DECOMMISSIONING OPEN PITS WITH ECOLOGICAL ENGINEERING

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ABSTRACT

Ecological Engineering, a biotechnological approach to the decommissioning of base metal mining wastes, is being tested on two open pits (Gloryholes) in Newfoundland, Canada. Pit #1 has a volume of 208,000 m^3 (pH ranges between 5.5 and 7). Pit #2, with a volume of 66,200 m^3, has an average pH of 3.5.

Organic substrates are used to form sediment and provide carbon and nutrients for microbial ecosystems which reduce sulphate and generate alkalinity. Enclosures (4 m diameter and approx. 3.5 m depth) were placed in both pits to test the suitability of different organic amendments (peat and sawdust) as carbon and nutrient sources. Microbial alkalinity-generation was evident 95 days after placement of the amendment on July 4, 1989. Zinc concentrations in the enclosures in Pit #2, dropped from an average of 35 mg/L to about 2 mg/L or less by day 480, and by day 300 in Pit #1.

A scaled-up experiment has been under way since August 25,1990, where 390 m^3 are treated in Pit #2 and 750 m^3 in Pit #1. Research continues on the determination of factors which can limit the ARUM process.

INTRODUCTION

The applicability of Ecological Engineering as a decommissioning approach to the Buchans waste management area was assessed in 1988. The assessment was favourable, and in 1989, the hydrological and geochemical conditions of the site were delineated.

The decommissioning approach with Ecological Engineering utilizes a combination of natural water cleansing processes, such as the ARUM process (Acid Reduction Using Microbiology) to reduce metal concentrations (such as Zn and Cu) in effluents from the gloryholes and from the tailings ponds. Biological polishing, which utilizes attached filamentous algae, will be established in the outflow region of Pit #1. Together, both ARUM and biological polishing are expected to reduce metal concentrations to environmentally acceptable levels.

Experiments were carried out in 1989 in 43 m^3 enclosures in Pit # *1* and Pit #2. The objective was to determine what material would be most suitable to: a) initiate and b) maintain microbiological processes for alkalinity-generation and metal reduction (ARUM) over the long-term. The results from the 43 m^3 enclosures were encouraging, and therefore in 1990 curtains were installed to semi-enclose 750 m^3 in Pit #1 and 390 m^3 in Pit #2. Schematic 1 outlines the layout of both pits. A detailed discussion of the experimental enclosures has been given in Kalin 1992. This paper reports the results achieved since since the enclosures were scaled-up.

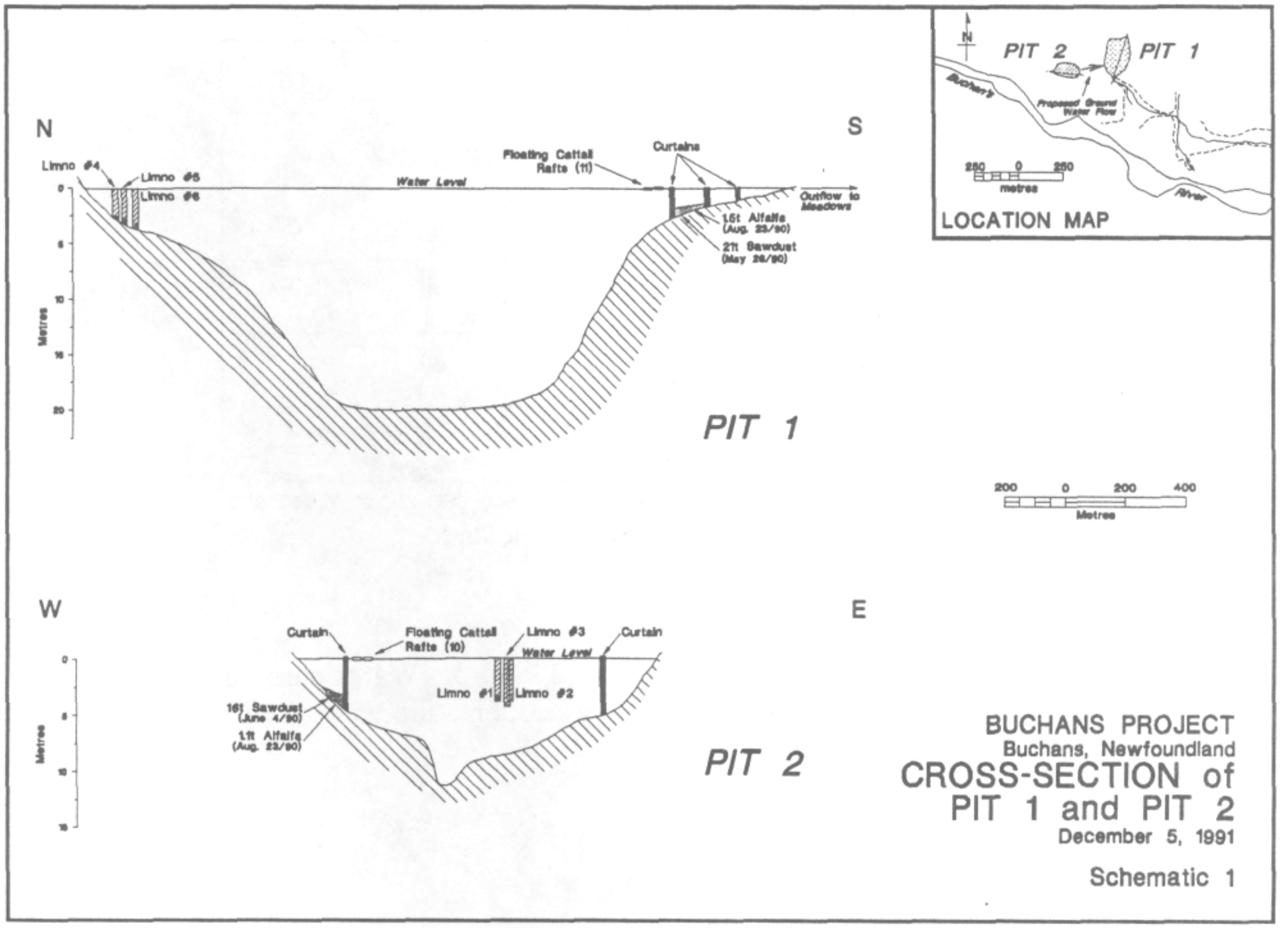
METHODS

Water-tight enclosures were set up in the pits, consisting of four components; a laminated Fabrene wall material, a upper floating ring (filled with styrofoam), a lower anchorage ring, and stabilization ropes. The resulting open-ended cylinder had a 4 m diameter and a depth of about 3.5 m, giving them an enclosed volume of about 43 m^3.

The experimental enclosures were numbered 1 to 3 in Pit #2, and 4 to 6 in Pit #1. The enclosures, 3 and 6, served as controls, i.e. did not receive amendment. Enclosures 1 and 4 received sawdust, and 2 and 5 received peat as the main amendment.

In the first three months no noticeable changes took place, so, a mixture of nutrients, Biolyte CX-70, and alfalfa was added to the enclosures with amendments at that time, to initiate microbial activity. The layer of organic amendment was approximately a i m thick.

The set-up for the scale-up implementation utilized curtains to contain the organic material. Amendments, added on the surface, sank to the bottom of the enclosures, forming the desired ARUM sediment. Twenty-one (21) wet tons of sawdust and 1.5 wet tons of alfalfa were placed between two curtains in the outflow channel of the Pit #1, representing a volume of 750 m^3 (Schematic 1; Plate 1). Sixteen (16) wet tons of sawdust and 1.1 wet tons of alfalfa were added to the 390 m^3 volume of water behind a burlap curtain in Pit *#2* (Schematic 1; Plate 2).



Schematic 1: Cross-sections of Pit #1 and Pit #2. Enclosures 1-6 are labelled limnocorrals. Limnocorrals 1-3 sit on the bottom of the pit to one side.

RESULTS AND DISCUSSION

Zinc concentrations in the 43 m3 enclosures in Pit #2 are given in Figure la, and for Pit #1 in Figure Ib.

Initially, for a period of about 95 days, no changes in zinc concentrations were noted. After 130 days, just before freeze-up, a mixture of alfalfa, sawdust and biolyte was added to the all enclosures with organic material. Within 10 days of this addition a decrease in metal concentrations occurred.

The pH started to increase, and concurrently the zinc concentrations decreased. After about 600 to 700 days, however, differences between the sawudust and peat amendment enclosures became evident. Although sawdust assisted in initially raising pH and lowering zinc concentrations, elevated pHs and lowered zinc in the peat enclosures have been stable through 3 winters. Factors which contribute to the differences in the organic material are being investigated. It should be noted, that the effectiveness of the peat, may not be solely

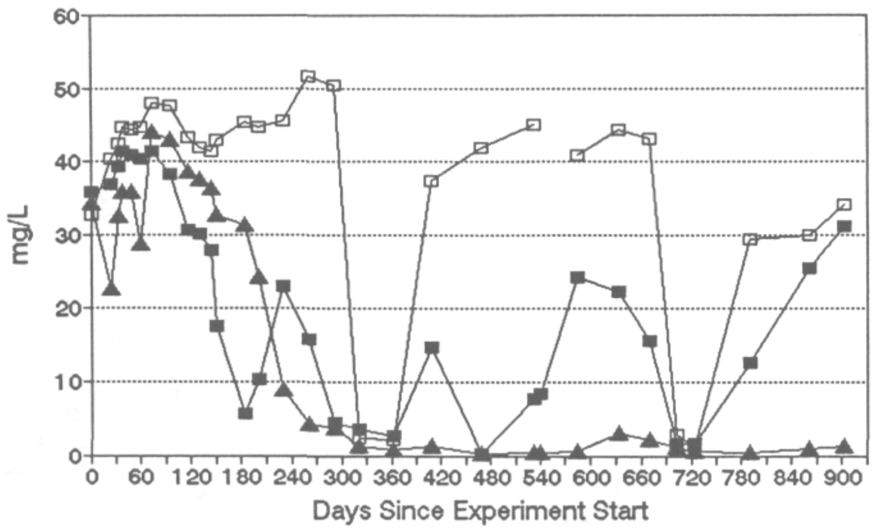


Figure la: Zinc concentrations in Enclosures 1,2, and 3. Water samples taken from the surface. Solid squares = #1; solid triangles = #2; open squares = #3 (control).

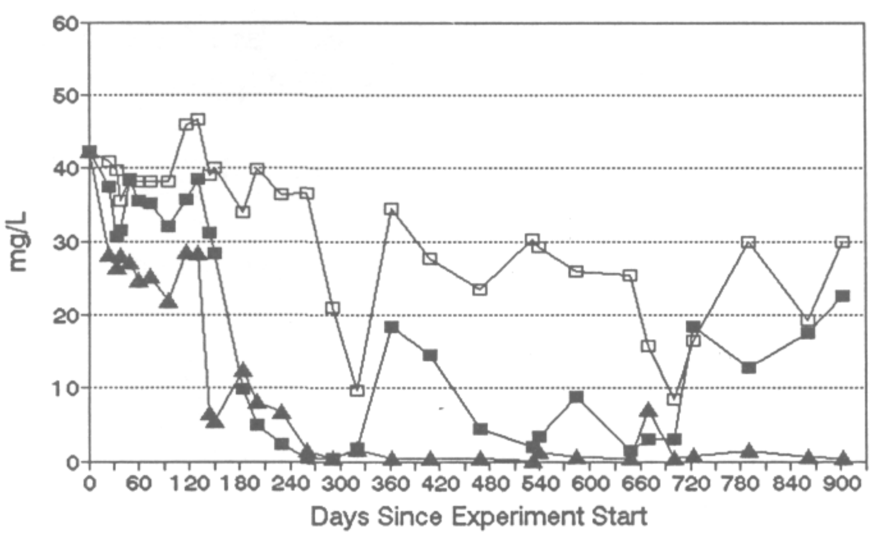


Figure Ib: Zinc concentrations in Enclosures 4,5, and 6. Water samples taken from the surface. Solid squares = #4; solid triangles = #5; and open squares = #6 (control).

due to providing a better food source for the microbial community, but could also be a reflection of the effectiveness of the enclosure and the physical surface area.

The decrease in zinc concentrations in the control enclosures, 3 and 6, reflects dilution of zinc originating mainly from precipitation products formed underground at the time of underground works flooding.

The results obtained in the scaled-up semi-enclosures (curtains) are presented in Figures 2a and 2b for pit # 1, and in Figures 2c and 2d for pit # 2.

The pH of Pit #1 has essentially not changed since the pit was flooded in 1987 (around 6.5). Zinc concentrations in Pit #1, however, have been decreasing steadily. Effects of the curtain, enclosing 750 m3 at the outflow, with a flow 10L/s, can not be detected. Extensive microbial activity is present in the organic material added to the enclosure. The metabolic gasses formed, cause the material to float. Floating amendment is, for the most part, aerobic, and hence will not function as an ARUM sediment (Plate 1).

In Pit #2, the water has been acidic since shortly after flooding. Alkalinity-generation or pH increases in the test enclosures were not apparent until after 120 days, the same period observed for the smaller enclosures (Kalin 1992). Microbial activity is expected to take longer in the scaled-up system, simply because the volume is 6-9 times larger. Assessment of the organic material within the curtains has indicated that a full microbial community has colonized the organic amendment layers.

The pH of pit #2 has been 3.5 since 1986 (Figure 2c). Slight increases in pH (to pH 4.5) were reported inside the curtain after 240 days (Kalin 1992). Again, as with the results of Pit #1, pH increases could not be positively attributed to a microbially-active ARUM sediment. When yearly zinc concentration averages are plotted from the time of flooding, it becomes evident that the rate of decrease has increased in 1991 (Figure 2d). Due to the sulphate-reducing activity in the ARUM sediment behind the curtain, and negative Eh values obtained in the sediment, the decrease in zinc concentrations is likely due to the active sediment. Pit #2 fulfils the conditions under which one would expect the ARUM process to function. In comparison to Pit #1, Pit *#2* receives a diffuse input of AMD from the underground workings and turns over completely only once or twice per year. In contrast, Pit# 1 is stratified, with active microbial communities in the amendment.

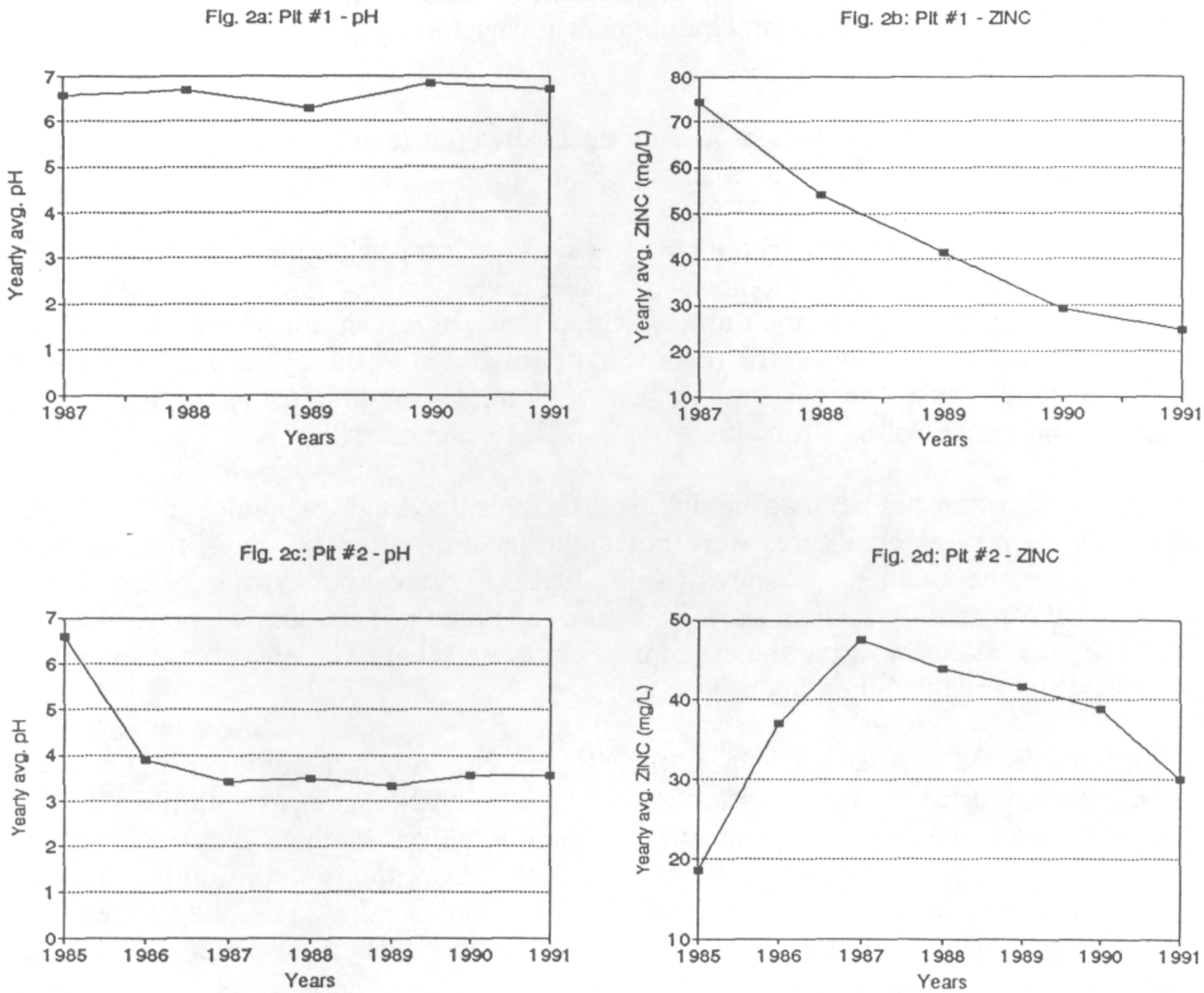


Figure 2: Mean yearly pH and zinc concentrations for Pit #1 since it began filling in 1987 (a,b); mean yearly pH and zinc concentrations for Pit #2, since it began filling in 1986 (c,d).

CONCLUSION

Both the microbiological and geochemical evaluations provided sufficient, albeit, indirect support of the hypothesis that observed metal removal in Pit *#2* could be attributed to the ARUM process. The first curtains contained sawdust and alfalfa. The differences between sawdust and peat, with respect sustenance of ARUM activity were not known at that time. A second enclosure was installed at the end of 1991 with peat and a readily available carbon source for initiation of ARUM. By 1993, it is projected that the ARUM sediment in Pit #2 will be fully active.

ACKNOWLEDGEMENTS

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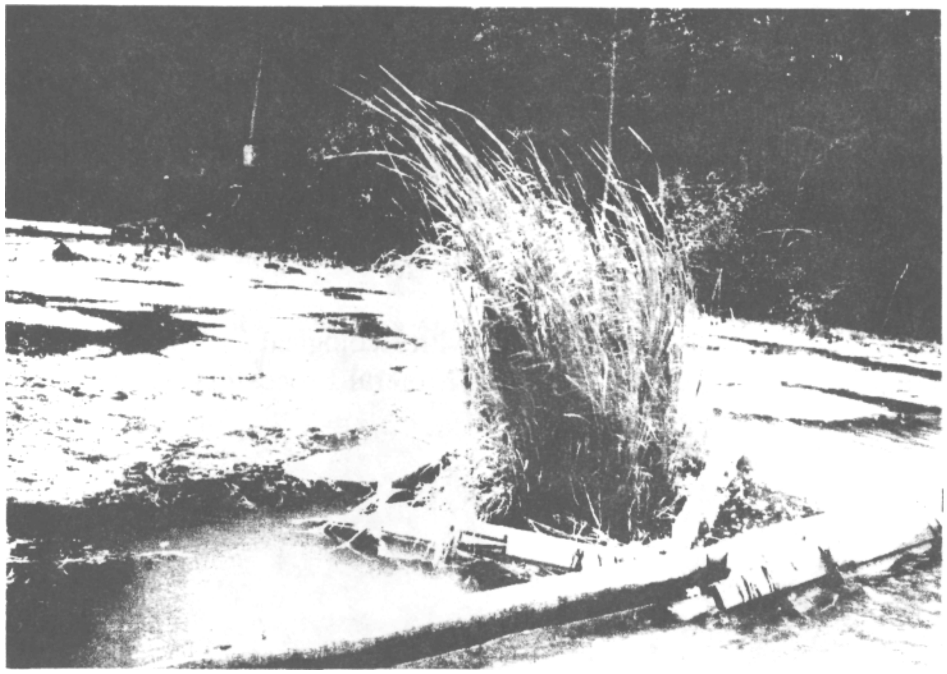

Plate 1: Circum-neutral Pit #1 with curtain, floating amendment and cattail raft.

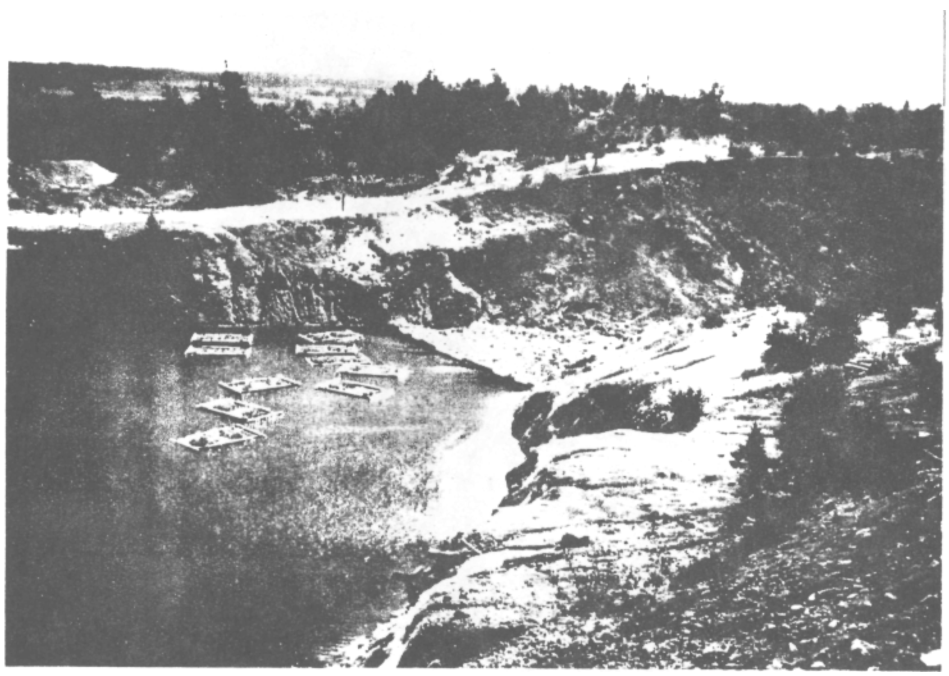

Plate 2: Acidic Pit #2 with amendment curtain, floating amendment and cattail rafts.