Geophysical Research Abstracts
Vol. 13, EGU2011-7897, 2011
EGU General Assembly 2011

Understanding the fate and linkage of N and S in earthworm engineered peat soil using nanoSIMS

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Earthworms, by changing soil physical properties, are efficient engineers that play a key role on the soil nutrient dynamics but their biological processes at the micrometric scale are still misunderstood. The nano-scale secondary ion mass spectrometry (NanoSIMS) is a new tool in the study of biophysical interfaces in soils with its ability to operate at high mass resolution, while maintaining both excellent signal transmission and high spatial resolution (down 50 nm). Based on this new technology, the aim of this study was to visualize at the micrometric scale the burrow-linings of Lumbricus rubellus L. and to determine the fate and linkage of nitrogen (N) and sulphur (S) deriving from this soil engineer.

Earthworms were triple labelled with isotopic tracers (15N and 34S) prior to introduction into unlabelled peat mesocosms for 24 days. Then, mesocosms were embedded in a polyester resin to carry out the NanoSIMS analysis (NanoSIMS 50^{TM}; Cameca, Gennevilliers, France).
Burrow-linings were analysed with a transect of images increasingly far of the biophysical interface (from poral space to inner of the burrow-lining) and we assessed the linkage of 15N and 34S with the soil micro-architecture by using the linescan technique. Isotopic compositions were determined by using image processing with the ImageJ software (W.S. Rasband, US National Institutes of Health) and thus nutrients transfers from labelled earthworms to soil burrow-linings were detected. We had a visible gradient with a decrease of percentage of 15N and 34S (2.00 to 0.38 % and 10.0 to 4.4 % respectively) and no transfer was detected beyond 1mm, which defined clearly the area of earthworm's influence (i.e. the drilosphere). Interestingly, the occurrence of spatially anti-correlated hotspots of 15N and 34S suggested either i) two kinds of earthworm's excretions (an excretion rich in N and poor in S, and an excretion poor in N and rich in S) or ii) two kinds of microbial activity linked with N or S cycle (15N or 34S microbial uptake). The speciation of these enriched hotspots are currently under analyzes.
By using the NanoSIMS tool coupled with isotopic tracers, we bring out new understandings of the impact of earthworms on the nutrients and thus their ability to sustain hot spots of microbial activity in cutover peat.

Keywords: Lumbricus rubellus L., peatland, triple isotopic labelling, biophysical interface