GENERAL INFORMATION

author(s)	Staelens J
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MATERIALS & METHODS

study area	5n (scientific zone, measuring tower)
time period	2002–2004
goal	quantification of the spatio-temporal variation of the water and ion fluxes to the forest floor in a broadleaved deciduous forest - quantification of the water and ion input (precipitation) above the canopy - quantification of the small-scale spatial heterogeneity of the water and ion fluxes below the deciduous canopy within a year and between the years - find a relationship between the variability in water and ion fluxes and the canopy structure and phenology
set-up	- water amount and chemical composition of water input above the canopy: 2 adjacent sites - water amount beneath the canopy: plot level and within-plot level o throughfall, stemflow, interception o temporal changes & spatial patterns - chemical composition of below-canopy water: plot level and within-plot level o throughfall & stemflow o seasonal changes & spatial patterns
data collection	see papers below
remarks	C2: water amount & chemical composition precipitation (Staelens_etal_2005_AtmEnv) C3: water amount throughfall+stemflow (Staelens_etal_2008_HydrolProc) C4: water amount throughfall, spatial patterns (Staelens_etal_2006_JoHydrol) C5: chemical composition throughfall+stemflow, seasonal (Staelens_etal_2007_CJFR) C6: chemical composition throughfall, spatial patterns (Staelens_etal_2006_EnvPoll) C7: chemical composition, modelling (Staelens_etal_2008_WaterAirSoilPoll)

RESULTS

<u>Bulk & wet-only precipitation</u>

The amount of rainfall at the two sites was similar, and the difference in ion deposition between the two sites was generally less than 5 %. While the amount of rainfall measured was almost the same for both collector types, bulk deposition was significantly ($p < 0.02$) higher than the wet deposition of all ions other than H^+ and NH_4^+. Averaged for both sites, bulk deposition was 129 % (K^+), 84 % (Ca^{2+}), 51 % (Cl^-), 50 % (Mg^{2+}), 46 % (Na^+), 32 % (SO_4^{2-}), 27 % (NO_3^-), 17 % (F^-), and 11 % (NH_4^+) higher than wet-only deposition. The acidity of bulk samples was significantly ($p < 0.06$) lower than the acidity of wet-only samples. Bulk NH_4^+ concentrations were only significantly ($p < 0.002$) higher than wet-only concentrations at one site because of the sensor-related, delayed closing of the wet-only lid at the second site. Although dry deposition significantly contributed to bulk precipitation measurements, bulk deposition exceeded the wet acidifying deposition of NO_3^-, NH_4^+, and SO_4^{2-} by less than 25 %.

Partitioning of rainfall water

At the annual level, throughfall amounted to 71 % of precipitation, stemflow 8 %, and interception 21 %. Rainfall partitioning at the event level depended strongly on the amount of rainfall and differed significantly ($p < 0.001$) between the leafed and the leafless period of the year. Therefore, water fluxes of individual events were described using a multiple regression analysis ($R^2 > 0.85$, $n = 205$) with foliation, rainfall characteristics and meteorological variables as predictor variables. For a given amount of rainfall, foliation significantly increased interception and decreased throughfall and stemflow amounts. In addition, rainfall duration, maximum rainfall rate, vapour pressure deficit, and wind speed significantly affected rainfall partitioning at the event level. Increasing maximum hourly rainfall rate increased throughfall and decreased stemflow generation, while higher hourly vapour pressure deficit decreased event throughfall and stemflow amounts. Wind speed decreased throughfall in the growing period only. Since foliation and the event rainfall amount largely determined interception loss, the observed net water input under the deciduous canopy was sensitive to the temporal distribution of rainfall.

Spatial variability of throughfall water

The spatial variability of TF was significantly higher during the leafed periods (coefficient of variation (CV) = 18%) than during the leafless periods (CV = 8%), and a strong negative relationship was observed between the CV of event TF and the TF fraction of rainfall in the open field. Geostatistical analysis showed that the cumulative TF water during the leafed periods was spatially correlated up to a distance of 3-4 m. There was a significant temporal stability of spatial TF patterns in the growing periods and in the dormant periods, but patterns differed largely between the two periods of the year. TF water during the growing periods significantly decreased with increasing canopy cover above the sampling locations ($r = -0.54$, $p = 0.014$, $n = 20$), but was more closely correlated with branch cover ($r = -0.77$, $p < 0.001$). However, the spatial pattern of TF during defoliated conditions was not related to the measured variation in branch cover.

Seasonal variation in throughfall and stemflow chemistry

Annual and seasonal ion fluxes to the forest floor were significantly higher than the incoming wet-only deposition for all ions measured other than H+. The annual throughfall to wet deposition ratio generally ranged from 2.1 to 4.8. Stemflow contributed 9-19 % of the ion input to the forest floor, except for H+. Throughfall enrichment of K^+, Ca^{2+}, Mg^{2+}, and NO_3^- was significantly higher in the leafed than in the leafless season, in contrast to Na^+, NH_4^+, and H^+. The temporal pattern of ion enrichment indicated canopy release of K^+, Ca^{2+}, and Mg^{2+} throughout the leafed season, of Na^+, Cl^-, and NH_4^+ from emerging leaves, and of Cl^- and SO_4^{2-} from senescing leaves. The contribution of canopy leaching to annual net throughfall and stemflow was estimated at 96 % (K^+), 54 % (Ca^{2+}) 40 % (Mg^{2+}), 12 % (Cl^-), and 7 % (Na^+, SO_4^{2-}). Dry deposition accounted for 58 -75 % of the total deposition onto the canopy. The throughfall enrichment during the leafless season indicated high particulate and gaseous dry deposition onto the woody canopy as well as K^+ release from European beech branches.

Spatial variability of throughfall chemistry

While the spatial variability of TF water amount and H+ deposition was significantly higher in the leafed period than in the leafless period, the spatial TF deposition patterns of most major ions were similar in both periods. The semi-annual TF depositions of all ions other than H+ were significantly positively correlated ($r = 0.68–0.90$, $p < 0.05$) with canopy structure above sample locations throughout the entire year. The amounts of TF water and H+ deposition during the leafed period were negatively correlated with branch cover. We conclude that the spatial heterogeneity of ion deposition under beech was significantly affected by leaves in the growing period and by branches in non-foliated conditions.

<u>Total atmospheric deposition</u>

For both forest plots, a semi-annual time step in the model gave similar results as an annual time step. Na+ was found to be more suitable as a tracer ion in the filtering approach than Cl^- or SO_4^{2-} . Using bulk instead of wet-only precipitation underestimated the potentially acidifying deposition. To compute canopy uptake of NH_4^+ and H^+, ion exchange with K^+, Ca^{2+}, and Mg^{2+} as well as simultaneous cation and anion leaching should be considered. Different equations to allocate NH_4^+ vs H^+ uptake had most effect on the estimated fluxes of the cation that was less important at a plot. More research is needed on the relative uptake efficiency of H^+, NH_4^+ and NO_3^- for varying tree species and environmental conditions.