Nutrient Leaching from Soils affected by Windfall in the High Tatra

Wolf-Anno Bischoff[1], Stephan Mayer[1], Marion Schrumpf[2] and Annette Freibauer[2]

[1]: TerrAquat Consultancy for Soil, Water, Nutrients, Contaminants
Steckfeldstr. 36, D-70599 Stuttgart, Germany
w.bischoff@terraquat.com

[2]: Max-Planck-Institute for Biogeochemistry
P.O. Box 10 01 64, D-07701 Jena, Germany
afreib@bgc-jena.mpg.de

Introduction

In 2004 a storm event with wind speed up to 170 km/h destroyed about 12 000 ha forest in the High Tatra National Park (TANAP). During the following months, the dead trees have been removed in most areas, in some small areas not. It was likely that the nutrient cycling will differ widely between extracted, non-extracted and intact sites in the forest. The CarboTatra project started in spring 2005 to investigate changes in nutrient cycle and microclimatic conditions due to the windfall.

Objectives

The objectives of this study were to examine the effects of windfall and consecutive forestry management on nutrient losses and element dynamics in the soil.

Material and Methods

The study was conducted at three different sites in the windfall area at TANAP. At the extracted windfall site (EX, Danielov Dom) the dead wood has been removed shortly after the windfall event. At the non-extracted Site (NEX, Jami) the trees have not been removed. The intact forest site (IF, Tower Site) was chosen as reference site without damage by the windfall event. The aim was to choose three sites with only low heterogeneity within and between the sites (Table 1).

The nutrient leaching was measured with Self-Integrating Accumulators (SIA). These measuring devices are installed under the undisturbed soil. Water percolates through the SIA whereby ions are adsorbed and accumulated within the SIA. The accumulated nutrients can be desorbed and measured after the measurement period to calculate the area specific leaching. We quantified nitrate-N, ammonium-N, Ca, Mg, K, Fe, Al, P, and S.

Table 1: Soil characteristics of the three sites under study.

pH (KCl)	Sand (%)	Silt (%)	Clay (%)	Stone (%)	C_{org} (%)	Soil types
3.0 – 4.5	> 70	20	< 10	EX: > 50 NEX/IF: 5-20	A horizon: 3 – 4	Dystrict Cambisols

At each of the three sites, SIA were installed below the A horizon and in 60 cm depth with 25 replicates for each depth. After the first installation in October 2005, the SIA were changed two times per year (May and October) up to May 2007.

The 25 measurement points of the SIA at the IF and the EX sites were according to the other measurement points of the CarboTatra project of the Max Planck Institute. Climatic parameters were measured in different heights of a tower that was the center of the measurement area. Three long and three short transects with six to seven and two to three measurement points, respectively, were arranged from this point.

The SIA at the NEX site were installed in one north to south transect through the area. The single points chosen reflect different microclimatic conditions.

Results and discussion

The nutrient fluxes below A horizon are mainly controlled by the turnover of organic matter (Fig. 1). The three sites differ mainly in the dynamics of the main nutrition elements N, K, P, and S. The leaching is lowest for the IF site because of the plant uptake. We assume that the decomposition of plant material leads to the higher fluxes for most elements at the NEX site.

The nutrient fluxes in 60 cm depth reflect the leaching from the main root zone. The leaching of all nutrients except P was enlarged due to the windfall event (Fig. 2). Lower nutrient uptake by plants in combination with higher decomposition rates were the reasons. The leaching is higher at the EX site compared to the NEX site for most elements. The bare soil at the EX site leads to more pronounced temperature extremes at EX than at NEX (data not shown). This difference is also reflected in higher mean temperatures and a lower mean humidity (Fig. 3).

The bare soil at the EX site leads to a more extreme climate that is reflected in higher mean temperatures and a lower mean humidity (Fig. 3). The temperature extremes are more pronounced at EX than at NEX (data not shown). This leads to higher mineralization and mineral weathering resulting in higher fluxes.

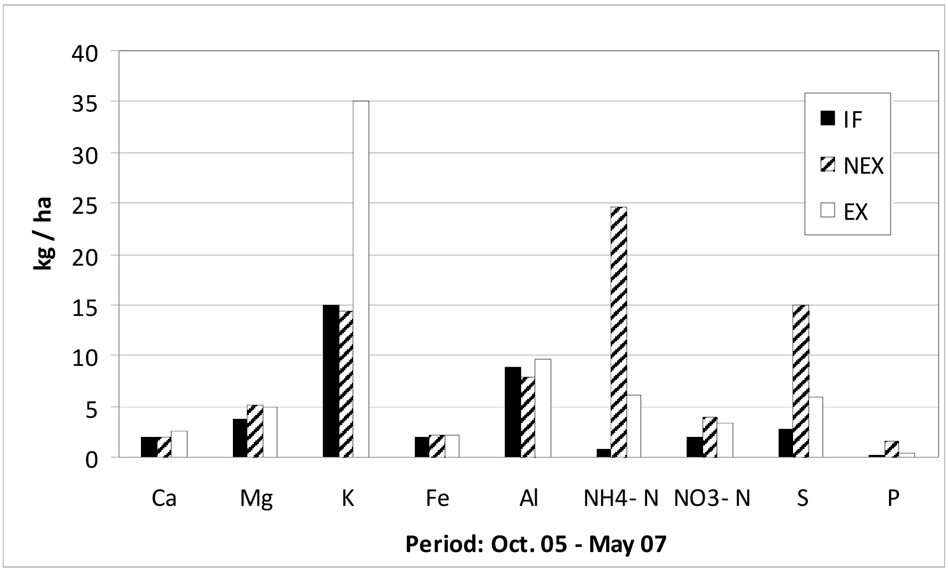

Fig. 1: Nutrient leaching: All means below Ah horizon.

The molar sum of Ca and Mg is comparable to the leached K amount. This is an indicator for the weathering of feldspars.

Al and also Fe are released and leached at all sites. This indicates that the pH values are low enough for activating not only the Al but also the Fe soil buffer.

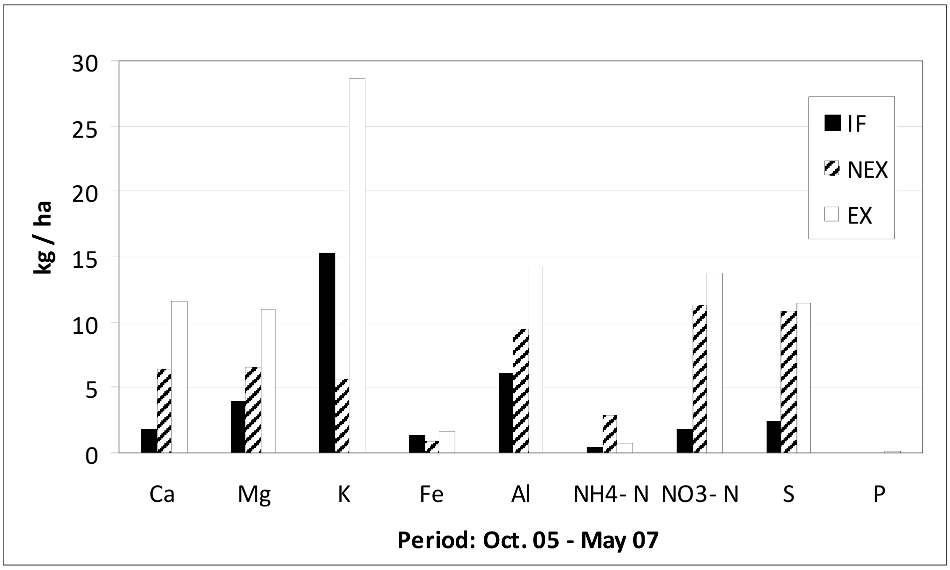

Fig. 2: Nutrient leaching: All means in 60 cm depth.

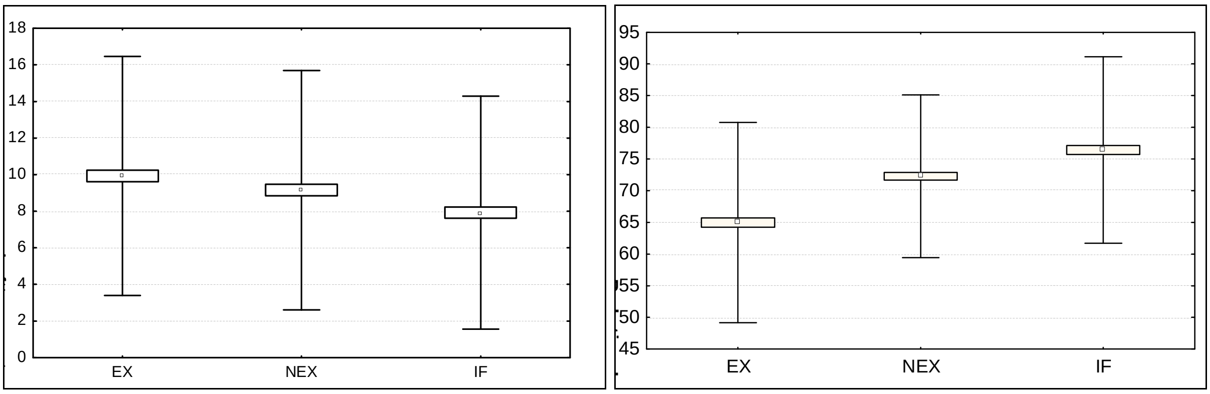

Fig. 3: Air temperature (°C, left) and air humidity (%, right): Mean of selected time periods (mean, standard error and standard deviation).

Ammonium is the dominating N species below A horizon at EX and NEX (Fig. 4). We assume that the low pH value in combination with hot and dry periods slow down nitrification. Between the topsoil and 60 cm depth, a high percentage of the ammonium is transformed into nitrate because of an increasing pH value. Only at NEX an appreciable amount of ammonium is left in 60 cm depth.

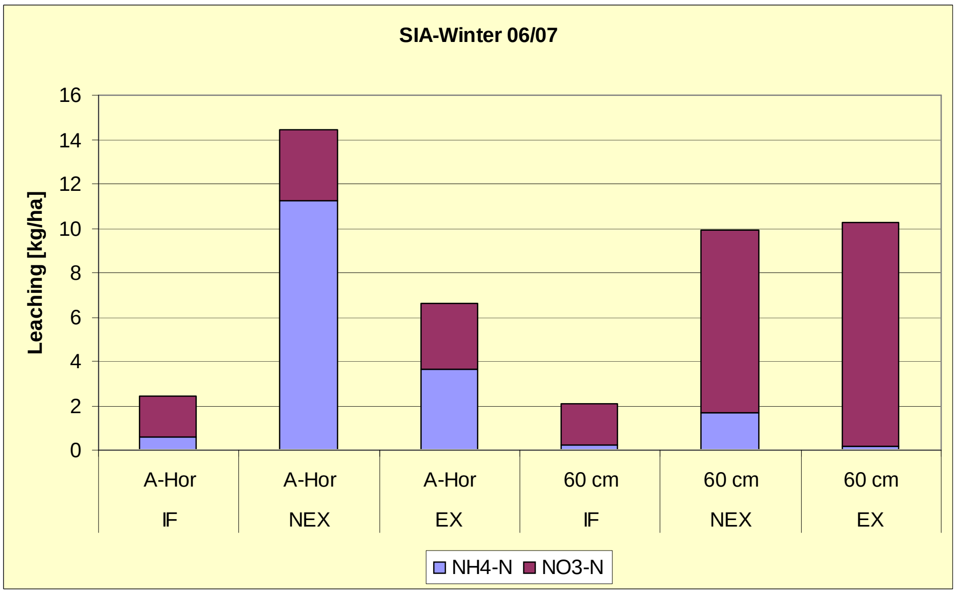

Fig. 4: N dynamics for winter 06/07: Mean of ammonium-N and nitrate-N for all three sites in both depths.

We used the fluxes of the measured elements in 60 cm depth to calculate a charge balance. The cation and anion fluxes increase from IF to NEX and EX because of higher mineralization and weathering (Fig. 5). For IF and NEX about 1000 mol_c/ha of negative charge are not detected with the elements under study, for EX about 2000 mol_c/ha. DOC has predominantly a negative charge and it is not possible to catch DOC with the SIA method. Therefore, we assume that the missing anions are largely DOC. The DOC concentration is expected to be higher at the EX site because of the higher decomposition rates (see above). As we used NaCl for the extraction of the SIA, the leaching of these two elements could not be quantified. The concentrations of Na and Cl are usually neglectable in the soil water of subsoils at continental sites. Hence, we assume that the error by disregarding these elements is low.

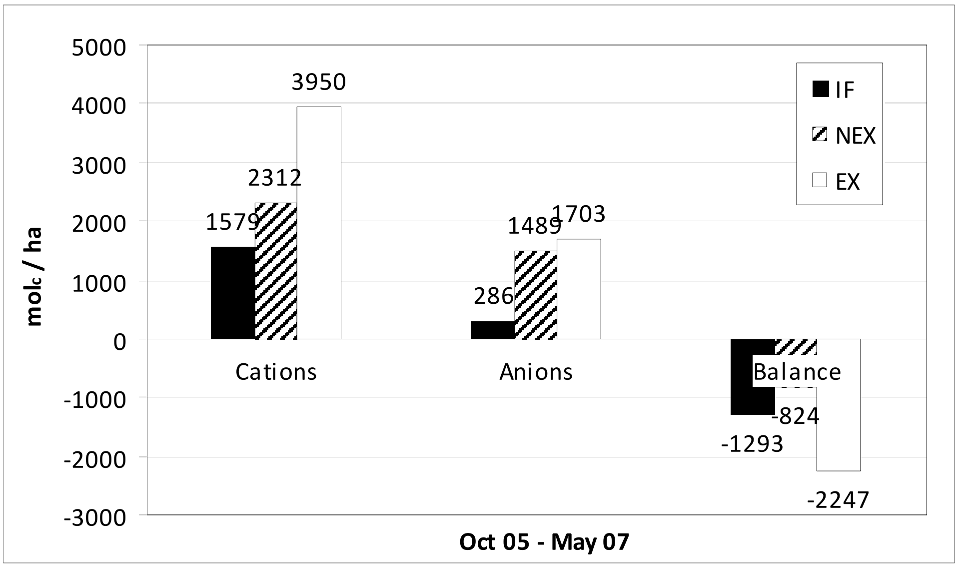

Fig. 5: Charge balance in 60 cm depth.

Conclusions

We measured Ca, Mg, K, Fe, Al, ammonium-N, nitrate-N, S, and P leaching at three sites (IF, EX, NEX) in two depths in forest after a windfall event in the High Tatra. The losses of all nutrients (except P) increased due to windfall in the order EX > NEX >> IF. Al and Fe are released due to buffering reactions at low pH values. The weathering of Feldspars causes that the sum of Ca and Mg is comparable to the released K.

At EX and NEX the N is mainly released as ammonium. Nitrification processes during the transport to 60 cm depth are partly inhibited at NEX.

It is possible to calculate a charge balance with the measured data. The deficit of negative charge can be interpreted as DOC that can not yet be measured with the SIA method.

Acknowledgements

We thank TANAP Tatranska Lomnica for logistical support and all the help, and the Co-workers at MPI and TerrAquat for their support in field and laboratory work.