Mercury Levels in Fish in the La Grande River Area, Northern Quebec

by ERIC C. SMITH and FIKRET BERKES
Marine Sciences Centre, McGill University, Montreal
and
JOHN A. SPENCE
Department of Biology, McGill University, Montreal

High mercury levels in organisms in inland waters have usually been attributed to pollution (e.g. FIMREITE et al. 1971). But there is evidence that high mercury content in rocks in some regions (CAMERON and JONASSON 1972) may be responsible for high mercury levels in organisms. It has been known for some time that fish in the southern James Bay region contain concentrations of mercury often exceeding 0.5 ppm on a fresh (wet) weight basis in areas likely to be contaminated, but also in areas not obviously affected by industrial discharges.

The natural background levels of mercury in the environment are of considerable interest in establishing baselines and in assessing the extent of pollution by industrial mercury. There is a dearth of information on the mercury content of freshwater fish populations remote from industrial sources. This study deals with the northern James Bay area, the site of an extensive hydroelectric and mining development project; there have been no previous published accounts on the mercury content of organisms from this area.

Materials and Methods

The fish were collected by a variety of catching methods between August 12 and 30, 1972. The samples came from the following localities:
Mile 21, La Grande River (LG-1)
Mile 120, La Grand R. at Sakami River
Mile 190, La Grande R. (LG-3)
Mile 395, La Grande R. at Lac Puisseau
Kaniapiscau River at Lac Delorme (Praslin Lodge)
Kaniapiscau R. at Lac Lemaitre (K-River Lodge)

All samples were taken from the lateral musculature of fish, and were preserved in formalin. A total of 45 samples were analyzed by flameless atomic absorption spectrophotometry. The analytical method was essentially the same as that of HATCH and OTT (1968). One-gram samples were digested in 25 ml of concentrated sulfuric acid and 3 ml of 50% hydrogen peroxide. All the mercury was converted to mercuric mercury with potassium permanganate. Excess permanganate was reduced with hydroxylamine hydrochloride. Mercury was reduced to the atomic state, and conveyed to the absorption chamber where it was measured by the absorption of the 253.7 A line. The analyses were performed using a Coleman Mercury Analyzer model MAS-50, which has a reported sensitivity

Bulletin of Environmental Contamination & Toxicology,
Vol. 13, No. 6 © 1975 by Springer-Verlag New York Inc.

of equal to or better than 0.01 ppm for the sample size used. The procedure is comparable to that described by UTHE et al. (1970) who reported a standard deviation of ±0.039 at the 0.1 ppm level. They observed a possibility of error arising due to mercury vapor loss after the addition of stannous chloride. In the present work, samples were kept in well-sealed bottles during the final preparation, and were resealed immediately upon addition of the stannous chloride. UTHE et al. (1970) also observed a possibility of error due to a rapid decrease in absorbance readings after the maximum was reached. However, the unit used in the present study was equipped with a "memory" for the automatic recording of the peak value.

All samples were analyzed in duplicate. One sample was analyzed in five replicates, resulting in a 9.1% standard deviation relative to the mean. All values were expressed as total mercury on a ppm wet (fresh) weight basis.

Results

Table 1 gives mercury concentrations in the muscle tissue of fish from the La Grande area. The highest levels occurred in one large northern pike (Esox lucius), and in one large lake trout (Salvelinus namaycush), both containing 1.21 ppm. One sample of yellow walleye (Stizostedion v. vitreum) yielded 0.78 ppm. The arithmetical means for pike and lake trout were 0.65 and 0.60 ppm, respectively. By contrast, brook trout (Salvelinus fontinalis) averaged 0.25 ppm; non-anadromous lake whitefish (Coregonus clupeaformis), two specimens, 0.16ppm; and anadromous lake whitefish (Coregonus clupeaformis), 0.09 ppm. Five replicate analyses of one sample yielded a standard deviation of 0.11 ppm at the 1.21 ppm concentration level.

The overall relationship between body weight and mercury levels can be expressed as a single regression line representing all fish, regardless of sampling locations and species. The equation developed from the data by means of step-wise regression (TAUCHI 1968) is:

$$\log_e (\text{ppm Hg}) = 0.82 \log_e (\text{wt}) - 7.21$$

The fit was significant ($p<0.01$ by F-test). The equation explained 62.9% of the variance of the mercury concentration in different samples. The mathematical relationship between body weight and mercury suggested that fish smaller than about 2800 g tend to contain less than 0.5 ppm mercury.

Using the same method as above, the relationship between age and mercury levels may be expressed as:

$$\log_e (\text{ppm Hg}) = 1.35 \log_e (\text{age}) + 3.14$$

which is also signigicant ($p<0.01$), but explains only 27.7% of the variance. The amount of variance explained by multiple regression with both the weight and age data was no greater than by regression with weight alone.

TABLE I

Total mercury, body weight and age of fish, by species and by sampling station.

Locality/Species	N	Mercury, ppm $\bar{x}$	Mercury, ppm range	Body weight, g $\bar{x}$	Body weight, g range	Age, years
Mile 21, La Grande River						
Coregonus clupeaformis	10	0.09	0.06-0.14	459	337 -712	4+ to 6+
Mile 120, La Grande at Sakami R.						
Coregonus clupeaformis	1	0.13	--	1500	--	13+
Esox lucius	9	0.76	0.45-1.21	3194	1775-4785	5+ to 9+
Stizostedion v. vitreum	1	0.78	--	920	--	13+
Mile 190, La Grande River						
Esox lucius	1	0.33	--	4250	--	8+
Salvelinus fontinalis	7	0.23	0.12-0.38	1117	739-1600	4+ to 6+
Mile 395, Lac Puisseau						
Esox lucius	2	0.72	0.51-0.94	4725	3500-5950	9+ to 11+
Salvelinus fontinalis	3	0.32	0.12-0.57	1005	890-1225	4+ to 5+
Salvelinus namaycush	3	0.55	0.40-0.69	2170	1750-2760	7+ to 9+
Kaniapiscau, Praslin Lodge						
Salvelinus fontinalis	2	0.20	--	928	830-1025	6+
Salvelinus namaycush	3	0.77	0.53-1.21	1427	580-3700	5+ to 11+
Coregonus clupeaformis	1	0.22	--	2750	--	14+
Kaniapiscau, K-River Lodge						
Salvelinus namaycush	2	0.44	0.32-0.57	3250	2000-4500	8+, 9+

Discussion

There are no sources of industrial mercury contamination in the La Grande area, the nearest source being some 500 km or more to the south of the area where the samples were taken (see map, FIMREITE et al. 1971). The rivers in the area run east-west. There probably is some aerial mercury fallout, but it has been estimated that this source would not explain the higher mercury values in animals far from industrial sources (WEISS et al. 1971). Thus, the high mercury levels in the La Grande area cannot to any large extent be attributed to pollution.

CAMERON and JONASSON (1972) found mercury levels averaging 0.513 ppm, which they indicated to be high, in the Aphebian shale in central and northern Quebec, near the headwaters of the La Grande. Other studies on natural sources of mercury and on food-chain accumulation were in progress at the time of writing. Considerable information exists on the mercury levels in animals of the southeastern James Bay region, but these data were not available.[1]

The number of samples in the present study was too small to develop a statistically meaningful analysis for differences both between-species and between-areas within species. In an extensive study of eleven fish species from Manitoba and northwestern Ontario, SCOTT and ARMSTRONG (1972) found such differences, and determined the size ranges within which at least 95% of the individual fish would have less than 0.5 ppm mercury. However, the authors warned against trying to predict mercury values from the size of the fish. In the present study, fish under 2800 g of body weight generally tend to contain less than 0.5 ppm mercury, regardless of the sample location and the species of fish. In view of SCOTT and ARMSTRONG's (1972) findings, this is a first approximation only.

In an area that already has relatively high levels of largely natural mercury, the present study provides some baseline figures to monitor any possible changes in mercury concentrations in fish as a result of hydroelectric and mining developments, entailing land clearance, flooding, and perhaps an increased mobilization of mercury already present in the environment.

[1] Personal communication, July 19, 1974 from the Chief of the Ecological Impact Control Division, Ecological Protection Branch, Environment Canada, Ottawa, to J. A. Spence.

References

CAMERON, E.M. and I.R. JONASSON: Geochim. et Cosmochim. Acta 36, 985 (1972).

FIMREITE, N., W.N. HOLSWORTH, J.A. KEITH, P.A. PEARCE and I.M. GRUCHY: Canadian Field-Naturalist 85, 211 (1971).

HATCH, R.W. and W.L. OTT: Anal. Chem. 40, 2085 (1968).

SCOTT, D.P. and F.A.J. ARMSTRONG: J. Fisheries Research Board Can. 29, 1985 (1972).

TAUCHI, H.J.: Remote access statistical system (RAX statistical system). Los Angeles, IBM Corp. 1968.

UTHE, J.F., F.A.J. ARMSTRONG and A.P. STAINTON: J. Fisheries Research Board Can. 27, 805 (1970).

WEISS, H.W., M. KOIDE and E.D. GOLDBERG: Science 174, 692 (1971).