IMPACT OF AIR-BORNE COPPER AND ZINC POLLUTION LICHEN AND BRYOPHYTE VEGETATION NEAR A BRASS FOUNDRY

University of Lund, Department of Plant Ecology, Ö Vallgatan 14, S-223 61 Lund, Sweden

Air-borne Cu and Zn from a brass foundry at Gusum, SE Sweden, have considerably disturbed the lichen and bryophyte vegetation in the coniferous forest environs. The occurrence of lichens on spruce twigs decreases rapidly with increasing Cu concentration in Hypogymnia physodes above 90 ppm (background value 10-15). The epiphytic vegetation is reduced within 2-3 km from the foundry. Only stunted individuals occur in the close vicinity of the pollution source.

The cover of one of the quantitatively most important mosses, Hylocomium splendens, is greatly reduced by the heavy-metal deposition. Cover values of 20-50 % are not uncommon at distant sites (Cu conc. 15-35 ppm). There is a significant negative correlation between Cu conc. in the moss and its cover. The moss cannot survive much more than c. 130 ppm Cu (and 360 ppm Zn). Live individuals are no more found within 1.5 km from the foundry.

INTRODUCTION

Lichens and bryophytes are frequently used as indicators of air-borne heavy-metal pollution. Since they lack roots and, usually, conducting organs, these lifeforms depend on aerial deposition for their mineral nutrition. The ion-exchange capacity of the tissue is (LAAKSOVIRTA and OLKKONEN 1977).

Severe damage to bryophyte and lichen vegetation due to smelter emissions has been documented in the Sudbury area in Canada (LEBLANC, RAO and COMEAU 1972) and in Pennsylvania (NASH 1975).

Large amounts of zinc and copper are since great (RÜHLING and TYLER 1970). The long emitted from a brass foundry at Gusum, properties mentioned make these tiny a village (1600 inhabitants) situated 150 km organisms efficient accumulators of heavy SW of Stockholm. The aim of the present metals. At the same time lichens and research is to document the effects of the bryophytes are sensitive to heavy metals. heavy-metal deposition on the composition Injury to epiphytic lichen vegetation has been of the vegetation in the surrounding forest reported, for instance, in the vicinity of a area. In this report some examples of the metallurgical-chemical complex in Finland influence on lichens and mosses are given.

MATERIAL AND METHODS

Within 0-7 km from the foundry 180 sample squares (25x25 m) were distributed in coniferous forest (see FOLKESON 1979 for details and for description of the study area). At each site the occurrence of epiphytic lichen vegetation on Picea abies (L.) Karst. twigs, and other substrates, was estimated according to the scale shown in Fig. 1. The ground cover of different plant species, including the mosses (Musci), was analysed using the cover scale

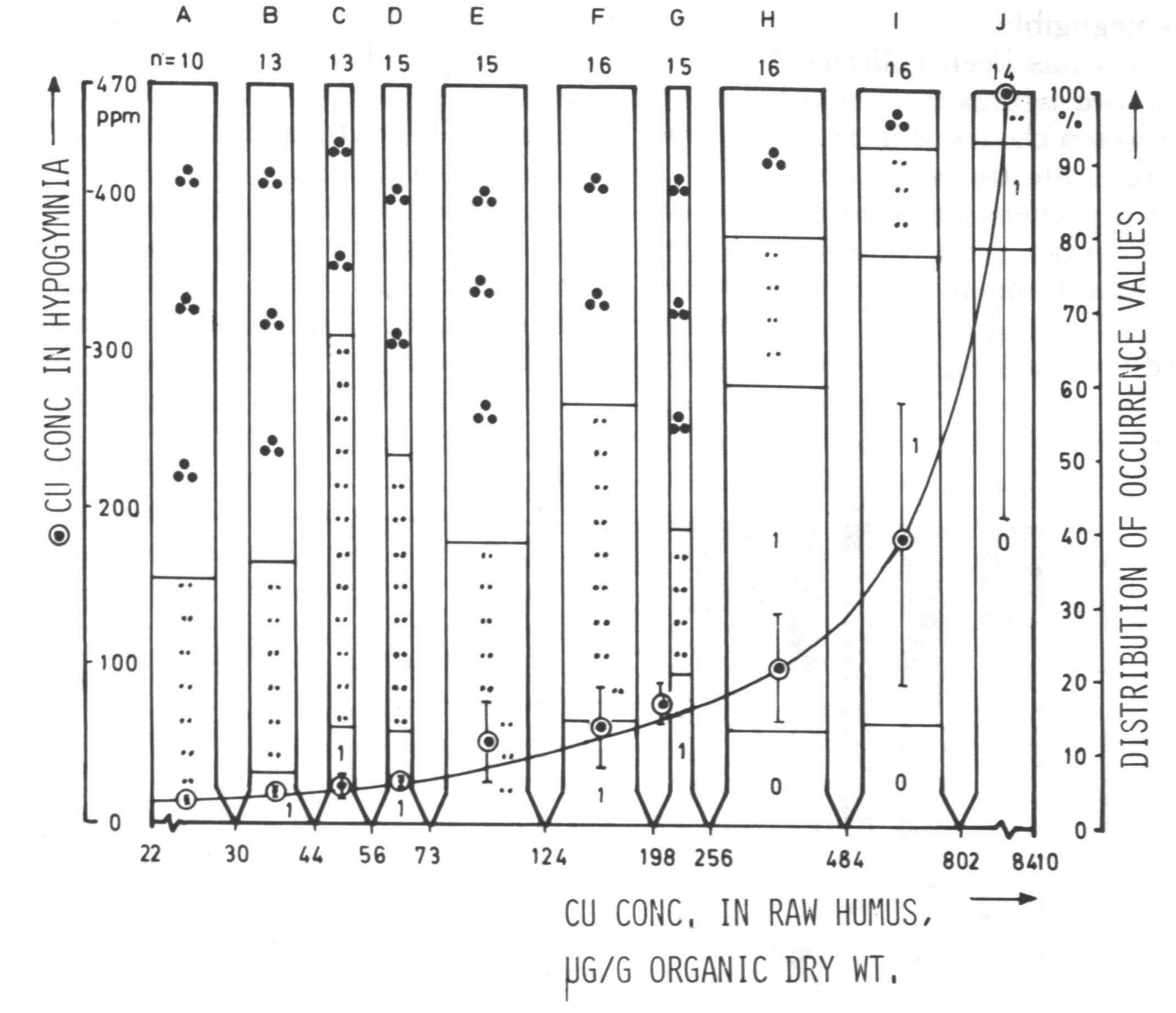


Fig. 1. Occurrence of lichen vegetation on spruce twigs in relation to Cu concentration in Hypogymnia physodes and in raw humus.

According to the Cu concentration in raw humus 157 sample sites have been grouped into classes A-J, comprising 15 (A, C, J) or 16 (B, D-I) sites each. The epiphytic vegetation has been estimated at 15, 14, 15, 16, 13, 14, 15, 15, 14 and 14 sites in class A, B, C, D, E, F, G, H, I and J, respectively. n = number of sites for Cu analysis inHypogymnia.

Mean ± s. d. of Cu concentration in lichen. Abscissa logarithmic, ordinates linear.

EPIPHYTIC LICHEN VEGETATION:

3 ABUNDANT 2 ORDINARY

> O ABSENT, OR NEARLY SO

in Fig. 2. Samples of several lichen and moss species were collected from all possible sites. The total concentrations of several metals in

the dried samples were determined with flame AAS after digestion in conc. HNO₃+HClO₄.

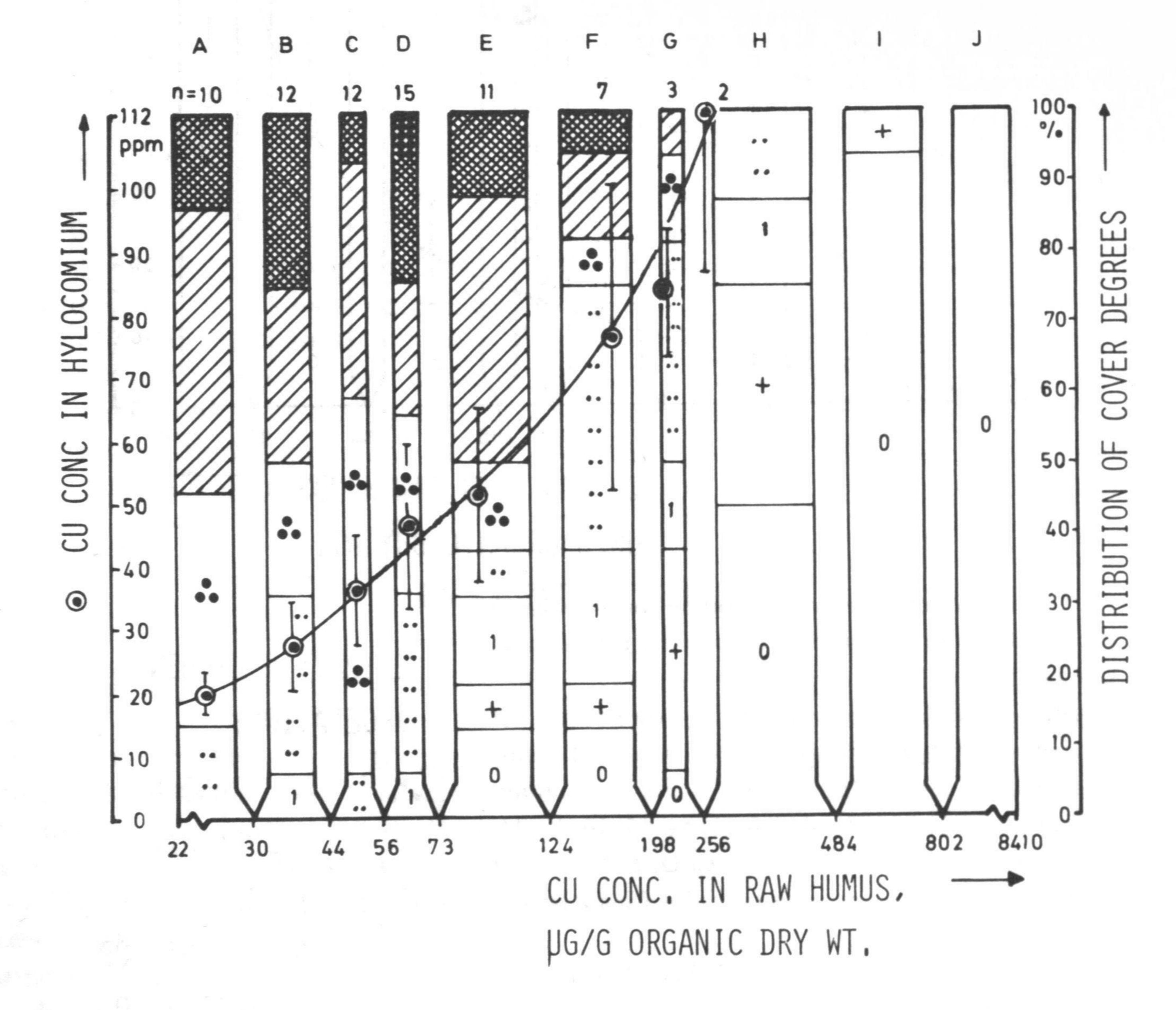
RESULTS

There is a steep gradient in the total load of organic dry weight. The concentration from sites 6–7 km from the foundry the mean of copper concentration values is $27 \mu \text{ g/g}$

copper and zinc in the area as shown by the increases continuously to a maximum of 8410 concentration in raw humus under Cladonia $\mu g/g$ at the closest site, 240 m. The effects on rangiferina (L.) Wigg. For the samples collected vegetation are here discussed in relation to copper only, even if they are due to both metals emitted. The SO₂ emission from the foundry is negligible.

Raw humus has been collected from 157 sites. In the two figures these sites have been grouped into ten classes of increasing copper load. Figure 1 illustrates the change in the occurrence of lichens on spruce twigs with increasing copper concentration in raw humus (abscissa) and in Hypogymnia physodes (L.) Nyl. collected from Pinus sylvestris L.

total copper load, as measured in raw humus, there is a steady increase in the concentration in the epiphytic lichen. The mean value increases from 14 ppm for the least polluted class (A) to 470 ppm for the most polluted class (I). In most of the classes A-G more than 50 % of the sites have an epiphytic lichen vegetation that has been estimated as abundant. In class H (mean copper concentrunks (ordinate). Along with the increase in tration in the lichen 101 ppm) there is a clear



DEGREE OF COVER OF 25x25 M SQUARES:

	6	> 50 %
	5	20 - 50
	4	5 - 20
•••	3	1 - 5
• •	2	0.1 - 1
1	1	0.005 - 0.1
+	+	< 0.005
0	0	NOT FOUND

Fig. 2. Cover of Hylocomium splendens in relation to Cu			
concentration in the moss and in raw humus under Cla-			
donia rangiferina.			

Degrees of cover have been estimated at all 157 sites. n = number of sites for Cu analysis in Hylocomium.

impoverishment of the lichen vegetation. The epiphytes are abundant at 20 % of the sites only, and 13 % are devoid of epiphytes, or nearly so. In the two most polluted classes there is a further sharp reduction in the occurrence of lichens. Epiphytes are (almost) absent from spruce twigs at 79 % of the sites in the most polluted class. The occurrence of lichens correlates highly significantly with the copper+zinc concentration both in raw humus (Spearman $r\varsigma = -0.59***; n=144$) and in Hypogymnia (-0.69***; n=149). This applies also to the distance from the foundry (0.63***; n=166).

Hylocomium splendens (Hedw.) Br. Eur. is included here as an example of a moss very sensitive to copper and zinc pollution (Fig. 2). At 40 % or more of the sample sites belonging to the five least polluted classes Hylocomium covers more than 5 % of the ground. A cover degree of 20–50 % is not uncommon. There is no apparent correlation between moss cover and copper concentration in the moss as long as the value is less than c. 50 ppm. The deterioration of the bottom layer the background value in the region is c. 8-12 microenvironment of the soil is greatly (RÜHLING and SKÄRBY 1979). Sites wit- changed. This, together with the toxic effects hout Hylocomium appear in class E. The high degrees of cover are increasingly more uncommon through classes E to H. Only from (TYLER 1976). Furthermore, the destruction two sites in class H has it been possible to collect living moss in sufficient quantity for cop-

per analysis (mean 112 ppm). The classes I-J are practically devoid of Hylocomium. The species has only occasionally been recorded from sites within 1.5 km from the foundry.

The cover of Hylocomium is thus beginning to decrease when its copper level has increased to c. 50 ppm. There is a marked reduction in cover with increasing copper concentration. The highest value recorded is 130 ppm. The tolerance range of the species is thus very narrow. The correlation coefficient between the cover of Hylocomium and its Cu+Zn concentration is low but significant $(r\varsigma=-0.28**; n=74)$. The cover is, however, closely correlated with the Cu+Zn concentration in raw humus (-0.76***; n=156) and with the distance from the foundry (0.78***; n=180).

There is thus a distinct reduction in the occurrence of epiphytes and cover of one of the quantitatively most important forest mosses in the area surrounding the brass foundry. As a consequence of the of the heavy metals, strongly influences also the soil animal and microbiological life of the bottom layer renders the thin soil susceptible to erosion.

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