

POLLEN ALLERGEN CONCENTRATIONS IN A PRE-SCHOOL BUILDING AND A DAY-CARE CENTRE

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ABSTRACT

This present paper focuses on pollen allergens in children's environments. A field study was conducted in one pre-school and one day-care centre. Concentrations of birch pollen allergens were measured simultaneously indoors and outdoors, using sampling pumps equipped with membrane filters. Analysis of the data was done by means of the ELISA method. The results showed that the allergen concentrations indoors were influenced by the indoor activity and ventilation. The indoor/outdoor pollen allergen concentration ratio was about twice as high with indoor activities and with the ventilation system on compared to the case without indoor activities and ventilation. The measurements showed a significant increase of indoor pollen allergen levels caused by the open windows, ventilation and indoor activities when the pollen concentration in the outdoor air was above 1 ng/m³.

INDEX TERMS

Pollen allergens, Day care centre, Children, Field measurements, Indoor air.

INTRODUCTION

In recent years the number of people suffering from allergies caused by pollen exposure has increased considerably. Pollen allergens in the ambient air can lead to serious symptoms of rhinoconjunctivitis and asthma in afflicted subjects, and have recently been demonstrated to be a risk factor for respiratory-disease mortality (Brunekreef et al. 2000). Although pollen allergens originate outdoors, they can be transported to the indoor environment through ventilation or on clothes, which mostly can occur during the pollen season (Pehkonen et al. 1993). In late spring, when the pollen-flowering season starts, the concentration of pollen particles in the outdoor air reaches its highest rate. The variations from day to day are highly influenced by local meteorological conditions (Dahl and Strandhede 1996; Rantio-Lehtimäki et al. 1994). Temporarily, when the windows are left open, it is possible that the indoor concentrations of pollen allergens may be as high as the outdoor.

Convincing evidence has accumulated showing that pollen allergens, once introduced to the indoor environment, remain in settled dust a long time after the end of the pollen season (Kvernes et al. 1999). The most sensitive group to be affected by the adverse effects of pollen allergens are young children because of less immunity to respiratory infections and immature lungs (Samet et al. 1991). Therefore, preventing the indoor environment from the pollen allergens exposure is of great importance where young children are present. A ventilation system equipped with a common fine filter removes between 95 and 99% of birch pollen allergens, depending on the filter class (Ekberg et al. 2000).

However, the information available about pollen allergen concentrations indoors remains limited. Only a few studies have been carried out in children's environment (Kvernes et al.

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1999, Holmquist and Vesterberg, 1999). Thus, more information about the pollen allergen concentrations and transport is needed.

This paper focuses on birch pollen allergens in two buildings where young children spend most of their days. The aim is to examine and clarify the relationship between outdoor and indoor birch pollen allergen concentrations. The attention is concentrated on the effect of indoor activity, ventilation system and weather conditions. The results from both a day care centre and a pre-school are presented here. As mentioned, the study is based on birch pollen allergens and pollen grains were not measured. However, it is known that each pollen grain contains about 6 pg of pollen allergen (Schäppi et al. 1997).

METHODS

During the pollen season in April-May 2000, airborne birch pollen allergens were sampled in the indoor air. Two series of measurements were carried out, one in the pre-school and another in the day-care centre. Simultaneously with indoor measurements samples were collected outdoors. In both cases 5 sampling pumps were used. Typically 3 of them were located in the indoor environment and the other 2 outdoors. All the samples were taken during the daytime. The data about indoor activities throughout the measurements were recorded, as were the characteristics of the ventilation system in each building. Daily weather data were supplied by the authorities of weather station in Gothenburg. For measuring the pollen allergen concentrations, air-sampling vacuum pumps of the GilAir Sampler (Gilian Instruments Corp.) type and Airchek Sampler model 224-PCXR7 (SKC Inc.) were used. Each pump was wrapped in foamed plastic in order to reduce the noise level. The air flow of these pumps was adjusted at 2 litres per minute. Birch pollen allergens were collected on membrane filters (Millipore AA), which were analysed by an ELISA technique. The analysis was carried out at the Allergy Laboratory, Sahlgrenska University Hospital, in Gothenburg.

In the day care-centre, measurements were conducted within a 7-day period in May. Sampling durations varied from 4.7 to 11.1 hours. The earliest sample was taken at 7.30 am and the latest sampling record was at 20.30. Pollen allergen concentrations were measured in 5 different locations simultaneously. There was only 1 permanent outdoor location placed near the main entrance. Other locations used for measuring the outdoor pollen concentrations were situated on the opposite side of the building. For the indoor sampling four different locations were chosen: the hall, the playroom, the kitchen and close to the supply air inlet. In the indoor environment the most frequently measured sampling point was located in the playroom, where allergens were collected 1.5 meters above the floor.

The building was ventilated by a mechanical ventilation system. A coarse particle filter was used for filtering the outdoor air. The ventilation system was adjusted to be in operation only on workdays from 4.30 am in the morning until 7.00 pm.

In the pre-school the measurements were performed in April and May. The sampling durations in a day varied from 4.2 to 11.7 hours. Similarly to the day care-centre, measurements were made simultaneously in several locations. The indoor sampling locations were: near the supply air inlet, in the middle of the room and close to a wall opposite to the supply air device. Indoors, the membrane filters were positioned 2.5 meters above the floor. For measuring the pollen concentrations in the outdoor air, two sampling devices were placed close to the air intake outside the building.

The pre-school is a building with large dimensions of the supply air channels without any particle filters. The air change in the monitoring room is provided by a mechanical exhaust air system, which is in operation 24 hours a day even on weekends.

RESULTS

Allergen concentrations in the day-care centre

In May 2000, when measurements were carried out in the day-care centre, the weather was sunny and the wind speed varied from 2 to 3.5 m/s. The relative humidity showed small differences between the days (see Table 1). There was no rain prior and during measurements.

Table 1 Birch pollen allergen concentrations recorded during the day care centre measurements, together with information about the operational status of the ventilation system, children’s activity and meteorological conditions.

Day	Vent. system	Indoor activity	Windows position	Indoor/outdoor ratio of pollen allergen	Temp. °C, aver.	Relative humidity %, aver.
May10	Off	Low	open	0,68	15.5	53
May11	Off	Low	sligh.open	0,41	16.5	54
May12	On	High	closed	0,47	15.7	44
May14	Off	No	closed	0,26	10.3	68
May16	On	High	open	0,80	14.7	52
May20	Off	No	closed	0,76	12.6	68

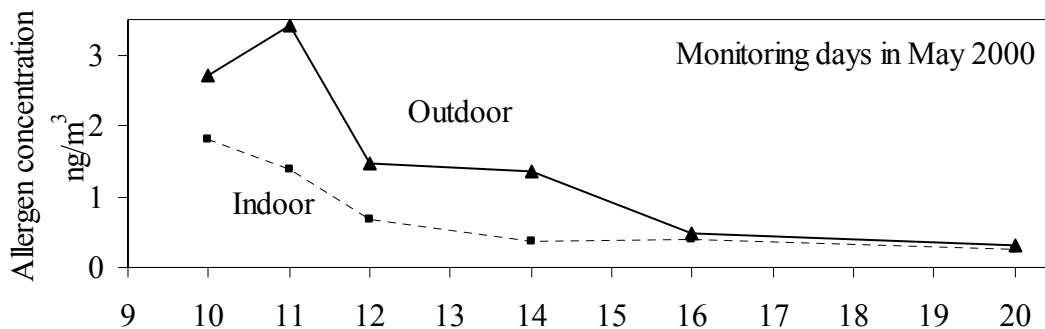


Figure 1 Birch pollen allergen concentrations measured in the day care centre reported as the average values from different outdoor (solid line) and indoor (dashed line) locations, respectively.

The concentration of pollen allergens in outdoor air showed high levels in the beginning of measurements, peaking on May 11th. Until May 20th May the concentration decreased gradually reaching its lowest level on May 20th with a value of 9 % of that of May 11th as depicted in Figure 1. The indoor pollen concentrations were lower than those outdoors. Though, on May 16th and 20th, the amount of pollen allergens indoors was identical to that outdoors. The highest pollen particle concentration indoors, about 70% of the outdoor level, was measured on May 10th. From that day, the amount of pollen allergens decreased rapidly until May 14th. On May 16th there was a small increase compared to the previous level.

The indoor allergen concentration ratios varied from 26 to 80 % (see Table 1). A comparison of the first two days, 10th and 11th May, shows a lower I/O concentration ratio on the 10th of May. On both days the ventilation system was off and indoor activity was described as low. However, there was a difference in the position of windows, with the windows being more

open on May 10th than on the 11th. A significant difference was found between the 12th and 16th of May as an effect of low pollen levels on May 16th. On the 14th and 20th of May the indoor activity and the ventilation characteristics were the same, but the I/O ratio showed a considerable difference. It should be noted that the outdoor concentration was very low (about 0.5ng/m³) on May 20th.

Allergen concentrations in the pre-school

During the measurements on April-May 2000 in the pre-school there were some changes in the weather conditions. On the second day the weather was rainy and a small amount of rain was also falling on the 7th day. As shown in Table 2, when it was rainy all day the relative humidity was unusually high. On the 7th day, the rain did not have significant influence on the humidity. The wind speed varied from 1.8 to 3.2 m/s.

Table 2 Birch pollen allergen concentrations recorded during the pre-school measurements, together with information about the operational status of the ventilation system, level of indoor activity and meteorological conditions.

Day	Vent. system	Indoor activity	Weather conditions	Indoor/outdoor ratio of pollen allergens	Temp. °C, aver.	Relative humidity %, aver.
April21	On	No	Sunny	0,03	12.5	68
April24	On	No	Rain	1,22	10.6	97
April26	On	High	Sunny	0,03	12.3	63
April28	On	No	Sunny	0,18	18.9	61
May1	On	No	Sunny	0,13	21.5	61
May2	On	Low	Sunny	0,51	20.8	48
May3	On	Low	Little rain	0,41	17.6	60
May4	On	High	Sunny	0,33	12.5	60
May5	On	High	Sunny	0,38	11.0	62
May7	On	No	Sunny	0,46	12.4	50

On April 21st, the measurement started with low pollen allergen concentration in the outdoor air. The lowest concentration was recorded on April 24th as seen in Figure 2. Until the 1st of May the outdoor pollen concentration showed a considerable increase reaching the highest level together with a rise of temperature. On May 2nd the concentration of birch pollen allergens started to decrease gradually until May 5th, close to a value observed on the 26th of April. On the 7th of May the outdoor allergen concentration showed an increase compared to the previous days as depicted in Figure 2.

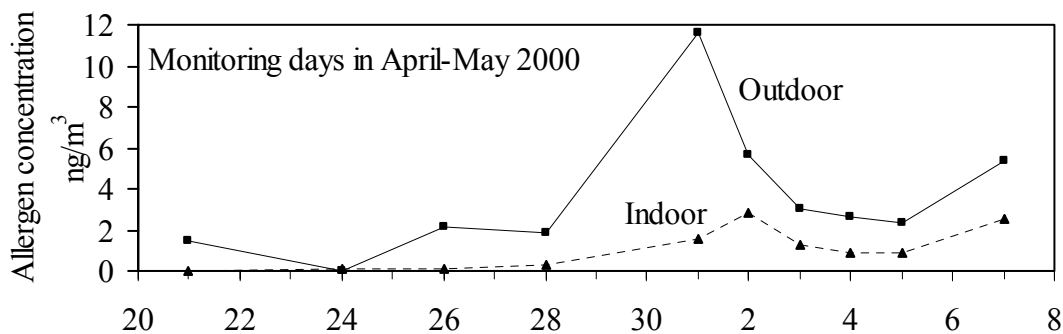


Figure 2 Birch pollen allergen concentrations in the pre-school reported as the average values from the different outdoor (solid line) and indoor (dashed line) locations, respectively.

The pollen allergen concentrations in the indoor air were almost zero on 21st, 24th and 26th of April. On 26th of April, the concentration started to increase slowly until the 2nd of May. Until the 4th of May the indoor allergen level decreased down to 1 ng/m³. On the 7th of May there was a little increase compared to the previous level. The highest pollen allergen concentration in the indoor environment, about 50% of the outdoor level, was measured on May 2nd as seen in Figure 2. The last five measurements show a clear correlation between the indoor and outdoor pollen allergen concentrations.

The indoor pollen allergens concentrations during the pre-school measurements varied from 3 to 122 % of those outdoors. A comparison between the 21st and 28th of April as well as the 1st of May showed that the amount of pollen allergens indoors was less than 20% of that outdoors. Common for these days was that there was no indoor activity.

The highest I/O ratio, more than 1.2, was calculated in April 24th. On that day the amount of pollen allergens both in the indoor and outdoor air were at the lowest level. During the measurements between the 2nd and 5th of May, when the indoor activity level varied from low to high, the indoor concentrations were between 33% and 51% of those outdoors. There were two exceptions, on 26th of April and 7th of May, where the previously mentioned correlations between indoor activity, ventilation operation and outdoor concentrations could not be seen.

Figures Figure 3 and Figure 4 show a summary of the results obtained in the day-care centre and pre-school studies. The measurements carried out with in the same setting of various parameters were grouped, and then the average I/O concentration ratio for each group was calculated.

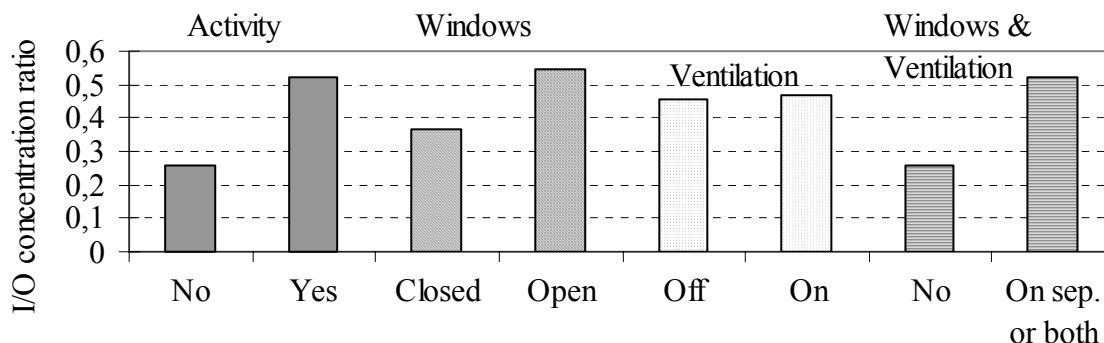


Figure 3 The average I/O concentration ratios have been calculated for various groups of parameters obtained in the day-care centre measurements.

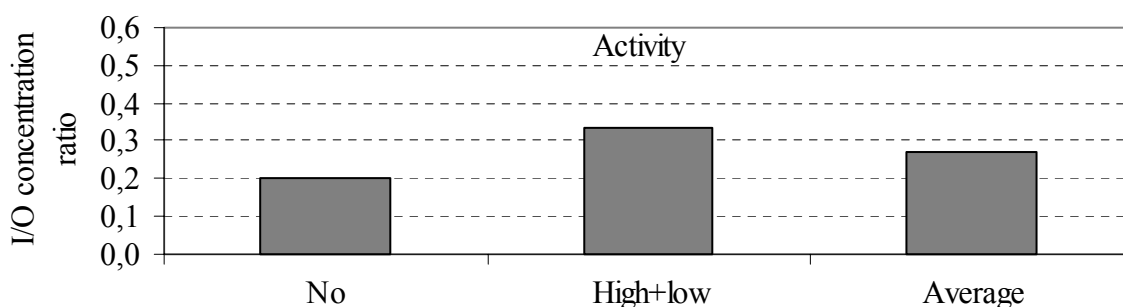


Figure 4 The average I/O concentration ratios based on the activity levels obtained in the pre-school measurements.

DISCUSSION

The present study, conducted during the pollen season in April-May 2000, showed that the birch pollen allergen concentration in the indoor air of children's environments increases due to indoor activities and open windows (see Figure 3). This reflects a more efficient transport and dispersion of pollen particles into the room, as suggested previously (Pehkonen, et al. 1993). The measured concentrations of pollen allergens indoors were correlated to the concentrations in the outdoor air, especially when outdoor pollen allergen concentrations were above 2 ng per cubic meter. The amount of birch pollen allergens indoors varied up to 2.8 ng/m³. Since the actual pollen counts were not measured, only an approximate estimation can be made using previously gathered data. The number of birch pollen grains in the South of Sweden alternates during the season typically in the range 50-1000 pollen/m³ (Dahl and Strandhede, 1996).

CONCLUSION

- The concentration of birch pollen allergens were substantially lower indoors than outdoors
- The I/O birch pollen allergen concentration ratio was about twice as high with indoor activities compared to the case without indoor activities.
- The I/O birch pollen allergen concentration ratio was about 50% higher with open windows compared to the case with closed windows.
- A further decrease of the I/O concentration ratio was observed when windows were closed and the ventilation system was out of operation.

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