HEI

STATEMENT

Synopsis of Research Report 156

HEALTH EFFECTS INSTITUTE

Concentrations of Air Toxics in Motor Vehicle–Dominated Environments

BACKGROUND

Motor vehicles and other combustion sources emit many air toxics whose levels are not regulated by the U.S. Environmental Protection Agency (EPA), but that are known or suspected, with sufficient exposure, to cause adverse health effects. Among these are mobile-source air toxics (MSATs), compounds the EPA has identified as derived, at least in part, from motor vehicles and whose emissions need to be reduced. Although monitoring has been performed by some state and local agencies in some locations, characterization of ambient levels of and personal exposure to air toxics has been limited. Though their ambient levels are generally low, there may be so-called hot spots where concentrations of one or more air toxics, and exposure of the population, are expected to be elevated. Such elevation may be due to the proximity of the hot spot to one or more pollution sources or to transient or sustained localized conditions that lead to elevated levels of particular pollutants. In 2003, HEI targeted research to identify and characterize potential hot spots.

APPROACH

Dr. Eric M. Fujita and colleagues measured the concentrations of several MSATs and other pollutants on urban highways in Los Angeles County with a varying mix of gasoline- and diesel-powered traffic and at various fixed sites in the vicinity of the roads. The main goals were to compare on-road concentrations with those at fixed sites and those measured at monitoring sites managed by the South Coast Air Quality Management District (SCAQMD) and to estimate the contributions of gasoline- and diesel-powered vehicles to MSATs, particulate matter ≤ 2.5 µm in aerodynamic diameter ($PM_{2.5}$), and elemental carbon (EC).

The pollutants measured were carbon monoxide (CO), oxides of nitrogen (NO_x), MSATs (benzene, toluene, ethylbenzene, xylene, styrene, naphthalene, *n*-hexane, 1,3-butadiene [BD], methyl *tert*-butyl ether, formaldehyde, acetaldehyde, and acrolein) and other volatile organic compounds (VOCs), $PM_{2.5}$, EC, and black carbon (BC).

The study was conducted in the southern portion of Los Angeles County for several weeks during the summer and fall of 2004. A combination of time-integrated and continuous measurements were made in the following location classes: (1) on roads; (2) at sites at various distances from the roads (referred to as spatial surveys); and (3) at three near-road sites with varying proportions of gasoline- and diesel-powered vehicles. For the on-road sampling, a van equipped with monitoring instruments and operating with windows and vents fully opened and a circulating fan turned on was driven for 1 hour on three commuting routes at peak commuting times and on one freeway loop with a higher fraction of diesel-truck traffic (referred to as the truck route). Spatial surveys were conducted immediately after the morning on-road sampling and immediately before the afternoon on-road sampling by stopping the van for a few minutes at locations at various distances from these routes. The three near-road sites, Long Beach, Lynwood, and Diamond Bar, were located in the same general geographic area as the routes for the on-road measurements and were sampled for 24 hours.

Source apportionment was conducted using the chemical mass balance model to estimate the contributions of gasoline- and diesel-powered vehicles to VOCs, the sum of benzene, toluene, ethylbenzene, and toluene (BTEX), total carbon (the sum of EC and organic carbon), and EC. The model uses measured pollutant concentrations, along with source composition

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information, to determine the contributions of primary sources to the measured concentrations.

RESULTS AND INTERPRETATION

Measured Concentrations The spatial patterns of on-road concentrations of BC, NO_x, CO, and total VOCs (all measured with continuous monitors) differed. Concentrations of CO and VOCs were higher on the commuting routes, whereas concentrations of BC and NO_x were higher on the truck route. The spatial and temporal variations of on-road concentrations of BTEX and BD were similar to those of corresponding time-averaged continuous CO and total VOC concentrations — higher on the commuting routes in the morning, and in the fall. Formaldehyde and acetaldehyde showed less diurnal variation. The concentrations of MSATs were consistently higher (by about a factor of 2) on the commuting routes than on the truck routes.

The on-road concentrations of nearly all pollutants were higher than those at the survey sites, the near-road sites, and the SCAQMD sites. Unexpectedly, on-road concentrations of acrolein were lower than those at the SCAQMD air toxics sites (but higher than those at the near-road sites).

The findings of higher on-road concentrations are consistent with results of studies that have found that the levels of pollutants decrease with distance from roads. Meteorologic factors (such as wind direction and speed) play a major role in the shape of the decay curves. However, the Review Committee, in its independent review of the study, thought that in the absence of information about the relationship between the roads and the fixed sites, such as the distance between the sites and the sampled roads and other roads, only general qualitative relationships can be inferred from this study. An additional factor that makes comparisons between on-road and near-road measurements difficult to interpret is the different durations of sampling for MSATs (1 hour on road during peak pollution and 24 hours at the near-road sites).

Source Apportionment Apportionment of total VOCs to sources showed that gasoline exhaust was the predominant source for both on-road and near-road concentrations, ranging from 70% for some of the samples at the near-road sites to about 100% for on-road samples. The contribution of diesel exhaust was small (22%) and more significant on the truck route. Apportionment of BTEX showed that gasoline was the dominant source (94% to 100%) for all on-road samples (including those from the diesel-dominated road) as well as those from the near-road sites (83% to 100%).

Apportionment of ambient total particulate carbon (TC) associated with particulate matter to the near-road samples showed a greater contribution from diesel exhaust (averaging 46% to 52%) than from gasoline exhaust and evaporative emissions, which ranged from 10% to 17% in the summer, but did not show any significant contribution in the fall (0% to 4%). About 40% to 50% of TC was not apportioned to mobile sources. These results are consistent with our knowledge of the emission compositions of gasoline and diesel vehicles when the study was conducted.

Apportionment of EC showed that diesel exhaust contributed 88% to 94% at the three near-road sites. Although the authors interpret these results to be an indication that EC may be a good surrogate for diesel exhaust, the Review Committee noted that the correlation between EC and truck counts was not as good as that with total traffic counts. Overall, the Committee noted that it was difficult to assess the accuracy of the quantitative split between the contributions from diesel- and gasoline-powered vehicles to EC.

CONCLUSIONS

The HEI Health Review Committee thought that Fujita and his colleagues had conducted a comprehensive study focused on the characterization of MSATs and other gaseous pollutants and carbonaceous PM on Los Angeles freeways and roadways and in several locations in the Los Angeles air basin, and that they had collected high-quality data. The study's main conclusions are that (1) on-road concentrations of all pollutants measured, including several MSATs, were higher than those measured at fixed sites away from the roads, (2) gasoline-powered vehicles are the main sources of VOCs (including BTEX) at the near-road sites, and (3) diesel- and gasoline-powered vehicles contribute about 50% to 60% of TC associated with PM.

Though on-road concentrations were higher than near-road concentrations, the question of whether busy highways during commuting hours are hot spots for exposure to MSATs is hard to address, given the design of the in-vehicle sampling, which does not reflect the ventilation conditions in the vehicles of most commuters. However, concentrations as high as those measured in the study may be encountered by commuters if the driving conditions are similar to those examined in this study. The near-road sites were chosen because they were assumed to be affected by traffic, but the investigators do not discuss whether they could be hot spots for exposure. Thus, this question remains unresolved.

Emissions from motor vehicles have been changing rapidly as a result of new emission control technologies and new fuels. The data collected in this study on MSATs and other pollutants on and near roads provide important baseline information for ongoing and future studies.

HEALTH EFFECTS INSTITUTE

101 Federal Street, Suite 500
Boston, MA 02110, USA
+1-617-488-2300 phone
+1-617-488-2335 fax

pubs@healtheffects.org
www.healtheffects.org