GUIDANCE FOR FINE PARTICULATE MATTER ($PM_{2.5}$) IN RESIDENTIAL INDOOR AIR

Background

Fine particulate matter ($PM_{2.5}$) is a general term for all small particles found in air measuring equal to or less than 2.5 µm in aerodynamic diameter. It is a complex mixture whose constituents vary in size, shape, density, surface area, and chemical composition (Health Canada and Environment Canada 1999; US EPA 2009). In 1987, Health Canada published Exposure Guidelines for Residential Indoor Air Quality, which set maximum acceptable long- and short-term exposure ranges for $PM_{2.5}$ in homes. These guidelines are being revised to reflect the most up-to-date science on the health effects and residential exposure for $PM_{2.5}$.

Exposure

Indoor $PM_{2.5}$ is composed of indoor-generated $PM_{2.5}$ from sources such as smoking, cooking, and cleaning, and $PM_{2.5}$ that has infiltrated from the outside. In studies conducted by Health Canada in different Canadian cities, average indoor $PM_{2.5}$ concentrations were less than 15 $\mu g/m^3$ in homes without smokers, and less than 35 $\mu g/m^3$ in homes with smokers (Health Canada 2010). In general, indoor $PM_{2.5}$ levels were lower than outdoor concentrations measured directly outside the home, except in homes with smokers.

Health Effects

Outdoor $PM_{2.5}$, as measured at area monitoring stations, has been shown in a large number of studies to be strongly associated with cardiovascular and respiratory mortality and morbidity endpoints (Health Canada and Environment Canada 1999; WHO 2005; US EPA 2009). There is no recognized threshold of health effects for outdoor $PM_{2.5}$ regardless of where exposure occurs (i.e., indoors or outdoors), and there is evidence that adverse health effects occur at current levels of exposure.

A much smaller number of studies have investigated the relationship between indoor $PM_{2.5}$ and health. There is some evidence for a relationship between indoor $PM_{2.5}$ levels and declines in lung function and increases in exhaled nitric oxide, a marker of airway inflammation, in asthmatic children (Koenig et al. 2003; Delfino et al. 2004; Koenig et al. 2005; Trenga et al. 2006). However, changes in exhaled nitric oxide were more strongly associated with outdoor $PM_{2.5}$ than indoor $PM_{2.5}$ (Koenig et al. 2003; Koenig et al. 2005; Allen et al. 2008). Associations between indoor $PM_{2.5}$ and subtle changes in markers of cardiovascular disease have also been observed in older adults (Delfino et al. 2008; Liu et al. 2009; Allen et al. 2011).

Guidance

The acceptable long- and short-term exposure ranges established in the 1987 exposure guidelines should be rescinded and replaced with this new guidance focusing on indoor source control to minimize long-term exposure to $PM_{2.5}$ indoors.

Indoor levels of $PM_{2.5}$ should be kept as low as possible, as there is no apparent threshold for the health effects of $PM_{2.5}$. It is impossible to entirely eliminate $PM_{2.5}$ indoors, as among its sources are essential and everyday activities, such as cooking and cleaning, as well as infiltration from outdoor sources, over which residents have little or no control. However, any reduction in $PM_{2.5}$ would be expected to result in health benefits, especially for sensitive individuals, such as those with underlying health conditions, the elderly or children.

The focus should be on reducing indoor sources over which homeowners and residents have some degree of control. The main recommended strategies to reduce exposure to the major sources of indoor-generated $PM_{2.5}$ are:

- Cessation of smoking
- Use of a stove top fan while cooking

Other actions to reduce indoor $PM_{2.5}$ levels include ensuring there is adequate ventilation, especially when doing activities that may generate $PM_{2.5}$. The potential benefits of ventilation, however, may be reduced or eliminated, if outdoor $PM_{2.5}$ levels are high. There is also evidence that some in-duct air filters or portable air cleaners with filters may help reduce indoor $PM_{2.5}$ levels. Filter efficiency, however, is highly variable among products and the effectiveness of filters as a method to reduce indoor $PM_{2.5}$ will depend on the product used and how it is maintained. A discussion of how to properly select and maintain air filters and portable air cleaners is beyond the scope of this document.

The above recommendations are consistent with Health

Canada guidance to homeowners to focus on identifying the potential sources of contaminants in the home, and then on improving air quality through source control, improved ventilation and other remedial measures such as air filtration. Identification of potential sources is, in most situations, more informative and cost-effective than indoor air quality testing and comparison of measured values to quantitative guideline values.

Quantitative residential indoor air guidelines may be of use to public health and building professionals for the interpretation of results of indoor air quality studies and for the development of performance standards. With respect to indoor $PM_{2.5}$, Health Canada is not proposing a specific maximum exposure limit, but is recommending that indoor $PM_{2.5}$, at a minimum, be lower than $PM_{2.5}$ outside the home. Having an indoor level that is greater than the outdoor level indicates a strong indoor source(s) of $PM_{2.5}$ that needs to be addressed. The ratio of indoor to residential outdoor $PM_{2.5}$ levels can therefore serve to highlight situations where strategies to reduce indoor-generated $PM_{2.5}$ are necessary and will be most effective. The recommended $PM_{2.5}$ reduction strategies can be employed in all homes. However, for those homes with a ratio of indoor to outdoor $PM_{2.5}$ levels greater than one, targeted efforts to identify and remove indoor sources of $PM_{2.5}$ are a priority.

References

Allen, R.W., Carlsten, C., Karlen, B., Leckie, S., van Eeden, S., Vedal, S., Wong, I. and Brauer, M. (2011) An Air Filter Intervention Study of Endothelial Function Among Healthy Adults in a Woodsmoke-Impacted Community. *American Journal of Respiratory and Critical Care Medicine*., In press.

Allen, R.W., Mar, T., Koenig, J., Liu, L.-.S., Gould, T., Simpson, C. and Larson, T. (2008) Changes in lung function and airway inflammation among asthmatic children residing in a woodsmoke-impacted urban area. *Inhalation toxicology*, **20**(4):423-433.

Delfino, R.J., Quintana, P.J.E., Floro, J., Gastanaga, V.M., Samimi, B.S., Kleinman, M.T., Liu, L.-.S., Bufalino, C., Wu, C.- F. and McLaren, C.E. (2004) Association of FEV1 in asthmatic children with personal and microenvironmental exposure to airborne particulate matter. *Environmental Health Perspectives*, **112**(8):932-941.

Delfino, R.J., Staimer, N., Tjoa, T., Polidori, A., Arhami, M., Gillen, D.L., Kleinman, M.T., Vaziri, N.D., Longhurst, J., Zaldivar, F. and Sioutas, C. (2008) Circulating biomarkers of inflammation, antioxidant activity, and platelet activation are associated with primary combustion aerosols in subjects with coronary artery disease. *Environmental Health Perspectives*, **116**(7):898-906.

Health Canada. (2010) Health Canada Exposure Assessment Studies: PM2.5 Sampling Data Summary. Report: HC-IACAS-2010-09 - PM Data (unpublished).

Health Canada and Environment Canada. (1999) National Ambient Air Quality Objectives for Particulate Matter Part 1: Science Assessment Document.

Koenig, J.Q., Jansen, K., Mar, T.F., Lumley, T., Kaufman, J., Trenga, C.A., Sullivan, J., Liu, L.-.S., Shapiro, G.G. and Larson, T.V. (2003) Measurement of offline exhaled nitric oxide in a study of community exposure to air pollution. *Environmental Health Perspectives*, **111**(13):1625-1629.

Koenig, J.Q., Mar, T.F., Allen, R.W., Jansen, K., Lumley, T., Sullivan, J.H., Trenga, C.A., Larson, T.V. and Liu, L.-.S. (2005) Pulmonary effects of indoor- and outdoor-generated particles in children with asthma. *Environmental Health Perspectives*, **113**(4):499-503.

Liu, L., Ruddy, T., Dalipaj, M., Poon, R., Szyszkowicz, M., You, H., Dales, R.E. and Wheeler, A.J. (2009) Effects of indoor, outdoor, and personal exposure to particulate air pollution on cardiovascular physiology and systemic mediators in seniors. *Journal of Occupational and Environmental Medicine*, **51**(9):1088-1098.

Trenga, C.A., Sullivan, J.H., Schildcrout, J.S., Shepherd, K.P., Shapiro, G.G., Liu, L.-.S., Kaufman, J.D. and Koenig, J.Q. (2006) Effect of particulate air pollution on lung function in adult and pediatric subjects in a Seattle panel study. *Chest*, **129**(6):1614-1622.

US EPA. (2009) Integrated Science Assessment for Particulate Matter (Final Report). United States Environmental Protection Agency (US EPA),U.S. Environmental Protection Agency, Washington, DC.

WHO. (2005) World Health Organization (WHO). Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update 2005 Summary of risk assessment.

Cat.: H129-16/2012E