Modeling of Urban Greening Effects on Air Quality in an Undeveloped Residential Area

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1. Introduction

Urban green development has influence on pedestrian comfort and pollutant dispersion. For this reason, the development of public open spaces is adapted to the new lifestyle in compact cities by upgrading the public environments used by pedestrians. Not only visual aspects like compactly, technical or social criteria, but also environmental, urban climate, air quality and thermal comfort must be highly considered. A framework for urban greening in a new undeveloped area in Madrid was developed in the ‘ECO-Valle Mediterranean Verandahways’ project within LIFE Program.

- Objective: Analyze the effect of different types of vegetation in the main boulevard on pedestrian wind comfort and air quality in this undeveloped urban zone in Madrid.

2. Numerical Simulation Description: Cases of Study

Three main scenarios have been simulated considering different phases of urban greening development:

- **Case A**: Base case without vegetation.
- **Case B**: Green spaces at three specific locations.
  - Case B₁: Current development conditions, with three artificial trees.
  - Case B₂: Replacing artificial trees with natural vegetation (Leaf Area Density (LAD) = 0.5).
  - Case B₃: Different green spaces along the main boulevard (LAD >0.5).
- **Case C**: Vegetation 2: 5m high
  - Case C₁: Vegetation 2: 5m high
  - Case C₂: Vegetation 4: 18m high

- Evaluation of simulation carried out in the case B, by means of experimental wind velocity measurements.

- Wind velocity has been monitored in six points located inside the northern artificial tree during winter period.

The scatter plot shows a good correlation between simulated and measured wind speed monitored in six points located inside the northern artificial tree.

Given the available evaluation data, the CFD model used in this study is deemed acceptable for the simulation of flow in this scenario.

3. Results

- Values are calculated at pedestrian level (1.5 m) for prevailing Northeast wind direction.
- Emissions are imposed assuming the number of vehicles is the same in all streets.
- Cnrom is the normalized concentration. Cnrom = C/Cmax(Δt =1.5m for case A).

3.1. Wind Field

- Wind field.

3.2. Pollutant Dispersion

- Limitation of pollutant dispersion.

4. Conclusions

- A CFD model has been used to evaluate the effect of green vegetation development in new residential areas.
- Simulation results of wind velocity for the current conditions in the main boulevard were evaluated with available experimental measurements.
- Wind field and pollutant concentration have been analyzed in different scenarios representing several green vegetation development (possible future scenarios).
- The presence of vegetation modifies wind velocity in all cases, especially in cases C (natural vegetation along the boulevard), reducing the ventilation.
- The modifications of airflow induce an increase of concentration in the boulevard, especially in cases C. E.g. for case C₁, the maximum of concentration increases 72% respect to base case A and for case C₃ (taller vegetation) the zone with normalized concentration higher than 0.5 increases a factor 5 respect to base case.
- Future work: Analysis of other wind directions and other processes such as deposition of pollutant on vegetation or thermal comfort.

References


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