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Opinion

The Crucial Influence of Tree Planting Should be Comprehensively Considered in Neighborhood Environment Simulations

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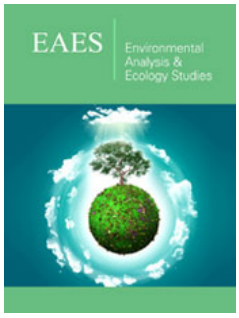

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Opinion

Numerical simulations are frequently carried out in the neighborhood scale to investigate the urban environmental issues including pollutant dispersion, exposure risk assessment, heat island and thermal comfort. Idealized building array and/or street canyon models are usually used without considering the influences of doors, windows, moving cars and tree plantings. In fact, those factors could greatly change the simulated results. Especially, the influences of tree planting are crucial, as the influences of tree plantings are comprehensive, and in terms of energy balance, air temperature, humidity, shading and aerodynamics. However, the comprehensive influence of tree plantings have rarely been considered in previous investigations. In most of the simulations that concerning on air pollution and/or pollutant dispersion, the aerodynamics influence of tree plantings were consequently considered. When thermal comfort was the main concern, the shading influence of tree plantings acted an important role. Theoretically, there exists interaction among all of the influencing aspects. In sunny days, tree canopy shading changes the distribution of ground and/or wall temperature. The high-temperature of ground (T_g), solid wall (T_w) and/or tree leaf (T_l) would causes local air temperature (T_a) gradients, which would further generate thermal buoyancy and affect the pollutant dispersion in terms of dynamics. The wind condition is also one of the key factors affecting the thermal comfort.

Take the environment within a street canyon as an example. Under the perpendicular inflow wind conditions, a main circulation dominating the airflow within the street canyon, as indicated by the gray dashed lines in Figure 1. The existence of tree plantings influence airflow characteristics by the drag force of tree canopy. The situations in sunny days would be more complex, where the solar radiation act an important role. In sunny days, solid walls, ground and leaf surface that absorbed sunlight would be heated. With convective heat transfer on top of the heated walls, the air warmed, and thus the Air Temperature Gradients (ATG) are observed near the heated walls. It should be noted that, the ATG is the foundation for the generation of thermal buoyancy flow [1]. Influences of heated solid walls on air temperature and airflow characteristics near an isolate building or within street canyons have been reported in detail. However, how and to what degree the tree planting would influence the Ta distribution and airflow characteristics in the neighborhood environment? It is still not clear, as the comprehensive influence of tree plantings on the neighborhood scale atmospheric environment haven't been fully investigated.

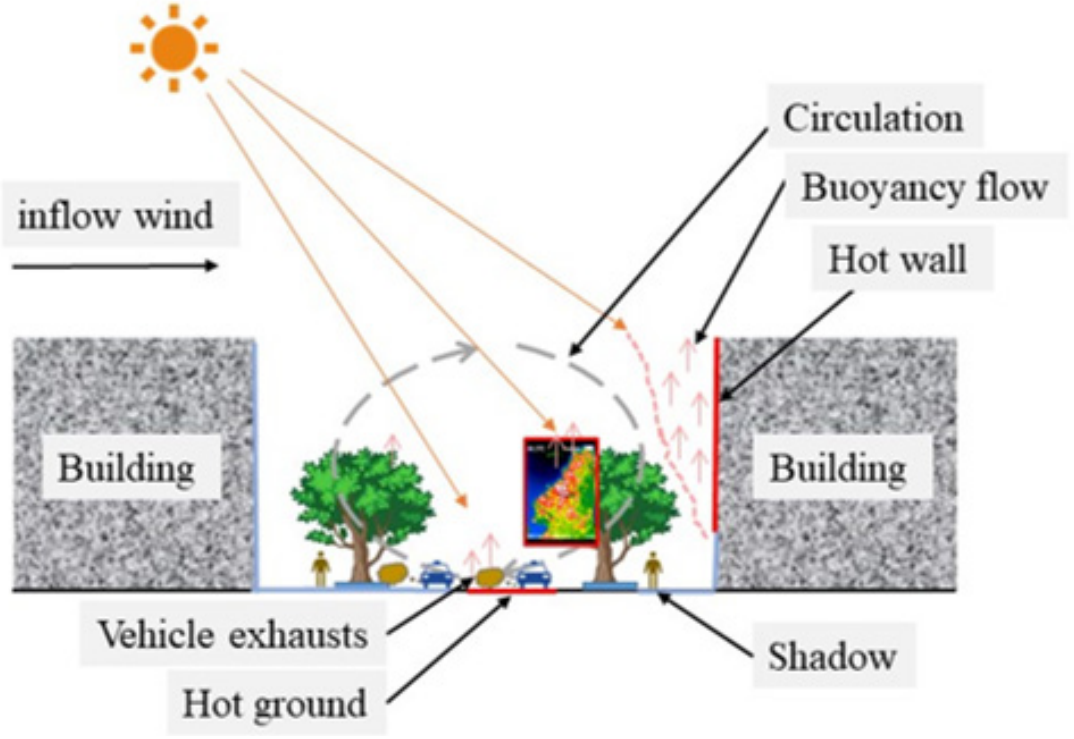

Figure 1: 2D schematic diagram on the environment conditions within a greening street canyon in sunny days.

The crucial influence of tree plantings on the local atmospheric environment is firstly manifested that tree shade can improve the thermal comfort of pedestrians. In addition to affecting on the T_g and T_w, the temperature of tree leaves on the sunward side of the crown could be increased as well. The temperature difference between hot leaf surface and air (ΔTl-a) can reach over 10 ℃ [2]. In figure 1, a measurement result on Tl of a tree canopy is exhibited in the red rectangle schematically, in which ATG was also observed near the crown shape boundary. The most concern here is the aerodynamics influence of the ΔTl-a and the consequently induced buoyancy turbulent flow around the tree canopy. In simulations on the dispersion of vehicle exhausts, the buoyancy turbulent flow acts as a key role. In addition, tree plantings can also adsorb particulate pollutants, absorb carbon dioxide, and release volatile organic compounds. Overall, the impact of greening trees on the neighborhood atmospheric environment is multifaceted and complex.

In order to model the influence of greening trees on local air temperature distribution and buoyancy turbulence, Tl of greening trees should be determined [3], and the buoyancy turbulence should be simulated accurately. Different from the solid walls, greening tree leaves are living organisms with physiological function. The respiratory function of leaves and the influence of latent heat of evaporation make it difficult to determine the surface temperature of tree leaves [4], which is the biggest challenge in the development of thermal dynamic models for tree plantings. Moreover, the ATG is the theoretical basis for thermal buoyancy, and the impact of thermal buoyancy can be accurately simulated only by accurately simulation on the air temperature distribution around the tree canopy.

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