Simplified CFD Modeling of Air Pollution Reduction By Means of Greenery in Urban Canyons

S. Lazzari[1], K. Perini[1], E. R. di Schio[2], E. Roccotiello[3]

[1]University of Genova, Dept. of Sciences for Architecture, Genova, Italy
[2]University of Bologna, Dept. of Industrial Engineering, Bologna, Italy
[3]University of Genova, Dept. of Sciences of Earth, Environment and Life, Genova, Italy

Abstract

As known, air quality in urban areas is dramatically affected in particular by the noteworthy presence of respirable suspended particulate matter (such as PM2.5), nitrogen oxides (NOx), carbon monoxide (CO) and hydrocarbons (HC), which are mainly due to traffic-induced emissions [1, 2, 3]. On the other hand, it is also known that vegetation can help restoring the environmental quality of dense urban areas by reducing the "heat island effect", improving energy performance of buildings, managing storm-water and realizing a trap effect on air pollutants [4, 5]. The latter effect is getting a growing interest, especially for street canyons where vegetation specific characteristics (e.g., species used, plant shape, leaf area index, porosity, etc.) play a key role in potential air quality improvements [6]. In order to study the effect of vegetation on urban air quality, several approaches are considered and well described in the literature, ranging from on-field to experimental chamber measurements, from wind tunnel tests to numerical simulations.
In the present paper, the first part of a wider study concerning air quality enhancement in dense urban areas by means of greenery is presented. Final objective of the complete work is to evaluate the influence of plant species features in reducing the most dangerous pollutants for public health, with reference to urban canyons under different conditions regarding air flow, urban morphology, orientation (e.g. N-S axis), pollutants type and concentrations. In detail, the goal of the present paper is to study to which extent a quite simple numerical model can be usefully adopted to evaluate the greenery performance. In detail, starting from some basic assumptions about passive deposition performance given by plant species according to their geometrical arrangement, CFD simulations will be performed by means of COMSOL Multiphysics® for different wind velocities. Air will be assumed as an ideal gas that transports diluted chemicals representing the investigated pollutant and the presence of car traffic inside the canyons will be taken into account by imposing a steady "source of pollutant" boundary condition. The resulting 2D and 3D maps of the pollutant's concentration in the whole canyon as well as specific concentration values in some representative positions (e.g. at selected heights) will be used to find out the best arrangement criteria and to critically analyze the main effects of vegetation.

Reference

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