Cutting ammonia emissions is a cost-effective way to prevent air pollution deaths

November 4 2021

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Tackling pollution from the emission of nitrogen compounds, particularly ammonia, could reduce many of the 23.3 million years of life that were lost prematurely across the world in 2013 due to nitrogen-

related air pollution, an international study led by Chinese scientists has discovered using a modeling framework, including the IIASA GAINS model.

A research team led by scientists from Zhejiang University in China used the IIASA GAINS model, among other tools, to develop a new metric, called the 'Nitrogen-share' (N-share), to estimate the contribution of nitrogen compounds to $PM_{2.5}$ (fine particle) air pollution and the associated health effects.

N-share expresses the contribution of a given compound containing nitrogen to an effect in question.

$PM_{2.5}$ air pollution is the largest environmental risk factor for human health worldwide. Sulfur dioxide and nitrogen compounds such as nitrogen oxides (NO_x), deriving from fossil fuel combustion in power plants, industrial furnaces or boilers, as well as vehicle emissions, and ammonia (NH_3) emissions mainly from agricultural and natural sources are important precursors of $PM_{2.5}$ formation in the atmosphere.

The study, published in *Science*, revealed, via a cost-benefit analysis, that ammonia mitigation is one of the most cost-effective ways to improve global air quality and public health.

The research team used three atmospheric chemistry transport models to simulate total $PM_{2.5}$ concentration with and without nitrogen compound emissions and found that NH_3 emissions have a larger contribution to $PM_{2.5}$ than NO_x emissions. Using the GAINS model developed by IIASA, the team was able to quantify the potential to reduce emissions, and the financial costs such measures would have.

They compared implementation costs of nitrogen compound abatement across sectors and countries with the benefits of reduced mortality to

estimate the overall effects of abatement programs, and to derive important policy conclusions.

The study found that:

1. The NH_3 contribution to $PM_{2.5}$ is larger than NO_x globally, and in most countries, indicating that $PM_{2.5}$ formation is more strongly limited by NH_3 than by NO_x.
2. Total years of life lost from $PM_{2.5}$ pollution caused by nitrogen compound emission increased from 19.5 to 23.3 million globally between 1990 and 2013.
3. The global average marginal cost of premature mortality caused by nitrogen compound emission in 2013 was 33% higher than 1990 due to the increasing emissions and higher willingness to invest in health care.

The study assessed costs and benefits of NH_3 and NO_x emission reductions and found the global average cost in US$ of reducing NH_3 emission ($1.5 per kg of NH_3-N) is over four times **lower** than the global health benefits ($6.9 per kg of NH_3-N), but the abatement cost of NO_x emission ($16 per kg of NO_x-N) is over two times **higher** than the global health benefits ($7.3 per kg of NO_x-N). This effectively means the marginal global cost of ammonia emission abatement is only 10% of nitrogen oxide emission abatement, meaning ammonia reduction is cheaper and more effective.

"The GAINS model is a perfect tool to align abatement cost and effects of air pollution, allowing for robust policy recommendations," said IIASA researcher Shaohui Zhang.

IIASA researcher, Wilfried Winiwarter, added that the N-share approach has great value because of its wide applicability across impact studies.

"We have started looking at N compounds because they allow novel views to identify measures that benefit the environment in more than one aspect," he said. "We now can look more easily into pollution related effects including biodiversity or climate change that are also severely affected by nitrogen compounds."

Nitrogen cycles at multiple scales have been the focus of a range of IIASA activities, as compounds investigated allow to differently perceive seemingly unrelated problems, and to identify pathways of joint solutions directed to a range of environmental impacts simultaneously.

The research was published in *Science*.

More information: Baojing Gu et al, Abating ammonia is more cost-effective than nitrogen oxides for mitigating PM2.5 air pollution, *Science* (2021). DOI: 10.1126/science.abf8623.
www.science.org/doi/10.1126/science.abf8623

Provided by International Institute for Applied Systems Analysis