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Effects of a Cattleskin Tannery on Stream Quality and Benthic Macroinvertebrates in Central Maine

R. L. Duval[1], C. R. Ferris, R. B. Owen, Jr., K. E. Gibbs[2], L. K. Fink, Jr.[3], and F. E. Woodard[4]

School of Forest Resources, University of Maine, Orono, ME 04469

The main stem of the Sebasticook River in central Maine receives wastes from a cattleskin tannery located at Hartland. Prior to 1977, when a secondary waste water treatment plant was constructed, the effluent contained excess fat, hair, grease, sulfides, caustic soda, calcium hydroxide, sulfuric acid, chromium sulfate, oils, dyes, and varying amounts of heavy metals. Because of these discharges water quality in a section of the river below the tannery was among the poorest in Maine.

We characterized stream quality and benthic macroinvertebrate communities to determine the effectiveness of waste water treatment. Our objectives were to (1) determine the influence of tannery discharges on several water quality parameters; (2) characterize the effects of effluents on benthic macroinvertebrate communities; and (3) examine the accumulation of heavy metals in bottom sediments and selected benthic invertebrates.

STUDY AREA AND METHODS

The study area was a 15-km section of the Sebasticook River from the outlet of Great Moose Lake to Pittsfield (Figure 1). Between these points stream elevation decreases 13 m, and mean river width is 160 m. Total drainage for the main stem is 22,015 ha.

Water quality measurements were made once each month from June-September, 1976, at five locations along the river (A-E, Figure 1). Station A was above the tannery, all others were below. Water samples were collected near the substrate surface at a depth of 0.5-1.0 m with a 2 l Van Dorn water sampler. Determinations were made of color (Hellige Aqua-tester Color Comparator), turbidity (Jackson candle), conductivity (Beckman RB3 Solu-bridge), total suspended solids (A.P.H.A. et al. 1971), total volatile solids (A.P.H.A. et al. 1971, except at 460°C for

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[1]Present Address: Northern Prairie Wildlife Research Center, P.O. Box 1747, Jamestown, ND 58401

[2]Department of Entomology, University of Maine, Orono, ME 04469

[3]Department of Oceanography, University of Maine, Walpole, ME 04573

[4]Dale E. Caruthers Co., Engineers, Gorham, ME 04038

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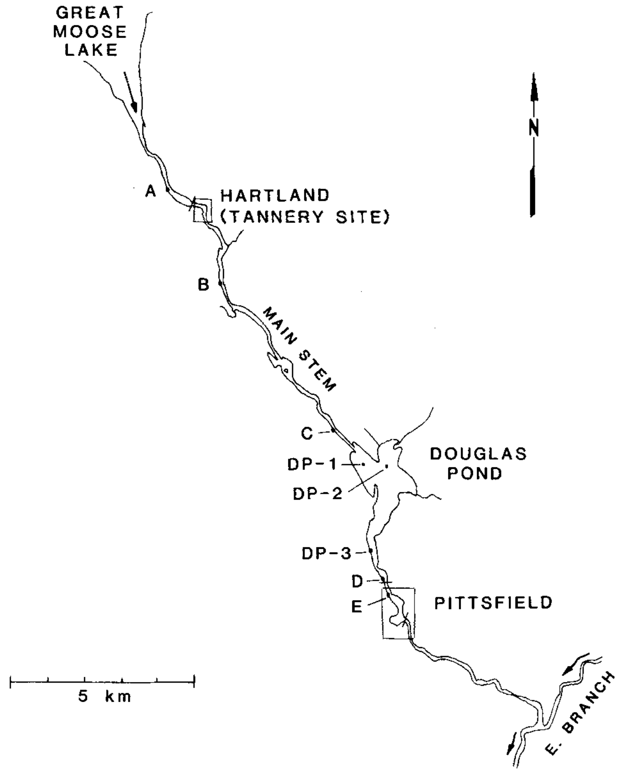

Figure 1. Main stem of the Sebasticook River showing location of tannery and sample stations.

10 min.), dissolved oxygen (Yellow Springs Instrument Model 51B, and iodometric method with azide modification), and pH (Corning Model 610A Expand Portable pH meter).

Sediment samples were collected in August at each of the five river sites (A-E) and in Douglas Pond (DP-3), and again in Douglas Pond (DP-1 and DP-2) in October. Sediments were dried at 80°C for 48 h and passed through a 2 mm soil seive. Total organic matter was determined by ignition in a muffle furnace at 600°C for 3 h (SAVIELLO 1974). Heavy metal content was measured by atomic absorption spectroscopy following hot nitric acid extraction.

Benthic macroinvertebrates were sampled using artificial substrate samplers at each of the five river sites. Samplers consisted of cylindrical wire baskets (26 cm long and 16 cm diameter) filled with stones approximately 6 cm in diameter. At each station three samplers were set out at the beginning of each month (June-September) and left for 4 weeks. Samples were washed through a U.S. Standard soil seive No. 30 (600 μm); the invertebrates were

TABLE 1. Physicochemical parameters of stream water and percent organic matter in bottom sediments from five sampling stations along the Sebasticook River during June, 1976.

STATION	Dissolved Oxygen ppm	Dissolved Oxygen % saturation	pH	Total Alkalinity (mg/L $CaCO_3$)	Conductivity (umho/cm 24°C)	TSS (mg/L)	TVS (mg/L)	Percent Organic Matter of Sediment
A	8.5	96	6.3	12.2	26	3.3	2.0	1.8
B	2.3	25	6.4	19.5	74	7.4	1.9	49.5
C	0.0	0	6.9	37.9	230	64.3	31.9	30.6
D	0.4	4	6.7	28.6	140	4.5	1.2	9.5
E	6.5	73	6.8	28.0	138	7.8	5.2	3.1

sorted, identified, and dried at 80°C for 48 h. Invertebrates were collected for heavy metal analysis with a sweep net, sorted, and prepared for analysis.

RESULTS AND DISCUSSION

The influence of tannery discharge on water quality was most evident during June, the period of lowest water flow in 1976. Normally streamflow is highest in May and June, and lowest in July or August. Physicochemical parameters indicated that water quality was beginning to deteriorate at Station B, 1.9 km below the tannery, and was poorest at Station C, 6.9 km below the tannery (Table 1). Dissolved oxygen was reduced from 8.5 ppm (96% saturation) at Station A to 0 ppm (0%) at Station C; pH, total alkalinity, conductivity, TSS and TVS all showed marked increases at Station C. Water quality at Stations D and E was slightly improved over that at C, but was poorer than at B. The increase in dissolved oxygen at Station E was due to a small dam and riffle between Stations D and E. The accumulation of organic matter in sediments was highest at Station B, and decreased progressively downstream, until at Station E, organic matter was similar to Station A.

The reduction in water and substrate quality resulting from the tannery discharge affected the benthic invertebrate communities in two ways. First, the total number of taxa present was reduced nearly 60% between Stations B and C, and Station A (Table 2). At Station D, the number of taxa was similar to that at A, and Station E actually had more taxa present. However, the total number of individuals collected was highest at B and C, exceeding the number collected at Station A by 10-fold. Total individuals collected at D and E was still higher than at A by several times, but less than at B and C.

Diversity (Brillouin's H) was lowest at Stations B and C due to low numbers of taxa (richness), and because of low evenness (Table 2). Nearly all of the individuals collected at B (97%) and C (86%) belonged to a single taxon (Chironomidae). The concentration of individuals in a single taxon at Stations D (70%) and E (46%) was less than at B and C, but was still sufficient to reduce the community diversity below A, even though similar or higher numbers of taxa and individuals were present.

TABLE 2. Characteristics of benthic macroinvertebrate communities sampled at five stations along the Sebasticook River from June-September, 1976.

	STATION				
	A	B	C	D	E
Total Taxa	34	13	12	33	38
Total Individuals	475	4,733	4,212	2,499	1,444
Species Diversity (H)[1]	2.75	0.44	0.61	1.54	2.33
Evenness (H/H max)	0.61	0.12	0.18	0.32	0.49

[1]Composite species diversity including data from the 4 sample periods.

Several authors have suggested that characteristics of benthic invertebrate communities can be used as indicators of stream quality. There is disagreement, however, over which characteristics to use. WILHM & DORRIS (1968) suggested that diversity indices are the best overall measure of community stability, whereas HOCUTT (1975) found that the healthiest communities were those in which the greatest numbers of both taxa and individuals were present. Diversity indices are influenced too much by the evenness with which individuals are distributed among taxa, and communities with a large number of individuals in a single taxon should not necessarily be considered less healthy (HOCUTT 1975). The problem with this interpretation is that pristine streams are often low in nutrients and support low numbers of taxa and individuals, while moderate levels of nutrient inputs from pollution may increase the numbers of individuals without degrading the environment enough to eliminate taxa. In this study diversity was closely related to water and substrate quality, while the ordination method proposed by HOCUTT (1975) would have considered Stations E and D to have healthier invertebrate communities than Station A. The physicochemical parameters we measured show that stream quality at Stations D and E was well below that of Station A.

Comparison of heavy metals in bottom sediments below the tannery with those above indicated that the tannery was discharging not only Cr, which is inherent to the tanning process, but significant amounts of Ag, Cd, Cu, Pb, and Zn as well. This is the first documented report of associated toxic metals resulting from a tannery and, as such, indicates the necessity of considering metals other than the presumed target metal in licensing and monitoring procedures by responsible State and Federal agencies. In contrast, levels of Fe, Mn, and Ni were not different from those above the tannery, further indicating the specific source of Ag, Cd, Cr, Pb, and Zn input.

The tannery effluent comprised liquid wastes, flocculent sludge, and other solids. The accumulation pattern of metals downstream of the tannery reflects the distribution of the metal-laden sludge and its behavior as a stream-borne sediment, rather than absorption on bottom sediments. Concentrations of Cu, Cd, Pb, and Zn were highest at Station B, with progressively decreasing levels downstream (Table 3) due to increasing admixtures of sludge and normal riverine sediments. Ag increased to Douglas Pond (DP-1) and then decreased. Chromium levels were also high at B, but showed greater concentrations in Douglas Pond (DP-2) which served as a settling basin for the sludge behind Waverly Dam. Subsequent sediment coring indicated sludge accumulations in Douglas Pond up to 82 cm thick. The variability of Cr levels in the grab samples is due in part to inherent variability of the extreme concentrations in the sludge and in part to the degree of sludge dilution by mixing with other sediments during transportation and subsequent deposition. The sludge behaved, hydraulically, like a very fine sediment and accumulated in quiet locations rather than in the main channel or other high velocity or turbulent parts of the river.

TABLE 3. Heavy metal content (ppm/dry weight) of bottom sediments collected in the Sebasticook River (A-E) and Douglas Pond (DP1-3).

SITE	METAL								
	Cd	Cu	Cr	Pb	Ag	Zn	Fe	Mn	Ni
A	0.2	11	13	7	ND[1]	33	19	200	20
B	6.1	55	21,000	890	0.4	360	8	120	23
C	3.9	39	20,000	510	0.7	240	16	150	22
DP-1	3.3	50	17,000	490	1.4	200	11	180	22
DP-2	2.3	48	24,000	440	1.4	330	14	130	22
DP-3	1.8	34	13,000	300	0.9	150	14	320	20
D	0.3	15	2,700	87	0.3	69	15	150	20
E	ND	7	270	21	ND	37	16	550	19

ND = not detected

TABLE 4. Heavy metal content (ppm/dry weight) of selected invertebrates from Douglas Pond.

		METAL								
SAMPLE	SITE	Cd	Cu	Cr	Pb	Ag	Zn	Fe	Mn	Ni
Helisoma sp.	DP-3									
Shell		3.6	8	22	45	4.4	7	340	130	10
Body		1.1	13	440	19	0.6	70	1200	130	3
Helisoma sp.	DP-1	2.6	10	89	38	4.3	20	380	76	8
Physa sp.	DP-1	3.5	98	140	44	4.1	74	950	120	11
Enallagma sp.	DP-1	1.3	20	360	40	ND[1]	90	670	120	0

[1]ND = not detected

Contamination was greatest for Cr; concentrations in bottom sediments were over 1800 times those found above the tannery. Maximum concentrations for the other metals were: Pb 130 x's, Cd 33 x's, Zn 11 x's, and Cu 5 x's. Silver was undetected at Station A.

Detectable levels of all metals were found in at least one species of invertebrate collected from two locations in Douglas Pond (Table 4). Chromium levels were highest, ranging from 22-440 ppm, followed by Cu 7.9-98 ppm), Zn (7.1-90 ppm), Pb (19-45 ppm), Ag (0-4.4 ppm) and Cd (1.1-3.6 ppm). Silver was the only metal found in larger concentrations in invertebrates than in sediments.

The number of invertebrates sampled for heavy metals was too small to make any conclusions about the effects of metals on invertebrate communities. However, the concentrations of metals found in the few invertebrates tested approached levels that could be lethal or cause physiological stress in aquatic invertebrates (NEHRING 1976, SPEHAR et al. 1978), particularly if the metals are further concentrated through food chains.

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