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Nitrogen dynamics in earthworm casts: possible hotspot of N2O production in soil

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Introduction

Nitrous oxide (N_2O) has been recognized as a potent and long-lived green house gas. Its global warming potential (GWP) is 310 times greater than CO_2. N_2O is also linked to ozone depletion strongly. So increasing anthropogenic emission of N_2O is now pressing problem. To understand, estimate the effect of human activity on N2O budget, correct estimation of N_2O production rates from relatively small scale, like regions, landscapes, and individual fields, are needed.

Earthworms change soil structure and influence nitrogen and carbon cycle in soil. Previous study shows that earthworm casts have high nitrification and denitrification rate. In the few studies N_2O emission from casts are measured but almost no study focus on the change of N_2O emission related to cast ageing.

We evaluated the change of pH, mineral N content, N_2O emission rate, C/N, total organic C, and microbial respiration related to cast ageing and investigate what causes the change of N_2O emission rate. We also use two different species of earthworm and check the species effect.

Materials and Methods

Earthworms (*Amynthas hupeiensis* and *Metaphire megascolidioides*) and soil are collected on Kamakura central park, Kamakura, Kanagawa and pre-incubated in laboratory during 3 days. The samples of fresh casts from each earthworms and soils (5.0g of wet matter) were placed into glass bial and incubated. We measured N_2O emission rate after 0,1,4, and 10 days of the cast formation. Subsequently, sample in the bial are separated and pH, C/N ratio, NH_4^+, NO_3^-, TDN (Total Dissolved Nitrogen), TOC (Total Organic Carbon) were measured.

Results and Discussion

N_2O emission from soils is almost constant during incubation period (-0.004 to 0.004 microgN/g/day). N_2O emission from *A. hupeiensis*'s casts decreased from 0.023 microgN/g/day (0-day cast) to 0.005 microgN/g/day (10 day cast). N_2O emission from *M. megascolidioides*'s casts also decreased from 0.147 microgN/g/day (0-day cast) to 0.027 microgN/g/day (10-day cast). Irrespective of species, N_2O emission from casts is significantly higher than soil, so casts may contribute to N_2O emission from soil in the actual field.

pH decrease and NO_3^- concentration increase with time are shown in casts from both species. NH_4^+ and TDN concentration in *A. hupeiensis*'s casts increased in 4-day and 10-day cast. In *M. megascolidioides*'s casts, on the other hand, NH_4^+ concentration is gradually decreased and TDN concentration are almost constant. Previous study shows decrease of NH_4^+ concentration. So NH_4^+ increase in *A. hupeiensis*'s casts may caused by ammonification, mucus secretion. Microbial respiration in casts are higher than soil in both species. TOC concentration shows sharp decline between 0-day and 1-day and fluent decline between 4-day and10-day casts from both species.

N_2O emission from casts and TOC are related significantly (*A. hupeiensis*: r^2=0.61, *M. megascolidioides*: r^2=0.47), and it shows possibility that TOC decrease control N_2O emission from casts. It is known that microbial activity in earthworm casts decreases after cast formation. This decrease is thought to be caused by decrease of available carbon, antagonistic interactions between microbial communities, and so on. The results from this study support the limitation by available carbon.

Keywords: earthworm, cast, nitrogen dynamics, nitrous oxide (N2O)