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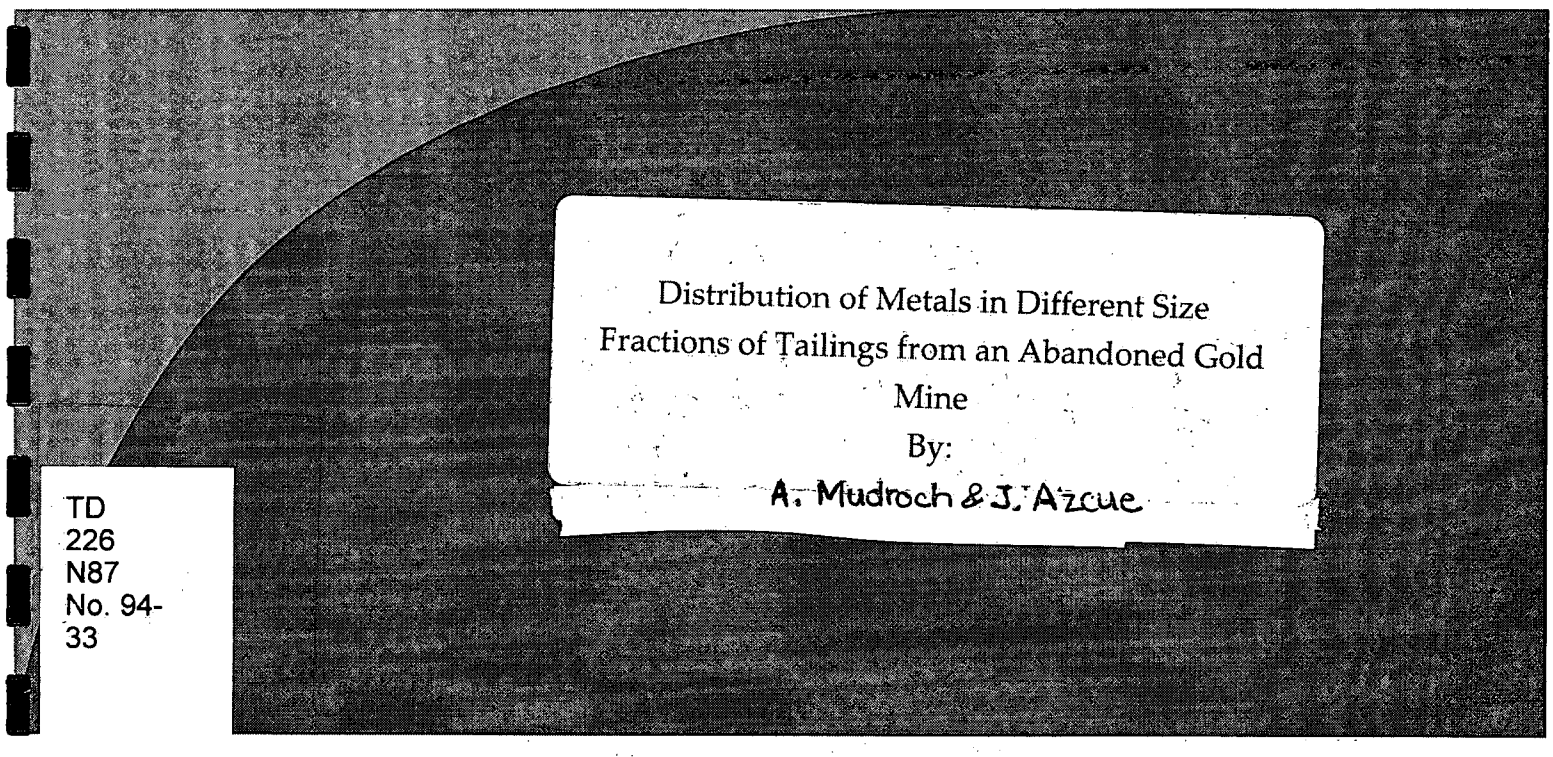

Distribution of Metals in Different Size Fractions of Tailings from an Abandoned Gold Mine

By:

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MANAGEMENT PERSPECTIVE

Studies of the effects of abandoned and operating gold mines in Canada showed transport of contaminated fine particles from on-land and under-water disposed mine tailings. At an abandoned gold mine at Wells, British Columbia, fine tailing particles containing up to 3,470 ug/g Pb (background concentrations in soils and sediments are up to 25 ug/g) were transported across Jack of Clubs Lake and contaminated the bottom sediments in the lake. Fine particles from tailings disposed by presently operating gold mine were eroded from a tailing pond and transported across Larder Lake, Ontario. High concentrations of As, Cu, Pb and Zn in the particles severely impacted the benthic community structure in the lake and generated widespread toxicity to Tubifex tubifex in laboratory bioassays. Up to 7.1 kg of As originating from past mining activities was transported monthly by suspended solids in streams connecting Shubenacadie River headwater lakes, Nova Scotia. Transported As, Hg, Pb and Zn from past gold mining sites are being deposited in downstream lakes, gradually contaminating a large part of the Shubenacadie River system. Studies have shown the importance for proper disposal of tailings in preventing the contamination of surface waters. To avoid contamination of lakes and rivers in the vicinity of a gold mine, the tailings and waste rock need to be safely confined. In particular, proper confining of the tailings should prevent erosion of contaminated fine tailing particles into streams and lakes. Preparation of economically feasible remediation plans for the tailings left at abandoned gold mines and select sites with high priority for remediation, was suggested.

DISTRIBUTION OF METALS IN DIFFERENT SIZE FRACTIONS OF TAILINGS FROM AN ABANDONED GOLD MINE

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Gold mining has been very important industry in Canadian economy for more than a century. Similar to other industries, gold mines produce liquid and solid materials which need to be disposed. Solid material from gold mining contains elements from minerals associated with the gold ore and its host bedrock as well as elements and compounds introduced during the recovery of the gold from the ore, such as Hg and cyanides. Environmental implications and remediation of gold mine tailings and waste rock are site-specific, and depend mainly on the physico-chemical character of the material. The tailings may have a different granulometric composition which depends on the nature of the mining practices, such as milling and grinding. Physical character of the tailings may affect their properties, such as water holding capacity, surface area of the tailing particles, adsorption and desorption of different elements, etc. Tailings generated by gold mining have been usually disposed on the ground or into a tailing pond near the mine and/or into a lake in the vicinity of the mining operations.

At an abandoned gold mine at Wells, B.C., the tailings were disposed on the northeast shore of Jack of Clubs Lake. Some of the tailings were disposed into the lake along the northeast shore. In addition to the tailings in the lake, considerable erosion of the tailings disposed on the shore resulted in deposition of tailing particles across the 2-km long Jack of Clubs Lake. The size of the tailing particles ranged from <2 um to about 130 um. In addition to other metals and trace elements, the tailings contained up to 1,500 ug/g As and 470 ug/g Pb (Mudroch et al., 1993). A survey of the sediment geochemistry in the Jack of Clubs Lake showed that the greatest concentrations of As in bottom sediments were along the northeastern shore of the lake in the vicinity of the disposed tailings. On the other hand, the concentrations of Pb in the bottom sediments were similar across the lake. The only source of As and Pb in the lake were the tailings. A study was carried out to investigate the transport of As and Pb within the lake. The concentrations of As and Pb in lake water were <0.2 and <0.02 ug/L, respectively, indicating that the transport of Pb across the lake was maintained mainly by particulate matter. Tailing samples collected from the northeast shore of the lake were separated into following particle size fractions: 43 to 53 um, 37 to 43 um, 27 to 37 um, 19 to 27 um, 13 to 19 um and <13 um. Warman cyclosizer was used in the separation of the tailings into different particle sizes (Mudroch and Duncan, 1986). The concentrations of As and Pb in each particle size fraction are shown in Table 1.

TABLE 1. Concentrations of As and Pb in six particle size fractions of the tailings (in ug/g dry weight)

Size Fraction um	As	Pb
43 to 53	>2,000	25
37 to 43	1,150	50
27 to 37	950	250
19 to 27	450	355
13 to 19	250	400
<13	310	3,470

The greatest concentration of Pb (3,470 ug/g) was found in particles <13 um. The concentration of Pb decreased with increasing size of the tailing particles. Therefore large quantities of Pb associated with the fine particles can be mobilized by erosion of the tailings and transported across the lake. On the other hand, the concentration of As was greatest (>2,000 ug/g) in the 45 to 53 um particles with decreasing concentrations in the finer particles (Table 1). The results indicated that As associated with larger particles is less succeptible to the transport across the lake than Pb. This explains considerably greater concentrations of As in the bottom sediments along the northeast shore than in the rest of Jack of Clubs lake.

Transport of particulate metals and trace elements originating from gold mine tailings was observed during a study of Larder Lake, Ontario. Fine particles from the tailings

containing up to 1.2% S and disposed on the bottom of the lake were transported by resuspension across the lake (Mudroch et al., 1994). Using the concentrations of S in the sediments as an indicator, it was possible to distinquish the effects of the resuspension of the fine tailing particles from those of liquid effluent from the tailing pond on the quality of the sediments in Larder Lake. Severe impact on benthic community and widespread toxicity to Tubifex tubifex were found in Larder Lake. It was concluded that relatively high concentrations of available metals, particularly Ni, and high total concentrations of As, Cu, Ni and Zn in sediment pore water and lake water contributed to the sediment toxicity.

Past gold mining practices at Waverley, N.S., Canada, have left unconfined tailings and waste rock containing As and Hg which have been affecting water, biota and sediment quality in the Shubenacadie headwater lakes. The transport of As and Hg through the chain of the headwater lakes was investigated (Mudroch and Clair, 1985; 1986). It was found that the greatest quantity of As (7.1 kg) was transported by suspended solids in fall, while most of the Hg was transported by suspended solids during spring and fall. Results of the study suggested that transported As, Hg, Pb and Zn originating from past mining activities are being deposited in downstream lakes, gradually contaminating a larger part of the Shubenacadie River system.

The studies of effects of past and present gold mining on

aquatic environment at Wells, B.C., Larder Lake, Ontario, and Shubenacadie headwater lakes, N.S., showed the importance of proper disposal of tailings in prevention of contamination of surface waters. To avoid the contamination of lakes and rivers in the vicinity of a gold mine, the tailings and waste rock need to be safely confined. Proper confining of the tailings should prevent erosion of contaminated fine tailing particles into streams and lakes. Further, the conditions of disposed tailings at abandoned gold mining sites and their effects on aquatic environment should be evaluated. Remedial plans for economically feasible remediation of the tailings should be prepared and the sites with high priority for remediation should be selected.

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