Source apportionment study and modelling of air pollutants from residential heating in Tartu

M. Maasikmets[1,2], E. Teinemaa[1], H. Keernik[1] and H-L. Kupri[1,3]

[1] Estonian Environmental Research Centre (EERC), Marja 4d, 10617 Tallinn, Estonia
[2] Estonian University of Life Science (EULS), Institute of Agricultural and Environmental Sciences, Kreutzwaldi 5, 51014 Tartu, Estonia
[3] Department of Environmental Engineering, Tallinn University of Technology, 19086, Tallinn, Estonia
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Presenting author email: erik.teinemaa@klab.ee

The use of wood to generate heat in small scale stoves in private houses is increasing to due increasing prices of the other energy carriers. Tackling with climate change and reducing carbon dioxide emissions have extra influence on use of renewable energy sources as biomass. The price of wood is competitive enough as well. Downside of the use of biomass is deterioration of air quality due to increased emissions of certain pollutants. Particulate matter with PAH adsorbed onto it is by far most important of these pollutants if focusing on possible health effects. The wood burning in residential areas is contributing to pollutant levels in urban areas as sources having relatively low height and the concentrations around the sources can be very high. Majority of the stoves in the households are old type batch combustion masonry stoves. Particulates from batch combustion masonry stoves were more potent inducers of programmed cell death and genotoxicity than the particles emerging from the continuous combustion in a modern pellet boiler (Tapanainen et al., 2011). In Tartu the levels of PM2.5 and BaP have been constantly high during cold season. The BaP levels have been exceeding EU target value 1 ng/m^3 during past years. During earlier PM2.5 measurement campaign an urban increment of 6 μg/m^3 for Tartu was identified (Elser et al., 2016). In same study the possible contribution from waste burning in residential stoves was seen in HR-ToF-AMS mobile measurements.

Stationary air quality monitoring station and mobile air laboratory was used to assess contribution of residential heating to the PM2.5, BC and BaP levels in Tartu. During the measurement campaign PAH and heavy metals were analyzed from daily PM10 samples (High-Vol sampler Digitel DHA-90), equivalent black carbon (eBC) was measured using 7-wavelength Aethalometer (Magee Scientific, model AE33), aerosol farctional distribution was measured using TSI APS model 3321. Gaseous substances (NO_x, SO_2, CO) were measured in parallel using Horiba ambient air analyzers (APNA-370, APSA-370 and APMA-370). Aerosol chemical composition in one location using Aerodyne Aerosol Chemical Speciation Monitor (ACSM) was conducted. The measurements were carried out in winter 2015/16 in Tartu, with the measurement point near to roadway and residential wood combustion (RWC) area.

Emission database for residential heating was compiled using emission factors from previous study of (Maasikmets et al. 2015). Dispersion modelling was used to calculate levels of PM2.5, BC and BaP using ensemble of three different dispersion models (SMHI Gauss, SMHI Grid and Austal2000). The dispersion modelling results were compared against fixed measurements.

Measurement data was analysed using positive matrix factorization (PMF) using SoFi software (Canonaco, Crippa, Slowik, Baltensperger, & Prévôt, 2013). Strong correlation between modelled and measured BC and BaP was identified in monitoring sites in residential areas. For PM2.5 the correlation was weak and influence of regional PM2.5 level was seen.

Dispersion modelling using ensemble of three different type (Gaussian, Eulerian and Lagrangean) models showed difference between the models. Good agreement with measurement and modelling data was seen for Eulerian model used in current study. Description of variation of real emissions in emission database is on of key sources of uncertainty. The emission factors used to compile emission database gave good agreement between measurements and modelling.

Study demonstrated that during intensive pollution episodes in residential areas in Tartu during cold season the modelling techniques can be used to assess contribution of key pollutants from residential heating to ambient air quality. The contribution of residential heating to BaP and BC levels during heavy pollution episodes is as high as 70-80% in selected residential areas in Tartu.

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