How ammonia affects city's air

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(PhysOrg.com) -- Motor vehicles and industry are primary producers of ammonia in Houston's atmosphere, and cars and trucks appear to boost their output during the winter, according to a new study by researchers at Rice University and the University of Houston (UH).

Ammonia's role in air quality draws minimal oversight from the Environmental Protection Agency (EPA), but researchers at both Houston institutions are learning what it means to life in and around the metropolis.

The study led by Rice Professors Robert Griffin and Frank Tittel in collaboration with UH researcher James Flynn and Professor Barry Lefer revealed the seasons play a role in ammonia produced by vehicles. Their instruments also measured plumes of airborne ammonia from isolated incidents. The results appeared in a recent research paper in the journal Atmospheric Chemistry and Physics.

The findings are not cause for immediate concern, said Griffin, an associate professor of civil and environmental engineering. "There may not be a health risk from ammonia itself, but the fact that ammonia is a precursor to particles is a big deal. They can get into your lungs and do some damage."

Ammonia quickly combines with other airborne elements: sulfuric acid to make ammonium sulfate salts or, in cooler conditions, nitric acid to make ammonium nitrate. The particles could impact air quality as well as atmospheric visibility, cloud formation, climate patterns and nutrient cycling, he said.

Ammonia is found throughout the atmosphere in levels ranging from parts per trillion to parts per billion (ppb), he said. People can detect ammonia at five to 50 parts per million (ppm). Concentrations above 100 ppm are uncomfortable to most, according to the EPA.

The sources are many: industry, motor vehicles, agriculture (as a major component of fertilizer) and livestock. Even humans produce ammonia. (Household ammonia is highly diluted with water -- but one should still avoid the pungent fumes.)

Wondering how much ammonia is in the atmosphere at any given time, the researchers gathered data 24 hours a day over two weeks in February and six weeks in late summer, 2010.

Readings were taken atop the University of Houston's tallest building, North Moody Tower. The residence hall is ideally situated to pick up changes in the wind not only from the nearby Houston Ship Channel and its associated industries to the east, but also power generation facilities to the southwest and Houston traffic in every direction.

Tittel, a pioneer in laser sensing and Rice's J.S. Abercrombie Professor of Electrical and Computer Engineering, and Rafal Lewicki, a co-author and graduate student in Tittel's laser science group, designed and built an apparatus to collect the data. Their external-cavity quantum cascade laser-based sensor is finely tuned to pick up signs of ammonia from air samples continuously cycled through the closed system. Real-time readings were taken with a resolution of less than five parts per billion and autonomously monitored at Rice via the Internet.

Sampling at a single site produced results that at first seemed contradictory, Griffin said.

For example, while overall levels were highest in the summer, ammonia emissions from vehicles were found to be highest in winter when harder-working car and truck engines reduced the performance of catalytic converters. (Carbon monoxide levels recorded by UH instruments on the tower correlated nicely, the study showed.)

Part of the answer was blowing in the wind. The researchers found the prevailing wind during winter morning rush hours came from the southeast -- past several major highways and Houston's William P. Hobby Airport -- and carried a high level of vehicle emissions.

During summer morning rush hours, the wind whistled in from the northeast, passing the ship channel and increasing readings from industrial activity and including occasional spikes, including a nearby traffic accident, that raised the average.

Winter levels of airborne ammonia ranged from 0.1 to 8.7 ppb with a mean of 2.4 ppb. A larger range -- 0.2 to 27.1 ppb with a mean of 3.1 ppb -- was observed during the summer.

In the Aug. 14 accident, two 18-wheeled tankers collided on Interstate 45 two miles north of the tower. One was carrying fertilizer and pesticide, and the fumes from the resultant chemical fire reached the sensor, which recorded a spike in airborne ammonia to about 21 ppb. "If the wind was blowing the other way, we wouldn't have captured it," said Owen Gong, a graduate student in Griffin's lab and first author of the paper. "There is a bit of luck associated with this kind of field work."

A similar spike occurred a few weeks later when winds from Hurricane Hermine in the Gulf of Mexico blew emissions from industries in and around Texas City -- 40 miles south of downtown Houston -- to the tower. The next week, ammonia levels reached 27 ppb, but no source of the emissions was identified.

Griffin appreciated having access to the UH site and Lefer and Flynn's help. "Without their data to give us wind direction and other chemical information, analysis of the ammonia time series would have been difficult," he said.

He admitted that, as an environmental scientist, he lives in interesting times -- and in an interesting place. The researcher, who came to Rice from the University of New Hampshire three years ago, said few talk about airborne particles in Houston because the city is currently "in attainment with respect to the air quality standard." The team's next study will track the source and fate of other components in airborne particulate matter.

Griffin did not foresee the EPA monitoring ammonia for the sake of establishing a standard. "But because it can be such a significant precursor to particulate matter, the EPA needs to keep an eye on it," he said.

More information: Read the abstract at www.atmos-chem-phys.net/11/972 … cp-11-9721-2011.html

Provided by Rice University