ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS IN NORWAY: TEMPORAL AND SPATIAL TRENDS STUDIED BY MOSS ANALYSIS

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Abstract. The atmospheric deposition of sixteen trace elements, as inferred by their concentration in moss samples collected in 1985 from 500 sites in Norway, is compared with data from a similar survey in 1977. The deposition patterns of V, Zn, As, Se, Cd, Sb, and Pb are substantially influenced by long-range transport from other parts of Europe, but a general decline is evident from 1977 to 1985, most strongly for Pb. For Cr, Fe, Co, Ni, and Cu the deposition patterns are largely determined by contributions from point sources within Norway and on the Kola peninsula close to the Russian/Norwegian border. The moss data for Br, I, and partly Se reflect airborne supply from the marine environment, whereas Al and Sc serve as indicators of contributions from soil dust. Contributions to the trace element concentrations in moss from sources other than atmospheric deposition are identified and discussed.

1. Introduction

Mosses have been found to be useful as monitors of atmospheric deposition of trace elements because they lack a root system and thus absorb chemical substances from deposition and throughfall (Tamm, 1953; Rühling and Tyler, 1971). Mosses have a very high capacity to retain many metals from solution (Rühling and Tyler, 1970), and they also intercept particles from dry deposition. In particular, carpet-forming mosses are suitable for monitoring purposes. Since the feasibility of the moss technique was first shown for mapping of atmospheric deposition patterns of metals on a larger geographical scale (Rühling and Tyler, 1973), several studies on a national or multi-national scale have been carried out in Scandinavia (Pakarinen and Tolonen, 1976; Steinnes, 1977; Rühling and Skärby, 1979; Rambaek and Steinnes, 1980; Gydesen et al., 1983; Rühling et al., 1987).

In Norway a test survey was carried out in 1976 including about 50 sites, for the selection of a suitable receptor species (Steinnes, 1977) and the development...
of a suitable multi-element analytical technique for this kind of investigations (Steinnes, 1980). Among various moss and lichen species tested, the carpet-moss *Hylocomium splendens*, which has also been used in most of the other studies listed above, was selected for the first full-scale national deposition survey in 1977, comprising about 500 sampling sites. As different from other Nordic moss surveys, employing atomic absorption spectrometry (AAS) and thus limiting the number of elements that could be conveniently dealt with to about 10 or less, the Norwegian survey was based on instrumental neutron activation analysis (INAA), and supplemented by AAS for the elements Cu, Ni, Cd, and Pb where INAA was unsuitable. Altogether 26 elements were studied in the 1977 national moss survey (Rambæk and Steinnes, 1980). A full presentation of this larger-scale multi-element study has been given recently (Schaug et al., 1990; Steinnes et al., 1992).

For the 1985 survey the number of elements was reduced from 26 to 16, excluding some which were either present at levels close to or below the detection limit (Ag, Mo), were poorly retained in the moss (Na, Cl), or were assumed to be derived mainly from sources other than atmospheric deposition (Mn, Rb, Cs, La, Sm, Th). In this paper the results from the 1985 survey are presented and compared to the 1977 data in order to evaluate temporal deposition trends.

2. Experimental

Samples of *Hylocomium splendens* were collected at 519 sites (Figure 1). Four additional sites were sampled in Svalbard (Spitsbergen). Although the number of sites was nearly the same as in 1977, the sampling network was designed in a somewhat

Fig. 1. Sampling network of the 1977 and 1985 national deposition surveys in Norway.