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Project Summary

Pollutant Emission Factors for Gas Stoves: A Literature Survey

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Published emission factors for CO, NO, NO_2, NO_x have been summarized for gas-fired kitchen stoves. Analysis of variance was then used to investigate the importance of three binary factors: type of combustion, burner position, and method of sampling. The emission factor data were then used to estimate coefficients in various multivariate regression models. The influence of gas flow rate on emission factors was investigated separately. The data were also used to investigate the sensitivity of predicted airborne concentrations to uncertainties in emission factors. Finally, the data were used to identify critical gaps in understanding emission factors.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

The Survey

Published emission factors for CO, NO, NO_2, and NO_x for gas-fired kitchen stoves have been summarized. To the extent that data exist, the emission factors have been used in a statistical analysis to investigate the most important factors influencing emissions.

First, the data were used to construct normal probability and log probability plots based on the cumulative distribution of the emission factors. Correlation coefficients were computed for both types of plots. Results showed that the log probability plot provided a better fit to the CO and NO_2 data with reasonably high correlation coefficients, suggesting that the emission factors for these pollutants may be approximated by lognormal distributions. Either normal or lognormal distributions were satisfactory for NO and NO_x. For consistency, the emission factors for all four pollutants were assumed to be distributed lognormally in subsequent analysis.

Analysis of variance was then used to investigate the importance of three binary factors in explaining the observed variations in emissions: (1) type of combustion (poorly adjusted or well adjusted), (2) burner position (front or rear), and (3) method of sampling (direct or indirect). The results showed that roughly half of the observed variance in log EF (base 10 logarithm of the emission factor) for CO can be explained by noting if the combustion is poorly adjusted. For NO_2, roughly 30% of the variance can be explained by this factor. For NO and NO_x, the fraction of variance explained by this factor depends on the subset of the data chosen: fractions ranged from 0.088 to 0.56. Burner position and method of sampling were both relatively unimportant in explaining the observed variance for any of the four pollutants.

The emission factor data were then used to estimate coefficients in various multivariate regression models. The first regression model incorporated several factors: type of combustion, burner position, method of sampling, the three two-way interactions between these factors, and (M-1) binary factors corresponding to the M stoves for which data were available (M=27, 26, 26, and 8 for CO, NO, NO_2 and NO_x, respectively). Subsequent multivariate regression models were constructed by sequentially eliminating a factor or factors from the previous model. Results of these tests showed that stove differences were significant at the 95% level in explaining the variance in CO,

NO_2, and NO_x emission factor. Type of combustion was significant for CO, NO, and NO_2. Burner position had a smaller but still statistically significant effect in explaining the variance in CO and NO_2 emissions. Similarly, the method of sampling had a small but statistically significant effect for NO_x emissions.

The influence of gas flow rate on emission factors was investigated separately. Statistical tests were not run for this factor due to both a lack of data and the presence of detailed data from only one study. Results of plotting all of the data for each pollutant on a common graph showed that CO and NO_2 emissions vary considerably with gas flow rate, while emissions of NO and NO_x are less variable.

The data were used to investigate the sensitivity of predicted airborne concentrations to uncertainties in emission factors. The solution of a one-compartment mass balance model was used as the predictor of concentration. For the existing distribution of emission factor data, the current uncertainty in CO is responsible for a larger fraction of the variance in predicted concentration than uncertainty in air exchange rate. For NO and NO_2, however, the uncertainty in air exchange rate is more important than the emission factor uncertainties.

Finally, the data were used to identify critical gaps in understanding emission factors and to suggest future experiments. Overall, it is concluded that the influence of stove design, gas flow rate, and characteristics of stove use are key factors which merit further study.

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The complete report, entitled "Pollutant Emission Factors for Gas Stoves: A Literature Survey," (Order No. PB 87-171 328/AS; Cost: $18.95, subject to change) will be available only from:
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