Clean Air in Cities:
Impacts of the Layout of Buildings in Urban Areas on Pedestrian Exposure to Traffic-Related Pollutants

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Research Topic

Southern California is no stranger to auto-related pollution. Areas near roadways typically demonstrate much higher pollutant concentrations; as a result, pedestrians and residents in these areas face greater exposure to air pollutants. In dense urban areas like Los Angeles, near-roadway environments can include most street-level outdoor spaces. At the same time, traffic-related pollution levels in urban areas are highly variable. Although the connection between built environment and street-level pollutant concentrations is a nascent field of study, it is clear that the design of the built environment plays a major role on pollution concentration.

In this piece, we considered the effect of different building configurations on the concentrations of traffic-related or other pollution. For this study, we used a numerical model capable of reproducing the very complex airflows at small scales in urban areas (the Quick Urban and Industrial Complex model, QUIC). We then validated the model's data against an extensive field dataset collected in an earlier study. Drawing from this dataset, we explored the value of open space interspersed with tall buildings, and of clustering buildings instead of spacing them evenly in dense urban areas.

Main Findings

1. Our model successfully reproduced the trend in ultrafine particle concentrations observed at five sites in Southern California. Ultrafine particles (UFP) offer a corollary measurement for traffic-related pollution. Each of the five sites had distinct building configurations: all-low building, tall street canyons, an isolated skyscraper, a site with two isolated skyscrapers, and a wall of medium-tall buildings on one side of the main road adjacent to a park.

2. Using the model, we explore the importance of ground-level open space in determining pollutant concentrations. Holding total building volume constant, having both more ground-level open space between buildings and fewer, taller buildings reduces concentrations near the ground. Placing short buildings instead of open space between the tall buildings increases pollutant concentrations.

3. Also holding building volume constant, UFP concentrations at street level are generally lower if the tall buildings are clustered together with larger open spaces between buildings rather than evenly dispersed with smaller spaces between buildings.

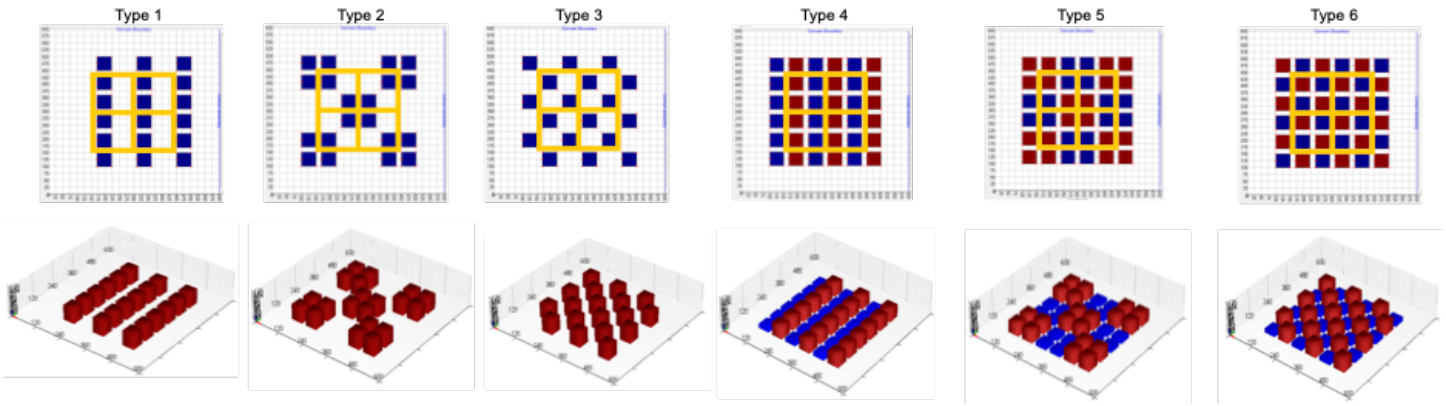

Figure 1: Six model built environment configurations. The main and sub-main streets within the 2½ x 2½ blocks are highlighted with yellow. The upper row shows the 2D visualization, and the lower the 3D visualization. Buildings are shown in red or blue; open space is white.

Approach

We first tested the ability of the QUIC model to reproduce observed real-world concentrations, using measured meteorology, traffic flows and other inputs. The model was able to produce good agreement between the observed daily average pollutants in the five benchmark sites, although it somewhat underpredicted the differences between neighborhoods.

We chose six model built environment types, shown in Figure 1: Types 1 – 3 have identical 60m tall (50 x 50m footprint) buildings with three different arrangements; Types 4 – 6 are arranged in the same manner as Types 1 – 3 but the buildings are only 45m; the extra volume is placed in 15m buildings that occupy space between the taller buildings. Ground-level pollutants are strongly impacted by the wind direction, especially for the highly regular model building configurations.

Conclusions

1. We recommend increasing open space between buildings. Open space -- plazas, surface parking lots, gardens, etc. -- between buildings allow for more dispersion of pollutants and lower pollutant concentrations for residents and pedestrians in the area.

2. We recommend clustering tall buildings rather than dispersing them evenly.

3. While in many areas winds can come from many directions, areas with consistent winds from a few directions can benefit from careful consideration of the building layout.

For More Information

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