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Decreasing concentration of air pollutants and the rate of dry and wet acidic deposition at three forestry monitoring stations in Hungary

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Abstract

Concentration and dry + wet deposition of acidic atmospheric pollutants were determined in three Hungarian forestry monitoring stations between 1988 and 1992. Concentration of most important acidic compounds (sulfur and nitrogen dioxide) does not reach the critical level therefore forest decline as consequence of direct effects (foliar uptake through stomata) may be excluded. Total (dry + wet) deposition of acidic pollutants are 187 mg H^+ m^{-2} yr^{-1} as an average of three stations. The acidic load at Hungarian forestry stations frequently exceeds the critical value recommended by international organizations. Though concentration and deposition of atmospheric acidic compounds has considerably decreased in the recent years, futher monitoring of acid deposition in forests is necessarry because the accumulation effects of acid load to forest soil.

1 Introduction

Air pollution affect directly and/or indirectly the forest health. Air pollutants through stomata initiate biochemical processes which can affect the leaves directly. Indirect effect of acidic substances appears in the long term acidification of forest soil. Acidification of forest soils, forest decline, furthermore the fact that Hungary belongs to moderately polluted countries in Europe support the need for continuous monitoring of the rate and trend of atmospheric acidic deposition in Hungarian forests.

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Meteorological Service have started a monitoring program in 1988 at the three forestry monitoring stations.

The aim of this paper is to summarize the result of the first five years of the monitoring program (1988-1992), to calculate the concentration and deposition of acidic compounds for forests and compare them with standards and recommendations.

2 Measuring programs

The three forestry monitoring stations are situated in pine forests at the west (Farkasfa:φ=45°55', λ=16°18', H=312 m masl) and the middle of Hungary (K-puszta: φ=46°58', λ=19°33', H=126 m masl) as well as in the Mátra-Mountains, north-east of Hungary (Nyírjes: φ=47°57', λ=19°58' H=560 m masl). Forestry stations were located on openings in the forest.

The sampling period is 24 hours for the most important acidic gaseous pollutants (sulfur dioxide, nitrogen dioxide, nitric acid and ammonia) and for the aerosol particles (their ammonium, sulfate and nitrate contents are determined). Chemical composition of precipitation is also measured on the basis of monthly wet-only sampling. Detailed description of sampling and analytical methods including the estimated average dry deposition velocities can be found in Horváth [1] or Pais and Horváth [3]. Calculation of acid deposition rate is described by Horváth [1]. It can be respected as the upper limit of acidity. Therefore, instead of uncertain net (acidic and alkalinic) deposition we prefer to use the term of possible highest rate of acid deposition.

3 Concentration of air pollutants

Direct effects of acidic air pollutants are related to their high atmospheric concentrations. There are different approaches to estimate the air quality standards for forest ecological systems. According to WHO [6] the harmful level of sulfur dioxide and nitrogen dioxide for forests (for the two most important air pollutants from the point of view of acidification) is 30 μg m^{-3} as a yearly average. These figures correspond to Hungarian standards determined for "particularly protected" areas (MSZ [2]). Proposed critical loads for forests are 20 and 30 μg m^{-3} as a yearly average for sulfur dioxide and nitrogen dioxide, respectively (Várallyay et al. [4]).

Yearly averages for sulfur dioxide and nitrogen dioxide as well as the variation of mean monthly values can be seen in Fig. 1. The yearly mean values of pollutants do not reach the harmful level. From west to east concentrations of sulfur and nitrogen dioxide increase.

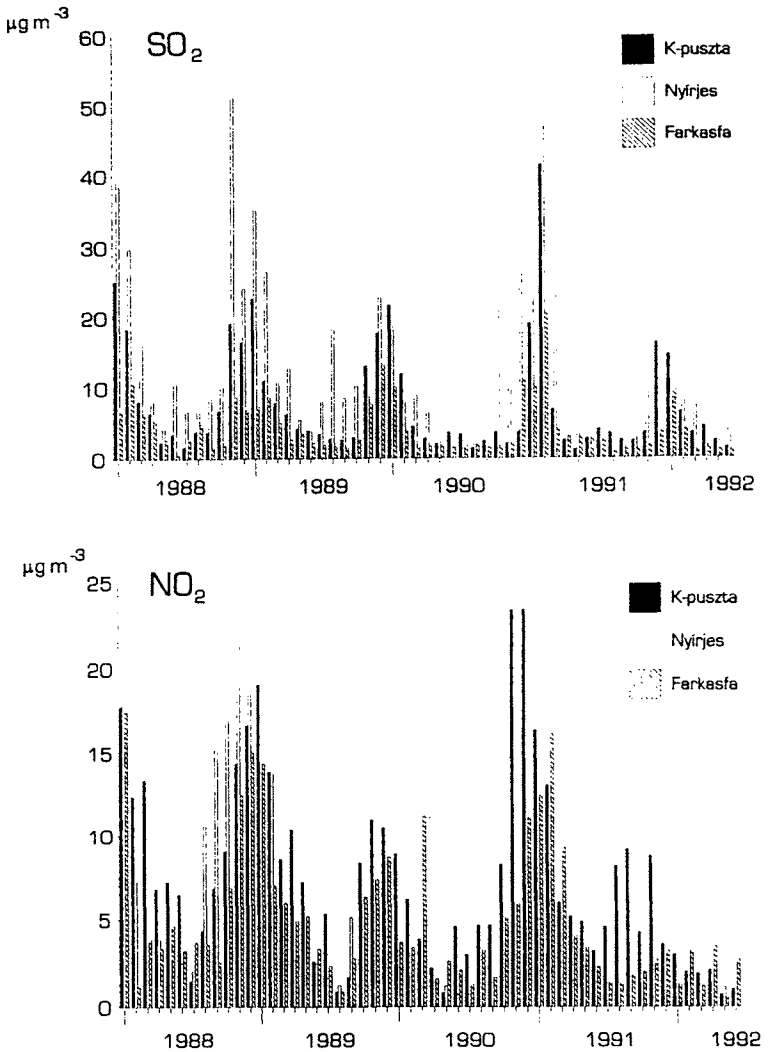

Figure 1. Variation of the mean monthly concentration of sulfur dioxide and nitrogen dioxide

Further important information is that higher sulfur dioxide and nitrogen dioxide levels occur during the winter half-year, out of the vegetation period. For deciduous forests the foliar uptake of gases is possible only during the vegetation period (practically during summer half-year, from April to November). In the case of coniferous forest the uptake of sulfur and nitrogen dioxide is minimized in the winter half-year because of closed stage of stomata.

4 Deposition of air pollutants

In contrast with high atmospheric level of pollutants dry and wet deposition of acidic substances (sulfur and nitrogen compounds) may affect the forest health by indirect processes through accumulation in the forest soil. The average rate of total deposition (for the period of 1988-92 as an average of three stations) is 187 mg H^+ m^{-2} yr^{-1}. The share of dry and wet deposition is approximately the same. However, in the summer half-year the wet, in winter half-year the dry deposition dominates (Fig. 2). Dry deposition has a winter, wet deposition has a summer peak. Consequently, there is no expressed annual variation in the total deposition.

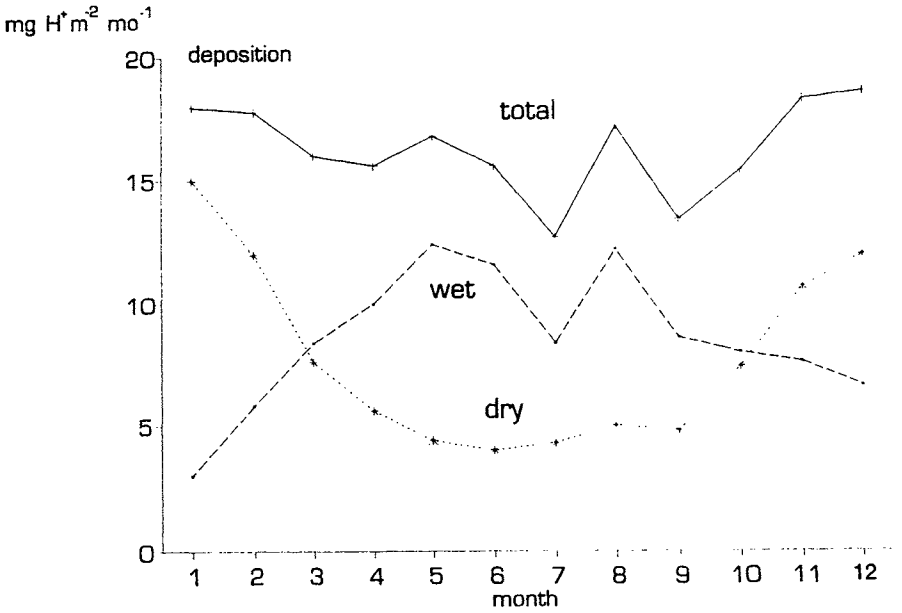

Figure 2. Annual variation of dry, wet and total acidic deposition as an average of the three forestry stations.

The ratio of sulfur to nitrogen compounds in the total deposition is 42 and 58%. The relative importance of sulfur compounds is continuously decreased from 46% to 36% during the 5 years. It is in agreement with our earlier results (Horváth, [1]) suggesting that N/S tatio is increasing in the acidic deposition.

The average yearly acidic depositions of Farkasfa and K-puszta stations are similar, 164 and 172 mg H^+ m^{-2} yr^{-1}, which can be regarded as a "background" acid deposition for

Hungary. For Nyírjes station the acidic deposition is higher, 224 mg H^+ m^{-2} yr^{-1} indicating local pollution effect. The yearly deposition figures for the tree stations generally do not exceed the proposed critical load for Hungary. The critical load of total acid deposition is 280 mg H^+ m^{-2} yr^{-1} (Várallyay et al. [4]).

According to the recommendation of UN and ECE (RIVM [5]), Hungary is divided into different grids according to sensibility of the given area. The critical loads for the 4 different areas for Hungary are 20-50; 50-100; 100-200 and >200 mg H^+ m^{-2} yr^{-1}. Lowest figures are generally determined for western and northern part of Hungary. Taking into consideration these recommendations we can see that in the majority of the cases the critical load is exceeded.

5 Trends in concentration and deposition

Concentration of most important acidic compounds (sulfur and nitrogen dioxide) as well as total (dry+wet) deposition of pollutants have decreased during the 5 years of investigation. This result is summarized in Fig 3. The atmospheric level of pollutants and the rate of acidic deposition have reached to the half of the value measured in 1988. It is probably due to reduced sulfur and nitrogen emission in Hungary and in the neighbouring countries as a consequence of change in economical structure of East European region.

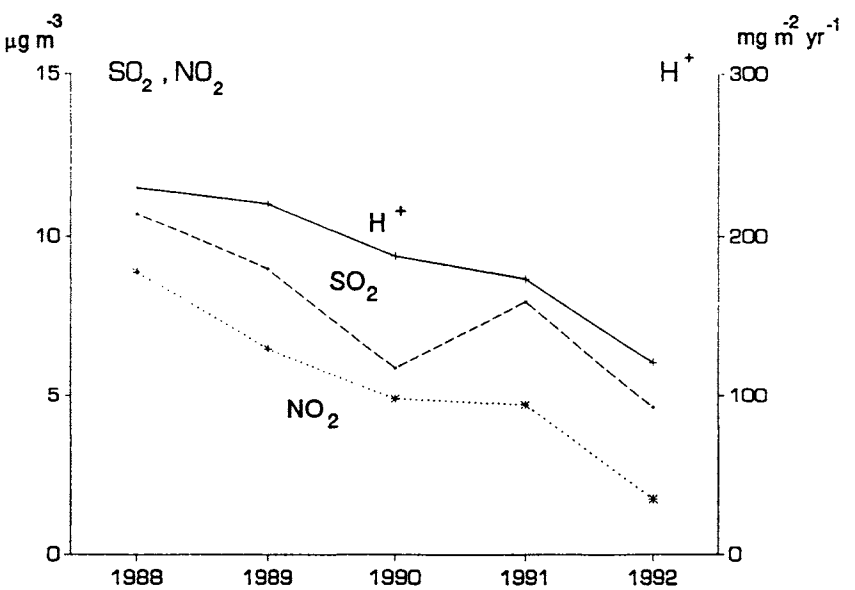

Figure 3. Variation of the concentration of air pollutants and the rate of total acidic deposition

This fortunate tendency suggests that we can not probably face the danger of direct forest decline in the near future caused by increased level of pollutants. In spite of the decreasing deposition rate the critical loads recomended by international organizations are frequently exceeded. For this reason the continuous monitoring of acid deposition is needed for the effects of pollution may accumulate in the forest soil (e.g. accumulation of nitrogen loading, mobilization of heavy metals, decrease of buffer capacity against acid stress) causing long term indirect damages in forest.

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