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One year monitoring of fire-induced effects on dissolved organic matter and nutrient dynamics under different land-use

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It is supposed that the changing climate will promote extreme weather events that in turn will increase drought periods and the abundance of fire events in temperate climate regions such as Central Europe. The impact of fires on the nutrient budgets of ecosystems is highly diverse and seems to depend on the ecosystem type. For example, little is known about fire effects on water-bound organic matter (OM) and nutrient fluxes in temperate managed forest ecosystems. Fires can strongly alter the distribution (forest floor vs. mineral soil), binding forms (organic vs. inorganic) and availability (solubility by water) of OM and associated nutrients.

To elucidate the effects and seasonality of low intensity fires on the mobilization of dissolved organic carbon and nutrients, an experimental ground fire was conducted in November 2014 in the Hainich region, Central Germany. In addition, differences in response patterns between two land-use types (pasture and beech forest) were investigated. Lysimeters (n=5 controls/ 5 fire-manipulated) with topsoil monoliths (0-4 cm), rainfall/throughfall samplers, littertraps as well as temperature and moisture sensors were installed on three sites of each land-use type. During the one year of monitoring (Sep14-Dec15) soil solution, rainfall, and throughfall samples were taken biweekly and analyzed for pH, dissolved and particulate organic carbon (DOC, POC) and nitrogen (DN, PN) as well as for nutrients (e.g. K, Ca, Mg, P, S).

Compared to the control sites, the ground fire immediately induced a short-run release peak of DOC in both land-use types. Within two weeks these differences were muted in the post-fire period. The effect of fire was land-use specific with annual DOC fluxes of 82 and 45 kg/(ha*a) for forest and pasture sites, respectively. In contrast, nitrogen fluxes responded differently to the fire event. In the forest, a significant increase in DN concentrations was notable five months after the fire, at the beginning of the vegetation period and lasted until November with DN concentrations in June being 4 times higher compared to the control (82 vs. 18 mg DN/L) and being negatively correlated with pH-values ($r=-0.51$ $p<0.001$). Annual DN fluxes from fire manipulated forest plots were two times higher compared to control ones (62 vs. 29 kg DN/(ha*a)) whereas only low impact was found at the pasture with 45 and 38 kg DN/(ha*a) for fire-manipulated plots and control, respectively.

In general, the results exhibit highly differing response patterns of elements to fire between the two land-use types and with season. Starting in spring higher DN fluxes following fire event at the forest site could be associated with accelerated activity of soil microbes mineralizing released organic substances from burned forest floor and/or from dead roots. This mineralization process resulted in a significant increase in acidity of the soil solution that may affect important ecosystem functions like nutrient cycling and primary production. Hence, high resolution monitoring following a low intensive fire indicated nutrient losses from the forest ecosystem that could be a hazard for managed forests on nutrient poor soils if fire frequency increases with climate change.