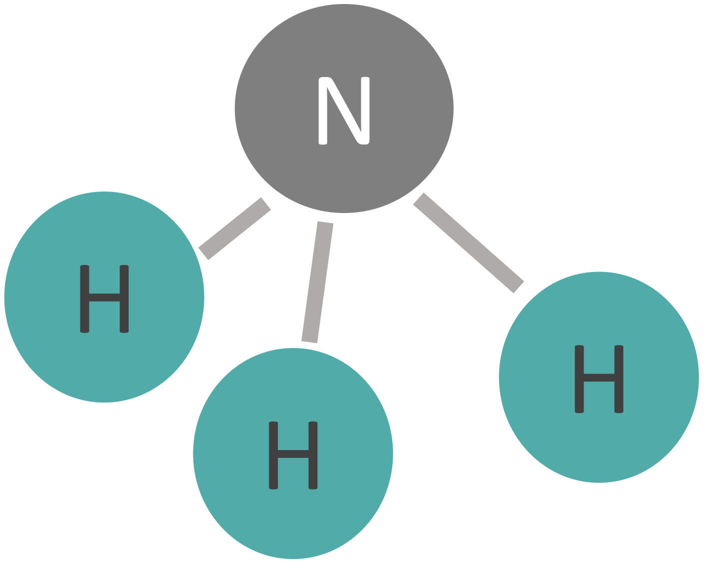
UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Farming for a Cleaner Environment: How can I help reduce ammonia emissions from my farm?



Ammonia NH_3

Source: UNECE

UNECE

Introduction

Reducing ammonia (NH_3) emissions is essential for protecting human health, the environment, and biodiversity. Ammonia contributes to the formation of fine particulate matter, which causes severe health issues, including cardiovascular and respiratory diseases. Additionally, ammonia plays a role in the formation of acid rain and increases soil acidity, harming plants, agricultural crops, forests, and other ecosystems. Reducing ammonia emissions will help create a healthier environment, benefiting both population and nature.

The guide *"Agriculture for a Clean Environment: How to Reduce Ammonia (NH_3) Emissions from My Farm?"* offers effective strategies for minimizing ammonia emissions in agriculture, specifically providing recommendations for the livestock and poultry sectors. The recommendations include:

- Efficient feed management in livestock and poultry production to prevent excess nitrogen excretion.
- Improved manure management and storage practices to reduce ammonia emissions.
- Proper application of manure to soil based on crop and soil requirements to minimize environmental impact.
- Adoption of good agricultural practices that decrease reliance on chemical fertilizers and enhance soil and air quality.

Implementing these methods will help protect wildlife habitats, prevent water pollution, and preserve ecosystems.

Farming for a Cleaner Environment: How can I help to reduce ammonia emissions from my farm?

45 YEARS 1979-2024 AIR CONVENTION

UNECE

Geneva, 2024

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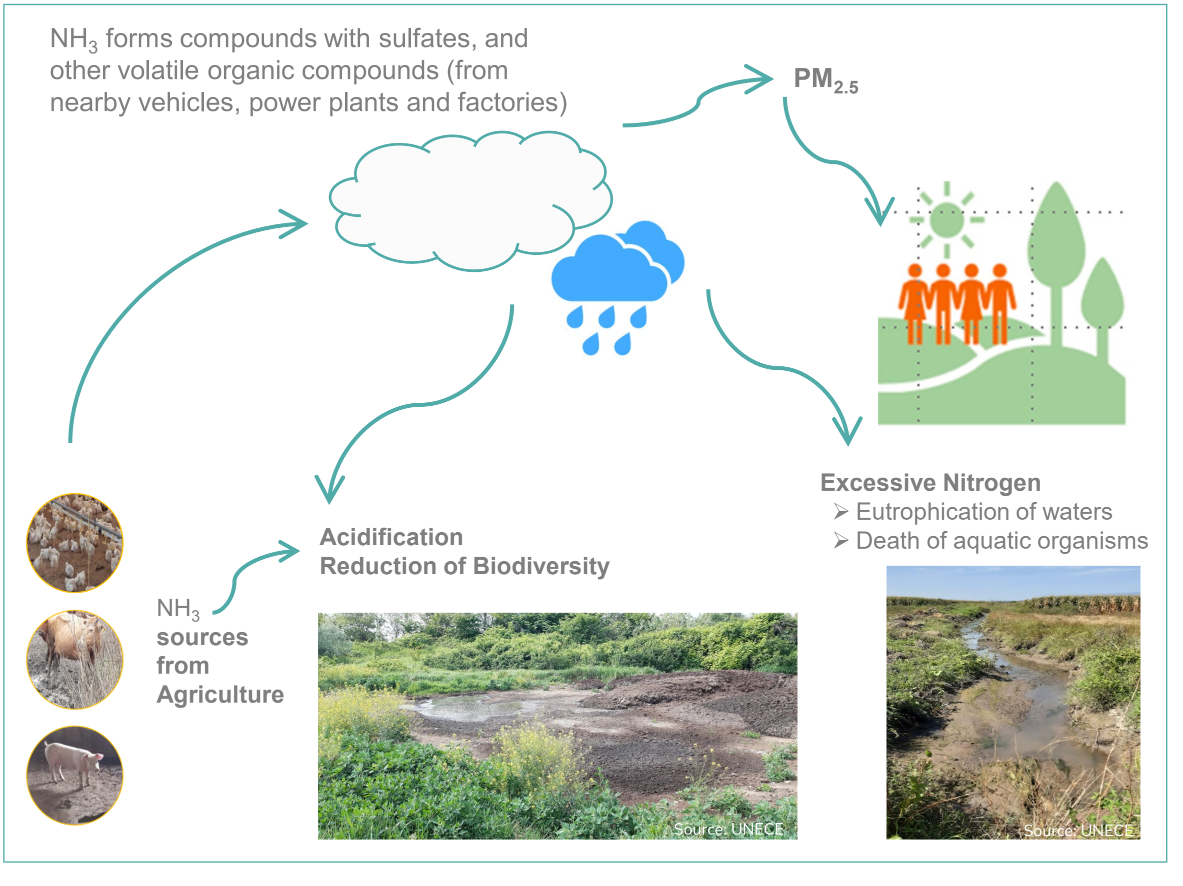
Ammonia (NH_3)
A pollutant that affects air quality

Ammonia (NH_3) is an inorganic gas composed of nitrogen and hydrogen, known for its sharp, suffocating odor. While low concentrations are generally not harmful for humans, NH_3 can contribute to air pollution when released into the atmosphere. It plays a role in forming fine particulate matter ($PM_{2.5}$[1]) and acid rain, which affect human health, ecosystems and the climate. When inhaled, $PM_{2.5}$ can penetrate deeply into organs, leading to cardiovascular and respiratory diseases.

Agriculture is the leading source of atmospheric NH_3, accounting for over 80% of global NH_3 emissions. The primary sources of NH_3 emissions from agriculture include:

- Livestock and animal production
- Manure handling and storage
- Livestock housing and manure/slurry application
- Use of nitrogen-based chemical fertilizers

The contribution of each agricultural activity to NH_3 emissions varies significantly based on local and regional farming practices.



[1] Fine particulate matter ($PM_{2.5}$) is defined as particles that are 2.5 microns or less in diameter

Agriculture and NH_3 emissions

NH_3 is released into the air from animal manure and slurry. Livestock excreta, like urea and feces, break down and release NH_3. This happens through several microbiological processes. Manure contains enzymes, which are proteins that act as biological catalysts, speeding up the chemical reactions that produce NH_3.


Source: Adobe stock

Factors like temperature, pH, and air circulation affect how quickly NH_3 is released into the atmosphere. Improper manure handling and storage, along with delayed soil incorporation, increase NH_3 emissions, contributing to air pollution and environmental damage.

Avoid pooling urine (urea) with feces (which contains enzyme-producing microbes) to reduce NH_3 emissions.

Keep litter as dry as possible to limit moisture, which promotes microbial activity and accelerates chemical reactions. This helps minimize NH_3 release and its environmental impact.

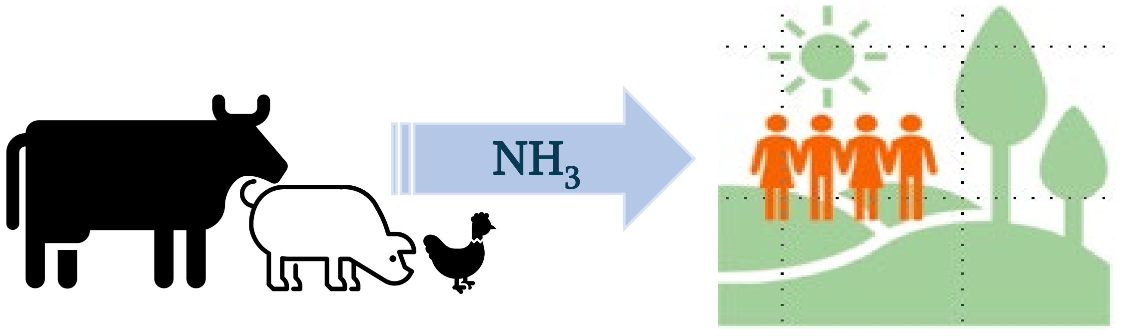
Why do we need to reduce NH_3 emissions?


Source: UNECE

The UNECE Air Convention's Gothenburg Protocol and the EU National Emission Ceilings (NEC) Directive mandate that signatory countries reduce NH_3 emissions to protect human health and the environment. Substantial reductions can be achieved through consistent implementation of good nitrogen management practices and widespread adoption of Good Agricultural Practices. To be effective, measures to reduce NH_3 emissions should be applied at all stages of farming – from livestock diet and housing to manure storage and spreading –, because nitrogen retained at one stage can be lost as NH_3 in the next.

By following Good Agricultural Practices, you will help improve air quality and protect wildlife habitats that showcase Georgia's natural landscapes and biodiversity. Your efforts contribute to a healthier environment and support the preservation of essential ecosystems.

Mitigation strategies



Diet

- Reduce surplus of nitrogen excreted by animals

Housing

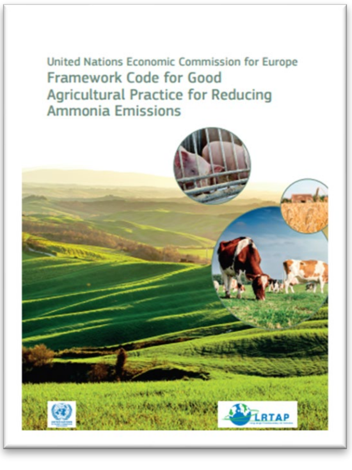
- Separate urine and feces

Storage and application of manure

- Reduce contact of slurry with the air

Measures for air treatment

- Filtrate the exhaust air from animal houses



All these measures are presented in detail in the Code for Good Agricultural Practices published by UNECE and re-transcribed by MEPA for Georgia

Cattle housing, feeding and removal of manure

How do I reduce the amount of nitrogen excreted by my cattle?

To reduce the amount of nitrogen excreted by your cattle, you can improve feed efficiency through the following steps:

- **Match nitrogen content** of feed (crude protein) to the cattle's production level and growth stage
- **Establish protein requirements** for your animals and adjust feed accordingly
- **Seek advice** to formulate balanced rations for cattle
- **Know the crude protein content** of home-grown forage
- **Conduct full nutritional analysis** of all forages when possible

These actions help optimize nitrogen use and minimize excess nitrogen excretion, benefiting both your livestock and the environment.

You can reduce crude protein (CP) in animal diets without negatively impacting performance, health, or welfare. Excess nitrogen from crude protein in the diet is excreted by cattle primarily as urea in urine, which not only increases NH_3 emissions but also represents a financial loss, as the excess nitrogen is wasted. Optimizing CP levels in the diet can reduce both environmental impact and costs.


Source: Stock images

Nitrogen in Cattle manure

Ruminants are poor nitrogen converters, absorbing only 5-30% of ingested nitrogen, with 70-95% excreted in feces and urine. Cattle slurry and manure contain **organic nitrogen, ammonium nitrogen (NH_4^+),** and **nitrate nitrogen (NO_3^-):**

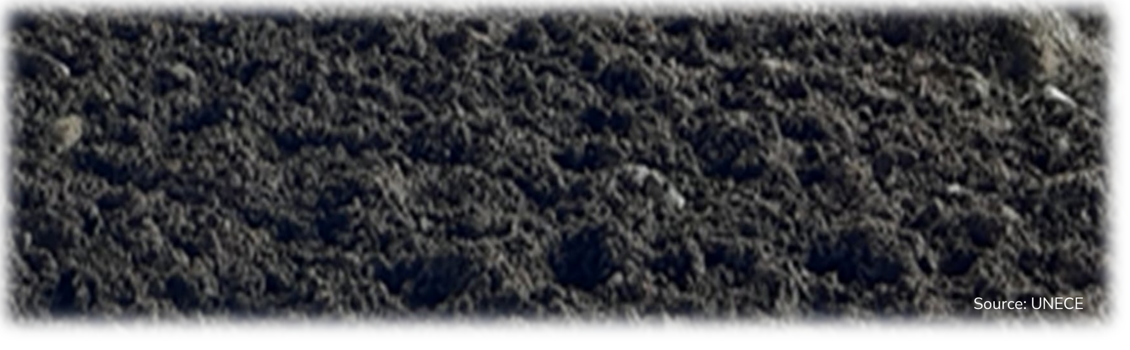
Organic Nitrogen: Nitrogen bound in organic compounds of manure must be broken down by soil microbes into ammonium and then nitrate before plants can use it.

Ammonium Nitrogen (NH_4^+): Readily available to plants but can be lost through volatilization if manure is left on the surface.

Nitrate Nitrogen (NO_3^-): Highly available to plants but can leach into groundwater if not managed properly.

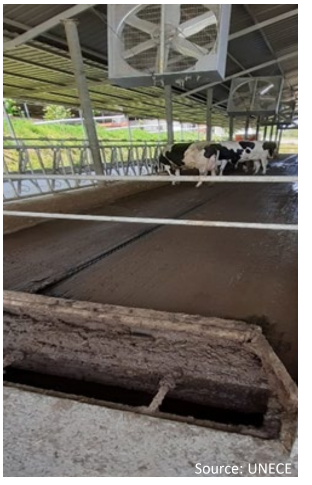
The higher the percentage of Total Ammonium Nitrogen (TAN) in manure, the greater the potential for NH_3 loss through volatilization, especially if the manure is not properly managed.

By carefully managing manure, you can improve ammonium nitrogen retention, reducing NH_3 **loss and decreasing the need for manufactured fertilizers. This leads to better nutrient use and cost savings.**


Source: UNECE

How can I reduce NH_3 emissions in cattle housing?

You can significantly reduce NH_3 emissions by:



- Regularly washing and scraping floors
- Designing floors to drain effectively, preventing pooling of urine and slurry
- Frequently transferring slurry to proper storage
- Maximizing excreted material transfer to channels:
  - Using sloped floors to drain urine into channels
  - Emptying channels regularly, either manually or with scrapers/flushing
- Optimizing shed cooling through natural ventilation to lower temperatures, especially in summer
- Avoiding ventilation directly above slurry channels to minimize airflow over manure
- Increasing straw use in bedded systems to absorb urine and keep floors dry

Methods that I can use to move slurry

By frequently cleaning passages and yards you can reduce emissions by up to 20%. Methods to move slurry include:

- Hand cleaning regularly
- Automatic cleaning systems (passage scrapers or robotic scrapers)
- Washing scraped surfaces (though this may increase slurry volume)

These practices reduce the time slurry is exposed to air, limiting the reaction between urease in feces and urea in urine, which causes NH_3 to volatilize.

Properly designing a sloped barn floor (1-2% slope) allows urine to drain quickly, minimizing its contact with feces, which reduces NH_3 emissions. Since housing floors collect both urine and feces, regular removal of slurry or using low-emission flooring systems that separate urine, and feces efficiently will further reduce emissions. This design improves cleanliness and air quality in the barn.

Examples of some Low emission flooring systems

Sloping floor profile design with a gutter allowing the urine to drain away quickly

Grooved floor system

Slatted floor system

Slatted floor with slurry storage beneath

Standard slatted floors rely solely on gravity and cow traffic to clean the slats of manure.

Good practices for cattle housing and housing periods

Reducing cattle housing periods can lower NH_3 emissions, as cows release less NH_3 while grazing, and no additional emissions occur during manure storage and spreading. However, grazing may increase other nitrogen pollution, such as nitrate leaching and nitrous oxide (N_2O), depending on climate and soil factors. Complete 24-hour grazing is more effective at reducing NH_3 emissions than partial grazing, as buildings and manure stores continue emitting NH_3 when dirty.

In loose housing with straw bedding, NH_3 emissions decrease because straw absorbs urine and keeps floors dry. Increasing bedding and changing it frequently can further reduce emissions, though this may increase methane (CH_4) production. The physical properties of bedding, like absorbency, are key in reducing NH_3 emissions.

Poultry housing, feeding and removal of manure

Source: Stock images

How to reduce the amount of nitrogen excreted by my birds?

To improve nutrient utilization efficiency and reduce NH_3 emissions from undigested proteins and uric acid, consider the following strategies:

- Use fibrous diets, such as distiller dried grains plus soluble (DDGS)
- Modify diets with feed additives and enzyme supplements to enhance digestibility
- Match nutrient requirements throughout all production stages for precise nutrient supply
- Decrease crude protein levels in feed, supplemented with amino acids and other additives

Consult nutritionists to regularly review and adjust diets for optimal least-cost formulations that meet nutrient needs effectively.

How can I reduce NH_3 emissions in poultry housing?

High levels of NH_3 in housing negatively affect animal health and welfare. To reduce NH_3 emissions, you need to keep the litter as dry as possible, as poultry manure emits more NH_3 when wet. This includes:

- Inspecting building structures and water drinkers for leaks to maintain dry litter
- Providing comfortable, non-toxic, moisture-absorbing litter for chickens

These practices will help improve air quality and enhance the welfare of the animals.

The pH of excreted poultry manure and litter typically ranges from 7.5 to 8.5, which is optimal for NH_3 production bacteria. By lowering the pH levels in manure or litter, you can inhibit the decomposition of uric acid and the conversion of ammonium into NH_3 gas.

You can use acid scrubbers or bio trickling filters to remove NH_3 from exhaust air.

In layer housing, you can reduce emissions by frequently collecting manure with manure belt systems, moving it to covered storage outside, and using intensive ventilation to increase the manure's dry matter content.

Pig housing, feeding and removal of manure

How to reduce the amount of nitrogen excreted by my pigs?

To improve nutrient supply precision and reduce NH_3 emissions, you can:

- Match nutrient requirements at all production stages
- Enhance feed conversion efficiency to weight gain and minimize feed surplus by ensuring optimal use of feed, especially protein
- Monitor feed and water intake alongside growth rates
- Regularly review and adjust least-cost diet formulations to meet nutrient needs
- Consider professionally formulated diets that include synthetic amino acids, enzymes, and other feed additives to further reduce nutrient excretion

Consult a nutritionist or feed expert to make informed changes in ration formulation before adjusting your pig diets. Their expertise can help ensure that dietary modifications effectively meet nutrient requirements while minimizing waste and optimizing pig health and performance.

How can I reduce NH_3 emissions in pigs' housing?

You can reduce NH_3 emissions by addressing various factors that influence emissions from buildings, such as floor type, ambient temperature, humidity, ventilation, and exhaust air scrubbing.

For floor type:

- Maximize the transfer of excreted material to channels
- Ensure solid floors are slightly sloped to allow urine to drain into gutters
- Frequently empty channels using scrapers, vacuum systems, or water flushing
- Provide pigs with functional areas for different activities to promote rapid drainage, keeping urine and feces separate, as NH_3 forms when they mix
- Keep solid floor areas clean and dry by providing sufficient bedding material, such as straw, for complete urine absorption and changing it frequently
- Monitor for leaks in drinking systems to prevent excessive moisture in bedding

Manure storage and application

Factors for NH_3 loss from manure

Key factors that increase or decrease NH_3 loss from manure

Minimises NH_3 loss -	Increases NH_3 loss +
Low temperatures	Warm to high temperatures
Reduced air flow over manures	Increased air flow over manures
Reduced to no exposed surface area of manure	Large exposed surface areas of manure
Urine and feces kept separate	Mixing urine and feces

The interaction between urine and feces creates conditions that promote NH_3 production. Urease-producing bacteria in feces break down urea in urine into NH_3. When urine and feces mix, the pH increases, favoring the conversion of ammonium (NH_4^+) into gaseous NH_3, which can then volatilize into the air.

Additionally, urine provides the moisture necessary for bacterial activity, facilitating the breakdown of urea into NH_3. The formation of a slurry-like material also increases the surface area from which NH_3 can volatilize, further enhancing emissions.

How can I reduce NH_3 emissions from my solid manure storage?

To minimize wind movement over solid manure and reduce NH_3 emissions, you should:

- Cover manure heaps with plastic sheeting that will also help to retain nutrients and reduce odors
- Ensure the covering is securely fastened to prevent it from blowing away
- Store fertilizers at least 10 meters from watercourses and 50 meters from wells or boreholes to prevent nitrate pollution in water sources
- Minimize the surface area of manure stacks by storing them in ‘A’-shaped heaps or constructing walls to increase height rather than expanding

How to reduce NH_3 emissions from my slurry storage?

To minimize wind movement over manure and reduce NH_3 emissions, you need to:

- Decrease the surface area of emissions by using impermeable covers such as plastic sheets, floating covers, tents, or rigid roofs
- Utilize permeable covers like chopped straw, light expanded clay granules, or floating plastic hexagons
- Encourage crusting on the surface by adding chopped straw
- Increase the depth of the manure store instead of spreading it out

These strategies help reduce NH_3 volatilization and improve nutrient retention.

You can also decrease NH_3 emissions by acidifying the slurry, a method suitable for farms that already have a good level of technical development. Acidification helps lower the pH, which inhibits the conversion of ammonium to gaseous NH_3, thereby reducing overall emissions.

Do not allow your liquid manure to spill or leak into the environment

Several types of slurry liquid storage systems are available, to meet your specific needs

- Lagoons
- Cylindrical metal store
- Concrete stores
- Bags

Concrete store (uncovered)

Covered stores and lagoon with natural crust

Concrete store (with a dome roof)

Slurry bag

How can I reduce NH_3 emissions when applying manure to land?

To reduce NH_3 emissions when applying manure to land, consider the following practices:

For solid manure:

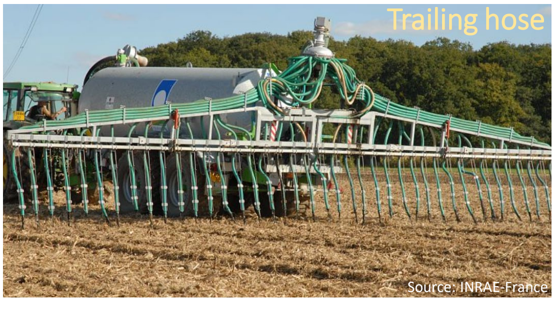
Rapid incorporation: Incorporate manure into tilled land within 12 hours of application. Tilling or ploughing can help minimize emissions.

For slurries:

Avoid splash plates: Do not use splash plate equipment, as it increases emissions.

Immediate incorporation: If changing equipment is not possible, incorporate the slurry immediately after application.

Invest in efficient systems: Consider investing in less expensive systems, such as band spreading methods like trailing hoses or trailing shoes.



Plan manure and slurry application according to soil type, nutrient status, and crop needs to maximize benefits while minimizing NH_3 emissions and nitrate leaching.

Analyze manure regularly to ensure you get the maximum agronomic and financial benefit by applying the right amount at the right time.

Use of manufactured fertilizers

How can I reduce NH_3 emissions when applying chemical fertilizers?

To effectively manage chemical fertilizers and reduce nitrogen loss, follow these guidelines:

General practices

- **Avoid over-fertilization:** Apply only the necessary quantities of chemical fertilizers based on crop needs.
- **Adopt fertilizer management plans:** Manage chemical fertilizer inputs as a complement to nutrients from manure.

Soil analysis

- **Analyze your soils:** Conduct soil analyses to determine nutrient needs, which can save costs on mineral fertilizers.

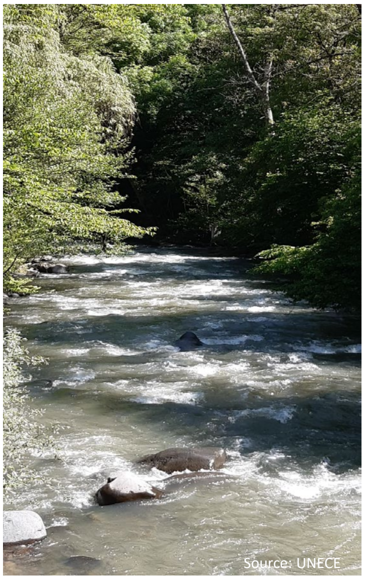
Choosing fertilizers

- **Prefer ammonium nitrate:** Nitrogen loss as NH_3 from urea-based fertilizers can be up to 20% higher than from ammonium nitrate, so it is preferable to avoid urea.
- **Use urea-based fertilizers wisely:** If using urea, apply when the weather is cold, rainfall is expected, and ensure the soil is moist (not wet). Incorporate it immediately after application.

Timing for application

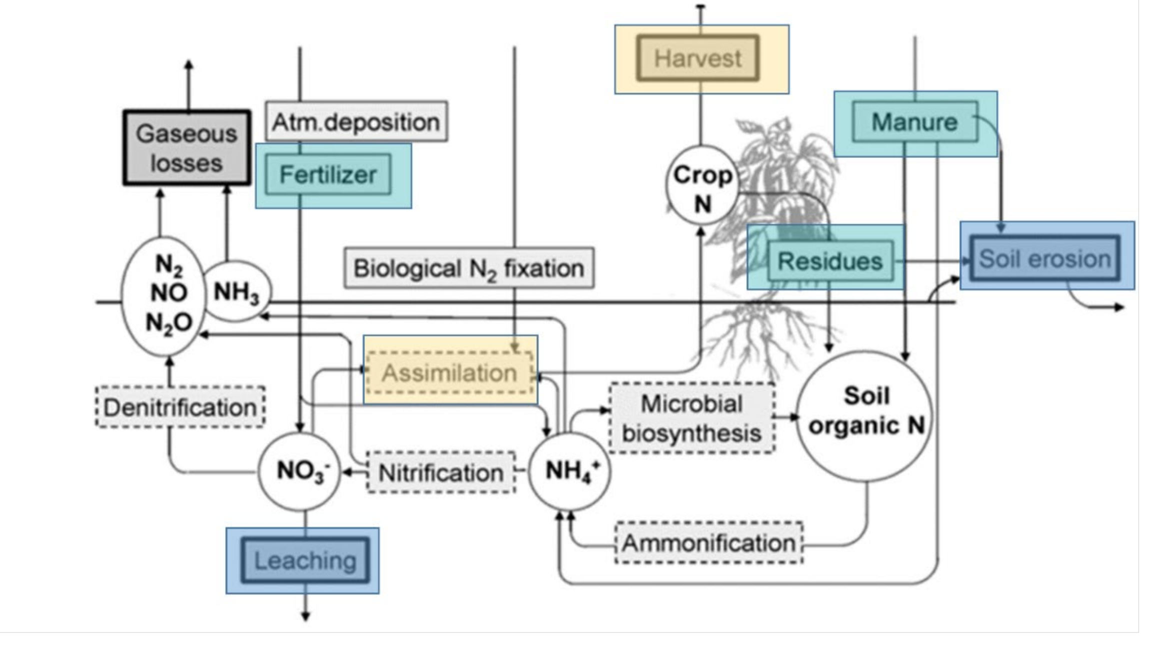
- **Ammonium nitrate application:** Apply in cool, moist conditions, by avoiding application when rainfall is expected to minimize nitrogen loss to both air and water.
- **Avoid urea on sandy soils:** Do not apply urea on light sandy soils, grassland, or arable crops during dry periods.

By following Good Agricultural Practices, you will effectively reduce NH_3 emissions and decrease your reliance on chemical fertilizers, which will lower production costs and prevent excess nitrogen from entering the environment. This approach contributes to improved air quality, protects wildlife habitats, and mitigates the risks of eutrophication and aquatic life loss in watercourses, ultimately preserving Georgia's natural landscapes and biodiversity.

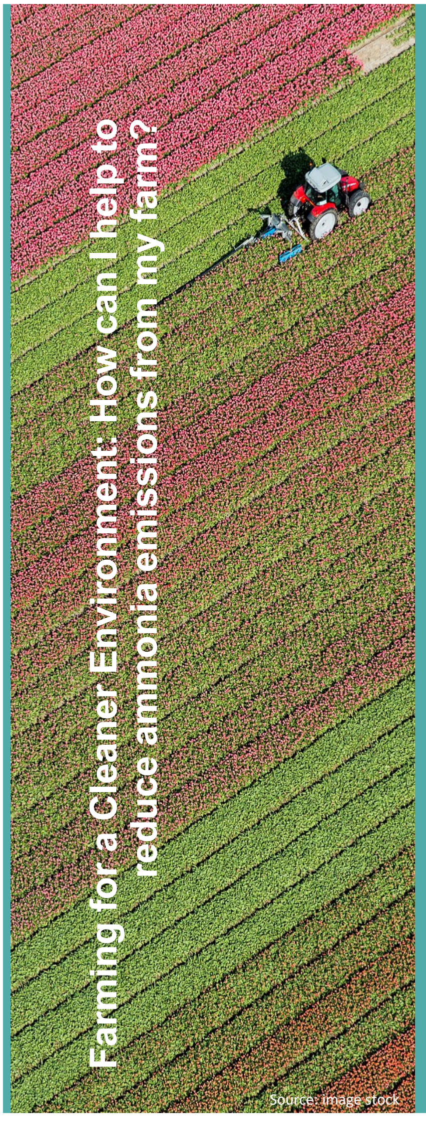


Different forms of nitrogen in the soil/air and transformation processes

Ammonium (NH_4), Nitrate (NO_3), Ammonia (NH_3), Nitrogen oxides (NOx), gaseous nitrogen (N_2)



Adapted from Browman et al., 2009



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