Earthworm influence on nitrous oxide emissions under constant and fluctuating soil moisture conditions

Chen Chen, Joann K. Whalen
Department of Natural Resource Sciences, McGill University, Montreal, Canada. Corresponding author: chen.chen6@mail.mcgill.ca

INTRODUCTION

Nitrous oxide (N_2O) is a greenhouse gas that is released from both nitrification and denitrification processes. Soil moisture content is a key controller for N_2O emission, causing a switch between nitrification and denitrification processes.

Earthworm biostructures (casts, middens, and burrows) may favor the activity of both nitrifiers and denitrifiers, even when the conditions are not favorable for earthworm feeding or other activities (too dry or too wet). Biostructures may be a more important source of N_2O emission from earthworm-worked soil than the earthworms themselves, in the long term.

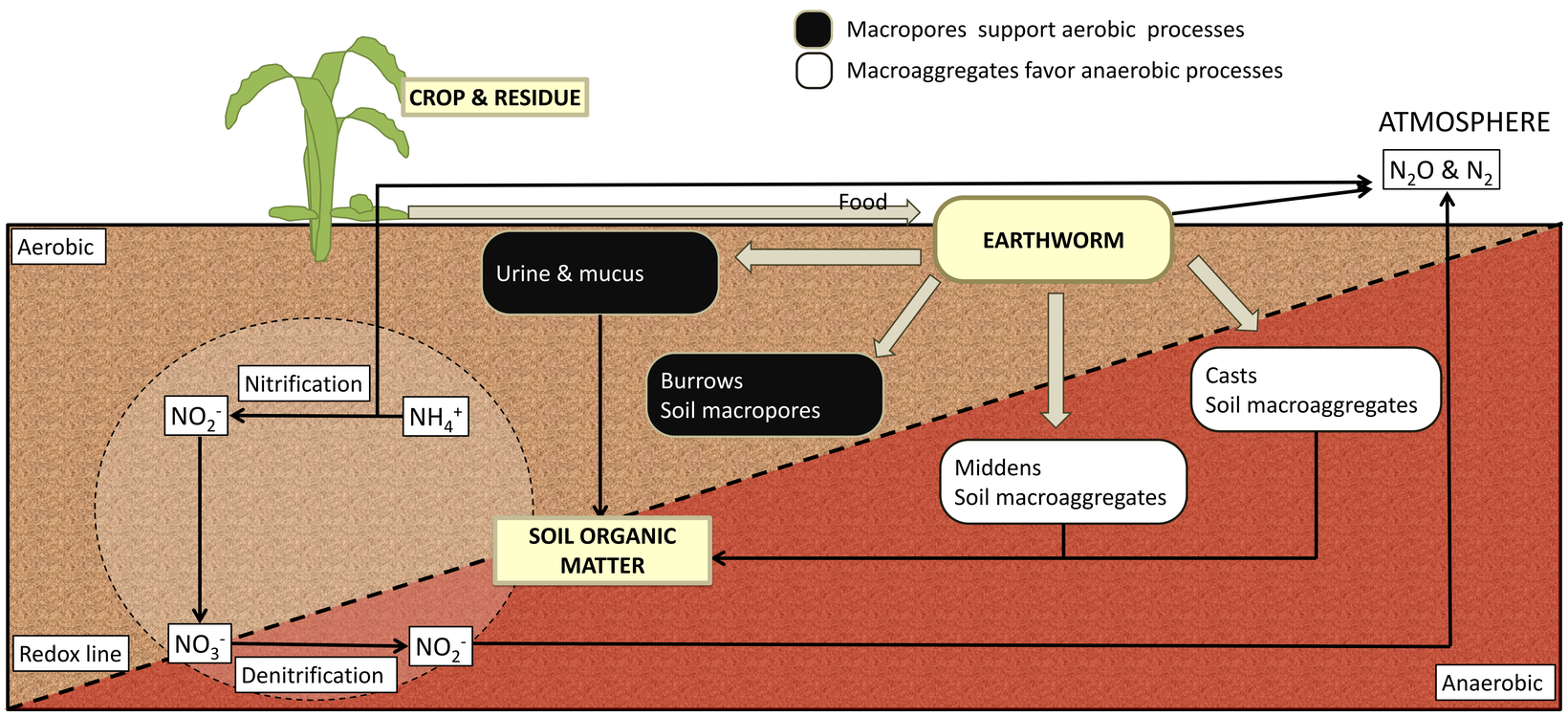
Soil moisture between 40% and 70% water-filled pore space (WFPS) supports high earthworm activities, which is expected to enhance the N_2O emission from earthworms and their biostructures. However, it is not known how fluctuating soil moisture conditions affect N_2O emission from earthworm-worked soil.


Casts


Middens


Burrows

NITROGEN CYCLING IN THE DRILOSPHERE IS CONTROLLED BY AEROBIC AND ANAEROBIC PROCESSES



OBJECTIVES

The objectives were to (1) evaluate the soil moisture effects on earthworm activities, and (2) link these effects to earthworm-induced N_2O emissions under three soil moisture conditions (constant aerobic, constant anaerobic and fluctuating anaerobic-aerobic).

MATERIALS AND METHODS

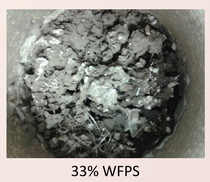
This experiment involved a completely randomized factorial design with 2 earthworm treatments (with and without earthworms), and 3 soil moisture conditions (constant 33% WFPS, constant 97% WFPS, and wetting-drying fluctuating from 97-33% WFPS).

Earthworms were selected from endogeic *Aporrectodea turgida* and anecic *Lumbricus terrestris*

The mesocosms were kept in 10 cm diameter by 20 cm tall PVC tubes, with 5 replicates of each soil moisture condition, and 5 additional replicates to evaluate earthworm growth rates.


97% WFPS


70% WFPS


33% WFPS

Mesocosms prepared without earthworms or with earthworms (endogeic and anecic)

↓

Mesocosm incubation for 3 fluctuating cycles (~ 2 months)

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N_2O fluxes were quantified every one to three days

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Earthworm growth rates were measured at the end of each fluctuating cycle

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At the end of the incubation, earthworm growth rates and potential denitrification rates of mesocosm soil were measured

RESULTS

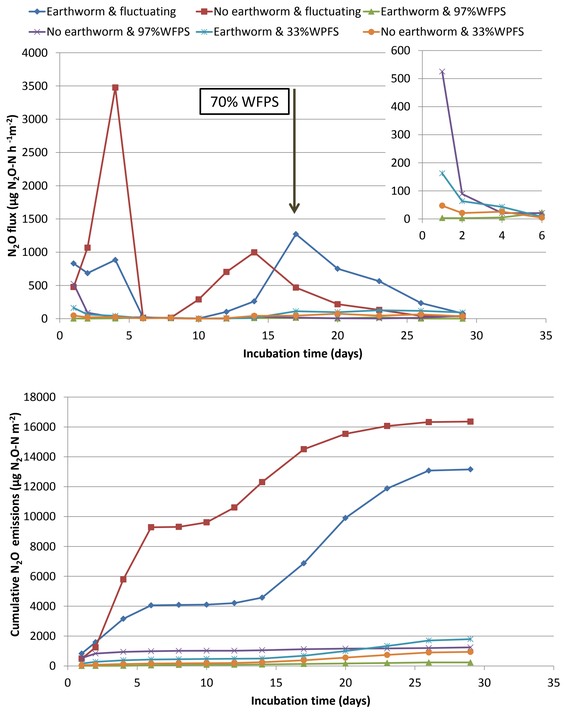

Figure 1 The N_2O flux and cumulative N_2O emissions under different soil moisture conditions. There is a shift from nitrification to denitrification around 70% WFPS.

Table 2 Earthworm survivorship from start of experiment to the end of the first fluctuating cycle

Treatment	Experiment start				The end of first fluctuating cycle (day 34)			
	Endogeic		Anecic		Endogeic		Anecic	
	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number
Fluatuating	0.23 ± 0.03	15	2.09 ± 0.23	10	0.32 ± 0.12	16	2.57 ± 1.58	4
97% WFPS	0.26 ± 0.06	15	2.57 ± 0.58	10	0.29 ± 0.09	12	3.00 ± 0.56	7
33% WFPS	0.22 ± 0.05	15	2.22 ± 0.25	10	0.18 ± 0.01	7	4.40 ± 2.73	9

- Earthworm survivorship was from 40% - 107% during the first fluctuating cycle (Table 2) and subsequent fluctuating cycles (data not shown).
- Fluctuating moisture favored *A. turgida* (reproduction) but was detrimental to *L. terrestris.*

- Due to earthworms activities, the soil moisture decreased faster in earthworm treatments than no earthworm treatment (data not shown).
- The constant anaerobic soil without earthworms showed a peak in N_2O flux in the first 4 d of the study, thereafter it had relatively constant N_2O flux.
- In the fluctuating moisture treatment, soil without earthworms gave higher N_2O flux from denitrification when soil moisture exceeded 70% WFPS. The peak in N_2O flux of soil with earthworms occurred later in the cycle (as soils became drier), suggesting that nitrification reactions could be generating N_2O in earthworm-worked soils.
- Cumulative N_2O production: fluctuating soil moisture >> 97% WFPS = 33% WFPS.

CONCLUSIONS

Earthworm enhanced N_2O emissions more under aerobic conditions than anaerobic conditions, which may suggest earthworms are conducive to the production of N_2O from nitrification more than denitrification.

In fluctuating soil moisture condition, earthworm activities were restricted when the soil was too wet or too dry, but favor microbially-mediated processes of nitrification and denitrification, thereby giving greater N_2O emissions than constant soil moisture in the long term.

ACKNOWLEDGEMENTS

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