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Contribution of Root-derived Sulphur to Sulphate in Throughfall in a Douglas Fir Forest

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Abstract

The relative contribution of root-derived sulphur to sulphate in throughfall is determined for a Douglas Fir forest using ^{35}S-radiotracer. The experiment took place at Speuld, The Netherlands, from July 1993 until April 1994. It is shown that the relative contribution of root-derived sulphur contributes to throughfall of 3% on average, with slightly higher values (8-12%) during autumn. Leaching is higher for an experimental plot receiving a double annual input of ammoniumnitrate and ammoniumsulphate on the forest floor compared to a reference plot. The calculated contribution is probably overestimated by a factor of about 2. This is subject to further study.

1. INTRODUCTION

Analysis of throughfall and stemflow can be used effectively for the estimation of atmospheric deposition to a forest if certain conditions are met. Wash-off of components deposited on the canopy via dry- and occult deposition should be quantitative. Furthermore, the leaching of root-derived plant components should be small relative to wash-off of deposition.

In this report, results are given from a ^{35}S radiotracer experiment in a Douglas Fir forest. The experiment took place at Speuld, The Netherlands, from July 1993 until April 1994. The aim of the study is to quantify foliar leaching of root-derived sulphur to throughfall. The study was initiated in order to find a possible explanation for the observed difference for several locations in The Netherlands between sulphate deposition estimated via inference and throughfall measurements, respectively. Additionally, the influence of acid deposition on foliar leaching of sulphate was studied.

The relative contribution of root-derived sulphur to throughfall is given by the ratio of the ^{35}S specific radioactivity (i.e., Bq/mg sulphate) of throughfall sulphate and the leachable sulphur pool in the canopy. One of the major uncertainties in this isotopic study therefore arises from the radioactivity-determination of the leachable sulphur pool if isotopic equilibrium is not obtained for all sulphur pools. It is further assumed that leaching occurs only via foliage, neglecting leaching from twigs.

2. EXPERIMENTAL

^{35}S-labeled sulphate is applied to the forest floor of two selected plots at Speuld, The Netherlands, at unfrequent intervals as aqueous solutions using a high-density drainage tubing system. The first period of radiotracer application started on June 29th (1993) and ended on November 16th (1993, 8 events). The second period started on March 10th (1994) and ended in October (1994). In this report, only results obtained between June 1993 and April 1994 are discussed. For plot 1, the ^{35}S-sulphate radiotracer is dissolved in artificial rain water. For plot 2, the tracer is added to a concentrated solution of ammoniumsulphate and ammoniumnitrate. In this way, the annual input of ammonium, nitrate and sulphate to the soil of plot 2 is doubled as compared to the estimated atmospheric input in 1989.

Throughfall and rainwater are collected from the site at 1–4 week intervals, depending on season and rain events. Foliage is collected from the canopy at approximately monthly intervals starting on July 20th (1993).

Throughfall composition is determined using ion chromatographic methods. The ^{35}S specific radioactivity is determined in needles (total sulphur), throughfall (as sulphate) and water-extractable sulphate from the foliage using liquid scintillation counting techniques. Detailed description of all methods will be published elsewhere.

RESULTS AND DISCUSSION

As explained in the Introduction, the relative contribution of foliar leaching of sulphate to sulphate in total throughfall is given by the ratio of the ^{35}S specific activity of sulphate in throughfall and the water-leachable sulphur from the canopy at any time. The results have been plotted in Fig. 1. The contribution is approximately 3% on average for both plot 1 and 2. Only during one occasion (November 1993) the relative contribution was larger than 10%. The contribution of root-derived sulphur to sulphate in throughfall is therefore relatively small. The result are in accordance with results obtained at other sites for different types of vegetation (Garten 1988, Cape 1993). Despite the large uncertainties in the specific radioactivity of the sulphur pools, results for plot 1 and 2 are highly correlated. The differences between plot 1 and 2 observed for certain periods are therefore realistic. Foliar sulphate leaching from the canopy was relatively large during the autumn of 1993. During this period, sulphur leaching is larger for plot 2.

The question remains if the underlying assumptions for calculating the contribution of foliar leaching to throughall are valid. It is assumed that by soaking freshly collected needles for 24 h in water, the 'leachable' portion of root-derived sulphur from the needles is obtained. Most likely, the water extract will also contain sulphate from dry deposited sulphate aerosol and sulphur dioxide. This means that the root-derived ^{35}S labeled 'leachable' sulphate is diluted with unlabeled, dry deposited sulphur. Under these circumstances, the specific activity of sulphate measured in the extract is not representative for the root-derived leachable sulphate. This effect will increase if sampling of needles is preceeded by long dry periods. The relative contribution of foliar leaching to sulphate in bulk-throughfall given in Fig. 1 should therefore be regarded as upper limit at any time for leaching of root-derived sulphur.

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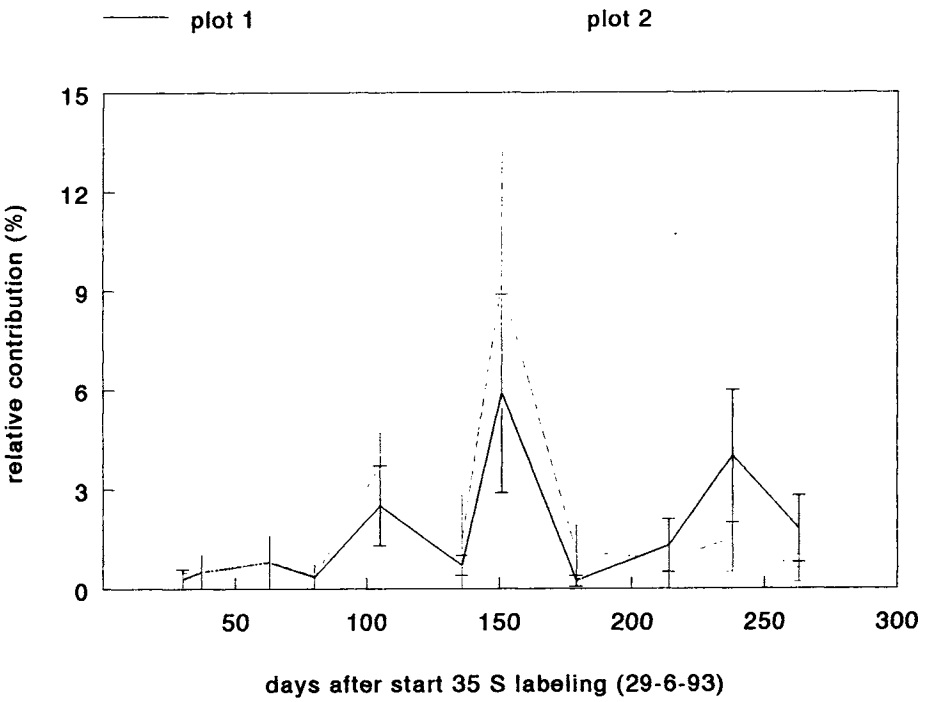

Fig. 1
Relative contribution of Douglas Fir foliar leaching to sulphate in throughfall calculated from ^{35}S specific activity of water–leachable sulphate and throughfall–sulphate measured at two selected plots at Speuld, The Netherlands.