Geophysical Research Abstracts
Vol. 13, EGU2011-12918-1, 2011
EGU General Assembly 2011

N budget in intensive agriculture under monsoon climate: an extensive balance approach for nitrogen fluxes on landscape scale

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Intensive agriculture in Central Korea is characterized by excessive N fertilization against the background of a strong summer monsoon season. Strong monsoon rains together with predominantly sandy soils with low fertility and upland farming is predestined not only for high erosion and low fertilizer use efficiency but also for extensive losses of nitrogen during the cropping season.
We measured the contribution of agricultural fields to the nitrogen export to the groundwater and thus, out of the catchment in a summer monsoon area. Furthermore, we identified typical amounts of N accumulation in soil and N removal by five major Korean crops and their fertilizer use efficiencies. N budget was estimated for five typical crops of Central Korea (Summer Radish, Cabbage, Potato, Bean and Rice) in more than 40 field sites with a large spatial distribution within the catchment. To calculate nitrogen balances on the farm scale and gain insights into the dimension of N losses, we used a simple input-output approach for the croplands:
N budget = Input (Fertilizer, seed, atmospheric deposition, Nmin) – Output (Harvest).
To appreciate all Nitrogen pools, we additionally measured N retention in soil before fertilizer application in spring as well as at harvest time at the end of the cultivation period of each crop type. By comparing the calculated N losses with the N outflow at the catchment outlet, we will additionally be able to prepare an estimation of the contribution of the forest sites. The efficiency with which crops take up nitrogen fertilizer and convert it into biomass is calculated as:
NUE = [(total crop N removed) - (N coming from soil + N deposited in the rainfall)] / fertilizer N applied to crop.
To complete this data set, we additionally collected several parameters of soils (texture, nutrients, CEC, pH, Corg), plants (nutrients, LAI, biomass development, CO2 fluxes), landscapes (slope, field size), climate (precipitation) as well as management (fertilization, ploughing, pesticides, planting and harvest dates).
Although, the fertilizer application rates can be as high as 200 up to 350 kg N ha-1, there is no big difference between the total nitrogen values in the soil profile before fertilization and right after harvest. This suggests that the entire fertilizer applied at springtime is taken up by plants, leached to the groundwater or emitted to the atmosphere. If we compare N input and output data without accounting Nmin, we observe that at some fields the nitrogen output with harvest is bigger than the nitrogen input with fertilizer, seed and deposition. This difference is highest for European cabbage, where we can observe losses in soil up to 50kg N ha-1. Complementary studies with 15N suggest that the main loss pathways are plant uptake as well as leaching to the groundwater. On the other hand, fairly high surpluses were found at potato and radish field sites with an average surplus of 52 kg N ha-1and 56 kg N ha-1, respectively. Finally, these farm scale data were up-scaled to landscape level and a general budget with uptake, losses, surpluses and retention was calculated.