THE EFFECT OF COAL COMBUSTION IN DOMESTIC HEATING UNITS ON MERCURY CONCENTRATION IN THE AIR OF RURAL AREAS

Urszula Zielonka[1], Stanislaw Hlawiczka[1], Janina Fudala[1] and Ingvar Wängberg[2]
[1] Institute for Ecology of Industrial Areas, 6 Kossutha Str, 40-844 Katowice, Poland, *s.hlawiczka@ietu.katowice.pl*
[2] IVL Swedish Environmental Research Institute Ltd, P.O. Box 47086, 411 33 Göteborg, Sweden

ABSTRACT
Low capacity domestic heating units (DHU) are common heating sources, especially in the Central and Eastern Europe. Very often low grade coal is used in these units. In Poland in 2001 mercury emission from DHU was 1150 kg. We investigated the impact of coal combustion in DHU on air quality in a typical rural area in Southern Poland. A field experiment was carried out in an area where 85% of the houses used DHU fuelled with hard coal during the heating season. Concentrations of Total Gaseous Mercury (TGM) and Total Particulate Mercury (TPM) in ambient air were measured during summer and winter campaigns to find the relationship between coal combustion and mercury concentration in the air. During the summer campaign TGM mean concentration was 1.63 ng m^{-3}, whereas during the winter campaign the TGM mean concentration was 2.5 times higher. TPM mean concentration during the summer campaign was 0.11 ng m^{-3}, while in the winter campaign the concentration was 10 times higher. Also bulk dry deposition of mercury during the winter campaign was over 7 times higher than in the summer.

INTRODUCTION

For the first time airborne mercury species across Europe were simultaneously measured at 10 sites in the Northwest Europe and Mediterranean area [1]. The results indicate that mercury concentrations are higher in the air of Mediterranean area than in Northwest Europe. It was found that under certain wind conditions particulate mercury might be transported from the source areas in Central Europe about 500-800 km northward.

Measurements of mercury concentration carried out up to now have proved that we are still having insufficient data to get reliable and complete information about the distribution of background mercury concentrations in the air in Europe. This refers particularly to Central and Eastern Europe. The aim of our work was to provide some more information on this issue.

SITE LOCATION AND CHARACTERIZATION

The measurement campaigns were performed at a typical agricultural area in Southern Poland – Lichwin (49^{o} 52.957´N, 20^{o}57.024´E). Lichwin is a small village of 1180 inhabitants, where during the heating season 85% of the households are heated by hard coal combustion in DHU. In Lichwin there are 265 houses using DHU. In Poland the average combustion of coal in individual DHU is 2.5 Mg during the heating season. According to data on mercury emission factor the estimated mercury emission from the Lichwin village during the heating season was assessed to 0.073 kg [2].

The site was situated in upland area approximately 20 km south from anthropogenic sources of mercury emission (power and mercury cell chlor-alkali plants) downwind to the main wind direction for the area. The sampling equipment was set up on an open area in the village.

The measurements of airborne mercury species and deposition of mercury were performed during one summer campaign (18-29

August 2003) and one winter campaign (26 January – 3 February 2004).

METHODS

All samples were collected on a daily basis (22–24 h). The mercury content in all samples was determined using CVAAS method.

The manual gold trap method was used for sampling of Total Gaseous Mercury (TGM) [3]. A sampling flow rate of 0.3-0.4 l min^{-1} was used. The mercury associated with particulate matter (TPM) samples were collected using 47 mm Teflon filter (0.45 μm pore size) [3]. A sampling flow rate ranging from 10 to 12 l min^{-1} was applied.

Precipitation was collected using an open collector with an acid washed glass bottle. For the days with no precipitation, particulate matter deposited on the open collector and glass bottle were washed with distilled water. The obtained solution was filtered using Teflon filter (0.45 μm).

RESULTS AND DISSCUSION

High variability of wind speed and temperature were observed during the experiment. Wind speed during the summer and the winter campaigns ranged from 0.0 – 16.2 and 0.0 – 17.3 m s^{-1} respectively. For temperature the relevant values were from 11 to 34^{o}C and from –8 to 9^{o}C. Wind direction observed during the experiments was from Western sector.

The mean TGM concentration (Fig. 1) during the summer campaign was 1.63 ng m^{-3} (median value of 1.69 ng m^{-3}), and 4.15 ng m^{-3} during the winter campaign (median value of 3.80 ng m^{-3}). The highest value of TGM was observed at the lowest wind speed e.g. <0.5 m s^{-1}. Mean TGM concentration during the winter campaign was 2.5 times higher than during the summer campaign.

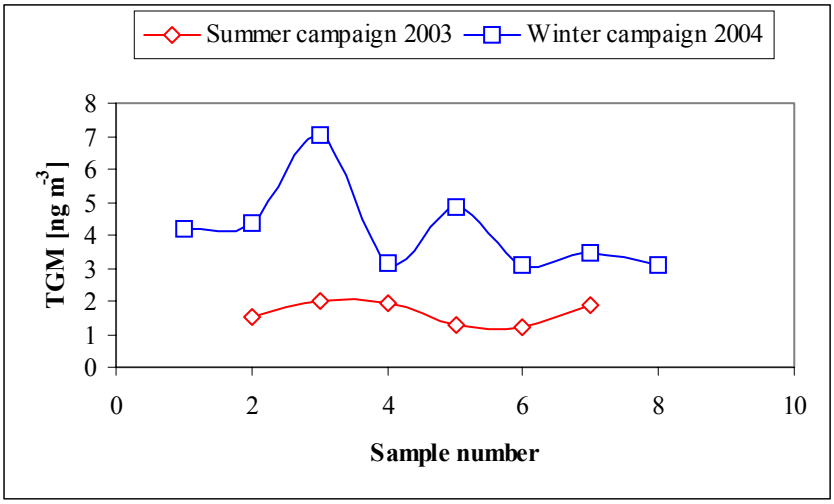

Figure 1. Comparison between summer and winter TGM concentration.

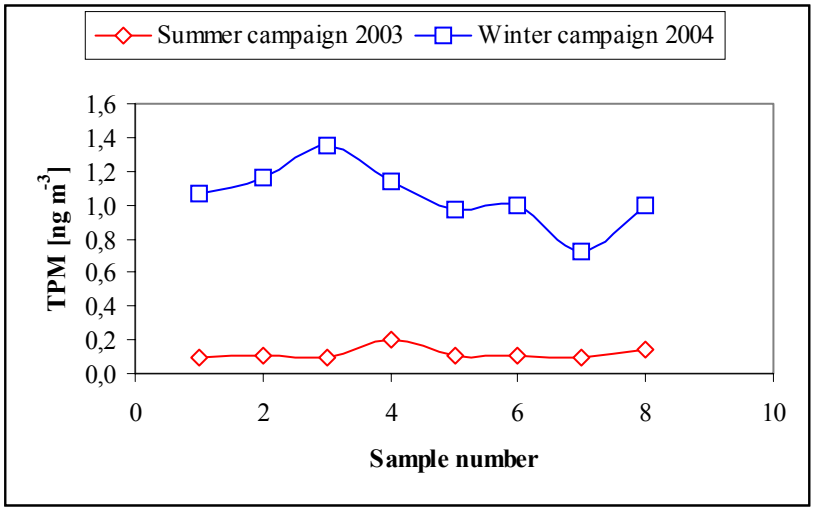

Figure 2. Comparison between summer and winter TPM concentration.

The mean TPM concentration (Fig. 2) during the summer campaign was 0.11 ng m^{-3} (median value of 0.10 ng m^{-3}), and 1.05 ng m^{-3} during the winter campaign (median value of 1.03 ng m^{-3}). Mean TPM concentration during the winter campaign was 10 times higher than during the summer campaign. Mean TPM/TGM ratio obtained during the summer campaign was 0.07, while in the winter campaign – 0.25.
During the summer campaign no precipitation was observed. The measurement of 24 h bulk dry deposition of mercury ranged from 19.27 to 45.90 ng m^{-2} d^{-1}, with the mean value of 35.19 ng m^{-2} d^{-1} (median value of 37.42 ng m^{-2} d^{-1}). During the 8-days winter campaign 2 days were with snowfall, 2 days with rainfall and 4 days without precipitation. For the days with no precipitation, 24 h bulk dry deposition of mercury varied from 227.89 to 686.40 ng m^{-2} d^{-1}, with the mean value of 365.38 ng m^{-2} d^{-1} (median value of 273.62 ng m^{-2} d^{-1}). Median 24 h bulk dry deposition of mercury during the winter was over 7 times higher in comparison with the summer. Based on median 24 h bulk dry deposition of mercury and average number of days in heating and no-heating season in Poland bulk dry deposition of mercury was estimated. The estimated bulk dry deposition of mercury for non-heating season for rural areas of Southern Poland was 7.20 μg m^{-2}, whereas for heating season – 43.78 μg m^{-2}.

SUMMARY AND CONCLUSIONS

Average 24 h TGM concentration obtained during the summer campaign in Poland is comparable with the background value of TGM concentration in the air throughout world – 1.5 ng m^{-3} [4]. At the control station in Italy, average TGM concentration obtained during the winter season was approximately 2 times lower than in the summer season [5]. In the USA TPM vary substantially in concentration, typically from 1 to 600 pg m^{-3}, depending on the location [6]. At the control station in Italy,

average TPM concentrations obtained both during the winter and summer campaigns were the same - 20 pg m^{-3} [5]. The higher TGM, TPM concentrations, TPM/TGM ratios and bulk depositions of the mercury observed in Lichwin during the winter campaign were due to use of DHUs. Coal combustion in DHU constituted the only mercury emission source in the local area.
In Poland, about 15 million tones of hard coal are annually burnt in DHU for heat production purposes [7]. This is why much higher concentrations of TGM, TPM and bulk dry deposition were obtained during the winter season.
Data on mercury species concentrations in the air presented in this study may characterize average values of TGM and TPM concentrations in rural areas in Central Europe during summer season.

ACKNOWLEDGEMENTS
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