United Nations Economic Commission for Europe

Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions

United Nations Economic Commission for Europe
Convention on Long-range Transboundary Air Pollution

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With the success of policies to reduce SO_2 and NO_x emissions across the UNECE, ammonia (NH_3) emissions remain a key challenge for the future. They are one of the largest contributors to acidification and eutrophication, while adding to the burden of particulate matter. As ammonia now offers 'low-hanging fruit' for further pollution control, combined with local and transboundary effects on health and ecosystems, there is a strong case to step up international efforts.

The Gothenburg Protocol states that each Party "shall establish, publish and disseminate an advisory code of good agricultural practice to control ammonia emissions". In this context, in 2001 the UNECE established a first "Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions".

In now publishing this revised Framework Code, and disseminating it more widely, we hope that it can stimulate fresh efforts to establish the national codes. It is a challenge not just for the environment, but an opportunity for farmers to take the benefit through nitrogen savings.

This revision has been conducted by the Task Force on Reactive Nitrogen through its Expert Panel on Mitigation of Agricultural Nitrogen. It was prepared by the following authors: Shabtai Bittman, Martin Dedina, Barbara Amon, Harald Menzi, J. Webb, Karin Groenestein, Tom Misselbrook, Nick Hutchings, Helmut Dohler, Klaas van der Hoek, Steen Gyldenkærne, Laura Valli, Christian Pallière, Clare Howard, Oene Oenema and Mark Sutton. We are grateful for stakeholder feedback and funding through the European Commission for the Edinburgh workshop and costs of publication. We thank Peter Meulepas, Roald Wolters (EC), Ilka Neumann, Pierre-Loïc Nihoul, Clare Taylor, Candice Hansotte (PRACSIS) and Alisher Mamadzhanov (UNECE) for their contributions to the process.

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LRTAP
Long-range Transboundary Air Pollution

Contents

Nitrogen management, taking account of the whole nitrogen cycle

A. Introduction

1. Nitrogen (N), together with other plant nutrients, is essential for plant growth and sufficient amounts need to be available for plants to achieve optimum crop yields. Nitrogen is readily lost from agriculture through a number of pathways including leaching and run-off of nitrate and organic N to water and gaseous emissions to air. From the perspective of agriculture's role in air pollution, ammonia (NH_3) and the greenhouse gas nitrous oxide (N_2O) are of the most concern. Although this Framework Code is mainly about NH_3 emission, there are interactions between this and other nitrogen transformations, losses and crop uptake which should be considered together. It is, therefore, important to consider the whole N cycle in devising effective strategies for:

(a) Minimizing both water and atmospheric pollution;
(b) Optimizing N use for crop production;
(c) Taking into account the effects of NH_3 abatement on other N losses.

2. Most of the plant-available N in manure or slurry is in the form of ammonium nitrogen, which can substitute directly for mineral fertilizers. NH_3 emissions from organic and inorganic fertilizers represent a loss of valuable N and thus increase the requirement for commercial fertilizers to optimize crop yields. For this reason, the basic obligations and annex IX to the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) to the Convention on Long-range Transboundary Air Pollution request each Party take due account of the need to reduce NH_3 losses from the whole N cycle. In agriculture, this applies especially in livestock, crop and mixed farming systems. In particular, the Protocol provides guidance to the Parties in identifying the best available options for reducing the release of NH_3 from agriculture in the guidance document on preventing and abating ammonia emissions from agricultural sources (Ammonia Guidance Document) (ECE/EB.AIR/120).

3. NH_3 emissions originate mainly from manures produced by housed livestock as slurries or solid manures and from applied mineral N fertilizers, and to a lesser extent from urine excreted by grazing animals and directly from crops. Emissions from manures occur sequentially from livestock buildings, manure stores and following application to land. Because the losses are sequential, the percentage of savings of NH_3 from measures employed at each production stage are compounded rather than additive. This also means that measures to reduce NH_3 emissions at an early stage (i.e., during housing and storage) should be followed by measures at a later stage (i.e., during manure spreading) to fully profit from the early savings if early savings are not to be lost. In many circumstances, optimized land application of slurry and livestock feeding strategies offer the greatest and most cost-effective opportunities for reducing emissions.

B. Elements of good nitrogen management

4. Nitrogen management varies greatly across the United Nations Economic Commission for Europe (ECE) region, and NH_3 emissions vary accordingly. In general, emissions of nitrogen tend to decrease when:

(a) All nitrogen sources on the farm are managed considering fully the "whole farm" and "whole nitrogen cycle" perspectives;
(b) Amounts of nitrogen used are matched to the needs of growing plants and animals, including considerations of local breeds/varieties, soil conditions, climate, etc.;
(c) As aspects of good husbandry to achieve high production, other limitations to production (such as other nutrient limitations, pests, stress) are minimized to the extent practical;
(d) Nitrogen sources are stored effectively, then used in a timely manner and applied with appropriate techniques, in the appropriate amounts, and in the appropriate places;
(e) All important nitrogen loss pathways are considered in a coherent manner to ensure that measures do not have unintended side effects.

5. All N sources used on the farm should be carefully planned, and the amount of N used should not exceed crop or livestock requirements. All N-loss pathways should be taken into account: for example, conserving NH_3 from land-applied manure may increase leaching if the optimum rate of N for the crop has been exceeded. Application rates and losses may be reduced if N excretion is reduced by better matching feed N to animal requirements. Adopting measures to reduce NH_3 emission following manure and fertilizer application will also directly contribute to better management by conserving N for crop uptake. In countries that limit annual N applications, NH_3 abatement from both manure and fertilizer will also improve crop yields and protein concentration.

C. Aids to optimize nitrogen management

6. Good N management on farms is a challenging task that requires knowledge, technology, experience, planning and monitoring. Tools for predicting optimum fertilizer rates and tools to calculate the N balance and N-use efficiency (NUE) are valuable aids for managing N on farms. While the detailed approaches adopted should be consistent with the size of the farm business concerned, there are suitable actions available for all farm types.

7. Fertilizer recommendations based on soil and crop testing provide indicative values on the nutrient requirements of crops and grassland to safeguard against over-application, which would contribute to emissions. Techniques like fertigation (fertilizer applied in irrigation) may also reduce emissions by potentially reducing application rates. Fertilizer recommendations are calibrated for local conditions and economic considerations and are therefore provided at the national or regional level in most countries. This helps farmers to dose their crops appropriately with manure, other organic amendments and mineral fertilizer to optimize yields and avoid nutrient surplus. However, this technology is still inexact and an active area of research in many countries. On-farm testing can be very helpful.

8. N-balance tools compare N inputs with N outputs. The "N input-output balance" (also referred to as the "farm-gate" balance) is the total, at the farm level, of all nitrogen inputs coming into the farm (fertilizer, feed, bedding, animals, as well as N fixation by legumes and atmospheric N deposition) minus all nitrogen outputs in

products (crops, animals products, manure) leaving the farms. The “field balance” is the total of field nitrogen inputs including manure and fertilizer (including N fixations, deposition and irrigation), minus harvested products such as grain, fodder or fruit. In all nitrogen balances, the difference between nitrogen inputs and nitrogen outputs may be positive (surplus) or negative (deficit). An “Nsurplus” is an indicator for pressure on the environment while a deficit indicates nutrient depletion; both are expressed in terms of kilograms (kg) of nitrogen per hectare (ha) per year.

9. The total nitrogen outputs divided by total nitrogen inputs is a measure of NUE (amount of exported nitrogen per nitrogen input, expressed as kg per kg). Note that crop or animal yield per nitrogen input provides another important measure of NUE. In addition to using this measure, total N losses from agricultural systems must be carefully considered with respect to their impact on the environment.

10. Decreases in nitrogen surplus and increases in NUE over a period of years indicate improvement in nitrogen management. For this purpose, it is recommended that five years represents a suitable evaluation period. Nitrogen management can be improved until a “best management practice” level is approached. Both nitrogen surplus and NUE values can be used to assess farms relative to one another or for comparison with model farms. However, different farm types vary in their characteristic NUE and Nsurpluses. Tools to calculate the nitrogen balance and NUE are available in many countries.

11. A wide range of options to reduce NH_3 emission are presented in the following sections, where the effectiveness is mainly described as a percentage reduction compared with a reference method. In general, while all emission reductions represent helpful contributions, achievement of a 30% reduction in emissions from a component source can be considered as a suitable performance benchmark for good practice. Many methods are available that offer more ambitious reduction opportunities.

II

Livestock feeding strategies

A. Introduction

12. Reducing emissions from feed inputs requires good animal husbandry, such as:

(a) Diet correctly balanced to animal needs;
(b) Good animal health and welfare;
(c) Good management of the animals' environment;
(d) Good stockmanship skills;
(e) Appropriate genetics.

13. Ensuring that farm livestock are not fed more protein than required for the target level of production can reduce the N excretion per livestock unit and per unit of production. This should include maximizing the fraction of protein in the diet that can be metabolized and minimizing the fraction that cannot be metabolized. Decreasing the amount of N in manure will not only abate NH_3 emissions at all manure stages, but also other potential N losses (leaching, denitrification). N excretion by different livestock categories is strongly dependent on the production system. Hence, standard excretion values should be calculated on a national or regional level.

14. Protein surplus in livestock rations is primarily excreted in the form of urea (or as uric acid in the case of poultry manure). These compounds are rapidly degraded to NH_3 and ammonium that have a high emission potential. Reducing protein in feed will reduce the amount of N in the excreta and the proportion of inorganic N, thereby affecting the total amount of inorganic N excreted (i.e. as total ammoniacal nitrogen in excreta). Since dietary optimization alters the total input to this flow of nitrogen, it offers a promising option for reducing ammonia emission. Furthermore, the consequent emission abatement is effective at all stages of manure management (houses, storage, treatment, application).