Geophysical Research Abstracts
Vol. 18, EGU2016-13232, 2016
EGU General Assembly 2016

Ground-fire effects on the composition of dissolved and total organic matter in forest floor and soil solutions from Scots pine forests in Germany: new insights from solid state 13C NMR analysis

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Fires represent an ecosystem disturbance and are recognized to seriously pertubate the nutrient budgets of forested ecosystems. While the effects of fires on chemical, biological, and physical soil properties have been intensively studied, especially in Mediterranean areas and North America, few investigations examined the effects of fire-induced alterations in the water-bound fluxes and the chemical composition of dissolved and particulate organic carbon and nitrogen (DOC, POC, DN, PN). The exclusion of the particulate organic matter fraction (0.45 μm < POM < 500 μm) potentially results in misleading inferences and budgeting gaps when studying the effects of fires on nutrient and energy fluxes. To our best knowledge, this is the first known study to present fire-induced changes on the composition of dissolved and total organic matter (DOM, TOM) in forest floor (FF) and soil solutions (A, B horizon) from Scots pine forests in Germany.

In relation to control sites, we test the effects of low-severity fires on: (1) the composition of DOM and TOM in forest floor and soil solutions; and (2) the translocated amount of particulate in relation to DOC and DN into the subsoil. The project aims to uncover the mechanisms of water-bound organic matter transport along an ecosystem profile and its compositional changes following a fire disturbance.

Forest floor and soil solutions were fortnightly sampled from March to December 2014 on fire-manipulated and control plots in a Scots pine forest in Central Germany. Shortly after the experimental duff fire in April 2014 pooled solutions samples were taken for solid-state 13C NMR spectroscopy to characterize DOM (filtered solution < 0.8μm pore size) and TOM in unfiltered solutions.

Independent from fire manipulation, the composition of TOM was generally less aromatic (aromaticity index [%] according to Hatcher et al., 1981) with values between 18 (FF) – 25% (B horizon) than the DOM fraction with 23 (FF) – 27% (B horizon). For DOM in FF solution, fire manipulation caused an increase in aromaticity from 23 to 27% compared to the control, due to an increase of the aryl-C and a decrease of the O-alkyl-C and alkyl-C signal. Fire effects were leveled out in the mineral soil. For TOM, fire effects became notable only in the A horizon, exhibiting a decrease in aromaticity from 22 to 18% compared to the control, due to increased O-alkyl-C and diminished aryl-C proportions.

Compared to the control, fire only caused minor DOC release rates (< 10%) in the FF and mineral soil, while DN in the FF was significantly mobilized (+ 40%) by fire exhibiting annual values of 33 at the control sites compared to 46 kg DN ha-1 at the fire treated sites. Compared to the control, fire events did not significantly enhance the proportion of POC and PN in the total C and N amounts exhibiting values between 10 and 20%. To fully understand the quality and amount of translocated organic C and N compounds within soils under both ambient as well as fire environments, dissolved and particulate size fractions need to be considered.