Climate Change Research: Evaluation and Policy Implications
S. Zwerver, R.S.A.R. van Rompaey, M.T.J. Kok and M.M. Berk, (Eds.)

Modelling the emission of dinitrogen oxide from mown and from grazed grassland

J. Bril, H.G. van Faassen and H. Klein Gunnewiek

Institute for Agrobiological and Soil Fertility Research,
P.O. Box 129, 9750 AC Haren, The Netherlands

Abstract

The integrated model SONICG was developed to simulate the emission of dinitrogen oxide (N_2O) from grassland soil. The model comprises modules on soil physico-chemical conditions and processes, and on soil microbial carbon and nitrogen turnover and makes use of data from an existing model on grass development. Some typical model results are shown for the daily emission of N_2O from mown and from grazed grassland, with special attention for effects of urine.

1. INTRODUCTION

Based on literature data on N_2O emission, intensively managed grazed grasslands were expected to be a major biogenic source of N_2O emission in The Netherlands. A high contribution of intensively managed grassland to N_2O emission might be explained from the low efficiency of high nitrogen (N) inputs in dairy farming. Furthermore, high concentrations of mineral N in urine spots in grazed grassland form active centres for N loss by nitrification-denitrification. To get a better understanding of the complex relationships that result in N_2O emission from grazed grassland the model SONICG -Simulation Of the NItrogen Cycle in Grassland soil- was developed.

2. THE SIMULATION MODEL SONICG

SONICG mechanistically simulates the relevant soil physical, chemical and biological processes in grassland soil layerwise. The model considers 30 layers of 2.5 cm, each with its own properties. Above the soil a gaslayer of 2.5 cm is present in the model as a kind of gasbuffer between the soil and the atmosphere.
Figure 1 shows schematically the nitrogen cycle processes that play a central role in the model SONICG: *Nitrification* and *Denitrification*, including the production and reduction of N_2O. A separate M.I.T. module simulates mineralization-immobilization-turnover of organic matter. Inputs of organic matter in the form of dead grass litter and roots, as well the uptake of mineral N by the grass are derived from a separate mechanistic model on grass development (Verberne,1992).

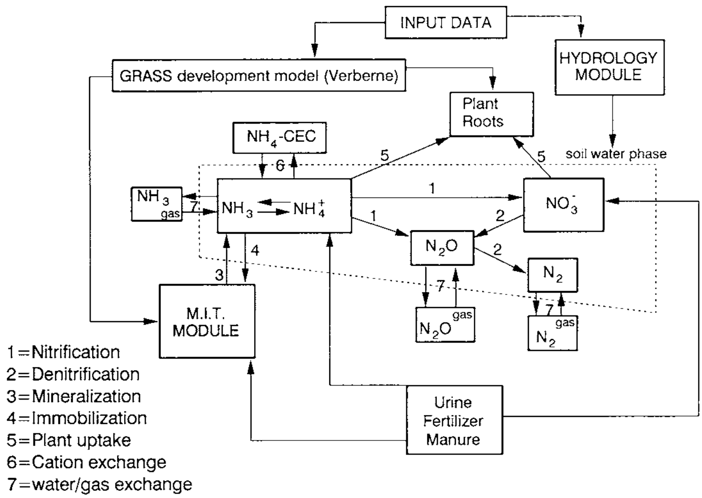

Figure 1. Nitrogen transformations and exchanges modelled in SONICG

The order of the different modules and processes in a timestep (one day) of the simulation is shown in Figure 2: input data are read from a hydrology module (daily weather data; soil data, including water-filled pore space fractions for each layer) as well as from a grass growth model (organic C and N inputs from and potential uptake of mineral N by the grass). Next the temperature profile of the soil is calculated. Thus the actual process rates of M.I.T., nitrification and denitrification can be calculated next, including temperature and moisture effects. At the field scale soil water-filled pore space is a major rate controlling factor for the production and reduction of N_2O (Groffman, 1991). Figures 3 and 4 show how M.I.T., nitrification and denitrification depend on WFPS in the model.

After the M.I.T. module the actual plant uptake of mineral N is calculated. Then nitrification rates -production of N_2O and nitrate- are calculated, followed by denitrification rates -nitrate and N_2O reduction. Next gas transport and transport of dissolved substances are calculated. As a final steps chemical equilibrium calculations are made for the following components: H_2O, H^+, Ca^{2+}, K^+, NH_4^+, NO_3^-, N_2O, CO_3^{2-}, Cl^-, CEC (Cation Exchange Capacity) and inert gas (all gasses except the explicitly modelled gasses CO_2, NH_3, and N_2O). For each layer cation exchange, complexation in solution, precipitation/dissolution of calcite and the exchange of gasses between the soil water- and gasphase are considered.

As the main parameter of interest here SONICG can calculate the daily emission of N_2O from the soil surface, as well as that of CO_2 and NH_3. Escape of gasses with drainwater at the lower boundary of the soil is also calculated. For details on SONICG see the endreport of NOP-project 852078 (Van Faassen and Bril, 1994).

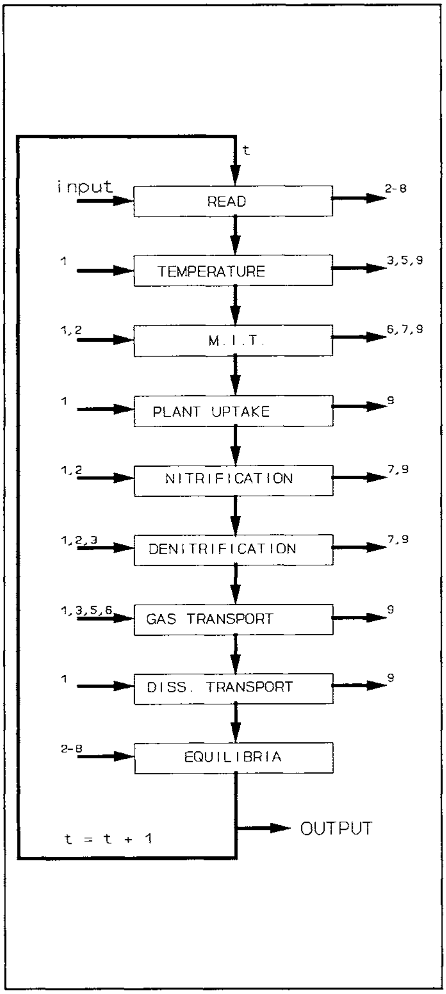

Figure 2. Flow chart of SONICG

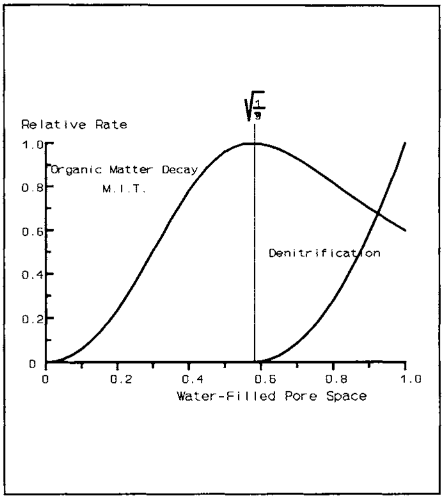

Figure 3. Dependance of organic matter decay and denitrification rates on soil water-filled pore space.

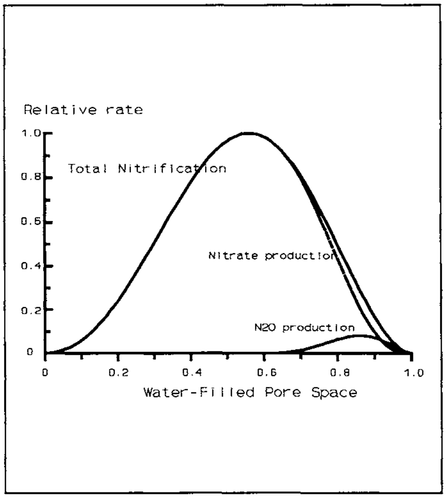

Figure 4. Dependance of nitrification, nitrate and N_2O-production rates on soil water-filled pore space.

3. SIMULATED EMISSION OF N_2O FROM MOWN AND GRAZED GRASSLAND

As an example of SONICG, mown grassland was compared with grazed grassland, fertilized with 480 and 360 kg of N per ha per year, respectively. To simulate grazed grassland, at least two situations have to be considered: urine spots and area unaffected by urine. Grazed grassland gets less fertilizer N than mown grassland, but in urine spots an excess of mineral N will be present over a long period. Urine spots were simulated to get additional N from urine equivalent to 420 kg per ha. To get an overall picture of grazed grassland, simulation results of urine spots and of area without urine have to be added on an areal basis. Large differences are found in the simulated emission of N_2O from mown grassland and from urine spots in grazed grassland. As shown in Figure 5, several months passed between the main N_2O emission and the deposition of urine.

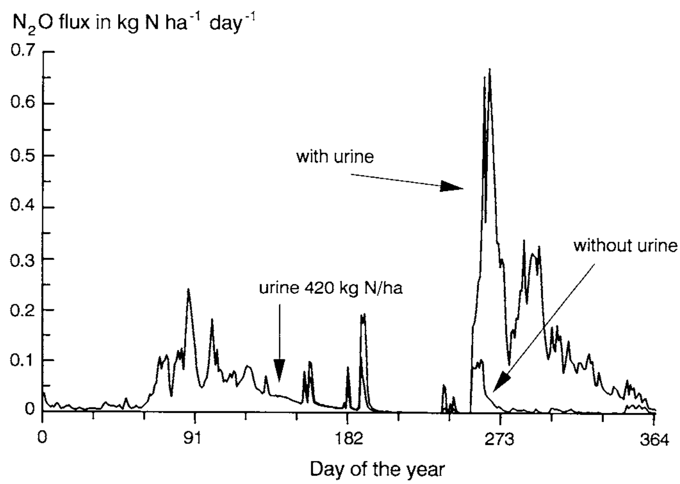

Figure 5. Simulated daily emission of N_2O from mown grassland and from urine spots in grazed grassland. Urine was deposited on day 140.

4. REFERENCES

1 E. Verberne, 1992. Simulation of the nitrogen and water balance in a system of grassland and soil. Nota 258. IB-DLO, Haren.
2 P.M. Groffman, 1991. Ecology of nitrification and denitrification in soil at scales relevant to atmospheric chemistry. In: J.E. Rogers & W.B. Whitman, eds., Microbial production and consumption of greenhouse gases, Am. Soc. Microbiol., p.201-218.
3 H.G. van Faassen & J. Bril, 1994. Modelling N_2O emission from grazed grassland. Endreport of NOP-project 852078. AB-DLO, Haren.