Monitoring Carbonaceous and Siliceous Airborne Particles in Urban and Rural Environments

Abstract

Tauber type pollen traps have been used to investigate the movement of pollen at both a regional and local scale and to calculate the quantity of pollen reaching the ground in different vegetation situations on an annual basis. These traps also collect any carbonaceous and mineral particles which are transported in the same way as pollen. In order to monitor the significance of this type of particle a trapping programme has been initiated within the city of Oulu, Finland. Five Tauber traps are located at ground level at points within the city which represent both industry and urban settlement. These will be emptied annually and analysed for quantity and type of pollen, carbonaceous and mineral particles. The results will be compared with those from four comparable type traps which are located on the roofs of buildings and are emptied monthly. A comparison will also be made with the content of six Tauber traps located at ground level on the island, Hailuoto, which is about the same size as the built up area of the town and situated due west of it, but which is entirely rural in nature. In this way it is hoped that the quantity, areal distribution and significance of man-made particles can be assessed and characteristic features, possibly traceable in recent sediments, delimited.

INTRODUCTION

The area of investigation is situated in northern Finland, within the boreal forest zone, at a latitude of 65°N (Fig. 1). An urban situation, the city of Oulu, is compared with a rural one, the island of Hailuoto. Oulu (Fig. 2), has an adminstrative area of 392.6 km^2 (which includes large areas of forest in the more outlying districts), and a population of just under 100,000. It is an industrial town and the service centre for the north of the country. In contrast Hailuoto (Fig. 3), with an area of 200 km^2, and a population of only 900, relies on agriculture, fishing and tourism for its livelihood. In both cases settlement is concentrated in one central area.

A network of traps (Hicks and Hyvärinen, 1986) located in different vegetation communities on the island have been monitoring pollen deposition

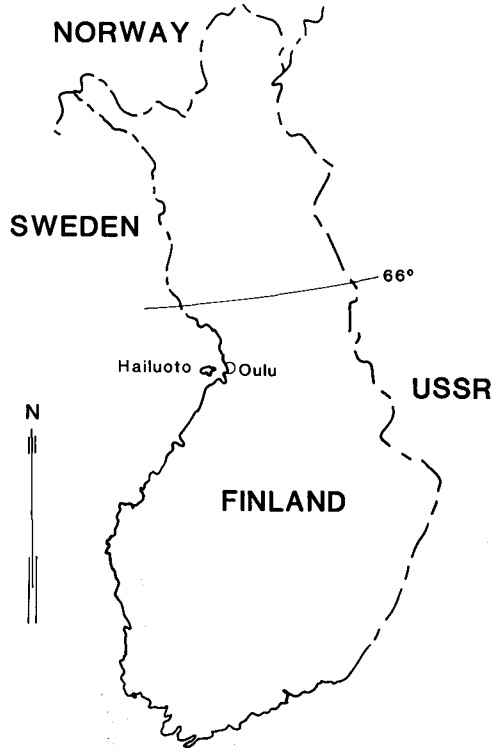

Fig. 1. Finland showing location of the city of Oulu, and the island, Hailuoto.

for some 10 years. From the results thus obtained, and from the results of a comparable network of traps in Lapland, it has been possible to obtain details of the actual amount of pollen reaching the ground in one year, the scale of movement and the distance of movement of particles of pollen grain size and, to a certain extent, the time of year when such movement is significant (Hicks, this volume). These same traps also sample other particles which are present in the air and they could very well be used to monitor the scale of deposition and distance of transport of carbonaceous and siliceous material on the same annual basis. With this in mind, a similar network has been established for the city with a view to comparing the two environmental situations.

The material presented here, therefore, is intended to illustrate a method by which an existing monitoring network can be adapted to provide information about many types of airborne particle and the extent of their presence in the cultural environment. It should be viewed more in terms of a research strategy and an assessment of potential applications rather than in terms of actual results.

METHODS

Pollen traps of the modified Tauber type have been placed at selected points in the city within both industrial (the peat-fired power station, the chemical factory and the pulp mill) and residential areas (a private garden and the University botanical gardens) as shown in Fig. 2. These traps are situated with their openings at ground level and will remain in the field all

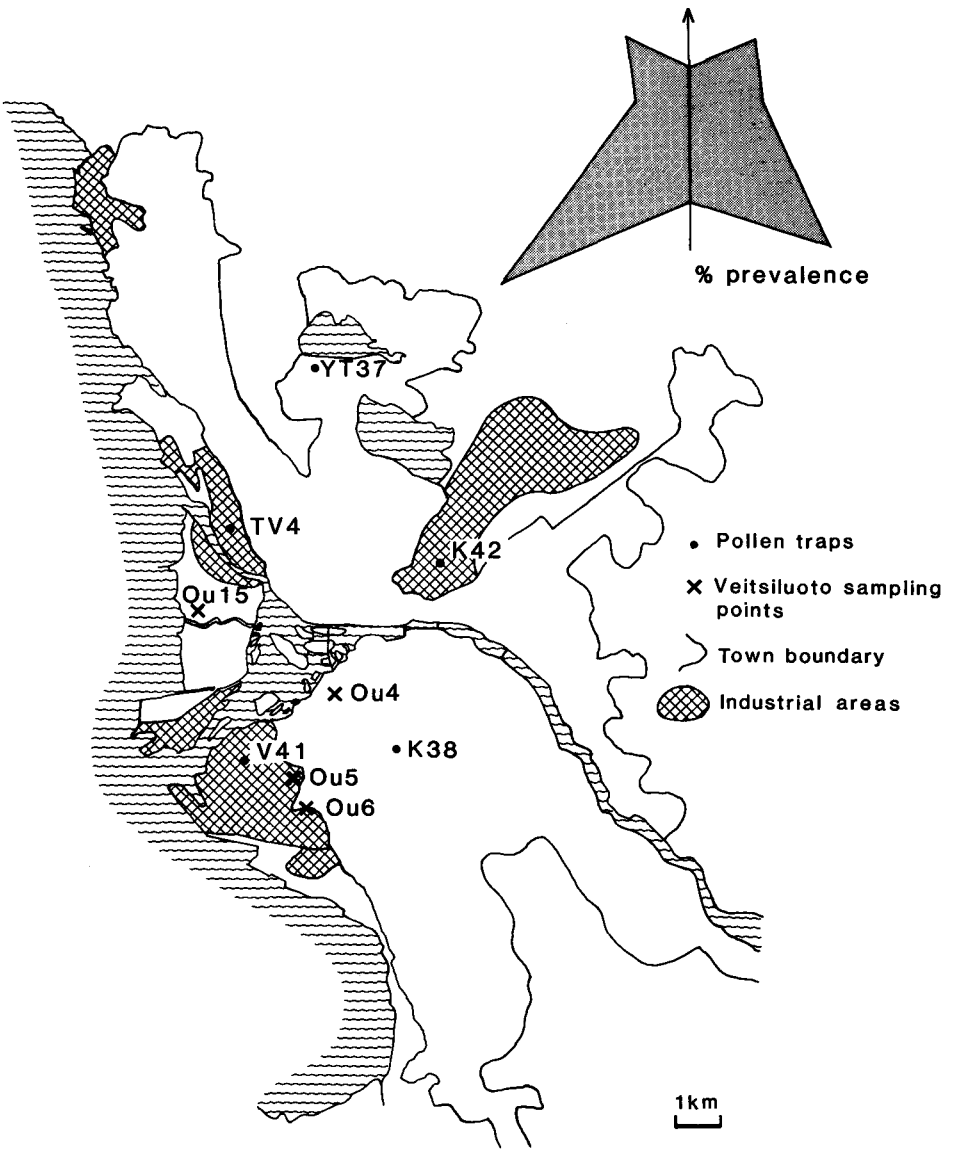

Fig. 2. The administrative area of the city of Oulu together with the location of the various traps and an indication of the prevailing wind directions in 1989.

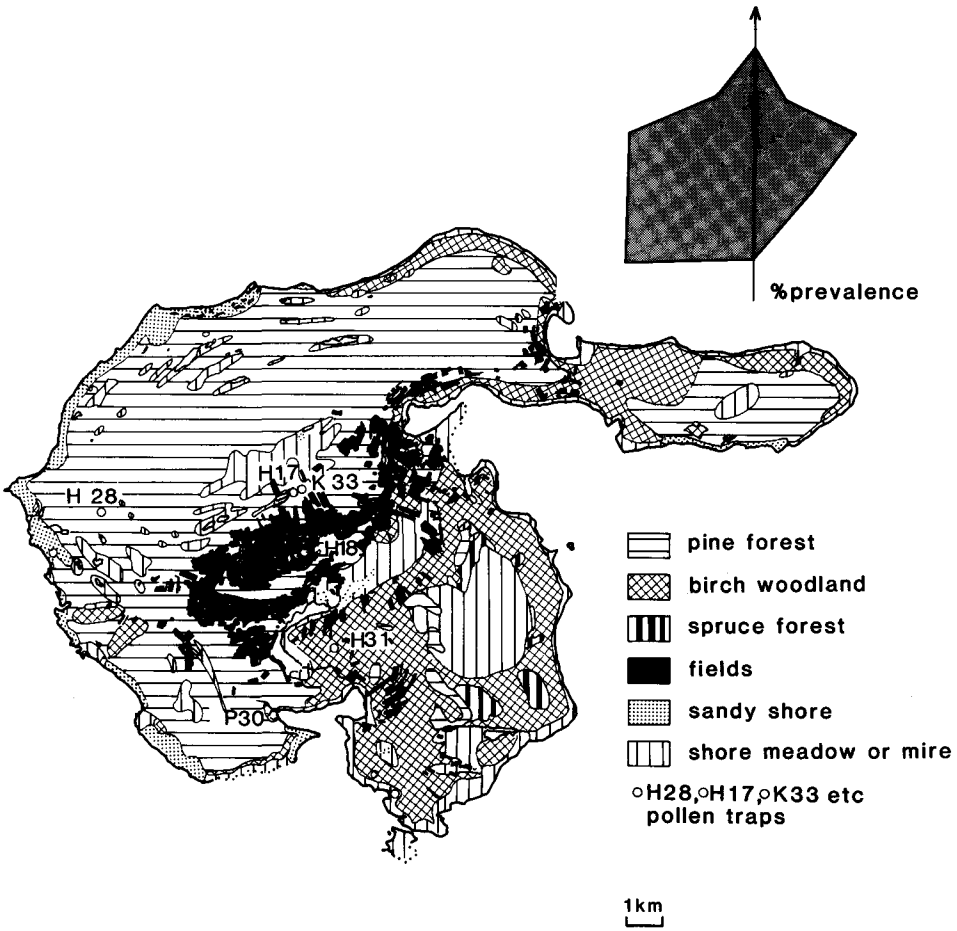

Fig. 3. The island of Hailuoto showing the main vegetation types the position of the pollen traps and the prevailing wind direction for 1989..

the year round, being emptied annually in October. Material is also available from four comparable samplers which are operated by the Veitsiluoto company in conjunction with the town of Oulu to sample atmospheric pollutants. These samplers are situated on the roofs of buildings and are emptied every month. Their relative location is also illustrated in Fig. 2. The location of the rural traps, which are at ground level and emptied annually, is shown in Fig. 3.

The aim is to analyse as many types of airborne particle as possible in order to elucidate both the area of distribution of each and the quantity involved. The following will be measured, calculated or analysed :

1. Total weight of the solid fraction deposited.

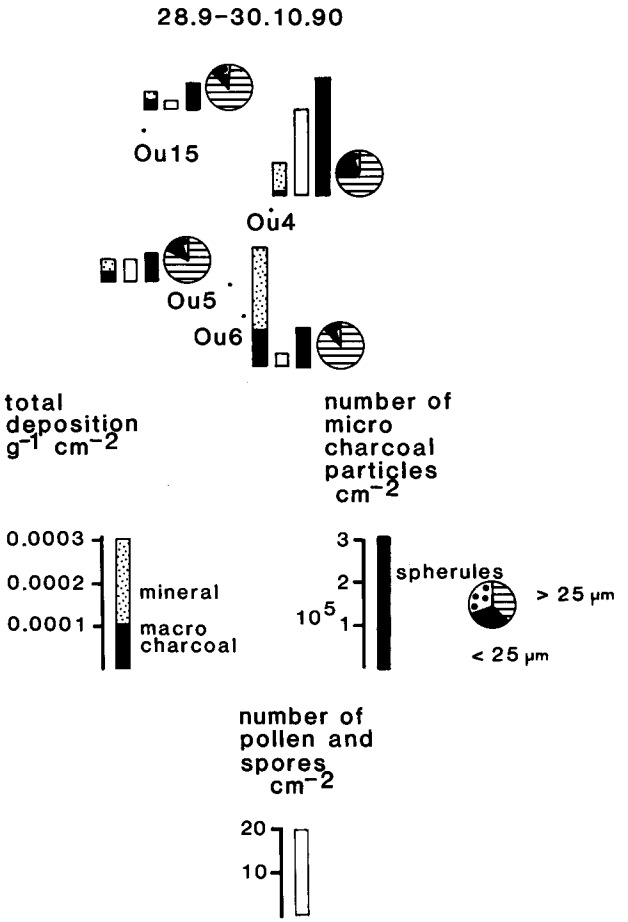

Fig. 4. Results of the preliminary analyses of the four Veitsiluoto traps for the month of October, 1990. Their relative location is as in Figure 2.

2. Macroscopic remains : seeds, fruits, leaves and needles, insects, charcoal etc.
3. Pollen (identified to taxa), spores, charcoal (in two categories, < 25 µm and > 25 µm), and carbonaceous spherules.
4. Phytoliths and diatoms.
5. The minerals comprising the inorganic fraction.

The Tauber trap results will be expressed as values cm^{-2} $year^{-1}$ and the Veitsilouto trap results as values cm^{-2} for the winter (October to April) and summer (May to September) seasons respectively. The results from the two types of trap will also be compared.

The trap contents will be compared with the land use and vegetation in the surroundings of the sampling point, taking circles of increasing radius

(20 m, 200 m, 500 m, 1 km) into account. A comparison will also be made between the annual trap values and selected climatic variables (wind direction, precipitation, temperature etc.), for the same time interval.

Discussion

The prevailing wind direction is from the south west (Figs. 2 and 3) so it is to be expected that the island will, indeed, provide a rural « control » situation with minimal influence from the city. Although, for reasons of security the industrial traps have been located within the power station/ pulp mill/factory boundary it is well appreciated that in this position they are not necessarily recording the output from these respective industries. In each case, the chimneys of the industry concerned are sufficiently tall to ensure a much wider dispersal of particles. It is the overall picture within the town as a whole, therefore, which will be relevant.

Preliminary analyses of the four Veitsiluoto traps for the month of October, 1990 show that the range of different particles outlined above can be identified and their amount calculated and that there are distict differences in particle type and quantity from trap to trap (Fig. 4).

By analysing the particle content of the air leaving each of the three chimneys it should be possible to determine indicator particle types which enable these three main sources of particle to be separated. For example, phytoliths may turn out to be specific to the power station and carbonaceous spherules to the pulp mill and a particular mineral to the chemical factory while charcoal may indicate domestic fires, and ruderal pollen the general urban environment. In this case the abundance of such indicators in the traps would give an indication of the extent of dispersal from each source. Work on pollen has so far suggested that distribution is very small scale within a closed forest but that the more open the environment the further the pollen is able to travel or, form the catchment point of view, the larger the source area of the material being deposited at any one site. It has been amply demonstrated that in the case of industrial activity, where the source is a tall chimney, the distribution area may reach hundreds of kilometres (Wik, Renberg and Darley, 1986, Wik and Renberg, 1987).

A further application would be to examine the particle content of the sediment of the two lakes in the northern part of the town and use the same indicator particle method to illustrate the extent of particle deposition at different points in time. A review of the past in this way enables a more reliable prediction for the future.

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I am grateful to the research group at Veitsiluoto Oy for kindly passing on to me their monthly samples and to both this company and the other industrial concerns in the city for allowing me to place traps on their land. The idea for this investigation received impetus from discussions with both Rick Battarbee and Ingemar Renberg to both of whom I offer my thanks. Raija Huttunen has given practical assistance with the analyses and Kristiina Karjalainen with the illustrations.

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