SCIENCE FOR ENVIRONMENT POLICY

Study elucidates why rainfall after drought releases large volumes of potent greenhouse gas

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Barrat, H. A., Evans, J., Chadwick, D. R., Clark, I. M., Le Cocq, K. and M. Cardenas, L. M. (2020) The impact of drought and rewetting on N^2O emissions from soil in temperate and Mediterranean climates. *European Journal of Soil Science*. DOI: 10.1111/ejss.13015.

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Scientists have performed the first systematic review of the causes of nitrous oxide (N^2O) 'hot moments' — when large amounts of this greenhouse gas (GHG) are released when soil is 'rewetted' after a drought. As climate change drives more frequent and intense weather events on a global scale, greater releases of N^2O are becoming increasingly likely. This study sought to understand the causes behind hot-moment emissions to better inform mitigating land management practices.

Nitrous oxide (N^2O) has a global warming potential nearly 300 times greater than carbon dioxide (CO^2). At present, little is understood about N^2O 'hot moments', but the gas is a known component of GHG emissions from soil. Soil microorganisms produce N^2O in a process determined by oxygen availability, which in turn is governed by soil moisture (which affects how oxygen diffuses and moves through soil). As extreme weather events such as flooding, storms and droughts become more frequent and intense, soil wetness fluctuates significantly — affecting microbial production of N^2O as a result.

Understanding the mechanisms behind rewetting hot moments is important for accurate modelling of climate-change scenarios, and to inform mitigating practices in land management. Soil health is a core part of the European Green Deal, which is committed to increasing organic farming to 25% in Europe by 2030 and lowering use of fertilisers and pesticides. These aims follow on from the goals of the Seventh Environment Action Programme, which sought to reduce soil erosion and increase soil organic matter.

According to a recent study, this is the first systematic literature review on this significant biophysical process. The researchers perform a detailed statistical review to understand how hot moments are impacted by the amount of moisture in the soil, and to assess the effects of the severity of the drought prior to the rewetting hot moment on the microbial communities and key substances available in the soil.

The review consisted of two literature searches using two sets of keywords and resulted in 14 studies being selected (of a possible 735). This selection was based on the design of the experiments, and the existence of suitable data that could be standardised for statistical analysis. The final statistical model included four variables related to soil water content (change and peak value), fertiliser use and land type.

The results show that the size of a hot moment is dependent on the amount of substrates in the soil

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(elements used by microbes to make N^2O), the intensity of the preceding dry period, and the amount of water added to the soil by rewetting. The larger the difference between the soil's dry and wet states, and the more saturated the soil after rewetting, the larger the hot moment. N^2O emissions were affected by land type — with grasslands more prone to larger hot moments, followed by similar (lower) levels in woodland and arable settings — the quantity and type of fertiliser used and the availability of substrates in the soil.

The researchers suggest that, once a hot moment is underway, the amount of N^2O released is controlled by the bioavailability and use of substrates by the soil microbial community. Microbes are believed to amass substrates during periods of drought, with these then becoming accessible during rewetting (although this remains uncertain). The behaviour of the microbes appears to be altered by drought, so that when the soil eventually becomes wet they utilise the available substrates differently. Hot moments were larger when more carbon- and nitrogen-containing substrates were present in soil.

The findings provide initial insight into the mechanisms behind rewetting hot moments and the release of the GHG nitrous oxide and highlight the need for more research into this important process. The researchers call for further studies to better understand the influence of microbial population structure, the severity and length of a preceding drought, and the possible impact of worms in soils (the abundance and diversity of which may lower the amount of N^2O released).