Biogeochemical aspects to improve Japanese nitrogen budgets estimation

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Artificial fixation of nitrogen (N) using the Haber–Bosch process provides reactive N (N chemical species other than molecular nitrogen [N_2]) according to demands. In conjunction with (NO_x) from fossil fuel combustion, the amount of anthropogenically created reactive N is now similar to that from natural sources. However, most of the created N is lost to the environment due to the low N use efficiency of human activities, approximately 20% in the whole human system. Eventually, the remainder is emitted to the environment, accelerating the N cycling of the Earth system. Reactive N consists of a variety of chemical species such as ammonia (NH_3), NO_x, nitrous oxide (N_2O), and nitrate (NO_3^-). Reactive N emitted to the environment moves throughout all the environmental media changing its chemical forms. Reactive N provides a variety of impacts such as global warming, air pollution, water pollution, acidification, eutrophication, and in consequence jeopardizes human and environmental health. This complex cycle is known as the N cascade. The human acceleration of N cycling is a strong concern with respect to the planetary boundaries. Quantification of N flows between human sectors (energy, industry, agriculture, fishery, human settlements, waste, sewage, trade, etc.) and environmental media (atmosphere, soil, water, sea) is useful to know the status of N cascade, as N connects all the human sectors and environmental media. This is N budgets estimation. According to the Guidance Document on National Nitrogen Budgets in Europe, N budgets estimation provides the following advantages; an efficient instrument for visualizing the N cascade and its potential impact and thus help to raise awareness; information to policymakers to identify intervention points and developing efficient emission reduction measures; a tool for monitoring the impact and environmental integrity of implemented policies; an useful indicator for comparisons across countries; and pinpoint knowledge gaps and thus contribute to improving the scientific understanding of the N cascade. The Towards INMS (International Nitrogen Management System) project funded by the Global Environment Facility has a task to develop methods of national N budgets estimation. Our activity is a part of this task.
Methodological guidelines have been provided by the EPNB (Expert Panel on Nitrogen Budgets) /TFRN (Task Force on Reactive Nitrogen) in Europe and the CHANS (Coupled Human and Natural Systems) model developed in China. We are now modifying the CHANS model for Japan. The CHANS model defines major sectors and media as respective pools and quantifies N flows between the pools. For the Japanese modification, we set the following pools; Energy and fuel, Industry, Cropland, Livestock, Grassland, Fishery, Human settlements, Solid waste, Wastewater, Forest, Urban green, Atmosphere, Surface water, Groundwater, and Coastal zone. Subpools are also defined within the pools as necessary. Nitrogen flows between the pools/subpools are estimated, and the N budgets are estimated summing the total input and output. In this estimation, biogeochemical knowledge is required for N flows between human activities and the environment, N flows between the environmental media, and stock changes in the environment. Concrete themes are as follows: 1, anthropogenic N emissions to the atmosphere; 2, anthropogenic N input to land (soil); 3, surface water use and N discharge to surface water; 4, groundwater use and direct and indirect N leaching to groundwater; 5, anthropogenic N discharge to coastal zone; 6, atmosphere–land interactions involving a variety of processes; 7, terrestrial N processes and N

accumulation; 8, N flows through surface water, groundwater, and coastal zone; and 9, N flows between coastal zone and ocean. We will introduce the outline of CHANS-Japan and the current estimation methods of the abovementioned themes to discuss possible ways for methodological improvements.

Keywords: Nitrogen budgets, Atmosphere, Land, Surface water, Groundwater, Coastal zone

