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Scientists discover that charcoal traps ammonia pollution

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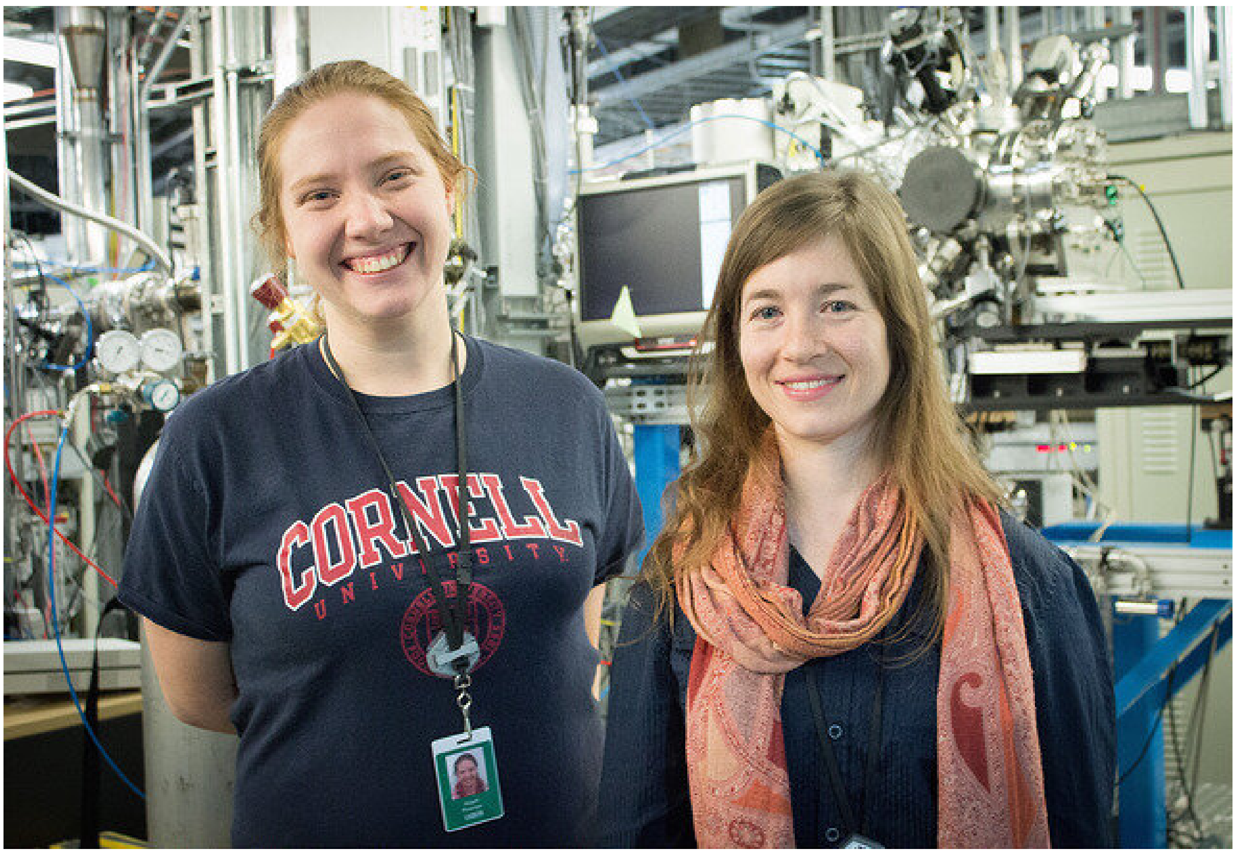

Rachel Hestrin (right) on the beamlines at Canadian light Source with fellow Cornell researcher Angela Possinger. Credit: Canadian Light Source

Cornell University scientists Rachel Hestrin and Johannes Lehmann, along with collaborators from Canada and Australia, have shown that charcoal can mop up large quantities of nitrogen from the air pollutant ammonia, resulting in a potential slow-release fertilizer with more nitrogen than most animal manures or other natural soil amendments. The results were published Friday in *Nature Communications*.

Ammonia is a common component of agricultural fertilizers and provides a bioavailable form of the essential nutrient nitrogen to plants. However, ammonia is also a highly reactive gas that can combine with other air pollutants to create particles that travel deep into the lungs, leading to a host of respiratory issues. It also indirectly contributes to climate change when excess fertilizer inputs to soil are converted into nitrous oxide, a potent greenhouse gas.

In Canada, ammonia emissions have increased by 22 per cent since 1990, and 90 per cent are produced by agriculture, particularly from manures, slurries and fertilizer applications. Mitigating this pollutant—without limiting fertilizers and food growth for our growing world population—is key to a sustainable future.

Charcoal, also known as fire-derived organic matter or biochar, is both a natural material found in the environment and an agricultural amendment. Recent investigation into the potential agricultural benefits of charcoal have sparked interest in its chemical properties and capacity to retain and supply essential nutrients to plants.

The researchers used the Canadian Light Source at the University of Saskatchewan to examine how ammonia gas interacts with charcoal under natural conditions. According to Lehmann, "The unique end stations at CLS are great for this kind of nitrogen X-ray spectroscopy."

Hestrin and Lehmann's study identifies charcoal's ability to capture nitrogen from airborne ammonia through the formation of covalent bonds, which could provide a long-term slow release fertilizer for field and greenhouse crop production. Previous studies showed that these reactions occurred between ammonia and engineered carbon materials under high temperatures, but there was no evidence for ambient temperature and pressure conditions.

Hestrin says that using the beamline capabilities at the Canadian Light Source was essential to this game-changing discovery and turned it into a much bigger project than originally planned.

"The CLS beamline provided the best method to investigate how charcoal can retain nitrogen from ammonia. Discovering that nitrogen was retained through a variety of covalent bonds was a real game-changer in our research. It implies that nitrogen captured from compost or manure might be less susceptible to loss through leaching or volatilization than we previously thought."

Nitrogen plays an important role in climate change, and it is present in numerous forms, some essential for living organisms, and others that are toxic or noxious gases. Providing sufficient nitrogen to crops while reducing nitrogen leaching into groundwater or gaseous emissions into the atmosphere has important environmental consequences.

Currently, up to 50 per cent of the nitrogen that goes into a composting facility can be lost as ammonia gas—capturing it directly at the source could significantly cut pollution and loss of a valuable plant nutrient.

Further research into this ground-breaking discovery indicates that the environmental impact of charcoal's nitrogen capture from ammonia gas could play an important role in the global carbon and nitrogen cycles. In addition to its potential for improving agricultural nutrient management, the influences of charcoal in soils, air and water on nitrogen storage and availability in natural ecosystems should also be considered.

More information: Rachel Hestrin et al. Fire-derived organic matter retains ammonia through covalent bond formation, *Nature Communications* (2019). DOI: 10.1038/s41467-019-08401-z

Provided by Canadian Light Source