Smog Simulator Offers Unique Capabilities to Study Health Impacts of Urban Air Pollutant Mixtures

For decades, EPA officials have set health standards for major air pollutants, including particulate matter (PM), ozone, and other common pollutants. The risk of health effects arising from elevated levels of ozone and PM in the air are indicated in the color-coded Air Quality Index that ranges from good air quality (0–50) “Code Green” and moves through several colors up to “Code Maroon” for hazardous air quality (above 300).

But what happens when these pollutants co-exist in the atmosphere? Does the presence of two pollutants edging close to the upper limit of the “good” category double the health risk? What if one pollutant affects the lungs, while the other impacts the heart or vascular system? And how do the effects of other co-pollutants or so-called “natural” sources of pollution—such as certain biogenic compounds from trees or ash from wildfires—enter into the equation?

It’s precisely these kinds of questions that a team of EPA researchers may soon answer with the help of a new mobile smog simulator that can replicate mixtures of pollutants found in places as diverse as Denver, Los Angeles, or Houston. After two years of construction and testing, the smog simulator and testing facility began operating in May, 2014 and is running its first set of experiments.

**Objectives**

Research findings will help support EPA’s evaluation of air mixtures as part of the agency’s periodic reviews of the National Ambient Air Quality Standards. In addition, the ability to study health effects from different sources of pollutants will be invaluable in developing approaches for controlling air pollution in ways that maximize public health benefits. Importantly, the smog simulator has a unique feature to enable climate-based adjustments, including temperature and the composition of the air, to study impacts of a changing climate on air photochemistry and physics and subsequent impacts on human and ecological health.

“The smog simulator’s capabilities are generating excitement that we can actually provide quantitative data to inform the Air Quality Index settings,” says Ian Gilmour, an EPA toxicologist and chief of the Cardiopulmonary and Immunotoxicology branch of the agency’s Environmental Public Health Division.

“If you have high ozone and high PM, should the Air Quality Index be more than just the highest level of one pollutant?” asks Gilmour. “What we want to do is to test whether exposure to a combination of...
pollutants results in an overall increase in adverse health outcomes than what would be expected from any individual component."

While there have been some attempts to study mixtures in the past, doing these experiments with real-world reactive atmospheres and more sophisticated and sensitive biomarkers will position researchers to answer questions about health effects of multipollutant mixtures. The smog simulator can be used to study realistic formation of many types of multipollutant atmospheres, as well as their potential health impacts through the testing of animal models and human cell lines.

The EPA team can create customized smog “recipes” for different parts of the country. The pollutant mixtures can then be used to study the pathophysiology and toxicity pathways that signal the progression to diseases, such as asthma and cancer, and to develop biomarkers for oxidative stress, an early sign of health impacts. They can also use animal models of cardiovascular and pulmonary diseases to evaluate how these diseases affect sensitivity to these atmospheres and under what circumstances. Moreover, these recipes can also be used with other in vitro (cell) and plant-based test systems to explore a variety of biological outcomes.

The four experiments being conducted this year are mimicking a pollution profile seen in many cities in the Southeast that features ozone and particles termed secondary organic aerosols, which form through the photochemical reaction of gasoline vapor, nitric oxide from car exhaust, and alpha-pinene (a biogenic that comes from pine trees). Future research will enable investigations of other real-word atmospheric scenarios that could include a variety of air toxic mixtures.

**Smog Simulator Features**
The smog simulator is a mobile unit and could be used in diverse locations. It consists of a 14-cubic meter Teflon-lined box that allows in light from 120 ultraviolet bulbs to simulate sunshine, a necessary ingredient for the creation of secondary pollutants such as ozone.

While pollutant simulators for the study of air chemistry date back some 30 years, this is the first one that has been developed specifically to link the air physico-chemistry and climate parameters for health effects research. The simulator’s unique capability to modulate temperature of the photochemical reaction of mixtures precisely controlled from 45 to 110 degrees Fahrenheit makes it highly flexible for the study of smog formation under different climatic conditions. Finally, the system is fully automated with custom software that controls the injection of various atmospheric chemicals, as well as the light cycles, flow rates, and other dynamic operations, and can operate consistently for weeks to months at a time.

“We over-engineered the system so it could sit in the North Carolina sunshine at 95 degrees and hold a temperature of 70 degrees inside with 120 four-foot lights turned on,” Gilmour adds. The smog simulator will advance our understanding of urban air mixtures and the interrelationship between climate change and air quality.

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