Annex 3 Detailed working group reports.

'Effects' Working Group

Introduction

An assessment of current knowledge, process understanding, availability of indicators and models and gaps in knowledge was carried out by the group and is presented in ANNEX 2 in tabular form. Here, a summary is provided together with six priority recommendations including priority areas for research.

Species change

The evidence for effects of nitrogen on species diversity was separated into semi-natural vegetation, faunal and soil micobial communities. With respect to semi-natural vegetation the state of knowledge was agreed to be well known with a reasonable understanding of underlying processes. Dynamic models are under development and some are now available for testing. Steady state empirical loads and mass balance approaches have been quantified for a variety of ecosystems/receptors but we need further refinement of impact criterion and thresholds when unwanted changes occurs. There is also need for intermediate targets/changes which will enable attribution of change and path to be identified Gaps in knowledge were agreed to be data availability outside NW of Europe. A major need for improvement is the continued development of dynamic models which link soils, waters and biodiversity. With respect to effects on fauna and soil microbes, there is some evidence for effects but underlying processes are not well understood. There are few indicators and models and further work is required particularly to understand the implications of changes in food chains and ecosystem functioning. With respect to species change in general, feedbacks from species change to biogeochemistry fluxes and ecosystem functioning is a longer term aim but work needs to be initiated now.

Soils

With respect to soil quality, evidence of changes which result in nutritional imbalances and soil acidification were thought to be well known Underlying processes and model availability were thought to be reasonable and well known respectively. Indicators of nutritional imbalance are available in the Mapping Manual together with chemical criteria, however this is only well known and tested for forests systems. For soil acidification, effects are well known with well-tested models covering major impacts. For impacts of nitrogen on productivity of forests, there is evidence of effects and process understanding but patterns are spatially complex due to interactions with other drivers (e.g. climate, ozone, management). Impacts on production in semi-natural vegetation is far less well known or quantified. There is evidence for increased sensitivity to events such as drought and disease but this is generally based on case studies with some examples of habitat specific models but there is a need for this to be expanded.

Waters

There is good evidence for impacts on surface waters together with process understanding and a variety of well tested models with some links to biodiversity and production effects. Most common criteria are pH and ANC with country specific limits for eutrophication linked to the Water Framework Directive. For marine systems, there is good evidence of effects and some understanding of processes but models beyond estuary models are required together with improved process understanding.

Climate

Effects of nitrogen on nitrous oxide emissions are well quantified and understood with models available. For methane, the effects are more variable and less well understood with a need for more data and models which are relevant for different soils/habitats/regions. Effects of nitrogen on soil organic matter decomposition and CO_2 flux (effects on carbon fixation by vegetation are included in production above) is an area of debate which requires further quantification and model development. Effects for all three gases can be expressed as CO2-equivalents. Particulates were not discussed, but it was recognised that nitrogen contribute to the formation of fine secondary particulate matter which affect the radiative forcing at large-scale geographical scales.

Materials, Human Health and Visibility
We acknowledged that nitrogen pollution also contributes to the corrosion and soiling of materials but did not have expertise to further discuss this issue. The effects have been monitored and modelled on test sites over Europe. In addition, the human health issues are clearly of importance but were beyond the expertise of the group. Visbility issues have been well studied in N America but they have not been a focus for policy development in Europe.

Generic issues
- The differential effects of oxidised and reduced nitrogen for all ecosystem components effects (soils, waters and vegetation) is poorly quantified.
- Information is biased towards NW Europe with a need to expand observations, process understanding and model applications to Central and Southern Europe.
- Timing of effects were thought to be dependent on whether N inputs where acute or chronic (i.e. changes could be fast if inputs increased quickly to very high levels) but are generally quicker for vegetation than for soils and waters.
- Interaction of N effects with other drivers (climate change including elevated CO2, management, ozone) and feedbacks are poorly known at present

Recommendations:
(1) gather and make available sources of available monitoring and modelling data for use in development of models and indicators/criteria
(2) clarify further the major effects, intermediate parameters together with [harmful] endpoints and
(3) compile existing dose response relationships from case studies and extensive monitoring programmes and make available for the community
(4) bring together models and observations for further validation and explore potential for applications at large geographical scales
(5) The main priorities for research needs to fulfil near future policy needs were identified as:
(i) Continuation of **model development** to link soils and biodiversity to assess past and future trends in species change at the regional level under different deposition scenarios. This will require an **expansion of monitoring and experimental work** to provide the data for process understanding, model development and testing.
(ii) quantification and development models which enable the **interactions** with other drivers (e.g. ozone, greenhouse gas emissions, climate change including elevated CO2, management) to be able to interpret spatial and temporal trends in ecosystem compartments and forecast for the future
(iii) quantification of **feedbacks** between ecosystem components. This needs to include changes in diversity of plants (a particular focus is needed on mosses and lichens due to their sensitivity), fauna (macro and micro) and soil microbes and include implications for biogeochemical functioning and ecosystem resilience to stresses
(iv) there is a need to separate the effects of **oxidised vs. reduced** nitrogen for all ecosystem components
(v) development of methods to build an **Integrated Assessment Model** stepwise to advice on emission reduction requirements and develop methods for upscaling
(vi) to identify the major paths in **causal the chain** of emissions, atmospheric transport and effects on specified receptors.

Working Group on Emissions and Policies

Peringe Grennfelt (chair), Adrian Leip (rapporteur), Jurgen Augustin, Klaas van der Hoek, Sabine Augustin, Ulrich Daemmgen, Janina Fudala, Nicholas Hutchings, Zbigniew Klimont, Peter Kuikman, Jorgen E. Olesen, Michel Sponar

Introduction

Agriculture is the most complex sector for emissions of nitrogen compounds into the environment, not only with regard to understanding of the processes leading to (net) production and emission of these compounds but also with regard to options, costs, and efficiencies for abatement (UN-ECE, 2005).

Agriculture is also the most important sector for ammonia emissions and contributes with a similar amount of nitrogen as that emitted as nitrogen oxides from energy sources (Lövblad et al., 2004). Agricultural sources emit about 10% of the GHG in Europe (CH_4 and N_2O) or about 66% of the N_2O emitted in Europe (EEA, 2005). Opportunities for ammonia, nitrous oxide and nitrate abatement include nutritional measures, animal housing and manure storage design, fertilization practices and cropping and land use planning (ECCP, 2002; ECCP, 2003; UN-ECE, 2005). As nitrogen is 'cascaded' through various stages in agricultural production systems before its eventual emissions, measures aiming at mitigation in an earlier stage will have (positive or negative) effects on emissions at later stages. These interactions are not always simple and have to be evaluated using a mass-balance model (EMEP, 2003).

Therefore, the working group on emissions and policies focused on the agriculture sector; expertise of the participants covered all aspects from detailed agronomic and process understanding to integrated assessment and EU legislation.

Recommendations

The working group on emissions and policies saw urgent need for future research in five main scientific areas: experimental research, data collection, model development, increasing efforts in trans-disciplinary research and a paradigm shift for agricultural abatement options.

6. **There is need to a larger pool of experimental observations of high quality to close knowledge gaps and to be used for statistical analyses and model validation**

The complex interactions between various processes involved in agricultural nitrogen emissions are far from being understood, large knowledge gaps persist, e. g. the onset of nitrate leaching in nitrogen-saturated systems, the impact of litter quality on microbial activity, etc. Measurements are needed to understand the processes and to be able to statistically derive specific emission factors for conditions and regions that so far are under-represented, such as central-eastern Europe and the Mediterranean. Mass flux budgets at the farm scale, for the soil profile or at the regional scale, cannot yet be closed; this implies the need to continue to measure also inert components such as di-nitrogen, to obtain additional constraints for a closed budget. Research on interactions and effects of other compounds, such as carbon and phosphorus, must be included. Process models will be able to deliver policy-relevant indicators combining the effect of different but simultaneously acting drivers, but a robust dataset for thorough model validation is still lacking. For all purposes, however, highest quality of experimental data including metadata is a prerequisite which should be emphasized and promoted, for example, in emission Guidelines.

7. **There is the need to bridge the scale between models with clear boundary definition and upscaling from the micro-scale to the regional scale**

The high complexity of processes leading to emissions from agriculture and the high non-linearity of effects makes upscaling of models and results obtained at the plot or farm scale one of the biggest challenges in the next future. To avoid the risk of oversimplified models leading to biased messages or being unable to react to unforeseen situations, it is necessary to work at the 'micro-level', to cross-check models at various complexity, and to bridge information obtained at various scales and with different methodologies, e. g. from bottom-up and top-down approaches. Boundaries must be strictly defined to enable models to communicate; for example, nitrogen must be taken up by transport models where they are emitted from the farm or ecosystem model and deposited where it can be received by an ecosystem or landscape model. For each 'box' mass conservation must be ensured.

8. **There is the need for relevant management data and information on abatement options**

One of the biggest obstructions for reliable estimates of nitrogen fluxes from agriculture at the European scale is the complete lack of comprehensive and harmonized management data. Information on animal housing, feeding and manure management systems, fertilizer and tillage practices, cropping and irrigation patterns are fundamental for depicting the environmental impact of agriculture in a realistic way. Technical abatement options for agriculture are still poorly defined, in particular the quantification of the costs involved and how they change with farm size.

9. **There is the need for integrated assessment, both of different environmental issues and socioeconomic aspects within a model across the scales**

The relationship between nitrogen and the environment can be described as being multi-source, multi-pollutant and multi-effect. The answer were multi-policies. These need to be integrated in order to being able to profit from opportunities of synergies, avoiding swapping effects and for being realistic and cost-efficient in assessing and realizing mitigation measures. Integration implies also to be proactive with respect to future societal demands. A strong driver for the agricultural sector and a large potential for mitigation (as technical options are limited) is the behavior of the consumers. Assessment of agriculture without considering the socio-economic dimension can never give the whole story. Therefore, the development of detailed integrated assessment tools for the agricultural sector is urgently required. These tools must also be able to reflect (externally driven) structural changes in agricultural systems and serve as tools for scenario calculation and communication ("smart") to ensure the socio-economic acceptance.

10. **There is the need for innovative thinking with respect to agricultural production and regional mitigation options**

We need new thinking and design in agriculture to improve environmental performance; reduce emissions and increase production efficiency at the same time. In order to achieve that we suggest verifying what can be learned from best industrial operation practice - industrial thinking. Potentially a bit controversial term "*Industrial* *thinking*" is understood here as a vehicle for optimizing the flow of material and the use of resources in agricultural systems (cascading of primary resources) and must not be confounded with an industrialized agriculture. The optimum system will neither be the most intensive (with high negative effects on other policies, e.g. animal welfare) nor the most extensive one (where many mitigation measures are not applicable). Rather, it must be found by internalizing the costs for environmental effects and make (omitted) emissions valuable. The extension of the IPPC directive to cattle farming and introducing new thresholds for pig and poultry farms, as foreseen in the Thematic Strategy on Air Pollution, will be a first step. The regional assessment of abatement will be essential in order to identify conflicts with other policies and to prioritize measures.

References

ECCP: European Climate Change Programme-Working Group 7: Agriculture. Final Report: Mitigation potential of Greenhouse Gases in the Agricultural Sector, European Commission Agriculture Directorate-General, 2002.

ECCP: European Climate Change Programme (ECCP) - Working Group on Sinks Related to Agricultural Soils. Executive Summary, European Commission Agriculture Directorate-General, 2003.

EEA: Annual European Community greenhouse gas inventory 1990 - 2003 and inventory report 2005. Submission to the UNFCCC secretariat, European Environment Agency, 2005.

EMEP: Joint EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition October 2002, updated 2003, http://tfeip-secretariat.org/unece.htm, 2003.

Lövblad, G., Tarrasón, L., Tørseth, K. , and Dutchak, S., (eds.) 2004. EMEP Assessment, Part I. European Perspective: Convention on Long-range Transboundary Air Pollution, Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe

UN-ECE, (ed.) 2005. Control techniques for preventing and abating emissions of ammonia. EB.AIR/WG.5/1999/8/Rev.3

Working Group on Transport - Exchange - Deposition of Nitrogen

Mark Sutton (chair), Albert Bleeker (rapporteur), Klaus Butterbach-Bahl, Hilde Fagerli, Robert Gehrig, Laszlo Horvath, Andreas Krein, Silvia Kugler, Joakim Langner, Tuomas, Laurila, Anita Lewandowska, Attilla Machon, Kjetil Torseth, Zdenek Zelinger

Introduction

The working group on transport-exchange-deposition of nitrogen addressed this topic by making an inventory of important and/or missing issues by means of a brainstorming session. A complete list of the issues brought up during this session is given in Annex 1. The brainstorming session was followed by a prioritisation of the different items, were the criteria for prioritisation were:

1. scientifically uncertain (current scientific results would lead to misleading policy development);
2. influencing policy implementation (e.g. compliance assessment) and
3. integrating between phases of the nitrogen cascade

Based on the brainstorm session and the subsequent prioritisation, the following five main points of attention for future research were identified by this working group.

11. **There is need to get more insight in missing and/or poorly quantified sources**

From the brainstorm session it was recognized that there is need to get more insight in some missing and/or poorly quantified sources. Sources that were mentioned in this context are organic nitrogen and nitrogen emissions from water surfaces, flood plains and wetlands/filter beds. These sources are thought to contribute to the overall nitrogen budget to a large extend. However, the actual contribution cannot be quantified at the moment and should therefore be subject to future research on this topic.

12. **There is the need to come to catchment scale N budget studies**

In order to be able to quantify the nitrogen cascade from small or regional catchments, there is the need to come to nitrogen budget studies at this spatial scale. Such a study will give more insight in the source, sinks and pools of nitrogen at this scale. Results from a catchment scale N budget study can be used as an input for an independent verification approach e.g. in the context of the NitroEurope IP. As an example for performing such a catchment scale study, the 15N labelling approach was mentioned at a landscape level. It was recognized by the group that this might be a novel and challenging way to perform such a study. However, the feasibility of such an approach is not known yet and should be investigated.

13. **There is the need for more insight in emission-concentration relations and their trends**

Based on previous studies, it was recognized by the group that there is an ongoing need for more insight in the relation between emissions and the resulting concentrations and the changes in trends for these two items. This insight is needed for different reasons. Firstly, it can be used for model checking: from the information of both the emissions and concentration trends, an indication can be obtained of the validity of either the models used or the emissions. Secondly, a valid relation between emissions and concentrations will give confidence in the model estimates for the future situation and will, therefore, also adequately give information about the effects of different abatement strategies. A prerequisite for such a comparison between emissions and concentrations is the availability of adequate measurements, both in time and space (e.g. 3D-observations).

14. There is the need for studies on the consequences of upscaling and downscaling the nitrogen cycle

It was recognized by this working group that there is the need for studies on the consequences of upscaling and downscaling the nitrogen cycle. Through up- and/or downscaling there is the possibility of linking the analysis of the nitrogen cycle at different spatial scales, i.e. plot-scale, landscape-scale, regional catchments and national/regional scale. The up- and downscaling process progressively incorporates additional sources and/or sinks and transport scales. Part of this up- and downscaling process will be addressed during the NitroEurope IP activities in the 'Landscape' Component (C4).

15. **There is the need for incorporate recently identified mechanisms into regional models**

Different items were identified during the brainstorming session that need incorporation into the available regional models. These items were: effects of NO-NO_2-O_3 triad in canopy, effects of gas-particle interconversion in canopy, meteorology as a driving force on NH_3 and other N emissions. In general it was recognized that a lot of the detailed science on N-fluxes is yet to reach the application stage.

Annex 3.1 List of issues from the brains storm session

- European landuses; adequate measurement understanding
- fast flux measurement techniques (single height)
- upward emissions (biosphere atmosphere)
- canopy redeposition (within canopy cycling NO_x, NH_3 + chemistry)
- denitrification to N_2
- dispersion simulation
- advection and complex terrain (flux measurements)
- verification through whole catchment N-budgets: small & large scale catchments
- contribution of atmospheric deposition to land to riverine N inputs to sea
- emission-concentration links and trends
- magnitude of water surface emissions (sea & river) buffering mechanism (N_2O, N_2, NH_3) flood planes & estuaries
- climate effects sensitivity of transport & deposition: need for an integrated approach
- organic N: quantifying the role & magnitude
- wetland as a filter for pollution
- integrating aerosols into effect of N on GHG (global warning /cooling)
- vertical measurements (mountain top)
- scale of models & LRT
- coupling of NH_3 & meteorology
- cascade: measuring fluxes from original sources
  –following the cascade
  –landscape scale 15N-labelling