ENVIRONMENT

RUMINANT LIVESTOCK FARMING **AND AIR QUALITY**

UNDERSTANDING & EXPLAINING THE SERVICES PROVIDED BY LIVESTOCK FARMING

«What is the role of ruminant livestock in the air quality?»

1

Feed, the entry point of nitrogen into the livestock system, is the primary mean of reducing ammonia emissions.
Reducing the nitrogen concentration in animal rations helps decrease ammonia emissions by reducing the nitrogen content in effluents.

2

The proper management of effluents when animals are in the barn is a key step to limit nitrogen losses and thus preserve air quality, with the essential objective of limiting the time effluents spend in the building.

3

To minimize nitrogen losses during effluent storage, solutions are gradually being adopted by farmers, such as physical covers or crusts on slurry pits.

4

For spraying, levers exist to reduce the volatilization of ammonia by particularly favoring equipment that allows for direct and rapid burial.

5

On pasture, gas emissions are limited because the grasslands directly use the nitrogen from waste ; thus storage phase is avoided.

6

The ability of legumes to fix atmospheric nitrogen helps to mitigate ammonia emissions because they do not require nitrogen input and return it for the following crop. Introducing them into cropping systems is an important lever for reducing emissions, and ruminant livestock is the main contributor thanks to its pastures and alfalfa production.

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WHAT ARE WE TALKING ABOUT?

Air quality is affected by pollutants that can be distinguished into primary particles, directly released into the air, and secondary particles, obtained thru chemical reactions of gaseous compounds (precursor particles) or with other particles. The main gaseous precursors are nitrogen oxides (NO_x), sulfur oxides (SO_x), ammonia (NH_3), and volatile organic compounds (VOCs).

Natural phenomena such as volcanic eruptions, sea spray, or sandstorms, as well as all sectors of human activities such as transportation, industry, residential heating or agriculture, release gases and particles directly into the atmosphere, contributing to air pollution. In the agricultural sector, livestock farming affects air quality primarily thru its waste.

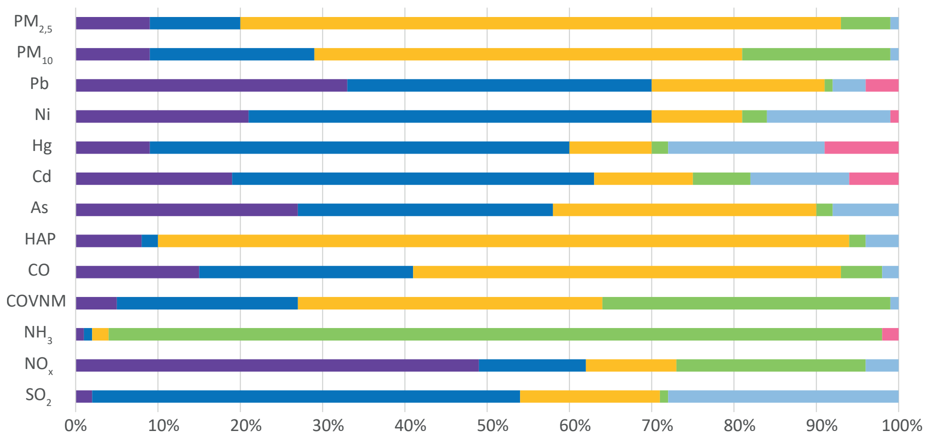
Over the past 20 years, air quality has generally improved, but air pollution continues to be a major public health problem, particularly in urbanized areas. It should be noted that these different sectors do not emit the same atmospheric pollutants, and when they do, the proportions of emissions vary. A new national plan for reducing atmospheric pollutant emissions (PREPA 2022-2025) brings together all the actions aimed at reducing pollution in all sectors (transport, industry, construction, agriculture) and thus protecting public health.

The main gases emitted in livestock farming and involved in air quality are listed below in order of quantitative importance:

- **Ammonia (NH_3)**, 94% of which national emissions come from agriculture, 37% from livestock activities, and 22% from cattle (CITEPA, 2023b ; Manneville *et al.*, 2023);
- **Non-Methane Volatile Organic Compounds (NMVOCs)**, 15.5% of which agricultural emissions come from the bovine sector (animals only). The agricultural sector represents nearly 35% of national emissions (Agriculture et Sylviculture – CITEPA, 2023a);
- **Nitrogen oxides (NO)** also impact air quality, but the contribution of livestock to national emissions is very low (1.2%) and it is 0.8% for the bovine sector.

In the rest of this sheet, ammonia gas (NH_3) will be the main gas considered. Regarding other emissions, those of NO_x are particularly low, and NMVOCs encompass a series of highly diverse compounds that will not be addressed here. It should be noted, however, that their emissions have been reduced by more than half (-55%) between 2000 and 2020. This evolution is mainly due to actions taken in the fields of organic solvents and the automotive sector.

SHARE OF DIFFERENT SECTORS OF ACTIVITY IN THE EMISSION OF ATMOSPHERIC POLLUTANTS (CITEPA,2023B)

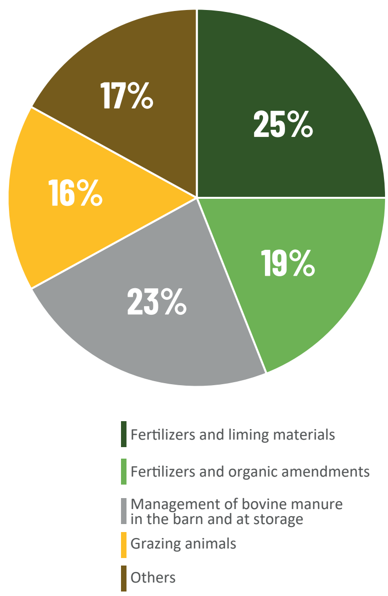


THE ORIGIN OF AMMONIA IN LIVESTOCK FARMING

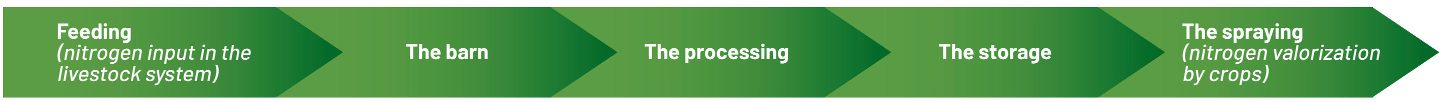
Nitrogen is an essential element for the production of animal and plant proteins. It is fixed by plants, which are then assimilated by animals. During digestion, a portion of the nitrogen from plants is transformed into ammoniacal nitrogen and then excreted in urine and faeces (Interbev, Idele, CNIEL, CITEPA, 2022). Nitrogen losses in the form of ammonia or nitrogen oxides (NOx and N_2O) represent between 20 and 70% of the nitrogen excreted by animals (Hassouna *et al.*, 2015). The recycling of nitrogen from animal waste allows for soil fertilization and thus promotes plant production. Part of the nitrogen can, however, end up in the water thru leaching, the soil, and in the atmosphere thru volatilization in the form of NH_3. Gaseous emissions occur throughout the management of livestock effluents (in the pasture, in the barn, during storage, during spraying). Mastering the effluent management chain but also ruminant feeding opens up room to limit ammonia losses and thus preserve air quality and reduce the purchase of mineral nitrogen fertilizers.

European and national regulations related to air quality aim for a 13% reduction in NH_3 emissions by 2030, compared to 2005 (National Plan for the Reduction of Atmospheric Pollutants, in accordance with the Convention on Long-Range Transboundary Air Pollution and Directive (EU) 2016/2284). In 2019, a 4% reduction was achieved. Further reductions are necessary to achieve the 2030 target. In France, the reduction of NH_3 emissions related to livestock farming primarily involves better management of the nitrogen contained in livestock effluents, fertilizers, and animal feed.

SHARE OF THE DIFFERENT NH EMISSION SOURCES IN THE AGRICULTURAL SECTOR IN 2021 (CITEPA, 2023B)



NITROGEN PATHWAY IN LIVESTOCK SYSTEM (ADEME, 2020)



1 Animal feed

Feed efficiency in animal nutrition, one of the levers to reduce nitrogen emissions from livestock

Optimizing the protein content in the ration to closely match the animals' needs helps limit protein intake and thus reduce nitrogen emissions thru manure. This would notably reduce the excretion of urinary nitrogen, which is difficult to conserve in livestock effluents because it volatilizes within a few hours in the form of ammonia. It is particularly advised to first aim for the reduction of highly degradable nitrogen inputs (Godinot *et al.*, 2022), to prefer the semi-complete ration with individual distribution of concentrates while ensuring the animals' needs are met (ADEME, 2020).

Ruminants do not share their plate with humans

It is often criticized that livestock farming, by using animals for protein production, automatically causes higher losses of reactive nitrogen than those caused by producing the same amount of plant-based proteins. However, it should be remembered that ruminant feed is not very competitive with human feed because the majority of the proteins consumed by ruminant herds in France are not consumable by humans. Many ruminant farms can produce more protein than they consume by improving their nutritional quality. Dairy sectors are on average all net producers of protein for human consumption. Thus, ruminants efficiently convert foods that are not edible for humans into edible products for them and of high nutritional value (Rouillé *et al.*, 2023). The ERADAL project aims to move toward a more efficient use of food resources in dairy production to produce food for humans (www.idele.fr/eradal/).

KEY FIGURES

For cows producing 8,000 kg of milk/year, **4%** of ammonia emissions are avoided when the nitrogen concentration of the ration is reduced by 10% (Manneville *et al.*, 2023).

The vast majority of proteins consumed by ruminants are not consumable by humans:
86% in dairy goats,
89% in dairy sheep,
89% in dairy cattle,
93% in beef cattle,
90% in meat sheep
(Idele, 2022c).

2 The management of livestock effluents in the barn

Axes of improvements to reduce emissions in the barn

The barn is a strategic place for reducing nitrogen losses. Indeed, the animals deposit their waste there, and the ammonia volatilizes. These emissions mainly depend on the nature of the droppings, the surface area and contact time between the droppings and the air, and the moisture content of the litter. The sector is considering the implementation of good practices with the main objective of limiting the time the droppings remain in the barn (for example, by increasing the frequency of scraping the operational environment). The increase in straw input is also being considered to reduce emissions primarily related to liquid manure (ADEME, 2020). Urea being the main source of ammonia, techniques that induce phase separation (urea/feces) have a beneficial effect in mitigating its emissions.

The potential for reducing NH_3 emissions can reach **20%,** if scrapings is done every 3 hours (Manneville *et al.*, 2023).

KEY FIGURES

The main sources of NH_3 emissions in cattle farming: **26%** barn/manure management, **20%** storage, **29%** spraying, **10%** grazing, and **15%** mineral fertilization (Manneville *et al.*, 2023).

Between 1990 et 2021, NH_3 emissions decreased by **19%,** particularly in the area of bovine waste management in barns and storage (-24% of emissions from this area) (CITEPA, 2023b).

3 The management of livestock effluents during storage

Possibilities for emission reduction during storage

Nitrogen emissions occur during manure storage (mainly in liquid form): ammonia but also methane are then produced. To limit their transfer to the atmosphere, various solutions are gradually being adopted: covering slurry pits reduces ammonia emissions by 60% to 80%.

Nevertheless, this technique needs particular care because it can increase CH_4 emissions by causing the temperature of the slurry to rise by a few degrees. A uniform vegetative crust does not have this drawback and, moreover, promotes methanotrophic bacteria that consume the CH_4 emitted by the slurry. The presence of a vegetated crust, natural or induced, allows for a 50% reduction in emissions.

By reducing ammonia emissions, the implementation of covers allows for the retention of nitrogen in the effluent, thus preserving its full fertilizing value, drastically reducing odours, potentially valorising methane into energy, or even reducing the volumes of slurry to be spread by protecting the pit from rainwater, which is therefore no longer collected (ADEME, 2020).

PERCENTAGES OF LIQUID MANURE STORED IN COVERED PITS (TARPING COVERAGE AND CENTRAL MAST + FLOATING TARPING COVERAGE) IN MAINLAND FRANCE (CITEPA, 2023a)
Reading note: the proportion of covered pits in sheep and goats is high, but constitute only a small part at national level since these species are not too managed in liquid systems.

	2015	2020
Cattle	1.3%	10.1%
Goats	8.5%	65.3%
Sheep	4.6%	35.5%

KEY FIGURES

The reduction in volatilization reaches **60%** with specific tarping coverage and **50%** with controlled vegetated crusting (Manneville *et al.*, 2023).

Between 1990 and 2021, **-27%** emissions of NH_3 in the beef industry (CITEPA 2022, processing Institut de l'Élevage).

4 The spreading of livestock effluents

Possibilities for reducing volatilization of ammonia during spraying

Rich in nitrogen, livestock effluents are excellent organic fertilizers and help increase the carbon stock of soils, a key element in the current context of climate change. They also help limit the use of synthetic fertilizers made from fossil fuels. Nevertheless, during spraying, some of the nitrogen escapes into the atmosphere in the form of ammonia. This is also the focus of the ENGAGE project, which aims to enhance and transfer knowledge about the spreading of liquid organic fertilizers to adopt a comprehensive approach to effluent management (Idele, 2022b).

To limit ammonia emissions during spraying, the main identified lever is to prioritize spreading equipment that allows for direct and rapid burial. As part of the TEpLis+ project, tests were conducted to measure ammonia volatilization based on spraying equipment (http://www.ouest.cuma.fr/dossiers/teplis).

Apart from the spraying technology, other parameters need to be considered: temperature (avoid hot periods), humidity (favour humid periods or spray before a rainfall), and wind (avoid windy periods). All these considerations, when properly taken into account, help reduce nitrogen losses thru volatilization and thus maintain good fertilizer value (Interbev, Idele, CNIEL, CITEPA, 2022).

The recent publication of the Less Emissive Spreading Equipment Plan 2020-2025 (Ministry of Agriculture and Food, 2019) should allow for the continued development of good spraying practices.

Nevertheless, the costs associated with certain effluent management techniques can be significant (boom sprayer, slurry pit cover, etc.). The plans for competitiveness and adaptation of agricultural holdings (PCAE) can help with such investments.

KEY FIGURES

40% of fertilizers used in France are organic (GIS Avenir Elevage, 2023).

7.8 Mt de CO_2 eq avoided in 2021 thanks to locally spread livestock effluents (compared to average synthetic fertilizers). This represents the annual carbon footprint of more than 700,000 French people. (GIS Avenir Elevage, 2023)

LEARN MORE... ... about effluent management

CHECK OUT THE SHEET ➡
« Ruminant livestock farming and Soil quality ».

5 *Grazing animals*

Grazing cows produce little ammonia

To reduce the cascading effect of ammonia emissions related to effluent management, it is recommended to increase the time that animals spend grazing. This eliminates the storage phase, and the grasslands directly use the nitrogen from the excrement (Peyraud *et al.*, 2012). Nevertheless, this practice is highly dependent on the climate, the farm's environment, and the livestock production system. In addition to reducing ammonia losses, this practice provides other services by storing carbon in the soil, improving animal welfare and health, and reducing the work of spreading effluents and grassland harvest.

LEARN MORE... ... about greenhouse gases emissions

CHECK OUT THE SHEET ➡
« Ruminant livestock farming and Greenhouse gases ».

KEY FIGURES

In beef cattle,
-5% emissions by increasing grazing time by 4% (to achieve 70% of time spent grazing).
In dairy cattle,
-7% emissions by increasing grazing time by 10% (to achieve 50% of time spent grazing)
(Manneville et al., 2023).

On average over the year,
25 to 30%
of urine in pastures ends up in an organized form in the soil; 30-35% are used by plants, 10-15% are lost in ammonical form (Peyraud *et al.*, 2012).

On average over the year,
60 to 70%
of fecal nitrogen in pasture is integrated into soil organic matter, 10-20% is taken up by the plant and 5-10% is lost thru emissions
(Peyraud *et al.*, 2012).

6 The fertilization of agricultural land

The introduction of legumes into the cropping system, a lever to reduce ammonia emissions

The fertilization of agricultural land emits NH_3 using nitrogen fertilizers, whether they are organic, mineral, or related to the grazing of herbivores.

Capable of capturing atmospheric nitrogen, legumes help reduce ammonia emissions when they are introduced into cropping systems. Indeed, they do not require nitrogen input and return it for the following crop. They can be introduced into the cropping system in association with another crop or in a grassland, as a supplement or replacement for other annual crops, or as a seed production crop (ADEME, 2020).

Ruminant livestock is the main contributor to nitrogen inputs thru symbiotic fixation of atmospheric nitrogen by legumes because 80% of the inputs come from legumes in permanent grasslands and 10% from lucerne crops (Cellier *et al.*, 2012).

It is also one of the priority themes of the PARTAGE project, whose aim is to establish an initial diagnosis to analyze needs, contexts, and share knowledge on emerging levers that allow for the completion of the nitrogen cycle (www.grandest.chambre-agriculture.fr). Other techniques for optimizing nitrogen inputs (organic or mineral) are recommended in the guide of good agricultural practices for preserving air quality (ADEME, 2020).

KEY FIGURES

Maintaining an alfalfa for 4 years allows for the return of **150 kg** of nitrogen to the following crop in the 1st year and **70 kg** in the 2nd year (Manneville *et al.*, 2023).

120 to 300 kg of atmospheric nitrogen per hectare per year fixed by legume-rich grasslands (Idele, 2022a).

ACTIONS AND TOOLS IMPLEMENTED BY THE SECTORS

RUMINH3 project

The first step of the project aims to quantify national ammonia emissions from the dairy and beef sectors in order to assess the evolution of emissions from 1990 to 2035 and to evaluate the performance of different emission reduction practices. The second step is a projection of technical mitigation measures to quantify the effects of reduction for the bovine sectors by 2035 (Interbev, Idele, CNIEL, CITEPA, 2022).

PARTAGE project (Regional Agronomic Program for Agro-ecological Transition in Grand Est)

22 stakeholders (Chambers of agriculture, cooperatives, technical institutes, research and experimental platforms) have come together around a European Innovation Partnership (EIP). The project focuses on 3 priority themes: innovative solutions to reduce nitrogen losses, the introduction of nitrogen into systems thru symbiotic fixation of legumes, and territorial management of organic matter. The aim was to establish an initial diagnosis (farms and territories) in order to analyze needs, contexts, and share knowledge on emerging levers that allow for the completion of the nitrogen cycle (www.grandest.chambre-agriculture.fr).

The guide of good agricultural practicess for preserving air quality

Developed by ADEME, this guide encourages the limitation of ammonia and particle emissions into the air in response to EU Directive 2016/2284 by promoting the dissemination of the most relevant agricultural practices. Its recipients are agricultural advisory organizations for livestock (cattle, pigs, poultry) and for plant production, mainly for the management of nitrogen fertilization and spraying methods (ADEME, 2020).

ClimAgri tool

At the scale of a territory, the tool aims to connect agricultural energy consumption, greenhouse gas and pollutant emissions, and agricultural raw material production (nutritional potential). The diagnosis of the initial situation allows the user to construct and test scenarios in order to evaluate and prioritize the actions to be implemented (Climagri, 2022).

ENGAGE project: Enhance and transfer knowledge on the spreading of liquid organic fertilizers to adopt a global approach to effluent management

Its objectives are to disseminate knowledge about organic fertilizers and to promote a comprehensive reflection on agricultural production systems. This project is led by the Pays de la Loire Chamber of Agriculture and its partners AILE, CUMA Ouest and Mayenne, and Idele.

TEpLis + project

The TEpLis project studies the transport and spaying of manure. Its objective is to help reduce the negative effects of slurry spreading by proposing alternative and complementary solutions to the slurry tanker organization. The project stakeholders identify, assess, test, and promote innovative slurry spreading solutions. TEpLis+ synthesizes the trials on the measurement of ammonia volatilization according to the spraying equipment (http://www.ouest.cuma.fr/dossiers/teplis).

CAP'2ER® tool

This tool allows an evaluation of environmental impacts and positive contributions at the scale of a ruminant farm, thru several indicators, including the «air/water quality», notably including ammonia emissions. It is multi-sectoral, and now applies to dairy cattle, beef cattle, goats, sheep, and field crops.

As of 31/08/2023, 1,882 advisors have been trained and 36,740 CAP'2ER® diagnostics have been conducted since 2015 in connection with the Carbon Dairy, Low Carbon Dairy Farm, Beef Carbon, Green Sheep, and Sustainable Goat Farming initiatives. The deployment of the tool is national but also European.

ACTIONS AND TOOLS IMPLEMENTED BY THE SECTORS

GESTIM+ : Development of a GESTIM+ guide by agricultural institutes (ARVALIS, Idele, CFTIFL, IFIP, IFV, ITAVI)

It is a methodological reference for estimating the environmental impacts of agricultural activities on climate change, the consumption of non-renewable energies, and air quality. GESTIM+ lists mobilizable resources and thus serves as a reference on these topics for engineers, researchers, technicians, teachers, and decision-makers.

The guide aims to list the different methods, tools, and activity data that can be used for environmental assessments at different scales (www.arvalis.fr/recherche-innovation/nos-travaux-de-recherche/gestim).

ERADAL project

The objective of the project is to evaluate the efficiency of food resource utilization in dairy production. It evaluates the production capacity of food (milk and meat), both in quantity (primary agricultural production) and quality (human nutrition), of dairy ruminant farms in France, and it proposes technical actions to improve it. In a context of significant tension over resource use, particularly plant-based resources, it is important to highlight the technical conditions that facilitate the evolution of dairy systems toward more efficient resource use.

Therefore, the operational objectives of the ERADAL project are:

- to identify, study, and describe innovative, efficient dairy systems that produce food in quantity and quality;
- to establish a clear link with the ability to compensate the work of the breeders;
- to create a professional and collective dynamic of operational groups, to fully benefit from everyone's experiences;
- to enrich advisory and teaching approaches, and technical information with the development of tools and indicators adapted to dairy production for each studied sector (www.idele.fr/eradal/).

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