What are the Contributions to Ambient PM and Ozone Concentrations from On-road Diesel and Gasoline Vehicles?

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research and development

Science Question

What are the contributions to ambient PM and O3 concentrations from on-road gasoline and diesel vehicles?

Research Goals

- Characterize "real-world" PM and ozone primary and precursor emissions from on-road mobile sources to improve emission factors and improve emissions and air quality models.
- Identify mobile source emission profiles and markers for use in air quality receptor models.
- Assess spatial and temporal variability in pollutant concentrations of PM and PM constituents near mobile source "hot spots" such as urban roadways.
- Determine the impact of emerging technologies (fuels and engine systems) on emissions and exposures to primary and precursor pollutants.

Methods/Approach

Facilities and Resources

- Heavy- and light-duty chassis dynamometers
- On-road, near-road, and in-vehicle monitoring equipment
- In-house capabilities for physical and chemical characterization of emissions
- Expertise for conducting control technology demonstrations

Dynamometer Studies

- Kansas City study: This study characterized "real world" exhaust emissions from 480 light-duty vehicles including gas- and particle-phase pollutants as well as chemical speciation and real-time monitoring.
- Gasoline/Diesel Split program: Speciated PM emissions were evaluated from gasoline and diesel vehicles in the Los Angeles area to develop PM chemical source profiles.
- National Low Emission Vehicle (NLEV) study: Vehicles meeting low emission standards were tested to develop modal PM and air toxic emission profiles for each vehicle.

NERL Portable Dynamometer used in Kansas City Light-Duty Vehicle Emission Study and the Gas/Diesel Split Study.

On-Road Emission Study

- PM emissions from low sulfur diesel fuel and 20% biodiesel fuel blend were evaluated by plume sampling
- Complete speciation of PM emissions for organic and inorganic constituents to develop chemical source profiles for the two fuels.

Diesel Emissions Aerosol Laboratory (DEAL) used during on-road testing in New Bern, NC during October 2004.

Near Roadway Testing

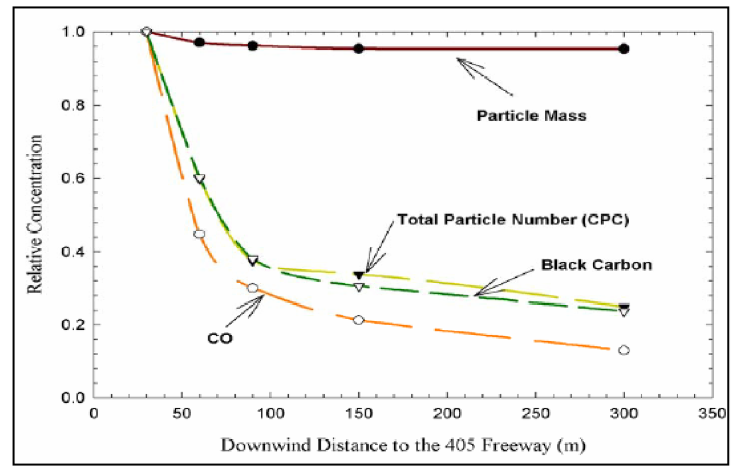
- Traffic-Related Exposure (T-REX) study: This study will evaluate concentration gradients related to motor vehicle traffic in the New York and Detroit metro areas. Data will be used to improve dispersion modeling techniques and assess exposure of effected populations.
- Kansas City construction dust study: Impacts of mud/dirt carryout PM-2.5 emissions were evaluated including physical/chemical characterization. Not only were the emissions lower than prior estimates, they contained a major vehicle exhaust component in the nanometer particle size range.

Mobile monitoring vehicle used in near road studies including the T-REX Study to be conducted in 2005.

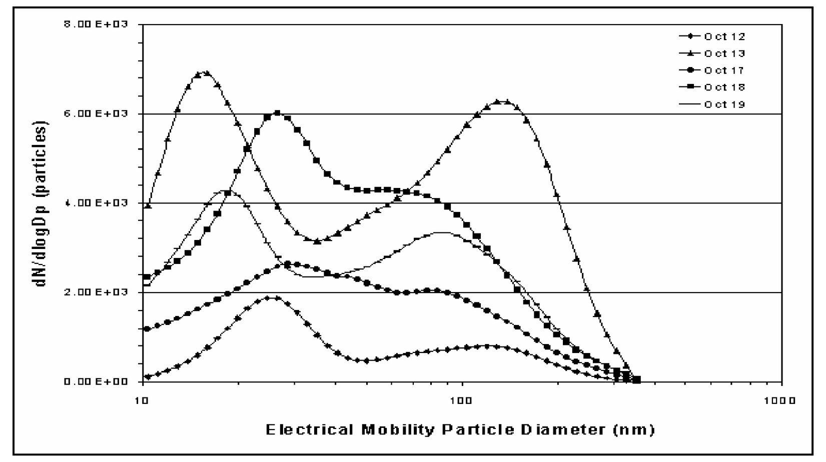
Test set-up for Kansas City construction dust study using both continuous (left) and manual (right) sampling arrays.

Results/Conclusions

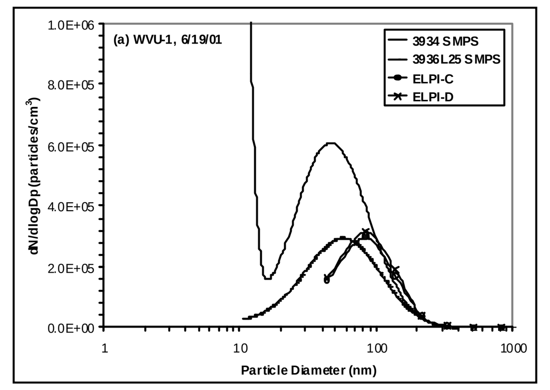
- Vehicle operating characteristics affect emission rates and chemical source profiles of PM and ozone precursor compounds.
- Distribution of PM emissions from the light-duty fleet may be dominated by small fraction of "high emitting" vehicles.
- Gasoline vehicles may contribute larger percentage to ambient PM-2.5 concentrations than diesel vehicles in certain regions of the U. S.
- Mobile source activities result in elevated concentrations of PM and PM constituents near major roads which may lead to adverse health effects.

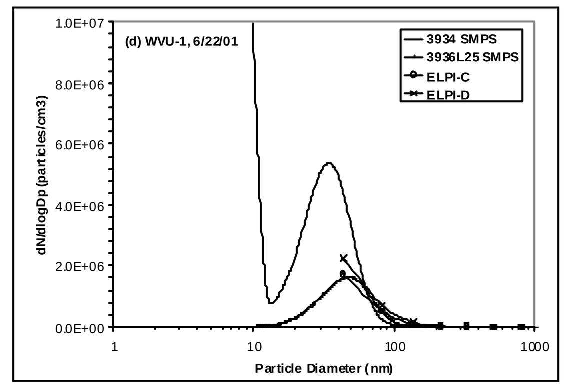


Example of PM and CO concentrations near major roads in a high PM background location (from S. California PM Center)

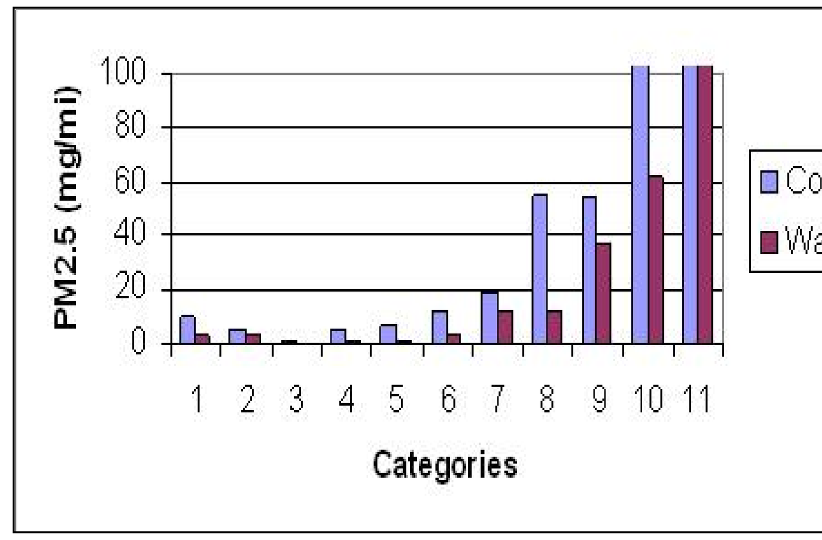


Example data from KC dust study showing differential particle size distributions of PM-2.5 emissions < ~ 400 nm





Particle size distributions of PM emissions from Detroit Diesel Series 60 engine installed in the NRMRL DEAL as tested on an engine dynamometer: (a) is for steady-state operation at 149 kW and (d) is for fast idle. This is an example of differences in PM emissions for two typical engine operating modes. (Nomenclature provided in box is for different particle instruments.)



Comparison of cold and warm start emissions from light-duty gasoline (strata 1 – 10) and heavy-duty diesel (strata 11) vehicles from the Gas/Diesel Split Study. For gasoline vehicles, higher strata numbers indicate older, higher mileage vehicles

Compound	Pre-Catalyst (123 sec)	Cold Start	Steady State	Warm Start	UDDS Weighted
Acetaldehyde	8.26	1.60	0.09	0.08	0.40
Acrolein	2.37	0.37	0.00	0.01	0.08
Benzene	66.65	17.48	7.26	5.03	8.76
1,3-butadiene	7.67	0.99	0.03	0.13	0.25
Ethylbenzene	32.17	5.87	0.16	0.34	1.38
Formaldehyde	16.99	4.26	1.30	0.47	1.68
Naphthalene	12.73	5.82	0.47	0.64	1.62
Toluene	128.08	24.98	1.75	2.82	6.82
m-&p-xylene	114.64	21.20	0.75	1.61	5.20
o-xylene	46.74	8.71	0.41	0.87	2.24

Cold start conditions result in elevated emission rates for PM, NOx and VOCs. Table shows speciated VOC results from the NLEV study

Future Directions

- Better characterize heavy duty diesel and light duty gasoline vehicle modal emissions under varying operating and environmental conditions
- Assess traffic and environmental conditions that lead to elevated pollutant concentrations near major roadways.
- Support near-road epidemiological investigations
- Identify secondary chemical reactions during transport and dispersion of mobile source emissions
- Assess the toxicological potency of gasoline vehicle PM emissions

Impacts and Outcomes

- Better information for mobile source regulatory development activities
- Produced chemical source profiles that have increased capability to determine mobile source contribution to NAAQS concentrations
- Supplied new information for model development and evaluation
- Data to support national monitoring network design and implementation
- Supported studies to assess and better understand the human health effects associated with on-road mobile sources
- Informed urban and transportation planning activities (e.g., NEPA, Conformity, Smart Growth)

Air Quality

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