

Aerosol Loadings and Cleaning Strategies in Denver Schools

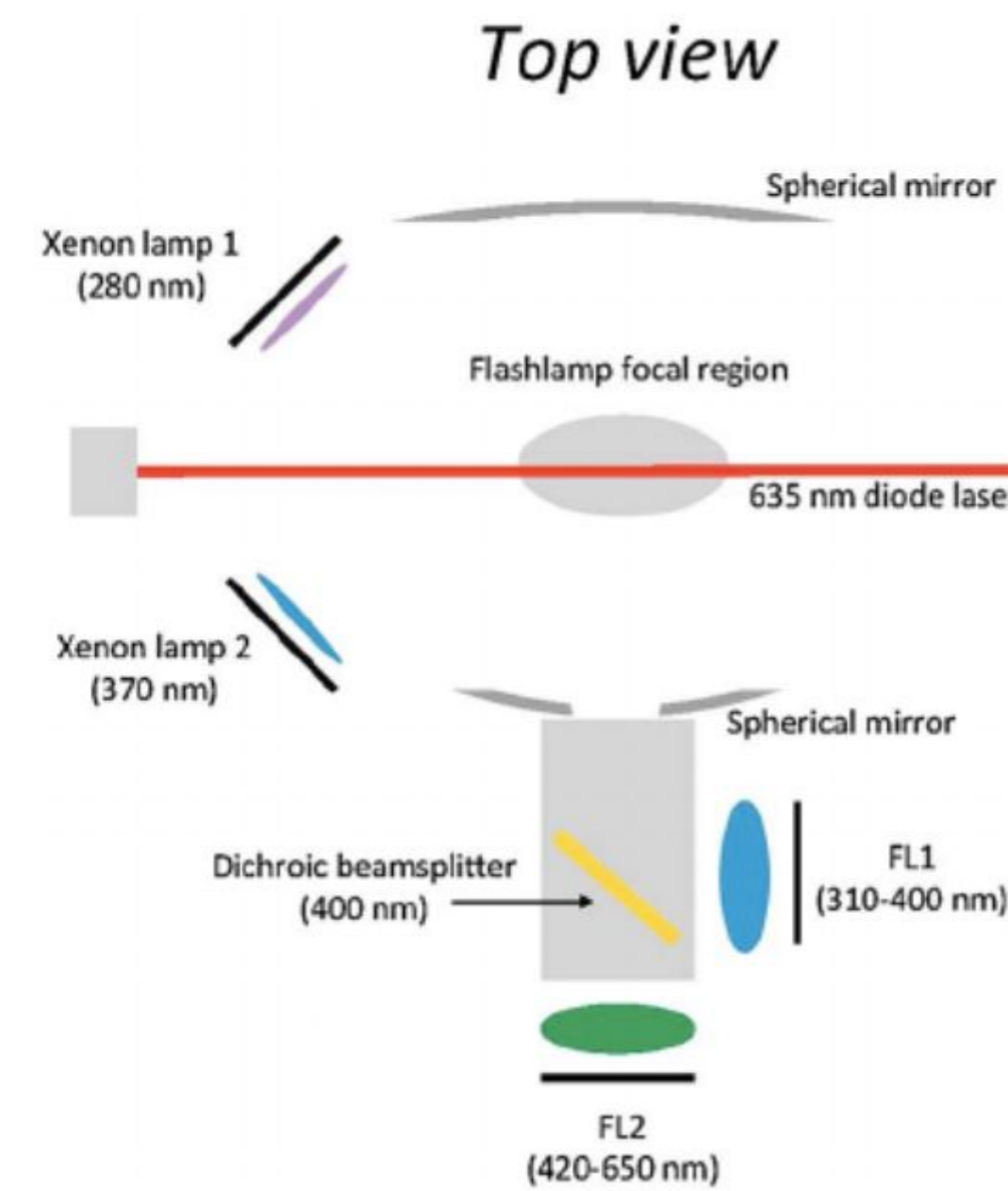
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Overview

Schools were abruptly closed due to the COVID-19 crisis and, often, air handling systems were shut down. As districts prepare to reoccupy school buildings it is critical to make these environments as safe as possible. Here we investigate the effects of various cleaning strategies on indoor aerosol loadings in Denver schools. The study is ongoing. Shown here is data from Phase 1 where airwashing was used in both clean and dirty classrooms to look at resuspendable particles and the effectiveness of air handling.

Sampling Methods



Fluorescence from individual particles (0.5-10 μm) was measured using an Instascope (Figure 1). For each particle that enters the cell, the instrument reports an optical size, and 3 pieces of fluorescent information. Using this information the instrument can distinguish between 3 broad classes of bioaerosol: bacteria, fungi and pollen (Figure 2).

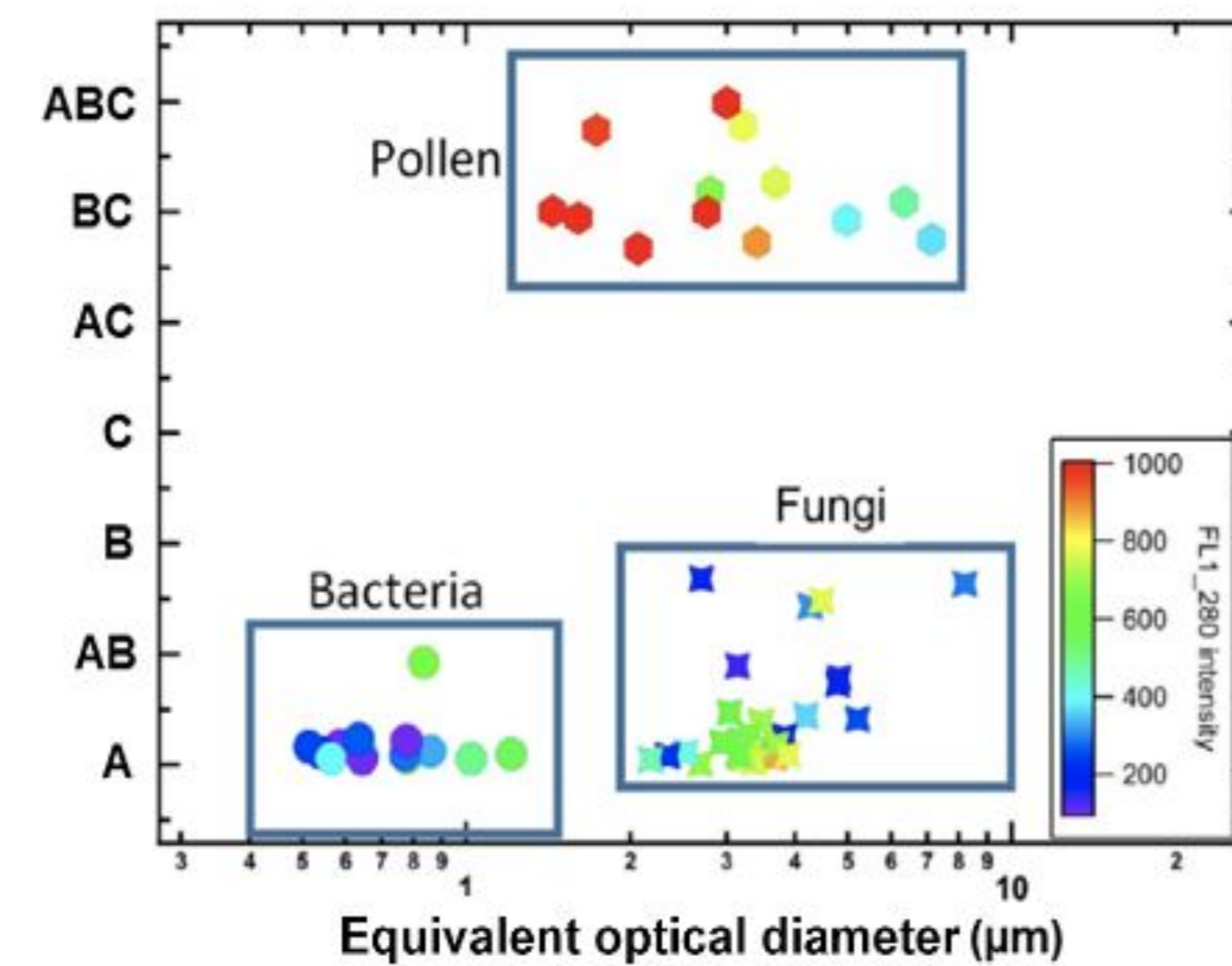


Figure 2: Fluorescence type and optical diameter of pure aerosolized species of bacteria, fungi, and pollen

Study Description

Data was collected in 6 classrooms each for South HS, Merrill Middle School, Greenwood, and Thatcher Elementary (Figure 4). Most (15.5) floors were carpeted, some were tile (7.5) and one was wood. Of the tile floors, 5 of them had not yet been cleaned with traditional janitorial techniques. During sampling 5 minutes of “baseline” data was first recorded. Then a large fan was used to airwash the room and 5 minutes of data was collected right after (“resuspension” data). Finally, the room was left for roughly the duration of two air turnover cycles before the collection of 5 minutes of “quiescent” data. Using custom Igor Pro software, total, fluorescent and bacterial concentrations were found for each phase. The resuspension phase was also used to calculate an observed air turnover rate for each room. (Figure 4)

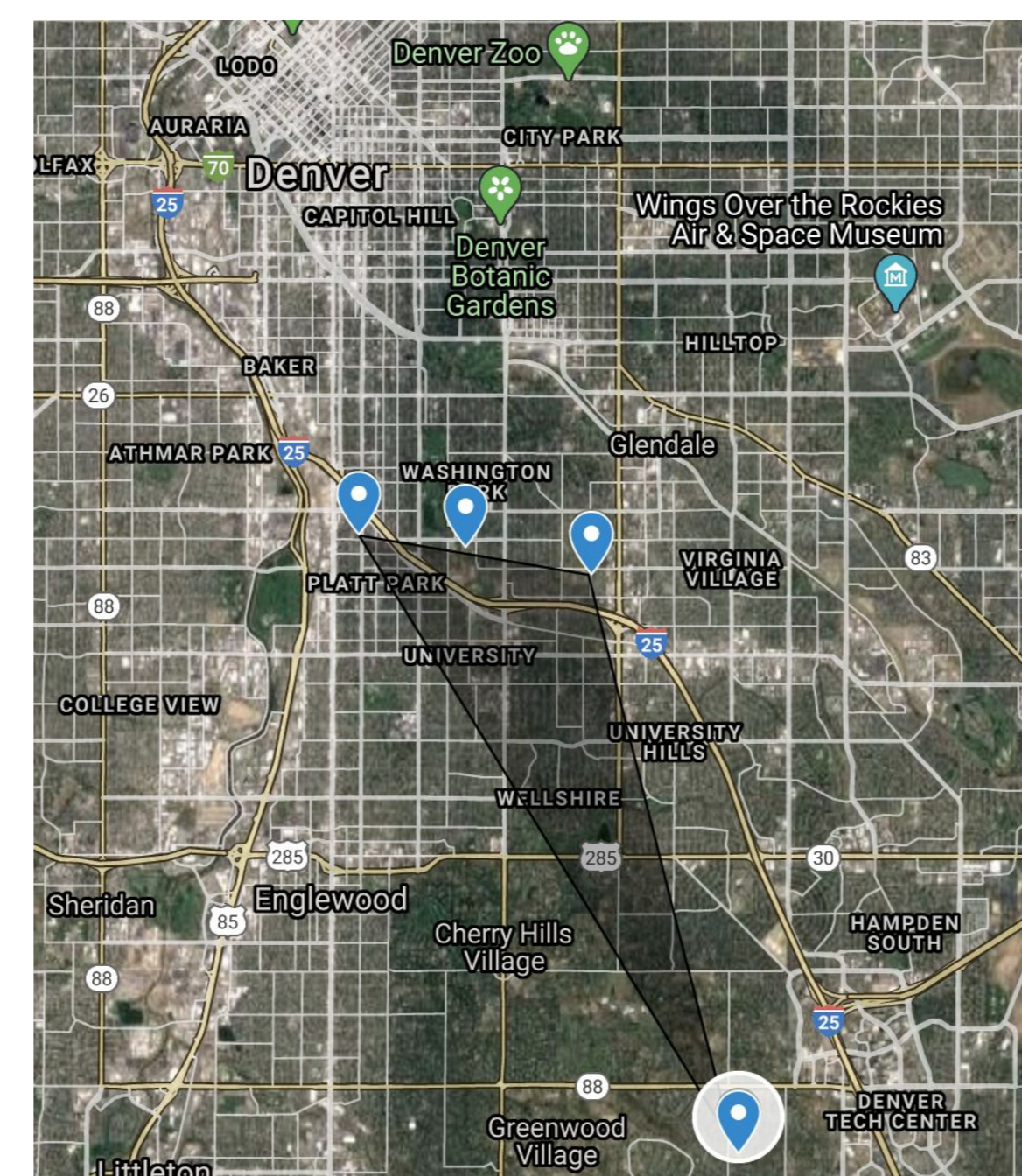


Figure 3: Map of school locations in the Denver metro area

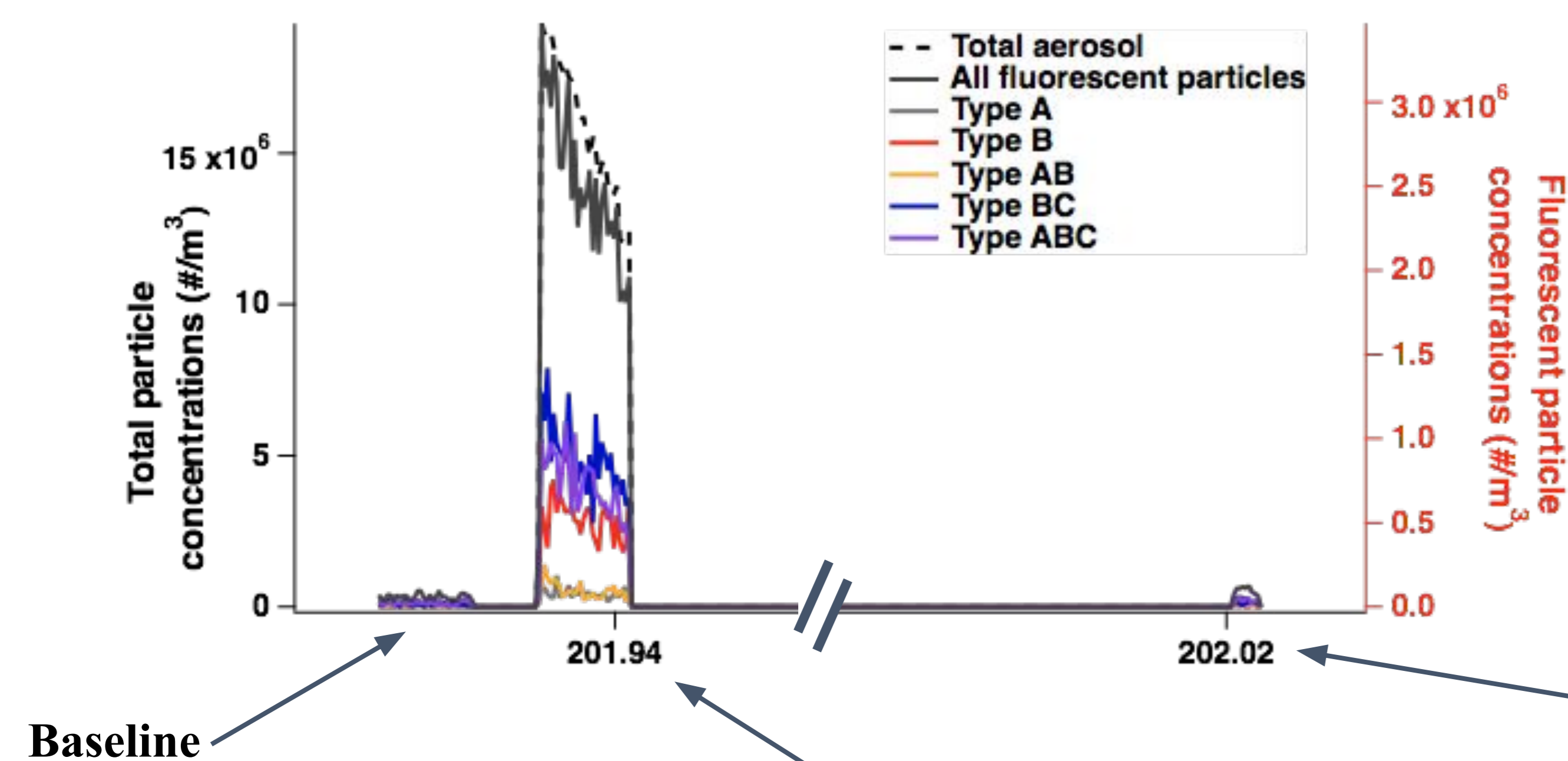


Figure 4: Sample time series of particle concentrations from one classroom

Results

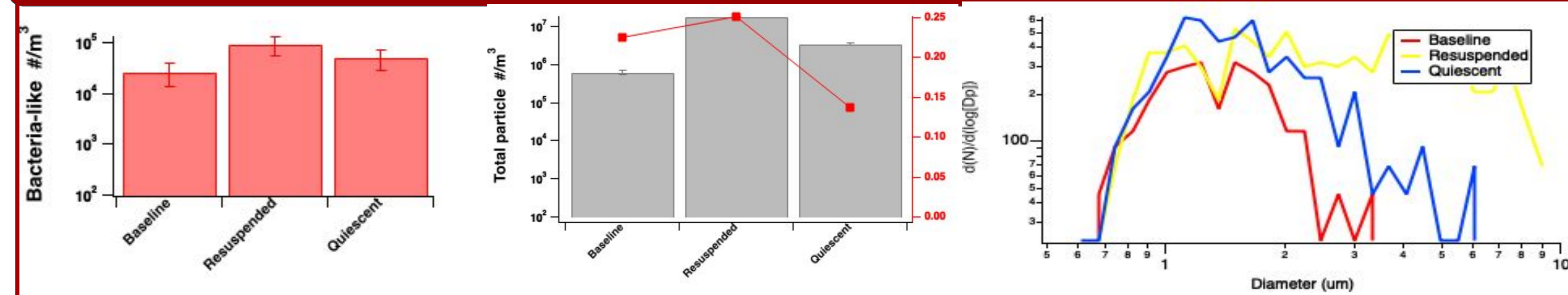


Figure 5: Bacteria (left) and total (center) aerosol concentrations and bacterial number distributions (right) during the three observational phases in a single room at Merrill Middle School

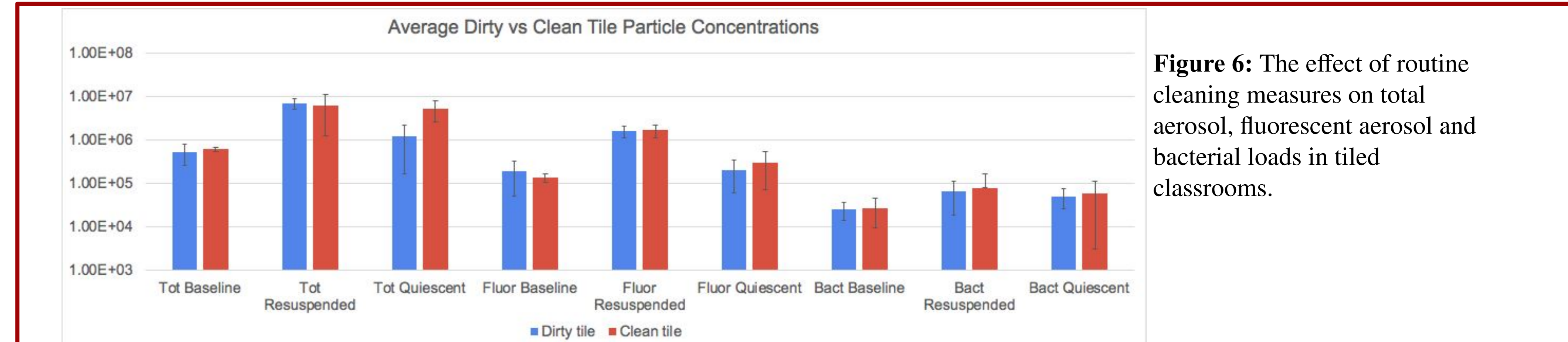


Figure 6: The effect of routine cleaning measures on total aerosol, fluorescent aerosol and bacterial loads in tiled classrooms.

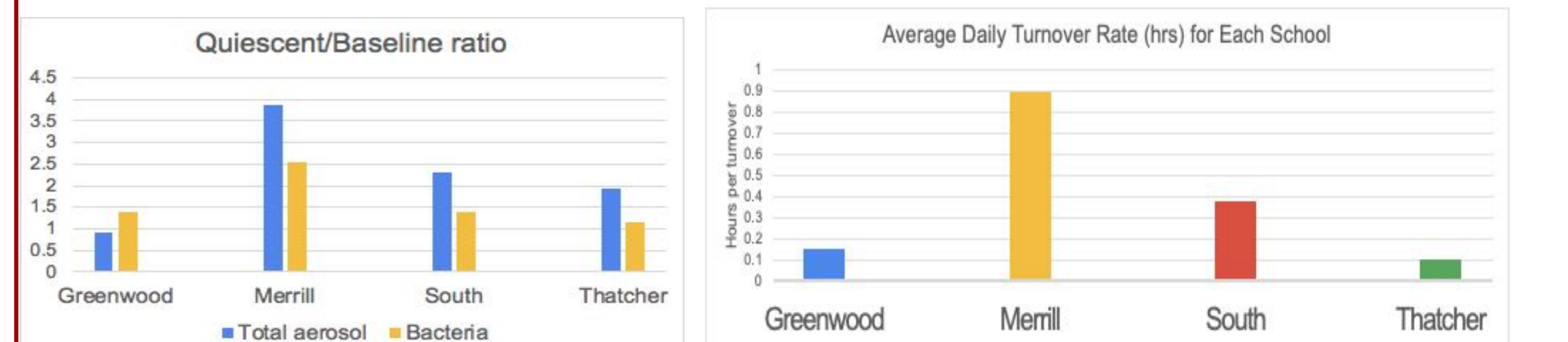


Figure 7: Average ratio of quiescent : baseline concentrations across all four schools for total (blue) and bacteria (yellow) concentrations

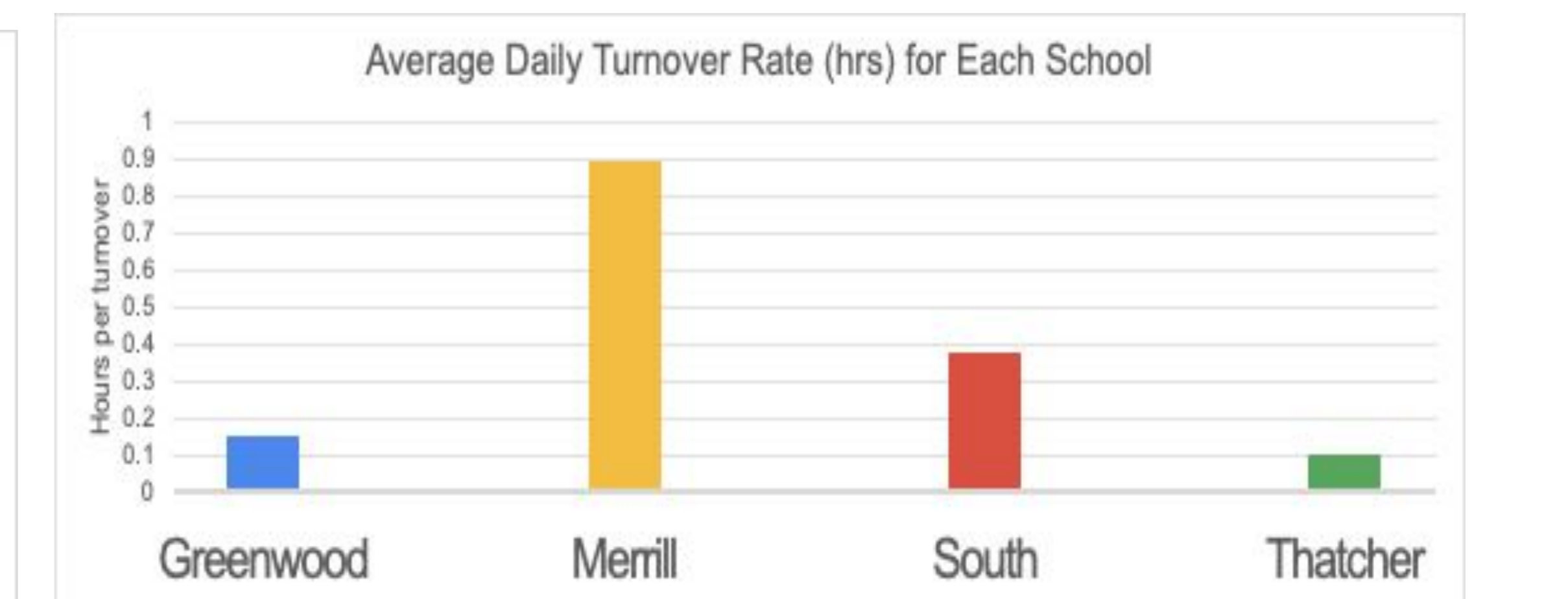


Figure 8: Average daily turnover rate in hrs per turnover for each school. Rates were averaged per school from each room. The time in hours required to bring enough new air to fill the room.

Main Findings

- Total and bacterial particle loadings increased substantially during airwashing and often remained elevated over an hour later
- Typical cleaning strategies have little effect on aerosol loadings in tiled classrooms
- Airwashing leads to an increased concentration of aerosol (bacteria and total particles), even after two air turnover times. Schools with slower observed air turnover (Merrill and South) have higher residual particle loads (Figures 7 & 8).

Future Work

- Investigate the effect of other techniques, HEPA filters and surface disinfection, on aerosol particle exposure in the same classrooms.

References

1. Perring, A. E., et al. (2015), Airborne observations of regional variation in fluorescent aerosol across the United States, *J. Geophys. Res. Atmos.*, 120
2. Hernandez, M., Perring, A.E., McCabe, K., Kok, G., Granger, G., Baumgardner, D., 2016. Chamber catalogues of optical and fluorescent signatures distinguish bioaerosol classes, *AMT*.