superfund National Priorities List. Since then, the Tennessee Department of Environment and Conservation, the Tennessee Valley Authority, the Tennessee Department of Health, the Agency for Toxic Substances and Disease Registry (ATSDR), and DOE evaluated current and past releases of chemical and radiological contaminants from the Oak Ridge Reservation into tributaries of the Clinch River and the lower Watts Bar Reservoir. The 1994 DOE Remedial Investigation for the Lower Watts Bar Reservoir and the 1996 DOE Remedial Investigation for the Clinch River/Poplar Creek concluded that the fish ingestion pathway is the most significant exposure pathway in terms of potential adverse health effects [2,3]. DOE's risk assessments and quantitative uncertainty analyses indicate the excess lifetime cancer risk is greater than one in one thousand (10^{-3}) for ingesting polychlorinated biphenyls (PCBs) contaminated fish from the Clinch River and the Lower Watts Bar Reservoir [2,3].

In February 1996, a health consultation of the Lower Watts Bar Reservoir by ATSDR concluded that levels of PCBs in Lower Watts Bar Reservoir fish are the only contaminants of current public health concern [1]. This health consultation characterized the risks and showed that frequent and long-term ingestion of moderate to large amounts (32 grams per day [g/day]) of PCBs contaminated fish from the reservoir poses a moderately increased risk of cancer in adults and may increase the possibility of adverse developmental effects in infants whose mothers consume fish regularly during gestation and while nursing [1]. Due to the uncertainty in the turtle ingestion rate, ATSDR health scientists have not been able to estimate exposure doses and excess cancer risk for consumption of reservoir turtles. Mercury has been a historical contaminant of concern because of the large quantities released from the Oak Ridge Reservation. However, the Agency concluded that other contaminants such as mercury in the surface water, sediment, and fish are currently not at levels of public health concern [1].

The Tennessee Department of Environment and Conservation has issued advisories for consumption of fish from the Tennessee River portion and the Clinch River portion of the Watts Bar Reservoir. These advisories are for certain fish containing elevated levels of PCBs. The advisory is based on the U.S. Food and Drug Administration (FDA) 2 parts per million (ppm) PCBs comparison value for fish. Also, in 1997, the Tennessee Department of Environment and Conservation reported that PCBs were detected in Watts Bar Reservoir snapping turtles [4].

Rationale for the Exposure Investigation

Data from previous studies pertaining to levels of PCBs and mercury in fish and turtles were reviewed for a number of species of fish and one species of turtle captured at numerous locations around Watts Bar Reservoir. The amount of information varied greatly by species and location [2,3]. The previous studies have shown that certain species of fish from the Watts Bar Reservoir contain PCBs up to about 8 ppm (averaging 1-2 ppm), or turtles from the Watts Bar Reservoir contain PCBs up to 3.3 ppm (mean 0.5 ppm) in muscle tissue and up to 516 ppm (mean 64.8 ppm) in adipose tissue [1, 4].

Using conservative (protective) exposure and dose-response assumptions, DOE=s risk assessments estimate an excess lifetime cancer risk of greater than one in one-thousand (10^{-3}) for people who eat more than one meal a week of certain species of fish from Watts Bar Reservoir for 30 years [2,3]. Similarly protective assumptions for mercury result in a hazard quotient of greater than one for a child ingesting more than 8 ounces of certain species of fish a week from Watts Bar Reservoir [2, 3]. Dose reconstruction studies, risk assessments, and quantitative uncertainty analyses conducted on the exposure pathway of fish from the Clinch River and Watts Bar Reservoir only *estimate* exposure doses and excess cancer risk. These studies do not confirm that people are actually being exposed, or have elevated levels of PCBs or mercury.

The determination of public health concerns from previous investigations and studies are based primarily upon estimated PCBs exposure doses and estimated excess cancer risk for people who frequently consume fish over an extended period of time. Sensitivity analysis indicates that the fish ingestion rate provides the largest uncertainty associated with these dose and risk estimates. Also, estimated PCBs exposure doses and excess cancer risks were not calculated for eating reservoir turtles due to the uncertainty in the turtle ingestion rate. These uncertainties in determining the degree of public health concern from eating reservoir fish and turtles were a major factor in finalizing the need for an exposure investigation at this site.

In addition, the Tennessee Department of Health=s contractor recommended to the Oak Ridge Health Agreement Steering Panel (ORHASP) that extensive region-wide evaluations of relevant exposures and health effects (e.g., fish consumption survey, PCBs and mercury prevalence survey, or epidemiologic health study) be made in counties surrounding the Watts Bar Reservoir. Therefore, a data gap pertaining to the documentation of *actual* elevated levels of PCBs or mercury exists and should be addressed prior to initiating any region-wide evaluations.

Purpose of the Exposure Investigation:

The purpose of the exposure investigation was to determine whether people consuming moderate to large amounts of fish and turtles (generally greater than 15 g/day) from the Watts Bar Reservoir are being exposed to elevated levels of PCBs and mercury. As an exposure investigation rather than a research study, the results are applicable only to exposure investigation participants. Because participation was limited to moderate to high fish consumers who volunteered to participate, the results cannot be extended to the general population. In addition, the results from this investigation are not intended to evaluate the need for, or efficacy

of, the current fish advisory.

Objectives:

- Measure serum PCBs and blood mercury levels among participants who consume large quantities of fish or turtles from the Watts Bar Reservoir.
- Identify appropriate follow-up health actions for participants and target health education activities.
- Provide new information to assist with evaluating the need for future region-wide assessments that have been recommended.

Methods

Target Population:

Identifying the target population was challenging for this exposure investigation. We chose as our target population, moderate to high consumers of fish or turtles from Watts Bar Reservoir.

There are four counties with approximately 115,000 people in close proximity to the Watts Bar Reservoir. Additionally, people come from other Tennessee counties and other midwestern and southern states to fish at the Watts Bar Reservoir. For logistical reasons, ATSDR elected to base the exposure investigation in a centrally located county health department, Roane County.

Preliminary information about consumption eligibility and willingness to participate was collected from more than 550 potential participants who volunteered information. These potential participants were identified through a variety of sources including: fishing license record review, information from bait shops and marinas, newspaper advertisements, radio and television coverage, posters and flyers, letters to churches, and word of mouth. Screened individuals who were included in the investigation during the past year, reported eating one or more turtle meals, six or more meals of catfish and striped bass, nine or more meals of white, hybrid, or smallmouth bass, or 18 or more meals of largemouth bass, sauger, or carp (see attachments). These screening criteria were based on fish data from previous investigations.

Data Collection and Analysis:

Data and samples for this investigation were collected from September 15-28, 1997. Eligible individuals wishing to participate were asked to visit the Roane County Health Department in

Kingston, Tennessee. A mobile unit was also utilized to provide interview and phlebotomy facilities at several field locations during the two-week period of the exposure investigation. The field locations were both prearranged locations with scheduled appointments, and ad hoc locations near favorite fishing spots. In both the health department and field locations, participants were given a consent form to read and sign (see attachments). Parents or guardians completed this form for minors. After the consent form was completed, an interview was conducted to obtain demographic information, length of residency near the Watts Bar Reservoir, what species were eaten, how much of each species was eaten, where on the reservoir they were caught, how they were cooked and prepared, and other variables (see attachments). Blood specimens were collected for PCBs and mercury analysis after the interview. All data were entered into Epi-Info for analysis.

Biologic Specimen Collection and Analysis:

Venous blood samples were collected from participants by trained phlebotomists. A sample of approximately 10 milliliters (mL) was collected for PCBs analysis. The serum was extracted and sent to Pacific Toxicology Labs in Los Angeles, California. Total PCBs and speciated analyses were conducted on the serum samples. The serum PCBs results are not adjusted for serum lipid levels. PCBs congener analysis was performed on all individuals with detectable total PCBs levels. A 10 mL venous blood sample was also collected and sent to National Medical Labs in Willow Grove, Pennsylvania, for both total mercury and organic mercury analysis.

Reporting of Results:

All participants (or their parents/guardians) received written notification and interpretation of their results from ATSDR. For participants identified as having elevated values, a follow-up interview with an ATSDR physician was offered to better determine potential pathways of exposure and possible ways to reduce exposure in the future. Four of the six participants with elevated values participated in the follow-up interviews.

Results

Questionnaire Findings:

The 116 participants in the exposure investigation reside in eight Tennessee counties and several other states (e.g., Kentucky, Ohio, and Florida). Participants consisted of 58.6% male and 41.4% female. The age range was from 6 to 88 years with a mean age of 52.2 years. High school education was completed by 65% of the participants, and four or more years of college was completed by 12%. Length of residence in the area varied with 10.3% living in Roane County for 5 years or less, 67.3% living in Roane County for 6 years or longer, and 22.4% from counties other than Roane County, Tennessee.

All participants ate fish from the Watts Bar Reservoir during the last year--80.2% for six or more years and 65.5% for more than 11 years. Additionally, 20.7% ate turtles from Watts Bar Reservoir in the last year. The distribution of fish and turtle meals per year from the Watts Bar Reservoir had a median value of 33.1 fish meals and a 95th percentile of 164.0 fish meals. The average daily consumption rate, based on self-estimated consumption frequency and meal size for fish or turtles, was 66.5 g/day.

Fish preparation and cooking methods were examined in the questionnaire. Most of the participants skin their fish (82.8%), fillet their fish (84.5%), and trim the fat (69.8%). Cooking techniques vary, but 42.2% usually pan fry their fish, 44.8% usually deep fry their fish, and 11.2% bake or broil their fish. It was noted that 55.2% of participants sometimes or usually re-use their cooking oil.

Most of the 550 people screened, about 80%, did not eat enough fish from the Watts Bar Reservoir to be included in the exposure investigation. Even those who were avid anglers released all or most of the fish they caught. The 116 individuals who volunteered to participate in the investigation represent 21% of those screened.

Biologic Findings:

PCBs

Serum PCBs levels in the participants ranged from non-detectable to 103.8 micrograms per liter (mcg/L or parts per billion [ppb]). The detection limit was 3 mcg/L (ppb). Only 46 individuals had non-detectable levels of PCBs in their serum. The median value was 4.25 mcg/L, and the 95th percentile was 16.8 mcg/L. Persons were considered to have elevated values if their total serum levels were ≥ 20 mcg/L. Only 5 of the 116 individuals tested were above 20 mcg/L, and only one of these was above 30 mcg/L.

Mercury

Total mercury levels in blood ranged from non-detectable to 20.0 mcg/L (ppb). The detection limit was 3 mcg/L (ppb), 89 individuals had non-detectable levels of mercury in their blood. The median value was below the detection limit and the arithmetic mean of the detections was 5.2 mcg/L. Organic mercury levels in blood ranged from 112 non-detects [detection limit 3 mcg/L (ppb)] to 11.0 mcg/L (ppb). The median value was below the detection limit, and the arithmetic mean of the detections was 6.0 mcg/L. Persons were considered to have elevated values if their total blood mercury was ≥ 10 mcg/L. Only 1 of the 116 individuals tested was above 10 mcg/L total mercury.

Discussion and Interpretation

Serum PCBs levels in the participants were very similar to those in previous studies of the general U.S. population, and less than we had anticipated in this group of moderate to high consumers of fish and turtles. The previous studies, however, used data from the 1970's and 1980's which may not adequately represent the distribution in today's population [5,6]. Blood mercury levels were also similar to what is found in the general population as reflected in previous studies. Only the individual with the serum PCBs of 103.8 mcg/L truly appears to be outside the general U.S. population distribution.

Prior to this exposure investigation, there was a large amount of uncertainty regarding fish consumption patterns such as the quantity and the species of fish eaten or whether and how many turtles were consumed. The data from this exposure investigation reduce some of this uncertainty. We have a better understanding of the variability of fish consumption patterns for those in the moderate to high consumption range in terms of the variety of species and amount consumed as well as fishing locations and typical methods of preparation. These data will contribute to our overall understanding of how these fish consumption patterns are associated with PCB and mercury exposure.

Conclusions

1. The exposure investigation participants' serum PCBs levels and blood mercury levels are very similar to levels found in the general population. In addition, the PCBs and mercury levels of the participants were lower than ATSDR health scientists expected to find in persons who consume moderate to large amounts of certain fish or turtles from Watts Bar Reservoir.
2. Only five of the exposure investigation participants had serum PCBs levels above 20 mcg/L. A level of 20 mcg/L level is considered to be an elevated total PCBs level. Of the five participants who exceeded 20 mcg/L, four had levels between 20 and 30 mcg/L. Only one participant with a serum PCBs level of 103.8 mcg/L appeared to be higher than the general population distribution.
3. Only one participant in the exposure investigation had a total blood mercury level higher than 10 mcg/L. A total blood mercury level of 10 mcg/L is considered to be elevated. The remaining participants had mercury blood levels that ranged up to 10 mcg/L, as might be expected to be found in the general population.
4. Follow-up interviews with those participants who had elevated PCBs levels did not reveal other occupational or environmental factors that might have contributed to the higher levels. Additional information was provided to the participants to help them to reduce possible future exposures to PCBs or mercury.
5. Based on the information obtained from the screening questionnaire, most of the more than 550 people screened for possible participation in the exposure investigation ate little

or no fish or turtles from the Watts Bar Reservoir.

6. Based on the information obtained from the interview questionnaire, most exposure investigation participants continued to eat the same amounts and kinds of fish or turtles from Watts Bar Reservoir, even if they were aware of the fish consumption advisory.

Recommendations

1. ATSDR recommends the reduction of possible PCBs or mercury exposures for those participants found to have elevated levels. It is further suggested that these participants make their primary health care providers aware of their elevated PCBs or mercury levels as a precautionary measure. If the exposure investigation participants or their physicians have questions or need further information, they should contact ATSDR at the toll-free telephone number, (800) 447-1544 and ask to speak with Robert H. Johnson, M.D..
2. ATSDR has suggested that the exposure investigation participant whose PCBs level was found to be 103.8 mcg/L seek clinical consultation through Association of Occupational and Environmental Clinics (A.O.E.C.), in order to repeat testing of the participant=s serum PCBs level in 3 to 6 months. In addition, ATSDR recommends that the participant=s spouse also be tested to determine the serum PCBs level.
3. ATSDR recommends that health education activities be targeted to provide needed information to those participants found to have elevated PCBs or mercury levels, as well as to local health care providers, pregnant and nursing mothers, and any other potentially vulnerable populations.

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