

## Nitrogen issues induced by human activities: A big issue in Earth system beyond watersheds

HAYASHI, Kentaro<sup>1\*</sup> ; EGUCHI, Sadao<sup>1</sup> ; ASADA, Kei<sup>1</sup> ; YOSHIKAWA, Seiko<sup>1</sup> ; ABE, Kaoru<sup>1</sup>

<sup>1</sup>National Institute for Agro-Environmental Sciences

Nitrogen (N) is indispensable for agriculture. Crop production has increased drastically since the Haber-Bosch process which provides chemical N fertilizers. Nitrogen fertilizers support the global population and increase meat production in many countries. Nowadays, approximately a half of the global population depend on the Haber-Bosch process. In contrast, it is estimated that crops uptake only approximately 25% of applied N to croplands as a global average (approximately 40% in Japan). Although a part of the remaining N can be stored in soils as organic matter, most of which turns into environmental N loads to soil, water, and air. Livestock waste also results in N loads to the environment. Nitrogen in the environment changes its chemical forms in its cycling (so-called nitrogen cascade). We see various environmental consequences due to the human-induced N loads, e.g., water pollution, air pollution, effects on global radiative forcing, stratospheric ozone depletion, eutrophication, and acidification. We collectively call it N issues.

A typical N issue in Japan is water pollution of groundwater, lake water, and enclosed coastal water due to excess N fertilizers in croplands, livestock farming, and miscellaneous drainage. However, N in water bodies is also connected to other environmental media through the N cascade. For example, atmospheric N deposition inputs N to watersheds. Nitrous oxide produced by nitrification and denitrification in soils, sediments, and water bodies is a potent greenhouse gas and simultaneously a strong ozone depleting substance when emitted to the atmosphere. Japan is a small and densely populated country, and highly depends on imports for food and feed (self-sufficiency ratios: food, 39%; feed, 26%). Recently in Japan, a huge amount of food is discarded without being consumed. Such the food waste is estimated to 5.8 Tg yr<sup>-1</sup>, which is larger than the food for aid in the world (4 Tg yr<sup>-1</sup>). A large proportion of N is eventually loaded to the environment without being recycled. Japan is one of the world's biggest countries in terms of N loads per unit area of land.

Maximizing N use efficiency and minimizing environmental N loads are dilemma important for the sustainability of food production, energy consumption, and Earth system. Therefore, N issues are receiving increasing attention in the world. The International Nitrogen Initiative (INI) organizes Nitrogen Conferences every three years and implements N assessments for major regions in the world. OECD is developing indicators to assess N issues in collaboration with INI. UNEP and INI are preparing an international project of the Global Environmental Facility, the International Nitrogen Management System to establish a system connecting science and policy to address N issues. The Future Earth starting in full from 2015, a huge international project involving all stake holders, situates the sustainable food production as a major theme, in which resolution of the N dilemma is an important research component.

Relevant efforts of Japan seem delayed in comparison with the world situation. A variety of respective studies of water quality, air quality, and global environmental issues have been progressed, whereas efforts to comprehensively understand the N dynamics in the N cascade and to share and discuss study results with other sectors like policy makers are still insufficient. We will present the current situation of N issues in Japan and the world efforts against N issues. And then, we aim to suggest the establishment of Japanese Nitrogen Expert Group to tackle with N issues. It is supposed that the N expert group will consist of several subgroups (e.g., agriculture, freshwater, marine, atmosphere, land, and industry) because of a variety of sectors involved in the N issues. We hope that relevant experts are interested in and join in the group.

**Keywords:** Nitrogen, Water quality, Air quality, Eutrophication, Global environment, International Nitrogen Management System