https://civileats.com/2019/09/19/the-greenhouse-gas-no-ones-talking-about-nitrous-oxide-on-farms-explained/

The Greenhouse Gas No One's Talking About: Nitrous Oxide on Farms, Explained

Nitrous oxide gets much less attention in ag circles than carbon dioxide and methane, but it's 300 times more powerful at warming the planet.

BY GOSIA WOZNIACKA

Posted on: September 19, 2019 Leave a Comment

This story is part of Covering Climate Now, a global collaboration of more than 250 news outlets to strengthen coverage of the climate story.

It doesn't steal headlines like carbon dioxide and isn't as quirky as the methane emitted by cows' burps. But nitrous oxide (N_2O), an often-overlooked greenhouse gas, is a significant contributor to global warming. Its concentration has greatly increased in recent decades due to human activity—no laughing matter, given that it's a lot more potent than other greenhouse gases.

How and Where Nitrous Oxide is Produced

Nitrous oxide has always existed in the atmosphere. It's mostly produced by microbes in soil and naturally released, especially from tropical rainforests, permafrost melting in the Arctic, as well as microbes in the oceans.

Human-made sources account for an increasingly larger share of N_2O emissions. An estimated one-third to one-half of the nitrous oxide released into the atmosphere today is a result of human activities. The biggest culprit: the increase in agricultural lands and synthetic fertilizer use in agriculture, which has steadily increased in recent decades. And industrial farming—especially of annual crops like vegetables and grains—are especially to blame, as farmers tend to over-apply fertilizers to boost their yields.

In essence, both synthetic and organic fertilizers increase the amount of nitrogen available to microbes in the soil, which turn it into nitrous oxide—though these two

types of fertilizers can have very different impacts on N_2O emissions. Livestock manure is another agricultural source that provides nitrogen to the microbes—the nitrous oxide is emitted during storage and treatment of the animal waste. There are also significant indirect emissions from nitrogen leaching and runoff.

Non-agricultural human sources of N_2O include industry processes, biomass and fossil fuel burning, and sewage (waste management).

Why Nitrous Oxide is a Growing Concern

Since the industrial revolution, the atmospheric concentrations of nitrous oxide have increased by an estimated 16 to 20 percent. Agricultural emissions of N_2O in the U.S. account for nearly 80 percent of the total human emissions of this gas—including 74 percent from cultivated soils and 5 percent from manure management. And while emissions from manure may not be as significant as from soil, disposing of large amounts of manure is challenging. On some large livestock operations, farmers inject the manure into soil using a shallow disk injector in hopes it won't run off into waterways, but that practice only increases nitrous oxide emissions. Although previous research suggested that emissions occur only during the growing season because microbes aren't active during winter, climate change is causing soils to warm up and thaw more frequently, activating the microbes and leading to winter N_2O emissions.

Although nitrous oxide accounted for just 6 percent of U.S. greenhouse gas emissions in 2017, it's significantly more potent than carbon dioxide (CO_2) or methane when it comes to driving climate change. Pound per pound, it's almost 300 times more powerful than CO_2 and remains in the atmosphere for well over 100 years before it's destroyed by chemical processes.

According to one study, N_2O emission is also "the single most important ozone-depleting emission, and is expected to remain the largest throughout the 21st century."

What Farmers Can Do to Reduce Emissions

Experts say the key to reducing agricultural emissions of nitrous oxide is using fertilizer more efficiently. This means figuring out the right amount to use and the right time to apply it. That's more challenging than it sounds, because modern agriculture relies heavily on over-production, and the simplest way to guarantee high yields is to use more nutrients than necessary.

The most obvious way to reduce the use of synthetic fertilizers is to switch to organic production, which doesn't allow them. But conventional growers also have options for cutting down.

"The good news is that there are a diversity of tools available to farmers to increase soil fertility and reduce nitrous oxide emissions," said Jeanne Merrill, Policy Director at the nonprofit California Climate and Agriculture Network (CalCAN). "Compost, cover crops, mulch, conservation tillage all help build soil organic matter and decrease the need for synthetic fertilizers."

Organic fertilizers release nitrogen more slowly than synthetic ones. As a result, they're able to better match plants' nutrient needs and get absorbed as they become available. This leads to less excess nitrogen for microbes to feast on and less leaching into groundwater. But many conventional farmers eschew organic fertilizers because using them can result in lower yields.

The key to reducing N_2O is the slower release of nitrogen, so some farmers have unwittingly slashed their nitrous oxide emissions by changing their irrigation techniques. In California, research shows N_2O emissions dropped when farmers switched to water-efficient technologies of micro-irrigation, such as drip and sub-surface drip that allow for the slower dosing of water and fertilizer, said William Horwath, professor of soil biogeochemistry at U.C. Davis.

With the older technique of flood irrigation in furrows, soil is soaked in water and nutrients are top-loaded to plants in large amounts at the sides of the furrow, Horwath said. Water-saturated soil conditions are often associated with higher N_2O emissions. Since most of the nutrients can't be absorbed right away, the excess is taken up by the microbes and converted into nitrous oxide.

Micro-irrigation, on the other hand, leaves more of the soil dry and allows farmers to dispense small amounts of nutrients in increments to match plants' daily requirements and allows most of the nitrogen to be absorbed by the crops. Horwath's research, which looked at 10 heavily fertilized crops, including wheat, corn, and almonds, found that growers using micro-irrigation techniques such as sub-surface drip have lower nitrous oxide emissions than other systems.

"The ability to spoon-feed the crops when they need the nutrients, rather than top-loading them, has made a big difference," Horwath said. "The plants are more competitive for the nitrogen with the microbial community, which leads to less nitrous oxide being emitted."

And efficient irrigation techniques usually result in higher yields because plants are more competitive for the water and nutrients, he said. “It’s a win-win from a climate change perspective.”

There are some challenges with converting to water-efficient systems, Horwath noted. In addition to high costs, efficient irrigation associated with precision fertilization may lead to more water being used overall, it does not recharge groundwater, and could result in salts accumulating in soil, Horwath said.

Another way for conventional farmers to reduce nitrous oxide emissions from cultivated soils is by using slow-release or controlled-release fertilizers, said Martin Burger, a senior environmental scientist at the California Department of Food and Agriculture. But in order to use time-released fertilizers, Burger said, farmers have to know their system well enough and apply them at the right time. And some crops cannot rely on slow-release because they need the nitrogen right away.

Optimizing fertilizer timing to the planting season is also key, experts say, instead of fertilizing months before the crops actually go into the ground. Applying fertilizer in the fall is common, particularly in the Corn Belt, where rain and snowmelt in the winter or early spring can lead to leaching and loss of most of the nitrogen. Instead, crop scientists, such as the ones at Cornell University, advise the fertilizer should be applied “as close to the time of maximum growth of the crop as possible.”

Challenges in Reducing Nitrate Emissions

Cutting N_2O isn’t easy, as the amount released from farmland can vary widely depending on the crop, irrigation method, climate, and soil type. In California, where over 200 different crops are grown, there’s a dearth of data and it’s therefore difficult to adapt best management practices, said Amrith Gunasekara, the science advisor to California’s Secretary of Agriculture, Karen Ross. Research is needed for each crop, including what rates of fertilizer can prevent excess, he said.

Many California field crops are still under flood or furrow irrigation, said Gunasekara, because it’s unclear whether irrigating with sub-surface drip and precision fertilizer feeding will lead to yields matching those obtained under conventional irrigation practices. “It’s not one size fits all,” he said. “You have to make it economical to the grower.”

And when it comes to cover crops, the jury is still out on how effective they are in reducing nitrous oxide. While they can absorb excess nitrogen, in some cases cover crops actually increase the release of N_2O. They tend to be most effective at

reducing the emissions when they are non-legume species, when their residues are not incorporated into the soil, and when they are used long-term in areas with less precipitation.

The biggest challenge to reducing nitrous oxide emissions comes from farmers reluctant to reduce the amount of fertilizer they use for fear of diminished yields. But experts say that in the long run, managing farms to reduce N_2O can also be profitable—it goes hand-in-hand with the general move toward regenerative agriculture, which focuses on soil health through conservation till, cover cropping and other practices. Regenerative agriculture is becoming popular among both conventional and organic farmers, who say it has the potential to increase profits because it leads to yields similar to conventional farming while decreasing the need for expensive fertilizer and pesticide applications.

Regenerative practices are currently all the buzz, with funders investing billions, state and local governments jumping in to increase funding for conservation efforts, and restaurants working to connect chefs and eaters with regenerative farmers. Several new labels, including the Regenerative Organic Certification and the Soil Carbon Initiative, will soon be available to further boost farmers' profits. And while regenerative agriculture is gaining steam because it can sequester carbon from the atmosphere, the heartening news is that many of the same practices also have the potential to reduce nitrous oxide.