Air-quality researchers tackle health implications of ultra-fine particles

September 2 2011

(PhysOrg.com) -- Three studies by a University of California, Davis, air-quality research group are adding to the growing body of data suggesting that very fine and ultra-fine airborne metal particles are closely linked to serious human-health problems, including heart disease.

UC Davis air-quality expert Thomas Cahill and colleagues report the findings of the three studies in the September special issue on aerosols and health of the journal Aerosol Science and Technology. The three papers were selected for publication by Paul Solomon, senior research scientist at the U.S. Environmental Protection Agency.

The research was conducted by UC Davis' Detection and Evaluation of Long-range Transport of Aerosols Group, including researchers at Arizona State University. The work was done in collaboration with the Health Effects Task Force of the nonprofit organization Breathe California of Sacramento-Emigrant Trails.

"These studies yielded unique epidemiological data supporting a growing body of evidence from laboratory and medical studies, which strongly suggests that very fine and ultra-fine metal particles are damaging to human health," said Cahill, a professor emeritus of physics and atmospheric sciences.

"These tiny metal particles penetrate deep into the lungs and the cardiovascular system, damaging arteries and the heart itself," Cahill said.

He noted that risk-assessment of these particles is made more difficult by the fact that standard air samples don't separate out the dangerous particles. Furthermore, there are almost no data available on the composition of these particles in the surrounding atmosphere.

In the three papers, Cahill and colleagues investigate the role that very fine and ultra-fine metal particles play in contributing to heart attacks, the reduction in heart attacks when ultra-fine particles were removed from the air in California's San Joaquin Valley, and the increase in estimated cancer rates downwind of a railyard in the Northern California town of Roseville. The results from these studies are as follows:

Fine and ultra-fine metallic particles in the Central Valley

Researchers took air samples at five sites in the Central Valley, from Redding south to Bakersfield, and analyzed 42 elements, including very fine metals in eight size ranges, as well as integrated organic species. The samples were taken every three hours during a 17-day period in January 2009, when weather conditions caused the air to stagnate in the valley.

The Central Valley runs the length of inland California; it is composed of the Sacramento Valley to the north and the San Joaquin Valley to the south.

The research team found a correlation between the levels of the particles in the air and the death rates due to ischemic heart disease, with the highest rates for both occurring in the southern San Joaquin Valley near Bakersfield. Ischemic heart disease is characterized by a reduction in blood supply, often due to the clogging of the arteries.

An analysis of local meteorology in that area revealed a nighttime flow

of air off of nearby Interstate 5 and Highway 58, both steep stretches of road that require heavy breaking by large trucks traveling down into the valley. The researchers suggest that the fine and ultra-fine particles likely come from the brake pads, brake drums and metal additives in lubricating oils of trucks and cars passing through the valley.

The researchers note that the findings from this study also may offer a clue as to why children who grow up near freeways are more likely to suffer loss of lung function.

Funding for the study was provided by the Sacramento Resources Legacy Fund, the Sacramento Metropolitan Air Quality Management District, the Yolo-Solano Air Quality Management District and Breathe California of Sacramento-Emigrant Trails.

Heart attack rates declined when ultra-fine particles were removed

In the second study, the researchers examined patterns in the atmospheric levels of very fine and ultra-fine aerosol particles of vanadium and nickel in the southern San Joaquin Valley. Levels of these metal aerosols, as well as ammonium nitrate and sulfate, had historically been much higher in the southern end of the San Joaquin Valley than in the northern end, due to the burning of crude oil to generate steam used to recover heavy petroleum from area oil wells.

Furthermore, the southern San Joaquin Valley also historically had death rates due to strokes and ischemic heart disease that were roughly 60 percent greater than the rest of the Central Valley.

In 1990, new technologies were developed that made it possible to use natural gas, rather than crude oil, to fuel the petroleum extraction

efforts. Cahill and colleagues measured the ultra-fine vanadium and nickel aerosol particles in 2009 and compared those levels to pre-1990 levels, when crude oil was still being used for petroleum recovery.

The data revealed that there was a sharp decrease in ischemic heart disease observed in 2007 in the southern San Joaquin Valley that was mirrored by a dramatic decline in the levels of vanadium and nickel aerosols. Those data support a growing body of evidence from laboratory and epidemiological studies, which suggest that the vanadium and nickel aerosols may play a role in causing ischemic heart disease.

These findings, along with other work by UC Davis' DELTA Group, also suggest that the rate of ischemic heart disease observed in communities downwind from the Port of Los Angeles in 2008 may be related to effluent from ocean-going ships that burn crude or residual oil.
Funding for this study was provided by the Resources Legacy Fund of Sacramento, Breathe California of Sacramento-Emigrant Trails and the Sacramento Metropolitan Air Quality Management District.

Aerosols monitored downwind from railyard

In the third study, Cahill and colleagues monitored inorganic and organic aerosols downwind from the Roseville Railyard, northeast of Sacramento, in order to develop a profile of emissions from the railyard activities.

The railyard is one of the largest such maintenance and service sites in the western United States, with more than 31,000 locomotives visiting annually.

The researchers found that most of the aerosols monitored at this site were associated with exhaust from the trains' diesel-fueled engines. Most of the particles, especially the known carcinogen benzol[a]pyrene, were

in the very fine and ultra-fine size-range, increasing the chances that they would be caught up in people's lungs.

The researchers also identified coarse-soil aerosols that were contaminated with metals and petroleum-derived particles.

Findings from this study identified very fine transition metals and contaminated soils that are potentially important to human health, and confirmed estimates of the health impacts of diesel exhaust downwind of the railyard that were made earlier by the California Air Resources Board.

Provided by UC Davis