WASHINGTON STATE DEPARTMENT OF ECOLOGY

Dredging Simulation Test on Similkameen River Sediments

Abstract

A laboratory test was conducted to simulate potential release of metals and cyanide during placer dredging for gold in the Similkameen River. Results indicated state water quality standards may be exceeded for copper and lead. Given the size of the river, metals concentrations downstream of the small-scale recreational dredger would be rapidly diluted. No cyanide was detected in the test sediments.

Summary

A test was conducted with sediments and river water collected behind Enloe Dam and at Eagle Rock to simulate the potential release of metals and cyanide to the Similkameen River from gold dredging. Results indicated this activity could increase water column concentrations of dissolved copper, arsenic, zinc, lead, cadmium, and total mercury by one-to-two orders of magnitude in the immediate vicinity of the dredge.

State water quality standards would likely be exceeded, in this test by approximately factors of 2 - 4 for copper (acute and chronic criteria) and a factor of 2 for lead (chronic criteria). Cyanide was not detectable in sediment or river water. Given the size of the river, the metals impact from the individual recreational dredger would be expected to dissipate a few feet downstream of the discharge.

These results may not be representative of material being dredged from deeper strata or at other locations. Depending on how the dredging is being done, the proportions of sediment and site water, contact time, and other parameters of the testing method may under- or over-estimate release of metals to the water column.

Recommendation

Conduct a more extensive chemical evaluation of Similkameen River sediments to determine if there are contaminants of concern in addition to metals.

Background

In response to a request from the Washington State Department of Ecology, Central Regional Office, we conducted laboratory tests to assess the potential release of metals and cyanide to the Similkameen River water column from placer dredging for gold. The

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metals analyzed were copper, arsenic, zinc, lead, cadmium, and mercury. The sampling was done September 23-24, 1998 during a larger survey of sediment quality in the river (report in prep).

Dredging activities have been traditionally allowed on the Similkameen under mineral prospecting leases. Most dredging has been recreational, with the exception of Great Expectations Mining, which has been working toward commercial mining over the last three years. The Department of Natural Resources (DNR) currently has a list of 25 recreational dredgers wanting leases on the river; the actual demand may be higher (Huestis, 1999).

The concern about metals in the Similkameen revolves primarily around arsenic and copper. Ecology routine water quality monitoring data show the river has order of magnitude higher arsenic levels than other Washington rivers, with peak concentrations typically occurring during spring freshets. Elevations in copper and cyanide are also seen in water samples. A few areas of the river have sediment concentrations of arsenic and copper that exceed guidelines for protection of benthic invertebrate communities (Johnson, 1997).

Mining in British Columbia appears to be the major source of metals. The cyanide detections are from BC monitoring data. It has yet to be determined conclusively if the elevations reported for cyanide are due to mining. Other unknown sources or sample contamination may be responsible. (Johnson, 1997; Ministry of Environment, Land & Parks/Environment Canada, 1998; Pommen & Ryan, 1992).

The dredging simulation test was done with sediment and water collected from two sites on the river, one just above Enloe Dam (river mile 8.9) and the other at Eagle Rock (r.m. 11.7) (see Figure 1). The sediment samples were composites of multiple grabs of the top 10 cm surface layer. Additional water samples were collected for determination of metals concentrations, cyanide, and hardness. The bulk sediment was analyzed for grain size, total organic carbon, EPA priority pollutant metals, iron, and aluminum.

The samples were subjected to the "Elutriate Test" described in Plumb (1981). This is a simplified simulation of the dredging process wherein pre-determined amounts of sediment and site water are mixed together to approximate a dredged material slurry. The supernatant resulting from vigorous 30-minute shaking of one part sediment with four parts water (vol/vol) is allowed to settle for one hour, centrifuged, and 0.45 micron filtered. The resulting elutriate is analyzed for constituents of interest. The tests were conducted by Jim Ross at the Ecology Manchester Environmental Laboratory. The samples were analyzed in duplicate (two separate aliquots from each sample).

The elutriate test is commonly applied to large dredging and disposal operations. The purpose of the test is to provide information on the potential effects of dredge disposal on water quality. Results can either be used to estimate the extent of a resource that will be influenced by the discharge or compared to appropriate water quality criteria (Plumb, 1981).

Figure 1. Location of Similkameen River Sediment Samples (△) Subjected to Dredging Simulation Test, September 1998

Users of the data presented here should be aware that the samples analyzed may not be representative of material being dredged from deeper strata or at other locations. It should also be recognized that no analyses have been done for other chemicals of potential concern (pesticides, PCBs, etc.).

Finally, depending on how the dredging is being done, the proportions of sediment and water, contact time, and other parameters of the testing method may under- or over-estimate release of metals to the water column.

Field Methods

The sediment samples were composites of multiple grabs collected with a 0.03 m^2 stainless steel Ponar bottom dredge. The top 10 cm layer was removed from each grab and homogenized in stainless steel beakers with stainless steel spoons. Six grabs were composited for Enloe Dam and three for Eagle Rock.

Sampling equipment was cleaned by washing with Liquinox detergent and sequential rinses with tap water, dilute nitric acid, and deionized water. The homogenate was split into glass jars with teflon lid liners, cleaned to EPA QA/QC specifications (EPA, 1990) or into twist-lock bags for grain size. The sediment samples were held on ice for transport to the laboratory.

River water for the elutriate test was collected in 2-liter polyethylene bottles, cleaned to EPA specifications. Water samples for determination of background metals concentrations were collected in 0.5 liter teflon bottles, pre-cleaned for low-level metals analysis by Manchester Laboratory (Kammin et al., 1995).

Dissolved metals were analyzed in samples filtered in the field through a 0.45 micron Nalgene filter unit, also pre-cleaned by Manchester. Metals samples were preserved in the field to pH<2 with sub-boiled 1:1 nitric acid. Water samples for cyanide and hardness were collected in polyethylene bottles, preserved with sodium hydroxide and nitric acid, respectively. The water samples were held on ice for transport to the laboratory.

Laboratory Methods

Copper, arsenic, zinc, lead, and cadmium in water samples were analyzed by ICP/MS using EPA method 200.8. Mercury in water was analyzed by CVAA, EPA method 245.7. Metals in sediment were analyzed by ICP, EPA method 200.7; GFAA, EPA methods 206.2 (arsenic), 239.2 (lead), 270.2 (selenium), and 279.2 (thallium); or CVAA for mercury, EPA method 245.5. Grain size and total organic carbon in sediment followed Puget Sound Estuary Program methods. Cyanide was analyzed by method SM4500CNC in sediment and as weak acid dissociable in water, method SM16-412H. Hardness was by method SM2340B.

All analyses were conducted at Manchester Laboratory, except grain size was done at Rosa Environmental & Geotechnical Laboratory in Seattle. Because of poor matrix spikes recoveries, the data on thallium and antimony in sediment are not reported. No significant QA/QC problems were encountered in the other analyses.

The analytical precision of the metals analysis conducted on the elutriates was 16% for cadmium, 27-30% for copper, arsenic, zinc, and lead; and 18-40% for mercury (relative percent difference between split samples).

Results

The results of the bulk sediment analyses are in Table 1. The samples from both areas were predominantly sand (>95%) and had a low total organic carbon content (≤0.3%).

Table 1. Bulk Sediment

	Enloe Dam	Eagle Rock
Percent Gravel	0.4	0.0
Percent Sand	97.2	96.4
Percent Silt	2.0	2.8
Percent Clay	0.3	0.9
Percent TOC	0.19	0.31
Iron (mg/Kg, dry)	14600	14700
Aluminum "	7275	7230
Zinc "	32	33
Copper "	21	24
Chromium "	14	13
Arsenic "	14	18
Nickel "	12	12
Lead "	2.8	3.0
Cadmium "	<.5	<.5
Selenium "	<.3	<.3
Beryllium "	0.23	0.23
Silver "	0.73	0.74
Mercury "	0.014	0.009
Cyanide (mg/Kg, wet)	<0.10	<0.10

There were only slight differences in the concentrations of metals at Enloe Dam and Eagle Rock. These levels are generally similar to fine sediments from other parts of the river. Higher concentrations of copper, to 60 mg/Kg (ppm), and arsenic, to 46 mg/Kg, do occur farther upstream in the reach between Nighthawk and Champneys Slough (Johnson, 1997; 1998 data, report in prep).

Cyanide was not detected in the Enloe Dam or Eagle Rock sediments, at or below 0.10 mg/Kg. This finding is consistent with results from other of our 1998 sampling sites.

Table 2 shows the water quality data for the river.

Table 2. River Water

	Enloe Dam	Eagle Rock
Dissolved Copper (ug/L)	0.66	2
Dissolved Zinc "	<.3	0.37
Dissolved Arsenic "	3.9	3.9
Dissolved Cadmium "	<.02	<.02
Dissolved Lead "	<.02	<.02
Total Mercury "	<.002	<.002
Cyanide "	<.005	<.005
Hardness (mg/L)	114	115

Except for arsenic, metals concentrations in the river were low. Arsenic concentrations are typically < 1 ug/L (ppb) in other Washington rivers, compared to 3.9 ug/L in these samples. During winter and spring, higher concentrations of metals would be expected to occur. Ecology ambient monitoring data for the Similkameen River @ Oroville, show maximum concentrations of 21.6 ug/L total arsenic and 10.1 ug/L dissolved copper on 11/12/95.

Cyanide was not detectable in the river, at or below 0.05 ug/L. There are upstream cyanide sources in BC – Nickel Plate Mine and Candorado Mines – but Pommen & Ryan (1992) concluded it was unlikely these were the cause of elevations in the river, which they attributed to analytical artifacts, road salts, or naturally-occurring sources. With the exception of the two samples analyzed in the present study, there are no cyanide data on water samples from the Similkameen River below the border.

Results of the elutriate test are summarized in Table 3.

Table 3. Elutriate

	Enloe Dam	Eagle Rock
Copper (ug/L)	51 +/- 7	27 +/- 3
Zinc "	42 +/- 6	30 +/- 2
Arsenic "	47 +/- 6	19 +/- 1
Lead "	6.0 +/- 0.9	2.5 +/- 0.25
Cadmium "	0.32+/- 0.02	0.17 +/- 0.01
Mercury "	0.022 +/- 0.005	0.002*
Cyanide "	na	na

*not detected in duplicate

Contacting river water with the sediments elevated the concentrations of all metals analyzed by one-to-two orders of magnitude. The highest concentrations occurred for copper, zinc, and arsenic. The elutriates for Enloe Dam were consistently higher than those for Eagle Rock. Because no cyanide was detected in bulk sediment or river water, it was not analyzed in the elutriate.

Table 4 shows applicable state water quality standards for protection of aquatic life (173-204A WAC). The metals criteria are for the dissolved fraction, except for the chronic criterion for mercury which is total.

The acute criteria are one-hour averages not to be exceeded more than once ever three years on average. The chronic criteria are four-day averages not to be exceeded more than once every three years on average.

Table 4. Water Quality Criteria*

	Acute	Chronic
Copper (ug/L)	19	13
Zinc "	129	118
Arsenic "	360	190
Lead "	74	2.9
Cadmium "	4.3	1.1
Mercury "	2.1	0.12
Cyanide "	22	5.2

* @ 115 mg/L hardness

The criteria for copper, zinc, lead, and cadmium are a function of hardness. The hardness at the time of sample collection for the elutriate test, 114 – 115 mg/L, was about midway between the extremes we have observed in the river. During low flow in August 1995, hardness ranged from 82 – 88 mg/L and during spring runoff in April 1996 the hardness was 133 – 144 mg/L (Johnson, 1997). The lower the hardness, the lower (more restrictive) the water quality criteria. The arsenic and mercury criteria are independent of hardness.

Comparison of the water quality criteria in Table 4 with the elutriate data in Table 3 shows copper and, to a lesser extent, lead exceed the acute and/or chronic standards, but that zinc, cadmium, arsenic, and mercury are well within standards. This can be more clearly seen in Figure 2 which plots metals concentrations as a ratio of the criteria, ratios >1 being exceedances. Copper exceeded the acute and chronic

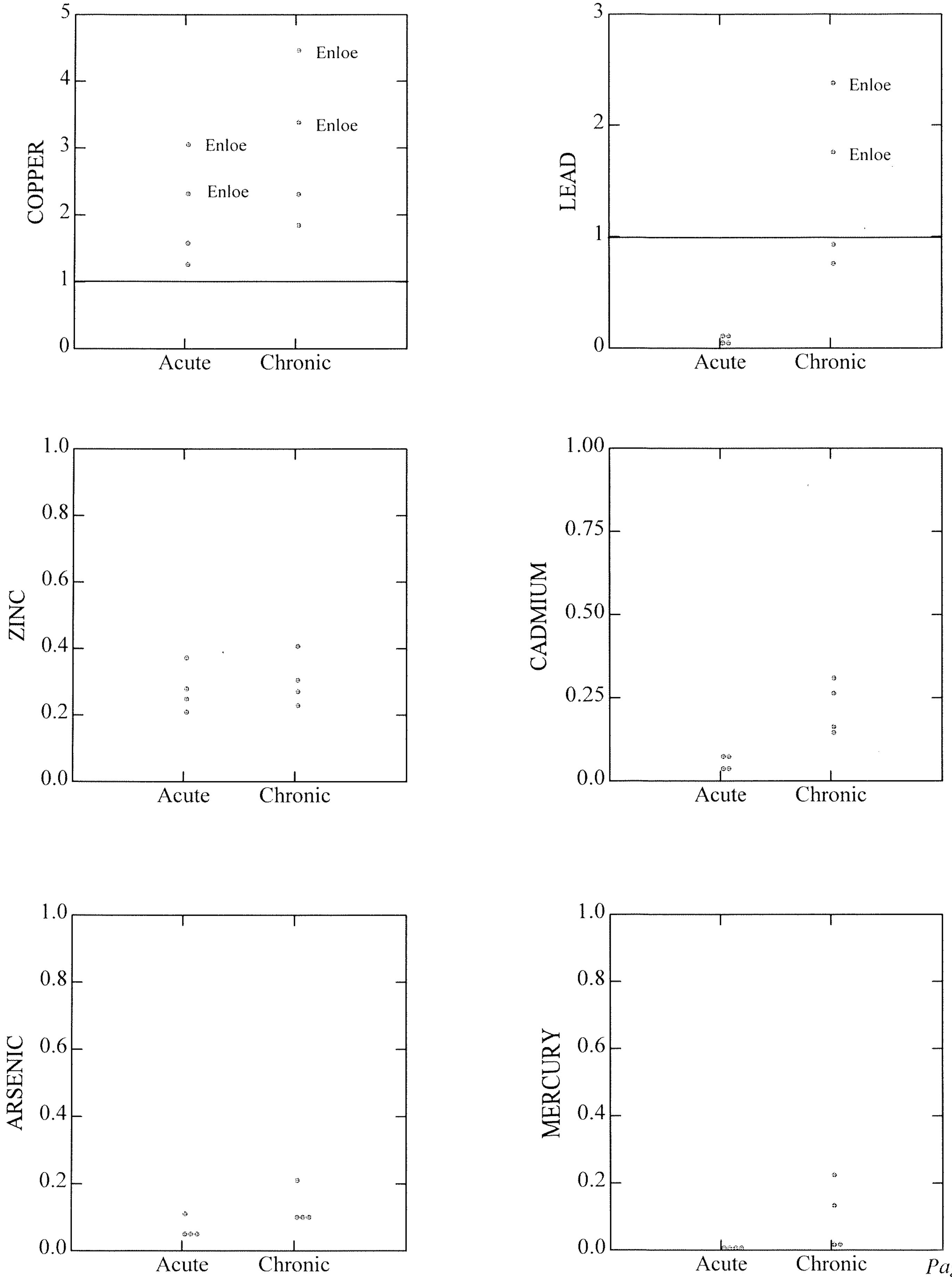

Figure 2. Metals Concentrations in Elutriates as Ratio of Water Quality Criteria (@ 115 mg/L hardness)

criteria by factors of approximately 2 – 4. Lead in the Enloe Dam elutriates exceeded the chronic criterion by approximately a factor of 2.

The lowest hardness measured at Ecology's ambient monitoring station near the mouth of the Similkameen at Oroville is 43 mg/L. If this value is used to calculate water quality criteria, copper and lead continue to be the only metals with exceedances. Copper exceeds by factors of 4 - 9 and lead by factors of 2 - 6 (chronic criteria only). This may not be a valid comparison since a lower hardness in site water could result in higher metals concentrations in an elutriate test. I do not know how large an effect this might be.

Given the size of the Similkameen River – the average flow for September is 616 cfs – dilution of dredge effluents would be rapid. Not having any figures for the flow rate of a dredge, various combinations of discharge rates up to one cfs (449 gpm), channel configurations, bank proximity, and river flows were tried in a point source dilution model (Fischer et al., 1979). Dilution factors >5 always occurred by 5 to 10 feet downstream, even at the 7-day, 10-year low flow of 182 cfs. With better information on the amounts of water being pumped by the dredges, the plumes from multiple or larger dredges could be similarly assessed.

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