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Distribution of Mercury in Sediments of the Nooksack River Drainage

Introduction

The growing public and governmental concern about the hazards of mercury toxicity has emphasized the need to establish background levels of mercury in the natural environment. In particular, Bellingham Bay, located in northwest Washington state, has recently been cited as an example of an area where considerable mercury pollution exists as a result of discharges from a mercury-cell, chlorine-caustic plant. Lee (1971) reports mercury concentrations of up to 9348 mg/kg in sediment samples from Bellingham Bay taken during 1970. A subsequent sample taken from the same locality in 1971 showed a considerably lower value of 56.3 mg/kg, possibly reflecting efforts by the chlorine plant to diminish mercury discharge. Despite the considerable adverse publicity given to this industrial source of mercury pollution, practically nothing is known of the natural sources which might contribute mercury to Bellingham Bay. The most obvious natural source is the Nooksack River and its tributaries which drain areas of known hydrothermal and volcanic activity. The purpose of this paper is to present the results of a study of the mercury distribution in the Nooksack River drainage. With these data it is possible to assess the relative contribution of the river system to the mercury content of Bellingham Bay.

Methods

Duplicate grab samples of stream sediment were taken at various localities along the Nooksack River and its tributaries as shown in Figure 1. Care was taken to collect only sediment being actively carried by the stream, rather than colluvium from the banks. At each locality, samples weighing 100 to 500 grams were collected and stored in sealed polyethylene vials. Before analysis the samples were dried in evaporating dishes at a constant temperature of 35°C. Drying was done near room temperature because preliminary studies showed a mercury loss of up to 10 percent from samples dried in an oven at 110°C. After drying, the samples were split and sieved to obtain the size fraction passing a —200 mesh nylon screen. This reduced sample was again split to obtain 2.00 grams of sediment for analysis.

Mercury concentration was determined by a flameless atomic absorption technique, using a Perkin Elmer Model 306 spectrophotometer. The procedure for sample preparation was essentially the same as that described by Hatch and Ott (1968). Calibration showed a linear response from 0.04 to 1.9 μg/ml in the standard solutions.

Replicate analyses done on separate splits of the same sample varied by less than

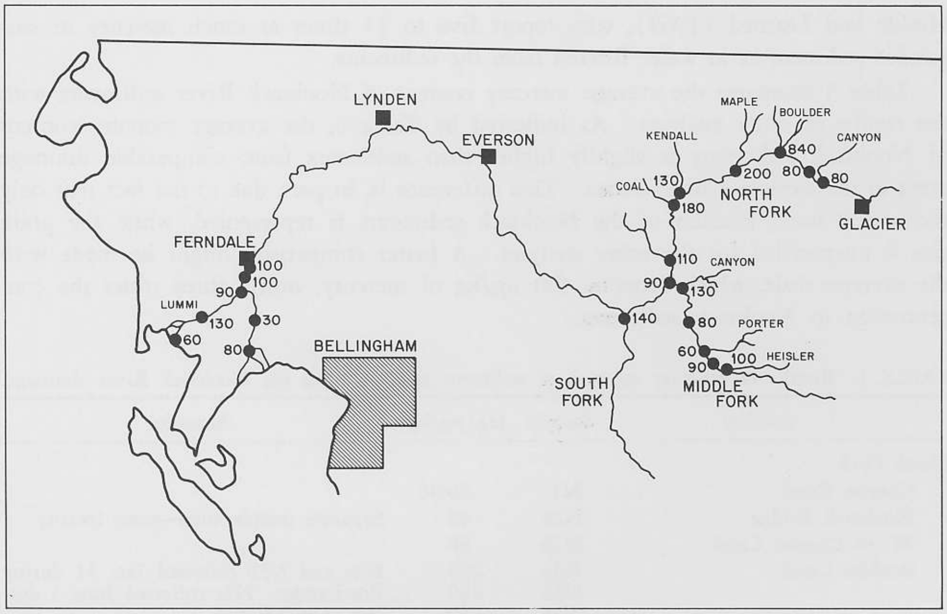

Figure 1. Sampling sites and distribution of mercury in the Nooksack River drainage (mercury values in micrograms/kilogram).

11 percent of the amount present. However, separate samples taken at the same locality showed much greater variability—up to 20 percent of the amount present. This suggests an inhomogeneous distribution of mercury on a scale of less than one meter within the sediment load.

Results and Discussion

Results of the analyses are listed in Table 1 and their distribution shown in Figure 1. Mercury concentrations range from 30 to 840 μg/kg with an average of 140 μg/kg. Distribution of mercury concentrations for various portions of the Nooksack River drainage are listed in Table 2. The highest concentrations occur at the confluences of Maple Creek and Boulder Creek along the North Fork of the Nooksack River.

Sample N4, taken at the confluence of Maple Creek with the Nooksack River, was split into four size fractions for analysis. As shown in Figure 2, mercury content is strongly skewed toward the finer grain sizes. The whole sediment sample contained 60 μg/kg mercury, while the —120, —140, and —200 mesh fractions had concentrations of 110, 130, and 200 μg/kg, respectively. This distribution suggests that the primary mechanism of mercury transport in sediment is by adsorption to clay-sized mineral surfaces.

To determine the degree of fractionation of mercury into the fluid phase coexisting with the sediments, interstitial water was removed from samples N3c and N5 by suction filtration. The interstitial water of N3c contained only 15 μg/l. mercury, while the —200 mesh sediment fraction contained 840 μg/kg. The water in N5 contained 10 μg/l. mercury, compared with a concentration of 130 μg/kg in the sediment. These values indicate that there is only a limited exchange of mercury between the adsorption sites and the coexisting fluid. This finding agrees with the results of

Hinkle and Learned (1969), who report five to 25 times as much mercury in suspended sediment as in water filtered from the sediments.

Table 3 compares the average mercury content of Nooksack River sediments with the results of other analyses. As indicated by Table 3, the average mercury content of Nooksack sediments is slightly higher than sediments from comparable drainage areas in the western United States. This difference is, in part, due to the fact that only the —200 mesh fraction of the Nooksack sediments is represented, while the grain size is unspecified for the other analyses. A better comparison might be made with the average shale, which contains 400 μg/kg of mercury; nearly three times the concentration in Nooksack sediments.

TABLE 1. Results of mercury analyses of sediment samples from the Nooksack River drainage.

Locality	Sample	Hg(μg/kg)	Remarks
North Fork			
Canyon Creek	N1	80,90	
Nooksack Bridge	N2a	80	Separate sample sites—same locality
W. of Canyon Creek	N2b	80	
Boulder Creek	N3a	200	N3a and N3b collected Jan. 31 during
	N3b	250	flood stage. N3c collected June 3 dur-
	N3c	840	ing normal flow.
Maple Creek	N4	60	Whole sample
	N4′	110	—120 mesh fraction
	N4″	130	—140 mesh fraction
	N4‴	200	—200 mesh fraction
Kendall Creek	N5	130,130	
Coal Creek	N6	180,200	
Bell Creek	N7	110	
Welcome—Kulshan Br.	N8	90	
Highway 9 Bridge	N9a	120	Separate sample sites—same locality
	N9b	160	
Middle Fork			
Canyon Creek	M1	110	Separate sample sites—same locality
		130	
Porter Creek	M2	90,90	
Mosquito Lake Br.	M3	90	
Heislers Creek	M4	100	
Main Stream			
Pioneer Park, Ferndale	G1	80	
Ferndale Water Pumping Station	G2	100	
Highway 1—Z Bridge	G3	30,30	
Marietta Bridge	G4	80	
Lummi River			
Confluence of Nooksack and Lummi	L1	90	
Slater Road Bridge	L2	130	
Lummi Bay	L3	60	

TABLE 2. Distribution of mercury in various portions of the Nooksack River drainage.

	Localities	Samples	Range (μg/kg)	Average (μg/kg)
North Fork, Nooksack River	10	13	80-840	190
Middle Fork, Nooksack River	4	4	80-130	100
Nooksack River, Ferndale to Marietta	4	4	30-100	80
Lummi River	3	3	60-130	90
Nooksack Drainage	21	24	30-840	140

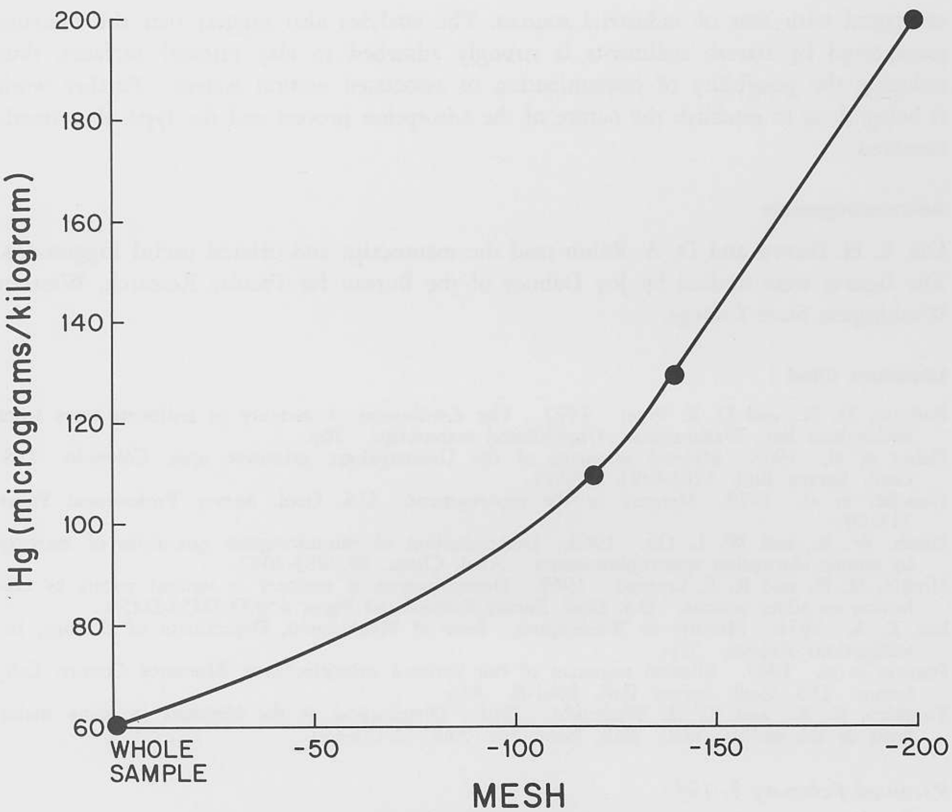

Figure 2. Distribution of mercury in different size fractions of sample N4.

It should be noted that average mercury content of surficial sediments in Bellingham Bay is nearly an order of magnitude greater than that of the clay-sized sediments being deposited by the Nooksack River. However, sediments in the bay at depths greater than 14 cm below the interface have mercury concentrations of less than 500 μg/kg, according to Bothner and Piper (1972). This background concentration in Bellingham Bay is exceeded in the Nooksack drainage by only one sample from Boulder Creek, which has a mercury content of 840 μg/kg and is inferred to reflect sulfide mineralization along the Boulder Creek fault zone.

The results of this study indicate that the hazard of mercury contamination from natural sources in the Nooksack River drainage is slight and that the contribution of Nooksack River sediment to the mercury content of Bellingham Bay is minimal when

TABLE 3. Mercury content in μg/kg of various sediments and sedimentary rocks.

	1	2	3	4	5	6	7
Mean	140	36	77	80	100	400	6900
Range	30-840	10-220	40-2000	10-290	10-700	------	800-17,400

1. Stream sediment from Nooksack River drainage (this paper).
2. Stream sediment from Bob Marshall Wilderness, Montana (Fleischer et al., 1970).
3. Stream sediment from Edna Mtns., Nevada (Fleischer et al., 1970).
4. Stream sediment from Ventana primitive area, Colo. (Pearson et al., 1967).
5. Stream sediment from Uncompahgre primitive area, Colo. (Fisher et al., 1968).
6. Average shale (Turekian and Wedgepohl, 1961).
7. Surface sediments from Bellingham Bay (Bothner and Piper, 1972).

compared with that of industrial sources. The analyses also suggest that the mercury transported by stream sediments is strongly adsorbed to clay mineral surfaces, thus reducing the possibility of contamination of associated natural waters. Further work is being done to establish the nature of the adsorption process and the type of minerals involved.

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