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Variability and Loading of Mercury in a Small Prairie River

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Bottom sediments of Thunder Creek, a tributary of the Moose Jaw River located in the upper Qu'Appelle River Basin (Figure 1) have been reported to contain total mercury concentrations as high as 38 ug/g (GUMMER and FAST 1979) and monomethyl mercury concentrations as high as 50 ug/kg (JACKSON and WOYCHUCK 1979). The uptake of mercury by biota of Thunder Creek has been reported by MUNRO and GUMMER (1979). Pike (Esox lucius), Walleye (Stizostedium vitreum), Goldeye (Hiodon alosoides) and other game fish in the Fishing Lakes of the Qu'Appelle River Basin contain mercury in excess of the Canadian guideline of 0.5 mg/kg (SASKATCHEWAN ENVIRONMENT 1979).

Whether the sediments of Thunder Creek are responsible for the fish contamination downstream, is at this time undetermined. However, transport of contaminated sediment is probably the major pathway by which mercury is moved through a river system (JACOBS and KEENEY 1974). These sediments deposit in lakes, reservoirs and quiescent reaches of rivers where they provide a continuing source of mercury to the biota (BACCI et al. 1978, HARRISS 1971). There is evidence that this is happening in the Qu'Appelle River Basin where GUMMER and FAST (1979) report mercury movement from Thunder Creek into the Moose Jaw River.

This paper presents the results of a study conducted on the Moose Jaw River near Burdick, Saskatchewan during the spring of 1979. Objectives were to investigate the magnitude and variability of mercury in the Moose Jaw River during a high flow period.

MATERIALS AND METHODS

Water samples of 500 mL were collected hourly during the period of April 18 to May 22, 1979 (35 days) using a Water Survey of Canada PWS automatic sampler (WATER RESOURCES BRANCH 1979). Aliquots of 100 mL were homogeneously extracted from each hourly sample and composited daily. Samples for total mercury determination

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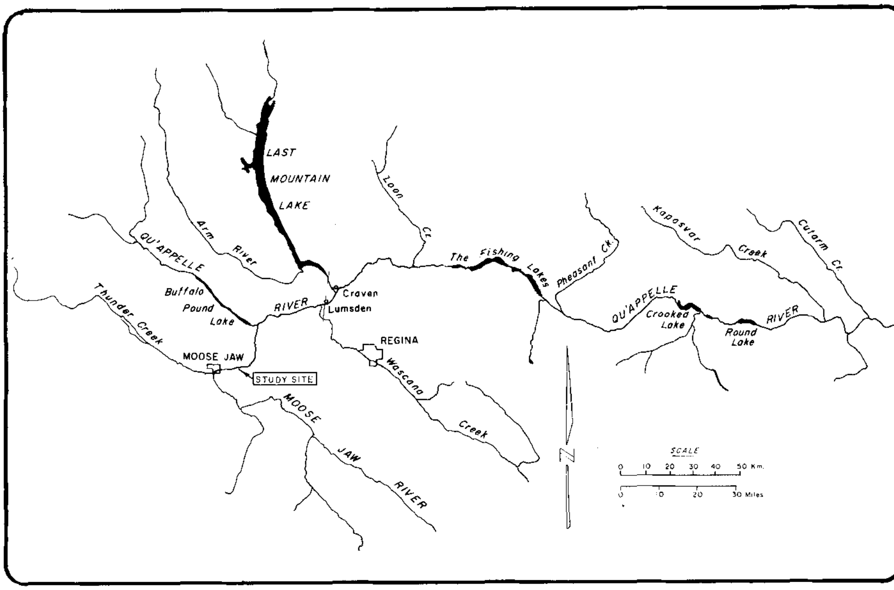

Figure 1 Qu'Appelle River Basin and study site.

were acidified with a mixture of concentrated nitric acid and 5% $K_2Cr_2O_7$ at a rate of 4 mL/250 mL of sample. Samples for dissolved mercury were centrifuged at 4000 RPM for 15 minutes and the supernatant extracted and acidified. Samples were shaken and mercury determined by flameless atomic absorption on an auto-analyzer. Particulate organic carbon and suspended solids analyses were also conducted. The analytical methods employed are found elsewhere (INLAND WATERS DIRECTORATE 1979).

Discharge and particle size information was obtained from Water Survey of Canada, Regina, Saskatchewan.

RESULTS

The variability of mercury forms is shown in Figure 2. The maximum total mercury level of 0.13 ug/L in Moose Jaw River water samples occurred at peak flow and corresponded with maxima in suspended sediment and particulate organic carbon levels (Figure 3). In contrast, the maximum level of mercury, 0.58 ug/g, in the suspended sediment unexpectedly occurred when the clay to silt ratio of weights was about one, prior to the maximum suspended sediment levels and prior to peak discharge. Throughout the remainder of the study, mercury in the sediments was generally 0.15 ug/g.

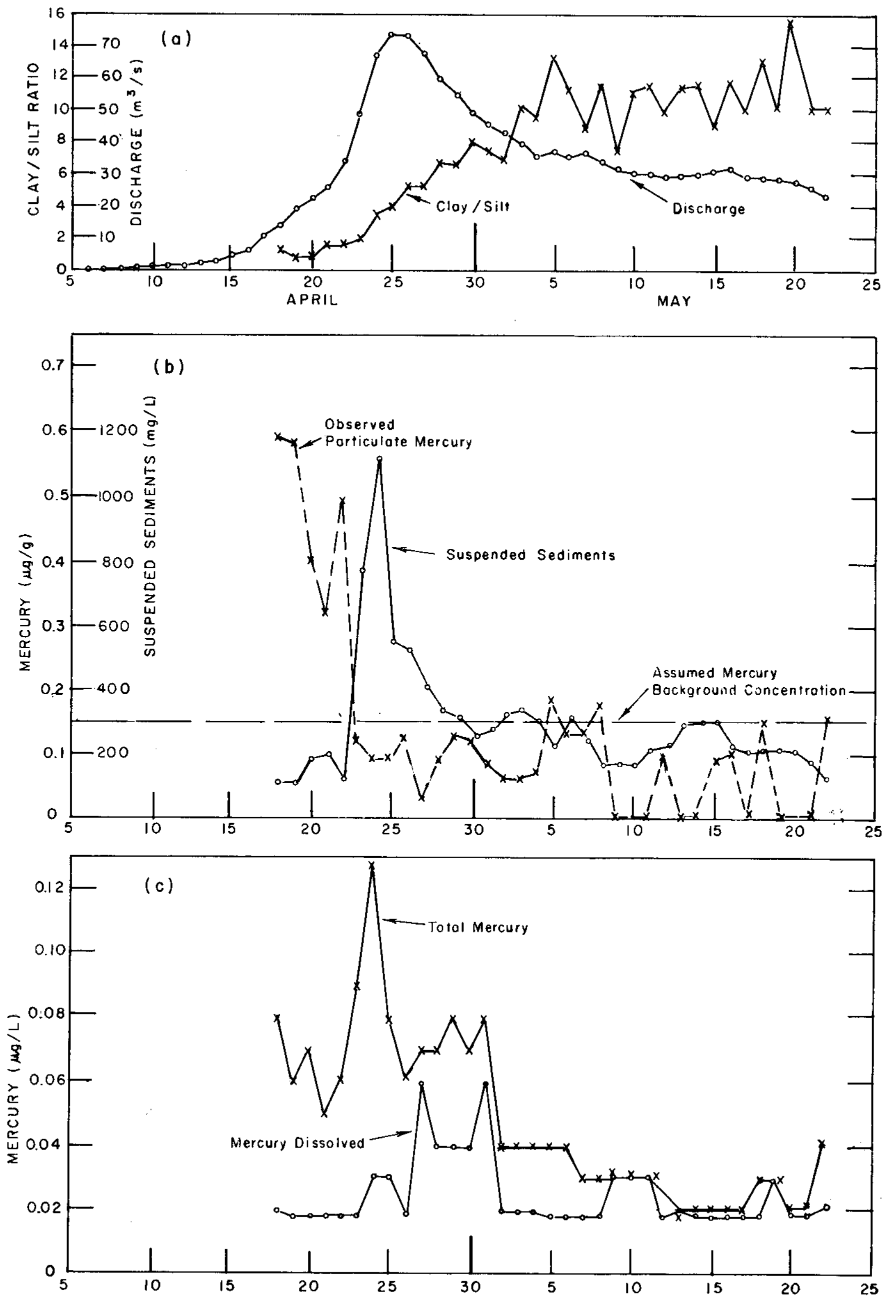

Figure 2 Variability of (a) discharge and of the clay to silt ratio; (b) suspended sediment and particulate mercury concentrations; (c) total and dissolved mercury concentrations

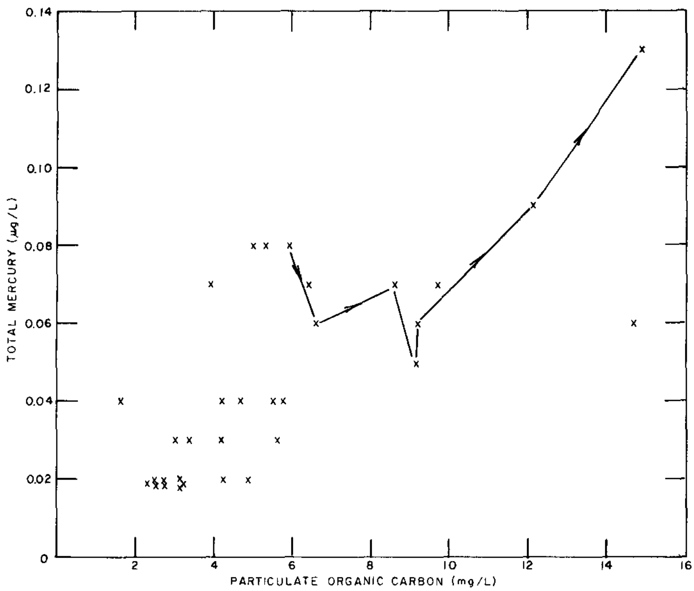

Figure 3 Relationship of total mercury to particulate organic carbon (Line joins those points associated with the rising hydrograph).

The predominent form of mercury was particulate with dissolved mercury at or below the analytical detection limit most of the time. Although dissolved mercury increased slightly during peak flow, maximum levels occurred during the recession of the hydrograph coinciding with a dramatic drop in the suspended sediment and particulate organic carbon levels.

The loading of mercury ranged from 92 g/day at the study commencement to 745 g/day at peak discharge and to 42 g/day when the study terminated (Figure 4). Approximately 6 kg of mercury was transported past the study site during the 35 day study period.

DISCUSSION

Mercury levels in sediments of prairie river systems typically range between 0.02 and 0.10 ug/L (GUMMER and FAST 1979, JACKSON and WOYCHUK 1979, LIAW and HUANG 1979, ALLAN and BRUNSKILL 1976). Natural levels in lakes sediments have been estimated by HARRISS (1971) as less than 0.06 ug/g. ARMSTRONG (1973) reports a natural level of 0.1 ug/g for lakes in the English-Wabigoon system. Based on the foregoing literature review, the natural mercury burden of uncontaminated suspended sediments for the Moose Jaw River is conservatively estimated as 0.15 ug/g.

When Thunder Creek contributes significantly to the mainstem Moose Jaw River flows, such as it did during the initial rise of the hydrograph prior to April 20th, the Creek channel near the mouth and the delta are very susceptible to erosion (KOWALCHUK 1979). It is therefore, hypothesized that active erosion of contaminated sediments in Thunder Creek resulted in the high levels of particulate mercury observed in the Moose Jaw River during the period April 18th to 22nd. If this hypothesis is correct, then the highest particulate mercury levels would have occurred earlier in April when Thunder Creek flows exceeded the mainstem river flows.

Although the study commenced too late to confirm this, a grab sample collected April 16th had a suspended sediment mercury level of 0.31 ug/g. This observation and the apparent correlation between total mercury and particulate organic carbon levels during the rising hydrograph, together with the observation by GUMMER and FAST (1979) that the Thunder Creek mouth and delta sediments are highly organic, lend support to the above hypothesis. It can be argued that, as the River stage rises above the elevation of the Thunder Creek mouth, the erosion of the delta and the Creek channel near the mouth decreases and mercury levels become controlled by factors more directly related to the Moose Jaw River.

Assuming a natural mercury level of 0.15 ug/g in suspended sediments, there are two distinct periods of anthropogenic loading (Figure 4). The first of these two periods can be attributed to Thunder Creek as earlier hypothesized. The second period exists because of the unexplainably high dissolved mercury levels. Collectively, these periods account for about 1.2 kg of mercury derived from what appears to be anthropogenic inputs. If the natural level is instead assumed to be 0.10 ug/g, then anthropogenic mercury is almost always present in the river and may account for as much as 2.3 kg of the mercury transported during the study.

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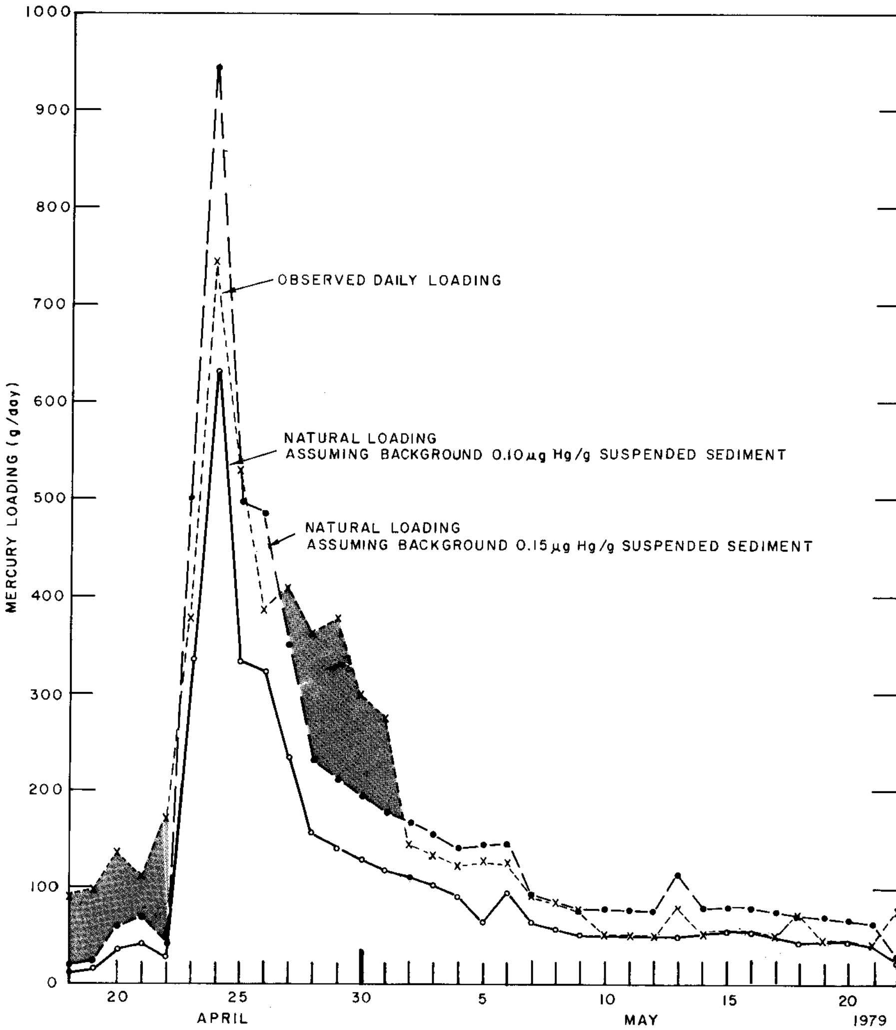

Figure 4 Variability in mercury load. The shaded areas represent major periods of anthropogenic loading assuming a background concentration of 0.15 ugHg/g suspended sediment and no background dissolved mercury.

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