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Mercury Accumulation in Biota of Thunder Creek, Saskatchewan

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Thunder Creek is a typical prairie stream which flows through the city of Moose Jaw, Saskatchewan where it discharges into the Moose Jaw River (Figure 1). Dredging of the Moose Jaw River and the confluence area of Thunder Creek to increase channel capacity began in October, 1978 as part of a Federal-Provincial Agreement. Due to the concern that dredging activities could liberate contaminants from the sediment into the water, the preliminary dredging was monitored. This monitoring revealed mercury concentrations of 3.0 mg/kg (dry weight basis) in the dredge spoils (GUMMER and FAST 1979). On the advice of the Federal and Provincial Environment Departments the dredging was temporarily halted, subject to a review of the extent of the mercury contamination.

As part of the review a number of sampling programs were undertaken as reported by GUMMER and FAST (1979). These sampling programs showed mercury contamination was extensive throughout the lower reaches of Thunder Creek and downstream into the Moose Jaw River. They reported concentrations ranging from near background (0.1 to 0.3 mg/kg) to as high as 38 mg/kg in the stream sediments and as high as 89 mg/kg in the sediments along the stream banks. The highly contaminated sediments found in these studies suggested that Thunder Creek was possibly a source of mercury which has caused the elevated levels of mercury reported in the fish of the Qu'Appelle Fishing Lakes (SASKATCHEWAN ENVIRONMENT 1979).

The majority of results reported by GUMMER and FAST were for total mercury with only three samples being analyzed for methyl mercury. Due to the sparsity of methyl mercury data, firm conclusions about the bioavailability of the mercury in Thunder Creek could not be made, as mercury must be methylated before it is biologically available (JERNELOV 1972).

The availability of mercury to biological organisms of the contaminated area is a prime concern, both in terms of predicting the impact of mercury contamination on the aquatic ecosystem and in terms of possible human

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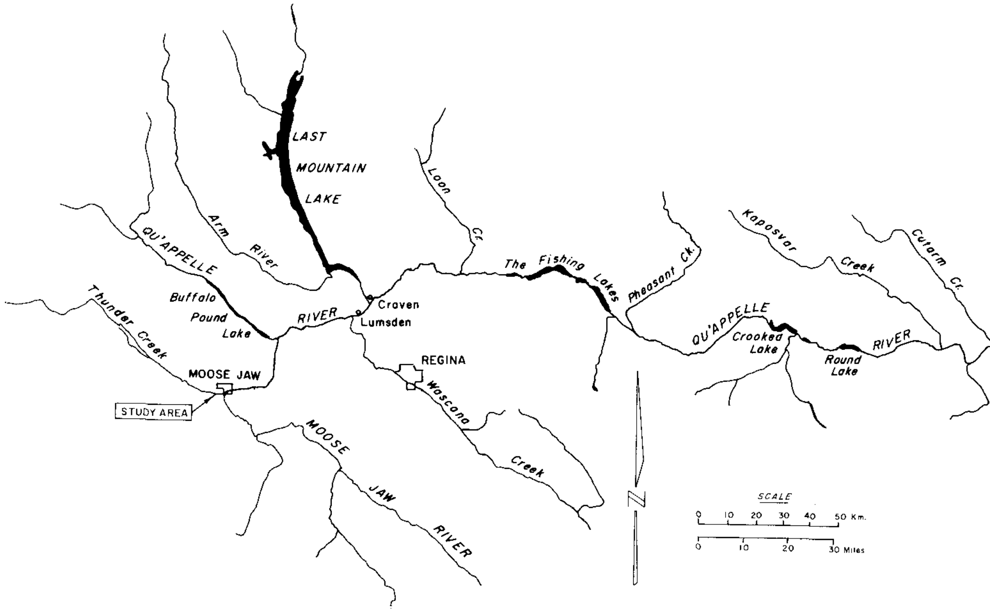

Figure 1 Map of Qu'Appelle River Basin Showing Study Area

health risks. Without this information, the potential seriousness of the mercury contaminated sediments could not be well assessed. Therefore, in October, 1979 the Water Quality Branch with the assistance of the National Water Research Institute and with funding from the Qu'Appelle Valley Management Board, conducted sediment sampling and analysis for monomethyl mercury. JACKSON and WOYCHUK (1979) report that these sediments collected from two study sites contained monomethyl mercury concentrations between 21 and 52 ug/kg on a dry weight basis. These concentrations, they say, are comparable to those reported in the contaminated English-Wabigoon River system.

Concurrently with the monomethyl mercury study, the Water Quality Branch undertook the collection of biological organisms to investigate the bioaccumulation of mercury in the food chain, the results of which are reported here.

METHODS AND MATERIAL

The collection of biological samples was conducted at two stations on October 17, 1979. The first, site #1, is situated immediately above the Highway #2 bridge in the area previously shown to have high mercury concentrations in the sediment. This site is the same as one of the sites examined for monomethyl mercury by JACKSON and WOYCHUK (1979).

The control or background site, site #2, is located approximately 2.5 km upstream, from site #1. This site is located 2.0 km upstream from the area reported by GUMMER and FAST (1979) to have mercury contaminated sediments. A beaver dam immediately downstream of the site acts as a barrier, preventing movement of organisms between the background and contaminated area during periods of low flow.

The selection of organisms for analysis was based on the presence and abundance of each at both locations. Only crayfish (Orconcetes virilis) pearl dace (Semotilus margarita) and brook stickleback (Culaea inconstans) were found to be sufficiently abundant. The organisms were collected using a 10 m X 1.5 m beach seine with 0.5 cm mesh. The fish samples were placed in polyethylene bags and packed on ice. The crayfish were also put in polyethylene bags and kept cool while transported to the Water Quality Branch laboratory in Regina. The fish were identified, measured and pooled into groups of individuals having approximately equal fork length. Each sample weighed approximately 10 gm and was composed of 4 to 13 whole fish. The samples were frozen and stored in polyethylene bags until analyzed. The live crayfish were grouped according to weight. The tail muscle was dissected from sufficient crayfish within each size group to make a sample of at least 2 gm. The samples were then placed in polyethylene bags and frozen until analyzed.

Analyses were performed by the Department of Fisheries and Oceans, Industry Services Laboratory at the Freshwater Institute in Winnipeg. Total mercury was determined by flameless atomic absorption after digestion with H_2SO_4/HNO_3 (4:1, v/v) at 180°C (HENDZEL and JAMIESON (1976). The results are reported on a wet weight basis.

RESULTS AND DISCUSSION

Sample descriptions and the mercury concentrations obtained are presented in Tables 1 and 2. Table 3 presents a summary of the mercury concentrations found in each group of organisms.

There was an approximate three-fold difference in the mean mercury concentrations in the crayfish collected from the two sites. The significance of the difference in the sample means was analyzed statistically using the student t-test and is highly significant at a 95% level of confidence (t=2.26, 9 degrees of freedom).

The mean mercury content of the crayfish at the upstream

TABLE 1
FISH SAMPLE DATA AND RESULTS

Location	# of Fish per Sample	Average Weight (gm)	Fork Length Range (cm)	Mercury Conc. (mg/kg)
BROOK STICKLEBACK				
1	9	1.2	4.7-5.0	0.15
1	11	1.0	4.2-5.0	0.15
1	13	0.9	4.2-4.8	0.15
1	7	1.5	5.0-5.5	0.14
1	9	1.2	4.5-5.2	0.15
2	6	1.6	5.1-6.0	0.11
2	9	1.1	4.3-5.0	0.09
2	10	1.0	4.4-5.0	0.09
2	10	1.1	4.7-4.9	0.07
2	8	1.5	4.8-5.6	0.07
PEARL DACE				
1	4	2.6	5.5-6.0	0.09
1	10	0.7	3.4-4.0	0.06
1	9	0.8	3.9-4.5	0.06
1	9	0.8	3.9-4.5	0.08
1	9	0.7	3.3-4.2	0.07
2	5	2.3	5.4-6.0	0.03
2	5	2.4	5.5-5.9	0.04
2	5	2.0	5.2-5.6	0.03
2	5	2.0	5.0-5.3	0.03
2	9	1.2	3.7-4.8	0.03

Mercury concentration is reported on a wet weight basis

and downstream sites were 0.08 mg/kg and 0.22 mg/kg, respectively.

The fish revealed a similar finding. Brook stickleback had a mean mercury concentration of 0.09 mg/kg at the upstream site and 0.15 mg/kg at the downstream site. The difference is statistically significant at a 95% level of confidence (t=2.78, 4 degrees of freedom). Pearl dace had mean mercury concentrations of 0.03 mg/kg and 0.07 mg/kg at the upstream and downstream sites, respectively; the difference is also statistically significant at a 95% level of confidence (t=2.78, 4 degrees of freedom).

Although the concentrations of monomethyl mercury in

TABLE 2
CRAYFISH SAMPLE DATA AND RESULTS

Location	# of Crayfish per Sample	Average Live Weight (gm)	Live Weight Range (gm)	Mercury Conc. (mg/kg)
1	5	7.1	6.1-8.1	0.35
1	4	12.5	10.4-14.7	0.22
1	1	25.3	-	0.19
1	4	7.9	7.5-8.2	0.18
1	6	5.4	5.1-6.0	0.31
1	6	4.4	4.0-4.6	0.20
1	5	6.1	5.5-6.4	0.24
1	6	4.7	4.5-4.8	0.21
1	6	4.6	4.4-4.7	0.17
1	6	5.0	4.6-5.2	0.14
2	2	15.1	10.9-19.3	0.10
2	2	9.5	9.3-9.7	0.09
2	3	8.0	7.9-8.0	0.08
2	3	7.1	6.9-7.3	0.08
2	4	6.8	6.5-7.1	0.08
2	3	5.8	5.4-6.1	0.06
2	4	5.0	4.7-5.5	0.08
2	4	4.4	4.0-4.7	0.08
2	5	3.7	3.4-4.1	0.08
2	6	3.3	3.1-3.5	0.06

Mercury concentration is reported on a wet weight basis

TABLE 3
MERCURY CONCENTRATIONS (mg/kg WET WEIGHT)
IN SELECTED THUNDER CREEK BIOTA

	CRAYFISH (TAIL)			STICKLEBACK (WHOLE)			PEARL DACE (WHOLE)		
SITE	N	RANGE	MEAN	N	RANGE	MEAN	N	RANGE	MEAN
1	10	0.14-0.35	0.22 (.061)	5	0.14-0.15	0.15 (.007)	5	0.06-0.09	0.07 (.004)
2	10	0.06-0.10	0.08 (.011)	5	0.07-0.11	0.09 (.015)	5	0.08-0.04	0.03 (.011)

Number in brackets ( ) is the standard deviation.

the contaminated sediments of Thunder Creek compare with those from the Wabigoon River system, the mercury concentration of crayfish at site #1 are approximately one order of magnitude lower than for crayfish found in the contaminated portion of the Wabigoon River system (SHERBIN 1979). However the mercury levels in Thunder Creek crayfish were comparable with crayfish from the Winnipeg River system (SHERBIN 1979) which is known to have elevated mercury levels. ARMSTRONG and HAMILTON (1973) stated that the crayfish Orconectes virilis which concentrate mercury to very high levels in the abdominal muscle is a very useful indicator organism of mercury pollution. Information on mercury levels in brook stickleback and pearl dace is not readily available in the literature so comparisons cannot yet be made with other systems. The importance of the data obtained, however, is not their comparability with other river systems, but is the significant difference in concentration between the upstream and downstream sites on Thunder Creek. This difference shows that more mercury is available to the biological community at site #1 than at site #2 confirming that mercury in the contaminated sediments is being methylated and taken up into the food chain.

Once mercury is biologically available it will be taken up by the biological community very rapidly (NATIONAL RESEARCH COUNCIL 1978) and is accumulated in the tissue. Once in the tissues of organisms, it can be further magnified through the food web (JERNELOV and LANN 1971). The organisms examined in this study are all prey species and are predated by mammals, birds and fish. Evidence of the presence of predator birds and mammals was observed during the survey. Predator fish species were not observed during this survey, however, their absence may be strictly due to the extremely low flow conditions prevailing at the time.

The relationship between the mercury contamination of Thunder Creek/Moose Jaw River and the high levels of mercury in the fish of the Qu'Appelle Fishing Lakes has not yet been investigated. With the recent findings of high mercury levels in the fish from the Qu'Appelle Fishing Lakes, and in Thunder Creek crayfish and fish, and the supposition that the mercury source is above Pasqua Lake JACKSON and WOYCHUK (1979), one must view the contamination of Thunder Creek as a potential source for the downstream problem. Additional biological surveys and studies into the extent and characteristics of mercury methylation downstream are necessary if the effects of this mercury source are to be fully understood.

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