EXPOSURE ASSESSMENT OF DIESEL BUS EMISSIONS

M. YIP[1], P. MADL[1], A. WIEGAND[2], L. MORAWSKA[2], and W. HOFMANN[1]

[1]Institute of Physics and Biophysics, University of Salzburg, A-5020 Salzburg, Austria

[2] International Laboratory for Air Quality and Health and Atmospheric Chemistry Group, School of Physical and Chemical Sciences, Queensland University of Technology, QLD 4001, Brisbane, Australia

Keywords: DIESEL ENGINES, ULTRAFINE PARTICLES, EXPOSURE ASSESSMENT

INTRODUCTION

Exposure to diesel exhaust emissions has been classified by international health organisations as probably carcinogenic to humans (Boffeta *et al*., 2001; IARC, 1989). Diesel exhaust contains a complex mixture of many gases and substances known to be hazardous air pollutants (CSE, 1999). In particular, diesel particulate matter (DPM) is perceived as one of the major harmful emissions produced by diesel engines (Majewski, 2000). Despite considerable amount of basic research, neither the formation of DPM in the combustion chamber, nor its physico-chemical properties or human health effects are fully understood at present. Almost all of the fresh diesel exhaust particle mass is in the ultrafine particle (UFP) range. Because of their minute sizes, these particles are easily inhaled and eventually trapped within the bronchial and alveolar regions of the lung. From a population exposure point of view, air quality in a street canyon is of major importance, since the highest pollution levels and the larger targets of impact are often concentrated in this kind of setting. The so-called *canyon effect* results in greater health complications (Spadaro & Rabl, 2001). DPM from mobile sources (buses) have a greater potential for human exposure (per g of DPM emissions) compared to combustion particulates emitted from point sources (USEPA, 2002).

METHODS AND RESULTS

This microenvironmental exposure study is of particular importance as it was carried out in an urban canyon, i.e. the semi-submerged Woolloongabba Busway Station (WBS), located in Brisbane, Australia. Here, DPM from mobile sources (buses) are emitted into the breathing zone of passengers. The study was conducted in the winter months during which temperature inversions frequently occur. Studies investigating the chemical and physical changes of DPM emissions suggest that there is little or no hygroscopic growth of primary diesel particles (USEPA, 2002). This observation suggests that the small size of DPM particles might be maintained during inhalation, particularly near the emission source. It was assumed that significant differences between platform and background distributions were due to bus emissions which, combined with passenger waiting times, yielded an estimate of passenger exposure to UFDP from diesel buses.

The particle number concentration was measured in real-time with a TSI-SMPS system for both the outbound platform and for the background locations. The particle diameter ranged from 13.3 nm to 805 nm with a sampling flow rate of 0.3 L/min (monodisperse aerosol) and scanning times of 300 s to accurately detect DPM concentrations grouped into 113 different size classes. Personal exposure can be calculated as the product of pollutant concentration and the time spent in a specific microenvironment. As expressed in the equation below, personal exposure of DMP, E is given by:

$$E = c_{particle} \cdot t_{waiting}$$

where $c_{particle}$ is the DPM concentration [#/cm^3] and $t_{waiting}$ is the DPM exposure time [min].

Data from particle size distribution and concentration data were analyzed. An automated series of routine calculations were created to analyze the passengers' waiting time data and merged with the particle data from the SMPS system, enabling extrapolation with a computer generated model for the assessment of exposure concentrations due to buses. Conversion from particle number into particle mass (volume) is achieved by using a standard density conversion factor for DPM density ($\rho = 1 g/cm^3$) (Willeke & Baron, 1999).

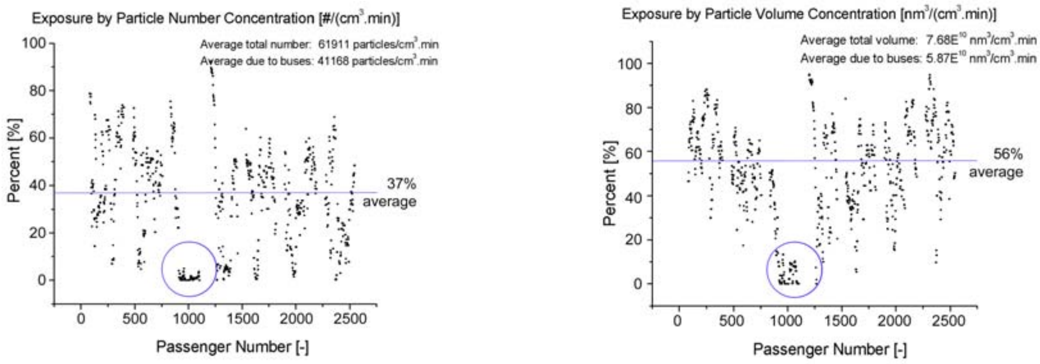

Figure 1.Exposure due to particle number concentration (left) and exposure due to volumetric concentration (right). The circled area in both graphs indicates the flushing effect when strong winds blow through the WBS-canyon.

Conversion is necessary as the dose (mass) of DPM inhaled prevails over the particle number concentration. In this study it was found that there is a significant exposure of DPM due to buses. A particle load of 37% (number concentration) and 56% (volume concentration) was observed (horizontal lines in figure 1). The semi-submerged design of the platform increases exposure, and ultimately increases the risk to suffer from respiratory diseases.

ACKNOWLEDGEMENTS

The authors wish to thank the Centre Operations at Woolloongabba Busway Station and the Queensland Environmental Protection Agency for their kind assistance.

REFERENCES

Boffetta, P., Dosemeci, M., Gridley, G., Bath, H., Moradi, T., & Silverman, D. (2001). Occupational exposure to diesel engine emissions and risk of cancer in Swedish men and women, *Cancer Causes and Control*, 12, 365-374.

CSE, Center for Science and Environment (1999). Engines of the Devil. Why Dieselisation of Private Fleet Should be Banned – The Case of Dehli, New Dehli, India.

IARC, International Agency for Research on Cancer (1989). Diesel and gasoline engine exhaust. In: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol. 46: Diesel and Gasoline Engine Exhaust and Some Nitroarenes. Lyon: IARC, 41-185.

Majewski, W. A. (2000). Diesel Particulate Matter, *DieselNet Technology Guide*, www.DieselNet.com, Revision 2000.03B.

Spadaro, J., & Rabl, A. (2001). Damage costs due to automotive air pollution and the influence of street canyons, *Atmospheric Environment*, 35, 4763-4775.

USEPA, United States Environmental Protection Agency (2002). Health Assessment Document for Diesel Engine Exhaust, EPA/600/8-90/057F - USA.

Willeke K., & Baron P.A. (1993). *Aerosol Measurement - Principles, Techniques, and Applications*. New York, USA: Van Nostrand Reinhold.