Analysis of Soil Microbial Diversity and Activities in Mining Reclaimed Lands in Northern Ontario (Canada): Association with Plant Population Structure

K. K. Nkongolo[1,2], P. Michael[2], R. Narendrula[2], K. Goupil[1], G. Theriault[2] and K. Kalubi[1]

[1]Biology Department and [2]Biomolecular Sciences Program, Laurentian University, Sudbury, ON, Canada, P3E 2C6.

Introduction

Soil biota is implicated in most of the key functions soil provides in terms of ecosystem services, by driving many fundamental nutrient cycling processes, soil structural dynamics, degradation of pollutants and regulation of plant communities. The protection of the biodiversity in the soil is an efficient approach to maintain the proper functioning of the soil. The living population inhabiting soil includes macrofauna, mesofauna, microfauna and microflora (Cannon 1999; Nannipieri *et al*. 2003). There is evidence that soil biotic communities are coupled to their associated vegetation, such that there is a mutual dependence between above-ground and below-ground communities, and hence that compromised soil communities may curtail particular plant assemblages from forming (Luo and Zhou 2006). Based on several recent studies, by characterizing diversity one will be able to understand and manipulate the functions of ecosystems. The ability of an ecosystem to withstand serious disturbances may depend in part on the diversity of the system.

Objectives

1. To determine the association between soil microbial diversity, abundance and activities with diversity and sustainability of mining damaged ecosystems in Northern Ontario.
2. To assess the effects of soil liming on above and below ground biodiversity and community structures.

Materials and Methods

Sampling

- Nine forest populations in six areas were selected for this study.
- Three areas were contaminated with metals and each had limed and unlimed sites; another three metal uncontaminated were used as reference sites (Fig 1).

Ecological Analysis

- At each site, three transects of 10 m diameter areas were used to assess tree species richness and abundance.

Phospholipid Fatty Acid (PLFA) Analysis

- Phospholipid analysis (PLFA) was performed at FAME Lab, Microbial ID. Inc., Newark, Delaware (USA).

Soil Respiration

- Soil respiration was assessed using the Solvita soil test kit.

Results

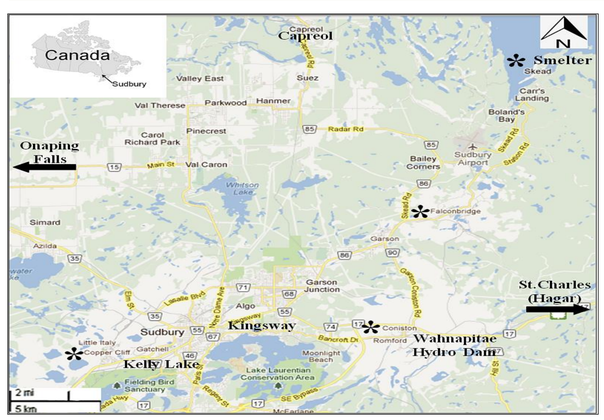

Figure 1: Location of sampling sites from the Northern Ontario Region. Unlimed and limed sites: Kelly Lake, Kingsway and Wahnapitae Hydro-Dam; Reference sites: Hagar, Capreol and Onaping Falls.

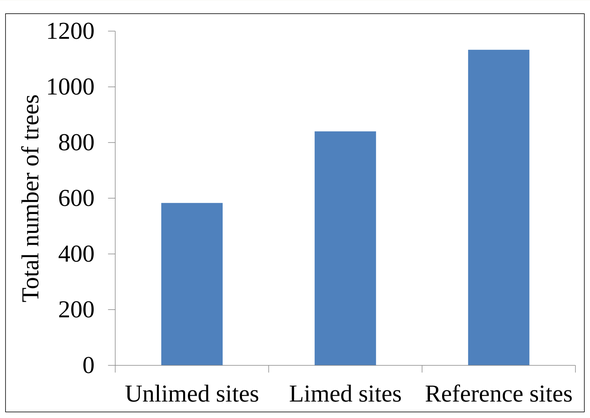

Figure 2: Total number of trees for unlimed, limed and reference sites from a Northern Ontario Region.

Results

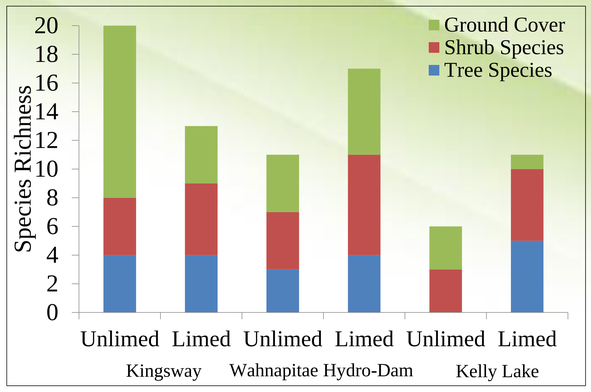

Figure 3: Species richness for ground cover, shrub and tree species for unlimed and limed sites from Northern Ontario.

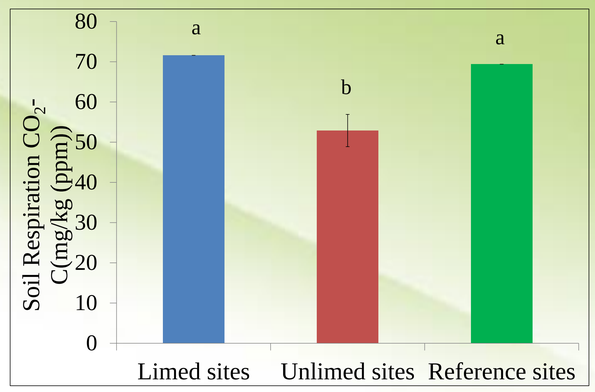

Figure 4: Soil respiration rates for limed, unlimed and reference sites in Northern Ontario Region.

Table 1: Abundance of various organisms identified in soil samples from Northern Ontario using phospholipid fatty acid (PLFA) analysis. Data in ng/g.

Sites	Total	AM Fungi	Fungi	Gram Negative	Gram Positive	Eukaryote	Anaerobe	Actinomycetes
Unlimed sites	145.72a ±33.73	6.10a ±2.12	11.81a ±6.13	67.10a ±40.06	37.29a ±16.51	5.06a ±2.64	1.64a ±0.68	16.72a ±6.95
Limed sites	339.63b ±83.25	14.91b ±2.57	26.72ab ±14.17	174.61b ±41.66	76.06b ±15.45	7.39a ±2.90	4.61b ±0.70	35.33b ±6.62
Reference sites	431.81b ±80.36	19.35b ±2.57	42.49b ±13.25	212.76b ±32.21	95.32b ±20.23	16.11b ±0.60	5.19b ±2.15	40.59b ±9.95

Means in columns with a common subscript are not significantly different based on Tukey multiple comparison test ($P \geq 0.05$)

Table 2: Microbial ratios determined based on phospholipid fatty acid (PLFA) data.

Sites	Fungi/ Bacteria	Predator/ Prey	Gram positive/Gram negative	Saturated/ Unsaturated	Mono/ Poly	16w/ 16 cyclo	18w/ 19 cyclo
Unlimed sites	0.18	0.04	0.74	1.17	3.82	2.43	0.80
Limed sites	0.14	0.02	0.55	0.77	6.44	2.64	2.30
Reference sites	0.16	0.05	0.48	0.74	4.00	3.00	1.12

Conclusions

- Ecological analyses revealed that liming increases forest trees diversity and abundance and the overall ecosystem health even 25 to 35 years after dolomic applications.
- Soil microbial biomass and respiration were also increased by liming.
- The main component of soil microbiome in limed, unlimed and reference sites within the vicinity of the restored lands was Gram negative bacteria.
- The ratios between fungi and bacteria and among other PLFA measures were extremely low suggesting that the targeted region is still under environmental stress.
- No associations among soil microbial biomass, soil respiration and forest plant diversity or abundance were observed.
- Soil pH and organic matter appear to be the main factors affecting these parameters.

Acknowledgements

We thank the Natural Sciences and Engineering Research Council of Canada (NSERC), Vale Limited and Glencore Limited for their financial support.

References

1. Cannon, P. F. (1999). Options and constraints in rapid diversity analysis of fungi in natural ecosystems. Fungal Diversity, 2, 1-15.
2. Luo, Y., and Zhou, X. (2006). Soil Respiration and the Environment. Burlington MA: Academic Press.
3. Nannipieri, P., Ascher, J., Ceccherini, M. T., Landi, L., Pietramellara, G., and Renella, G. (2003). Microbial diversity and soil functions. European Journal of Soil Science, 54(4), 655-670.

LaurentianUniversity
UniversitéLaurentienne