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Contributions of indoor and outdoor sources to fluorescent particle exposure in a residence

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SUMMARY
Residences are important sites of daily bioaerosol exposure; yet the relative contributions of outdoor and indoor sources are not well-understood. Biological particles can be detected using laser-induced fluorescence. Applying real-time instrumentation, this work investigated the contributions of indoor and outdoor sources to fluorescent aerosol particle exposures in a northern California residence with three human residents and a dog. Time- and size-resolved total and fluorescent particle concentrations were measured indoors and outdoors, using an ultraviolet aerodynamic particle sizer (UVAPS) and a switching valve. Time-resolved occupancy status and household activities, such as cooking and cleaning, were obtained using occupant-maintained logs and wireless electronic sensors. Our observations show the indoor to outdoor ratio of fluorescent particles is strongly influenced by occupancy, and that indoor sources contribute a considerable fraction of total daily fluorescent particle exposures at home. This work will improve understanding of the relationship between human activities and bioaerosol exposure in residences.

KEYWORDS
Bioaerosols; I/O ratio; Fluorescent airborne particles; Residential environment; Human exposure.

1 INTRODUCTION
It is important to understand bioaerosol exposure in residences because, for example, American spend about 70 percent of their time at home in the presence of various bioaerosol sources. A few studies have assessed the relationship between indoor and outdoor bioaerosol concentrations (e.g., Lee et al., 2006; Chen and Hildemann; Xie et al., 2017). However, the lack of time-resolved measurements in occupied spaces presents a barrier to developing better understanding of daily bioaerosol exposures in residences. This study utilized an UVAPS, which can detect viable biological particles in real-time using laser-induced fluorescence, to monitor indoor and outdoor fluorescent aerosol particle concentrations in a normally occupied northern California residence. The primary goal of this study is to understand the relative contributions of indoor and outdoor sources to occupants' daily bioaerosol exposures at home.

2 METHODS
A single-family home with three human residents and a dog, located in Contra Costa County, California, was continuously monitored for approximately two months during winter, 2017-2018. The house includes a kitchen, a living room, a family room, and three bedrooms, with hardwood floor throughout except for the family room which is carpeted. The UVAPS was placed in a shed adjacent to the living room window. Using an auto-switching valve, the

UVAPS was programmed to sample indoors for 50 minutes then outdoors for 10 minutes each hour (recorded at 1 minute time resolution). In addition, optical particle counters were deployed in multiple locations inside the house to assess the spatial distribution of airborne particles (1 minute time resolution). Occupants maintained occupancy status logs individually and a household activity diary. More than 60 wireless electronic sensors were placed in the house to obtain data on temperature, relative humidity, door/window open/close status, appliance usage, and room occupancy. The occupants followed their normal daily routines (occupied period) except for one week when the house was left vacant for 5 continuous days (vacant period). Doors and windows were closed during the vacant period, making infiltration the main source of indoor fluorescent aerosol particles.

3 RESULTS AND DISCUSSION

Figure 1 shows indoor and outdoor fluorescent aerosol particle concentrations during the occupied and vacant periods, respectively. The mean indoor fluorescent aerosol particle concentrations during the occupied period were one to two orders of magnitude higher than the vacant period, depending on particle size. Outdoor concentrations were comparable for the occupied and vacant periods. In addition, indoor concentrations were significantly lower than outdoor concentrations during the vacant period, while the indoor concentrations were more variable and often higher particularly for smaller particles during the occupied period.

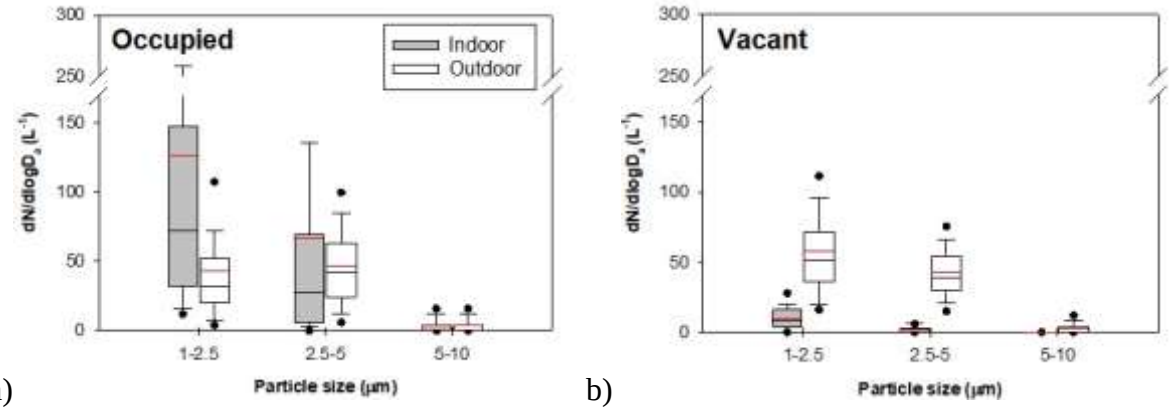

Figure 1. Box and whisker plots of fluorescent aerosol particle concentrations indoors and outdoors: a) during the house-occupied period (17 days), and b) during the house-vacant period (5 days). The red lines represent mean concentrations.

4 CONCLUSIONS

Indoor sources play a more important role than outdoor air in exposure to fluorescent aerosol particles during the cool winter period in the studied house in northern California.

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