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Fate of ¹⁵N labelled urea in a soil contaminated by heavy metal containing dust: An incubation study using a mine slag sampled from Kabwe city, Zambia, Africa

Yoshitaka Uchida and Miyuki Oka
Hokkaido University, Japan

Statement of the Problem: Heavy metal contamination of soils is a global issue, particularly around mining sites. The heavy metals can decrease plant and microbial activities in soils and this can be an issue to recover the slag (mine waste) dumping site using plants. With decreased plant and microbial activities, nutrients such as nitrogen (N) cannot properly cycle in soils. In N cycle, organic-N such as urea is decomposed in soils by microbes and becomes available to some plants as ammonium (NH₄⁺). Ammonium-N can further be oxidized by nitrifying microbes and becomes nitrate-N (NO₃⁻-N). These processes are extremely important in soils and must be maintained in soil. Thus, the purpose of this study is to evaluate soil microbial activities with increasing contamination levels by a slag.

Methodology & Theoretical Orientation: We conducted an incubation experiment to investigate the effect of slag containing Pb and Zn (100-3000 and 54-1620 mg/kg respectively), sampled from a site formerly used as a lead and zinc mine. After two weeks of the pre-incubation, ¹⁵N labeled urea (500 mg-N/kg) was added to the soil. Then changes in bacterial relative abundance, the concentration and ¹⁵N ratio of NO₃⁻-N and NH₄⁺-N were measured.

Findings: Increasing ratio of slag to soil had a stronger negative effect on nitrification. The bacterial community was significantly influenced by the presence of slag. Firmicutes had a positive and Planctomycetes had a negative correlation with the concentration of heavy metals.

Conclusion & Significance: We concluded that increased contamination levels by a slag in soil had a considerable impact on N dynamics in the soil. However, the sensitivities of the N cycle processes markedly varied. Mechanisms behind this variability needs to be further studied.

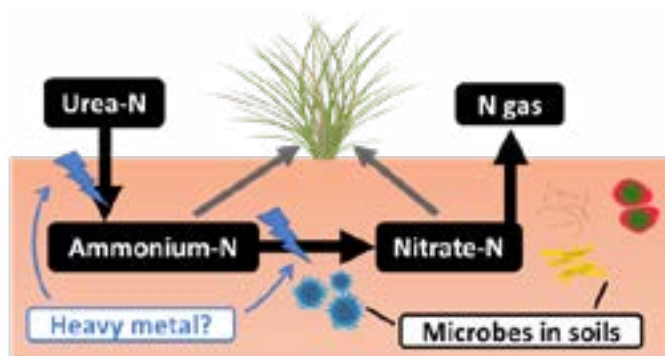


Figure 1: A part of nitrogen cycle can be damaged in soil contamination. Urea (organic-N) is hydrolysed in soils and ammonium-N is produced. The ammonium-N can be oxidised and becomes nitrate-N. Nitrate-N can be lost from the soils via denitrification process.

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Recent Publications

1. Hamamoto T et al. (2018) Small-scale variability in the soil microbial community structure in a semi-developed farm in Zambia. *Applied and Environmental Soil Science*. 2018:1-6.
2. Mukumbuta I, Uchida Y and Hatano R (2018) Evaluating the effect of liming on N₂O fluxes from denitrification in an Andosol using the acetylene inhibition and ¹⁵N isotope tracer methods. *Biology and Fertility of Soils*. 54(1):71-81.
3. Toda M and Uchida Y (2017) Long-term use of green manure legume and chemical fertilizer affect soil bacterial community structures but not the rate of soil nitrate decrease when excess carbon and nitrogen are applied. *Soil Research*. 55:524-533.
4. Wang Y et al. (2017) Responses of denitrifying bacterial communities to short-term waterlogging of soils. *Scientific Reports*. 7(1):803.
5. Shimotsuma M et al. (2017) The effects of rice (*Oryza sativa* L. spp. Japonica) husk biochar on nitrogen dynamics during the decomposition of hairy vetch in two soils under high-soil moisture condition. *Soil Science and Plant Nutrition*. 63(2):178-184.

Biography

Yoshitaka Uchida is currently an Associate Professor of Research Faculty of Agriculture at Hokkaido University, Japan. He has been studying soil microbes in relation particularly to nitrogen and carbon cycles. Recently, he started a project in Kabwe city, Zambia targeting a heavy metal contaminated soil and believes the recovery of plants and healthy soils is the key for the success of this project. In this study, he and his student used ¹⁵N-labelling approaches to evaluate the sensitivity of N cycle against heavy metals. The project will continue and he hopes to scale-up the experiments at the field level.

uchiday@chem.agr.hokudai.ac.jp

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