SRU Sachverständigenrat für Umweltfragen

NITROGEN:
Strategies for resolving an urgent environmental problem

Summary
January 2015






INTRODUCTION

The excessive release of nitrogen compounds into the environment is one of the biggest problems of our time. Nitrogen compounds, such as nitrogen oxides and ammonia, pollute the environment and endanger human health in numerous and complex ways:

- Nitrogen-induced eutrophication and acidification contribute to biodiversity loss.
- Nitrogen oxides in ambient air have a direct detrimental impact on human health, and together with ammonia form hazardous particulate matter and contribute to ground level ozone.
- Nitrate in drinking water and food endangers human health; nitrosamines are suspected to be carcinogenic.
- Nitrous oxides damage the ozone layer and contribute to climate change.

Nitrogen cycles through the soil, air and water and is key to the existence of all living things. Virtually all nitrogen (99 per cent) occurs as relatively inert atmospheric nitrogen, which, partly through natural processes, can be converted into chemical and biologically active (i.e. reactive) nitrogen compounds. The main reactive nitrogen compounds are ammonia (NH_3), ammonium (NH_4^+), nitrogen oxides (NO and NO_2), nitrate (NO_3^-), nitrite (NO_2^-), nitrous oxide (N_2O) and organic compounds.

Human activity is seriously impacting the natural nitrogen cycle, particularly owing to the development of industrial fertilizer production about a century ago, in which non-reactive atmospheric nitrogen is converted into reactive nitrogen compounds. Reactive nitrogen-compound emissions, mainly linked to fertilizer use, livestock farming, and combustion processes, have increased almost ten-fold since the dawn of the industrial revolution. Through the concentration of agricultural activities, such as livestock farming, in specific areas, some localities have become heavily polluted.

Reactive nitrogen compounds impact the environment at various spatial levels with partially interactive effects. Pollution of surface water and groundwater is primarily a local phenomenon, whereas ocean eutrophication primarily results from more remote sources of pollution, particularly inputs

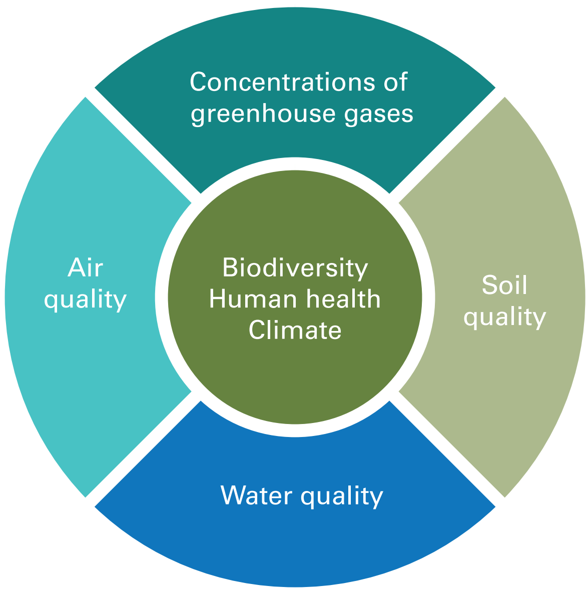

Figure 1: Nitrogen compounds have numerous deleterious effects (Source: SRU/SG 20105/Figure 1)

from rivers. On the other hand, climate change and damage to the ozone layer are global phenomena. Hence, political action is needed at all political levels.

While certain types of nitrogen emissions have been successfully rolled back, they remain unacceptably high as a whole. In Germany, the release of reactive nitrogen emissions into water, soil and air has led to severe pollution in some areas. As of 2009, 48 per cent of Germany's natural and semi-natural terrestrial ecosystems were exceeding eutrophication limits (see Fig. 3), 8 per cent were affected by acidification. The North and Baltic Seas are adversely affected by eutrophication. Around 27 per cent of all groundwater bodies exhibit a poor chemical status owing to elevated nitrogen concentrations, which also impact drinking water. In some regions, the limit value for nitrate in drinking water can only be adhered to through extensive interventions. Public health in densely populated regions is threatened by nitrogen oxide emissions and nitrogen-containing particulate matter.

Existing and partly legally binding clean air, water protection and nature conservation targets are clearly being missed. Germany has failed to adequately implement and enforce key environmental standards, leading the European Commission to introduce an infringement procedure against Germany for its failure to take actions against nitrate pollution in water.

From a global standpoint, it is a major cause for concern that ecological limits for nitrogen have already been exceeded. Long-term stability of ecosystems is threatened. According to some scientific experts, the global level of atmospheric nitrogen conversion attributable to fertilizer use needs to be reduced from its current level of 120 million tons per year to around 60 million tons per year, in order to keep nitrogen pollution below critical pollution thresholds.

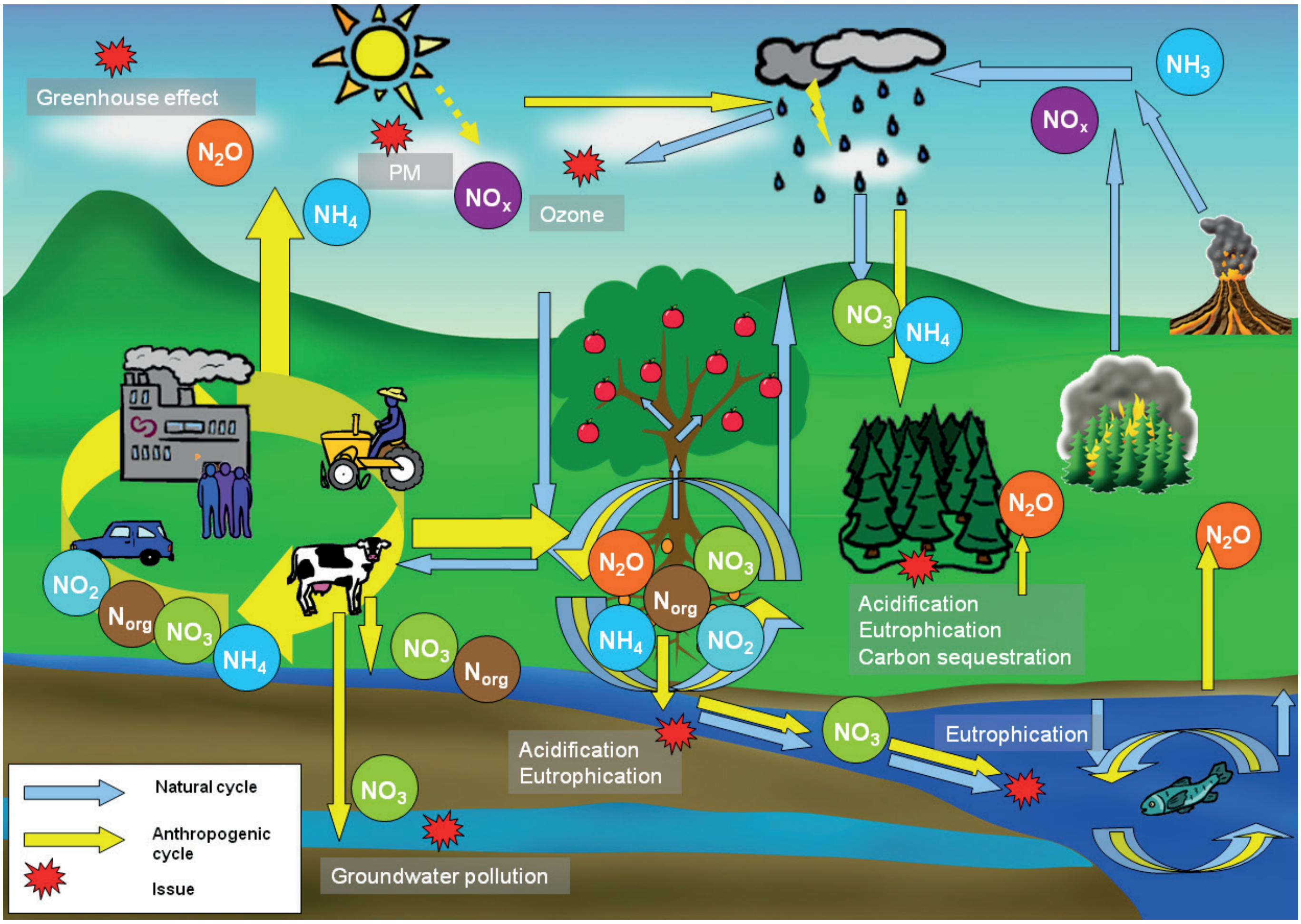

Figure 2: The nitrogen cycle (Source: Anne Christine Le Gall, INERIS (Copyright))

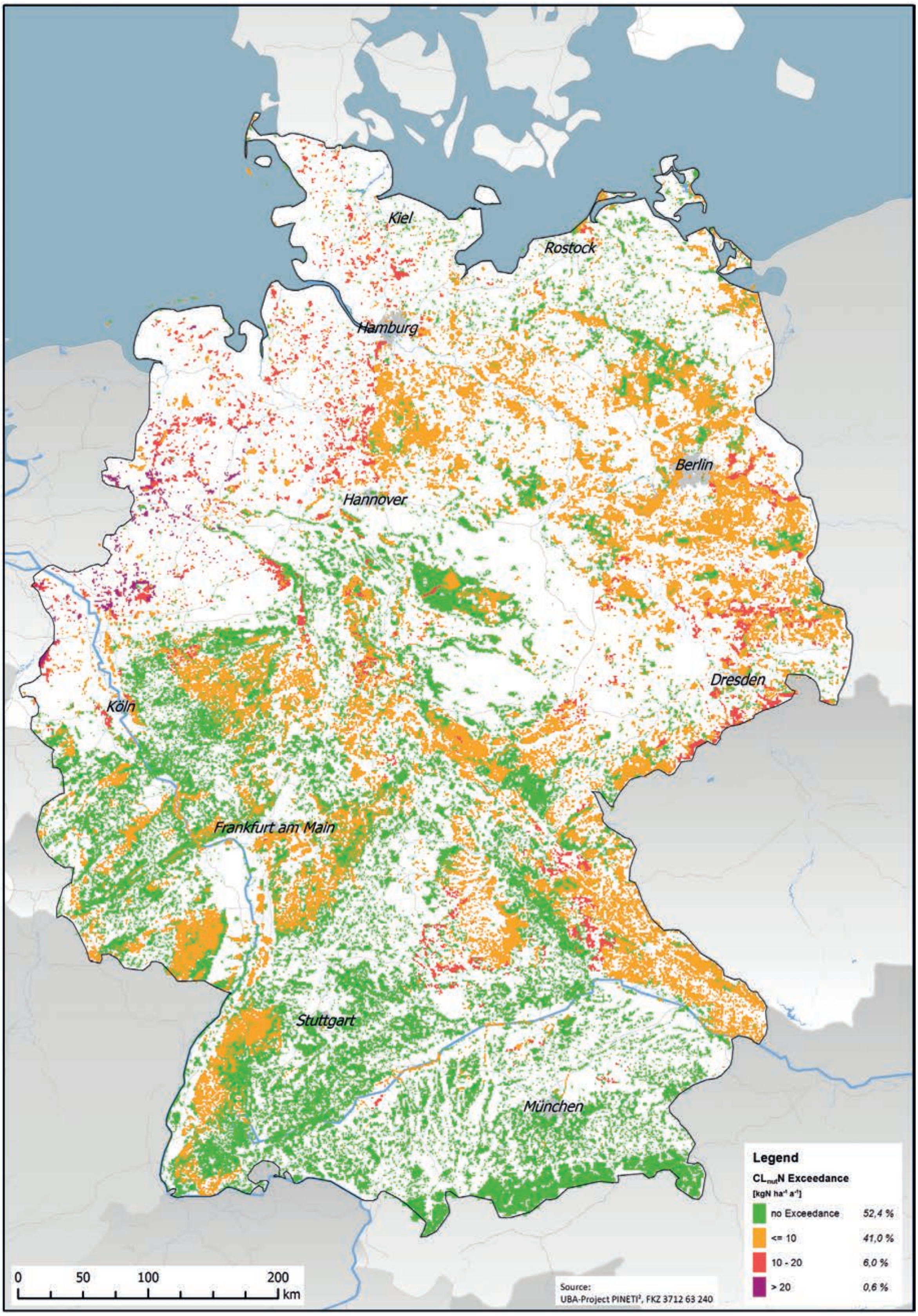

Figure 3: Exceedance of critical loads for eutrophication (Source: Schaap et al. (2014): Ermittlung und Bewertung der Einträge von versauernden und eutrophierenden Luftschadstoffen in terrestrische Ökosysteme. Interim report of the R&D project no. FKZ 3712 63 240 1, Dessau-Rosslau: Federal Environment Agency. In press.)

Biodiversity and nitrogen: a major cause for concern

Excessive emissions of reactive nitrogen are one of the main causes of biodiversity loss. Even very low input levels can have a deleterious effect on certain species and ecosystems. Without an effective strategy to reduce emissions of reactive nitrogen compounds, it will be next to impossible to achieve nature conservation targets and comply with conservation regulations, for example with the protection of species and the restoration of habitats to a "favourable conservation status" or the prevention of the "deterioration of natural habitats." Processes, such as acidification, nitrogen loading and species loss are irreversible or only reversible over long periods of time. The limit values that have been set for the protection of human health are woefully inadequate for protecting more sensitive species and ecosystems.

The key mechanisms that come into play here – eutrophication (nutrient enrichment) and acidification (reduced pH values resulting from base leaching) – alter species composition, reduce species numbers, and weaken resilience against shocks, such as the stress caused by drought and frost. The visible effects of these mechanisms include: the loss of species-rich meadows and field margins rich in wild herbs; the formation of excessive sea foam induced by algae blooms; and the substantially greater abundance of plants such as blackberries and nettle that thrive on nitrogen-rich forest soil.

The impact of these phenomena on biodiversity is in turn detrimental to ecosystem services, including the recreational value of landscapes. Also ecosystem services for agriculture are affected; when elevated nitrogen inputs result in the loss of flowering plants, then the food sources for insects are lost, and the insects are no longer available for either pollination or as food for birds.

The policy problem: inattention, fragmented responsibilities, lack of integration

For decades, environmental policy has concerned itself with regulating specific nitrogen compounds in certain environmental media. The environmental problems attributable to nitrogen are addressed by numerous policy instruments. Nonetheless, the full scope of the nitrogen pollution problem has yet to be understood or addressed. The main reason for this is that nitrogen compound emissions are inextricably connected to the basic production fundaments of the economy, particularly in the energy and agricultural sectors. In addition, there are policy and institutional restrictions:

- **Regulatory frameworks and responsibility in the environmental sector are fragmented.** The synergies between health and biodiversity protection and between water, soil, climate protection and clean air have not been given sufficient attention. Conflicts, for example between bioenergy policy and nitrogen pollution, have not been taken into account at an early stage. There is not sufficient coordination of the interconnected tasks of the various ministerial departments.
- **Environmental aspects are not sufficiently prioritized by the different ministries with their respective sectoral foci.** The ministries in charge of agriculture, transportation and energy are required to improve the nitrogen pollution problem. Certain environmental targets can only be achieved with regulations addressing these specific sectors. These ministries are sometimes directly responsible for implementing key environmental policy instruments (e.g. the Federal Ministry of Food and Agriculture is in charge of implementing the Fertilizer Regulation (Düngeverordnung, DüV) – the regulation, which governs fertilizer use). As the SRU sees it, despite the progress that has been made, administrative bodies often give too much weight to the economic interests of polluters and not enough to environmental protection and nature conservation.

RECOMMENDATIONS

1. Developing a national nitrogen strategy

The SRU recommends that the federal government and the German Länder jointly elaborate a national nitrogen strategy. Such a strategy would offer important starting points to solve the above mentioned political and institutional problems, including setting a policy agenda, creating a platform for social and political debates, providing an overarching framework for political action programmes; and formulating widely supported policy goals. A national strategy of this nature would serve as a basis for cooperation between various governmental and non-governmental actors. Such a strategy should also forge close links with the national sustainable development strategy and the National Strategy on Biodiversity. It could also promote implementation of the objectives of the EU's Seventh Environmental Action Programme, and provide a new impetus, over the long term, for European environmental policy.

The national nitrogen strategy should contain the following elements:

- Nitrogen related objectives should be bundled, and the target system further developed. As an orientation, an overarching target for the total acceptable level of reactive nitrogen input into the environment in Germany should be defined. This overarching target should be based on ecosystem resilience and should be established via an interactive process involving the scientific community and the relevant sectors of society. This process should be based on cross-media modelling of inputs and the environmental impact of reactive nitrogen compounds. The overarching target should be supported by targets for nitrogen inputs in the agricultural, as well as for nitrogen emissions in the transport and energy sectors.

- The nitrogen strategy should combine existing nitrogen reduction measures and regulations, and should identify medium- and long-term areas for action.

- The strategy should be underpinned by an ambitious action programme, and should be evaluated with regularized monitoring.

- The national nitrogen strategy should be mainstreamed. Its implementation should be promoted by adequate levels of human and financial resources, and by close cooperation with the German Länder and the relevant stakeholders.

- The first step toward roll-out of an integrated nitrogen strategy should be making nitrogen pollution a core element of the national environmental programme for 2030.

2. Improving the framework of targets on multiple levels

An ambitious strategy for the reduction of nitrogen pollution will require a target system that reflects the structure of the problem. Nitrogen pollution is characterized by its effects, nitrogen species conversion and cross-media substance flows at the local, regional and global levels. Although there are numerous quality objectives already on the books in German and EU environmental law, they are not being sufficiently implemented and lack an overarching treatment target:

- **Overarching reduction targets:** To give a directional orientation for action and to more effectively communicate this to the general public, reduction targets for the aggregate emissions of reactive nitrogen compounds should be set at the national, European and global levels. In Germany, this will presumably require that current nitrogen emission levels be at least halved, in order to meet existing national and European quality objectives. Even greater reductions will be necessary in highly polluted or sensitive areas.

- **Air emissions:** The maximum allowable national emission ceilings for nitrogen oxide and ammonia urgently need to be reduced. The reduction objectives for 2030 recommended by the European Commission in connection with the revised NEC Directive (39 and 69 per cent reduction for ammonia and nitrogen oxide, respectively) are a step in the right direction, but are insufficient in terms of environmental impact. If the European Commission's reduction objectives were met, around 40 per cent of Germany's natural and semi-natural terrestrial ecosystems would still exceed eutrophication limits in 2030, while in that same year the health hazards entailed by particulate matter and ground-level ozone would only have been reduced by 49 and 33 per cent, respectively. That said, the Federal Government should support the European Commission's recommendations nevertheless, and should make sure that these reduction objectives are under no circumstances weakened in the likely to be tough upcoming negotiations. The government should also proactively support additional legally binding interim standards for 2025, so as to ensure that the EU member states begin taking action now.

- **Air quality:** Although air-quality standards aimed at avoiding health hazards (particularly for busy roads) are still being exceeded regularly, these standards need to be strengthened. The SRU recommends that the annual mean limit value for nitrogen dioxide in the Air Quality Directive be reduced to 20 µg/m^3 and that the air-quality standards for particulate matter and ozone in the directive be harmonized with the stricter standards of the World Health Organization (ozone 100 µg/m^3 as an eight hour mean target value; PM_{10} 20 µg/m^3 as an annual mean limit value; $PM_{2.5}$ 25 µg/m^3 as a short term limit value and 10 µg/m^3 as an annual mean limit value).

- **Water protection:** The existing environmental quality objectives for water protection are ambitious, but they are being egregiously undercut. The envisaged measures and management plans for implementation of the Water Framework Directive are not sufficient to reach these objectives. In terms of marine protection, the SRU recommends that regionally harmonized nitrogen reduction targets be defined for the North Sea, along the lines of the reduction targets for the Baltic Sea.

- **Biodiversity protection:** In the EU, the critical loads and critical levels for ecosystems should not be exceeded over the long term (EU's Seventh Environmental Action Programme). The government's national biodiversity strategy sets forth an ambitious target, to the effect that by 2020 even sensitive ecosystems should be protected against eutrophication. There is a good chance that it will prove impossible to meet these objectives without a rapid, long-term change in policy. The SRU furthermore recommends that, in the interest of protecting terrestrial ecosystems, limit values for ammonia be incorporated into the Air Quality Directive as well, and that compliance with these values be promoted by regional clean-air plans.

3. Pursue interrelated approaches

Because the local and regional environmental impact of reactive nitrogen compounds varies greatly, a cross-media nitrogen strategy should be based on a set of interrelated approaches:

- **Reduction of background pollution:** Reactive nitrogen emissions should be greatly reduced across the board, so as to protect sensitive terrestrial ecosystems, the oceans, and human health.

- **Reduce inputs in hotspots and sensitive areas:** Certain regions of Germany exhibit exceedingly high nitrogen surpluses from farming activities. The air in congested agglomerations exhibits very high levels of nitrogen dioxide in some cases, while other areas such as raised bogs are particularly vulnerable to nitrogen inputs. Loads in hotspot regions and sensitive areas should be reduced through efficient local and regional measures. These could, for example, take the form of air pollution control plans and implementation of the Water Framework Directive.

- **Strengthen ecosystem protection through nature conservation measures:** Where these measures do not adequately protect sensitive areas, additional nature conservation management measures should be taken. For example, existing legal instruments for local protected-area management could also be used to reduce agricultural fertilizer use. Buffer zones could be established around nature conservation areas; the land in these zones could be used for agricultural purposes, but only with certain restrictions. Moreover, contractual nature conservation and agri-environmental measures could reduce nitrogen inputs and mitigate the impact of unavoidable nitrogen inputs.

- **Protect relatively unpollued areas:** In these areas, species and ecosystems have survived that would be under threat were nitrogen pollution to increase. Hence it is crucial that nitrogen inputs not be permitted to rise any further.