Lead Concentrations in Native Trout

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The background levels of lead in the environment, as evidenced by snow samples from Greenland, have been increasing at an exponential rate (BRYCE-SMITH, 1971). A base level of 20 μg/ton was observed up to 1750. By 1860 it was 50 μg/ton; in 1940, 80 μg/ton; in 1950, 120 μg/ton and by 1965 the concentration was 210 μg/ton. In the past 30 years the increasing use of lead has culminated in an environmental level far above that which would normally exist, with possible harmful effects on health (PATTERSON, 1965 and PATTERSON, et al., 1966). The major sources of lead contamination are leaded gasolines and pesticides, manufacturing, combustion of coal, incineration of refuse, leaded paints, and earthenware pottery that has been improperly glazed.

Tetraethyl lead and tetramethyl lead are added to gasolines to increase their octane ratings. The national average is 2.40 grams of TEL/gallon or 1.54 grams of lead per gallon. The amount of lead discharged to the atmosphere in exhaust gases varies from 25% to 75% depending upon driving conditions (HALL, 1972 and MILLS, 1971). As a consequence the atmospheric concentrations near highways are an exponential function of distance from the roadway (DAINES, et al., 1970). The lead level near the highway is relatively high, but drops off rapidly during the first 150 feet from the highway. The concentration is reduced 50% within the first 10 to 30 feet from the highway.

Soils and plants along heavily traveled highways show that lead concentrations increase with traffic volume and decrease with distance from the highway (MOTTO, et al., 1970). Much of the lead was a removable surface contaminant on the plants and the increase in the soil was limited to the surface material.

The West Gallatin River in southwestern Montana flows adjacent to U.S. Highway 191 for forty miles. As a consequence, the automobile traffic will increase the lead concentration in this region. In this paper we report the lead concentrations found in native trout taken from the river and compare them to similarly obtained values for fish from the Federal Fish Hatchery in Bozeman, Montana and from Yellowstone National Park.

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Method of Analysis

The fish analyzed in this study were caught with hook and line. Figure 1 illustrates a map of the West Gallatin River. Four sample collection sites are within Gallatin Canyon; another was in Yellowstone Park near the mouth of Fan Creek. Fish samples were also collected from the Federal Fish Hatchery in Bridger Canyon northeast of Bozeman. Water samples were taken at the same time as the fish.

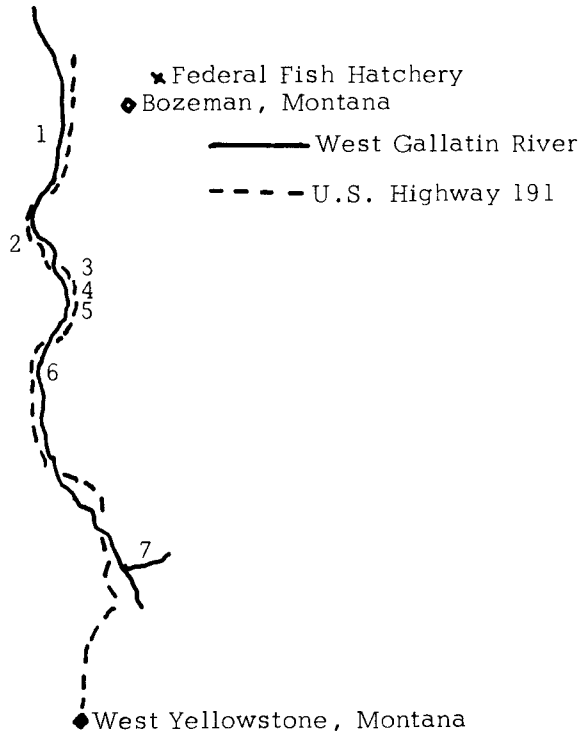

Figure 1: Fish Sampling Area of West Gallatin River

The fish were frozen shortly after collection and stored for a short period prior to analysis. The first segment of the analysis involved thawing of the fish, dissection and subsequent freeze drying of the tissue in a Thermovac lyophilizer. Gill tissue, portions of the backbone and the liver were utilized. After freeze drying the samples were wet digested in a mixture of nitric and perchloric acid. The lead concentration in the resulting solution was determined using flameless atomic absorption spectrophotometry. A more detailed discussion of the analytical method has been presented (PAGENKOPF, et al., 1972). The relative standard

deviations for the fish samples are large and reflect variation from fish to fish and not the precision of the analytical method. Large standard deviations also have been observed in other related studies (SMITH, et al., 1970, THOMAS, et al., 1967, HEUTER, et al., 1966).

Results and Discussion

The water analyses are listed in TABLE I. See Figure 1 for the particular location.

TABLE I

Lead Concentrations in River and Hatchery Water

Location	Pb ng/ml
West Gallatin River	
1. North of Gallatin Gateway	2.93
2. North of Cascade Creek	2.56
3. South of Cascade Creek	2.94
4. North of Greek Creek	2.65
5. South of Greek Creek	2.96
6. Porcupine Creek	2.81
7. Fan Creek	2.65
Federal Fish Hatchery	1.41

The lead concentrations in the West Gallatin River are in the low range of values found in other rivers in the U.S. The national average for lead in major rivers is 23 ng/ml with a low value of 2 ng/ml (KOPP, et al., 1970). The average for the West Gallatin River is 2.81 ng/ml. This is far below the value of 25 μg/ml which is required to retard brook trout growth (DOREMAN, 1969).

A total of thirty-six fish were collected at five locations along the West Gallatin River and Federal Fish Hatchery at Bozeman, Montana. The fish included 27 Rainbow Trout (Salmo gairdneri), 4 Cutthroat Trout (Salmo clarki), 3 Brown Trout (Salmo trutta) and 2 Whitefish (Coregonus williamsoni). The fish ranged in length from 6 to 18 inches. Of the thirty-six samples, four were from the Federal Fish Hatchery, twenty-seven from the canyon of the West Gallatin River and five from the headwaters of the West Gallatin River lying in Yellowstone National Park. U.S. Highway 191 closely parallels the river in the canyon section. Fish samples were taken at sites 3, 4, 5, 6 and 7 as shown in Figure 1.

Growth rate studies of trout in the West Gallatin River conducted by the Montana State Fish and Game Department indicate that the average length of a one year old fish is 5.2 inches; a two year old is 7.7 inches; a three year old is 9.4 inches and a four year old is 12.0 inches (VINCENT, 1972). Using these guidelines

the fish from the canyon have been separated into age groups. TABLE II lists the age groups and the lead concentrations.

TABLE II

Correlation of Fish Age and Lead Concentration[a]

Age	# of Fish	Mean Conc. Pb (ppm Dry Wt. Basis ± S.D.) Bone	Gill	Liver
1-2	6	2.91 ± 1.54	1.25 ± .59	4.18 ± 3.65
2-3	6	4.00 ± 2.03	2.04 ± .61	1.37 ± .57
3-4	8	3.97 ± 1.26	2.44 ± 1.18	1.57 ± .36
4+	6	4.81 ± 1.27	3.18 ± 2.26	1.35 ± 1.16

[a]Fish from the canyon area of the West Gallatin River

There is a general trend in the bone data indicating that the older fish have higher lead levels. However, the significance of the difference in the means is not high due to the relatively large standard deviation. Comparison of the means for the bones by the "null hypothesis" results in only one grouping being significantly different at the 95% level. This is for the comparison of the two extreme age groupings.

The fish have been geographically divided into three groups, those taken in Yellowstone National Park, those taken in the canyon of the West Gallatin River and those from the Federal Fish Hatchery. TABLE III lists the observed lead concentrations.

TABLE III

Tissue Type	Location	No. of Fish[a]	Mean Conc. Pb (ppm Dry Wt. Basis ± S.D.)
Bone	Canyon	24	3.86 ± 1.64
	Park	5	2.73 ± 0.41
	Hatchery	4	0.95 ± 1.00
Liver	Canyon	15	1.56 ± 0.71
	Park	5	1.93 ± 0.62
	Hatchery	4	0.61 ± 0.62
Gill	Canyon	16	2.43 ± 1.21
	Park	5	2.12 ± 0.55
	Hatchery	4	0.62 ± 0.33

[a]The age of these fish was two years or greater.

Comparison of the means for the samples from the canyon and the park with those from the hatchery indicate that there is a significant difference at the 95% confidence level. Comparisons of the means for the canyon with those of the park indicate that there is no significant difference between the gill and liver tissue. However, there is a difference for the bone samples at the 88% confidence level.

The major contributor to the difference between the river samples and the hatchery samples is probably due to the lead concentrations in the water. The water from the hatchery has a lead concentration one half that of the river. Freshwater fish adsorb water through the gills. The blood of freshwater fish is ionically stronger than the fresh water and therefore fresh water passes through the semipermeable membranes of the gills and into the bloodstream (CURTIS, 1949).

The park fish were taken in an area removed from U.S. Highway 191 whereas the canyon fish were taken where the highway and the river were adjacent. As a consequence, the canyon fish should be subject to higher lead levels, presumably through the food chain, than the fish in the park. The average traffic load on U.S. Highway 191 is 1178 vehicles/day with peak loads of greater than 2500 vehicles/day during the summer months (REISER, 1972). This is not a large traffic load and thus one would predict a small if any enhancement of the lead concentration in the fish. Analysis of the data in TABLE III indicates that there is no enhancement for the gill and liver tissue and possibly a slight increase in the bone.

The lead concentrations observed for these fish are similar to those observed for other fish: salmon, 1.3 μg/g; tuna 1.2 μg/g; oyster, 4.3 μg/g; sardine, 1.3 μg/g and crabmeat, 0.85 μg/g (MERANGER, et al., 1968).

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