CHARACTERIZATION OF AEROALLERGEN CONCENTRATIONS IN INDOOR AND OUTDOOR MICROENVIRONMENTS

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Abstract

Relatively little is known about indoor and outdoor microenvironmental concentrations of aeroallergens, or about the relationships between them. Consecutive 12-hour samples of airborne pollens and spores were collected simultaneously at two fixed site ambient air monitoring stations and inside and outside of each of 12 houses during the period June-October in Houston. Outdoor concentrations of pollen were spatially less heterogeneous than those of spores, and showed greater seasonal and diurnal variation. Indoor levels of both pollen and spores were uniformally lower than outdoor levels for all 12 air-conditioned homes, with indoor pollen counts on average 30% of outdoor values, and indoor spore counts on average 20% of outdoor values.

Introduction

The important influence of diverse indoor and outdoor microenvironmental concentrations of air pollutants on personal exposures has become recognized in recent years (5,7). However, most of the information on microenvironmental exposures is limited to regulated chemical pollutants. Comparatively little is known about the microenvironmental heterogeneity of biogenic aeroallergenic species such as pollens and mold spores, which have been clearly implicated in disorders such as allergic rhinitis, asthma, and other allergic conditions (3).

As part of the exposure assessment component of an air pollution health effects study (2,6), parallel residential indoor/outdoor measurements and fixed site ambient air monitoring of pollens and spores was performed over a five-month period (June-October, 1981) in Houston, Texas. An analysis of the monitoring data with regard to indoor/outdoor differences and the representativeness of fixed site measurements is presented here.

Methods

Consecutive 12-hour samples of aeroallergens were collected throughout the study using intermittent rotorod samplers (Ted Brown Associates, Los Altos Hills, CA) at two fixed site air monitoring stations. Each fixed monitoring site was centrally situated within one of two study neighborhoods. The Clear Lake (CL) study area is approximately 26 km (16 mi) southeast of the Sunnyside (SS) area. Parallel measurements were

performed inside and outside twelve study subject homes, for a period of approximately one week at each home. Each home was located within 4 km (2.5 mi) of one of the fixed monitoring sites. Eight homes were in the Clear Lake area and four were in Sunnyside. The sampling periods were divided into daytime (7 a.m. to 7 p.m., CDT) and nighttime (7 p.m. to 7 a.m.) periods. Additional details concerning description of study sites, monitoring protocol, house selection, and data validation have been given elsewhere (6).

After sampling, the silicone-coated glass rods were sent to an experienced laboratory (Pollen Research Associates, Inc., San Mateo, CA) for microscopic analysis. Total pollen and total spores were differentiated and counted. Although the number of pollen and spore species in each sample was qualitatively reported, there was no attempt to conclusively identify nor quantify individual species.

The monitoring data set employed in these analyses was derived only from the periods during which simultaneous residential and fixed site measurements occurred. Appropriately matched data subsets were used for all comparisons.

Results and Discussion

The five-month study period included one of the characteristic seasons of elevated levels of airborne allergens along the upper Texas coast of the Gulf of Mexico. During September and October high pollen counts are typically dominated by ragweed pollen. Moderately elevated concentrations of mold spores may also be expected during this time because of increased rainfall relative to the preceding dry summer months. Temporal sequential plots of the aeroallergen data from the fixed site samplers in this study confirmed the expected strong seasonal influence on the measured concentrations, especially for pollen (6).

Table 1 presents a summary of the pollen and spore concentrations measured at the Clear Lake fixed monitoring site, stratified according to both season (June, July, August vs. September, October) and day/night sampling intervals. The data subset employed for this analysis consisted of matched data pairs from the two fixed sites.

Table 1: Seasonal and diurnal variations in geometric mean concentrations of pollen and spores at the CL fixed site (counts/m3).

	Pollen			Spores		
	N	Xg	SDg	N	Xg	SDg
June-Aug.						
Day	51	18.4	1.77	51	862.6	1.72
Night	39	5.3	2.58	39	678.6	2.29
Sept.-Oct.						
Day	36	98.5	3.78	36	1188.0	1.54
Night	27	19.7	2.41	27	1002.2	1.99

Distributions of both pollen and spores from this study appeared to be better characterized by log-normal than by normal distributions, so geometric statistical parameters have been employed here, and all tests of statistical significance have been performed with log-transformed data. It is clear from Table 1 that both diurnal and seasonal variations were much greater for pollen (3-5X increase) than for spores (20-50% increase), although all differences were statistically significant, according to T-test results ($p < 0.001$ for overall day/night and season comparisons of pollen concentrations, and for season comparison of spore concentrations; $p < 0.05$ for day/night comparison of spore levels). Similar patterns were found with the Sunnyside fixed site data. Overall, spore concentrations at Sunnyside were significantly lower than at Clear Lake ($p < 0.001$); pollen concentrations were also slightly lower, but not significantly ($p = 0.19$).

The outdoor spatial heterogeneity of airborne pollen and spores over community-scale distances was also investigated. Data subsets in which outdoor measurements at the houses in each neighborhood were matched with measurements at the fixed site for that neighborhood, along with the matched CL/SS subset used previously, were employed for linear regression analyses. The results are summarized in Table 2. House data were regressed on the appropriate fixed site data for the intra-neighborhood analyses, while SS data were regressed on CL data for the inter-neighborhood analyses. These analyses are summary regressions, employing both day and night measurements from the entire five-month study period.

Table 2: Linear regression parameters for analysis of paired outdoor measurements.

	Pollen				Spores			
Y/X	N	Coeff.	Int.*	R	N	Coeff.	Int.*	R
House/CL	106**	0.55	1.4	0.94	107	0.49	148.5	0.56
House/SS	58**	0.89	5.2	0.96	59	0.64	195.0	0.64
SS/CL	153	1.05	5.4	0.79	153	0.27	406.2	0.41

* Units for intercepts are counts/m3.
** One extreme data pair (outlier) deleted from data subset for this analysis.

In each of the original house vs. fixed site regression plots for pollen, there was identified one extreme outlier data pair with an atypically high ratio of house to fixed site concentration. No such obvious outliers were apparent in the spore plots, where there was generally more data scatter. The large influence of the pollen outliers can be seen when comparing the correlation coefficients (R's) for the original data (0.74 for House/CL; 0.75 for House/SS) with those presented in Table 2. These data suggest that pollen concentrations are more highly correlated over these distances than are spore concentrations. Results of T-tests indicated that measurements outside the CL homes were significantly lower than those at the CL fixed site, for both pollen ($p < 0.01$) and spores ($p < 0.001$). Measurements at the SS homes, however, were not significantly different

than those at the SS fixed site, for both pollen (p = 0.66) and spores (p = 0.08). The differences between concentration gradients observed within each study area are most likely due to the closer proximity of the CL fixed site to a primary source of aeroallergens, i.e., open fields of wild vegetation (6).

Consideration of the potential for human exposure to these aeroallergens requires that indoor microenvironmental concentrations and their relationship to outdoor concentrations be investigated. Table 3 is a summary of paired daytime indoor-outdoor measurements at the twelve homes, stratified by season. The June-August period encompasses the first seven residential monitoring periods; the last five homes were monitored during September-October. This table also includes the arithmetic means in each category of the individual pair indoor/outdoor (I/O) ratios.

Table 3: Summary of indoor-outdoor residential measurements.

	Pollen				Spores			
	N	X	Xg *	SDg	N	X	Xg *	SDg
June-Aug.								
Outdoor	51		10.0	2.12	50**		391.5	2.56
Indoor	51		1.5	1.70	50**		77.5	2.66
I/O	51	0.2			50**	0.3		
Sept.-Oct.								
Outdoor	32		100.5	3.78	32		897.8	1.82
Indoor	32		4.0	3.03	32		91.8	2.72
I/O	32	0.1			32	0.1		

* Units are counts/m3.
** One extreme data pair (I/O = 11) deleted from data subset for this analysis.

One atypical data pair from the first monitored house, with a large influence on the mean I/O ratio, was deleted from the spore concentration data subset used here. Indoor concentrations of both pollen and spores are clearly much lower than corresponding outdoor levels. This is true for both seasons, day and night intervals, and both study neighborhoods. Seasonal and diurnal variations of outdoor levels were reflected indoors, but to a lesser extent. Both outdoor and indoor daytime concentrations of pollen were significantly higher ($p < 0.001$) than nighttime values. Although spore concentrations measured outside the homes did not show a significant diurnal difference ($p = 0.64$) indoor concentrations did ($p < 0.001$). Higher daytime concentrations of spores indoors may have been due to greater average infiltration from outdoor air caused by greater indoor-outdoor activity (i.e., door openings) as well as to re-entrainment of settled particles by a higher level of indoor activity of residents during the day.

An examination of house-specific indoor-outdoor relationships showed considerable uniformity across all homes. House-average I/O ratios ranged from < 0.1 to 0.5 for both pollen and spores, with an overall mean of 0.3 for pollen and 0.2 for spores. These values are consistent with the previously reported large filtering effect of buildings on outdoor

aeroallergens, as observed indoors (1,4). The contribution to indoor spore concentrations from interior fungal growth appears not to be a major factor in these twelve air-conditioned homes, although the residents of the home with the highest mean indoor concentration of spores did report the presence of a "musty" odor indoors. The mean I/O ratio for this home was 0.2. One of the two homes with window air-conditioners, instead of central air-conditioning, showed higher than average I/O ratios for both aeroallergens, but the other did not.

Conclusions

The results of this study suggest that the main determinants of personal exposure to pollens and spores for the residents of these homes are the seasonal and diurnal influences on outdoor aeroallergen concentrations and personal indoor-outdoor activity patterns. Relatively little inter-home variation was found in the rather large attenuation of outdoor concentrations indoors. Predictions of outdoor concentrations over community-scale distances from fixed site measurements would appear to be more reliable for pollen than for spores.

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