Geophysical Research Abstracts
Vol. 18, EGU2016-14152-1, 2016
EGU General Assembly 2016
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Tracing nitrogen accumulation in decaying wood and examining its impact on wood decomposition rate

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Decomposition of dead wood, which is controlled primarily by fungi is important for ecosystem carbon cycle and has potentially a significant role in nitrogen fixation via diazotrophs. Nitrogen content has been found to increase with advancing wood decay in several studies; however, the importance of this increase to decay rate and the sources of external nitrogen remain unclear. Improved knowledge of the temporal dynamics of wood decomposition rate and nitrogen accumulation in wood as well as the drivers of the two processes would be important for carbon and nitrogen models dealing with ecosystem responses to climate change. To tackle these questions we applied several analytical methods on Norway spruce logs from Lapinjärvi, Finland.

We incubated wood samples (density classes from I to V, n=49) in different temperatures (from 8.5oC to 41oC, n=7). After a common seven day pre-incubation period at 14.5oC, the bottles were incubated six days in their designated temperature prior to CO_2 flux measurements with GC to determine the decomposition rate. N2 fixation was measured with acetylene reduction assay after further 48 hour incubation. In addition, fungal DNA, (MiSeq Illumina) δ15N and N% composition of wood for samples incubated at 14.5oC were determined. Radiocarbon method was applied to obtain age distribution for the density classes.

The asymbiotic N2 fixation rate was clearly dependent on the stage of wood decay and increased from stage I to stage IV but was substantially reduced in stage V. CO_2 production was highest in the intermediate decay stage (classes II-IV). Both N2 fixation and CO_2 production were highly temperature sensitive having optima in temperature 25oC and 31oC, respectively. We calculated the variation of annual levels of respiration and N2 fixation per hectare for the study site, and used the latter data together with the 14C results to determine the amount of N2 accumulated in wood in time. The proportion of total nitrogen in wood originating from N2 increased from 0.4% (class I) to 22% (V). Despite significant N inputs, N2 fixation explained only 34%-57% of the increase in wood N content of classes III-V. The DNA results indicated that mycorrhizal colonization of wood could only partially explain the remaining increase in N content. However, majority of the samples contained one or more wood decomposing fungal species that have been reported to have the capability to produce rhizomorphs or mycelial cords used for scavenging nutrients from outside sources. Assuming that the remaining increase in N content was due to fungal activity, we modelled the δ15N variation of wood from class I to V and compared the modelled and measured δ15N values ($r = 0.95$, $p<0.05$). The increase in wood nitrogen content in time was observed to have a significant, positive impact on the respiration rate (I-IV: $r = 0.57$, $p<0.01$).