Quantifying trace elements in the emitted particulate matter during cooking using an electric stove

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Cooking is one of the main sources of indoor particulate matter (PM). Cooking even with cleaner sources of energy (gas, electricity) may also pose risks to human health. PM emissions from cooking contain trace elements, some of them being toxic and/or carcinogenic (As, Cd, Ni, Cr). Food, utensils, meat and cooking oil were suspected to contribute trace elements in PM. The main objective of this study is to report size segregated mass concentration and emission rate and flux of 25 trace elements emitted during heating corn oil, corn oil with table salt and grilling beef meat.

A controlled study was conducted to understand the contribution of each cooking component including corn oil and beef meat on trace elements in PM emissions. No mechanical ventilation and natural ventilation existed on the sampling site. In each experiment, corn oil, corn oil with table salt and beef meet were heated using an electric stove. Each set of experiments lasted 20 minutes (14 minutes heating and 6 minutes cooling for corn oil experiments, 18 minutes grilling and 2 minutes cooling for beef experiments).

An Eight-Stage, Non-Viable Andersen Impactor was employed to collect the generated particles ranging from 0<0.43 µm to 3.3 µm (six cut sizes) on 81 mm quartz fiber filters including a backup filter for collecting PM0.43. Metal analyses were performed using an Inductive Coupled Plasma-Mass Spectrometry (ICPMS).

The average mass emission rates over the sampling period were calculated using a mass balance approach assuming instantaneous mixing throughout an effective volume.

$$S = (a+k)\ V\ C_{in}$$

Where "S" represents emission rate, "a" is air exchange rate, "k" is a deposition rate, "V" is an effective volume, "C_{in}" is indoor particle concentration. The effective volume was determined using $PM_{2.5}$ emission flux obtained by Amouei Torkmahalleh *et al* (2012) and "(a+k)" values reported by Wallace *et al* (2004).

The highest mass concentrations of trace elements were found during heating oil (1.29 mg.m^{-3}), followed by meat grilling (0.83 mg.m^{-3}) and heating of oil with table salt (0.18 mg m-3). With oil cooking, Fe, Ti, Sr are the most abundant elements with mass concentration of 0.65, 0.46 and 0.04 mg.m^{3}. Comparing with WHO average annual recommended limit, it shows that mass concentrations of V, Mn, Ni, Cd, Pb in heating oil and meat exceeded the recommended levels.

The results indicated bimodal size distribution of trace elements for the oil and beef experiments with mode diameter values of 1.1-2.1 µm and less than 0.43 µm for oil and 3.3-4.7 µm and less than 0.43 µm for meat. For corn oil with salt, there is a unimodal distribution with mode diameter of 0.43-0.65 µm.

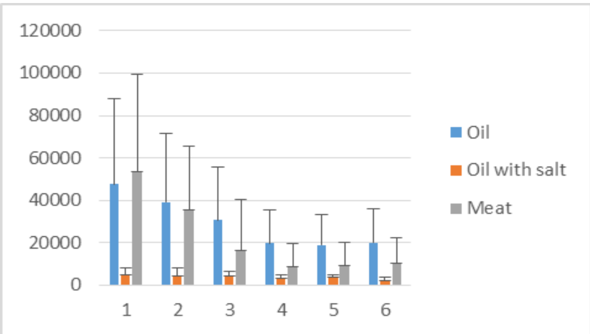

Figure 1. Emission flux of total trace elements, µg min^{-1} m^{-2}

The health risk estimates suggest that for carcinogenic (As, Cd, Cr, Ni) and non-carcinogenic elements (Cr, Mn, Co, Ba) the risk is much higher than acceptable level (for oil experiment, assuming 2 hours cooking per day, ELCR 5.97×10^{-3}, HQ 52.2) exceeding the acceptable level by 3 orders of magnitude for carcinogenic and 52 times for non-carcinogenic.

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Amouei Torkmahalleh, M. et al (2012) *Indoor Air*, **22**, 483–491.

Wallace, L., et al. (2004) *Atmospheric Environment*, **38**, 405–413.