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Annual Pattern of Sulphur Content in Spruce Needles from Heavily and Less Polluted Areas

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Summary

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Needles of twenty years old spruces from Prednji vrh, an area affected by Šoštanj power station, and from Pokljuka, Alps region, with a relatively unpolluted environment, were analysed for total sulphur (S_t) and total nitrogen content (N_t). Sulphur measurements were taken in a period between April and August twice monthly, and in the period from August to April every four weeks (May 1993 - June 1994). Sulphur content in current and one year old spruce needles from Prednji vrh were much higher (current year needles 2.06 - 2.50 mg/g dry weight, 1993) than in needles from Pokljuka (current year needles 1.05 - 1.25 mg/g dry weight, 1993). Nitrogen contents and ratio N_t/S_t for current year needles from Pokljuka were higher (12.3 mg/g dry weight, N_t/S_t 10.2, November 1993) than in needles from Prednji vrh (10.8 mg/g dry weight, N_t/S_t 5.3, November 1993).

Introduction

Measurements of total sulphur content in spruce needles have been used for many years as an indicator of presence of SO_2 in the air. Already in 1883 these measurements were used to identify SO_2 affected plants (Schöder und Reuss, cited in HÜTTL 1992). Sulphur is an essential nutrient but at excessive supply it accumulates in leaves and needles and causes toxicity. Plants are taking up sulphur through roots in form of SO_4^{2-} or as SO_2 gas by leaves and needles via stomata (FIEDLER & THAKUR 1985). Total sulphur concentrations in the foliage are between 7 to 10% of nitrogen concentrations (SCHULZE & al. 1989). The levels of total sulphur content in current and older needles differ very much and are used as indicator for estimations of SO_2

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impact on forest trees. HÜTTL 1992 states critical values of total sulphur contents in current and one year old spruce needles from 1.1 to more than 2.1 mg S_t/g dry weight.

Mineral nutrient content in the foliage changes during the year. There are different factors which affect on nutrient content, such as availability in the soil, bulk deposition, seasonal displacement, differences between different parts of crown and exposure of needles and leaves, and their age.

The bioindication method of sulphur emission determination in Slovenia is based on total sulphur content in needles of Norway spruce (*Picea abies* (L.) Karst), while in the areas where spruce is not grown, black pine (*Pinus nigra* Arnold) and Scots pine (*Pinus sylvestris* L.) are used. Current year and one year old needles are analysed and the results are used for classification into four total sulphur content classes. Classification is based on needle samples from a 16 to 16 km bioindication net and from other research work (STEFAN 1991, KALAN & al. 1990): first class = less polluted area, fourth class = heavily polluted area.

Materials and Methods

Needles were taken from the seventh whorl of vital trees from the sun-exposed part of crown (trees belong to predominant and dominant classes - forest with closed canopy). The needles were oven dried (60°C for 24 hours) and ground. Total sulphur was determined by SULMHOMAT 12 - ADG (KALAN 1990) and total nitrogen by micro-Kjeldahl method.

Results and Discussion

Total sulphur content (S_t) in spruce needles (April 1993 - July 1994) from Prednji vrh varied between 1.54 and 2.58 mg/g dry weight (third and fourth class of sulphur content), and in needles from Pokljuka between 0.86 and 1.30 mg/g dry weight (mostly first and second class of sulphur content class, only exceptionally third class). In current year needles, S_t contents were lower in May and June (1993) on both locations (before intensive young needles growth), than in other months (Fig.). After this period S_t contents increased. During dormancy of trees, the S_t contents were relatively constant at Pokljuka but not at Prednji vrh, where are high SO_2 winter emissions (October - February, 1993/1994). S_t needles contents on both sites decreased in March and began to increase again in June (at the end of intensive growth of current year needles).

As shown in the table, nitrogen contents and ratio N_t/S_t of current year needles from Pokljuka were higher (12.3mg/g dry weight; N/S 10.2, November 1993) than in needles from Prednji vrh (10.8 mg/g dry weight; N_t/S_t 5.3, November 1993). The nitrogen contents in needles from both sites are in the deficiency range. The N_t/S_t ratios, using Zech values (N/S > 8 recommended, HÜTTL 1992), indicate that at Prednji vrh this N_t/S_t ratio in needles is unbalanced because of both insufficient N_t and excessive S_t contents. At Pokljuka the N_t/S_t ratio is balanced and in the recommended range, but because of insufficient content of N_t and low S_t content.

Total sulphur in spruce needles shows that the site Prednji vrh is in the area with high emissions of SO_2. Here some damage is to be expected caused by the emissions of SO_2. The Pokljuka site is less polluted and sulphur contents are only in a few cases above the normal sulphur contents (in current year spruce needles 1.0 mg/g dry weight). At Pokljuka there is no great difference between sulphur content in current and older needles. These differences are greater at Prednji vrh. In May (Prednji vrh) and June (Pokljuka), before intensive needle growth the S_t contents decreases quickly.

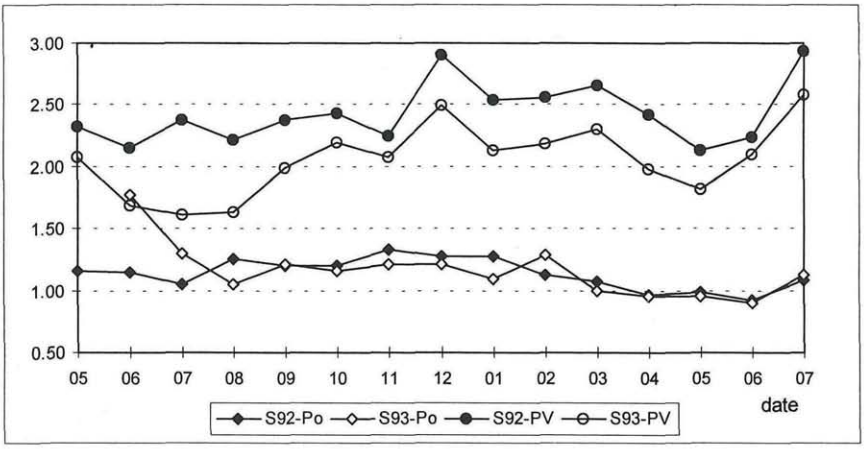

Fig. The annual cycle of total sulphur content in current and one year old needles, in a twenty year old spruce trees from Pokljuka (S92-Po, S93-Po) and from Prednji vrh (S92-PV, S93-PV), May 1993 - July 1994 (monthly average).

Tab. Nitrogen content and N_t/S_t ratio in current year needles in a twenty year old spruce trees from Prednji vrh and Pokljuka.

Sampling location	sampling date	$N_t$content (mg/g)	S_t content (mg/g)	N_t/S_t ratio
Prednji vrh	Nov. 93	10.8	2.70	5.3
Pokljuka	Nov. 93	12.3	1.20	10.2

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