Plant diversity, abundance and distribution on an abandoned copper-nickel roast yard near Sudbury, Canada: the impact of soil toxicity.

Nicole Baks[1], Peter Nosko[1], Graeme Spiers[2] and Keith Winterhalder[3].
[1] Biology Department, Nipissing University, North Bay, Ontario, Canada P1B 8L7
[2] Centre for Environmental Monitoring, Laurentian University, Sudbury, Ontario, Canada P3E 2C6
[3] Wintergreen Ecological Services, 885 Regent Sudbury, Ontario, Canada P3E 5M4

Abstract

In the early 20th century, sulphur-rich, copper-nickel ore mined in the Sudbury region was pretreated in open bed roast yards to burn off excess sulphur compounds prior to smelting. Of such facilities, the O'Donnell roast yard, operating from 1915 to 1929, was the largest in the world (2286 m x 52 m). Ore was piled to a height of 5 m on top of a 1 – 2 m high pile of logs. When ignited, the ore would "roast" for three to six months. This practice resulted in intense ground-level SO_2 fumigations and the deposition of acidifying compounds and toxic metals. For decades after decommissioning, the roast bed surface remained devoid of any vegetative cover. Recently, various metal-tolerant plant species have colonized the roast yard. Our objective was to characterize the diversity, abundance and distribution of plants on the roast bed as affected by pH and toxic metal concentrations of the "soil". A total of 280 regularly spaced 1x1 m plots were examined across the roast bed (28 transects [25 m apart] x ten plots). The percent cover for all plant species and a soil sample (-5 to -15 cm) was recorded/taken at each plot. The concentration of various potentially-toxic metals was determined for each soil sample using XRF, as was pH (paste method). Plant cover by species and functional group was related to soil chemistry variables using bivariate and multivariate statistical methods. Soil pH averaged 3.3; however values as low as 2.1 were measured. Metal concentrations were highly variable and generally high with Fe, for example, having a mean concentration of 26%. The mean concentrations of Ni (2569 $\mu g\ g^{-1}$), Cu (1654 $\mu g\ g^{-1}$), Mn (296 $\mu g\ g^{-1}$) and Cr (265 $\mu g\ g^{-1}$) were also high. Concentrations of Pb, Zn and As averaged 83, 80 and 9 $\mu g\ g^{-1}$, respectively. The average plant cover on the roast bed was 9.8% with 51% of plots having no plant cover. Graminoids (3.7%), dominated by *Agrostis scabra* and *Carex scoparia,* and bryophytes (3.3%), dominated by *Pohlia nutans,* accounted for much of the total plant cover. A comparison of edge, transition and interior plots showed no zonation of soil acidity or soil metal concentrations; however, plant cover, especially of woody species, was greatest along the edge of the roast bed and lowest in the interior. Bivariate statistical tests showed no clear relationships between plant cover and the concentration of Cu or Zn. Only the cover of the lichen *Stereocaulon tomentosum,* appeared to be related (negatively) to Ni concentration. A principlal components analysis suggested a strong positive relationship for each of *Agrostis scabra* and *Carex scoparia* with soil pH and Mn concentration and a negative relationship between these species and Fe and Pb. The occurrence of several species was strongly related to the presence of *Betula papyrifera,* suggesting a possible "nurse" effect, with respect to plant colonization. We found 17 plant species (+2 species outside our plots) on the O'Donnell roast bed. This compares with only 4 species reported for this location in a study conducted in 1994. The O'Donnell roast yard presents a unique opportunity to examine natural recovery of a disturbed ecosystem from a "worst case scenario" perspective. Understanding the challenges to the establishment of a plant cover here may provide solutions to the problem of restoring the ecological integrity of other damaged ecosystems that are more representative of the Sudbury industrial barrens.