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Parallel 2d: Long-term Ecological Research

Increasing dissolved organic carbon (DOC) and nitrogen (DON) levels in temperate forests under acidification recovery in Flanders, Belgium

Introduction and methods

DOC and DON play an important role in terrestrial C and N cycles and in the transport of nutrients and C to aquatic environments.

DOC levels are predominantly increasing in surface waters and temperate forest soils under recovery from acidification, but little information is currently available about the direction of DON trends.

We studied five ICP Forests Level II plots in Flanders, Belgium under recovery from acidification following a decline in acidifying depositions (Table 1, Fig. 1 and 2). We monitored the concentrations and fluxes of DOC (2002–2013) and DON (2005–2013) in the atmospheric deposition and soil solution (Fig. 3) and evaluated trends of DOC, DON and DOC:DON.

Table 1 Characteristics of the five ICP Forests intensive monitoring (Level II) plots in Flanders, Belgium.

Plot	Coordinates N	Coordinates E	Elevation m	MAT °C	MAP mm	Tree species	Planting year	Former use	Humus type
Coniferous forests									
RAV	51°24'07"	05°03'15"	35	10.4	887	*Pinus nigra* ssp. *laricio* var. *Corsicana* Loud.	1930	heath	mor
BRA	51°18'28"	04°31'11"	14	10.8	882	*Pinus sylvestris* L.	1929	heath	mor
Deciduous forests									
WIJ	51°04'11"	03°02'14"	31	11.0	867	*Fagus sylvatica* L.	1935	arable	mor
GON	50°58'31"	03°48'15"	26	10.6	786	*Quercus robur* L., *Fagus sylvatica* L..	1918	old growth	moder
HOE	50°44'45"	04°24'47"	129	10.7	854	*Fagus sylvatica* L.	1909	old growth	moder

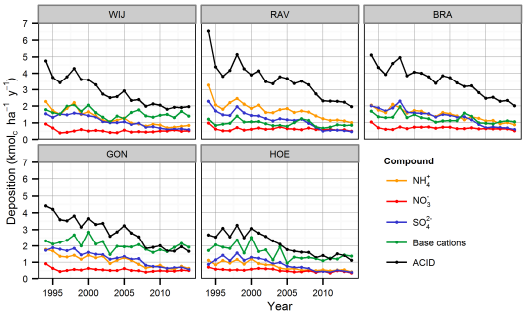

Fig. 1 Annual deposition (throughfall + stemflow) (kmol$_c$ ha^{-1} y^{-1}) of NH_4^+, NO_3^-, SO_4^{2-}, base cations (Ca^{2+} + K^+ + Mg^{2+}) and ACID (SO_4^{2-} + NH_4^+ + NO_3^-) (1994–2014).

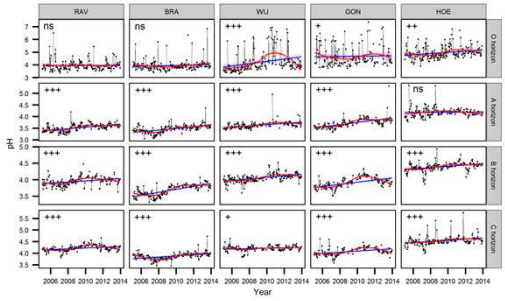

Fig. 2 Soil solution pH (2005–2013) and significance of Seasonal Mann-Kendall trends (ns: not significant, (+): p < 0.1, +: p < 0.05, ++: p < 0.01, +++: p < 0.001), with trend lines (blue: linear regression line, red: LOESS curve).

Fig. 3 Top: schematic bulk collector (left), precipitation collectors (middle), throughfall collector (right).
Figa. 3 Bottom: stemflow collector (left), zero-tension lysimeter in the forest floor (middle), suction cup lysimeters in the mineral soil (right).

Results

- DOC and DON concentrations increased under recovery from acidification (Fig. 4)
- Similar results were found for DOC and DON fluxes (not shown)
- Throughfall DOC and DON concentrations showed a positive correlation with air temperature (Fig. 5)
- Soil solution DOC:DON peaked after drying and rewetting in 2007 (Fig. 4)

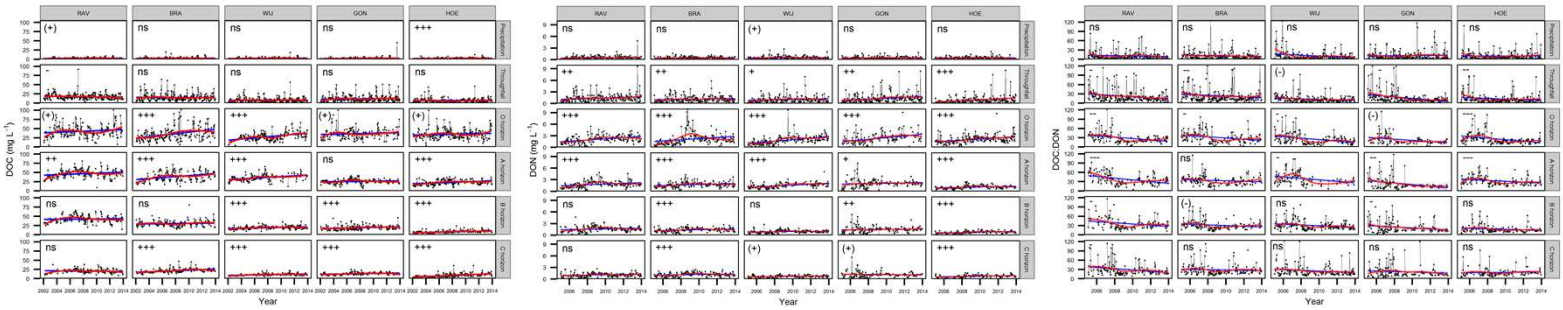

Fig. 4 Fortnightly DOC and DON concentrations (mg L^{-1}) and DOC:DON ratios in precipitation, throughfall (including stemflow) and soil solution, with significance of Seasonal Mann-Kendall trends (ns: not significant, (+/–): p < 0.1, +/–: p < 0.05, ++/––: p < 0.01, +++/–––: p < 0.001) and trend lines (blue: linear regression line, red: LOESS curve).

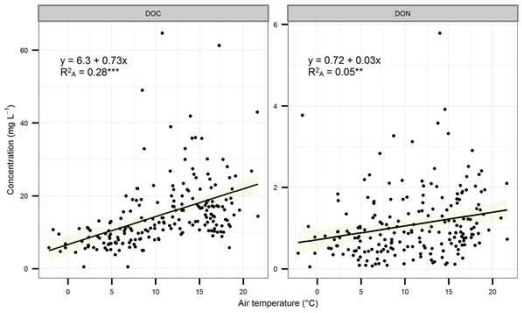

Fig. 5 Throughfall DOC and DON concentrations in function of air temperature at the BRA site (2005–2013).

Conclusions

- Concentrations and fluxes of DON and DOC will likely increase under acidification recovery, but the changing environmental conditions could alter dissolved organic matter composition.
- Increasing DOC and DON leaching from forest soils may impact aquatic environments and could result in higher atmospheric CO_2 levels
- Given the considerable variation in site characteristics included in this study, the observed trends and patterns of DON and DOC:DON should be further validated on a wider spatial scale, using aggregated long-term data from international networks like ICP Forests.