Air Pollution from Wood-burning Fireplaces and Stoves

Dr. Sheela V. Basrur
Medical Officer of Health

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Authors: Sarah Gingrich and Ronald Macfarlane

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Distribution: Health Promotion & Environmental Protection Office
Toronto Public Health
277 Victoria Street, 7th floor
Toronto, Ontario
Canada M5B 1W2
Telephone: 416 392-6788
Fax: 416 392-7418

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1. INTRODUCTION

Many Canadians continue to use wood-burning fireplaces and wood stoves to heat their homes even though other energy sources are available. One motivation for doing so is the belief by some members of the public that burning wood (a renewable fuel source) creates fewer environmental impacts than using fossil fuels (a non-renewable fuel source). However, fireplaces and wood stoves can emit substantial quantities of pollutants to outdoor and indoor air. When compared to conventional fireplaces and wood stoves, advanced-combustion wood-burning appliances and natural gas fireplaces emit substantially reduced pollution emissions.

The objectives of this report are to describe the air quality and health impacts of residential wood burning in Toronto, and to explore policy options to reduce the exposure of Toronto's residents to contaminants from residential wood smoke. The report describes different types of wood-burning appliances and emissions from residential wood burning. The health impacts of residential wood-burning emissions and current relevant policy in Canada are summarized. This information is then used to recommend approaches to reducing wood smoke emissions in the City of Toronto.

Although the quantity of wood burned in Toronto is not known, a significant portion of the respirable particulate matter (particulate matter of diameter less than or equal to 2.5 micrometres, or $PM_{2.5}$) in Toronto's air is thought to come from wood smoke emissions. Fine particulate pollution is important for health because $PM_{2.5}$ can be drawn deep into the human lung, and it is known to contribute to respiratory and cardiovascular problems in both healthy people and at-risk groups including children and elderly persons. Province-wide, it is estimated that residential wood burning accounts for 11 percent of the $PM_{2.5}$ found in Ontario's air, 0.8 percent of the total particulate matter (PM), and 15 percent of volatile organic compounds (VOCs) (OMOE, 1999). In the City of Toronto, the contribution of residential wood burning to air pollution is likely lower than these provincial estimates because wood burning for home heating and cooking is more prevalent in rural areas. Reducing emissions from the residential wood-burning sector presents an opportunity to improve Toronto's air quality.

1.1 A Note on Terminology

In this report, "residential wood-burning appliances" refers to wood stoves and fireplaces. All residential wood-burning appliances sold in Canada must be certified for safety. In addition, the Canadian Standards Association (CSA) and the US Environmental Protection Agency (US EPA) have developed standards for low-emission appliances. In the USA, all wood stoves and fireplaces sold must be certified as having low emissions. In Canada the low-emission certification is required only in British Columbia. In this report, "CSA/EPA-certified" refers to low-emission certification by the Canadian Standards Association and/or the US Environmental Protection Agency. CSA/EPA-certified appliances are sometimes described as "advanced-combustion" stoves or fireplaces.

Acronyms used in this report:

CCME	-	Canadian Council of Ministers of the Environment
CO	-	carbon monoxide
CSA	-	Canadian Standards Association
CWS	-	Canada-wide Standards
ERMD	-	Emissions Research and Measurement Division, Environmental Technology Advancement Directorate, Environment Canada
HPAC	-	Hearth Products Association of Canada
IGWGRWC	-	Intergovernmental Working Group on Residential Wood Combustion (established under the Canada-wide Standards process)
NEIPTG	-	National Emissions Inventory and Projections Task Group (part of the CCME process)
NO_X	-	nitrogen oxides
NRC	-	Natural Resources Canada
OLA	-	Ontario Lung Association
OMOE	-	Ontario Ministry of the Environment
PAH	-	polycyclic aromatic hydrocarbon
PM	-	atmospheric particulate matter
$PM_{2.5}$	-	particulate matter of diameter less than or equal to 2.5 micrometres
PM_{10}	-	particulate matter of diameter less than or equal to 10 micrometres
SO_X	-	sulphur oxides
SO_2	-	sulphur dioxide
TPH	-	Toronto Public Health, City of Toronto
US EPA	-	United States Environmental Protection Agency
VOC	-	volatile organic compound
WES	-	Works and Emergency Services, City of Toronto

2 SIGNIFICANCE OF WOOD SMOKE EMISSIONS

Emissions from wood-burning stoves and fireplaces consist of a complex mixture of gases and particles including inhalable PM (particulate matter of diameter less than or equal to 10 micrometres, or PM_{10}), the finer respirable PM ($PM_{2.5}$) and contaminants that contribute to poor air quality and smog, for example sulphur oxides (SO_X), nitrogen oxides (NO_X) and CO. Residential wood-burning emissions also contain carcinogenic compounds, including polycyclic aromatic hydrocarbons (PAH), benzene, formaldehyde and dioxins (NEIPTG, 2000; Larson and Koenig, 1994; ERMD, 2000). Many of these substances are known to impact health. Residential wood burning is one source of many sources that contribute to the atmospheric burden of pollutants in Toronto's air.

In May 2000, a study from the Toronto Medical Officer of Health, *Air Pollution Burden of Illness in Toronto*, concluded that poor air quality contributes to hundreds of premature deaths and thousands of hospital admissions every year in the City of Toronto (TPH, 2000). The study

estimated air pollution-related illness rates and assessed the relative importance of key smog-related air pollutants contributing to poor health. Until now, smog has been considered a problem that we face only in the summer. However, the *Burden of Illness* report indicated that smog pollutants are emitted all year long and even winter sources of pollution contribute to air-quality related illness. Residential wood burning is one source of the contaminants that contribute to smog formation, including SO_X, NO_X and PM (NEIPTG, 2000).

In response to the *Burden of Illness* study, the Board of Health requested that the Medical Officer of Health investigate the policy options available to the City to reduce air pollution from key contributors including residential wood stoves and fireplaces.

In 2002, the Medical Officer of Health released another report entitled *Ten Key Carcinogens in Toronto Workplaces and Environment* (TPH, 2002). The report concluded that nine of the ten carcinogens studied are present in Toronto's outdoor air at levels that approach or exceed the one-in-one-million cancer risk level deemed "tolerable". Residential wood burning in the City of Toronto is one source of several of these carcinogens, including PAH, benzene, formaldehyde and dioxin (Rogge et al., 1998; Larson and Koenig, 1994).

It is also important to note that wood stoves and fireplaces can be significant sources of contaminants to indoor air. Improper use or maintenance of the wood stove or fireplace, leakage from pipes, or backdrafting from a chimney are primary causes of wood smoke leaking into the home (OLA, 2002). As indoor concentrations of some contaminants can exceed their outdoor concentrations, and most Toronto residents spend the majority of their time indoors, the impact of wood smoke on indoor air quality must be taken into consideration.

3 TYPES OF RESIDENTIAL WOOD-BURNING APPLIANCES

Common types of wood stoves and fireplaces are described below. It is important to distinguish between a conventional appliance and an advanced-combustion appliance that burns cleanly enough to be CSA/EPA-certified. As described later in this report, advanced-combustion appliances have dramatically lower emissions for a number of substances that can affect human health.

3.1 Wood Stoves

Wood stoves, which are freestanding space heaters, can be divided into three categories; conventional wood stoves, CSA/EPA-certified wood stoves and masonry heaters.

Conventional wood stoves do not have the advanced-combustion technology required to meet CSA/EPA emission standards. Advanced-combustion wood stoves (CSA/EPA-certified wood stoves) meet the US EPA standard or the CSA B415 standard for emissions, meaning that the stoves' emissions of PM are below the required threshold. PM emissions are used as a surrogate for a variety of pollutants emitted by wood-burning appliances. Advanced-combustion wood

stoves can be non-catalytic or catalytic. Non-catalytic stoves employ a secondary combustion chamber and a system to pre-heat the air supply. This allows for more complete combustion of the gaseous and particulate pollutants emitted from the burning fuelwood. Catalytic stoves contain a ceramic combustor that is coated with a platinum or palladium catalyst, again to ensure more complete combustion of the emissions. The performance of catalytic and non-catalytic advanced-combustion wood stoves is similar (NEIPTG, 2000).

The third type of wood stove, the masonry heater, consists of a combustion chamber that releases exhaust gases into channels flowing through a large masonry structure, and then to a chimney. The hot gases heat the masonry structure which slowly releases heat to the room for up to 24 hours, and relatively complete combustion is achieved (NEIPTG, 2000).

3.2 Wood-burning Fireplaces

A fireplace is generally considered to be a wood-burning device that is built into the structure of a living area and that allows one to view the fire as it burns. However, wood-burning stoves and fireplaces now have fewer distinctions between them. For example, advanced wood stoves have glass panels in their doors, making them look like fireplaces, and advanced fireplaces have a closed combustion chamber like that of a wood stove. In this report, a wood-burning fireplace refers to a wood-burning device that is built into a wall.

Conventional fireplaces are of two general types. Masonry fireplaces (made of materials such as brick or stone) are assembled in the home and are normally attached to a masonry chimney. Factory-built fireplaces, also called zero-clearance or prefabricated, are made of metal, installed as a package and attached to a metal chimney. Conventional masonry or factory-built fireplaces may or may not have glass doors, but they do not employ emission-reduction technologies.

Conventional fireplaces are generally not very effective for home heating because they require a lot of dilution air and have inadequate means of transferring heat to the home. The high requirements for dilution air mean that large quantities of heated household air are swept into the fireplace and up the chimney when the fire is burning. Consequently, conventional masonry fireplaces can be very inefficient and in some cases can even result in overall heat loss, or an efficiency less than zero (ERG, 2001).

Because large quantities of air flow through a conventional fireplace, the combustible gases emanating from the burning wood are swept out through the chimney before they are completely burned. The pollutants generated by this incomplete combustion process are released to the outdoor air. If a fireplace is inappropriately installed or operated, products of combustion can also contaminate indoor air through back drafting and leakage. Therefore, contrary to the common belief among members of the public that wood burning is an environmentally friendly practice, conventional wood-burning fireplaces generally result in high levels of pollutant emissions (US EPA, 1996).

Fireplace inserts are wood stoves that have been designed to fit within the firebox of a masonry fireplace. Some fireplace inserts are CSA/EPA-certified as having low emissions, allowing a homeowner to convert a conventional fireplace to a CSA/EPA-certified appliance.

3.3 Natural Gas Appliances

Natural gas fireplaces are considered a convenient, low-emission alternative to wood-burning appliances. In Toronto, which is supplied with natural gas, they are becoming more popular. Natural gas appliances are low in emissions. Total PM emissions from natural gas fireplaces are even lower than those from CSA/EPA-certified wood-burning fireplaces (Houck and Tiegs, 1998). However, as with wood-burning appliances, care must be taken so that they are vented correctly, and CO detectors are employed where required.

4 CONTAMINANTS IN WOOD SMOKE

4.1 Estimating Emissions of Individual Contaminants

While the identities of many wood-smoke constituents are known there is less certainty regarding the quantities of these chemicals that are emitted. This is in part because the burning of fuelwood is largely an unregulated industry, making it a challenge to quantify wood consumption. Further, most residential wood burning involves the random combustion of batches of fuel. It is also difficult to measure emissions because steady state combustion does not occur in residential appliances (NEIPTG, 2000). When emissions data are unavailable, emission factors can be used as a means of predicting them. Emission factors are quantitative estimates of the amount of an individual chemical that will be emitted when a quantity of fuel is consumed in a given appliance.

4.1.1 Particulate Matter

While a range of estimates exists, a significant portion of the fine particulate pollution in Toronto's air is understood to come from residential wood burning. According to one estimate, approximately seven percent of the $PM_{2.5}$ in Toronto's air comes from wood smoke emissions (Environment Canada, 2001). This estimate was based on data averaged over a time period that excluded the coldest months of the year, and therefore it is likely an underestimate. Contributions for Ontario are similar, with an estimated 11 percent of $PM_{2.5}$, and 0.8 percent of total PM, resulting from residential wood burning (OMOE, 1999). Nationwide, residential wood burning accounts for an estimated 25 percent of the $PM_{2.5}$ found in Canada's air (Environment Canada, 1999). This national average value overestimates the proportion of $PM_{2.5}$ from residential wood burning in Toronto because wood burning is less common in urban than rural areas.

By mass, residential fuelwood combustion can account for up to an estimated 5,400 tonnes of total PM emitted to outdoor air in the City of Toronto (Eric Loi, OMOE, pers. comm. Nov. 19,

1999). In all of Ontario, 28,600 tonnes of total PM and 28,030 tonnes of $PM_{2.5}$ are estimated to result from residential fuelwood combustion (OMOE, 1999).

4.1.2 Carbon Monoxide

Indoor concentrations of carbon monoxide (CO) can increase as a result of residential wood burning if there is leakage of exhaust gases or backdrafting from the chimney into the home.

4.1.3 Polycyclic Aromatic Hydrocarbons

PAH are a group of chemicals that are formed during the incomplete burning of organic materials including coal, oil, gasoline, diesel fuel, wood and garbage. In the home, they are present in tobacco smoke, smoke from wood products and smoke from barbecues.

The burning of wood in stoves and fireplaces produces a range of PAH (Houck and Tiegs, 1998). When studied in Montreal, mean levels of PAH at a site influenced by residential wood combustion were higher than those measured downtown, which was mostly influenced by vehicle emissions (Environment Canada et al., 2000). This suggests that residential wood burning can have a significant impact on ambient PAH concentrations in some urban environments.

4.1.4 Dioxins

Polychlorinated dibenzo-*p*-dioxins (PCDDs), a group of chemicals commonly known as dioxins, form in minute quantities as unwanted impurities during numerous combustion activities. Dioxins have been identified as a priority for reduction through the Canada-wide Standards (CWS) process.

Trace levels of dioxin are detectable in residential wood-burning emissions. The latest estimate is that residential wood burning emits approximately three percent of Canada's total annual dioxin emissions.

4.1.5 Volatile Organic Compounds

Residential wood burning was estimated to account for as much as 15 percent of Ontario's VOC emissions in 1995 (OMOE, 1999). In one residential area in Montreal, known to have a high use of residential wood-burning devices, residential wood burning was found to be a more significant source of VOCs than vehicular transportation, a well known source of VOCs (Environment Canada et al., 2000

4.2 Emissions from Different Types of Fireplaces and Stoves

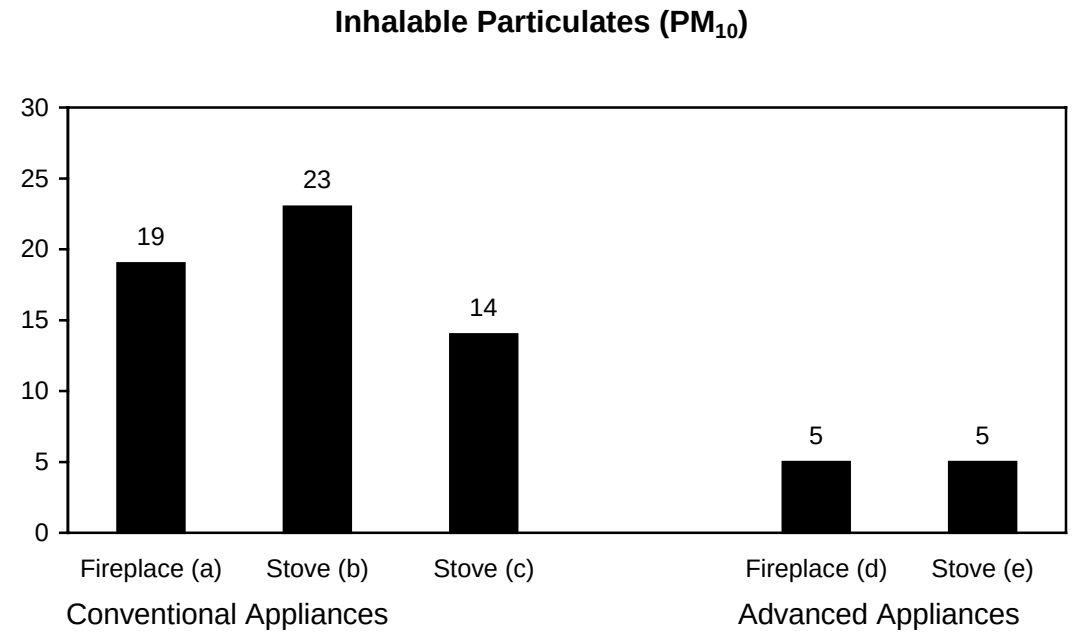
The composition of residential wood-burning emissions is strongly influenced by the type of stove or fireplace employed and the wood or other material used as fuel, among other factors. In preliminary laboratory tests CSA/EPA-certified wood stoves were shown to reduce emissions of

PM by 94 percent relative to conventional wood stoves (ERMD, 2000). While all wood burning produces PAH, preliminary tests have shown CSA/EPA-certified stoves to reduce PAH emissions by 85 percent, relative to conventional appliances (ERMD, 2000). More research is needed before the difference in dioxin emissions from conventional versus CSA/EPA-certified appliances can be assessed (J.-F. Banville, Environment Canada, pers. comm. Nov. 20, 2001). However, preliminary results have shown that CSA/EPA-certified wood stoves emit 80 percent less VOC compared with conventional wood stoves (ERMD, 2000).

Emissions from CSA/EPA-certified residential wood stoves are much lower than those from conventional wood stoves. According to Environment Canada scientists, the air quality benefits overwhelmingly justify the use of CSA/EPA-certified stoves over conventional stoves.

Using emission factors (estimated kilograms of contaminant released per tonne of dry fuel), another Canadian study concluded that emissions of a number of contaminants are lower from CSA/EPA-certified wood stoves and fireplaces than from conventional wood stoves or fireplaces. Emission factors were found to be lower for total PM, PM_{10}, $PM_{2.5}$, VOCs and CO, as shown in Figure 1 for three of these substances (NEIPTG, 2000).

Figure 1. Air contaminant emission factors for residential wood combustion (kg/tonne of dry fuel).



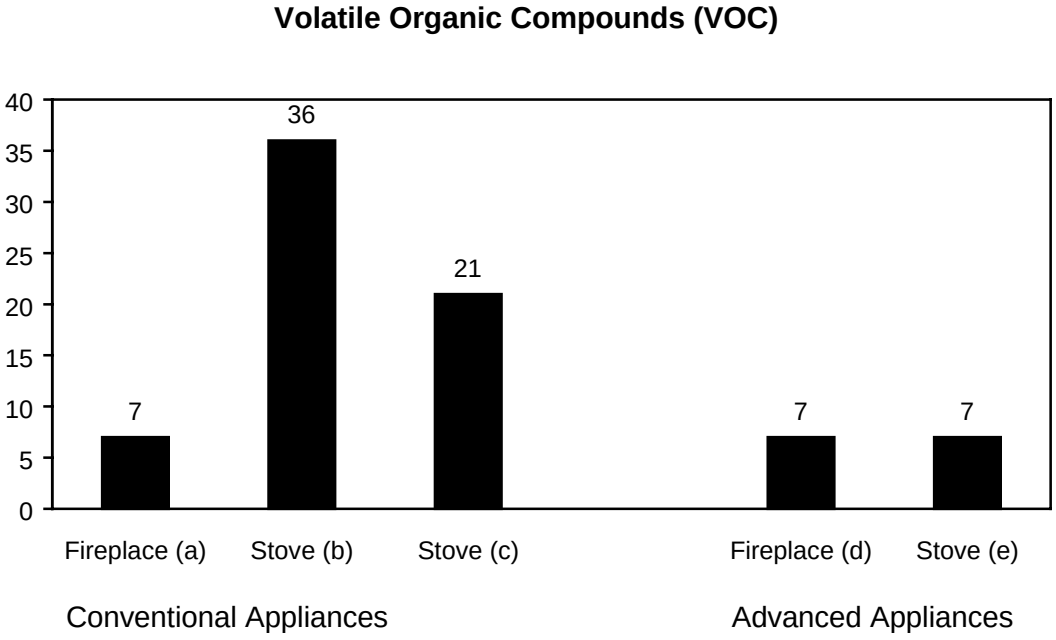
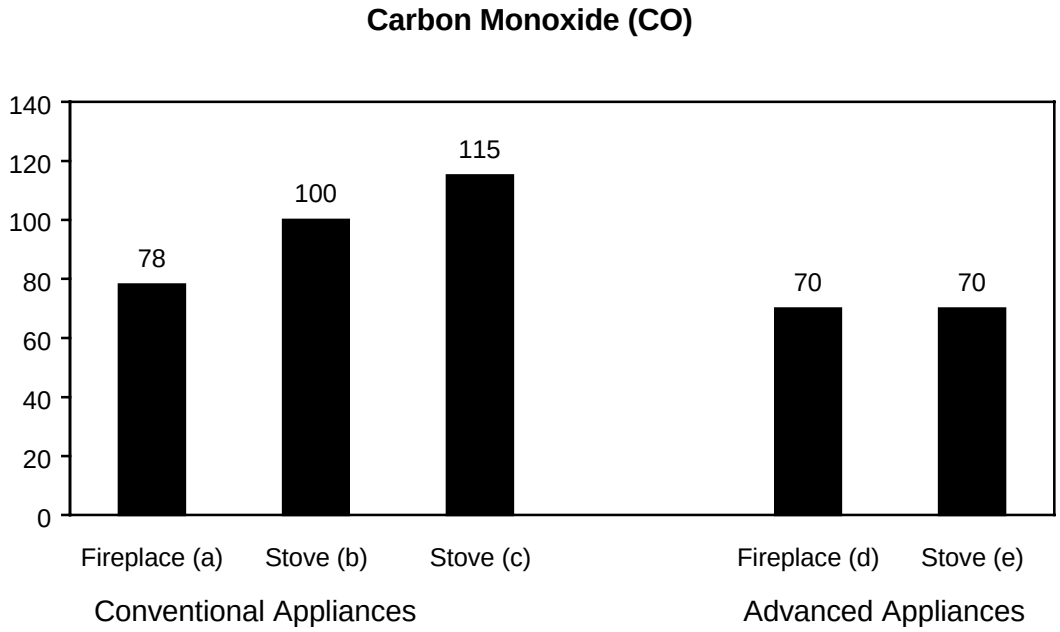


Figure 1 (continued)



Notes:
(a) Conventional fireplace without glass doors
(b) Conventional wood stove – not air tight
(c) Conventional wood stove – air tight
(d) Advanced technology fireplace (CSA/EPA-certified)
(e) Advanced technology wood stove (CSA/EPA-certified)

Source: Adapted from NEIPTG, 2000.

Emission factors for benzene have been quoted as 1.0 and 0.7 g/kg wood for conventional wood stoves and EPA/CSA-certified catalytic wood stoves, respectively, again showing lower emissions from advanced-combustion appliances (ERG, 1996). Comparing the emissions of individual contaminants from different wood-burning fireplaces and stoves highlights the air quality benefits to be gained from employing CSA/EPA-certified appliances. CSA/EPA-certified appliances provide substantially lower emissions of numerous contaminants than conventional wood stoves or fireplaces.

A comparison of emissions from natural gas residential heating appliances can be made with those of wood-burning appliances. Wood is a solid fuel measured by weight (e.g. kilograms) while natural gas is measured by volume (e.g. cubic metres or standard cubic feet). However, emissions from burning these two fuels can be compared if they are reported per unit heat produced. On the basis of total PM emissions per unit of delivered heat (g/MJ), CSA/EPA-certified fireplace inserts are estimated to emit approximately 95 percent less PM than conventional fireplaces (0.5 g/MJ and 8.6 g/MJ, respectively). Total PM emissions from natural

gas fireplace inserts were found to be even lower and are considered negligible (Houck and Tiegs, 1998). Natural gas is generally considered to be an extremely clean-burning fuel, however its combustion does result in emissions of nitrogen oxides, as does the combustion of all fossil fuels.

4.3 Impact of Fuel Type on Emissions

Burning clean wood, instead of household garbage, wet wood, plywood, glossy magazines and other waste materials, can dramatically reduce the emissions of dioxins and other contaminants from an existing wood stove or fireplace (J.-F. Banville, Environment Canada, pers. comm. Nov. 20, 2001). Environment Canada emphasizes the importance of burning only clean, dry wood.

Toronto Public Health does not have sufficient evidence to determine whether burning synthetic firelogs increases or decreases emissions relative to burning clean, dry wood. While some studies have found that PM emissions from commercial wax logs are almost 70 percent lower than from wood (Houck and Tiegs, 1998), other studies show PAH emissions to be greater when burning a synthetic log (Rogge et al., 1998). Emissions from synthetic logs depend directly on their composition, and more than one type is available. Natural Resources Canada (NRC) has stated that insufficient data are available on the toxicants released from synthetic logs, and recommends that synthetic logs not be used unless their composition is known. Some synthetic logs are made of sawdust bound together with spent bitumen oil, and the emissions from these binding materials are not well understood. NRC does not include synthetic logs in its definition of clean wood.

It is recommended that the characterization of the emissions from burning artificial logs and assessment of their performance as an appropriate fuel for residential wood-burning appliances be done.

5 HEALTH EFFECTS OF WOOD SMOKE

5.1 Health Effects Associated with the Mixture of Contaminants in Wood Smoke

Most studies on the health effects of wood smoke have been undertaken in countries where cooking over an open fire is still common and therefore pollutant exposure is higher. Increased rates of chronic bronchitis, decreased pulmonary function and respiratory symptoms were observed in communities in India, Nepal and New Guinea where women spend many hours close to an indoor, unvented fire (Larson and Koenig, 1994). Another study undertaken in Mexico City studied non-smoking patients who lived in the countryside away from urban sources of air pollution. The study's authors suggested that participants' lung disease was due to wood smoke exposure, primarily from wood used in home cooking. The subjects had abnormal chest X-rays and their pulmonary function tests were consistent with mixed restrictive-obstructive lung disease (Sandoval et al. 1993).

Cooking or heating with wood is an environmental factor that influences susceptibility to the development of asthma in predisposed individuals (NHLBI, 2002). An epidemiological study undertaken in Michigan concluded, "young children living in homes heated by a wood-burning stove had a greater occurrence of moderate and severe chronic respiratory symptoms than children of the same age and sex who did not live in homes heated with a wood-burning stove" (Honicky and Osborne, 1991). Children are at increased risk for adverse effects of inhaled irritants because they have higher ventilation (breathing) rates relative to body size and immature immune systems. The Ontario Lung Association (2002) has described the health impacts of products of combustion indoors, including those from residential wood burning and natural gas cooking ranges. Indoor combustion products can exacerbate asthma, increase respiratory symptoms, decrease lung function, and contribute to lung cancer.

When Northern California experienced a six-year drought with air stagnation and decreased visibility, there were numerous reports that wood smoke was causing adverse respiratory effects. A source apportionment analysis found that residential wood smoke was the largest single source of PM_{10} in one county, approximately equal to the sum from motor vehicle emissions plus entrained road dust. An examination of the relationship between this ambient air pollution and emergency room visits demonstrated "an association between ambient wintertime PM_{10} and exacerbations of asthma in an area where one of the principal sources of PM_{10} is RWC" (residential wood combustion) (Lipsett et al., 1997).

While quantitative data describing wood smoke emissions, exposures and health effects in Toronto are not available, evidence from other locations indicates that in high concentrations the complex mixture of contaminants in wood smoke impacts respiratory health.

5.2 Health Effects Associated with Individual Contaminants in Wood Smoke

As it is not impossible to identify all of the chemicals that are released in the complex mixture, the health impacts associated with the release of selected chemicals from wood stoves and fireplaces are described below.

5.2.1 Particulate Matter

An estimated ninety-eight percent of the total PM emitted by residential wood combustion is in the respirable category, $PM_{2.5}$ (OMOE, 1999). $PM_{2.5}$ can be respired deep into the human lung, causing lung irritation in healthy people and exacerbating asthma and other respiratory illnesses in at-risk groups such as children, the elderly and those with pre-existing illness. This very fine PM has a greater impact on health than the coarser fractions, highlighting the importance of reducing wood smoke emissions both indoors and outdoors.

In Toronto, airborne PM was found to be responsible for a substantial burden of illness. The Medical Officer of Health's study, *Air Pollution Burden of Illness in Toronto*, reported that close to twenty percent of the air pollution-related premature mortality and cardio-respiratory hospitalizations in Toronto are linked to inhalable PM. This includes fine dusts, metal fumes and

acid aerosols that form in the atmosphere from gases including sulphur dioxide (SO_2) and NO_X (TPH, 2000).

Recent epidemiological evidence indicates an association between exposure to smog pollutants and increased mortality from lung cancer. The researchers highlighted the health concern over exposure to airborne fine particles (Pope et al., 2002). While most of the health data on PM examines outdoor air, the Ontario Lung Association suggests that there is an association between exposure to PM in indoor air and exacerbation of asthma, inflamed airways and increased allergic immune response (OLA, 2002). Data suggest that respirable PM can contribute to nasal irritation, respiratory infections, bronchitis and lung cancer. Heating with wood is one potential source of PM to the indoor environment (NHLBI, 2002).

5.2.2 Carbon Monoxide

CO has been estimated to contribute to approximately thirty percent of premature mortality in Toronto due to air pollution (TPH, 2000). It is a colourless, odourless gas and closely associated with adverse effects on the heart. CO exposure is particularly a problem indoors, where concentrations can build up undetected, potentially causing death. CO binds with haemoglobin in the blood, reducing the ability of the blood to carry oxygen. People with heart disease are most at risk, as well as pregnant women, fetuses, infants, children, elderly persons and people with anemia and respiratory disease.

5.2.3 Polycyclic Aromatic Hydrocarbons

Some PAH are carcinogenic to humans. Because this group of compounds covers a wide range of physical-chemical properties, some PAH are found in air on particles while others are gaseous. PAH of both forms may be deposited in the lung.

A study done in Brazil found levels of PAH and suspended PM to be significantly higher in kitchens with wood stoves than those with gas stoves. Based on the elevated air concentrations of PAH and PM, the authors concluded that domestic wood burning is a risk factor for some of the upper digestive and respiratory tract cancers observed in Brazil (Hamada et al, 1992).

5.2.4 Dioxins

Dioxins are carcinogenic to humans. They are extremely toxic, persist in the environment and bioaccumulate in animal tissues. Exposure to dioxins has been linked to a number of adverse health effects including developmental, reproductive, hormonal, respiratory and cardiovascular problems (CCME, 2001).

5.2.5 Volatile Organic Compounds

Some individual VOCs are believed to pose a threat to human health, for example benzene is considered carcinogenic. Benzene, along with PAH and dioxin, have been identified as priorities for carcinogenic emission reductions in Toronto (TPH, 2002).

6 CURRENT POLICY ON RESIDENTIAL WOOD-BURNING EMISSIONS

6.1 National Level

In 2000, the Canadian Council of Ministers of the Environment (CCME) endorsed Canada-wide Standards for Particulate Matter (PM) and Ozone. To reduce production and emissions of these two substances, a list of Joint Initial Actions was developed, and this list includes the following actions to reduce emissions from residential wood combustion:

> *Participate in new initiatives to reduce emissions from residential wood burning appliances including:*
>
> *a) an update of the CSA standards for new wood-burning appliances;*
> *b) development of a national regulation for new, clean burning residential wood heating appliances;*
> *c) national public education programs;*
> *d) an assessment of the option of a national wood stove upgrade or change-out program.*

The Joint Initial Actions are to be implemented by 2005, and federal staff indicate that they are on schedule. Items a) and b) are under development. Items c) and d) are currently being implemented, as described later in this report. A working group made up of federal, provincial, territorial and municipal governments, called the Intergovernmental Working Group on Residential Wood Combustion (IGWGRWC) is responsible for implementing the Joint Initial Actions.

British Columbia is currently the only Canadian province that requires new residential wood-burning appliances to be CSA/EPA-certified when they are sold. Older, existing wood stoves or products purchased outside of British Columbia are exempt. British Columbia's standard, introduced in 1994, is based on the US EPA standard that was introduced in 1992. The Hearth Products Association of Canada (HPAC) has been urging the Government of Ontario and the federal government to adopt similar regulations.

As described earlier, CSA/EPA-certified appliances have greatly reduced emissions of a number of substances. A national regulation requiring that all new residential wood-burning appliances must be CSA/EPA-certified is a priority. The Federal and Ontario Ministers of Environment should be encouraged in their efforts to implement the commitments made to reduce emissions from residential wood-burning appliances, as described in the list of Joint Initial Actions in support of the Canada-wide Standards for Particulate Matter (PM) and Ozone.

6.2 Ontario Government

6.2.1 Ministry of Municipal Affairs and Housing

The Ontario Building Code offers another opportunity to ensure that all newly installed residential wood-burning appliances are CSA/EPA-certified. The current Code addresses the safety of wood-burning appliances and their installation, but it does not address their emissions.

The Ontario Minister of Municipal Affairs and Housing should be requested to include provisions in the Ontario Building Code that require newly installed residential fireplaces and wood stoves to be CSA/EPA-certified.

6.2.2 Ministry of the Environment

The province is involved in the development of a regulatory framework on wood stoves at the Canada-wide level. The Ontario Ministry of the Environment (OMOE) would be supportive of efforts to control wood stove emissions by encouraging the public to only burn clean wood. Educational activities are the only means by which this objective can be achieved.

6.3 Municipal Government

Complaints related to residential properties are dealt with by the municipality. Municipalities have a role to play in environmental protection, especially in areas they oversee such as land-use planning. In addition, they are better equipped to deal with issues related to neighbour disputes, property standards and zoning conflicts. At the City of Toronto, Works and Emergency Services (WES) deals with neighbour disputes about air quality, and Public Health Inspectors also receive air quality complaints. Both WES and Toronto Public Health receive few complaints regarding residential wood burning. Most complaints are regarding extreme cases of residential emissions where the complainant observed thick smoke and an offensive odour coming from the chimney of a neighbour suspected of burning waste. Toronto Public Health inspectors routinely advise members of the public on the dangers of carbon monoxide in indoor air (one source of which is residential wood burning), and on the need to install carbon monoxide detectors in the home.

7 HEALTH PROMOTION OUTREACH ACTIVITIES

Natural Resources Canada (NRC) has taken the national lead on education related to reducing emissions from residential wood burning. Through its *Burn It Smart* campaign, NRC provides educational materials on selecting a lower-emission wood-burning appliance and reducing emissions from an existing appliance. Educational materials are available on the campaign's website (www.burnitsmart.org). This campaign also includes a wood stove "change-out" program, described below. Other complimentary educational programs address indoor air quality, including the Lung Association's program, *C.A.N. DO, the Movement for Clean Air Now*. The Canada Mortgage and Housing Corporation also provides educational materials on

how to reduce the indoor air quality impacts of residential wood-burning appliances. Toronto Public Health will help promote existing educational programs that aim to reduce air pollution and health impacts from residential wood burning and assist members of the public to reduce their emissions.

7.1 Burning Clean Wood

The literature on emissions from residential wood burning consistently states that proper maintenance and use of a wood stove or fireplace substantially reduces pollutant emissions. For example, as described above, fireplaces and wood stoves should burn only clean wood that has been cut and dried for the purpose of home heating. Both government and industry are supportive of educational programs encouraging members of the public to burn only clean wood instead of waste materials in their wood stoves and fireplaces.

7.2 "Change-out" Programs

A "change-out" program encourages members of the public to upgrade from a conventional wood stove or fireplace to cleaner technology, such as a CSA/EPA-certified wood stove. Change-outs generally provide a financial incentive and include an educational component to increase awareness about the need for wood stove and fireplace users to burn only clean wood. Incentives are required because the cost to purchase an CSA/EPA-certified wood stove or fireplace is approximately $500 to $700 greater than that of a conventional wood-burning appliance (Laurus, 2002). However, given their higher efficiencies and reduced wood consumption (Houck and Tiegs, 1998), the operating costs of certified appliances will be lower than for conventional appliances.

Change-out programs in Canada have been a collaborative effort between the Federal government (Environment Canada, NRC), the Provincial government (OMOE in Ontario), and industry (e.g. the HPAC).

As part of the CWS Joint Initial Actions listed above, NRC is leading a wood-stove education and change-out program. From January to March, 2002, NRC organized a series of workshops in each of eight locations across Canada. Each series was organized and implemented by a local community organization with support from NRC. From September 2002 to March 2003, NRC is undertaking another set of residential wood-burning educational workshops, some of them including a change-out program. Workshop series are implemented by local organizations at twenty cities or regions across Canada, with a contribution from NRC for each city or region. The local organization implementing the workshop series is expected to hold twelve public workshops demonstrating means to improve wood-burning safety, increase efficiency and reduce emissions. It is not clear whether the program will be repeated in the near future.

Educational initiatives, change-out programs and other activities to reduce emissions from wood burning provide opportunities to achieve cleaner air as part of the City's overall Air Quality Strategy. The Commissioner of Works and Emergency Services, as Chair of the Toronto Inter-departmental Environment Committee, should be requested to ensure that the City's Air Quality

Strategy includes consideration of measures that can be taken to reduce emissions of, and exposure to, residential wood smoke.

When harvested sustainably, wood is a renewable resource. However, given the low emissions of PM and other substances from natural gas, natural gas fireplaces are one cleaner-burning alternative. This approach is especially effective in urban areas where natural gas is readily available. Should such a change-out program be adopted for Toronto in the future, Toronto Public Health suggests that any change-out or educational program in Toronto should promote switching from conventional wood-burning appliances to CSA/EPA-certified appliances or natural gas fireplaces.

8 CONCLUSION - OPTIONS TO REDUCE WOOD-BURNING EMISSIONS

Residential wood burning in Toronto is a known source of numerous contaminants that can affect health. Older appliances, those that are ill-maintained and those used to burn waste materials instead of clean wood, can be an even greater source of contaminants to the outdoor and indoor air. The relative contribution of wood burning to the City's burden of atmospheric contaminants is not known, but in the case of $PM_{2.5}$, it is estimated to be of significance. Province-wide, it is estimated that residential wood burning accounts for 11 percent of the $PM_{2.5}$ found in Canada's air and 15 percent of VOCs (OMOE, 1999). In the City of Toronto, the contribution of residential wood burning to air pollution is significant, but likely lower than these provincial estimates due to differences in the prevalence of wood-fired cooking and heating. Alternatives to conventional wood burning are available, including wood stoves and fireplaces that are CSA/EPA-certified, or natural gas fireplaces.

This report recommends that:

(1) the commitments made by the Federal and Ontario Ministers of Environment to reduce emissions from residential wood-burning appliances, as described in the list of Joint Initial Actions agreed upon under the Canada-wide Standards for Particulate Matter (PM) and Ozone, be implemented by 2005;

(2) the Federal Minister of Environment include the characterization of emissions from burning artificial logs, and assessment of their performance as a clean fuel for residential wood-burning appliances, as an additional focus of the IGWGRWC; and

(3) the Ontario Minister of Municipal Affairs and Housing include provisions in the Ontario Building Code that require newly installed residential fireplaces and wood stoves to meet the low-emission certification requirements of the Canadian Standards Association or the US Environmental Protection Agency.

Toronto Public Health is committed to increasing public awareness of the strategies to prevent or reduce emissions from wood burning. Public Health will continue to collaborate with others in the corporation and community to improve air quality through its public education activities.

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