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Technical Information

Characteristics and Temporal Distribution of Airborne Pollen in an Urban Area of Japan

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Abstract

Using a sampling device of our own making, airborne pollen has been monitored in Kyoto, Japan from the middle of February to the end of May 2004. From the morphological analysis of pollen grains by Scanning Electron Microscope (SEM), it was possible to identify some pollen types like Cryptomeria, Pine, Alder, Cyclobalanopsis, Chamaecyparis, and Equisetum. Daily average airborne pollen counts show strong variations from the day to day which makes the appropriate daily forecasts that could be of practical use for patients difficult. Diurnal variation of airborne pollen grains at our local sampling site is very irregular and shows no similarity between pollen types. The highest concentrations of Cryptomeria and Alder pollens in the south-west wind directions might be attributed to the airborne pollen transport, while the increase in Pine pollen grain in the southern wind direction was probably due to the local spread. Prevailing wind direction (SW) during the pollinating periods of Cryptomeria and Alder pollens could suggest a long-distance transport from a distant mountain.

Key words : Pollen, Bioaerosol, Scanning electron microscope

1. INTRODUCTION

Bioaerosols are airborne particles of biological origin (e.g., bacteria, fungi, pollen, viruses). Some biological contaminants trigger allergic reactions, including hypersensitivity pneumonitis, allergic rhinitis, and some types of asthma. In Japan, one of the major causes of seasonal allergic rhinitis and seasonal allergic conjunctivitis is the Japanese cedar pollen.

Plants produce microscopic round or oval pollen for their propagation. In some species, the plant uses the pollen from its own flowers to fertilize itself. Other types must be cross-pollinated; that is, in order for fertilization to take place and seeds to form, pollen must be transferred from the flower of one plant to that of another plant of the same species. Insects do this job for certain flowering plants, while other plants rely on wind transport. The types of pollen that most commonly cause allergic reactions are produced by the plain-looking plants (trees, grasses, and weeds) that do not have showy

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flowers (Samochowiec *et al.*, 1992).

It can be considered that pollen contributes to the organic carbon fraction in TSP. In addition, the ragweed plant can produce pollen in huge quantities. For example, a single ragweed plant can generate a million grains of pollen a day. Therefore, though pollen granules are small and light, they can also attribute to the mass concentration of ambient aerosol particles during the main pollen season (Farn *et al.*, 1990).

From this point of view, to study the species of pollens, their distribution and concentration can be helpful to understand their ambient behavior and public health, etc.

This study is focused on the characterization of airborne pollen grains and their temporal distribution in an urban area of Japan

2. MATERIALS AND METHODS

2. 1 Collection

For the sampling of the freely falling pollen grains, a plane sampling stage (185 × 185 mm) consisted of four-Petridish (80 mm diameter) and 1.2 m height legs which was designed in this study, was set-up outside for 24-h. To reduce pollen bounce by wind, the polyethylene wall with 1.5 m height was installed around the sampling stage. Sampling of pollen grains was performed at height of 25 m above ground level of a Kyoto University building from the middle of Febuary to the end of May 2004. During sampling period the range of daily average wind speed was 0.9 ~ 3.4 m s^{-1} and wind was blowing from all directions. The temperature and relative humidity were around 3.6 ~ 25.1°C and 30.7 ~ 85.0%, respectively. Sampling procedure consisted of placing a non-hole carbonate filter (Nuclepore filter) onto the 80 mm diameter petridishes that were installed on sampling stage. And then, pollen grains were allowed to settle on the surface of the Nuclepore filter. The samples for 31 days were collected during our campaign period.

2. 2 Identification and numbering

The SEM is revealing new levels of detail and complexity in the amazing world of micro-materials and miniature structures. SEM can also provide specimen number concentration and size distribution. The SEM creates the magnified images by using electrons instead of light waves (Martin and Drew, 1969; Farn *et al.*, 1990).

In this study, for the purpose of observing and measuring the morphological and physical properties of airborne pollen grains, a SEM (HITACHI S-2000) was employed. The procedures of sample pretreatment and SEM analysis are as follows: Samples are coated with a very thin layer of platinum by a machine called a sputter coater. Samples have to be prepared carefully to withstand the vacuum inside the microscope. The sample is placed inside the microscope's vacuum column (10^{-6} Torr) through an air-tight door. The working condition of SEM was 15 ~ 20 kV.

Several tens of filter pieces from a whole filter (80 mm diameter) have to be pretreated by a sputter coater because the area of sample stage for SEM examination is too small. As a result, the countering of pollen grains using SEM is very time consuming. Hence, after finishing the species identification of pollens by SEM, pollen species were also microscopically (KEYENCE, VH-7000) distinguished. And then each kind of pollen deposited on four-Petridish (80 mm diameter) counted under the 450x magnification for whole field.

3. RESULTS AND DISCUSSION

3. 1 Morphological description

SEM images of several types of pollens are shown in Photo 1. Classification of pollen grains using SEM was based on morphological characteristics such as shape, size, apertures and ornamentation. The combination of these characteristics makes some pollen grains easily identifiable. However there were also pollen grains sharing several common characteristics that makes identification difficult. Since the source plant of several pollen grains was not determined with certainty, six identified pollen grains are reported here. Each pollen has

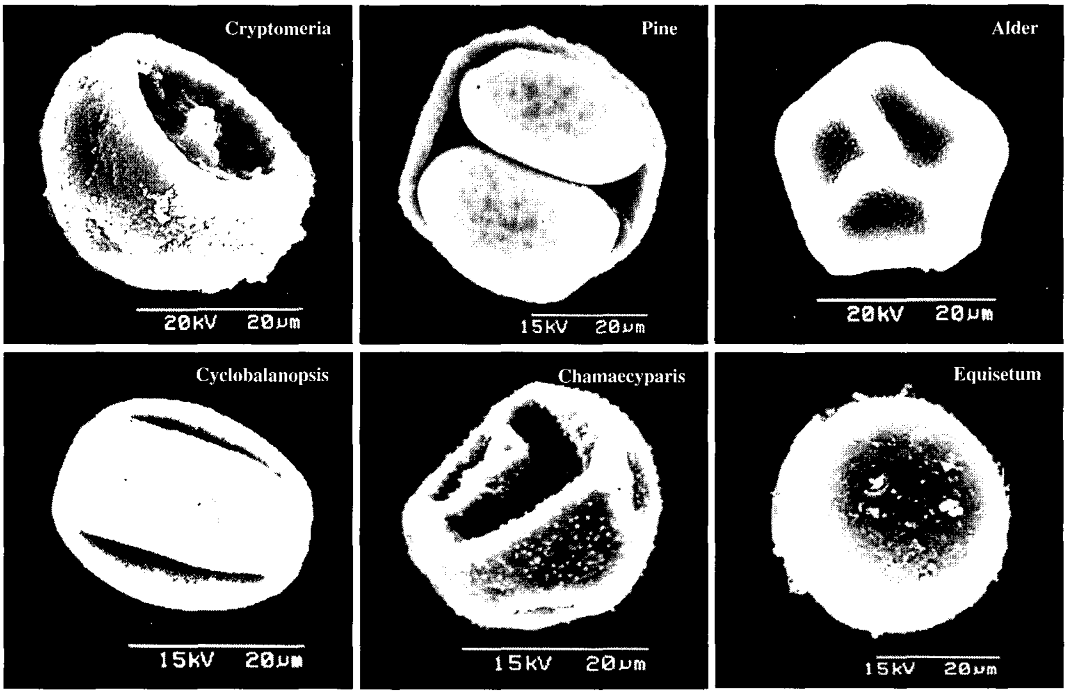

Photo 1. SEM images of several types of pollens.

peculiar shape with fine structure of surface. The airborne pollen grains have various sizes between 20～50 μm.

The size, shape, exine sculpturing and the number and type of apertures are the most common features used to identify pollen grains. The size of a pollen grain is easy to determine. Pine pollen shows the largest size (about 50 μm) among the identified types here. On the other hand, alder pollen has size around 20 μm. Although it is easy to determine the size of a pollen grain, identification of pollen by its size has many drawbacks. Because sizes cited in the reference books may vary as a result of numerous factors including water content and the age of the grains measured. Pollen size can also change with geography, length of flowering period, temperature and availability of water (Thompson, 1990).

The shape of pollen grains is also a feature that varies greatly and is only useful and reliable for pollens that have distinctive shapes. Equisetum and Alder pollens have the complete spherical and pentagonal shapes, respectively. On the other hand, Cryptomeria and Chamaecyparis pollens show the hemispheric shape. However, as with size, the shape of pollen can be altered by adhesive and mounting mediums. For example, spheroidal grains can appear ellipsoidal if not fully hydrated, and ellipsoidal grains can appear spheroidal if over-hydrated. Apertures are openings in the exine that permit the exit of compounds held in the intine. Germinal apertures that are used in pollen identification are described as either pores or furrows. In the case of Cyclobalanopsis has the dicolpate with the two furrows. Some pollen grains, for example Pine, have a small, circular cap or lid of wall material that covers the center of the aperture. This cap is referred to as an operculum. Often the opercula fall off the pollen grains during air transport.

3. 2 Diurnal fluctuation

The time series variations in airborne pollen grains, especially with respect to daily concentration

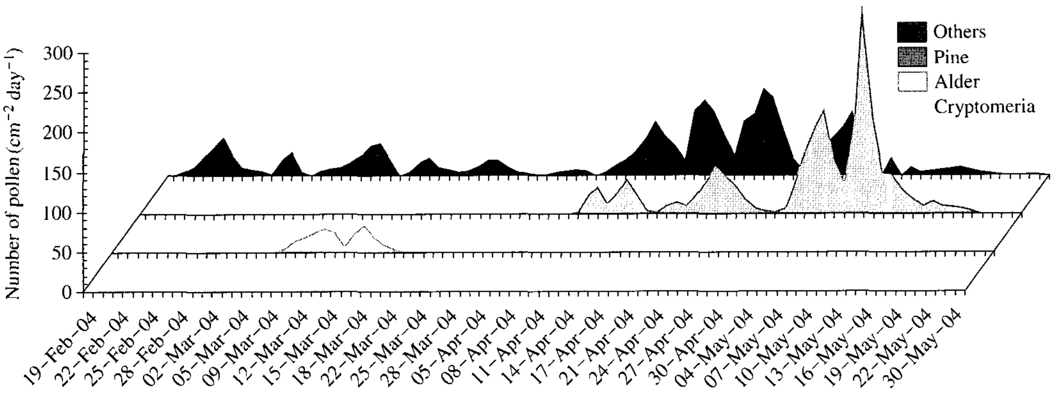

Fig. 1. Diurnal fluctuation of airborne pollen in Kyoto, Japan.

levels and number of days with high pollen counts are certainly of importance for patients suffering from pollinosis (Kofol and Cegnar, 2002). Fig. 1 shows the diurnal fluctuations of airborne pollen in Kyoto, Japan. The plotting pollen counts as a time-series allow a direct comparison with pollen calendars. The fluctuations in daily concentrations of atmospheric pollen presence are shaped for every pollen type.

Pine pollen took place from April 13 and May 22 with the occurrence of maximum concentration values on May 11. Pine is a tall coniferous tree with a blackish bark and irregular or flattened dense crown. It occurs in forests, is often planted for timber and survives dry, sandy soils or mountainous areas. It is becoming rare because this pine often becomes infected by a severe fungus disease. Pinus is the most variable, widespread and valuable member of the conifers.

Cryptomeria (Japanese cedar, also called the Sugi tree) pollen disperses in advance of other pollens in the first half of the pollen season with the maximum concentration around the middle of March. Cryptomeria is an evergreen growing 30 to 50 meters tall. Its needles shift from a pale opal in the summer to bright red towards the autumn. It is the most important timber tree in Japan where about one-third of the area under cultivation is devoted to it. Japanese cedar pollen is the most common allergen for seasonal allergic rhinitis in Japan.

Alder pollen is present in relatively short period from Mar 6 until Mar 23. Alders are wind pollinated, so production and dispersal are very good. Alder pollen is common in the northern hemisphere.

There are very large variations in total daily amounts. In whole microscopic field for total types, 1,260 pollen grains were counted. Of these, 226 of pollen belonged to Cryptomeria pollen, 23 to Alder pollen, 542 to Pine pollen and 469 to others. Pine pollen (43.0%) was the chief constituent of the airborne pollen around our local sampling site. Followed by Cryptomeria (17.93%), other types of pollen (37.2%) and Alder pollen (1.8%). The daily total pollen concentration was higher between the middle of April and the middle of May.

It can be thought that the atmospheric presence of these pollen grains can vary depending on the plant, actual weather situation (mainly air temperature and precipitation) and pollinating period.

3. 3 Relation to weather situation

Plants manufacture small, light, dry pollen granules that are scattered in the wind (Stach and Silny, 2000). Because airborne pollen is carried for long distances, the pollen counts are examined in relation to wind direction. Fig. 2 shows the distribution of total pollen as a function of wind direction. Wind direction was monitored with a wind vane with an accuracy of 5° for wind speeds greater than 0.7 m s^{-1}.

The highest reported concentrations of Cryptomeria

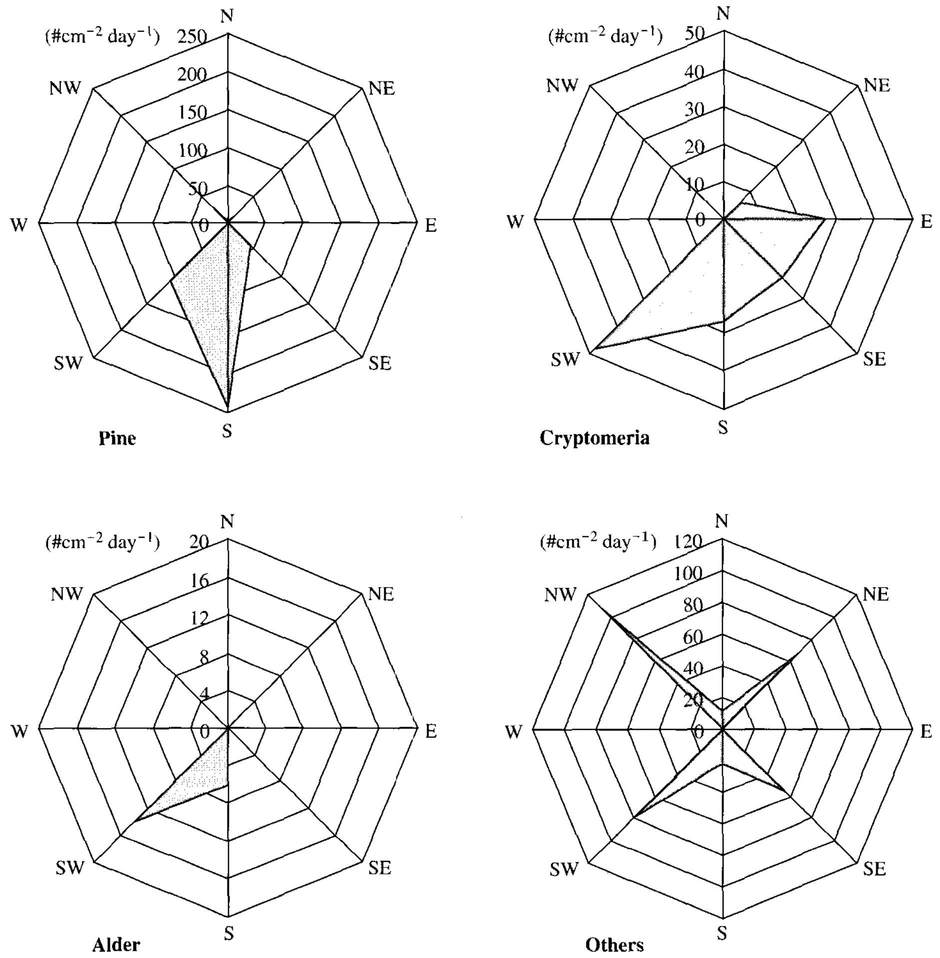

Fig. 2. Distribution of total pollen as a function of wind direction.

and Alder pollens are usually connected with the south-west wind directions. It suggests that the Cryptomeria and Alder pollens were driven from the mountainous areas of the south-west part of Kyoto. While, in the case of Pine, pollen grains show the main distribution when air parcel came from south. Though we mentioned above that pollen grains are light, however, pine pollen is relatively heavy. Hence, it tends to fall straight down and does not scatter. It could therefore be suggested that Pine pollen derived from the vicinity of sampling site. As might be expected, other types of pollen were affected from the transport of various kinds of airborne pollen from all directions.

The data concerning daily concentrations enable not only the construction of regional pollination graphs, but also the calculation of preliminary statistics with the other independent variables such as weather conditions (Rodriguez-Rajo *et al.*, 2000). A variety of meteorological parameters influence pollen production, pollen release and dispersal. In order to consider a counterplan for pollen, to know the relationships between airborne pollen concentrations and meteorological parameters is indispensable. The pollen counts are examined in relation to wind speed, relative humidity and temperature in

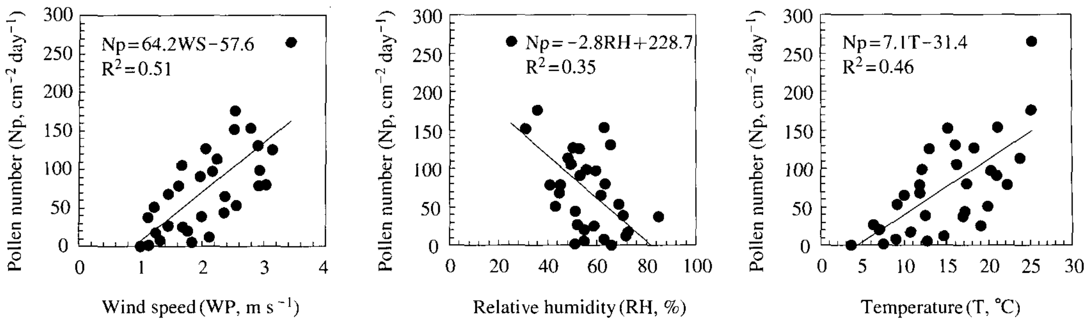

Fig. 3. Relationships between airborne pollen concentration and meteorological parameters.

Fig. 3. For the measurement of wind speed, an anemometer (EKO MA-110) with the range of 0~60 m s^{-1} was used. Ambient temperature and humidity were measured by a thermo-hygrometer. As might be expected, the pollen number concentration has a positive correlationship with wind speed and temperature. Whereas there is a negative correlationship between the pollen number concentration and relative humidity. An analysis of simple regression between pollen concentration and selected meteorological parameters does not show the high correlationship. This result seems to indicate that other parameters also play a considerable part in generation of pollen grain. As described earlier, the presence of pollen grains can vary depending on the plant (i.e. biological parameters). The main pollination period, seasonal pollen trend and main pollen sources undoubtedly have also relevance to pollen concentrations.

4. CONCLUSIONS

To know the species of pollen grains, their temporal distribution and ambient concentration is very important to understand their ambient behavior and public health.

This study was intended as an investigation of the physical properties of airborne pollen grains and their temporal distribution. Six kinds of pollen grains were apparentely identified from their peculiar shapes. The diurnal analysis of the appearance of total pollen population shows the peak concentrations between the middle of April and the middle of May. It could be suggested that the pollen production and emission factors are related to biological parameters rather than meteorological conditions. The temporal variation fo pollen obtained from this study can be used as well by the palynologists, by the clinicians or by a forecast system to predict pollen dispersion. However, to cope with the pollen problems (environmentaly and healthly), it is necessary to continue not only the monitoring of airborne pollens but also the monitoring of the spread of the source plants.

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