National nitrogen flows in Germany

Martin Bach[1], Stephan Fuchs[2], Markus Geupel[3], Uwe Häußermann[1], Jürg Heldstab[4], Laura Klement[1], Lukas Knoll[1], Judith Reutimann[4], Bettina Schäppi[4], Tatyana Weber[2], Lutz Breuer[1,5]

[1] Institute for Landscape Ecology and Resources Management, Justus Liebig University Giessen, Germany
[2] Institute for Water and River Basin Management, Karlsruhe Institute for Technology, Germany
[3] Federal Environment Agency Germany, Dessau-Roßlau, Germany
[4] INFRAS AG, Zürich, Switzerland
[5] Centre for International Development and Environmental Research (ZEU), Justus Liebig University Giessen, Germany

E-mail: martin.bach@umwelt.uni-giessen.de

Abstract

Emissions of reactive nitrogen (N_r) cause a bundle of severe environmental damages. For the development of remediation measures it is necessary to quantify sources, sinks and flows of N_r. Therefore the National Nitrogen Budget was compiled for Germany and nearly 150 N flows was determined for the time period 2010 – 2014. A key finding is that almost 1.63 million tonnes of reactive nitrogen are released annually in Germany.

Keywords: Germany, nitrogen flow, national nitrogen budget

1. Introduction

How much reactive nitrogen is introduced into the nitrogen cycle each year, and where does it come from? Where does this N go? How reliable are the results about the N-flows? These are the central questions regarding the national budget for reactive nitrogen flows (BMU, 2017). The environmental impacts of reactive nitrogen differ for the individual N-species (NO_3, NH_3/NH_4, N_2O, NO, NO_2) and will also depend on which vulnerable sector is considered (e.g. human health, climate, groundwater, surface waters, or nitrogen sensible vegetation). According to the "Guidance document on national nitrogen budgets" (ECE 2013) the N_r -flows in Germany were determined for eight pools: Atmosphere, Energy and Fuels, Material and products in industry, Humans and settlements, Agriculture, Forest and semi-natural vegetation, Waste, and Hydrosphere. For each pool the trans-boundary N-flows (imports and exports) are also calculated. The N-flows are taken directly from statistical reports, publications, etc., or are calculated as the product of the quantity of transported or converted substance and the mean nitrogen contents. Some 150 N-flows are described (ref. Bach et al., 2019).

2. Results

In Germany, approximately 6275 kt N_r is introduced into the nitrogen cycle every year (mean value 2010 - 2014), thereof 43 % by ammonia synthesis. Domestic extraction of nitrogenous fossil fuels (lignite, coal, crude oil) and imports contribute 2335 kt N a^{-1}. Natural nitrogen fixation converts 308 kt N a^{-1} into organically bound nitrogen. Thus, ammonia synthesis in Germany currently introduces 8 10-times more N_r into the nitrogen-cycle than the natural process of nitrogen fixation in soils. As a further illustration of the size of the problem, in Germany ammonia synthesis alone (2690 kt N a^{-1}) produces more reactive nitrogen every year than the total amount stored in German forest trees (~2260 kt N).

Conversely, processes involving the combustion of fossil fuels and regenerative fuels and the refining of crude oil to mineral oil products result in 2711 kt N a^{-1} being transformed to N_2. In waters, soils, and wastewater treatment plants, denitrification leads to the disappearance of 1107 kt N_r a^{-1} as molecular nitrogen. Via the atmosphere and hydrosphere,

Germany exports 745 kt N a^{-1} to neighbouring countries and the coastal waters. On balance, reactive nitrogen totalling 1627 kt N is released in Germany every year, with negative impacts on the ecosystems and their functions. However, the national nitrogen budget involves considerable uncertainties, firstly because the uncertain statistical data for the input material flows and their N-contents. There is also insufficient knowledge about denitrification in soils, waters, and solid waste. These uncertainties this should be taken into consideration when interpreting the results. Further investigations are required if the national nitrogen budget is to provide more reliable results.

Acknowledgements

The project was coordinated and funded by the German Environment Agency in the framework of the environment research plan of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (project no. 3716 51 2000).

References

Bach M, Häußermann U, Klement L, Knoll L, Breuer L, Weber T, Fuchs S, Heldstab J, Reutimann J, Schäppi B, 2019. Reactive Nitrogen Flows in Germany 2010 - 2014 (DESTINO Report 2). Umweltbundesamt, Dessau-Roßlau, UBA-Texte, 162 S. (in print)

ECE, 2013. Guidance document on national nitrogen budgets. Economic Commission for Europe (ECE), Executive Body for the Convention on Long-range Transboundary Air Pollution, ECE_EB.AIR_119.

BMU, 2017. Nitrogen input in the biosphere. First nitrogen report from the Federal Government. Federal Ministry for the Environment, Nature Conservation and Nucelar Safety.