Study on Toxic Exposures in Urban Environments

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Columbia University researchers have found that steel dust generated in the New York City subway significantly increases the total amount of airborne iron (Fe), manganese (Mn) and chromium (Cr) that riders breathe. The airborne levels of these metals associated with fine particulate matter in the subway environment were observed to be more than 100 times greater than levels observed in home indoor or outdoor settings in New York City. Their research findings are scheduled to appear in the January 15th issue of Environmental Science & Technology, a peer-reviewed journal of the American Chemical Society, the world's largest scientific society.

The results are part of the TEACH (Toxic Exposure Assessment, a Columbia and Harvard) study to understand pathways and levels of personal exposures to potentially toxic air pollutants in inner city areas of New York City and Los Angeles. This research was funded by the Mickey Leland National Urban Air Toxics Research Center and the NIEHS Center for Environmental Health in Northern Manhattan, at Columbia University's Mailman School of Public Health.

"This study in no way suggests that people should avoid riding the subway. There are no known health effects at the levels that we observed in the NYC subway system. Furthermore, reducing subway ridership would just increase surface traffic emissions," says Dr. Steven N. Chillrud, a geochemist with the Lamont-Doherty Earth Observatory, a division of The Earth Institute at Columbia University, and lead author of the manuscript.

For the NYC field research, a total of forty-one students attending the A. Philip Randolph Academy, a public high school in Harlem with enrollment from four of the five NYC boroughs, participated during the winter and summer of 1999. Air samples were collected over 48 hour time periods from rooftop sites in Harlem and Rockland County, New York and from inside and outside of each student's home. At the same time, students carried a specially designed backpack with a battery-operated pump to collect what were called personal samples as they went about their normal daily routines.

Comparing the samples collected from each of these locations showed that the vast majority of the personal samples had higher Fe, Cr and Mn levels that could not be explained by levels observed inside of the subjects' homes or in outdoor locations. Looking at elemental ratios allowed the team to conclude that while the indoor and outdoor samples appeared to obtain their Fe and Mn primarily from re-suspended dirt particles, the personal samples were primarily exposed to a single type of steel that was ground into a fine dust. This was evident since both Fe and Cr concentrations had a strong tendency to follow Mn concentrations and the personal ratios of these metals, that is the Fe to Mn and Cr to Mn ratios were significantly different from the ratios naturally found in dirt. Several clues made the research team suspect the subway system as a potential source of the steel dust. For example, the data from the winter samples showed that all of the students who had to commute a long distance to school were included in the group with the elevated levels of Fe, Mn and Cr. During the summer, when the students were not commuting to school, the geographic pattern of elevated levels was more random.

The subway hypothesis was tested by sending a Columbia University student underground with two personal monitoring pumps and a particle counter for a total of eight hours. The airborne levels of Fe, Mn, and Cr in these two subway samples were more than two orders of magnitude higher than indoor and outdoor levels measured in the TEACH study. Just as important, the samples collected by the student backpacks had the same 'source signature' as the samples collected during the subway study in that they had the same ratio of Fe to Mn and Cr to Mn.

"All indicators for the increased exposure levels point to the subway microenvironment as the source of steel dust exposure," says Dr. Chillrud. "The non-subway riding students showed levels of metals similar to the home and outdoor levels while the subway riders showed increased exposure. Interestingly, the particle counting data showed that particle numbers were 5 to 10 times lower in air conditioned subway cars as compared to underground subway stations. This suggests that the filtration systems of the car air conditioners are very effective at removing the steel dust from the passenger cars and that much of the increased exposure is probably occurring on the station platforms."

"It is important to stress that there are no known health effects at these levels," emphasizes Dr. Patrick Kinney, principal investigator of the TEACH project and associate professor of environmental health sciences at the Mailman School of Public Health and a member of the Earth Institute. "Even though the levels of Mn, Cr and Fe observed in the subway system were more than 100 times greater than those observed in ambient and home indoor settings, the subway levels are more than 1000 times lower than the United States Occupational Safety and Health Administration's Permissible Exposure Limit guidelines for workers." Dr. Sonja Sax, a co-author from the Harvard School of Public Health, adds, "One way of putting into perspective the potential health risks of these levels of exposure is to consider published cancer risk guideline concentrations, which roughly estimate the risk of obtaining cancer from chronic exposures to single chemicals such as Cr. These estimates together with the data from the TEACH study suggest that the cancer risks associated with exposure to Cr due to commuting by the subway would be much smaller than those that people get from exposure to a variety of volatile organic compounds in the home."

On the other hand, there is increasing interest in whether there are health effects from long-term exposure to low-levels of pollutants such as chromium and manganese, as well as from inhaling airborne transition metals. "With the large number of people who ride in underground subways, we do think subway exposures are worth investigating further," comments Dr. Chillrud. Along these lines, the Columbia researchers are beginning a study to look at whether the elements in airborne steel dust are absorbed into the bodies of transit workers in NYC.

The TEACH study suggests that subway systems would be conducive to health studies as well as comparison studies with different subway systems in order to better understand how design characteristics can effect air pollutant exposure levels. Dust produced in different subway systems could potentially have different levels and mixtures of elements. For example, the steel used in NYC was relatively devoid of nickel (Ni), but many types of steel do contain Ni as well as higher levels of Cr or Mn. And some subway systems use rubber wheels. The few published articles on other underground subway systems have primarily focused on increased levels of particulate matter mass or a single steel element such as iron. Nickel, manganese and chromium were identified in an amendment to the 1990 US Clean Air Act as among 189 Hazardous Air Pollutants potentially warranting ambient air regulation by the US Environmental Protection Agency.

The online version of the research paper cited above was initially published December 17, 2003 on the journal's Web Site. Journalists can arrange access to this site by sending an e-mail to newsroom@acs.org.

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The Center for Environmental Health in Northern Manhattan is funded by the National Institute for Environmental Health Sciences to bring researchers together to study health issues and understand the role of the environment in cancer, respiratory disease and, neurological diseases The Center's overall goals are to carry out research on environmentally related diseases, form partnerships with Northern Manhattan community groups and residents to address environmental health issues of concern, to promote education of the local communities on environmental health issues that concern them, and foster awareness of the Center's research efforts and their public health significance at the local, state, and federal levels. For more information, visit http://cpmcnet.columbia.edu/dept/niehs/index.html

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