Extended abstract No. 324

HOW PEATLAND IS AFFECTED BY NEIGHBORING AGRICULTURE – A COMBINED APPROACH TO DETERMINE ATMOSPHERIC NITROGEN DEPOSITION AT A MODERATELY-DRAINED PEAT BOG SITE

Miriam Hurkuck, Johann Heinrich von Thünen-Institute, Bundesallee 50, 38116 Braunschweig, Germany, phone: +49 531 5962685, miriam.hurkuck@vti.bund.de

Christian Brümmer, Johann Heinrich von Thünen-Institute, Braunschweig, Germany

Werner L. Kutsch, Johann Heinrich von Thünen-Institute, Braunschweig, Germany

SUMMARY

In this study, we aim to quantify dry atmospheric nitrogen (N) deposition at a semi-natural peat bog site. First results show ammonia (NH_3) being the site's most important reactive N species on a quantity basis. Ammonia concentrations range from 0.9 to 13.0 µg m^{-3}. Based on these results, we found a total dry N deposition of about 5 kg ha^{-1} during the first eight months of the experiment. Extrapolation of data to one year amounts approximately to 9 kg ha^{-1} yr^{-1}.
Our results suggest that the intensive agricultural practices of surrounding areas most likely leads to increasing N input into the bog and a shift in both vegetation composition and local hydrology is expected.

KEY WORDS: nitrogen deposition, ammonia, raised bog, KAPS denuder

INTRODUCTION

Traditionally, raised bogs are regarded as nutrient-poor ecosystems and are considered to be highly sensitive to increasing nitrogen (N) input. Nitrogen enrichment can have pronounced effects on the vegetation composition with shifts in dominance of plant species. One of the main sources of N in terrestrial ecosystems is atmospheric deposition (Bobbink et al, 2010). The investigated area has been subjected to artificial drainage and followed by peat cutting since the 1950s. Large areas have been converted from natural peat bogs to arable land resulting in an increase in agricultural practices.
As one of the last protected areas in this region, our study site – a moderately drained raised bog – is located in a natural park. It is expected that the surrounding highly fertilized agricultural land and poultry farms have an influence on the N balance in the investigated area with increasing N input into the ecosystem. Critical loads of total N in this region have been estimated as <5 kg ha^{-1} a^{-1} indicating the vulnerability of the system (Nagel et al., 2004).
The aim of our study is to quantify dry atmospheric N deposition into the peat bog area. For this approach, we use a KAPS denuder system to determine concentrations and depositions of various reactive N species.

MATERIALS AND METHODS

Study site

Flux measurements are carried out in the ombrotrophic peat bog 'Bourtanger Moor'. It is partly located in Northwestern Germany and in The Northeastern Netherlands and was one of the largest raised bogs in mid Europe. However, since the beginning of its cultivation in the 17^{th} century about 98 % of peat has been cut (Casparie, 1993). The study site (52° 39' 21.42" N, 7° 11' 1.75", 19 m a.s.l.) – a moderately drained peat bog – is declared as natural park and is one of a few remaining protected areas in this region. The surrounding area, however, is characterised by industrial agriculture including cultivation of rape seed, sugar beet, maize, winter wheat and potatoes as well as and the establishment of poultry farms.
The peat body depth is approximately 4 m and the mean ground water level is around 2.5 m. Natural vegetation comprises *Eriophorum vaginatum, Molinia caerulea, Erica tetralix,* sphagnum moss and single birches.

Dry N deposition measurements, lab and data analysis

A KAPS (Kananaskis Atmospheric Pollutant Sampler; Peake and Legge, 1987) denuder system is used to collect NH_3, its atmospheric reactants and atmospheric products for subsequent chemical analysis.

KAPS denuder consist of a sample air inlet with cyclone, three glass tubes connected in series and a dual filterpack. Ambient air is sucked through the inlet and the cyclone is set up to separate coarse particles. They are removed by a secondary air flow. The mean air flow is about 6 m^{-3} d^{-1}. Two subsequent glass tubes coated with basic solution deposit acidic trace gases (HNO_2, HNO_3 and SO_2) and a third glass tube coated with acidic solution collects NH_3. After separation of reactive gases, fine particles (<2 µm) are collected. For this purpose, sample air passes through a PTFE-filter and a nylon-backup-filter to deposit aerosol NH_4, NO_3 and SO_4.

Altogether eight KAPS denuder are mounted in two heights (1.5 m and 6 m) to measure day- and night-time concentrations integrated over one week periods of the above mentioned trace gases and particles. Determination of concentrations from end of March 2011 to end of August 2011 was performed without diurnal differentiation. Both filters and glass tubes were eluted with 15 ml bidistilled water. Elution of filters was executed in ultrasonic bath (1 h, 40 °C). The solutions were analysed by ion chromatography with cation (NH_4-N, NO_3-N, SO_4-S) and anion column (NH_4-N, NO_2-N, NO_3-N, SO_4-S).

Using the KAPS denuder system within a gradient setup, fluxes of different N species can be calculated. Concentrations of both measurement heights are considered as well as micrometeorological data (e.g. solar radiation, temperature, precipitation, horizontal wind) and plant physiological parameters. Calculation of deposition rates is then executed by the Plant-Atmosphere Interaction Model (PLATIN) (Grünhage and Haenel, 1997).
Beside denuder measurements, total input of airborne reactive nitrogen is determined using a ^{15}N isotope dilution method named 'Integrated Total Nitrogen Input' (ITNI). Different monitor plants labeled with a ^{15}N tracer are exposed to the site's natural conditions within a controlled experiment. At the time of this writing, results of plant, soil and nutrient solution N content are not yet available.

RESULTS

First results from April 2011 to November 2011 show average NH_3 concentrations ranging from 0.9 to 13.0 µg m^{-3}. A first maximum of 8.8 µg m^{-3} could be observed in spring followed by relatively stable concentrations with a mean of 3.7 µg m^{-3} in summer. Autumn NH_3 concentrations reached a second peak of 13.0 µg m^{-3}. By now, winter concentrations tend to be in the same range than those during the rest of the measurement period (Fig. 1).
Day- and night-time concentrations follow a generally similar development with increasing NH_3 concentrations in September 2011 and in October 2011. Although day-time maxima values of NH_3 are slightly higher than those at night they do not significantly differ ($p > 0.05$) (Fig. 2 and 3).

Calculation of deposition rates was performed by the PLATIN Model. Ammonia deposition was is the range from 0.08 to 0.23 kg ha^{-1} $week^{-1}$. According to investigated concentrations of different N species, deposition was found to be highest for NH_3; about 20 % of total measured nitrogen is related to HNO_3, aerosol NH_4 and NO_3. HNO_2 concentrations and deposition rates are negligible compared to the other compounds.

The first months of investigation result in a total dry N deposition of about 5 kg ha^{-1}. Extrapolation of data to one year amounts approximately to 9 kg ha^{-1} yr^{-1}.

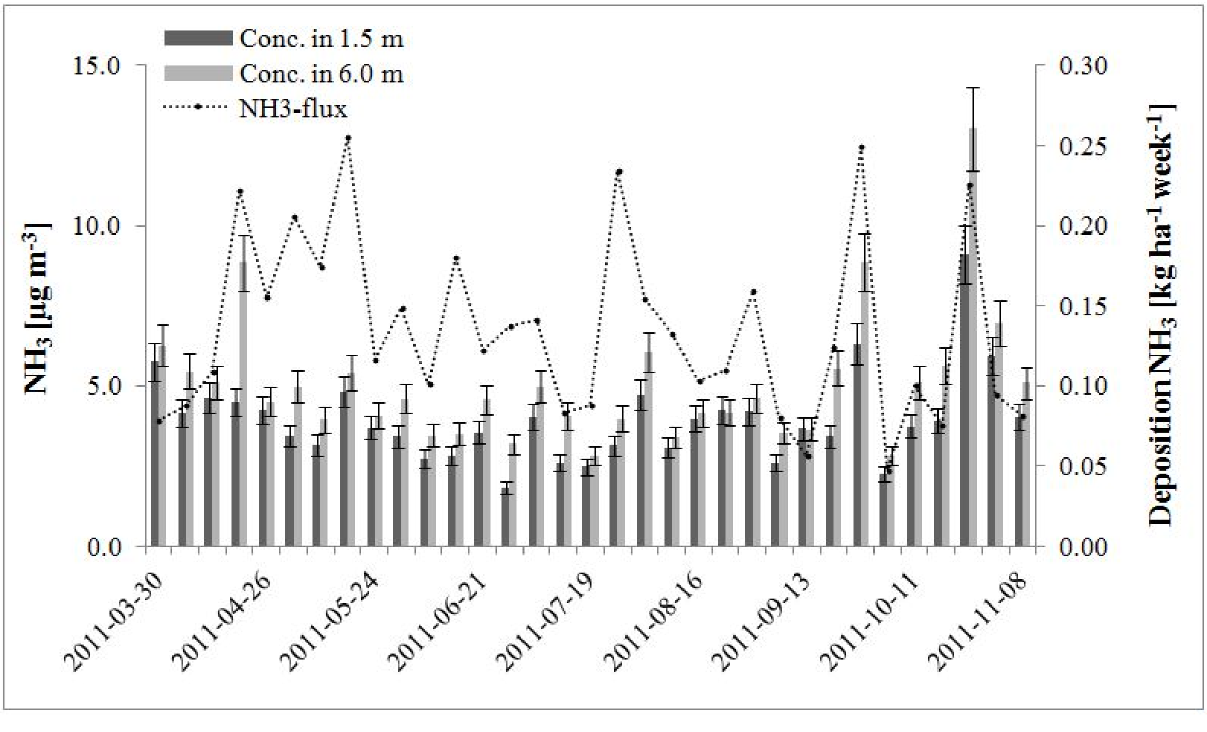

Fig. 1: NH_3 concentrations (± standard deviation) in two measurement heights (1.5 m, 6.0 m) and dry NH_3 gas deposition over time (end of March 2011 to beginning of November 2011).

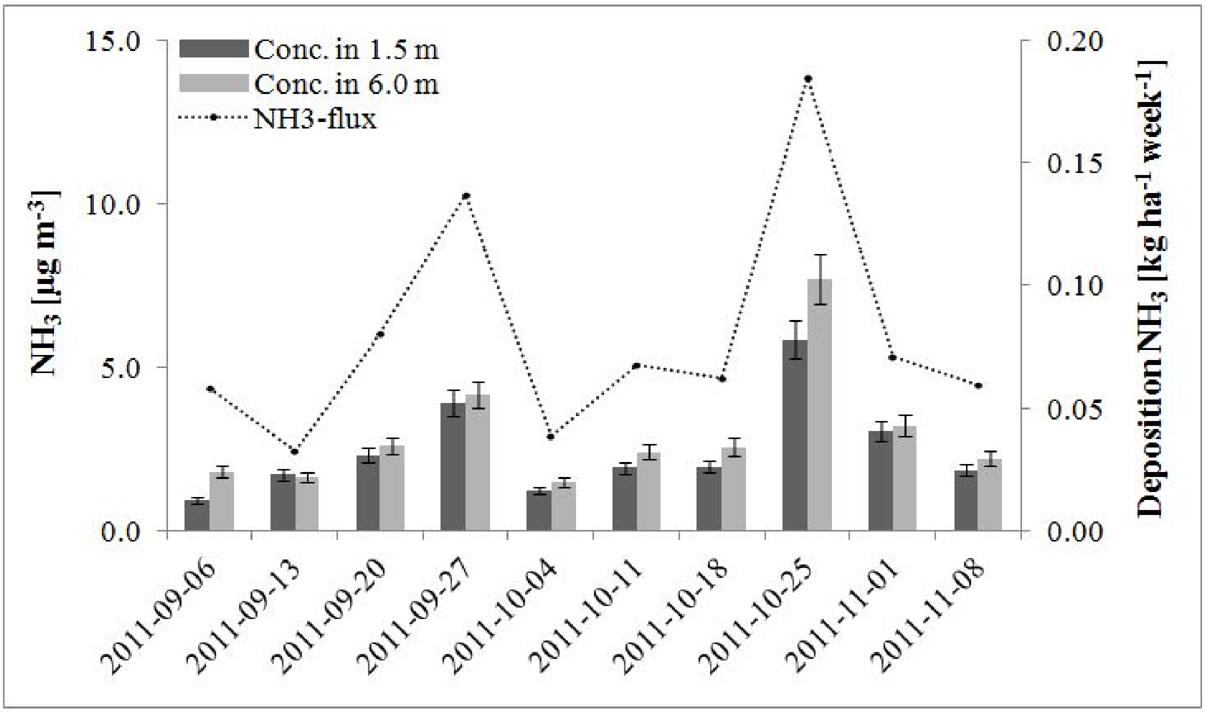

Fig. 2. Day-time NH_3 concentrations (± standard deviation) in two measurement heights (1.5 m, 6.0 m) and dry NH_3 gas deposition over time (beginning of Sept. 2011 to beginning of November 2011).

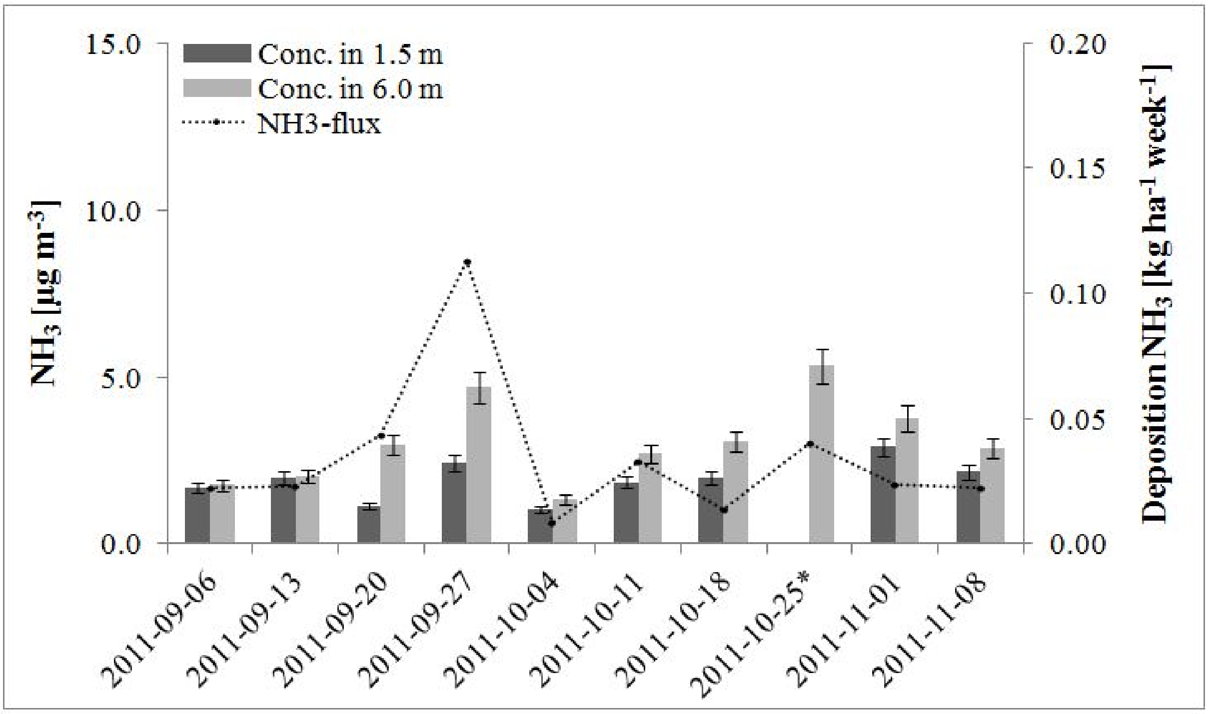

Fig. 3. Night-time NH_3 concentrations (± standard deviation) in two measurement heights (1.5 m, 6.0 m) and dry NH_3 gas deposition over time (beginning of Sept. 2011 to beginning of November 2011) (*=missing data of NH_3 concentration in 1.5 m).

CONCLUSION/DISCUSSION

Atmospheric N deposition into the peat bog was found to be about 5 kg ha^{-1} from April 2011 to November 2011. Quantification of various N species showed that NH_3 is the most important compound deposited and about 20 % of total measured N is related to HNO_3, aerosol NH_4 and NO_3 while HNO_2 deposition is comparatively negligible. Differentiation of day- and night-time concentrations did not show significant differences.

While the mean background level of NH_3 is about 4.5 µg m^{-3}, highest NH_3 concentrations were measured during spring and autumn 2011. This seasonality is in accordance with main manuring periods and gives rise to the assumption that NH_3 emissions from livestock and farming are the main driving factors for N deposition into the peat bog area.

Extrapolation of our data to one year reached an expected dry N deposition of 9 kg ha^{-1} yr^{-1}. Additionally, N input from wet deposition has to be taken into account. Regional wet N deposition is estimated to be in the range from 14 to 21 kg ha^{-1} yr^{-1} (Gauger et al., 2001). Total N deposition thus strongly exceeds the maximum load of 5 kg ha^{-1} yr^{-1} stated by Nagel et al. (2004). Further, it has to be considered that the NH_3 observation in this study area started at the end of March 2011 and the measurement period amounts not yet a complete year. Possible peaks in N input in earlier spring could thus not be detected. It is most likely that manuring of surrounding arable land after wintertime has a pronounced effect on N concentrations and deposition rates in the investigated peat bog. Extrapolation of data to one year might thus be under estimated and the total N deposition might be even higher.
An initial indication of the exceeded critical load of the ecosystem is the occurrence of *Molinia caerulea* and other less typical ombrotrophic peat bog vegetation. It shows that the increased N input might have a severe effect on the N balance and the ecosystem could be subjected to a shift in vegetation composition. Future changes in the dominance of plant species and subsequent alteration of the local hydrological regime can be expected.

REFERENCES

Bobbink, R., Hicks, K., Galloway, J., Spranger, T., Alkemade, R., Ashmore, M., Bustamante, M., Cinderby, S., Davidson, E., Dentener, F., Emmett, B., Erisman, J.-W., Fenn, M., Gilliam, F., Nordin, A., Pardo, L., De Vries, W. 2010. Global assessment of nitrogen deposition effects on terrestrial plant diversity: a synthesis. Ecological Applications, 20 (1), 30-59.

Casparie, W.A. (1993). The Bourtanger Moor: endurance and vulnerability of a raised bog system. Hydrobiologia 265, 203-215.

Dämmgen, U. (2007). Atmospheric nitrogen dynamics in Hesse, Germany: Creating the data base 2. Atmospheric concentrations of ammonia, its reaction partners and products at Linden. Landbauforschung Völkenrode 2/2007 (57), 157-170.

Gauger, T., Köble, R., Spranger, T., Bleeker, A., Draaijers, G. (2001). Deposition loads of sulphur and nitrogen in Germany. A comparison of national and international mapping results. Water, Air and Soil Pollution 1, 353-373.

Grünhage, L. and Haenel, H.-D. (1997). Platin (Plant-Atmosphere Interaction) I: A Model of Plant-Atmosphere Interaction for Estimating Absorbed Doses of Gaseous Air Pollutants. Environmental Pollution 98/1, 37-50.

Nagel, H.-D., Becker, R., Eitner, R., Hübener, P., Kunze, F., Schlutow, A., Schütze, G., Weigelt-Kirchner, R. (2004). Critical Loads für Säure und eutrophierenden Stickstoff. Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, Luftreinhaltung, Förderkennzeichen 200 85 212, 64-68.

Peake, E. and Legge, A.H. (1987). Evaluation of methods used to collect air quality data at remote and rural sites in Alberta, Canada. Proc. of the 1987 EPA/APCA symposium on measurements of toxic and related air pollutants. APCA, Pittsburgh,