Impact of residential wood combustion on wintertime atmospheric aerosol in Emilia Romagna region (Northern Italy)

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Keywords: wood burning; atmospheric aerosol; cold seasons; Po Valley.
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This paper investigates the influence of wood combustion on $PM_{2.5}$ in fall/winter, as the most favorable periods with presumed intense biomass burning for residential heating due to low temperatures. As a part of the Supersito project, nearly 650 $PM_{2.5}$ samples were collected daily at urban and rural sites in Emilia Romagna (Northern Italy) in five intensive experimental campaigns through the 2011-2014 years (Pietrogrande *et al*., 2014a, 2014b).

A set of 48 different tracers related to biomass burning were investigated in order to provide useful information on emissions from wood combustion: anhydrosugars, primary biological sugars, low-molecular-weight carboxylic acids, methoxylated phenols, polycyclic aromatic hydrocarbons (PAHs) and carbonaceous components (EC/OC).

Of these individual compounds, levoglucosan was by far the dominant anhydrosugar, both on a relative and an absolute basis (200-1042 ng m^{-3}), followed by mannosan (3-121ng m^{-3}) and galactosan (4-35 ng m^{-3}), indicating that wood burning for domestic heating is a diffuse regional source during fall and winter. Different diagnostic ratios between anhydrosugars (levoglucosan to mannosan) and methoxylated phenols (syringyls to vanillyls) were computed to discriminate the wood types used as combustion fuel, i.e., hardwood vs. softwood. It was found that smoke particles were emitted from a heterogeneous mix of combustions conditions, with the predominant contribution of hardwood.

19 high molecular weight PAHs were investigated in $PM_{2.5}$ samples, as they have been found largely emitted from residential heating, including wood and coal combustion and natural gas-fired home appliance or their mix. The total concentration of the investigated PAHs showed higher values at the urban site, mean value of 5.2 ng m^{-3}, than at the rural site, 2.9 ng m^{-3}, and was dominated by benzo[b+j]fluoranthene, followed by benzo[ghi]perylene and benzo[a], benzo[e] and indeno[1,2,3-cd] pyrenes. Also crysene is one of the most abundant PAHs in several samples. Such PAHs distribution profile indicated that wood combustion and traffic are the major emission sources in the studied area, in agreement with similar figures found in wintertime at other sites in Northern Italy (Belis *et al*., 2011).

The strong contribution of wood combustion to atmospheric PAHs was indicated by the positive correlation between levoglucosan and the most abundant PAHs (R^2=0.71÷0.79) and individually with benzo[a]pyrene (R^2=0.79). Using such a relationship, the contribution of wood burning to ambient concentration of benzo[a]pyrene ($BaP_{wb\%}$) was estimated.

The levoglucosan data were used to assess the contribution of wood burning to $PM_{2.5}$ (PM_{wb}) in the investigated sites (Table 1).

Monitoring campaign	Main Site		San Pietro	
	$BaP_{wb\%}$	$PM_{wb\%}$	$BaP_{wb\%}$	$PM_{wb\%}$
November 2011	62		98	
November 2012	79	13	90	5
February 2013	82	8	62	9
October 2013	32	3	75	1
February 2014	93	12	98	15

Table 1: Contribution of wood burning to BaP concentration ($BaP_{wb\%}$) and to $PM_{2.5}$ ($PM_{wb\%}$).

The computed results show that wood burning represents one of the main sources of atmospheric aerosol during the cold seasons, since it contributes from 5% to 15% to the total $PM_{2.5}$ mass. In addition, it represents the main source of BaP concentration, accounting from 62% to 98%, with higher contribution at the rural site San Pietro. Exceptions are data in October 2013, since its meteorological conditions were similar to late summer.

Our findings are in line with published data from various other sites in Northern Italy (Piazzalunga *et al*., 2011) and highlight the strong impact of wood burning in cold seasons.

This work was supported by the Regional Agency for Prevention and Environment as part of the Supersito project (DRG n. n. 1971/13).

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