NATIONAL BIOLOGICAL SERVICE
U.S. DEPARTMENT OF THE INTERIOR

NBS INFORMATION BULLETIN

NO. 25 1995

SEASONAL EFFECTS OF THE MCLAREN TAILINGS ON SODA BUTTE CREEK AND YELLOWSTONE NATIONAL PARK, MONTANA

McLaren Mine, once the largest gold mine in Montana, was established in 1933 and closed in 1953. During the mine's operation, a large tailings impoundment was placed in an oxbow of Soda Butte Creek immediately upstream of Cooke City, Montana. Because of continued erosion and potential flooding, the creek was rerouted through the north end of the tailings in 1969. In 1989, banks were stabilized and the mounds of tailings were contoured and seeded.

In spite of these efforts, the banks and the bed of Soda Butte Creek are continuously stained downstream of the tailings. The rust color is often visible on bedrock and banks for several kilometers downstream in Yellowstone National Park.

The possibility that the proposed New World Mine project would add additional tailings to the Soda Butte drainage was the impetus for assessing the level of toxicity in Soda Butte Creek. Studies were conducted in spring and fall 1993 to determine the effect of drains and seeps from the McLaren tailings on aquatic life in Soda Butte Creek and the influence of seasonal flow variability on the toxic substances in the Soda Butte Creek watershed. In a study conducted June 3–9, 1993, flow averaged 7.8 m/s; in a study on October 5–11, flow averaged 0.5 m/s.

FIELD SITES CHARACTERIZED THE EFFECTS OF MCLAREN TAILINGS

In spring tests, 10 initial sites were chosen on the basis of access and location. Two of the 10 sites were selected as reference sites because they were upstream of the tailings impoundment, and seemed relatively uninfluenced by past mining. In addition to the field reference sites, we used EPA's suggested synthetic reconstituted water as a consistent laboratory reference. The sites in Soda Butte Creek cover a 7-km reach from upstream of Cooke City, Montana, to just inside the northeast entrance to Yellowstone National Park. Water and sediment samples were collected in the channel of Soda Butte Creek and wherever we identified drains and seeps emerging from the tailings. Two of these seep sites tend to flow only in spring and samples could not be obtained in the fall study.

DAPHNIDS, FATHEAD MINNOWS, AND AMPHIPODS WERE BIOLOGICAL INDICATORS

If daphnids (*Ceriodaphnia dubia*), fathead minnows (*Pimephales promelas*), and amphipods (*Hyalella azteca*) are sensitive biological indicators of metal toxicity, they should be useful for determining a consistent pattern of toxicity along the sampling gradient of Soda Butte Creek.

To test this hypothesis, we conducted 7-day chronic tests in our portable field laboratory using these three organisms. Reproduction and mortality of these organisms were used as indicators of toxicity. Daphnids and 3-day-old larval fathead minnows were used to test surface water. Amphipods, because of their benthic nature, were used to test interstitial water produced by centrifuging collected sediments.

Monitoring in the field required measuring pH, temperature, conductivity, hardness, alkalinity, and dissolved oxygen. Inductively-coupled-plasma emission (ICP) was used to measure amounts of metals in water, interstitial water, and sediment with split samples analyzed by atomic absorption to ensure quality control.

LARGEST DRAIN FROM MCLAREN TAILINGS WAS ACUTELY TOXIC

Two seeps and one drain were sampled in spring. Of these, SB-8 (the largest and most discolored flow from the tailings), emerging from the base of the McLaren Tailings dam, was acutely toxic to daphnids and fathead minnows in spring and in fall. The other two sites were not acutely or chronically toxic to daphnids or minnows.

TOXICITY VARIED BY SEASON AND BASIN

Eight of the 10 sites, flowing both seasons, were chronically more toxic to test organisms in spring than in fall (Table 1). Reproductive averages for daphnids and percent survival of fathead minnows and amphipods were significantly lower in spring than in fall. Although acutely toxic to both daphnids and fish in both seasons, SB-8 was not acutely toxic to amphipods. Controlled experiments in spring–and later repeated and confirmed in 1994–suggested that the acute toxicity to daphnids and fish is caused by a high chemical oxygen demand because of the oxidation of iron or manganese or a combination of both. Other metals may also influence the oxygen demand but have not yet been identified as doing so. Amphipods probably survived because they were tested in interstitial water and metal concentrations were reduced by centrifuging. Amphipods also have a greater tolerance to lowered oxygen concentrations.

Water chemistry differed by season. In sites flowing both seasons, pH was significantly higher–and hardness and alkalinity were significantly lower–in spring than in fall. The Minteq A2 model, used to predict the bioavailability of $Fe(OH)^{++}$, Cu^{++}, Zn^{++}, and Mn^{++++} under different regimes of temperature, pH, hardness, and alkalinity, identified Cu^{++} as the more seasonally dependent toxic metal in the Soda Butte Creek watershed Seasonal decreases of hardness and alkalinity may also influence the bioavailability of Cu^{++}.

Metal concentrations also varied by season. In the water and sediment samples from Soda Butte Creek, metals generally tended to be lower in spring than in fall (Tables 2 and 3). Amphipods, used to test interstitial water, were exposed to higher metal concentrations than the daphnids and fathead minnows used to test surface water. Metal concentrations in the sediments tended to be higher in fall than in spring except for arsenic and cadmium (Table 3).

We found that the three species tested (daphnids, fathead minnows, and amphipods) did not show a consistent pattern of toxicity along the sampling gradient. We believe the inconsistent toxicity is probably the result of availability of metals in sediments in areas upstream and downstream of the tailings in areas of scouring and deposition. However, amphipods were consistently more sensitive than the other two species. Further studies should include additional organisms to ensure a more direct correlation between metal concentrations and toxicity.

For further information contact

DelWayne R. Nimmo
Midcontinent Ecological Science Center
Colorado State University Field Station
332 Aylesworth Hall
Fort Collins, Colorado 80523
(303)491-0695

or

Mary J. Willox
Colorado State University
330 Aylesworth Hall
Fort Collins, Colorado 80523
(303)491-7857

Table 1. Results of chronic toxicity tests in eight sites with waterflow in spring and in fall in the Soda Butte watershed.

	Mean reproduction (P = 0.0001)	Percent survival (P = 0.04)	
1993	Daphnids	Fathead minnows	Amphipods
Spring	20.7	63.1	46.3
Fall	24.5	73.3	70.8

Table 2. Metal concentrations in water samples (mg/L) from Soda Butte Creek Sites, Montana.

Sample ID	Sample location	Season	Cu	Zn	As	Pb	Cd	Fe	Mn
SB-1	Above tailings	Spring	0.01	<0.01	<0.01	<0.05	<0.01	0.02	<0.01
		Fall	<0.01	<0.01	<0.001	<0.05	<0.005	0.01	<0.01
SB-3	At tailings	Spring	0.01	<0.01	<0.001	<0.05	<0.01	0.01	<0.01
		Fall	<0.01	<0.01	<0.001	<0.05	<0.005	<0.01	<0.01
SB-6	At tailings	Spring	0.01	<0.01	<0.001	<0.05	<0.01	0.02	0.01
		Fall	<0.01	<0.01	<0.001	<0.05	<0.005	0.08	0.05
SB-9	Below tailings	Spring	0.01	<0.01	0.001	<0.05	<0.01	0.02	0.01
		Fall	<0.01	<0.01	<0.001	<0.05	<0.005	0.08	0.09
SB-10	Below tailings inside Yellowstone National Park	Spring	0.01	<0.01	0.001	<0.05	<0.01	0.02	<0.01
		Fall	<0.01	<0.01	<0.001	<0.05	<0.005	0.57	<0.01

Table 3. Metal concentrations of sediment samples (mg/kg) from Soda Butte Creek sites, Montana.

Sample ID	Sample location	Season	Cu	Zn	As	Pb	Cd	Fe	Mn
SB-1	Above tailings	Spring	111	76.6	4.22	33.5	2.40	2.21	0.055
		Fall	199	163	6.18	70.3	1.39	4.38	0.10
SB-3	At tailings	Spring	119	97.8	4.20	45.9	2.06	1.93	0.045
		Fall	241	134	5.87	80.8	1.16	4.52	0.08
SB-6	At tailings	Spring	131	72.3	5.36	40.3	1.43	1.77	0.037
		Fall	175	93.1	4.85	45.7	0.95	2.60	0.06
SB-9	Below tailings	Spring	247	71.0	0.13	57.6	2.51	2.20	0.027
		Fall	407	211	7.41	113	11.40	26.08	0.33
SB-10	Below tailings inside Yellowstone National Park	Spring	40	49.4	4.22	21.6	1.64	1.94	0.040
		Fall	75	79.3	4.53	29.7	1.16	4.19	0.07