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Use of the Pocketbook Mussel, *Lampsilis ventricosa*, for Monitoring Heavy Metal Pollution in an Ozark Stream

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Missouri has been recognized for lead production since the early 1800's and has been the primary producer of lead for the United States since 1902 (Wixson 1977). Most of this production took place in the "Old Lead Belt" located in southeastern Missouri. Huge piles of coarse to finely ground dolomitic residue (tailings) occur throughout the Old Lead Belt. Tailings contain relatively high concentrations of heavy metals (Schmitt and Finger 1982; Novak and Hasselwander 1980) and have resulted in the contamination of stream ecosystems (Jennett et al. 1981; Wixson 1977; Proctor et al. 1974). Reduced standing crops of benthic organisms and elevated levels of heavy metals have been reported in streams in the Old Lead Belt (Jennett et al. 1981; Buchanan 1980; Missouri Water Pollution Board 1964; and Czarnezki 1985). In 1977 a dam on the abandoned Desloge tailings pond in the Old Lead Belt ruptured and an estimated 90,000 cubic meters of tailings entered Big River (Novak and Hasselwander 1980). Erosion of tailings into Big River continue from this site as well as from other tailings piles in the region.

Freshwater mussels and clams have been used to monitor heavy metal and organochlorine contamination throughout the United States (Bedford et al. 1968, Foster and Bates 1978, Adams et al. 1981, Elder and Mattraw 1984, Schmitt and Finger 1982). Bivalves are well suited for *in-situ* monitoring of aquatic pollutants because they bioaccumulate environmental pollutants, and they are sedentary, numerous, large enough to provide tissue analysis, easily collected and hardy (Hartley and Johnston 1983).

The objective of this study was to determine which tailings ponds were the major sources of heavy metals in Big River by using caged pocketbook mussels (*Lampsilis ventricosa* C. Barnes 1823). The pocketbook mussel was selected for this study because it occurs throughout the Big River drainage basin, and it is large, and relatively unaffected by handling and confinement for extended periods of time.

MATERIALS AND METHODS

The study area included a 30-kilometer section of Big River,

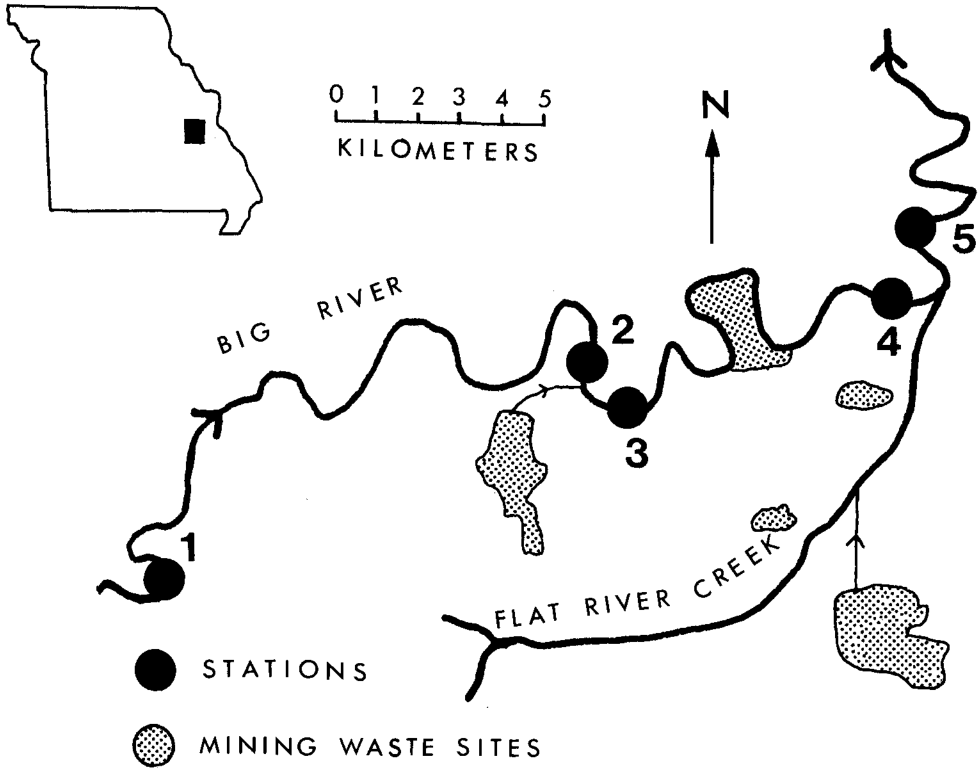

Figure 1. Location of sampling stations and mining waste sites on Big River, Missouri.

located in the Old Lead Belt (Fig. 1). Five stations were established: a control near Irondale, station 1; a second control 50 meters upstream from the confluence with Eaton Branch, which drains the Leadwood tailings pond, station 2; 1 kilometer downstream of Eaton Branch, station 3; 3 kilometers downstream of the ruptured Desloge tailings pond, station 4; and 1 kilometer downstream of Flat River Creek which drains two chat piles and the largest tailings pond in the Old Lead Belt, station 5 (Fig. 1).

Thirty-six pocketbook mussels of similar size collected from Bourbeuse River, a stream unaffected by lead mining or heavy metal pollution but in the same drainage basin, were placed in cages at each of the above sites during the summer of 1982. The cages were constructed of 1.3 centimeter mesh wire and dipped in polyethylene to prevent the mussels from concentrating metals from the cages. Five mussels were removed from each station after 2, 4, 8, and 12 weeks exposure, with the exception of stations 1, 2, and 3 where there was only one live mussel at 12 weeks. Mortality in the cages was probably due to the frequent flooding which occurred during the study. Mussels removed from the cages were depurated

Table 1. Lead and cadmium concentrations (μg/l) in water samples from Big River.

	Station									
	1		2		3		4		5	
	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
Low flow	1	<2*	4	<2	8	<2	31	3.4	36	2.6
Up .3 meter	2	<2	1	<2	7	<2	48	2.8	69	2.7
Medium flow	<0.5*	<2	0.7	<2	56	4.5	77	2.0	93	2.3

* Detection limit

Table 2. Lead and cadmium concentrations (μg/g)in pool substrate samples from Big River.

Station									
1		2		3		4		5	
Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
60	0.70	103	0.59	1,220	17.5	1,410	26.8	3,640	57.3

in flowing water for 3 days, and soft tissues were then removed and kept frozen until the whole body tissues were analyzed for lead and cadmium.

Stream substrate samples were collected during the 12-week study period from pools using a 7.6 centimeter diaphragm pump to draw bottom sediments through a 2-mm mesh sieve and into polethylene settling containers. Samples were allowed to settle for 12 hours, water was decanted off and substrate samples were frozen until they were analyzed for lead and cadmium. Water samples were collected during the 12-week study at low and medium flows in one liter polyethylene containers and preserved with nitric acid. All samples were analyzed by a private laboratory which used graphite furnace atomic absorption. Quality control program consisted of duplicate analysis on 10% of samples, 10% of samples were spiked and NBS reference samples were analyzed.

Mean values and standard error of the mean were calculated for lead and cadmium concentrations. Comparisons between sites and exposure times were made using Duncan's multiple range test. Statistical significance was assumed at the 5% level ($p>0.05$).

RESULTS AND DISCUSSION

Lead and cadmium concentrations increased in water and sediment samples with a downstream progression from station 1 to station 5

Table 3. Mean concentration (μg/g dry weight) of lead and cadmium in the whole body tissue of pocketbook mussels from Bourbeuse River and mussels placed in cages in Big River. Values followed by an asterisk are significantly different (Duncan's multiple range test $p < 0.05$) from mean values at Bourbeuse River. Within columns values followed by a minus sign (-) are significantly different from mean value at the control station 1. Within rows values followed by a plus sign (+) are significantly different from mean value at 2 weeks exposure.

			Exposure Time							
			2 weeks		4 weeks		8 weeks		12 weeks	
	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
Bourbeuse	0.42	0.32								
Station 1			0.57	0.35	0.67	0.39	0.64	0.39	1.3	.85
Station 2			0.46	0.49	0.53	0.42	1.6*	0.46	.74	.57
Station 3			0.99	0.74*	1.6*	0.99*	2.2*	1.5*+	3.9*+	2.0*+
Station 4			11.0*-	2.5*-	11.0*-	4.2*-	46.6*-+	6.4*-+	41.7*-+	10.2*-+
Station 5			12.4*-	1.9*-	21.2*-	4.6*-	45.2*-+	8.1*-+	74.2*-+	11.3*-+

(Tables 1 and 2). A noticeable increase occurred at station 3, 1 kilometer below the Leadwood tailings pond, the uppermost lead tailings pond in the Big River drainage basin. Lead and cadmium concentrations in water and sediment continued to increase at stations 4 and 5 as drainage from additional tailings ponds entered Big River (Fig. 1). Big River does not have the serious sedimentation problem from tailings at station 3 as it does at stations 4 and 5, where pools are filled and the interstices of riffles are clogged with tailings.

Lead and cadmium concentrations in the whole body tissue of mussels placed in cages in Big River were higher than background levels (Bourbeuse River) at all five stations and for all four exposure times. The concentration of lead and cadmium in water, sediment, and mussel whole body tissues increased with a downstream progression. The increase in lead and cadmium in whole body tissues was significant ($p < 0.05$) only at the stations 3, 4, and 5 which are affected by abandoned mining sites, and at station 2 where lead was significantly higher after an 8-week exposure (Table 3). The highest concentrations of lead (74.2 μg/g) and cadmium (11.3 μg/g) occurred at station 5 after a 12-week exposure. Lead levels increased by a factor of 175 and cadmium by a factor of 35 over background levels at station 5. At station 4, lead concentrations increased by a factor of 98 and cadmium by a factor of 32. At station 3, lead increased by a factor of 9 and cadmium by a factor of 6. Lead and cadmium levels increased at stations 1 and 2, the control sites, but these increases were not significant ($p < 0.05$). Lead and cadmium increased by a factor of 2 at station 2 and by a factor of 3 at station 1.

Lead and cadmium concentrations in whole body tissues at station 4 and 5 were significantly higher than at station 1 (the control) at all four exposure times. There also was a significant ($p < 0.05$) increase in lead and cadmium concentrations from the 2-week exposure to the 8 and 12-week exposure times at stations 3, 4, and 5 with the exception of lead at station 3 at the 8-week exposure (Table 3).

Heavy metal levels reported in this study were similar to those reported by other researchers. Schmitt and Finger (1982) reported slightly higher uptakes of lead and cadmium after an 8-week exposure while Adams et al. (1981) reported lower levels of cadmium; however, these mussels were exposed for only 7 days.

It is unlikely that heavy metal levels in mussels reached equilibrium with the environment after the 12-week exposure. Concentrations of heavy metals continued to increase between the 8-week and 12-week exposures. The highest concentration of lead (74.2 µg/g) after the 12-week exposure did not approach values (386 µg/g) reported for endemic mussels from Big River (Schmitt and Finger 1982).

Based on the results of this study, the main sources of heavy metals contamination to Big River are from the Desloge tailings pond and the ponds and chat piles located within the Flat River drainage basin. Big River also receives some heavy metal pollution from the Leadwood tailings pond, however, the contribution from this source is not as serious as from the other tailings ponds.

The pocketbook mussel worked very well for this study and should work in similiar studies. The mussels survived handling, transportation and being caged. They accumulated metals in a short period of time and were large enough to provide adequate tissue for analysis.

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