Ambient air pollution associated to domestic wood burning heating systems

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1. Context and objectives

Houses equipped with wood burning domestic heating systems are potential sources of pollutants such as particulate matter (PM, in particular fine particles $PM_{2.5}$), and associated species like polycyclic aromatic hydrocarbons (PAHs), heavy metals, dioxins and furans (PCDD/Fs). According to previous investigations, such heating systems could be considered as one of the major sources of fine particles and PAHs in ambient air. In residential neighbourhoods where wood heating is common, exposure to contaminants from chimney smoke could have a significant impact on health.

Main publications are considering effects of wood burning appliances on indoor air quality, which is a major issue in some countries. But impacts on ambient air, close environment and human exposure are rather poorly characterised so far. Besides, wood burning for domestic purpose may develop in the next years while promoting biofuels.

The aim of the ongoing study is to assess in which conditions associated air pollution and population exposure could be significant, this poster shows preliminary results of the impact of a village of 98 houses equipped with a wood burning heating system.

2. Materials and methods

As a first step of the research program, a theoretical approach by modelling (for both environmental concentrations and human exposure) has been chosen.

2.1. Compounds of concern

Compounds of interest regarding human exposure and potential health effects have been determined on:

- A scientific review on wood burning (Environment Canada, 2000, 2004);
- Available measurements of concentrations in flue gas, i.e. emission factors depending on speed (INERIS, 2002).

Considering emitted quantities and toxicological levels (the most drastic values are selected in case of several available), compounds were classified and major substances in terms of potential health effects were identified. Bioaccumulation potency in environment, food chain, and humans has also been considered.

The target compounds are thus:

- Gaseous compounds: NO_x, benzene, formaldehyde, acetaldehyde;
- Particulate matter and associated compounds: $PM_{2.5}$, PM_{10}, PCDD/Fs, PAHs, arsenic, cadmium, chromium, mercury, and lead.

2.2. Atmospheric dispersion modelling

Ambient air concentrations and soil deposition (both dry and wet deposition) are estimated through numerical simulation with second-generation Gaussian model ADMS3**.

The following hypotheses and input parameters have been adopted:

- The domain is defined as a 2km-wide square with a grid resolution of 30m;
- Each grid node is assumed to be the location of a house equipped with a wood stove;
- Simulations are conducted over a period of three consecutive years of meteorological data to characterise an annual average situation;
- Domestic heating appliances are 80% fire-places (closed or open) and 20% stoves;
- Wood burning is supposed to be effective between October, the 1st and April, the 30th
- During this period, emission flows are calculated considering:

  – a full speed between 6 and 9 am, and 6 and 12 pm;

  – a reduced speed between 0 and 6 am, and 9 am and 6 pm;
- percentiles 99.9 are calculated to assess hourly or daily concentration hot spots in ambient air, and then potential acute exposure.

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** *CERC (www.cerc.co.uk).*

3. Results

Table 1.
Annual average concentration for $PM_{2.5}$, PAHs and benzene calculated at an ambient air hot spot and comparison with urban ambient air data.

Pollutant	$PM_{2.5}$ (µg/m³)	PAHs (µg/m³)	Benzene (µg/m³)
Calculated annual average concentration in hot spot ambient air	6	9 E-4	0.6
Measured average concentration Quebec 1999-2002	12	1 E-3	2
Comparison with measured average concentration from Quebec	48%	70%	35%
Measured average concentration 2004-2005 from the Paris area	14	1 E-3	1
Comparison with measured average concentration from the Paris area	41%	76%	43%

$PM_{2.5}$, PAHs and benzene estimated annual average concentrations coming from a small village of 98 houses equipped with wood burning heating systems could represent 1/3 to 2/3 of annual ambient air levels measured in urban areas.

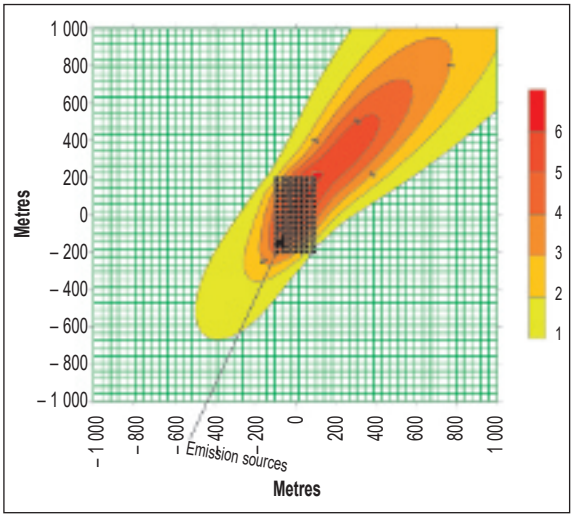

Figure 1.
$PM_{2.5}$ ambient air annual average concentration (µg/m³) in the environment of the village.

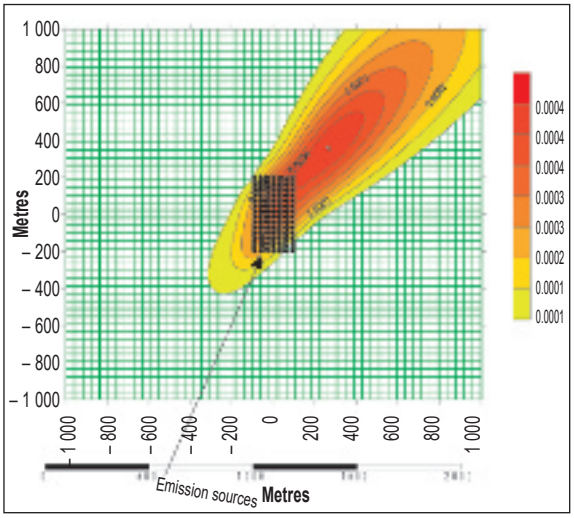

Figure 2.
16 US EPS PAHS annual average concentrations (µg/m³) in the $PM_{2.5}$ fraction of the ambient air in the environment of the village.

The maximum concentration is reached at quite a low distance from the centre of the village (200m).

More calculations taking into account the winter period only have been carried out for these three pollutants. The results showed that:

- Impact distance was not modified;
- The contribution to PM_{10} concentration measured in winter could reach 20 µg/m³.

4. Conclusion

This theoretical assessment based on modelling confirms that particulate matter has a real impact on local ambient air quality. $PM_{2.5}$, PAHs and benzene estimated concentrations can reach ambient air levels measured in urban areas. Work is ongoing in order to determine the threshold from which associated emissions could be significant in terms of population exposure and health effects.

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