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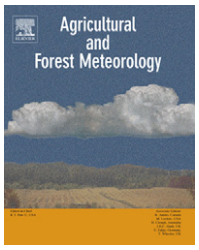

Short-term flux chamber experiment to quantify the deposition of gaseous ^{15}N-NH_3 to *Calluna vulgaris*

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ABSTRACT

A flux chamber experiment employing ^{15}N-NH_3 was run for a period of 15 days to quantify uptake of NH_3 into the component parts of *Calluna vulgaris* and peat substrate. The results showed that the total N recovered from the vegetation system correlated extremely well with AMANDA deposition measurement, over the whole 15-day period, accounting for all the deposited NH_3. The data showed that NH_3 was taken up into the above ground biomass over the 15 days of the experiment; 75% was found in green shoots and leaves and 11% in brown shoots. The larger uptake by green shoots and leaves was presumably related to the presence of stomata and the cuticular surface area. Only 1% was captured by the peat due to the closed *C. vulgaris* canopy. There was little translocation of N from deposited NH_3 into the roots and peat. For *C. vulgaris* it can be calculated that 75% of the above ground deposition was onto the cuticle and only 25% into the stomata.

1. Introduction

NH_3 emissions have increased near areas of semi-natural vegetation, mainly from agricultural sources (Dragosits et al., 1998). Increased NH_3 deposition results in eutrophication, acidification and direct toxicity to ecosystems (Pearson and Stewart, 1993; Krupa, 2003). Eutrophication has been particularly evident in semi-natural ecosystems such as moorlands and heathlands, where the dominant *Calluna vulgaris* (L.) Hull is being replaced by grassland vegetation (Prins et al., 1991; Pitcairn et al., 1995; Alonso et al., 2001). NH_3 deposition to an ecosystem occurs via two main routes: directly to the soil (or via leaf wash off into the soil) (Nemitz et al., 2001), and directly to the vegetation, where it can be taken up through the stomata or adsorbed onto the cuticle (Sutton and Fowler, 1993). Previous investigations have studied these uptake routes (e.g. Jones, 2006; Jones et al., 2007a,b); however, few have linked the amount of NH_3 deposited to the amount of NH_3-derived nitrogen found within the vegetation canopy and the soil.

NH_3 is deposited to vegetation via two main pathways, onto the cuticle and through the stomata (Bruckner et al., 1993; Schjoerring et al., 1998; Sutton et al., 1993; Jones et al., 2007a,b). Therefore, it might be expected that there would be differential deposition to the different parts of the plant, correlated with the distribution of stomata. For example it has been demonstrated that deposition of NH_3 is different to different plant structures; Gessler et al. (2002) showed that NH_3 at concentrations between 0 and 115 $\mu g\, m^{-3}$ deposited differently into the needles, and into the previous years and older bark, of *Picea abies*.

In view of the importance of examining differential deposition in plant canopies, the paper describes an experiment in which NH_3 enriched in a stable isotope of nitrogen

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($^{15}NH_3$) was supplied to *C. vulgaris*, the major component of heathlands and moorlands, in a flux chamber to examine the uptake pathways of NH_3 deposition to, and subsequent N fluxes within, the plant and soil system. Samples were collected daily from the green shoots, green leaves, brown shoots, roots and the peat. Ammonia measurement by annular denuder sampling with on line analyser (AMANDA) was employed at the same time as the $^{15}NH_3$ experiment so that exact ingoing and outgoing $^{15}NH_3$ could be measured, and thus the amount of $^{15}NH_3$ deposited to the vegetation could be quantified. These data were then compared to the measured values of ^{15}N uptake in the vegetation providing a powerful tool for inter-validating the ^{15}N results and the NH_3 exchange results.

Objectives were as follows:

- Account for all the deposited NH_3 in the flux chamber.
- Identify the difference in deposition between the vegetation and the soil.
- Identify the main areas of deposition within the vegetation canopy.
- Identify changes in NH_3 deposition throughout the experiment.

2. Methods

2.1. Experimental design

The experiment was conducted inside the NH_3 flux chamber as described in detail in Jones et al. (2007a). Briefly, a flux chamber, dimensions of 1.75 m × 1.75 m × 0.60 m (1.84 m^3), was housed inside an open-top chamber (OTC) (Fowler et al., 1989; Jones et al., 2007a) at Bush Estate near Edinburgh Scotland (55°51′N, 198 m altitude). Ambient air was pumped into the OTC manifold and passed through 10 activated charcoal filters to remove ozone, sulphur dioxide, nitric acid and nitrogen dioxide. Chamber conditions, including temperature and humidity were monitored, and inlet and outlet NH_3 concentrations were measured by an AMANDA system (Wyers et al., 1993). Calculation of the exact amount of NH_3 depositing to the vegetation was therefore possible. For this experiment, a new NH_3 source and NH_3 release system was designed, as it was necessary to supply a constant amount of ^{15}N-enriched NH_3 with time. $^{15}NH_3$ was generated by reacting a solution of 99.99 at% ^{15}N labelled $(NH_4)_2SO_4$ with NaOH (see Appendix A for definition of at%). A schematic of the ^{15}N generator is shown in Fig. 1. NaOH and $(NH_4)_2SO_4$ both 1 M, were pumped at ~1 ml min^{-1} into two ports of a three way connector. Air was pumped through the main tube of the connector at 0.8 l min^{-1}; this pushed and mixed the incoming NaOH and $(NH_4)_2SO_4$ through the system. The NaOH provided a coating over four consecutive coiled glass tubes, which allowed adequate mixing time to effectively convert the $(NH_4)_2SO_4$ into NH_3, H_2O and Na_2SO_4. After removal of the remaining liquid waste from the phase separator, the NH_3 was pumped directly into the OTC inlet manifold through 3 mm tubing, ensuring a continuous supply of $^{15}NH_3$ into the flux chamber at a concentration between 16 and 24 μg m^{-3} for the 15 experimental days. This NH_3 concentration range was selected to be consistent with earlier work (Jones et al., 2007a,b) and within the range of atmospheric concentrations observed in Northern Europe, especially around point

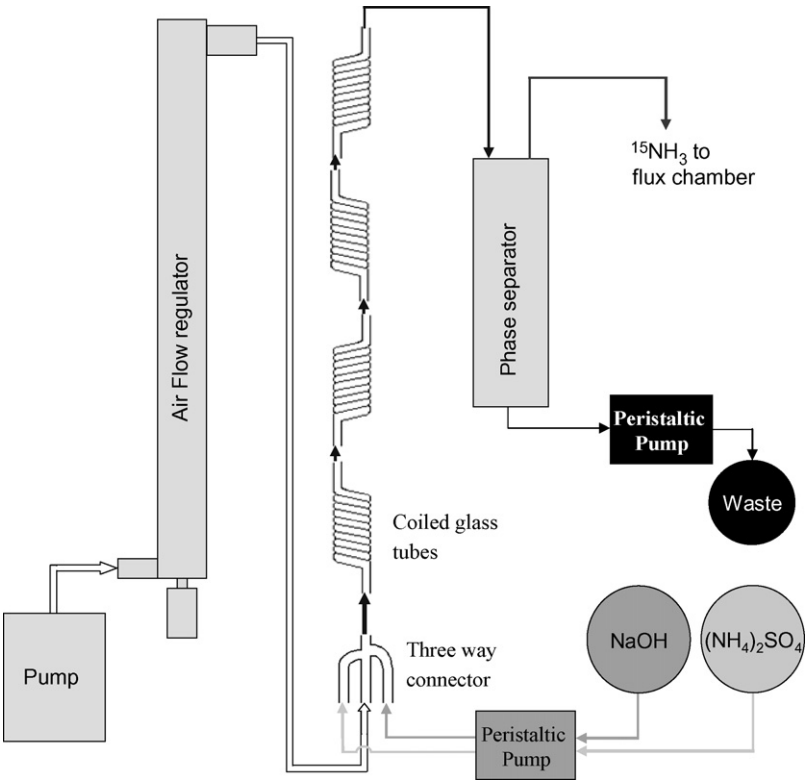

Fig. 1 – Schematic diagram of the system used to generate $^{15}NH_3$.