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IMPACT OF THE KUNDA CEMENT PLANT (NORTH-EAST ESTONIA) EMISSION ON THE DISTRIBUTION OF EPIPHYTIC LICHENS

Abstract. Epiphytic lichen cover on Scotch pines around the Kunda cement plant (North-East Estonia) was studied. It was established that total coverage of lichen groupings and percentage of acidophilic lichen species demonstrate strong correlation with some chemical characteristics of snow and tree bark and consequently they may serve as indicators of alkaline dust deposition.

Key words: epiphytic lichens, cement dust, chemical composition of tree bark and snow.

In order to investigate the impact of cement dust on epiphytic lichens, Scotch pine (*Pinus sylvestris* L.), the dominating forest tree species in the Kunda district, was chosen as phorophyte.

By the general classification of phorophytes used by lichenologists (Du Rietz, 1945; Barkman, 1958), Scotch pine belongs to the group of trees characterized by acidic bark poor in mineral nutrients. So the impact of the pollutants emitted by the cement plant (which raise tree bark pH and the content of mineral compounds in it) on the epiphytic lichen cover can be easily traced on pine trees.

The natural epiphytic lichen flora of Scotch pine on the territory of Estonia has been studied quite thoroughly (Sõmermaa, 1972), enabling us to compare the species composition of lichen groupings on pines in unpolluted areas with that in the regions of different technogenic loads.

As a geochemical basis, some chemical characteristics of snow cover and pine bark were studied at various distances from the cement works. The sites of sample collection and distribution of epiphytic lichen groupings lie mainly on transects to the north-west (16 km) and north-east (4 km) from the plant. The sample sites were chosen where suitable pine trees (25—30 cm in diameter at breast height, straight, open) were available; three sample sites in the north-east direction and nine sites to the north-west were selected. As a local background, the chemical characteristics of snow cover and pine bark, as well as descriptions of epiphytic lichen groupings from the territory of Lahemaa National Park, about 26 km to the west of Kunda, were used.

Snow samples were collected on March 13, 1985 after the first thaws; the analysis of their chemical composition was conducted by V. Uchvatov at the Institute of Soil Science and Photosynthesis of the Russian Academy of Sciences, Pushchino-on-Oka, using laboratory techniques described by Glazovsky and Uchvatov (Глазовский and Учватов, 1982).

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Table 1

Some characteristics of snow, tree bark, and lichen community

Site No.	Direction and distance from the plant, km		Snow			Pine bark					Lichens		
			pH	Ca^{2+}, mg · l−1	SO_4^{2-}, mg · l−1	Exposition	pH	Ca^{2+}, mg · g−1	SO_4^{2-}, mg · g−1	El. conductivity, μS · sm−1	Number of species	% of acidophils	Coverage, %
1	NE	1.5	8.2	45.5	132.8	NE	7.8	13.2	31.7	363.5	4	0	28
						SW	8.2	4.4	12.3	173.0			8
2	NE	3.0	7.6	46.0	124.9	NE	7.2	0.6	1.8		10	40	10
						SW	7.5	0.7	1.7				2
3	NE	4.0		37.5		NE	7.1	0.6	0.5	51.0	10	40	15
						SW	7.5	0.4	1.6	56.5			8
4	NW	1.0	9.2	45.5	112.6	NW	7.4	3.0	—	79.0	9	33	10
						SE	8.0	2.5	0.1	77.5			2
5	NW	2.0	9.0	21.0	104.8	NW	4.8	0.2	1.3		8	62	28
						SE	6.5	0.4	1.3				3
6	NW	3.0				NW	6.8	0.4	0.5	27.7	10	70	12
7	NW	5.0	−8.1	54.0	110.5	NW	4.6	0.5	1.8		10	70	9
						SE	4.8	0.3	2.0				4
8	NW	7.0				NW	5.8	0.5	1.0	28.0	12	83	33
9	NW	9.0	7.7	16.2	27.9	NW	4.1	0.1	1.1		11	81	38
						SE	4.2	0.2	1.6				6
10	NW	12.0				NW	4.0	0.2	1.7	23.0	8	100	43
11	NW	13.5				NW	4.0	0.1	1.0	18.5	7	100	51
12	NW	16.0	7.6	10.4	14.0	NW	3.9	0.2	0.4	24.4	9	100	60
Background	W	26.0	6.2	10.1	9.0	NW	3.8	—	2.5	31.4	8	100	33

Table 2

Correlation coefficients between some chemical characteristics of snow and tree bark and lichen community characteristics

	Distance from the plant	Snow pH	Snow Ca^{2+}	Snow SO_4^{2-}	Bark pH	Bark Ca^{2+}	Bark SO_4^{2-}	Bark el. conductivity	Lichen coverage	Number of species	% acidophils
Lichen coverage	0.91	−0.65	−0.92	−0.91	−0.74	−0.54	−0.32	−0.49	1.00	−0.31	0.83
Number of species	−0.25	−0.63	0.08	−0.39	0.30	0.02	−0.14	0.22	−0.31	1.00	−0.15
% of acidophils	0.91	−0.91	−0.66	−0.83	−0.79	−0.80	−0.17	−0.61	0.83	−0.15	1.00

Samples of pine bark were collected and descriptions of lichen groupings made simultaneously with snow sampling. Epiphytic lichen groupings were described on sample tree boles at the height of 1.3 m from base on two sides of the bole — that exposed to the cement plant and the opposite side — using a 20×20 cm sample quadrat.

Chemical analyses of bark water extracts were conducted at the Estonian Central Laboratory of Environmental Research and at the chemical laboratory of the Tallinn Botanical Garden, Estonian Academy of Sciences, according to the standard methods of chemical analysis of water.

The chemical composition of atmospheric pollution deposition and the spatial distribution of different deposition ingredients around the Kunda cement plant have been described in different papers and are reviewed by Mandre et al. in this volume (see pp. 156—173).

The impact of alkaline dust on some aspects of the vital functions of lichens has been reviewed and discussed by us before (Нильсон and Мартин, 1982). In the present short paper, we have compared some geochemical data and the distribution of epiphytic lichens growing on pine trees around Kunda.

Table 1 represents some data on the chemical composition of snow and Scotch pine bark, total coverage of epiphytic lichens, and percentage of common (acidophilic) species for pine bark in natural areas. The Table shows that as the distance from the factory increases in the NE or NW directions, a drop in snow pH and pine bark pH, in the content of estimated ions (calcium and sulphate), and in electrical conductivity of bark water extracts occurs. A higher pH value of the bark on the side of pine bole exposed to the dust pollution source was also noticeable. At the sites nearest to the dust pollution source, the bark pH on the exposed bole side was up to 8.2, which is drastically higher than the background value (3.8) in Lahemaa National Park. On the sites of the maximum calcium content snow pH was up to 9.2, while background value was 6.2.

Although the chemical composition and pH value of snow water and pine bark reflect the composition of atmospheric deposition during different seasons and periods and partly depend on different fall-out processes, a considerably good correlation ($r=0.82$) between the snow pH and pine bark pH at the NW side of the tree bole may be observed on the NW transect from the plant.

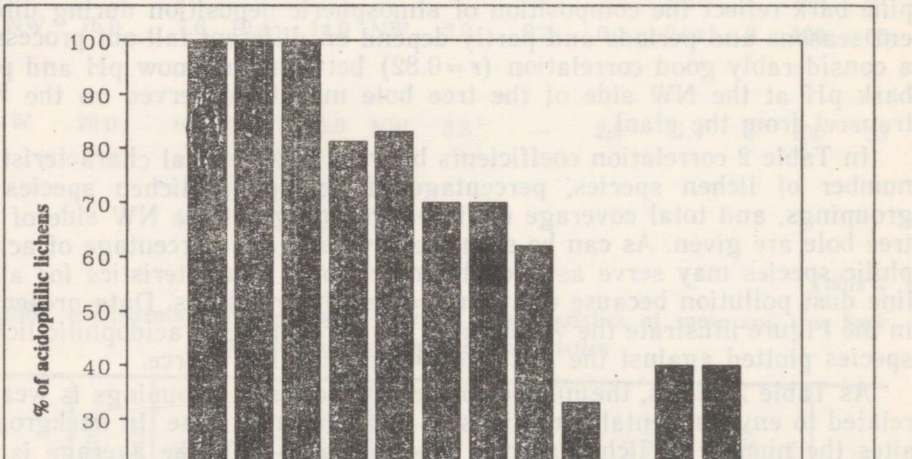
In Table 2 correlation coefficients between geochemical characteristics, number of lichen species, percentage of acidophilic lichen species in groupings, and total coverage of lichen groupings at the NW side of the tree bole are given. As can be seen the coverage and percentage of acidophilic species may serve as good bioindicational characteristics for alkaline dust pollution because of strong correlative relations. Data presented in the Figure illustrate the variation of the percentage of acidophilic lichen species plotted against the distance to the pollution source.

As Table 2 shows, the number of lichen species in groupings is weakly related to environmental conditions in this particular case. In background sites the number of lichen species amounts to 6—10 (the average is 8), all they are representatives of natural lichen flora of pine (species 1 to 15 in Table 3). As a result of a rise in bark pH when coming closer to the pollution source, these species are accompanied by new ones which, under natural conditions, can be found on the bark of broad-leaved trees. Although species more sensitive to alkaline dust (species 1 to 6 in Table 3) begin to fall out from lichen groupings, the overall number of species is still stable. As a result of a further rise of technogenic impact the number of species typical to pine is gradually decreasing and the overall number of species begins to drop. At the sites nearest to the cement plant, pine boles are covered with cement dust and only these species can be

Table 3

Distribution of epiphytic lichens on Scotch pine around the Kunda cement plant

Species of lichens	Site number												
	Background	12	11	10	9	8	7	6	5	4	3	2	1
1. *Chaenotheca ferruginea*	+	+		+									
2. *Parmeliopsis ambigua*	+	+	+	+									
3. *Bryoria* spp.	+		+	+	+								
4. *Usnea* spp.	+	+	+	+	+	+							
5. *Pseudevernia furfuracea*	+	+	+	+	+	+							
6. *Lepraria incana*		+					+						
7. *Parmelia sulcata*	+				+	+	+						
8. *Lecanora pulicaris*						+	+	+					
9. *Hypogymnia physodes*	+	+	+	+	+	+	+	+	+				
10. *Scoliciosporum chlorococcum*		+			+	+		+	+				
11. *Evernia prunastri*			+		+	+				+			
12. *Phlyctis argena*	+	+		+		+	+	+	+	+	+	+	
13. *L. expallens*		+	+	+		+	+	+			+	+	
14. *L. symmicta*					+			+	+		+	+	
15. *Ramalina farinacea*					+	+	+	+	+	+	+	+	
16. *Melanelia subaurifera*					+	+	+						
17. *Rinodina pyrina*							+			+	+	+	
18. *Lecanora dispersa*						+		+	+	+	+	+	+
19. *Caloplaca holocarpa*								+	+	+	+	+	+
20. *Physcia adscendens* & *P. tenella*					+			+	+	+	+	+	+
21. *Phaeophyscia orbicularis*										+	+	+	
22. *Xanthoria parietina*							+			+	+	+	+



Percentage of acidophilic lichen species on Scotch pine boles versus distance from alkaline dust pollution source (asterisks indicate NE part of the transect).

found on the bark which under natural conditions prefer strongly eutrophicated bark of broad-leaved trees or limestone as a substrate. The last group of species (*Caloplaca holocarpa*, *Lecanora dispersa*, *Phaeophyscia orbicularis, Physcia adscendens* + *P. tenella*, *Xanthoria parietina*) may under the given conditions be regarded as indicators of alkaline dust pollution.

The existing data on the subject allow us to make some retrospective comparisons. In 1927, floristic material was collected on the given territory by the Finnish lichenologist V. Räsänen. In his paper on Estonian lichens published in 1931 he mentioned 107 lichen taxa on the various substrates in the town of Kunda and its vicinity. Out of them 21 species were found on pine trees. At that time, species typical to pine (*Hypogymnia physodes*, *Parmeliopsis ambigua*) were still found on the territory of the town. By now, these species have disappeared even from the vicinity of Kunda. Räsänen also found nine lichen species common to eutrophicated bark growing on pine trees in Kunda (*Buellia punctata*, *Candelaria xanthostigma*, *Melanelia exasperatula*, *Pheophyscia orbicularis*, *Physcia tenella*, *Physconia grisea*, *P. distorta*, *Xanthoria parietina*, *X. polycarpa*). The lichens *Lecanora dispersa* and *Caloplaca holocarpa* whose frequency, at present, is 100% on pines within a radius of 4 km from the plant, were indicated by Räsänen to grow on other substrates — the former on limestone walls and the latter on the bark of deciduous trees and timber.

It may be concluded that the first 55 years of the operation of the Kunda cement plant altered the species composition of the lichen vegetation around it rather mildly. The following period of nearly the same duration has brought along more striking changes.

REFERENCES

Barkman, J. J. 1958. Phytosociology and Ecology of Cryptogamic Epiphytes. Van Grocum, Assen.

Du Rietz, E. 1945. Om fattigbark-och rikbarksamhällen. — Sven. bot. Tidsk., 39, 1, 147—150.

Räsänen, V. 1931. Die Flechten Estlands. — Ann. Acad. Sci. Fennicae, Ser. A, 34, 1, 1—162.

Sõmermaa, A. 1972. Ecology of epiphytic lichens in main Estonian forest types. — Scripta Mycol., 4, 1—117.

Глазовский Н. Ф., Учватов В. П. 1982. Химический состав атмосферной пыли и его изменение после осаждения на кроны деревьев. In: Взаимодействие лесных экосистем и атмосферных загрязнителей, 2. Таллинн, 67—87.

Нильсон Э. М., Мартин Л. Н. 1982. Эпифитные лишайники в условиях кислого и щелочного загрязнения. In: Взаимодействие лесных экосистем и атмосферных загрязнителей, 2. Таллинн, 88—100.

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