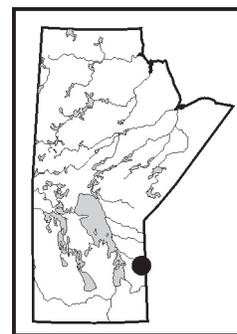


**Phytoremediation and revegetation of mine tailings
and bio-ore production: effects of paper mill sludge on
plant growth in tailings from Central Manitoba (Au)
minesite (NTS 52L13)
by S. Renault¹ and S. Green¹**



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Summary

A greenhouse experiment was designed to test the effects of paper mill sludge on plants growing in mine tailings. The addition of paper mill sludge to tailings increased the shoot growth of the selected species (alfalfa, red fescue and slender wheatgrass). The most significant increase in growth for the three selected species was obtained when both paper mill sludge and fertilizer were added. These preliminary results suggest that paper mill sludge has potential as a tailings amendment for revegetation of the Central Manitoba minesite.

Introduction

The Central Manitoba (Au) minesite is an abandoned mine located in southeastern Manitoba. This site contains approximately 20 ha of mine tailings, which have been without vegetation since the mining activity ceased in 1937. Parts of the tailings contain pyrite, which oxidizes creating acidity and a corresponding release of metals into the environment. Wind and water can physically move tailings off-site causing contamination of adjacent areas. Establishing a vegetation layer decreases oxidation and prevents erosion of the tailings. Since 2000, a series of studies has been underway to determine how to establish a vegetation layer and remove pollutants from the mine tailings. It has been suggested that low nutrient levels, low water availability, metal toxicity, acidity and poor physical structure all prevent plant growth on this site (Renault et al., 2001, 2002, 2003, 2004). The tailings at this site have high levels of copper (834–10,500 ppm), zinc (82–211 ppm), lead (18–88 ppm) and iron (5.49%) (Renault et al., 2000). In order to successfully establish a vegetation cover it is often necessary to alleviate stress on the plants by adding an organic amendment. Paper mill sludge, an organic byproduct of the pulp and paper industry, has shown positive effects on plants grown in mine waste (Feagley et al., 1994; Pichtel et al., 1994).

Objectives

The objective of this study was to determine the effects of paper mill sludge and/or fertilizer on the growth of red fescue (*Festuca rubra*), slender wheatgrass

(*Agropyron trachycaulum*) and alfalfa (*Medicago sativa*) in the Central Manitoba mine tailings. The long-term goal of this research is to define limiting factors for phytoremediation and revegetation of mine tailings and other sites contaminated with heavy metals. This study will establish the scientific basis for the remediation of mine tailings and extraction of heavy metals by phytomining techniques.

Experimental design

Four treatments were used: 1) tailings (control), 2) tailings with fertilizer, 3) tailings with paper mill sludge and 4) tailings with paper mill sludge and fertilizer. The experiment was replicated four times with five pots per treatment. Paper mill sludge was added to the mine tailings at a rate of 56 g of moist paper mill sludge per litre of air-dried mine tailings. Where applicable, N:P:K fertilizer (20:20:20) was applied at a rate of 141 kg/ha. Each pot was seeded with five or ten seeds depending on the species. Plants were grown in a greenhouse for a 14-week period under controlled conditions.

Results and discussion

Alfalfa, red fescue and slender wheatgrass showed an increase in shoot biomass when grown in the tailings with fertilizer and sludge compared to the tailings (control) alone (Table GS-20-1). The sludge and fertilizer treatment resulted in the most significant increase in shoot biomass.

It is likely that the fertilizer decreased the existing nutrient deficiency in the tailings and caused a corresponding increase in plant growth. Other studies have also shown that the application of fertilizer to mine tailings can cause an increase in plant growth (Feagley et al., 1994; Ye et al., 2002). The observed increases in growth could also be due in part to the paper mill sludge improving the chemical and physical characteristics of the soil. The addition of paper mill sludge caused an increase in organic carbon, which can cause an increase in water retention (Rawls et al., 2003). Paper mill sludge addition can also cause an increase in macroaggregation. Macroaggregation can lead to better aeration and water infiltration through the tailings, which could cause increased

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Table GS-20-1: Shoot dry weight (mg) of alfalfa, red fescue and slender wheatgrass grown in mine tailings with and without fertilizer and paper mill sludge for 14 weeks.

	Shoot dry weight (mg)
Alfalfa	
tailings (control)	5.8 ± 0.5
tailings with fertilizer	18.5 ± 3.4
tailings with sludge	15.6 ± 4.9
tailings with sludge and fertilizer	197.4 ± 22.3
Red fescue	
tailings (control)	6.3 ± 0.5
tailings with fertilizer	34.3 ± 5.7
tailings with sludge	47.6 ± 9.5
tailings with sludge and fertilizer	96.6 ± 20.9
Slender wheatgrass	
tailings (control)	12.3 ± 1.3
tailings with fertilizer	25.1 ± 3.7
tailings with sludge	32.8 ± 5.2
tailings with sludge and fertilizer	65.9 ± 10.1

plant growth (Ibrahim and Goh, 2004). Without paper mill sludge addition, the tailings became quite compact. Paper mill sludge addition lowered the bulk density and alleviated compaction. Since compaction often limits plant growth in mine tailings (Tordoff et al., 2000), decreasing compaction likely increased the growth rate. The addition of paper mill sludge also contributed some nutritional value to the plants as well. Paper mill sludge can supply nutrients such as N, P and Ca (Feagley et al., 1994).

Adding both paper mill sludge and fertilizer together had the greatest effects on the growth of all species. The increase in growth was likely due to a positive interaction between beneficial soil structural changes brought on by the addition of paper mill sludge and alleviation of nutrient deficiency by the addition of fertilizer. Field studies will be conducted to further investigate the potential of using paper mill sludge as a tailings amendment for revegetation of the Central Manitoba minesite.

Economic considerations

The re-establishment of self-sustainable forest systems in mine tailings areas is a major environmental issue. The development of methods that can limit the impact of industry on the environment will provide long-term benefits to Canada and people living near the mines. The utilization of waste products from the paper mill industry for revegetation of abandoned mines would provide a relatively low-cost reclamation technique.

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