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Fertilizer impact on biogenic nitric oxide emissions from agricultural soils of the Taklimakan desert (Xinjiang, China)

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It is known that soil microbial processes play a crucial role in the production and consumption of atmospheric trace gases worldwide. Soils are mostly a major source of biogenic nitric oxide (NO). The main influencing factors controlling soil NO emissions are soil moisture, soil temperature, as well as nutrient availability.

Adding fertilizer to agricultural soils changes the pool of nutrients and impacts the net NO emission from these soils. Irrigated and fertilized oases around the great Central Asian Taklamakan desert form the backbone of the agricultural output (80% of the Chinese cotton production) of the Xinjiang Uygur Autonomous Region (NW-China). While nowadays 90% of the agricultural output is produced on just 4.3% of Xinjiang's total area, recent and future enlargement of farmland and intensification of agriculture will definitely impact the regional soil NO emission and consequently the budget of nitrogen oxides and ozone.

We present a systematic laboratory study of the influence of urea (CH_4N_2O) and diammonium hydrogen phosphate ($(NH_4)_2HPO_4$, DAP) fertilizer on NO emissions from Xinjiang soil samples. Urea is the most widely and excessively applied fertilizer in Xinjiang. Typically, about 600 kg ha^{-1} yr^{-1}(in terms of mass of nitrogen) were applied to a cotton field in four separate events. In the laboratory, the fertilizer was applied accordingly, ranging from one quarter of the field amount within one of the four events (i.e. 37.5 kg ha^{-1} yr^{-1}) to quadruple of that (150 kg ha^{-1} yr^{-1}). Two different measurement series have been performed on six sub- samples (each out of a total of three soil samples taken in Xinjiang): the first series was conducted solely with urea fertilizer, the second one with a mixture of urea and DAP (2:1).

All sub-samples were prepared in a standardized way: a fixed mass of soil ($\sim$0.06 kg, dried in field) was sieved (2 mm) and stored at 4˚C. Then it was wetted up to a soil moisture tension of 1.8 pF. Subsequently, fertilizer was added and the experiments were started immediately, without any pre-incubation in a dynamic chamber system (6 individual chambers under controlled incubation conditions). Measurements were performed at alternating soil temperature levels, switching between 20˚C and 30˚C after every 6 chamber cycle. To inhibit fast drying of the soil, moist air (RH$\sim$80%) was used for flushing the chambers. Only towards the end of each experiment relative humidity of the flushing flow was gradually reduced to zero (computer controlled) to dry out each soil sample completely.

The experiments clearly demonstrated that the use of fertilizer causes significant changes of biogenic NO soil emissions. It seems that depending on the initial nutrient content of the soil, an addition of ammonium based fertilizer (urea) may increase or decrease net NO release rates. While addition of urea to soils with an already high initial nutrient content lead to a decrease, addition to soils of low initial nutrient content lead to an increase of net NO emission. After reaching a critical – most likely toxic – level of nutrient content in the soil, the addition of even more ammonium based fertilizer causes a decline of net NO emission. There is strong indication that the use of urea and DAP mixtures may lead to lower gaseous loss of nitrogen to the atmosphere than by application of urea alone.