

BLACK CARBON AS A NEW AIR QUALITY AND HEALTH INDICATOR OF TRAFFIC LIMITATION INTERVENTIONS IN MILAN: THE 'AREA C' LEZ MONITORING CAMPAIGN

INTRODUCTION AND AIMS



In the framework of the implementation of a new **Low Emission Zone (LEZ)** scheme for the city center called '**Area C**', ('**C**' is for **Congestion Charge**) the Milan Municipality has carried out an air quality monitoring project based on measurements of **Black Carbon (BC)**, which is considered a **valuable additional air quality metric** to evaluate the health risks of primary combustion particles from traffic including organics (WHO, 2013). Inside the LEZ the circulation of Euro 0-3 diesel cars, Euro 0 gasoline cars and HDVs longer than 7.5 meters is forbidden; electric, hybrid, LPG and NG powered vehicles are allowed to enter 'Area C' without charge while a ticket is required for the other vehicles. 'Area C' LEZ is operating on workdays from 07:30 am to 07:30 pm. The aim of this study was to assess the environmental and health potential effects of the 'Area C' LEZ by mean of an indicator of particulate toxicity.

MATERIAL AND METHODS

BC, PM10 and PM2.5 real-time measurements were performed contemporaneously in and outside LEZ at couples of fixed sites, in different seasons for several weeks and during pedestrian trips in order to represent different kind of traffic-proximity exposure. BC concentrations were measured at 5-minute time resolution with Aethalometers (mod. AE51, Magee Scientific Inc.) while PM with gravimetrically pre-calibrated Optical Particle Counters (mod. Aerocet 531, MetOne Instruments Inc.) with a 15-minute scheduled sampling time.

KERBSIDE SITES

The first couple of sites represents a 'direct proximity ground level residential exposure' in the city [Figures 1-2]. Both sites were situated on the main ring road of each zone considered, at less than 10 m from the roadway centerline. In these sites two different sampling campaigns were scheduled, in spring and summer, without residential heating emissions interference.



Fig. 1 - Outside 'Area C' LEZ (Maciachini Square)

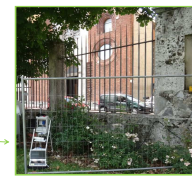


Fig. 2 - Inside 'Area C' LEZ (Sforza Street)

RESIDENTIAL SITES

The second couple of sites represents a 'roadside third floor level residential exposure' in the city. The monitors were placed on the terrace of two third floor offices [Figures 3-4], situated in a large square on which different important streets meet and are open to pollutants dispersion by wind. One-month sampling campaigns were scheduled in Winter, with residential heating in use, and in Autumn, before and during the turning on of residential heating.



Fig. 3 - Inside 'Area C' LEZ (Beccaria Street)



Fig. 4 - Outside 'Area C' LEZ (Porpora Street)

RESULTS

At **kerbside sites** the 24h mean (SD) BC concentration between the two areas were statistically different ($p < 0.0001$) while no statistically significant changes were found in PM10 and PM2.5 concentrations [see Figure 5].

BC/PM10 and BC/PM2.5 ratios were 50% and 59% lower inside 'Area C' LEZ.

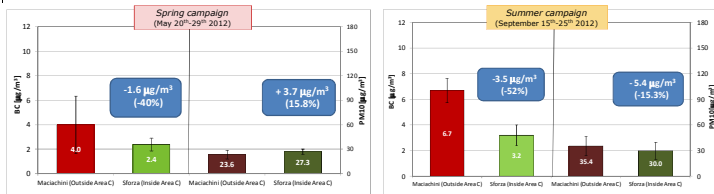


Fig. 5 - Mean BC and PM10 concentrations during working days, 'Area C' LEZ in force, at kerbside sites. The results obtained in this study are in agreement with literature, at kerbside sites (Reche *et al.*, 2011; Brukmann and Lutz, 2011) and a previous kerbside summer study on the same area (Invernizzi *et al.*, 2011).

At **third floor residential sites**, in February an absolute difference of 2.2 (1.3) µg/m³ was observed between the two areas for BC concentrations ($p < 0.0001$) or -28% inside the LEZ; no changes in PM10 and PM2.5 concentrations [Fig. 7]. **BC/PM10 and BC/PM2.5 ratios were 32% and 25% lower inside 'Area C' LEZ.**

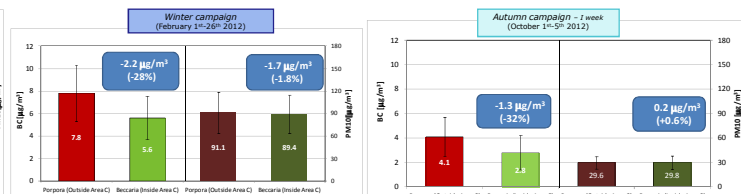


Fig. 7 - Mean BC and PM10 concentrations during working days, 'Area C' LEZ in force, at 3rd floor level. In Figure 8, as an example, BC concentrations measured during the October monitoring campaign are reported. Referring to the first week, characterized by more stable meteorological conditions and heating plants off, the 24h mean BC concentrations reached an absolute difference between the two areas of 1.3 (1.1) µg/m³ or -32% inside the LEZ. The BC percentage difference between in and outside LEZ decreased by about 50% with domestic heating on (-12% vs. -33%).

During **Pedestrian trips, personal exposure to Black Carbon concentrations were reduced to -43% inside 'Area C' LEZ and to -59% in Pedestrian Area** [e.g. see Figure 6].

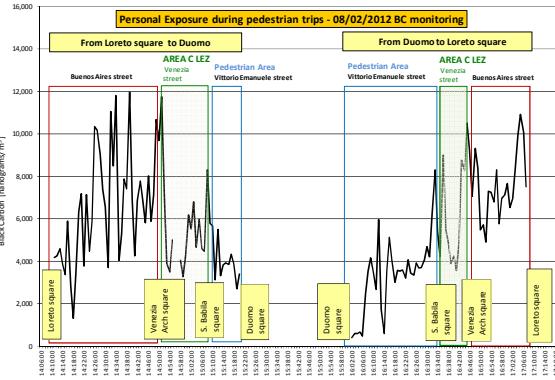


Fig. 6 - Personal exposure to BC during a pedestrian trip

CONCLUSIONS

A significant difference was found in BC concentrations inside 'Area C' LEZ, with an improvement of one to three BC epidemiological 'change units', a remarkable reduction in particulate toxicity and related expected mortality and morbidity (Janssen *et al.*, 2011) for living population and city users.

ACKNOWLEDGMENTS

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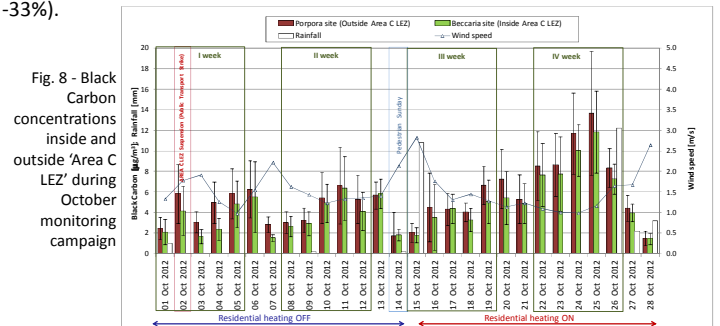


Fig. 8 - Black Carbon concentrations inside and outside 'Area C' LEZ' during October monitoring campaign

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