Ultrafine Particles and Freeways

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Comparison of PM10, PM2.5, and Ultrafine PM

PM10 (10 µm)
PM2.5 (2.5 µm)
Ultrafine PM (0.1 µm)

Human Hair (60 µm diameter)

Relative size of particles
Atmospheric Aerosols: Particulate Matter (PM) Size Distribution

Number Distribution

Ultrafine Particles

Mass Distribution

PM2.5

PM10

Source: Hinds 1999
Particle Regional Deposition for Light Exercise
Pathways of Particle Translocation Within and Outside Respiratory Tract

Translocation of UFP from NP and TB region along sensory neurons to CNS (neurodegeneration)

• Translocation of UFP to interstitium, capillaries, heart
• Uptake by endothelium; platelets
• Activation/interaction of endothelial cells, platelets and leukocytes

Alveolar inflammation
Publications Address Ultrafine Particles

Number of Publications

- Before 1996
- 1996-2005

Pollution | Health | Toxicity | Cardiovascular | Asthma
I-405 Freeway
Sampling Site

Day

Night
INSTRUMENTS

- Scanning Mobility Particle Sizer (SMPS): Particle Size Distribution (6-300 nm)
- Condensation Particle Counter (CPC): Total Particle Number Concentration
- Portable Aethelometer: EC
- Weather Wizard III: Wind speed and direction
- Dust Trak: Real time PM10, PM2.5
- Q-Trak: CO, CO2, Temp, Rh
Experimental Setup: 2001 Daytime
**Traffic Effect:** Total Particle Number Concentration & Traffic Density

![Graph showing traffic effect on particle number concentration and traffic density over time.](image-url)
◆ Normal Traffic

◆ Traffic Slowdown
RESULTS: Change in Ultrafine Particle Size Distribution with Increasing Distance

Zhu et al., 2002a
RESULTS: Number Concentration for Different Size Ranges Vs. Increasing Distance from Freeway 405.

Zhu et al., 2002a
RESULTS: Relative Particle Number, Mass, Black Carbon, CO Concentration, Vs. Downwind Distance from Freeway 405.
December 15 2002
Too freeway close?

Homes along the Southland's busy highways may be affordable, but new studies show pollution.

By William J. Kelly
Special to The Times

Study: Freeway air filled with unhealthy particles

By Kerry Cavanaugh
Staff Writer

People living downwind from freeways or major intersections may be inhaling air that is 30 times more concentrated with unhealthy particles, says a first-of-its-kind health study released Thursday.

Researchers at the University of California, Los Angeles, tested the air along the San Diego and Long Beach freeways and found that areas within 165 feet had particle concentration levels of up to 30 times greater than normal.

“Most people spend an hour a day on the freeway, maybe more,” said William Hinds, UCLA professor of environmental health sciences and co-author of the study. “They may be at more risk.”

Ultrafine particles—those less than 0.1 micrometers in diameter—can be more toxic than larger particles.

Fine particles are an especially dangerous form of pollution, which can reach into the deepest part of the lungs. Fine particles have been linked to respiratory and pulmonary problems.

The study also found that carbon monoxide and black carbon pollution was concentrated near freeways and busy intersections.

Researchers’ findings might seem obvious but the results will play an important role as scientists continue to study the effects of vehicle pollution on health, said Wendy Hunter with UCLA. Next, researchers want to look at human exposure to fine particles while driving on congested routes.

The study was funded by the U.S. Environmental Protection Agency, the California Air Resources Board and the National Institute of Environmental Health Sciences.

UCLA studies show air pollution worse downwind of freeways

Resident near freeways get more hazardous pollution

From staff reports

Anytime 165 feet away or closer.

That’s too close when it comes to freeways, say new UCLA studies that found people living or working in the freeway-close zone are subjected to vastly greater concentrations of hazardous particle pollution, from all those tailpipes.

Proximity to freeways or busy intersections particularly boosts exposure to the tiniest or “ultrafine” airborne bits, which are the hardest on human health, said two studies out of the UCLA Southern California Particle Center and SuperSite.

One study focused on the San Diego (405) Freeway while the other one looked at the Long Beach (710) Freeway.

The concentration of ultrafine particles downwind was 23 to 30 times greater than upwind of the freeways.

A 1999 study by a North Carolina research institute found that drivers in Los Angeles and Sacramento while in their vehicles were subjected to pollution levels 10 times higher than locations near the road. It’s not known how this data fits in with the UCLA studies.

Just think of how many hours people spend on the freeways. The exposure time could be very long.

—YIFANG ZHU, researcher with UCLA's Southern California Particle Center and SuperSite.
including, but not limited to, a prohibition of the approval by the governing board of a school district of the acquisition of a schoolsite by a school district unless prescribed conditions relating to possible exposure to hazardous substances are satisfied, and a prohibition on the approval of a related environmental impact report or negative declaration.

This bill would, in addition, prohibit the approval of a schoolsite within 1,000 feet from a freeway or busy roadway unless prescribed conditions are met and would make conforming changes.
Experimental Setup: 2004 Nighttime
RESULTS: Decay of Total Particle Number Concentration

Daily exposure to Ultrafine Particles: 3 folds of difference between the two cases
RESULTS: Decay of Total Particle Number Concentration
RESULTS: Temperature Effect

Temperature (°C):
0 10 20 30 40

Particle Number Concentration/vehicle (cm⁻³):
0.0 2.0e+4 4.0e+4 6.0e+4 8.0e+4 1.0e+5 1.2e+5

- 405 Fwy Summer
- 405 Fwy Winter
- 405 Fwy Night Time

Y=7.35e4-1.74e3X
R²=0.98

Y=5.17e3+1.17e5exp(-0.071X)
R²=0.99

Zhu et al, 2006
Indoor Study

- Sampling Site and Dominant Wind

Zhu et al., 2005
RESULTS: Effect of distance from freeways

◆ Apartment 1

◆ Apartment 2

Zhu et al., 2005
RESULTS: Effect of Ventilation Conditions on Size Segregated I/O Ratios
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[Graph showing the effect of ventilation conditions on size segregated I/O ratios.]

Zhu et al., 2005
In-Cabin Study
Outdoor and In-Cabin Size Distribution Time Series

Zhu et al., 2007
Average Outdoor UFP Distribution on Different Freeways

Zhu et al., 2007
Average In-Cabin UFP Distribution on Different Freeways

![Graph showing average in-cabin UFP distribution on different freeways with data points for μg=18.7 nm, σg=1.52 for In-Cabin, μg=62.5 nm, σg=2.07 for I-710 Fwy, μg=52.776 nm, σg=2.07 for I-405 Fwy, μg=24.2 nm, σg=1.61 for 110 Fwy, μg=75.7 nm, σg=1.68 for 110 Fwy.]

Zhu et al., 2007
Similar I/O Ratio Profiles on Different Freeways

Zhu et al., 2007
Effect of Ventilation Conditions on I/O Profiles

- Fan off & RC off
- Fan on & RC off
- Fan on & RC on

Zhu et al., 2007
TAKE HOME MESSAGES

• Because of dilution (and coagulation/condensation) ultrafine particles behave like a local source.

• Central station monitoring not useful for estimating dose

• 1 hr on freeway exceeds 23 hrs away from freeway.

• Newer vehicles with recirculation on helps to reduce in-cabin ultrafine particle exposure.
TAKE HOME MESSAGES

• Most ultrafine particles formed after exhaust leaves the tailpipe

• Cooling and dilution both occurring
  • Cooling increases nucleation
  • Dilution decreases nucleation

• Complex physical process
• Sensitive to environmental conditions
• Assessing Children’s Exposure to Ultrafine Particles from Vehicular Emissions
  
  Objective: To identify hot spots in South Texas where school children are likely to be exposed to high levels of UFPs and develop simple models to estimate children’s exposure to UFPs from vehicular emissions.

• Using In-Situ Observations to Quantify Emissions from Prescribed Fires in two Grassland-Pine Ecosystems
  
  Objective: To directly quantify UFP emissions from prescribed fires on DoD managed grassland and grass-shrub type ecosystems with different fuel types and fuel loadings.
Master and Ph.D. Students will be Financially Supported in Part by National Science Foundation (NSF) sponsored Center for Research Excellence in Science and Technology (CREST)- Research in Environmental Sustainability for Semiarid Coastal Areas (RESSACA) at Environmental Engineering Department at Texas A&M University-Kingsville.