



# LUND UNIVERSITY

A Model for Estimating Particle Concentration Indoors – Based on Information from Occupants' Questionnaires, Indoor Sources Emission Factors, Outdoor Concentration and Building Characteristics.

Wierzbicka, Aneta; Bekö, G.; Toftum, J.; Clausen, G.; Loft, S.; Karottki, G.; Massling, A; Hussein, T.

*Published in:*

Proceedings of 13th International Conference on Indoor Air and Climate 2014

2014

[Link to publication](#)

*Citation for published version (APA):*

Wierzbicka, A., Bekö, G., Toftum, J., Clausen, G., Loft, S., Karottki, G., Massling, A., & Hussein, T. (2014). A Model for Estimating Particle Concentration Indoors – Based on Information from Occupants' Questionnaires, Indoor Sources Emission Factors, Outdoor Concentration and Building Characteristics. In *Proceedings of 13th International Conference on Indoor Air and Climate 2014* International Society of Indoor Air Quality and Climate (ISIAQ).

*Total number of authors:*

8

## General rights

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

## Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117  
221 00 Lund  
+46 46-222 00 00

## **A MODEL FOR ESTIMATING PARTICLE CONCENTRATION INDOORS – BASED ON INFORMATION FROM OCCUPANTS’ QUESTIONNAIRES, INDOOR SOURCES EMISSION FACTORS, OUTDOOR CONCENTRATION AND BUILDING CHARACTERISTICS**

Aneta WIERZBICKA<sup>1,\*</sup>, Gabriel BEKÖ<sup>2</sup>, Jørn TOFTUM<sup>2</sup>, Geo CLAUSEN<sup>2</sup>, Steffen LOFT<sup>3</sup>, Dorina Gabriela KAROTTKI<sup>3</sup>, Andreas MASSLING<sup>4</sup> and Tareq HUSSEIN<sup>5,6</sup>

<sup>1</sup>Ergonomics and Aerosol Technology, Lund University, Sweden

<sup>2</sup>Department of Civil Engineering, Technical University of Denmark, Denmark

<sup>3</sup>Department of Public Health, University of Copenhagen, Denmark

<sup>4</sup>Department of Environmental Science, Aarhus University, Denmark

<sup>5</sup>Department of Physics, University of Jordan, Jordan

<sup>6</sup>Department of Physics, University of Helsinki, Finland

*\*Corresponding email: aneta.wierzbicka@design.lth.se*

Keywords: Personal exposure, Modelling, Indoor activities

### **INTRODUCTION**

Personal exposure to airborne particles in epidemiological studies is mainly assessed on the basis of outdoor concentrations, whereas recent studies indicate that on average ~60% of exposure to submicrometer particles in homes is attributable to indoor sources (Bekö et al., 2013). There is a need to account for the contribution of indoor sources to submicrometer particle exposure (Morawska et al., 2013). Conducting measurements in a large number of residences remains a challenge. Thus an alternative approach is suggested. The aim of this study was to develop a model that allows estimation of indoor number concentrations and describes evolution of submicrometer particles indoors. The estimates obtained with this model can be used as input data for personal exposure estimation in epidemiological studies.

### **METHODOLOGIES**

We developed a simplified version of the indoor aerosol model MC-SIAM (Hussein and Kumala, 2008) based on the mass balance equation and a simplified implementation of the dynamic behaviour of aerosol particles. Input data consisted of: frequency, time and duration of particle-generating activities (on the basis of activity logbooks/questionnaires); emission factors for indoor sources/activities (in particles/h) with geometric mean diameters of emitted particles; residence characteristics (volume, air exchange rate), penetration factor and outdoor number concentrations (obtained from urban monitoring station in Copenhagen). Forty eight-hour patterns of model simulated number concentrations were compared to measurements conducted in two residences in Copenhagen during winter season 2011/12.

### **RESULTS AND DISCUSSION**

Model simulated indoor number concentrations showed 6 and 30% higher average concentrations over the total 48h measurement period in two residences. Comparison of average concentrations during occupied time periods, relevant for exposure assessment

indoors, showed 9 and 35% higher values in model simulations, whereas the estimated median values were 33 and 35% lower than the measured ones. The model simulated concentrations and the measured concentrations indoors and outdoors are given for one of the residences in Figure 1. Emission rates for frying and toasting were calculated from measured data ( $1.4 \times 10^9$  and  $3 \times 10^7$  particles/h, respectively) and used in the model. Initial concentration indoors in model simulations was set to 4000 particles/cm<sup>3</sup>. Unknown activities, not specified in the logbook, were not accounted for in the model.

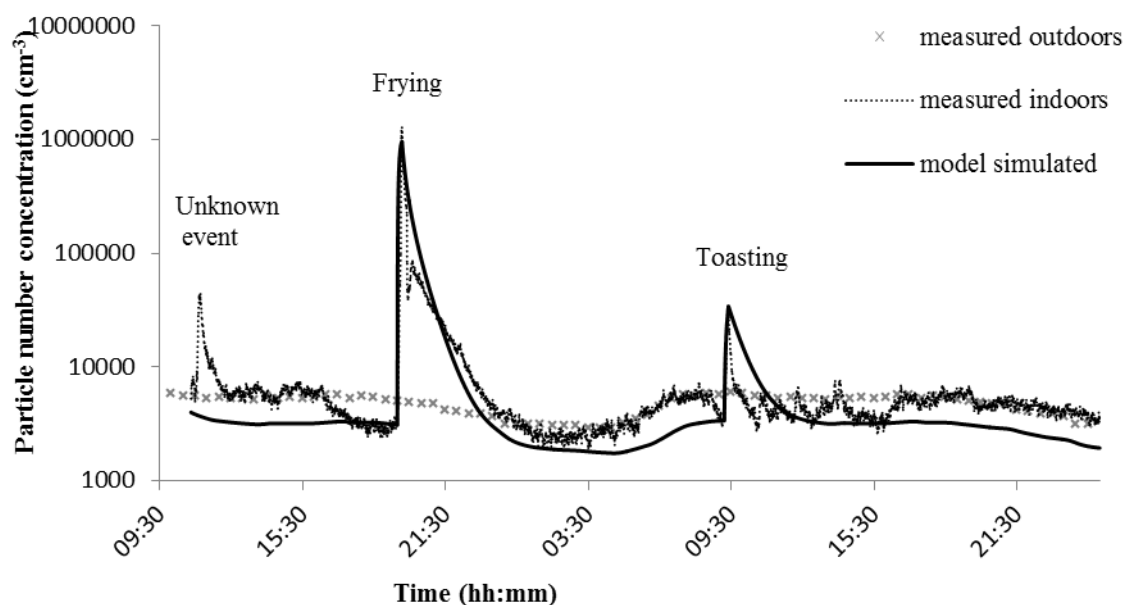


Figure 1. The model simulated number concentration of submicrometer particles in one residence in comparison to concentrations measured indoors and outdoors.

## CONCLUSIONS

A simple indoor aerosol model based on information acquired through questionnaires and outdoor concentrations could be a promising alternative for deriving proxy exposure data on population-representative scale to account for indoor exposures to submicrometer particles in epidemiological studies.

## ACKNOWLEDGEMENT

This work was financed by VINNOVA - Swedish Governmental Agency for Innovation Systems. The study was part of the Centre for Indoor Air and Health in Dwellings (CISBO) study, which was supported by the REALDANIA foundation.

## REFERENCES

- Bekö G, Weschler CJ, Wierzbicka A et al (2013) Ultrafine particles: Exposure and source apportionment in 56 Danish homes. *Environmental Science and Technology*, 47, 10240-10248.
- Hussein T. and Kumala M. (2008). Indoor Aerosol Modeling: Basic Principles and Practical Applications, Water, Air, & Soil Pollution: Focus, 8: 23-34.
- Morawska, L., Afshari, A., Bae, G.N. et al 2013. Indoor Aerosols: From Personal Exposure to Risk Assessment. *Indoor Air*, 23, 462-487