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Simulation and analysis of N losses under urine patches in a dairy grazing system

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The volume of urine excreted by grazers and the N dose, together with the uniformity and the timing of the deposition are the main determinants of N losses from pastoral dairy farms. Quantifying releases from this spatially distributed sources is still a challenge, especially for gaseous emissions as N_2O and NH_3. These two forms are often misestimated with general emission factors of national inventories that are not able to capture the effects of management, soil and climate factors. Process-based models are suitable tools to interpret and analyse the biogeochemical fate of the N inputs and overcome these limits. However, current models simulate animal excreta as uniform application at paddock scale, without considering the local effects introduced by these point sources. Conversely, simulating the spatial heterogeneity would come with potentially substantial computing expenses affected by redundancy.

With this study we analysed the N losses to air and groundwater from the deposition of urine patches in a real dairy grazing rotational system in Posieux (Switzerland). A *in silico* experiment assessed the effect of different patch application time during a year, coinciding with the rotational management, different patch size (from 0.05 to 1m^2) and N doses (from 0 to 100 g/patch). The PaSim grassland biogeochemical model has been applied at the scale of urine-patch simulating urine as ammoniacal-N application together with an additional 2 litres rain, while cow grazing actions were mimicked with cuts.

Results show that the N dose has a linear effect on NO_3 leaching and NH_3 volatilisation, while exhibiting a rectangular hyperbolic dynamic for N_2O emissions. Different application timing during the year, especially in situation of low soil water availability, lead to considerably variations in NO_3 releases and N_2O emissions (by a factor 5, with 0.1 m^2 as reference patch-size). The size of the patch is also relevant and indicates peculiar behaviours depending on the amount of water distributed per unit area. In fact, N_2O emission as well as NO_3 leaching shows higher values for smaller patch sizes. Conversely, higher NH_3 volatilisation occurred with large patch sizes, independent of the N dose distributed. Periods with low soil water availability trigger lower N_2O emission from the smaller patches (up to 65%, with the reference dose of 20 g/patch) compared to the larger ones, with a relatively low loss by NO_3 leaching independent of the patch-size.

These results can be used to address current gaps in the discretisation of gaseous emission, as N_2O, in process based-model that, up to know, predominantly assume a homogenous spreading of the animal excreta.