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Effects of ageing under field conditions on the stability and protection of particulate organic matter occluded in earthworms casts

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Context

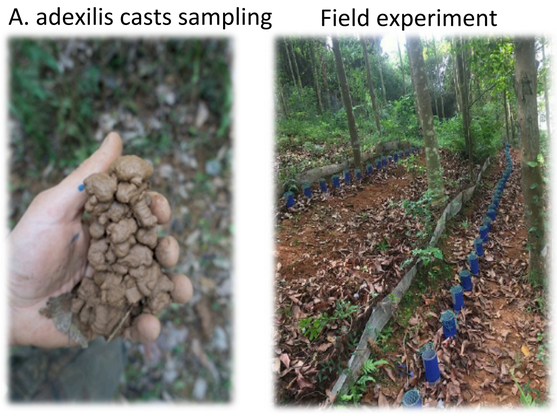
- Soils have a recognized capacity of carbon storage and they play a fundamental role on food production, water quality, biodiversity and climate change mitigation
- Through their feeding and burrowing activities, earthworms promote the inputs of organic matter (OM) to the soil and a pathway for the stabilization of soil organic carbon (SOC) through the formation of organo-mineral aggregates and the physical protection of particulate organic matter (POM) occluded in casts
- The mechanisms and kinetics of OM (physical) de-protection during casts ageing are poorly understood.

➢ We investigated the effects of ageing under field conditions on the OM dynamics contained in anecic earthworms' casts.

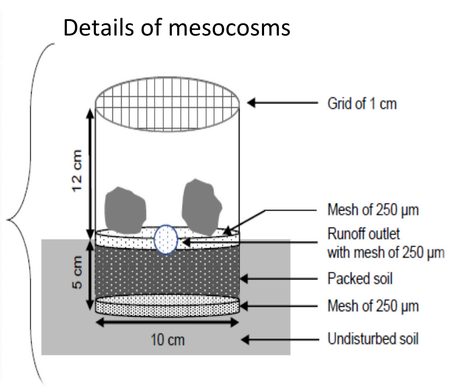
Materials and methods

- Freshly produced *Amynthas adexilis* casts were collected in a forest area (Dong Cao catchment) in Northern Vietnam and incubated under field conditions in mesocosms for 400 days.

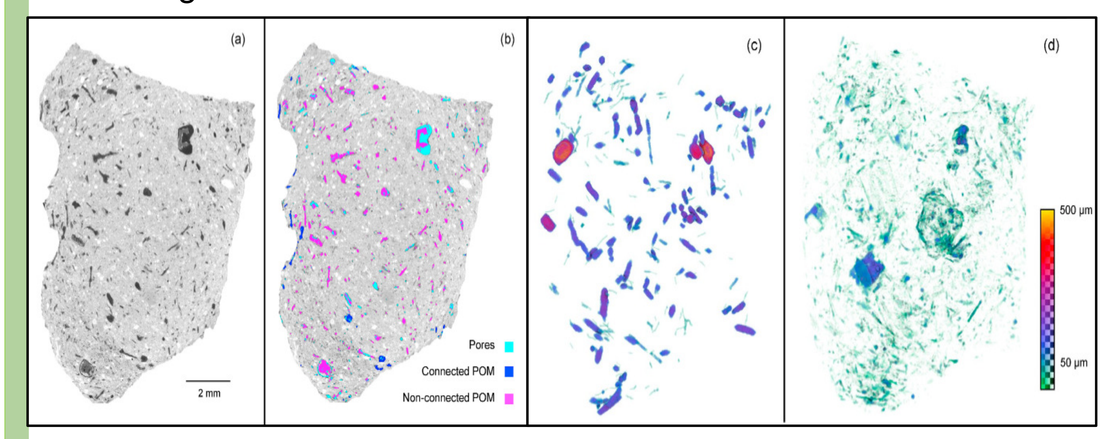
A. adexilis casts sampling | Field experiment



Details of mesocosms



- Fragments of earthworms casts and soil control aggregates were collected after 0, 26, 72, 320 and 400 days of field ageing, air dried and scanned with a micro-CT device.
- Micro tomographic X-ray image stacks were processed and analysed with Avizo and ImageJ softwares.
  - ➢ POM and Pores contents and their micro-scale spatial organisation were characterised



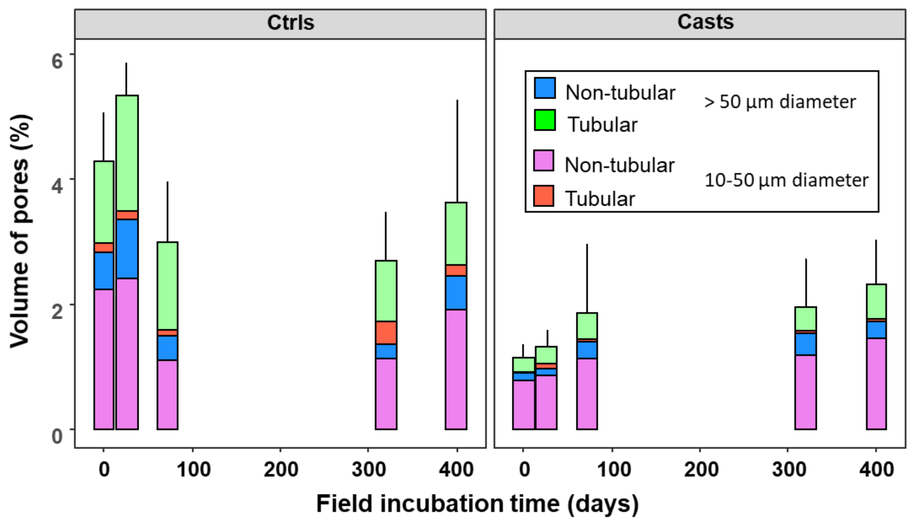
- The same casts fragments were then re-wetted (70% of field capacity) and incubated in laboratory for 80 days with regular measurements of CO_2 mineralisation rates.
- The cumulative CO_2 mineralisation was fitted with the first-order kinetic equation: $Ct = Cp * (1 - e^{-kt})$

Where: Ct is the cumulative C mineralisation after t time, mg/g; Cp is the potential mineralisable C in soil, mg/g; k is the turnover rate constant of C pool, d^{-1}; t is the number of days of incubation.

Conclusion

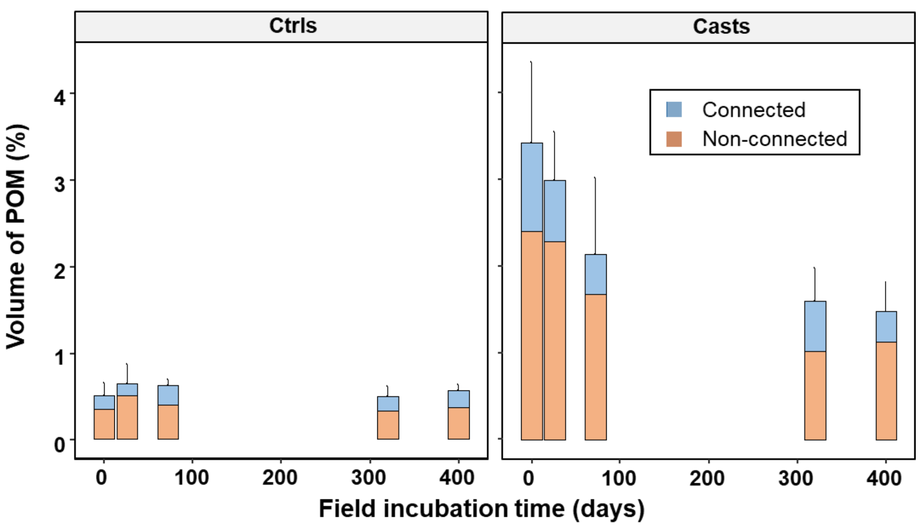
We conclude that earthworms, through their impacts on POM and pore spatial arrangements during their casts production, provide physical protection of SOC and in particular through increasing the contribution of POM unconnected to the outside of the cast, which may have led to prolonged SOC sequestration > 400 days.

Results



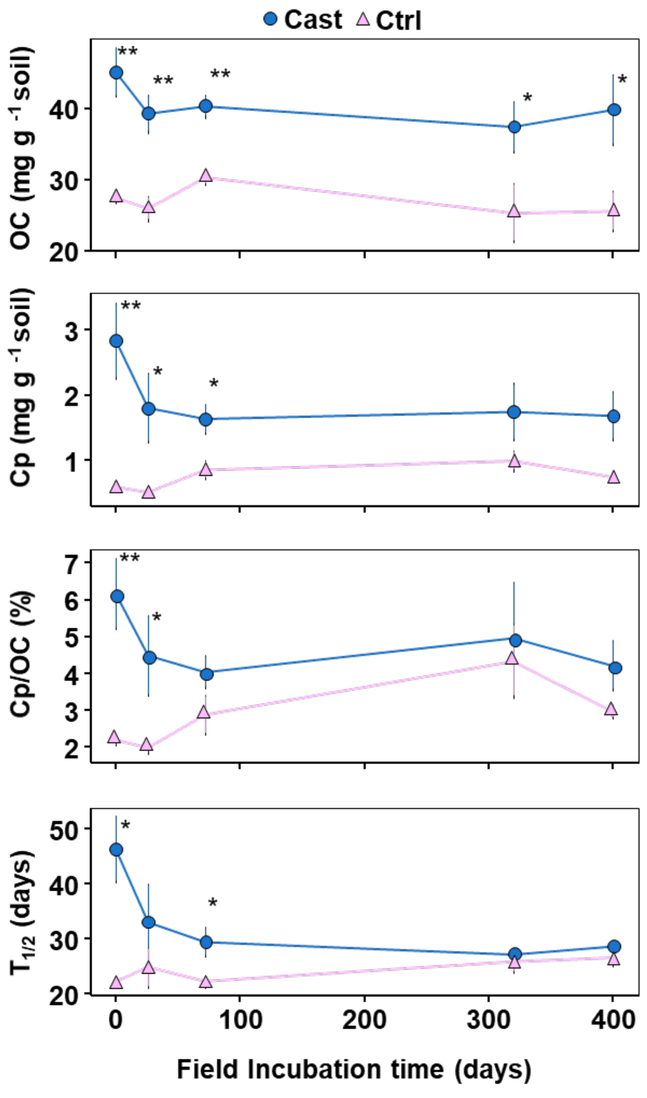
- Higher porosity in Ctrl than in casts
- Casts porosity tended to increase with their ageing
- At the end of the field experiment, casts had similar total porosity than Ctrl

Fig.1:Volume percentage of tubular and non-tubular pores having a diameter ranged between 10 and 50 µm and > 50 µm (histogram) measured on casts and aggregates (ctrl) before (0 d) and after 26, 72, 320 and 400 d of field exposure. Values are displayed as mean (n = 4). Bars show standard errors for total imaged porosity.



- fresh casts contained significantly more POM than Ctrl and field aged earthworm casts.
- At the end of the field experiment, casts still had higher POM content (2.5 fold) than Ctrl.

Fig.2: Volume percentage of connected and unconnected POM to the outside of aggregates measured on casts and aggregates (ctrl) before (0 d) and after 26, 72, 320 and 400 d of field exposure. Values are displayed as mean (n = 4) and bars show standard errors for total volume percentage of POM.



- fresh casts contained significantly more organic carbon (OC) than Ctrl
- higher mineralisation rates for casts than for Ctrl
- Carbon occluded in casts was more labile than SOC of Ctrl as indicated by their higher content of potentially mineralisable SOC (3-fold)
- after 72 days of ageing, the potentially mineralisable OM of casts was similar to those of Ctrl

➢ Physical POM protection became apparent after 72 days of ageing

Fig.3: (a) Soil organic C (SOC) content and parameters obtained from the cumulative C mineralization fitted with the first-order kinetic: (b) the potential mineralisable C (Cp), (c) the potential mineralisable C normalized by SOC content (Cp/SOC) and the half cycle ($T_{1/2}$) measured on cast and aggregates (ctrl) before (0 d) and after 26, 72, 320 and 400 d of field exposure. Values are displayed as mean (n = 4) and bars show standard errors.

Acknowledgements

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