TESTING SOIL MIXTURES FOR RECLAMATION OF DIAMOND MINE WASTES IN A SUBARCTIC REGION

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Introduction

Subarctic regions are recognized as one of the largest remaining pristine landscapes on earth (Walker, 1997). Within these regions, strong connections exist between the physical, chemical, and biological components of each ecosystem (Walker, 1997), and are recognized as vulnerable due to their sensitivity to change and disturbance (IUCN, 1993). Subarctic and arctic regions have been subject to increasing pressure from human activities, including mining, which have led to progressive degradation of these pristine environments (Deshaise *et al*., 2009). Rehabilitation efforts in subarctic regions have been minimal due to the lack of proper guidelines. This is mainly due to a limited understanding of fundamental ecosystem processes that exist within subarctic regions (Deshaise *et al*., 2009). Reclamation strategies aim to improve conditions, such as developing functional soils, to create conditions suitable for vegetation establishment (Munro, 2006). Therefore, it is important to understand the soil properties and relationships that can influence reclamation within subarctic regions.

Our research focuses on the reclamation of diamond mine wastes in subarctic regions, specifically at the De Beers Victor Diamond Mine. The De Beers Victor Diamond Mine is located within the Hudson Bay Lowlands, within Canada’s subarctic. Currently, it is the only active mining development within the Hudson Bay Lowlands. Mines that develop in northern regions can be a challenge to reclaim due to natural aspects of subarctic environments as well as the remote location of these mining developments. Due to their remote location, there is often a shortage of material that can be used to create cover soils during the process of mine reclamation.

The goal of our research is to examine how mines in northern regions, such as the De Beers Victor Diamond Mine, can use readily accessible material, including their mining by-products, to create cover soils for reclamation. To achieve this, various soil mixtures were created using local mineral and organic substrate materials at the Victor Mine, and their success and performance will be evaluated. The main objectives of this research are to (1) determine which mixture(s) of mineral substrates promote the most suitable conditions for the establishment of vegetation, and (2) determine how the quantity of organic matter influences vegetation establishment.

Methods

During the summers of 2013 and 2014, test mixtures were constructed on two areas of mine waste at the Victor Mine. In total, 48 test mixtures were constructed, measuring 5m x 5m. The raw materials used to create the soil mixtures included a silty loam marine overburden (OB), coarse and fine processed kimberlite (CPK and FPK respectively), and peat. Using these raw materials, four mineral mixtures were created, and tested with either 20% or 40% peat applications. The mineral mixture combinations include 100%OB, 50:25:25 OB:CPK:FPK , 50:50 OB:CPK, and 25:50:25 OB:CPK:FPK. During the summer of 2014 each test mixture was fertilized at a rate of 12.5g/m^2 (8-32-16 NPK), a local microbial inoculation mixture was applied, and were seeded with a variety of native nitrogen-fixing and non nitrogen-fixing plant species.

During the summer of 2015 various physical, chemical and biological parameters were examined to evaluate the success and performance of each mixture. The physical properties examined included root penetrability, texture, soil surface moisture, air temperature, bulk density, organic matter content, surface roughness and changes in moisture and temperature with depth. The chemical properties examined included soil pH, electrical conductivity, bioavailable nutrients, and C, N, and S content. The biological properties examined included microbial activity, aboveground biomass, and total plant cover and composition. These tests were also preformed on selected reference sites in order to compare the performance of our test mixtures in comparison to natural native soil conditions, a peat-OB mixture currently being used to reclaim a stockpile at the Victor Mine, and untreated waste rock piles at the Victor Mine.

Results

Results at this stage in our research show significant differences between several physical, chemical, and biological parameters of the mineral mixtures including soil bulk density, surface moisture, electrical conductivity, pH, and total plant cover. The greatest differences within these parameters were observed between the mineral mixtures containing 100% OB, and those containing high amounts of processed kimberlite. The mixtures containing 100% OB had greater surface moisture measurements, lower bulk densities, greater electrical conductivity measurements, lower pH measurements, and greater total plant cover scores during the first year of growth (Fig. 1) compared to the mixtures containing high amounts of processed kimberlite.

Significant similarities were also found between several physical, chemical and biological parameters of the test mixtures in comparison to native soil reference site conditions, in terms of bulk density, root penetrability resistance measurements, and electrical conductivity measurements. The test mixtures and peat-OB mixture had statistically significant similar estimated total plant cover scores.

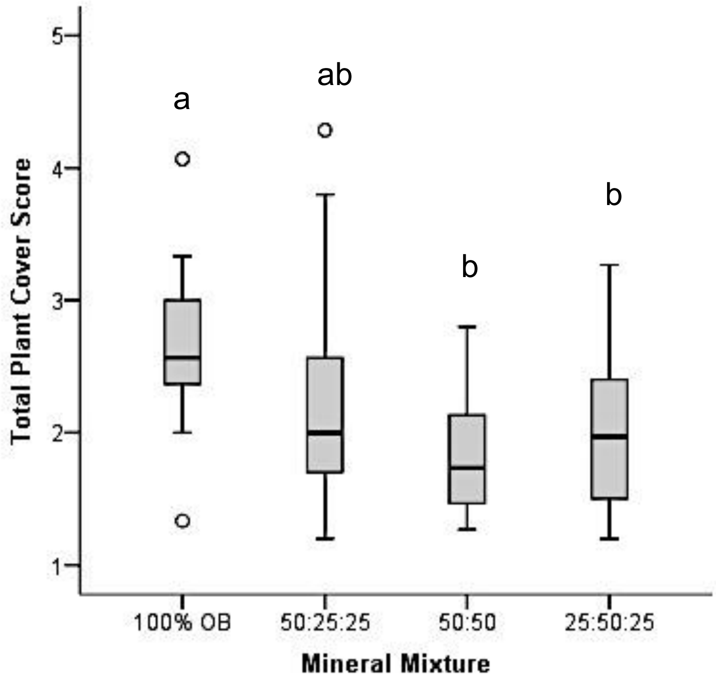

Fig. 1. Total plant cover variation observed on the mineral mixtures containing 20% and 40% peat in late August 2015 with post-hoc Tukey's test results (mineral mixture ratio OB:CPK:FPK, $P<0.05$). The scoring system used is as follows: 1=≤1%, 2=2-5%, 3=6-20%, 4=21-50%, 5=≥50% cover.

Conclusions

This research is still ongoing, however, we are observing that our test soil mixtures containing 100% OB were the most successful in terms of vegetation establishment during the first year of growth, and that our test mixtures resemble reference site conditions. During the summer of 2016 second year growth will be evaluated. This research will provide the De Beers Victor Diamond Mine with suggestions for a cover soil to use during mine reclamation. It will also provide insight into the challenges faced when restoring disturbed subarctic environments, and will be used to develop reclamation protocols for mine waste within the subarctic regions of Canada and others globally.

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