An Assessment of the Revegetation Potential of Base-Metal Tailings from the Tui Mine, Te Aroha, New Zealand.

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Abstract

The overall objective of this study was to investigate the revegetation potential of abandoned base-metal (Cu-Pb-Zn) tailings at the Tui mine site near Te Aroha, New Zealand. An estimated 100,000 m^3 of sulphide-rich tailings are the legacy of a once prosperous mining venture conducted at the site between 1967 and 1974 by the now defunct Norpac Mining Ltd. The oxidation of remnant sulphides, which constitute as much as 15% of the tailings by weight, has prevented plants from colonising the tailings for more than 20 years and resulted in the formation of Acid Mine Drainage (AMD) which continues to degrade ground and stream waters in the vicinity of the dam.

This study focused on characterising the physical and chemical properties of the tailings in terms of their plant growth potential using a variety of techniques including; Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectrometry (EDS), Flame Atomic Absorption Spectrometry (FAAS), X-ray diffraction (XRD) as well as field based observations and standard laboratory analyses. A long term incubation experiment (carried out over a 1½ year period) and two plant growth trials were also conducted to investigate the ability of liming materials and/or organic waste to ameliorate the tailings in order to provide a suitable growing medium for plants.

The research indicated that, whilst the tailings do not exhibit any major physical limitations to plant growth, chemically the tailings are an extremely hostile plant growth medium. The surface tailings exhibited variable but generally very low pH (2.76 - 3.85) and high concentrations of potentially phytotoxic elements including As (254 mg/kg), Cu (26-991 mg/kg), Pb (1503-27416 mg/kg) and Zn (123-2333 mg/kg). The high availability of these and other metals, including Al and Fe, under the acidic conditions prevailing in the tailings, were identified as the primary factors currently inhibiting plant growth.

The distribution of heavy metals, sulphate and total sulphur with depth indicated that the surface tailings (0-200 mm) have been extensively weathered since their deposition and contain relatively low concentrations of most heavy metals compared to subsurface

tailings. An assessment of the Acid Generating Potential (AGP) of the tailings, using both static and kinetic tests, similarly indicated that the surface tailings have a comparatively low ability to generate acidity by sulphide oxidation. The application of lime at a rate of about 50 Mg $CaCO_3$/ha is calculated to theoretically prevent the surface tailings from reacidifying. Below 200 mm depth, however, the AGP is appreciably higher (>140 Mg $CaCO_3$/ha) and concentrations of both total and labile (0.1*M* HCl extractable) Cu, Fe and Zn were found to increase substantially, reflecting an increase in the abundance of chalcopyrite ($CuFeS_2$), pyrite (FeS_2) and sphalerite (ZnS) and sulphates with depth. The presence of high concentrations of acid-generating sulphide minerals (primarily pyrite) at shallow depths has important implications in that revegetation of the tailings should be based on techniques that minimise the exposure of the largely unweathered, sulphide-rich, subsurface tailings.

The results obtained from the plant growth trials indicated that, on tailings treatments sown with metal-tolerant varieties of *Festuca rubra* or *Agrostis capillaris*, satisfactory cover was achieved upon the addition of lime at a rate of 16.5 Mg/ha or composted sewage sludge at rates >220 Mg/ha. These metal-tolerant plants were found to out yield their non-metal-tolerant counterparts on the limed treatments by as much as 4 and 10 times, respectively. Although vegetation was successfully established on Tui tailings treated with lime, dry matter yields were relatively low compared to treatments receiving high rates of sludge. The growth of all plant taxa was found to significantly decrease where very high rates of lime (112 Mg/ha) were added due to pH-induced nutrient deficiencies.

Results obtained from both the plant growth trials and the lime incubation experiment indicated that the application of low rates of lime and/or sludge (8.25 and 110 Mg/ha respectively) were ineffective at creating a suitable plant growth medium and, in fact, exacerbated growing conditions within a few weeks of application by increasing the availability of labile (0.1*M* HCl extractable) metals.

The findings of this study indicated that the use of amendments may provide a relatively inexpensive way of facilitating the establishment of plants on the tailings at the Tui mine site. It is envisaged that, at the very least, a vegetative cover will improve the aesthetic appearance of the site and at best reduce AMD by creating an oxygen-depleting, organic-rich cover which may ultimately facilitate the establishment of native species from the adjacent forest.

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