Responses of methane effluxes and soil methane concentrations to compaction

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CONTEXT AND OBJECTIVES

Forest soils host methanotrophic bacterial communities that make them a major methane sink worldwide. Soil compaction resulting from mechanization of forest operations is first affecting soil macroporosity, and thus gas and water transfer within the soil, leading to a reduced oxygenation of the soil. This reduction of gas diffusion is expected to promote methanogenesis in the deeper soil layer and to reduce the methanotrophic activity in the upper layers, leading thus to less CH_4 oxidation and more CH_4 production, affecting the overall soil CH_4 budget.

Objectives: Does the compaction reduce CH_4 uptake ?

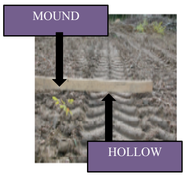
What is the impact of compaction on the seasonal CH_4 variability (net fluxes and consumption/production)?

II SITE DESCRIPTION

- Location: Azerailles Forest (NE of France)
- Precipitation : 950 mm /Mean annual temperature: 8.5°C
- afforested with 1600 sessile oak (*Quercus petraea* L.)/ha in 2007
- soil compacted in 2007 (treatments: control and compacted)
- In compacted treatment : 2 modalities defined by topography: hollow and mound
- soil type : luvisol
- soil texture : 50 cm of silty loam overlying a heavy clay

- bulk density (ρb) increase with depth (Fig.1).

ρb control < ρb compacted & ρb hollow > ρb mound in the upper layer



compaction of the soil in 2007 and due to the last passage of the truck, topographical variations (could reach 15-cm) leading to 2 modalities

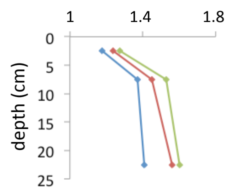


Fig.1: bulk density of the upper layers of the soil in the control (blue), hollow (red) and mound (green) modalities

III MATERIALS AND METHOD

➢ SOIL GAS CONCENTRATIONS

- Gas-permeable tubes (Accurel PPV8/2) inserted horizontally at 0, 5, 10, 25 and 40 cm below the soil surface during early summer 2013.
- Air was collected sequentially with solenoid-valves and pumped to CH_4 analyzer (FGGA, LGR).
- 3-hour frequency measurement/depth/treatment

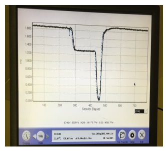
➢ SOIL FLUX

- 12 closed home-made-chambers (4 per treatment)
- opening/closing of chamber controlled by pneumatic cylinders.
- Frequency of measurement: 3h
- Air collected was analyzed with CH_4 analyzer (FFGA, LGR).

➢ SOIL TEMPERATURE AND WATER CONTENT

Temperature and soil water content devices (CS650 Campbell Sci.).
2 devices/treatment at following depths -10, -25 and -40 cm

soil efflux chamber



FGGA analyser

IV RESULTS

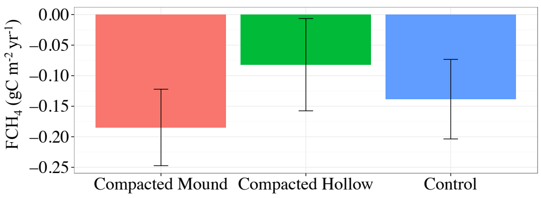


Fig.2: Cumulative CH_4 effluxes measured during one year *from nov 2014 to nov 2015* for the 3 treatments. Cumuls are the mean of 4 chambers

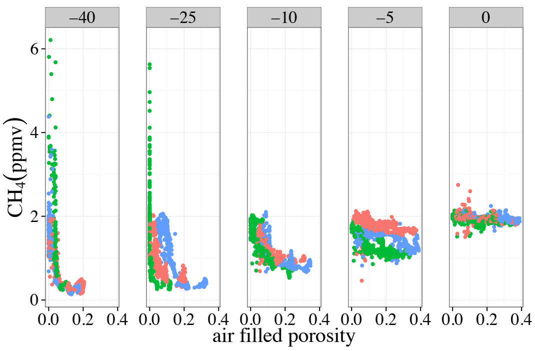


Fig.5: Relation between CH_4 concentrations and air filled porosity at each depth for the different treatments based on daily means.. *Each depth is represented by a rectangle from the deeper in the left to the shallower in the right (depth are in cm).*

No significant difference in CH_4 uptake by the soil between treatments (Fig 2) but strong seasonal variations linked to variations in air filled porosity (fig 3&4)

When air filled porosity is high (low SWC), higher CH_4 uptake by the soil (Fig4)

✓ CH_4 uptake is slightly higher in the compacted hollow when the air filled porosity is high

➢ higher consumption of CH_4 in the compacted hollow => higher microbial biomass and/or lower limitation by water availability compared to the others treatments increases the methanotrophic activity in compacted hollow

When air filled porosity is low (high SWC), CH_4 uptake by the soil is low (Fig.4) linked

✓ to limitation of CH_4 diffusion

✓ and to production of CH_4 in deeper layers (Fig.5). This CH_4 is preferentially oxidised in upper layers as soils become only occasionally CH_4 source (Fig 3 & 5)

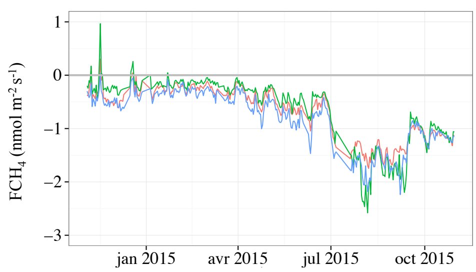


Fig.3: Time courses of daily averaged CH_4 effluxes *from nov 2014 to nov 2015 for the 3 treatments*

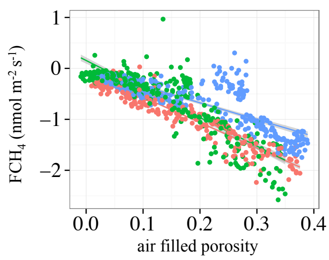


Fig.4: Correlations between CH_4 effluxes and *air filled porosity measured at -5cm depth. Each point represents daily means of 4 chambers for FCH_4*

V CONCLUSIONS

Compaction does not reduce **significantly** the yearly CH_4 uptake

But compaction increases the seasonal variations in the compacted hollow (increase uptake in summer / increase the production in depth in winter and reduce CH_4 uptake)

Future works: development of a flux-gradient approach model (AGU presentation n° B54A_03 by Delogu, Friday afternoon for the method) and $^{13}CH_4$ labelling in the field (i) to separate transport and biological production/consumption and (ii) to determine where the consumption takes place in the soil