Mapping the spatial variability of black carbon and fine particle concentrations in Londrina, Brazil, using bicycles as mobile sampling platforms

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Fine particles in urban environments

PM$_{2.5}$ and black carbon (BC) are airborne particles ubiquitous in urban environments. They reduce visibility and can cause or exacerbate cardiovascular and neurological diseases$^{1,2}$. BC is a short-lived climate pollutant and the second most important anthropogenic climate change agent, right after CO$_2$. More than 90% of BC particles are present in the PM$_{2.5}$ fraction.

Study area

We measured PM$_{2.5}$ and BC in the centre of Londrina, a 543,000-inhabitant city in Southern Brazil. The fleet in Londrina consists of 355,000 vehicles: 52% gasoline, 33% flex engines (that run on gasoline, ethanol or a blend of these fuels), and 7% diesel (heavy-duty vehicles).

Data sampling and treatment

We surveyed three routes using bicycles retrofitted with a platform and a tool bag to house: Aethalometers (AE-51, Aethlabs, USA), Photometers (DustTrak 8520, TSI, USA) and GPS (DG-100, GlobalSat, Taiwan).

The bicycles started sampling from the same point at the same time, completing each circuit in around 1 hour. We conducted six sampling sessions in the morning (08:00) and four in the afternoon (17:00). The data were pooled into coincident geographical positions to obtain statistics for 50-m transects.

Results

Considering all circuits together, BC and PM$_{2.5}$ concentrations showed large variability (Fig. 5). Some street transects presented coincident high levels of BC and PM$_{2.5}$ in the morning and/or in the afternoon (Fig. 6), suggesting common sources for these particles, most likely emitted by traffic exhaust.

Pollutant concentrations and relationship with:

Traffic volume

High BC and PM$_{2.5}$ concentrations were found on a busy avenue (sites 1A, 2A, 3A) in the morning (2,400 veh/h) and afternoon (3,000 veh/h). In contrast, low concentrations were monitored on streets with less traffic volume; for example, sites 2C and 3C (360 and 612 veh/h, morning and afternoon, respectively), and site 10A (64 and 128 veh/h).

Road slope, traffic lights and bus stops

Large concentrations were recorded on steep roads due to increased engine labour (green boxes in Fig. 7) and with several traffic lights and bus stops.

Conclusions

PM$_{2.5}$ and BC concentrations were largest on streets with high heavy-duty diesel traffic, within street canyons and on steep streets due to the enhancement in emission factors induced by increased vehicle thrust.

Acknowledgements

This work was supported by CNPq grant 404146/2013-9.

References