GS-21 Revegetation of tailings at the Gunnar minesite, Manitoba (NTS 52L14): preliminary observations on plant growth in tailings amended with paper-mill sludge

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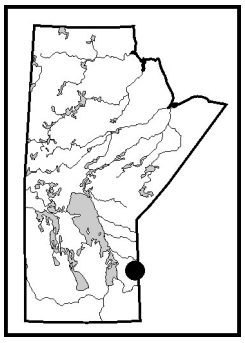

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Summary

A preliminary field experiment was designed to test the effects of tilling, fertilizing and amending Gunnar tailings with paper-mill sludge on plant establishment and growth. The addition of paper-mill sludge to tailings increased the growth of red fescue and alfalfa. Slender wheatgrass failed to establish in both amended and unamended plots. Although survival was similar, red osier dogwood seedlings planted in sites amended with paper-mill sludge seemed to suffer from less environmental stress than seedlings in unamended sites. These preliminary results suggest that amending the tailings with paper-mill sludge could be beneficial for plant growth in tailings and lays the groundwork for larger scale revegetation studies at the Gunnar minesite.

Introduction

The Gunnar gold mine in Nopiming Provincial Park (lat. 50°51.37′, long. 95°15.31′) was in operation from 1936 to 1942 (Slivitzky, 1996). The tailings are located in a depression south of the mine and cover approximately 11 ha. Acid mine drainage is not a major concern as the pH of the tailings ranges from 6.4 to 8.1 (Slivitzky, 1996; Lambert, 2001; Londry and Sherriff, 2005). In some areas of the tailings, concentrations of copper (160–580 µg/g), arsenic (10–290 µg/g) and cyanide (1.6–20.9 µg/g) exceed the Canadian Interim Remediation Criteria for Soil (CIRCS) agricultural and/or residential/parkland guidelines (Slivitzky, 1996). However, the surface water of the tailings did not contain substantial metals or cyanides.

Half of the tailings have been naturally revegetated showing a typical pattern of succession. Despite the lack of vegetation over the remaining area, some plants are growing along some cracks in the tailings and where organic debris has accumulated (Figure GS-21-1). The lack of vegetation on the tailings may be due to low organic matter content and compaction of the tailings, which limits oxygen and water availability. Previous studies have shown that the amendment of tailings with peat or paper-mill sludge and fertilizer followed by rototilling significantly improved plant growth on Central Manitoba (Au) mine tailings (Renault et al., 2004; Renault and Green, 2005).

Objectives

The objective of the study was to conduct a preliminary experiment to determine the effects of paper-mill sludge and fertilizer on the establishment and growth of

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Figure GS-21-1: *Isolated plant growth on Gunnar minesite tailings.*

two grasses, one legume and a shrub species in Gunnar tailings. The long-term goal is to provide recommendations for the revegetation of mine tailings in Manitoba.

Materials and methods

In May 2006, the locations of the experimental sites were chosen based on homogeneity in colour, topography and vegetation cover of the tailings. Experimental plots were prepared based on a randomized block design with two treatments and four replicates. One subplot from each replicate was randomly chosen and treated with 5.6 kg/m^2 of paper-mill sludge whereas no sludge was added to the control subplot (Figure GS-21-2). All subplots were fertilized with 700 kg/ha of 10-20-10 nitrogen-phosphorus-potassium (NPK) fertilizer plus 125 kg/ha of micronutrients and mixed to a depth of 15 cm with a rototiller. A seed mixture containing 30 kg/ha slender wheatgrass (*Agropyron trachycaulum*), 30 kg/hared fescue (*Festucal rubra*), and 30 kg/ha alfalfa (*Medicago sativa*) was sowed in ¾ of each subplot and red osier dogwood (*Cornus sericea*) seedlings were planted in the remaining portion of each subplot. In September 2006, plant establishment, growth and injury/stress were assessed. Tailings samples were collected in each plot for determination of bulk density and element content.

Results and discussion

The number of plants that grew in each treatment plot is summarized in Table GS-21-1. We recorded only a small number of plants in the control plots (rototilled and fertilized), while the addition of paper-mill sludge greatly improved the growth of red fescue and alfalfa to a lesser extent (Figure GS-21-3). The plants did not show any visible injury or symptoms of deficiency. Slender wheatgrass did not grow on the tailings, with or without paper-mill sludge. The red osier dogwood seedlings in both treatments survived; however, by early July, signs of stress expressed as reddening of leaves and marginal leaf necrosis could be observed. By early September, the only red osier dogwood that was actively growing was in the tailings amended with paper-mill sludge. Leaf abscission had occurred in red osier dogwood plants growing in the sludge-amended tailings whereas dry leaves were still attached to the plants in unamended control plots. This suggests that the leaves of the control plants may have been exposed to a more severe stress (such as drought)

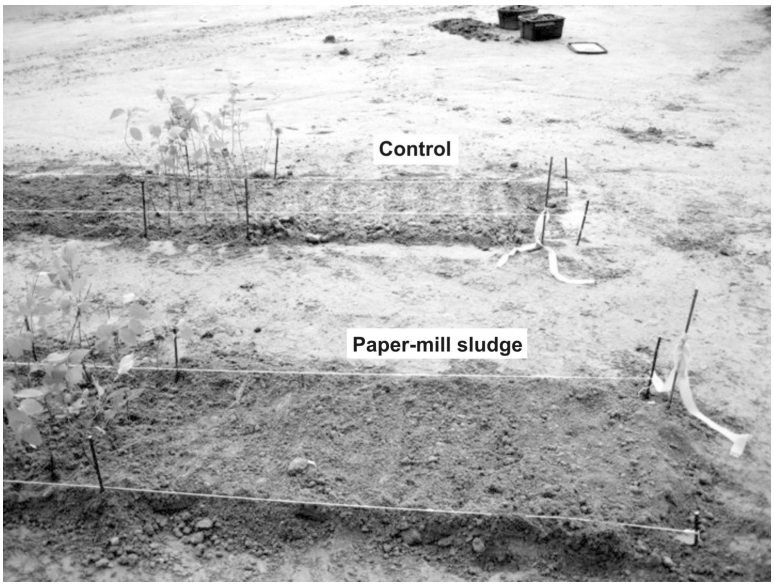

Figure GS-21-2: *Experimental plots at Gunnar minesite.*

Table GS-21-1: Number of plants growing in tailings amended with paper-mill sludge and in control plots at the end of the growing season. The values represent the means, plus or minus the standard error, of four replicates.

Plant/shrub	Sludge-amended plots (no. of plants)	Control plots (no. of plants)
Red fescue	11.75 ±3.20	2.00 ±0.91
Slender wheatgrass	0	0
Alfalfa	3.25 ±1.65	0.25 ±0.25
Red osier dogwood	1 plant actively growing 19 plants without leaves	no plants growing 20 plants with dry leaves

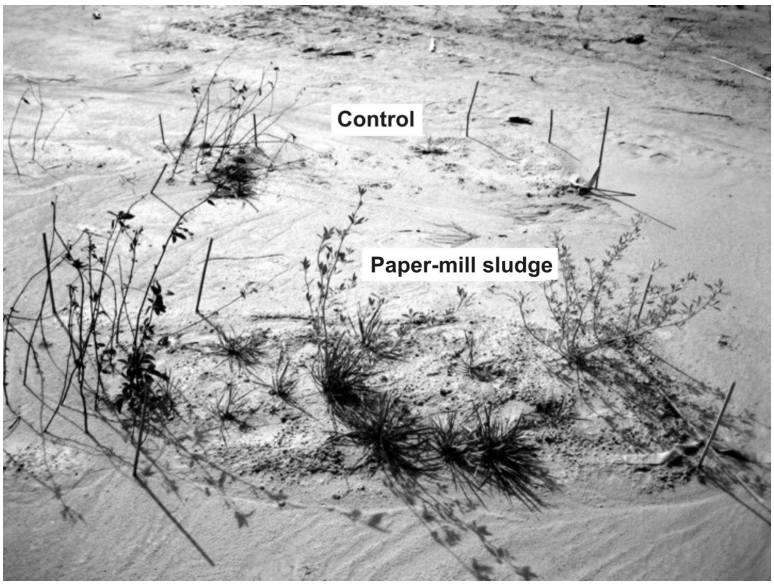

Figure GS-21-3: *Plants growing in unamended control plots and in tailings amended with paper-mill sludge, September 2006.*

than the ones growing in amended tailings.

These preliminary results suggest that the addition of paper-mill sludge to the tailings could improve plant growth by improving water and nutrient availability at least for some of the selected species. Paper-mill sludge has been shown to modify the physical properties of tailings from Central Manitoba minesite in a greenhouse experiment. An increase in organic content, macroaggregate content, field capacity and a decrease in the bulk density of the tailings was recorded (Green and Renault, unpublished data, 2006). To determine the suitability of paper-mill sludge, a larger scale field study will be undertaken in 2007 at the Gunnar minesite.

Economic considerations

Reclamation of land impacted by the extraction of natural resources is a current challenge for the government and industry. Fundamental revegetation techniques such as seedbed preparation, fertilization and seeding are oftentimes inadequate for successful revegetation of mine tailings (Munshower, 1994). Research oriented towards using readily available amendments, such as paper-mill sludge, to increase revegetation success on such sites would benefit the paper-mill industry, mining industry as well as the government and future land users.

Acknowledgments

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References

Lambert, C.M. 2001: Preliminary study of the mineralogy and geochemistry of the Gunnar mine tailings pile, Nopiming Park, Manitoba, Canada; B.Sc. (Hon) thesis, University of Manitoba, Winnipeg, 68 p.

Londry, K.L. and Sherriff, B.L. 2005: Comparison of microbial biomass, biodiversity and biogeochemistry in the three contrasting gold mine tailings deposits; Geomicrobiology Journal, v. 22, p. 237–247.

Munshower, F.F. 1994: Applied revegetation techniques for common disturbances; *in* Practical Handbook of Disturbed Land Revegetation, Lewis Publishers, Boca Raton, p. 161–211.

Renault, S., Szczerski, C., Sailerova, E. and Fedikow, M.A.F. 2004: Phytoremediation and revegetation of mine tailings and bio-ore production: progress report on plant growth in amended tailings and metal accumulation in seedlings planted at Central Manitoba (Au) minesite (NTS 52L13); *in* Report of Activities 2004, Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, p. 257–261.

Renault, S. and Green, S. 2005: 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); *in* Report of Activities 2005, Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, p. 167–169.

Slivitzky, M.S.C. 1996: The Manitoba model forest: an assessment of mineral development, with recommendations for ecosystem-based management; M.Sc. thesis, University of Manitoba, Winnipeg, 157 p.