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The Krakow receptor modelling inter-comparison exercise

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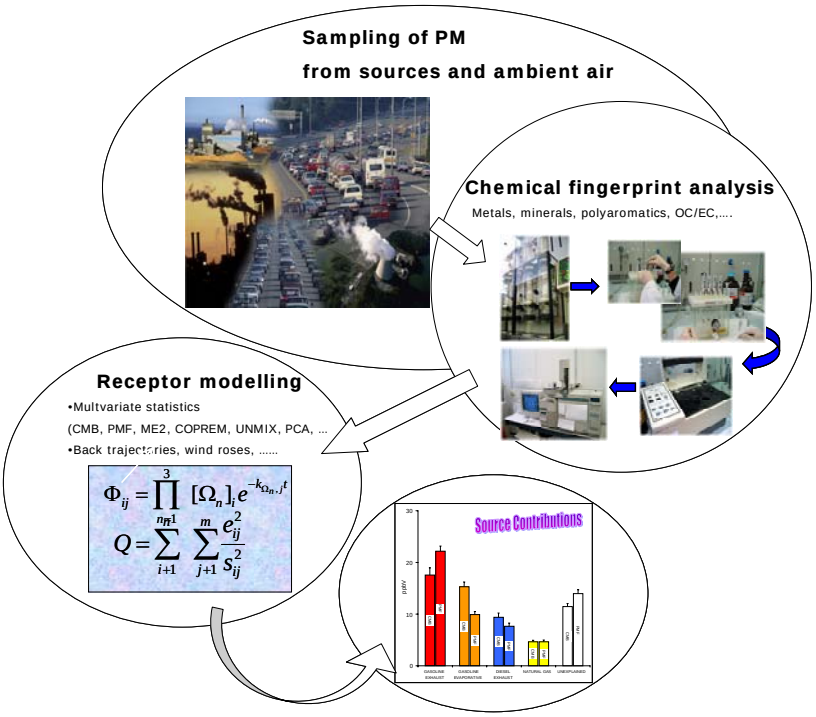

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Abstract

Second to oil, coal is globally the biggest energy source. Coal combustion is utilized mainly for power generation in industry, but in many metropolitan areas in East Europe and Asia also for residential heating in small stoves and boilers. The present investigation, carried out as a case study in a typical major city situated in a European coal combustion region (Krakow, Poland), aims at quantifying the impact on the urban air quality of residential heating by coal combustion in comparison with other potential pollution sources such as power plants, industry and traffic. For that purpose, gaseous emissions (NOx, SO2) were measured for 20 major sources, including small stoves and boilers, and the emissions of particulate matter (PM) was chemically analyzed for 52 individual compounds together with outdoor and indoor PM_{10} collected during typical winter pollution episodes. The data was analyzed using multivariate receptor modelling yielding source apportionments for PM_{10}, B(a)P and other regulated air pollutants associated with PM_{10}, namely Cd, Ni, As, and Pb. The source apportionment was accomplished using the chemical mass balance modelling (CMB) and constrained positive matrix factorization (CMF) and compared to five other multivariate receptor models (PMF, PCA-MLRA, UNMIX, SOM, CA). The results are potentially very useful for planning abatement strategies in all areas of the world, where coal combustion in small appliances is significant.

During the pollution episodes under investigation the PM_{10} and B(a)P concentrations were up to 8-200 times higher than the European limit values. The major culprit for these extreme pollution levels was shown to be residential heating by coal combustion in small stoves and boilers (>50% for PM_{10} and >90% B(a)P), whereas road transport (<10% for PM_{10} and <3% for B(a)P), and industry (4-15% for PM_{10} and <6% for B(a)P) played a lesser role. The indoor PM_{10} and B(a)P concentrations were not much lower than the outdoor concentrations and were found to have the same sources as outdoor PM_{10} and B(a)P The inorganic secondary aerosol component of PM_{10} amounted to around 30%, which may be attributed for a large part to the industrial emission of the precursors SO_2 and NO_X.

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