Sources and processes affecting carbonaceous aerosol in urban and rural areas in Emilia-Romagna region (Northern Italy)

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This paper analyses organic (OC), elemental (EC) and total carbon (TC) concentration in $PM_{2.5}$ samples collected over the last 4 years in eight intensive monitoring campaigns conducted in the Emilia Romagna region (Northern Italy), in the framework of the Supersito project (Pietrogrande *et al*., 2014a, 2014b). The monitoring stations describe the main city of Bologna (MS) and a rural background (San Pietro, SP) located in the Po Valley, characterized by high density of anthropogenic sources and unfavorable orographic and meteorological conditions that promote pollutant accumulation.

A distinct seasonality of OC and EC was seen with values from 2 to 2.6 times higher during the cold periods (TC ≈ 6.5 μgm^{-3} in November-March) compared with the warm periods (TC ≈ 3.3 μgm^{-3} in May-June). This trend follows the Planetary Boundary Layer (PBL) dynamics characterized by minimum PBL height in fall/winter (H_{mix} ≈ 300 m) in comparison to summer (H_{mix} ≈ 900 m). In addition, the increased strength of some sources (mainly residential heating) causes higher emissions during winter.

Concerning spatial variability, the two sites show nearly the same OC values in all seasons, while exhibit marked differences in the concentration of EC and OC/EC ratio that are more representative of different source types. Rural location is characterized by the lowest levels of EC (average values 0.4 and 1.1 μgm^{-3} in summer and winter, respectively) with OC/EC ratios between 5 and 7, while the road-traffic influenced urban site shows the highest EC concentrations (average values 0.8 and 1.8 μgm^{-3} in summer and winter, respectively) with lower OC/EC ratio close to 3.5.

The obtained OC/EC values also suggest a significant contribution of secondary OC, that is higher in summer, in agreement with higher solar radiation (≈ 300 Wm^{-2} and ≈ 80 Wm^{-2} in summer and winter, respectively). These results are confirmed by the levels of dicarboxylic and oxo-hydroxy carboxylic acids, as relevant markers of primary and secondary organic aerosol.

To give insight into the sources of primary OC, the concentrations of some markers were investigated, in particular polycyclic aromatic hydrocarbons (PAHs) related to combustion and levoglucosan, as unambiguous tracer for biomass burning.

The measured PAHs concentration distributions were related to literature emission profiles from wood combustion for residential heating (Orasche *et al*., 2012) and from vehicular exhaust of gasoline-powered and diesel-powered vehicles.

This study indicates that residential wood burning is the dominant source of PAHs during the cold seasons, while motor vehicle traffic is the most relevant source during the summer period. These results are also confirmed by high atmospheric concentrations of levoglucosan (≈ 400 ng m^{-3}) in November-March months. Using levoglucosan as the key tracer for the biomass combustion, the mono-tracer approach (Piazzalunga *et al*., 2011) was applied for estimating the contribution of wood burning emission to aerosol organic carbon (OC_{WB}) in the investigated sites (Table 1).

	Main Site	San Pietro
	OC_{WB}%	**OC_{WB}%**
June 2012	0.3	1
November	56	25
February	44	54
May 2013	10	2
October	17	5
February	47	52
May 2014	0.3	1

Table 1: Contribution of wood burning to Organic Carbon(OCwb).

The computed results show that the OC mass is strongly impacted by wood burning during the cold seasons (≈ 45% with typically higher values at the rural site.) and only weakly during May-June (≤10%). These results are similar to those found at other sites in Northern Italy (Sandrini, *et al.*, 2014).

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