The UPUPA project: Ultrafine Particles in the Urban Piacenza Area, Italy

M. Giugliano, G. Lonati, S. Ozgen and G. Ripamonti

Civil and Environmental Engineering Department, Politecnico di Milano, P.za L. da Vinci 32 – 20133 Milano, Italy
Energy and Environment Laboratory Piacenza, Politecnico di Milano, Via Nino Bixio, 27C – 29121 Piacenza, Italy
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Presenting author email: michele.giugliano@polimi.it

Emerging epidemiological and toxicological evidence indicates particle toxicity to be dependent on particle size. Ultrafine particles (UFP, d_p<0.1 µm) are believed to be more toxic than larger particles because of their higher number and surface area per given mass, and higher deposition probability in the deep lung region (Chio & Liao, 2008; Hoek et al., 2010). Nevertheless, regularly monitoring are scarce and the available knowledge on urban UFP appears still lacking compared with the complexity and variability of the phenomenon. For instance, scarce evidence exists on UFP levels in areas like the Po Valley, Northern Italy, a well-known European hot-spot for air pollution due to the particular local orography and to the high density of emission sources.

In 2011-2012 the UPUPA project took place in Piacenza (45.03 °N, 9.41 °E, 67 m a.s.l), a mid-sized city (about 100.000 inhabitants) located in the centre of the Po Valley, aiming to provide information on UFP levels in the urban area, on the diurnal and seasonal variation of particle number concentration (PNC) and particle number size distribution (PNSD). For the urban area of Piacenza about 60-120 events per year of PM10 daily limit exceedances have been reported in 2007-2011, with PM10 and PM2.5 annual averages in the 34-45 µg m^{-3} and 24-27 µg m^{-3} range, respectively.

Measurements of PNC and PNSD were performed at three different sites: a traffic exposed site (TR), about 20 meters from a highway flyover; an urban background (UB) site, in a park in a residential area at the outskirts of the city; a rural site (RU) located at about 20 km South-West of the urban area on the first hills of Apennine mountains. At each site measurements were performed either during cold period (October-March) and warm period (April-September). PNC in the 7 nm-10 µm ($PNC_{7\text{-}10000}$) and related PNSD in 12 size bins were measured by an ELPI™ (Electrical Low Pressure Impactor, - Dekati Ltd., Finland) that was displaced between sites.

Hierarchical cluster analysis applied to PNSD from ELPI data identified 4 size intervals with peculiar time patterns: $PNC_{7\text{-}29}$ (7<d_p<29 nm), $PNC_{29\text{-}95}$ (29<d_p< 95nm), $PNC_{95\text{-}264}$ (95<d_p<264nm), and $PNC_{264\text{-}10000}$ (264<d_p<10000nm). $PNC_{7\text{-}10000}$ levels were higher at TR site compared to UB site and RU site, with the latter site displaying the lowest average levels in any season and day of the week considered (Figure 1). Daily average $PNC_{7\text{-}10000}$ at TR site were in the 8.7-17.2·10^3 cm^{-3} range (lowest levels on warm Sundays, highest on cold workdays). Workdays' to Sundays' ratio for $PNC_{7\text{-}10000}$ varied from 1.6 during cold period to 1.3 during warm period, as reported for other urban areas (Jeong et al., 2006; Wang et al., 2011).

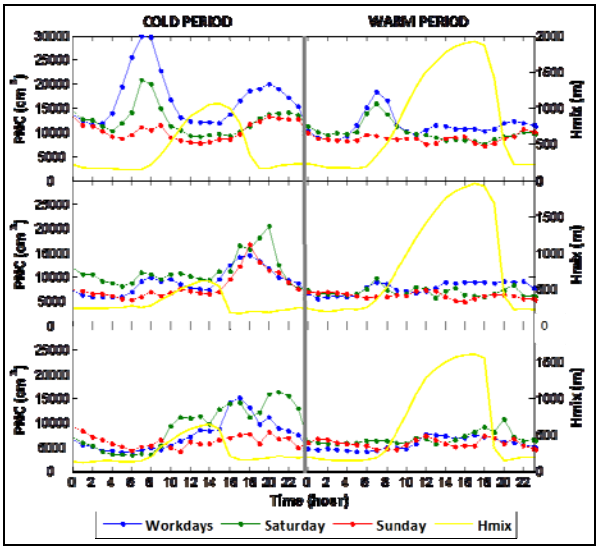

Figure 1. Average diurnal patterns of $PNC_{7\text{-}10000}$ on workdays, Saturdays and Sundays and of the atmospheric mixing height (Hmix)

UFP contribution to $PNC_{7\text{-}10000}$ was between 65-78% at TR site, 58-75% at UB and 56-78% at RU site, somewhat smaller than the European mean ratio (76%) reported by Putaud et al., 2010. At urban sites, all size fractions generally followed the same daily cycle of $PNC_{7\text{-}10000}$ but $PNC_{7\text{-}29}$ and $PNC_{29\text{-}95}$ levels increased on traffic rush hours (especially on cold season mornings). At TR site on warm workdays a third peak for $PNC_{7\text{-}29}$ was observed in the early afternoon (12.00-14:00); not correlated with traffic markers, this peak was likely of secondary origin, via photochemical nucleation of gaseous precursors.

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