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Research shows inaccuracies in emission measurements of important greenhouse gas nitrous oxide

May 12 2016

Nitrous oxide, carbon dioxide and methane are the most important greenhouse gases. Nitrous oxide also participates in the destruction of stratospheric ozone. To mitigate global warming, we have to control nitrous oxide emissions. A recent study by the University of Eastern Finland, the University of Helsinki and the Natural Resources Institute Finland provides new knowledge on nitrous oxide emissions and shows that there can be significant inaccuracies in the traditional emission measurements.

A major part of the carbon dioxide entering the atmosphere originates from the use of fossil fuels but microbial activities in our environment, especially in soils, are largely responsible for nitrous oxide emissions. Microbes are able to transform soil nitrogen to nitrous oxide. Microbial nitrous oxide production is enhanced by an increase in the availability of nitrogen in soil. Therefore, nitrogen fertilized agricultural soils are the most important sources of nitrous oxide.

Measuring nitrous oxide emissions from soils is demanding because the emissions have large spatial and temporal variation. Traditionally various chamber techniques have been used to measure these emissions. For the purpose, chambers with a diameter of about 50 cm are set on the soil surface and emissions are estimated from the gas accumulated in the chambers within a short measurement period (30 -60 min). Computer controlled chambers can also be used to measure emissions, e.g., for every hour. However, it is possible to use only a limited number of chambers at a site, such as an agricultural field. This implies that the spatial variation in nitrous oxide emissions can not be accurately determined causing inaccuracies in the emission calculations. Chambers can also cause bias in emissions because environmental conditions within chambers differ from those of natural conditions. New technologies are now available to the scientists to overcome the problems associated with chambers. The eddy covariance method uses accurate laser spectrometry for estimating nitrous oxide emissions and allows continuous measurements within an area of several hundred metres. With this method, temporal and spatial variations in emissions are averaged over the entire area. Because no chambers are needed, the measurement system does not change the environmental conditions and associated bias in the emissions is avoided.

Researchers from the University of Eastern Finland, the University of Helsinki and the Natural Resources Institute Finland applied the eddy covariance technique combined with the most-modern laser technology in the market to measure nitrous oxide emissions from a field where a bioenergy crop was cultivated (Maaninka, Eastern Finland). In the early summer, the nitrogen availability in the soil was high after the nitrogen fertilization. Nitrous oxide emissions were high during this time. The emissions, however, had significant diurnal variation. The emissions were higher during daytime than during night time. The researchers explained these results by the variation in soil temperature and moisture. Later in the growing season when the effect of nitrogen fertilization diminished, the diurnal variation in the emissions changed surprisingly. Then the emissions were higher during night time. Excluding the diurnal variation in nitrous oxide emissions causes inaccuracies in the annual emission estimates.

These results published in a highly ranked scientific journal, *Scientific Reports* (Nature Publishing Group), have international significance. The results support the development of reliable measuring methods for nitrous oxide emissions and improve our understanding of the nitrous oxide emission mechanisms and their controlling factors. Competition for soil nitrogen between plants and microbes has a crucial role for the nitrous production in the soil. When soil nitrogen availability is low, nitrous oxide emissions are higher during night- time than during daytime because plants do not consume soil nitrogen at night and more nitrogen is available for microbes and their nitrous oxide production. Stable isotope experiments with labelled nitrogen fertilizer additions confirmed the higher night time emissions observed by the eddy covariance technique.

The research shows how advances in measuring technology support the generation of new knowledge needed to obtain reliable emission estimates and to better understand the mechanisms behind greenhouse gas production in the soil. The understanding of the controlling factors behind the emissions allows the use of cultivation methods with low greenhouse gas emissions. The developing bioeconomy requires such cultivation practices for biomass production. This research was made possible by combining the knowhow and technological facilities of three leading Finnish organisations in greenhouse emission studies.

More information: Shurpali N.J. et al. Neglecting diurnal variations leads to uncertainties in terrestrial nitrous oxide emissions. *Sci. Rep.* 6, 25739: DOI: 10.1038/25739

Provided by University of Eastern Finland