Using ^{13}C-labeling to study the effect of litter addition on the palsa peat

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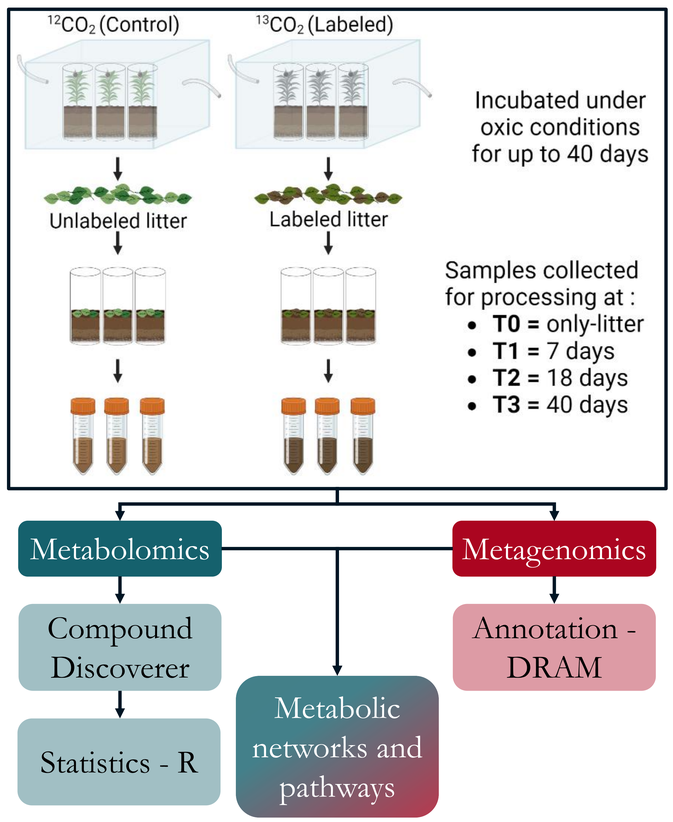
INTRODUCTION

- Permafrost peatlands store significant amounts of global soil carbon which can be released to the atmosphere as GHG with increasing temperatures [1].
- The Stordalen Mire is a heavily studied ecosystem that consists of three main "habitats" along a thaw gradient: frozen hummocks or palsas, semi-thawed *Sphagnum* dominated areas or bogs, and fully thawed sedge dominated areas or fens, each with unique hydrology, vegetation and microbial communities [2].
- The specific vegetation within each habitat will dictate the quantity and quality of litter inputs, which in return will have a strong impact on the peat metabolome and microbial composition [3, 4].
- Decomposition of plant litter is a crucial process in maintaining the carbon balance in peatland ecosystems [5].
- Stable isotope assisted metabolomics (SIAM) uses stable isotopes to help in the tracking, identification and quantification of litter degradation pathways [6].

METHODOLOGY



RESULTS

- A total of 249 features were detected in the water extracted fraction (WEOM), of which 60% were ^{13}C-labeled.

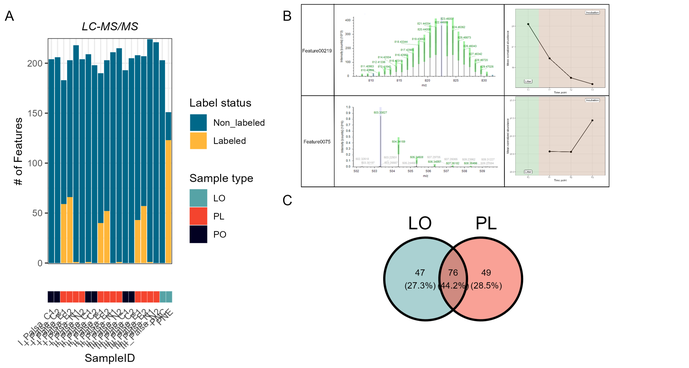


Figure 1. (A) Number of detected features in the experiment. (B) Labelling patterns of features detected in the litter-only (LO) samples and in the amended (PL) samples. (C) Venn Diagram showing the number of labeled features shared between LO and PL samples.

- Litter addition seems to have an immediate effect on the C cycling in the palsa peat, producing shifts in the metabolome composition (up until T1), while litter is possible being decomposed.
- However, the system is adapted to use the litter as such as time progresses (T2 and T3), the metabolome profile of the amended samples (PL) will change to reflect that of the unamended peat (PO). This shows that currently there is an equilibrium between the litter inputs and the carbon storage in the palsa peat.

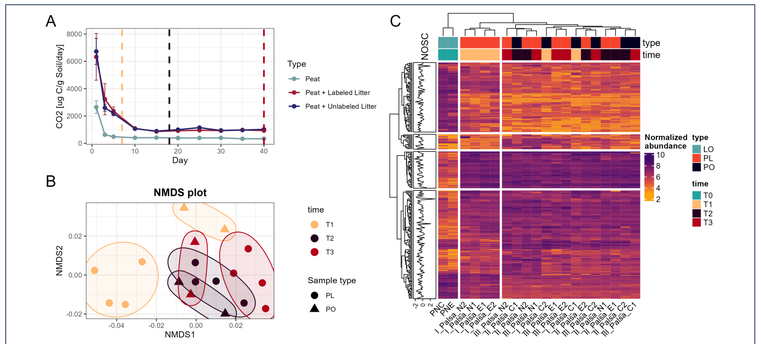


Figure 2. (A) CO_2 production rates. CO_2 production increases immediately after litter addition but reaches almost the level of unamended samples by T2; B) NMDS ordination of the samples based on their metabolome abundance (LC-MS). Similar to CO_2 production patterns, amended (PL) and peat only (PO) samples cluster separately only at T1. Litter only (LO) samples were removed to highlight the differences in the other sample types; (C) Heatmap of the normalized abundance of the detected metabolites (LC-MS) in all samples. "N, E, C" stand for unlabeled litter addition, labeled litter addition and no addition, respectively.

RESULTS

- Metabolites driving the differences between sample types tend to accumulate in the amended (litter addition)samples with time. These include lignin- and lipid-like metabolites which may be of microbial origin [4], or recalcitrant plant compounds [7].

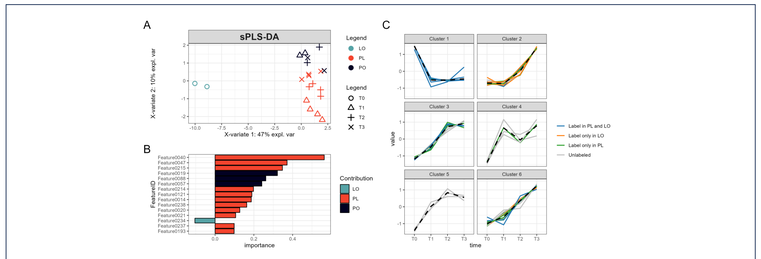


Figure 3. (A) Sample clustering using a sPLS-DA approach. Litter only (LO) samples are completely different that the amenden (PL) and peat only (PO) samples. (B) Top 15 features driving the differences between the different sample types. (C) Dynamic time warping clustering of differentially abundant metabolites (LC-MS) showing which are increasing (accumulating) or decreasing (consumed) during the experiment. Dotted line represent the centroids.

- Integrating metabolomics and metagenomics, allowed to infer potential metabolic routes for the degradation of litter (i.e., degradation of flavonoids or aromatic compounds), and the assimilation the released compounds (i.e., biosynthesis or amino acids).

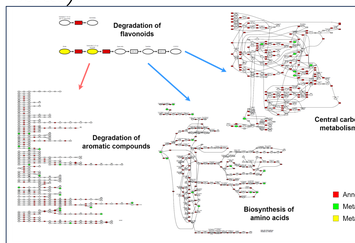


Figure 4. Potential degradation pathways of litter metabolites based on the genes annotated from the metagenomes. Arrows indicate potential degradation (red) or assimilation (blue) pathways.

- Next step is to build metabolic networks to identify the intermediate steps used by the microbial communities for litter degradation, as well as the SIP data to identify key microbial groups related to this process.

SUMMARY

- Litter decomposition seems to initially occur via the degradation of flavonoids and later via the degradation of aromatic compounds.
- Litter inputs produce an initial activity burst, but then the peat returns to its "basal" state (no evidence of priming).

ACKNOWLEDGEMENTS

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