

Exposure to some carcinogenic compounds in air, with special reference to wood smoke

Akademisk avhandling

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Avhandlingen baseras på följande arbeten:

- I Gustafson P., Barregård L., Lindahl R., Sällsten G. Formaldehyde levels in Sweden: personal exposure, indoor, and outdoor concentrations. *Journal of Exposure Analysis and Environmental Epidemiology* 2005; 15(3):252–260.
- II Gustafson P., Barregård L., Strandberg B., Sällsten G. The impact of domestic wood burning on personal, indoor and outdoor levels of 1,3-butadiene, benzene, formaldehyde and acetaldehyde. *Journal of Environmental Monitoring* 2007; 9(1):23–32.
- III Gustafson P., Östman C., Sällsten G. Indoor levels of polycyclic aromatic hydrocarbons in homes with and without wood burning for heating. *Environmental Science & Technology* 2008; 42(14):5074–5080.
- IV Sällsten G., Gustafson P., Johansson L., Johannesson S., Molnár P., Strandberg B., Tullin C., Barregård L. Experimental wood smoke exposure in humans. *Inhalation Toxicology* 2006; 18(11):855–864.

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ABSTRACT

The general population is exposed to air pollutants in both indoor and outdoor air from many different sources, including traffic, biomass burning, industries, cigarette smoking, and certain building materials. Air pollutants can cause a variety of health effects such as cancer and respiratory and cardiovascular diseases. The overall aim of this thesis is to increase the knowledge regarding the exposure to some carcinogenic compounds, especially those emitted by domestic wood burning, thereby contributing to risk assessment. The exposure has been assessed by personal sampling in the breathing zone as well as by stationary measurements.

Median personal exposure to formaldehyde was $23 \mu\text{g}/\text{m}^3$, which is within the guideline value range of $12\text{--}60 \mu\text{g}/\text{m}^3$ proposed in Sweden. Bedroom concentration, used as a proxy of personal exposure, accounted for 90% of the variability of personal exposure. Subjects living in single-family houses had significantly higher exposure to formaldehyde compared with subjects living in apartments. The within-individual (day-to-day) source of variability in personal exposure was low.

In a residential area where wood burning for domestic heating is common, significantly higher indoor levels of 1,3-butadiene, benzene, and several PAHs, such as benzo(a)pyrene (BaP), were found in homes using wood-burning appliances compared to homes without. High correlations were found between personal and indoor levels of 1,3-butadiene, benzene, formaldehyde, and acetaldehyde ($r_s > 0.8$). The 1,3-butadiene levels measured personally, indoors, and outdoors were low with respect to risk for cancer. By contrast, benzene and BaP levels in the wood-burning homes (medians $2.6 \mu\text{g}/\text{m}^3$ and $0.52 \text{ ng}/\text{m}^3$, respectively) were 2 and 5 times higher than their Swedish health-based guideline, which was also exceeded outdoors for BaP.

An experimental set-up of a system for studying human exposure in a chamber to the carcinogenic wood smoke constituents 1,3-butadiene, benzene, formaldehyde, acetaldehyde, and PAHs, as well as fine particles, was developed. Relatively constant particle mass and number concentrations were obtained over each exposure session. Exposure levels were, as expected, clearly higher (5–50 times) during the wood smoke session compared with the clean air session. Stationary measurements could be used to predict the personal exposure in the chamber.

In conclusion, this thesis demonstrates that personal exposure of formaldehyde is well reflected by the residential indoor concentration, which was higher in single-family homes than in apartments, and that a minor part of the general population is exposed to airborne concentrations of formaldehyde at levels associated with sensory irritation. Domestic wood burning can increase the indoor concentration of several PAHs, as well as 1,3-butadiene and benzene in homes with wood-burning appliances. BaP is the largest contributor to the increased cancer risk for people living in those homes. The developed experimental set-up for wood smoke exposure can be used to study effects of such exposure in humans by careful control of the burning process and characterization of the exposure.

Key words: formaldehyde, acetaldehyde, 1,3-butadiene, benzene, polycyclic aromatic hydrocarbons, particulate matter, domestic wood burning, exposure assessment, personal exposure, experimental study

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