

How to process and use animal waste as organic fertilizer in a small-scale farming operation

MODEL MANURE MANAGEMENT PLAN



Authors:

N. Parechina

Editors:

M. Staniszewska, O. Senova

Design & layout:

Coalition Clean Baltic (CCB)

For comments and questions:

CCB, secretariat@ccb.se

Suggested citation:

How to process and use animal waste as organic fertilizer in a small-scale farming operation. On the example of horse and goat manure management on a small farm.

© Coalition Clean Baltic, 2025

This brochure describes how to process and utilize animal manure for a small farm of 45 goats and 10 horses. Advice is given on what and how to consider so that your farm uses animal waste in an environmentally friendly, cost-effective way and in accordance with EU Directives and HELCOM recommendations.

The brochure will be useful for beginning farmers who farm in the Baltic Sea basin and are interested in reducing their environmental impact, as well as for those professionals who provide information and advisory support to interested farmers.

Co-funded by



Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA or BaltCF. Neither the European Union nor the granting authority can be held responsible for them.

Contents

1. Introduction

- 1.1. Environmental consequences of improper animal waste management
- 1.2. International regulation related to nutrient pollution problem from agriculture in the Baltic Sea region

2. Overview of manure management practices

- 2.1. Which farm characteristics should be taken into account when selecting the the best available manure treatment technology?
- 2.2. Which manure treatment technologies can be used?
 - 2.2.1 Technology 1 - Manure treatment by passive composting method
 - 2.2.2 Technology 2 - Manure treatment by long-term holding method
 - 2.2.3 Technology 3 - Manure treatment by biofermentation method
 - 2.2.4 Selection of manure and droppings processing technology
- 2.3. How to apply processed manure and droppings to fields?
- 2.4. Recommendations in case of epizootic outbreaks

3. Examples of good practices from the Baltic Sea basin countries

Conclusion

Annex 1. Calculation of excreta yield, mass of process water and bedding material for a small-scale farming operation

Annex 2: Helcom' main recommendations to reduce eutrophication from manure and droppings

Appendix 3. Examples of good manure and droppings management practices in the Baltic Sea Basin countries

For notes

Introduction

Eutrophication remains the main environmental threat to the Baltic Sea. It causes intensive growth of algae and depletion of oxygen reserves on the seabed, which further leads to the formation of vast areas of oxygen-free conditions in the Baltic Sea and affects the entire ecosystem.

Eutrophication is caused by excessive input of biogens, i.e. nitrogen and phosphorus compounds into the aquatic environment. River discharges are the main anthropogenic sources of nitrogen and phosphorus to the sea, with diffuse sources, such as runoff from agricultural land into rivers, supplying a significant share of biogens, while point sources contribute only a few percent of the total inputs.

Previous targets for reducing biogen inputs set in the original Baltic Sea Action Plan adopted by HELCOM in 2007 were not met by 2021. Therefore, the Baltic Sea Action Plan was updated in 2021.

The updated BSAP is divided into four segments with specific goals:

- Biodiversity, with its goal of a **“Baltic Sea ecosystem is healthy and resilient”**
- Eutrophication, with its goal of a **“Baltic Sea unaffected by eutrophication”**
- Hazardous substances and litter, with its goal of a **“Baltic Sea unaffected by hazardous substances and litter”**
- Sea-based activities, with its goal of **“Environmentally sustainable sea-based activities”**.

Agriculture, with the highest reduction potential, is currently the main source of diffuse biogen load to the Baltic Sea. Therefore, there is an increasing role for farmers, especially those involved in livestock production, to take more effective measures to reduce biogenic discharges from the agricultural sector. For this purpose, farmers should utilize best environmental practices and best available technologies.

For the countries of the Baltic Sea basin, EU legislation as well as the national legislation of each of the countries in the Baltic Sea region apply in the field of manure management. The key EU document on this issue is the Nitrates Directive (91/676/EEC), which regulates the use of manure and other organic fertilizers to protect water quality by reducing nitrate pollution from agriculture (see 1.2.)

In addition, the governments of the countries located on the shores of the Baltic Sea have signed the Helsinki Convention, according to which the countries assume additional obligations to reduce anthropogenic impact on the water area and coastal zone of the Baltic Sea, including within the framework of BSAP.

In this brochure we have tried to present in an accessible form the main HELCOM Recommendations and EU documents related to the issue of manure treatment and utilization in small-scale farms, as well as to present some manure treatment technologies and manure application rules as applied to small-scale farms. The combination of theoretical and practical information will allow farmers to choose the most economically feasible and environmentally sound ways of animal waste management, which will help to reduce pollution of natural waters of the Baltic basin.

1.1. Environmental consequences of improper manure and droppings management

Even though each small-scale farm does not have as strong an environmental impact as industrial farms, the cumulative impact of all small-scale farms is quite significant. It is also important to properly handle animal by-products in them in order to avoid economic losses for farmers and to reduce pollution of the rivers of the Baltic basin and the sea in general. Improper storage and application of manure and droppings to fields leads to soil contamination and leaching of nitrogen and phosphorus into groundwater and surface water bodies. This leads to pollution not only of rivers and the sea, but also of drinking water from underground sources.

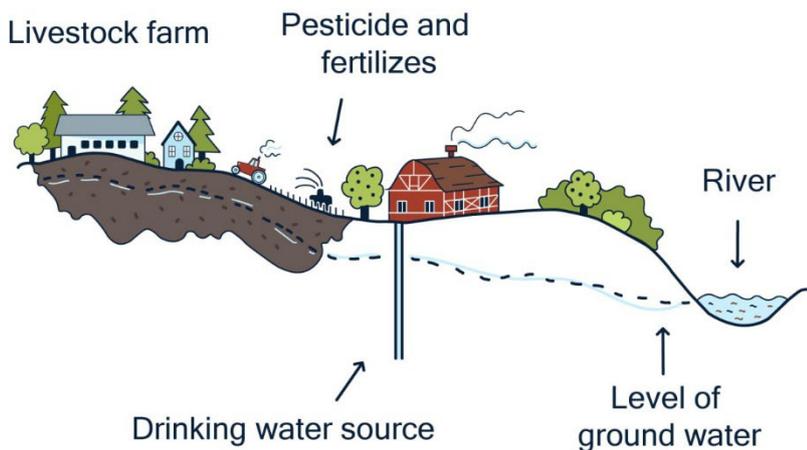


Fig.1. Pollution of water bodies by improper handling of manure and droppings

Eutrophication occurs as a result of too many nitrogen and phosphorus compounds (called nutrients) in the water. A large amount of nutrients causes a mass bloom of algae and cyanobacteria. The dying algae fall to the bottom of the reservoir, where they decompose, leading to oxygen deficiency in water, deterioration of water quality and living conditions of aquatic organisms with their subsequent death. Agricultural runoff in the Baltic Sea contributes 50% of Nitrogen load and 30% of Phosphorus load entering the Baltic Sea from watercourses. As a consequence, 97% of the Baltic Sea water area is subject to eutrophication.



Figure 2. Eutrophication of the Baltic Sea from the Space (the source - CCB)

Improper manure and manure management results in foul odors associated with ammonia emissions. The greenhouse gas methane is released, affecting global climate change. Proper operation of the animal housing system will reduce the risk of greenhouse gas emissions. Failure to dispose of manure and droppings in a timely manner can also lead to microclimate disruption and increased animal disease.

Environmentally sound manure and droppings management must be practiced at every stage. If the farm uses methods, techniques and technologies aimed at ensuring favorable environmental conditions, promoting human health, preserving and restoring soil fertility, it can contribute to the transition to organic farming and obtaining a certificate for organic production.

When manure and droppings are properly managed, the farmer:

1. Ensures that the optimal amount of humus in the soil, which is one of the indicators of soil

fertility, is maintained.

2. Reduces their costs for buying mineral fertilizers through the use of organic fertilizers derived from his own manure and droppings.
3. Receives an increase in yield due to the use of processed manure and manure droppings (percentage of assimilation of mineral fertilizers by plants is 40%; percentage of assimilation of processed manure and manure droppings by plants is 70%).
4. Eliminates the need to pay for negative environmental impact.

1.2. International regulation related to nutrient pollution problem from agriculture

In the European Union, manure is considered a livestock by-product, but it falls under specific regulatory frameworks aimed at managing animal waste, especially concerning its potential impact on the environment, public health, and animal health. Manure is the excrement of animals, often mixed with bedding material, such as straw or sawdust, and may also contain urine. It is typically produced on farms and is commonly used as fertilizer in agricultural practices due to its nutrient content. It is primarily classified as a fertilizer or soil conditioner rather than a direct by-product for human consumption, as it is primarily used for agricultural purposes. Manure utilization is regulated by specific agricultural and environmental guidelines. Manure that contains contaminants, like heavy metals, pathogens, or pharmaceutical residues (e.g., antibiotics), must be managed to prevent adverse impacts on the environment and public health. The Nitrates Directive (91/676/EEC) is a key EU regulation that directly impacts manure management.

The key EU documents related to the management of manure management in agriculture:

Nitrates Directive (91/676/EEC)

Regulates the use of manure and other organic fertilizers to protect water quality by reducing nitrate pollution from agriculture

<https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vitgbghm8hxi>

Many EU Countries have adopted national programs to implement the Nitrate Directive. For example, in Poland the “Action Program” has been developed and implemented, which is valid throughout the country. The introduction of the program was adopted in the Water Law of July 20, 2017/ This Programme requires all sectors of agricultural production, as well as activities involving the storage of animal excrement or the use of fertilizers, to be carried out in such a way as to prevent and limit water pollution by nitrates from agricultural sources. “The Good Agricultural Practice Guidelines”, published by the Ministry of Agriculture and Rural Development include:

- 1) periods when agricultural fertilizer use is not practical;*
- 2) agricultural fertilizer use on steeply sloping terrain;*
- 3) agricultural fertilizer use on frozen, floodable, waterlogged, or snow-covered lands;*
- 4) conditions for agricultural fertilizer use near natural watercourses, reservoirs, canals, and irrigation ditches;*
- 5) capacity and design of storage areas for animal excreta and runoff from stored plant materials, such as silage;*
- 6) agricultural use procedures, including rates and uniformity of fertilizer distribution, that ensure that nutrient losses to water are maintained at acceptable levels.*

BSR countries that are not part of the EC are governed by their own legislation in the matters of manure management. But the HELCOM recommendations (see full text in the Appendix 2) are common for all countries of the Baltic Sea catchment area.

HELCOM RECOMMENDATION 7/2

Recommendation concerning measures aimed at the reduction of discharges from agriculture
<https://helcom.fi/helcom-at-work/recommendations/>

HELCOM RECOMMENDATION 9/3

Recommendation concerning measures aimed at the reduction of nutrient discharges from agriculture
<https://helcom.fi/helcom-at-work/recommendations/>

HELCOM RECOMMENDATION 13/9

Recommendation concerning reduction of nitrogen, mainly nitrate, leaching from agriculture land
<https://helcom.fi/helcom-at-work/recommendations/>

HELCOM RECOMMENDATION 13/12

Recommendation concerning managing freshwater ecosystem for retention of nutrients
<https://helcom.fi/helcom-at-work/recommendations/>

HELCOM RECOMMENDATION 37/3

Recommendation concerning sustainable aquaculture in the Baltic sea region
<https://helcom.fi/helcom-at-work/recommendations/>

HELCOM Recommendation 41/3

Recommendation concerning the use of National manure standards
<https://helcom.fi/helcom-at-work/recommendations/>

HELCOM Recommendation 42-43/5

Recommendation concerning mitigation of ammonia emissions from agriculture
<https://helcom.fi/helcom-at-work/recommendations/>

2. Choice of manure processing technology for small-scale farms

2.1 What are the features of the farm that need to be taken into account?

The first stage of preparation is to conduct a general assessment of the farm as a production facility.

It is necessary to estimate:

1. Livestock by animal species and sex and age groups (adults/young animals).
2. Housing systems (stable/stall/pasture, etc*winter in stalls on deep bedding (straw). In summer period, goats are kept on pasture. The total number of goats was 45 (30 - adults, 15 - young animals). Horses are kept in winter period of the year in stalls on the “cosmetic” bedding (sawdust). In the summer period, horses are kept on pasture. The total number of horses is 10.

Further it is necessary to evaluate and take into account:

1. The manure and droppings removal technologies used, as this will determine the composition and consistency of the removed mass and the choice of processing technology.
2. The length of the stall and pasture period for all animal species * **(Note 1)**
3. Bedding consumption (straw, sawdust) per head.

It is important to take into account whether technological water from udder washing, for example, gets into manure and droppings, which affects the moisture content of manure and droppings and the choice of further processing technology. On small-scale farms, manure and droppings removal is often done manually with varying frequency depending on the season of the

year and as it fills up. Regular manure and droppings removal keeps the premises clean and limits the formation and penetration of harmful gases into the animal area.

In the pilot farm, horse and goat manure is removed manually: horse manure at least once a week, goat manure at least once every six months. The average stabling period for animals is 245 days, while the grazing period is 120 days. Straw consumption during stabling is 1 kg per head per day for adult animals and 0.5 kg per head per day for young goats. Sawdust consumption at stabling of animals is 4 kg per head per day for all groups of animals. Technological water from udder washing does not enter the manure. Detailed calculation of manure and droppings is given in Appendix 1.

After removal, usually all manure is transported to the place of storage and processing. In EU countries it's recommended storage and processing till 6 months and after it applied to the land. Below we describe technologies that allow you to process manure faster.

After processing, the manure is applied to the land to improve soil fertility and obtain the planned yield or as a fertilizer is transferred to other enterprises producing agricultural products. It is important to consider the distance of the land from the animal housing to further calculate the economic aspects of selling the processed manure and droppings. In the pilot farm described here, the manure removed from the housing is placed in wheelbarrows or a trailer and transported to a storage and processing site. After processing, it is applied to the land on crop plots. The distance to the land plots does not exceed 2 km.

* **Note 1:** *The duration of the stall and pasture period for all types of animals depends significantly on the climatic conditions at the location of the farm.*

Pasture capacity for small livestock based on experience in Poland:

For organic and sustainable production, it is recommended 1 LSU per 0,5-1,5 ha. (LSU – Livestock Unit)/

For example:

1 goat mother – 0,15 LSU, 1 goat babes till 3,5 month – 0,05 LSU, 1 goat babes up 3,5 month till 1,5 year – 0,08 LSU,

1 horse – 1,2 LSU, 1 colt above 2 years – 1,0 LSU, 1 colt between 1-2 years – 0,8 LSU, 1 colt between 6 months – 1 year – 0,5 LSU, 1 colt till 6 months – 0,3 LSU.

2.2 What manure and droppings processing technologies can be used?

Manure and droppings handling technology includes processes from loading, transportation, processing of manure and droppings to its application. Taking into account that on farms animals are usually kept on bedding, solid manure and droppings is formed at the exit from the livestock buildings. For the pilot farm, the most common technologies for processing solid manure were analyzed:

- Passive composting
- Long-term conditioning
- Biofermentation in an innovative autonomous chamber biofermenter.

The similarity of all these technologies is that a specialized waterproofed area is required for manure storage. It is recommended to make a canopy over the site, which ensures reduction of atmospheric precipitation (rain and snow) into the processed material, excluding over-wetting of the mixture and thus reducing the possibility of flushing of nutrients into the soil and groundwater. **
(Note 2)

For collection and drainage of precipitation liquid on the waterproofed (in particular concreted) site there should be provided curbs and grease collectors. The pilot farm site was sloped towards the perimeter of the sludge collectors. It is recommended to use additional moisture-absorbing materials

(straw and sawdust) to collect excess moisture, slurry, which after saturation is returned to the site for fertilizer production. All this is done to avoid infiltration of substances into the soil and further contamination of groundwater and plant products. The location of specialized manure storage areas should be on the leeward side and below local water intake structures. In addition to concrete bases, tightly welded film covers or a clay pad at least 20 centimeters thick with sides can be used.



Figure 3.

Example of a concrete pad without a canopy (Creative Commons) and with a canopy (Antoniniduea.it)

If there is insufficient space on the storage area, it is allowed to store it on isolated field sites before spreading (Figure 4). Temporary placement of processed manure before its application to fields is carried out for no more than 5 months, on agricultural lands outside the boundaries of water protection zones of water bodies and zones of sanitary protection of drinking water sources, on the top fertile layer without additional sealed bases.

Fig. 4. Manure pile on the field (Wikimedia Commons)



** Note 2. In this brochure we only consider solid manure, but it makes sense to mention here the approach from Polish experience in relation to not only solid but also liquid waste:*

- *there is necessary to have surface of impermeable places for storing solid natural fertilizers. The surface of places for storing solid natural fertilizers should allow for their storage for a period of 5 months.*
- *the appropriate capacity of covered (in particular with a flexible cover or floating cover) tanks for liquid natural fertilizers, which should have tight bottoms and walls. The capacity of tanks for liquid natural fertilizers should allow for their storage for a period of 6 months*
- *in the case of keeping farm animals on deep litter, manure can be stored in a livestock building with an impermeable floor.*

2.2.1. Technology 1 - Manure and droppings processing by passive composting method

Natural biological disinfection of the manure and manure mixture is carried out by composting in a separate pile on an open concrete pad with or without a canopy (Fig. 5).

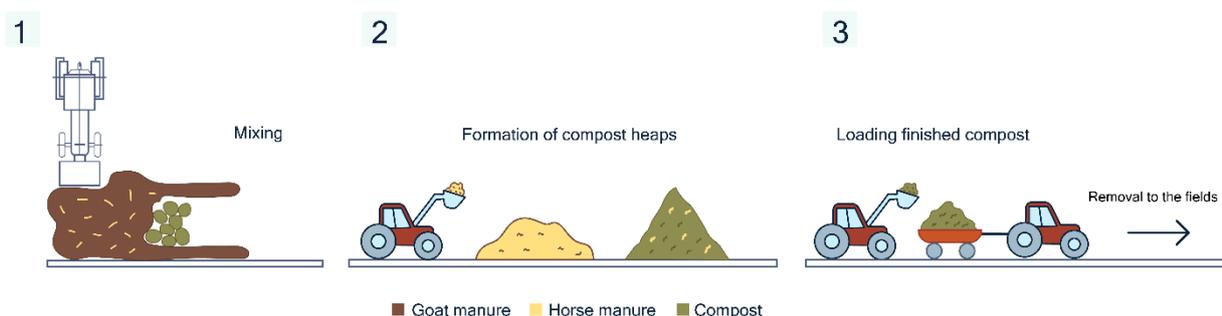


Fig. 5 Example of implementation of the technology “manure and droppings processing by passive composting”

For biothermal disinfection, the moisture content of the compost mixture is not more than 75%, which ensures that the temperature of the entire volume of the mass in the bunker reaches 50-60°C, with the period of keeping the mass in the bunker for at least 2 months in summer (April - September) and 3 months in winter (October - March). In winter, it is recommended to place the compost mixture in 1 stack (heap) to prevent freezing of the compost mixture.

If the manure is not mixed turned on the storage site, 6 months composting are required before it is applied to the land. But with passive composting, due to mixing (depending on the volume - manually, with a front loader or in another way), the mass is enriched with oxygen and composted faster - in 3 months, after which it is applied to the agriculture fields. Passive composting is carried out with the successive addition of new portions of manure on the same site (with visual separation of successive portions).

In the pilot farm, the mass of the mixture (horse and goat manure) for 3 months of the stable period is 52.6 tons, the volume of the mixture for 3 months is 65.8 cubic meters (the density of the mixture is 0.8 t/m³, the density can vary from 0.65 to 0.9 t/m³). The dimensions of the bunker are calculated based on the mass of manure, as well as the values of maximum permissible width and height to reduce the cost of making a concrete pad and are: length 7.3 meters, width 6 meters, height 3 meters. The dimensions of the concrete pad are 9x7 meters.

The entire process on the pilot farm, including accumulation for 2 months, active mixing for 3 months, and extraction for application to the fields, takes up to 8-9 months in total. This schedule (accumulation - holding with mixing - extraction for application to agricultural fields) applies to all portions successively accumulated on this site.

2.2.2 Technology 2 - Treatment of manure and droppings by long term holding method

All manure and droppings is mixed and stacked in one continuous stack on a concreted area with a shed. The area is divided into 2 parts. After expiry of the processing period, manure is transported to the place of application from one part of the site, and a new stack is formed on the second part of the site. Processing is carried out for 6 months.

Similar to 2.2.1. with this holding technology, the entire process on the pilot farm, including accumulation around 2 months, holding for 6 months, and extraction for application to the land, takes

up to 9-10 months in total. This schedule (accumulation - holding - extraction) applies to all portions successively accumulated on this site.

In the pilot farm the mass of the mixture (horse and goat manure) for 6 months is 100.6 tons, the volume of the mixture for 6 months will be 125.8 cubic meters. The dimensions of the stack will be: length 8.5 meters, width 8 meters, height 2 meters. The dimensions of the concreted site are 9x9 meters.

2.2.3 Technology 3 - Processing of manure and droppings by biofermentation in a chamber biofermenter

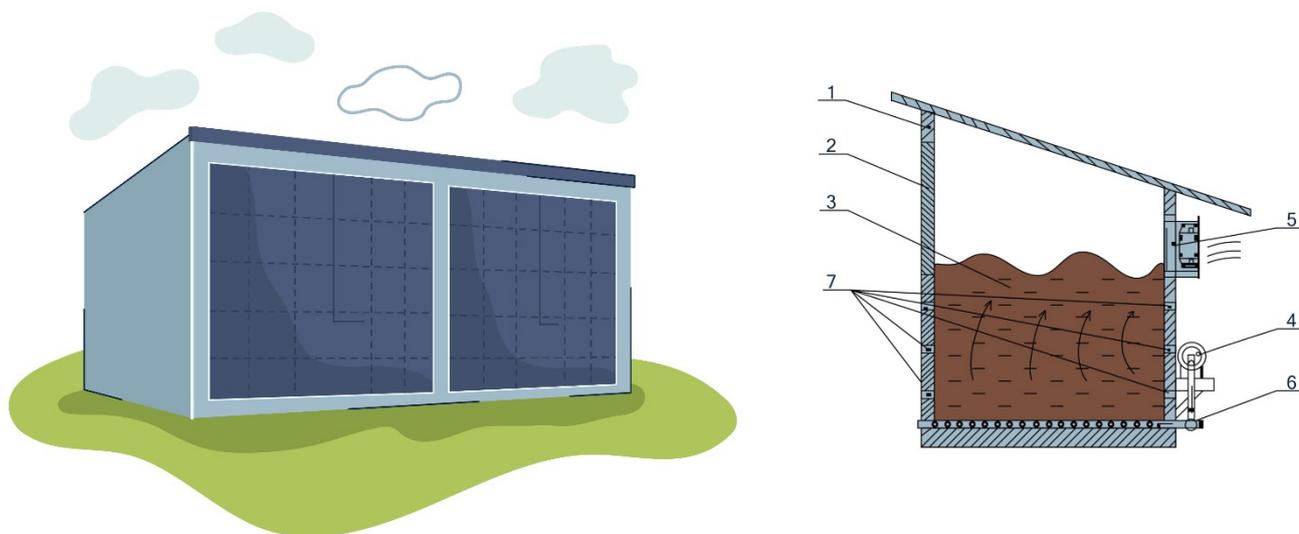


Fig. 6. Innovative autonomous chamber biofermenter. 1 - biofermenter; 2 - gate; 3 - material to be processed; 4 - pressure fan; 5 - exhaust fan; 6 - perforated duct; 7 - holes for temperature and oxygen content determination in the mixture.

Biofermentation technologies are based on oxidation of a part of organic matter by saturating it with atmospheric oxygen, which is accompanied by an increase in temperature. This technology implies provision of optimal conditions for aerobic microflora development in terms of humidity, temperature, reaction of the medium and carbon to nitrogen ratio:

- Humidity: 55...70%;
- Acidity: 5.5...8.0 pH;
- Carbon to nitrogen ratio (C/N): 25...35.

When these parameters are ensured, the guaranteed disinfection of waste from pathogenic microflora occurs.

As a result of researches on aerobic fermentation of the mixture of horse and goat manure on deep bedding it was established that at blending of components of the mixture it is necessary to take 1 share of goat manure on deep bedding and 2 shares of horse manure; the mode of aerobic fermentation is started and goes to thermophilic mode; in the process of aerobic fermentation the mass of the mixture is reduced by 30%, the humidity of the mixture is reduced by 6.5%. The optimal fermentation temperature is in the range of +55...+70 C.

While processing is carried out in the biofermenter, the next portion of animal manure and droppings is accumulated on a concrete pad with a shed before further processing. At the end of the processing period, the processed manure and droppings are unloaded from the biofermenter, temporarily stored before transportation on a free part of the shed area and then transported to the application site. A

new mixture accumulated in another part of the site is loaded into the biofermenter.

For the small-scale pilot farm described here, the external dimensions of the innovative self-contained chamber biofermenter are 2x2x2 meters. The dimensions of the concrete platform with a canopy are 5x5 m. The capacity of the biofermenter is 7.3 cubic meters. The daily mass of horse manure (excreta together with bedding material) is 376 kg (0.47 cubic meters). Since the capacity of the biofermenter is 7.3 m³ and the volume of daily horse manure production is 0.47 m³ (376 kg), it will take approximately 15 days to fill the biofermenter. After the biofermenter is filled, it is closed and the biofermentation process starts, which lasts 7 days. The aeration mode of the mixture is set as follows: after 8 hours of aeration, the compressor is off for 16 hours.

While the biofermenter is working, a new portion of manure (horse and/or goat manure) is accumulated on a concrete pad with a canopy. On the 8th day the processed manure is unloaded from the biofermenter. The next loading of manure from the concreted area with a shed into the biofermenter takes place. If the biofermenter is incompletely filled, the manure generated in the next day from the animal housing is loaded into the biofermenter until it is filled. This technology can be used in addition to technology 2.

The whole process is similar to technologies 1 and 2. For this technology it includes loading of mixture until the biofermenter is fully loaded, manure processing 8 days, and extraction for application to agricultural fields.

2.2.4 Selection of manure and droppings processing technology

In order to select the optimal technology, it is necessary to calculate the mass of manure and manure to be processed. Calculation of the mass of manure and droppings is carried out using the following formulas:

- mass of manure and droppings = mass of manure and droppings in non-pasture period + mass of manure and droppings in pasture period
- mass of manure and droppings during non-pasture period = mass of excreta + mass of bedding material + mass of process water
- mass of manure and droppings during grazing period = (excreta mass + droppings mass + process water mass) • correction factor

The correction factor takes into account the proportion of manure and droppings that remains in the animal housing during the grazing period (animals are on pasture during the day and in the animal housing at night).

The specific capital and operating costs per unit cost (SCPUC and SOPUC) should then be compared and the technology selected. These calculations can be used in an aggregated calculation of the production cost of processed manure and droppings.

Table: Environmental and economic indicators of the considered technologies for a pilot farm

Technology	Mass of processed manure t/year	Mass of nitrogen in processed manure, kg/year	SCPUC Rub/t Eur estimation 2023	SOPUC EUR/t
Technology 1 Manure processing by passive composting	170.6	700	19 - 25	5,3-5,7
Technology 2 Manure processing by long-	191.9	870	18 - 23	5,1 – 5,5

term holding method				
Technology 3: Manure processing by bio-fermentation method in a chamber bio-fermenter	203.7	940	31 - 39	6 - 11

* for manure storage area without canopy, which affects mass losses of nitrogen

The lowest specific capital costs for obtaining 1 ton of processed manure are observed at implementation of Technology 2. The highest one was when implementing Technology 3. Similar situation with specific operational costs: the lowest are at implementation of Technology 2; the highest are at implementation of Technology 3. However, at Technology 3 the least losses of nutrients in the process of manure processing are observed: the mass of saved nitrogen is 940 kg.

At introduction of Technology 2 from capital expenses will be only construction of manure storage under calculation of the formed volume of manure and droppings. Operational costs are lower, as fewer operations will be required for manure and droppings processing than in the other two technologies. Therefore, for this farm, Technology 2, i.e. Manure Treatment by Long Standing Method was selected.

A detailed calculation of the quantitative and qualitative characteristics of the manure produced on the pilot farm is presented in Appendix 1.

2.3 How to apply the processed manure and droppings to the fields?

Before spreading the processed manure and droppings on agricultural land, it is laboratory tested for compliance with the requirements. When manure and droppings is kept for a long time on a specialized site with a shelter, the weight loss is 1%. Loss of total nitrogen is 10%. For the pilot farm, the mass of manure processed (excluding manure left on pasture) is 200 t/year. The mass of nitrogen in the processed manure including 10% loss is 927 kg/year. Specific mass of nitrogen is 4.7 kg/t.

Manure and droppings should be applied to fields in accordance with the Helsinki Commission recommendations for the protection of the Baltic Sea marine environment from all sources of pollution described above (see section 1.2). The limiting factor in calculating the application doses of processed manure and droppings is their nitrogen content. Calculation of the application rate is based on the crop rotation and the crops being cultivated. According to the Helsinki Commission recommendations, the maximum amount of nitrogen that can be applied to fields with processed manure and droppings is 170 kg/ha. Application of processed manure and droppings should not lead to excessive accumulation of elements and their compounds in the soil.

Ryegrass and clover for green mass are grown on the land of the pilot farm. The application dose of processed manure for these crops is 36.2 t/ha. The application dose is calculated based on the specific nitrogen mass (4.7 kg/t) and the nitrogen application limit (170 kg/ha): $170/4.7=36.2$ t/ha. Since the mass of processed manure is 200 t/year (excluding manure left on pasture), the required land area for its application to ryegrass and clover is 5.5 ha. The area of available land on the farm is 7 ha. Surplus processed manure was sold.

2.4. Recommendations in case of epizootic outbreak

The entire volume of manure and droppings produced from the onset of the epizootic within 45 days is accumulated and processed separately. It is important to monitor the quality of manure and manure decontamination throughout the epizootic period. The choice of the method of manure and dung disinfection is made on the instructions of the veterinary service, taking into account the danger of

the epizootic situation, the type of pathogen, availability and type of chemical reagents and technical means.

It is necessary to keep constant control of sanitary and epidemiologic situation on the farm. In case of detection of manure and manure infected with pathogens of infectious and invasive diseases, it is necessary to organize sanitary measures to prevent the spread of infection outside the farm.

Conclusions

The experience of the pilot farm described above has shown that it is possible to organize storage, processing and use of manure in an environmentally friendly and economically feasible way on a small-scale farm. The described approaches are in line with current HELCOM and EU recommendations, can be replicated and can contribute to the implementation of the BSAP.

The Baltic Sea Action Plan (BSAP) <https://helcom.fi/baltic-sea-action-plan>, adopted by the HELCOM Contracting Parties in 2007 and updated in 2021, is HELCOM's strategic programme of measures and actions for achieving good environmental status of the sea, ultimately leading to a Baltic Sea in a healthy state. Since its adoption, the BSAP has resulted in a number of environmental improvements such as a reduction in nutrient inputs to the sea, a better state of biodiversity and a decrease in maritime incidents and spills.

The BSAP provides a specific basis for HELCOM work. It incorporates the latest scientific knowledge and innovative management approaches into strategic policy implementation, and stimulates goal-oriented multilateral cooperation around the Baltic Sea region.

The Baltic Sea Action Plan concerns not only the activities of national governments, but also of ordinary farmers living in the Baltic Sea basin. Sustainable manure and droppings management is not only an effective solution for managing organic waste on farms, but also an important step towards preserving the Baltic Sea ecosystem. Compliance with the requirements of the Helcom Action Plan allows farmers to minimize the negative impact of agricultural activities on the region's water resources, contributing to improved water quality and biodiversity conservation.

Investments in technologies such as composting, biogas plants and other recycling practices offer new opportunities to improve business profitability and add value. These practices not only recycle waste but also produce useful products such as organic fertilizers and renewable energy.

Adopting sustainable recycling practices will help farmers become active participants in the environmental movement and promote sustainability in their community. The synergy between agriculture and environmental stewardship will not only ensure that farms thrive, but also the health of future generations.

Remember, your actions can influence the environmental sustainability of the entire Baltic Sea ecosystem. Let's build a greener and safer future together!

You can read more about how to become an environmentally friendly Baltic Sea farmer and reduce your impact on the marine ecosystem on the website of the Clean Baltic Sea Coalition (CBC) in the document Acceleration of BSAP Implementation <https://www.ccb.se/accelerating-the-baltic-sea-action-plan-implementation-a-call-to-action-for-a-healthier-baltic-sea>.

Appendix 1

Calculation of excreta yield, mass of process water and bedding material for small-scale farms

The excreta yield from goats, process water mass and droppings mass was calculated based on experimental data. The excreta yield from horses, mass of process water and mass of bedding material was also calculated based on experimental data. Calculation of animal excreta and waste (process) water yields, as well as the need for bedding is given for each room separately. Calculation of manure storage is made without taking into account the mass of manure and droppings left on pastures.

Table 5. Results of goat and horse manure yield calculations

Animal group	Population, head	Excrement weight per 1 head, kg/day	Mass of process water per 1 head, kg/day	Weight of bedding per 1 head, kg/day	Weight of manure for 245 days stall period, tons	Weight of manure for the pasture period, t	Manure weight for a year, t	Manure moisture, %
Adult goats	30	4.2	0.5	1	41.9	17.4	59.3	67.9
Young animals	15	1.5	0.5	0.5	9.2	2.3	11.5	66.4
TOTAL	45				51.1	19.7	70.8	67.6
Stallions aged three years and older	3	42	0	4	33.8	14.1	47.9	74.8
Geldings, mares aged three years and older	7	30	0	4	58.3	24.3	82.6	73.6
TOTAL	10				92.1	38.4	130.5	74

Indicator	Value
Carbon content in horse manure, %	13.32
Nitrogen content in goat manure, %	0.86
Carbon content in goat manure, %	14.77
Weight of nitrogen in the mixture per year, t	1.03
Weight of carbon in the mixture per year, t	27.8
C/N	27

Table 6: Calculation of horse and goat manure mixture

Indicator	Value
Weight of horse manure per year, tons	130.5
Moisture content of horse manure, %	74
Weight of goat manure per year, t	70.8
Moisture content of goat manure, %	67.6
TOTAL mass of mixture per day, kg	584.5
TOTAL mixture moisture, %	71.7
Nitrogen content in horse manure, %	0.32

Appendix 2

HELCOM's main recommendations on manure handling in the Baltic Sea region

HELCOM RECOMMENDATION 7/2

(supplemented by HELCOM Recommendations 9/3, 13/7, 13/2 and 14/4)

Adopted 11 February 1986, having regard to Article 13, Paragraph b) of the Helsinki Convention

RECOMMENDATION CONCERNING MEASURES AIMED AT THE REDUCTION OF DISCHARGES FROM AGRICULTURE

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties to the Helsinki Convention that:

a) the farming practice should be managed under the following conditions:

- (i) the storage facilities for manure and silage should be improved, including effluent control;
- (ii) the cultivation practice should be carried out with optimum use of nutrients, e.g. fertilization plan, soil mapping, timing, dosage, spreading technique, crop rotation;
- (iii) in animal husbandry, a certain area of farmland should be designated per animal to avoid harmful leaching to the environment as a consequence of manure spreading and/or animal pasturing;
- (iv) water protecting zones should be established along specified eutrophication sensitive water bodies, taking into account local conditions;
- (v) household wastewater, washing water from milking, cleaning of machines etc. should be controlled;

b) the knowledge about agricultural practice and environmental problems should be improved, i.e. by:

- (i) informing and educating farmers and advisors on environmental effects of the use of fertilizers and agricultural practices;
- (ii) carrying out research work on environmental effects of farming management, cultivation practice, choice of crops, and developing the best cultivation practice from an environmental point of view;
- (iii) monitoring the losses of nutrients;

c) it should also be stressed that the Contracting Parties should have close cooperation and exchange of experience with regard to environmentally sound agricultural practice.

HELCOM RECOMMENDATION 9/3

(was supplemented by HELCOM Recommendations 13/7-13/12 and 14/4)

Adopted 15 February 1988, having regard to Article 13, Paragraph b) of the Helsinki Convention

RECOMMENDATION CONCERNING MEASURES AIMED AT THE REDUCTION OF NUTRIENT DISCHARGES FROM AGRICULTURE

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties to the Helsinki Convention that:

a) farming practice should be managed so as to favour the efficient use of the nutrients that are available in the agricultural system;

- b) farms with livestock production above a certain size should require approval with regard to environmental aspects;
- c) farming practice with regard to manure should be in accordance with the following principles:
 - (i) the capacity of the storage facilities should be sufficiently large to ensure that manure need only be brought out when the plants can use the nutrients;
 - (ii) the ammonia evaporation from the storage and use of liquid manure (urine and slurry) should be reduced by incorporating the manure without delay into the soil when it is used on bare soil;
 - (iii) the application of manure on bare soil in the autumn should be restricted; (iv) the application of manure on frozen soil should be restricted;
- d) where it is possible a large part of the cultivated area should be covered by crops - for example winter seed, grass or catch crop - during the autumn and winter;
- e) programmes should be developed to control and monitor the effect of these measures, or any other measures taken to reduce nutrient discharges from agriculture, on the pollution load on the surface waters.

HELCOM RECOMMENDATION 13/9

Adopted 6 February 1992 having regard to Article 13, Paragraph b) of the Helsinki Convention

REDUCTION OF NITROGEN, MAINLY NITRATE, LEACHING FROM AGRICULTURAL LAND

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties that:

- a) artificial fertilizers and animal manure should be applied according to crop need. This principle should be promoted, e.g., by the use of:
 - economic incentives used by the authorities to reduce nutrient application and to promote the development of a sustainable agriculture;
 - fertilizer and crop-rotation planning and calculation of nitrogen balance, i.e., with a specification of crop need and applied amounts of nitrogen fertilizers;
 - prognosis tools for nitrogen application, such as assessment of soil mineral nitrogen contents, soil nitrogen mineralization potential, or the use of calculation methods,
- b) utilization efficiencies of animal manures should be enhanced by:
 - application of animal manure shortly before or during the early growing season;
 - establishing of six to twelve month storage capacity for animal manure depending on farming system, climate and soil conditions;
 - develop governmental programmes for financial support for farmers' investments in storage capacity;
 - upper limits for application of animal manure, corresponding to 170 kg N (approximately 2 animal units) per hectare annually *); these upper limits might be exceeded in the following cases:
 - (i) long growing seasons,
 - (ii) crops with high nitrogen uptake,
 - (iii) high net precipitation in the vulnerable zone,
 - (iv) soils with exceptionally high denitrification capacity;
 - promote studies on nutrient contents of animal manures and the related conversion factors to animal units,
- c) utilization efficiency of artificial fertilizers should be promoted by integrated plant

production **),

- d) green fields should cover 50% of the agricultural land, or the highest possible percentage with respect to climate and soil conditions, e) further distribution and increased utilization efficiency of animal manure may additionally be promoted by, e.g.:
- slurry banks for surplus manure, possibly in connection with degassing of animal manure in large scale biogas plants;
 - use of large lorries, possibly in combination with small application units,

f) programmes should be developed and action taken to implement the above mentioned measures and to

report on the effect of these measures or any other measures taken to reduce nitrogen leaching from agricultural land,

Footnote:

*) The 170 kg N per hectare stems from the Nitrate Directive of the European Community.

**) In this aspect integrated plant production is a farming practice which optimizes the utilization efficiency of fertilizers through a precise determination of the optimal fertilization level and the use of appropriate crop rotations.

HELCOM RECOMMENDATION 13/12

Adopted 6 February 1992, having regard to Article 13, Paragraph b) of the Helsinki Convention

MANAGING FRESHWATER ECOSYSTEMS FOR RETENTION OF NUTRIENTS

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties that increased nutrient retention in freshwater systems should be considered through, e.g.:

- (i) programmes for re-establishing wetlands and smaller lakes;
- (ii) plugging of drainage pipes in abandoned meadows;
- (iii) allowing natural and re-establishing of the meandering of watercourses, inter alia, taking into account the infrastructure, by means of a combination of green fallowing and the restoration of watercourses;
- (iv) introduction of environmentally sound practices for weed mowing and maintenance of watercourses;
- (v) programmes should be developed and action taken to implement the above mentioned measures and to report on the effect of these measures or any other measures taken to reduce nutrient discharges,

HELCOM RECOMMENDATION 37/3

Adopted 11 March 2016,
with regard to Article 20, Paragraph 1 b)
of the Helsinki Convention

SUSTAINABLE AQUACULTURE IN THE BALTIC SEA REGION

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties to the Helsinki Convention to jointly develop by 2018 Best Available Technology (BAT) and Best Environmental Practice (BEP) descriptions for sustainable and environmentally friendly aquaculture in the Baltic Sea region and apply them, based on Annex II of the Convention and the following

principles:

1. to endeavor, when developing marine and freshwater aquaculture, to maintain or restore ecosystem functions and services, to prevent or minimize emissions and discharges, minimize negative environmental effects (by e.g. spatial planning) and to relieve pressure on wild fish stocks;
2. to ensure that possible negative impacts from aquaculture will not hinder the achievement of a good environmental/environmental/chemical status, as agreed upon in HELCOM BSAP and relevant national and international legislation;
3. to take full account of nutrient discharges and losses from marine aquaculture in an overall endeavor by the Contracting Parties to keep inputs within Maximum Allowable Inputs for nitrogen and phosphorus for the Baltic Sea basins, as agreed at the 2013 HELCOM Copenhagen Ministerial Meeting and in its possible future updates;
4. to foster development and innovation towards ecologically sustainable farms and aquaculture technologies, including nutrient neutral and nutrient extractive ones, to avoid or minimize, and mitigate discharges of nutrients, organic matter, litter, chemicals and handling of escapees and diseases, as relevant;
5. to employ regional planning as an instrument for directing aquaculture activities to suitable areas and for mitigating conflicts between aquaculture and other uses of that area. Fish farms should not be placed in areas reserved for nature protection, if that might conflict with the aims of protection for that area;
6. to avoid or minimize potential negative impacts when establishing new or enlarging existing aquaculture facilities in the Baltic Sea Region;
7. to manage marine and freshwater aquaculture on the basis of the Ecosystem Approach, taking into account, inter alia, potential risks and impacts on the environment arising from the introduction of non-indigenous species, and the ecological and genetic impacts on wild fish stocks and from unintended releases of indigenous species,
8. to make better use or establish and maintain national databases of aquaculture or water permits and monitoring data in co-operation with the aquaculture sector. A better assessment of the nutrient loads from aquaculture should be based on data collected and reported to the HELCOM PLC database;
9. to develop specific measures aimed at reduction/mitigation/prevention, as appropriate, of nutrient release into the Baltic Sea, which have to be implemented simultaneously with the growth of fish production, consistent with measures foreseen in the national aquaculture development strategies;
10. to avoid the use of genetically modified species;
11. to ensure that the use of hormones does not impact the environment negatively;
12. in areas where the water quality status is deteriorated and where ecologically possible, aquaculture that contributes to improving the status of the aquatic environment should be encouraged. The promotion of such aquaculture systems should not deter from measures to address nutrient input close to source.

HELCOM RECOMMENDATION 41/3

Adopted 4 March 2020
with regard to Article 20, Paragraph 1b)
of the Helsinki Convention

THE USE OF NATIONAL MANURE STANDARDS

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties to the Helsinki Convention:

- a) to establish as well as review and update, if necessary, the national standard values for manure every 4 years following the Guidance for advanced manure standards and sampling (Annex 1), and

on the basis of data specified in the Guidance for collection of manure management data (Annex 2), taking into consideration geographical and climate conditions as well as practices and structure of the national livestock sector;

b) to ensure efficient utilization of nutrients through fertilization planning at farm level, taking into account soil and climate conditions, soil nutrient content and soil type, previous crop as well as the planned crop;

c) to use updated national standard values for manure in fertilization planning and nutrient bookkeeping in compliance with the application rates for nutrients specified in Annex III part II of the Helsinki Convention or national fertilization limits if stricter than the limits in Annex III part II;

d) that in case complementary analysis of nutrient content in manure is needed, manure sampling and analysis are carried out in accordance with the Guidance for advanced manure standards and sampling (Annex 1);

e) that in case manure is processed, sampling and analysis to determine the nutrient content of the processed products are also carried out following the Guidance for advanced manure standards and sampling (Annex 1); f) to utilize the national standard values for manure to identify areas with surplus of nutrients, to quantify nutrient load from agriculture and to evaluate the effectiveness of measures in order to reduce nutrient leaching and to support implementation of the EU Nitrates Directive, Water Framework Directive, Marine Strategy Framework Directive, National Emission Ceilings Directive as well as implementation of other relevant national or international water protection regulations;

g) to use the national standard values for manure in inventories and reporting of ammonia and greenhouse gas emissions;

h) to use the national standards to enhance nutrient recycling;

i) to use various regional platforms for international dialogue to exchange information regarding national manure standards.

HELCOM RECOMMENDATION 42-43/5

Supersedes HELCOM Recommendation 24/3

Adopted 20 May 2024, having regard to Article 20, Paragraph 1b) of the Helsinki Convention

MITIGATION OF AMMONIA EMISSIONS FROM AGRICULTURE

THE COMMISSION RECOMMENDS to the Governments of the Contracting Parties to the Helsinki Convention:

A) that the following principles of nitrogen management in general are taken into account when considering measures to abate ammonia emissions from agriculture:

Principle a: It is important that there are different measures available to mitigate and reduce N emissions, but specific measures are needed to target ammonia emissions. Most of agricultural ammonia emissions are formed in livestock production and especially manure management, to which measures to reduce ammonia emissions should thus be targeted.

Principle b: The purpose of integrated sustainable nitrogen (N) management in agriculture is to decrease nitrogen losses to the environment, while ensuring high nitrogen use efficiency through appropriately balanced nitrogen inputs.

Principle c: Though potential trade-offs need to be addressed when abating/mitigating emissions, it is simultaneously necessary to enable the choice of a measure or a group of measures which have as efficient an impact as possible on ammonia emissions, while having the least trade-offs.

Principle d: Nitrogen input control measures influence all N loss pathways. These are attractive measures because reductions in N input (e.g., by avoidance of excess fertilizer, of excess protein in animal diets, and of human foods with high nitrogen footprint), lead to less nitrogen flow throughout

the soil-feed-food system. Principle e: It is both economically and environmentally sustainable to reduce N evaporation from livestock manure, as more N is then directed to fertilization in manure and subsequently to harvested yield, resulting in less supplementing fertilization needed.

Principle f: The nitrogen input-output balance encapsulates the principle that what goes in must come out, and that N input control and maximization of N circulation in agricultural systems (in manure, soil and plants) are main mechanisms to reduce N losses.

Principle g: In order to minimize pollution associated with N losses from fields, all factors that define, limit and reduce crop growth have to be addressed simultaneously and in balance to optimize crop yield and N use efficiency.

B) that the following most relevant or similarly effective measures to reduce ammonia emissions from agriculture are recommended for use on all farms when technologically possible and/or economically feasible. Additional measures to reduce ammonia emissions are included in annex 1.

1. Integrated sustainable nitrogen management

- Use nitrogen input-output budgeting tools to integrate N sources and N species for well-defined areas at various scales;

2. Livestock feeding strategies

- Adapt protein intake in diet of all livestock;
- Increase lifetime productivity (dairy and beef cattle);
- Increase longevity (dairy cattle);

3. Animal housing techniques

- Apply more frequent removal of manure to storage and cleaning of housing surfaces;
- Use ammonia-absorbing litter/bedding materials;
- Treat exhaust air by acid scrubbers or biofilters;

4. Manure storage

- Cover the manure storages, preferably with a tight lid, roof or tent or with plastic sheeting;
- Apply adequate storage capacity for the manure produced;
- Reduce the surface area of manure storages by e.g. encouraging replacement of existing lagoons by tanks/silos;
- Cover temporary (time limited) manure heaps;
- Encourage acidification of liquid livestock manure/slurry, if technologically feasible;

5. Field application of organic and inorganic fertilizers

- Compile/establish a fertilization plan;
- Apply nutrients at the appropriate rate and weather conditions;
- Use low-emission manure spreading techniques, such as trailing hose, trailing shoe, injection or acidification, rapid incorporation into soil;

6. Emission-reducing manure processing and nutrient recovery on farms, such as

- Mechanical solid-liquid separation of liquid livestock manure/slurry;
- Anaerobic digestion of manure;
- Pelletizing, granulation of manure;

The impact of manure processing on ammonia emissions depends on the technology chosen and also the measures taken prior to the processing step and with the storage and application of the end-products.

7. Other measures related to agricultural nitrogen

- Encourage sustainable and balanced grazing.

C) to monitor the ammonia emissions from agriculture and verify the impacts of the measures, e.g. with modelling.

D) to support research:

- that produces data and models required to optimize the management and use of N-fertilizers, including livestock manure;
- that quantifies the effectiveness of measures to reduce ammonia emissions with particular consideration of techniques and machinery used in practical farming (avoid experimental proxy systems);
- that analyses and develops the technical, economic and environmental aspects of fertilizer and manure management, application, processing technologies and other aspects that support the reduction of ammonia emissions.

Annex 1. Additional information on measures to reduce ammonia emissions from agriculture

This document provides background for measures to reduce ammonia emissions from agriculture. In addition to the measures recommended as most relevant in the Recommendation, annex 1 outlines also other examples of concrete measures to mitigate ammonia emissions from agriculture. The list is not exhaustive and other suitable measures may also be available.

1. Integrated sustainable nitrogen management

Measures:

- Nitrogen input-output budgeting tools to integrate N sources and N species for well-defined areas at various scales (from farms to continents) and that are easy-to-understand by farmers, advisors, fertilizer and feed producers, authorities and policy makers

Calculation is mainly an informational tool about the possible losses but not the tool to reduce ammonia emissions directly.

Additional measures:

- Stakeholder dialogue and communication are essential for exchanging views between actors in N management issues, which can help make the concepts transparent and facilitate the adoption of targets and the implementation of measures in practice.

2. Livestock feeding strategies

The most crucial step is to adapt the N content in the livestock diet as closely as possible to the requirements of the animals. This ensures the health and productivity of the animal, while avoiding unnecessary excretion of nitrogen into faeces and urine.

Measures:

- Adapt protein intake in diet of all livestock

Feeding measures include e.g. phase feeding, formulating diets based on digestible/available nutrients, using low-protein, amino acid supplemented diets, and feed additives/supplements. The crude protein content of the animal ration can be reduced if the amino acid supply is optimized through the addition of synthetic amino acids. For dairy and beef cattle increasing the energy/protein ratio in the diet is a well-proven strategy to reduce levels of crude protein.

- Increase lifetime productivity (dairy and beef cattle)
- Increase longevity (dairy cattle)

Increasing the nutrient use efficiency (NUE) by improving animal performance (milk yield, growth rate, feed conversion efficiency, etc.), so that a diminishing proportion of the total protein requirement is used for maintenance. Increase productivity while not decreasing longevity.

3. Animal housing techniques

Ammonia volatilization depends on temperature and pH; the higher they are, the higher the risk for volatilization. Limited manure surface area to ambient air reduces the risk.

Priorities for ammonia reduction: (i) reduction of indoor temperature, e.g. by optimized ventilation; (ii) reduction of emitting surfaces and soiled areas; (iii) reduction of air-flow over soiled surfaces; (iv) use of additives (e.g., acidification), and (v) regular removal of manure to an outside storage.

Measures:

- More frequent removal of manure to storage and cleaning of housing surfaces
- Use of ammonia-absorbing litter/bedding materials
- Treatment of exhaust air by acid scrubbers or biotrickling filters; use of acid air scrubbers (cattle, pigs, poultry), use of biological air scrubbers (pigs, poultry)

Additional measures:

- Immediate segregation of urine and faeces
- Reducing manure surfaces, such as soiled floors
- Using manure aisles with deeply grooved floors (cattle housing)
- Partly slatted floors in pig housing (slurry systems)
- Increase bedding material (cattle, pigs with solid manure)
- The collection of manure on belts and drying it in housing of laying hens; Rapid drying of poultry litter
- Keeping the litter dry in broiler housing and in storage
- Lowering the indoor temperature and ventilation as animal welfare and/or production allow
- Slurry acidification during housing (pig and cattle housing)
- Cooling the manure

4. Manure storage (slurry, solid manure, processed manure)

Ammonia volatilization from storage of manure and organic fertilizers is dependent on their pH and temperature, the type of storage and volume to surface ratio of storage. Covering and reducing the surface area of the storages reduce volatilization. Concomitantly it is good to consider measures to reduce methane emissions.

Measures:

- Covering the manure storage with tight lid, roof or tent or with plastic sheeting
- Adequate storage capacity for the manure produced
- Reducing the surface area of manure storages e.g. by replacement of lagoons by tanks/silos
- Covering of temporary (time limited) manure heaps
- Slurry acidification (manure storage)

5. Field application of organic and inorganic fertilizers

Ammonia is easily volatilized during and after the application of organic (incl. manure) and inorganic fertilizers. Application technology and the conditions (temperature, wind) during and after the application affect the emission risk significantly. Also, additives can be used to reduce the volatility of ammonia.

Measures:

- Compiling/establishing a fertilization plan
- Apply nutrients at the appropriate rate and weather conditions
- Low-emission manure spreading technique (trailing hose, trailing shoe or injection, rapid incorporation into soil)

Additional measures:

- Using well-studied urease inhibitors with urea or urea ammonia nitrate solution fertilizers
- Slurry acidification (during field application)
- Replacing urea-based fertilizers by ammonium nitrate based fertilizers
- Controlled release fertilizers
- Precision fertilization
- Fertigation: in areas subject to drought or limited soil water availability, the efficiency of water and

N use should be managed in tandem

- Limit and avoid the spreading of fertilizers and manure during high-risk weather conditions

6. Manure processing and nutrient recovery

Manure can be processed to concentrate nutrients into smaller volumes and/or to separate phosphorus and nitrogen into different fractions. The rationale behind manure processing can be nutrient recovery and enhancement of their use efficiency and/or reallocation of manure nutrients from regions of dense livestock production to regions with crop production. Some of the technologies are more feasible only on a larger scale, while others can also be used on a farm scale. The impact of manure processing on ammonia emissions depends on the technology chosen and also the measures taken prior to the processing step and with the storage and application of the end-products.

Measures:

- Mechanical solid-liquid separation of slurry
- Anaerobic digestion of manure
- Pelletizing, granulation;

Additional measures:

- Solid-state fermentation
- Thermal processes, such as combustion, gasification, pyrolysis, drying, hydrothermal carbonization
- Struvite precipitation
- Ammonia stripping and recovery
- Membrane filtration
- Evaporation

7. Other measures related to agricultural nitrogen

Ammonia gas, a localized pollutant containing nitrogen and hydrogen, is produced when urea, in urine, and the enzyme urease, in faeces, mix. When animals are out in the field, they rarely urinate and droppings in the same place. Therefore, when grazing animals urinate and urine is not mixed with faeces, there are reduced opportunities for the urease enzyme to breakdown the urea producing ammonia. Whilst urease is naturally present in the soil, it is at a much lower level than faeces and therefore the associated ammonia emissions are reduced.

Measures:

- Grazing

A reduction of ammonia emissions from ruminants can also be achieved by increasing the proportion of time that the animals spend grazing. This is because much of the urine infiltrates into the soil before urea is degraded and lost as ammonia. Nevertheless, the total N efficiency of grazing systems tends to be lower than that of cut grassland due to the uneven distribution of the excreta. The extent of grazing is typically limited by climatic and soil conditions as well as farm structure. A minimum period of grazing per year may be required in some countries for animal welfare reasons.

Appendix 3.

Examples of good practices from the Baltic Sea basin countries

These examples were taken from the results of the annual Baltic Sea Farmer Award and other open sources. Every two years WWF provides the Baltic Sea Farmer Award, addressed to farmers who make a difference, and sustainable organic waste and manure management among the most important priorities of this competition. The Baltic Sea Farmer Award recognizes farmers who implement measures on their own initiative to reduce nutrient runoff and help put a stop to eutrophication.

Gut Groß Voigtshagen farm (Germany): Enabling more targeted fertilization with biomass mapping.

<https://www.wwfbaicfarmer.org/manure-management-and-conservation-practices-yield-richer-harvests-at-this-farm/>

Farm facts:

Location: Mecklenburg-Vorpommern, Landkreis Nordwestmecklenburg, Region Klützer Winkel, Germany **Type of farm:** Conventional crop farm (860 ha)

Main production: Winter wheat, winter barley, spring barley, fieldbeans, winter oilseed rape, silage maize **Key practices:** Protecting soil structure from compaction, catch crops, enriching soil with organic matter, buffer zones, water management, nutrient balance and balanced fertilization, correct timing and conditions for fertilizer application, careful manure application techniques, use of manure in plant production, precision farming, nutrient recycling.

The farmers have implemented a number of measures to prevent nutrient runoff from their fields, including establishing 20 metre wide buffer strips along all watercourses and field troughs, and planting catch crops. They also take care to apply fertilizer as precisely as possible. A task that can be especially tricky given the changeable weather patterns of the region. “We farmers always have to make our decisions based on the short and medium-term weather patterns,” says Axel. “The more accurate the forecasts, the lower the risk of misapplication.” Gut Groß Voigtshagen also participates as a pilot farm in a project that involves binding carbon in the soil by building up humus with the hope of contributing to climate protection by selling certificates to companies. “Our current crop rotation already has a positive humus balance, but our goal is to improve this further,” says Axel. To achieve their goal, the farmers are expanding their crop rotation, cultivating catch crops, and using organic fertilizer.

An agricultural cooperative in Bartelshagen 1 (Germany): Conventional agriculture and environmental protection can go hand in hand. <https://www.wwfbaicfarmer.org/bsfya-germany-2019/>

Farm facts:

Location: Marlow in northern Germany

Type of farm: Conventional crop and livestock (3,420 ha)

Main production: Crops, including winter rape, beets, maize, winter barley, winter wheat, grain lupines, potatoes, winter rye, oats, and grass seed. Dairy cows, suckler cows and offspring, geese, ducks guinea fowls, chickens and turkeys

Key practices: Buffer zones, catch crops, catchment ponds, closed nutrient cycle, crop rotation, manure management, nutrient analysis, permanent grasslands, precision technology and timing, preservation of trees, shrubs and other natural elements.

Experiments on integrated crop protection and fertilization have been a key part of developing a better fertilization strategy. The selection of catch crop varieties has now been adapted according to nutrient requirements. Liquid manure is spread using drag hoses on growing crops in good weather

conditions and is immediately incorporated within two hours. Protective, 15–20 meter buffer zones have been added along all running water – subsequently reducing nutrient runoff by about 50%. Drainage system maintenance is also prioritized on the farm to further reduce nutrient leaching. Additionally, about 100 hectares of permanent grassland is maintained, free from fertilizers or chemicals. “By keeping broad crop rotations and catch crops, we’ve observed good pre-harvest effects which, in turn, has reduced fertilizer and pesticide expenditures,” says Wilfried of the results.

Kroghof Farm (Germany): Efficient nutrient usage is at the heart of all management decisions at this farm

<https://www.wwfbaicfarmer.org/germany-2018>

Farm facts:

Location: Börnsdorf in northern Germany

Type of farm: Conventional crop and livestock farm (182 ha)

Main production: Various field crops, cash crops, root crops, sugar beets, potatoes, dairy cows and pigs

Key practices: Samplings, rapeseed crop weighing, nutrient budgets, crop rotation, manure management

Kroghof Farm is a family enterprise. Their combined 182 hectares supports a diverse variety of cash crops, 75 milking cows, and 25 pigs. The efficient usage of nutrients has always been a core value of the family’s farming practices. In conjunction with the advisory, Alfred tested a number of measures with the objective of minimizing nutrient losses and runoff. The measures included sampling, rapeseed crop weighing, manure management and nutrient budgets. Implementation was so successful, a deep drilling sample later revealed that, of all the reference farm holdings, the plot tested on the Kroghof Farm had the lowest nitrate concentrations by far (40 mg/l).

Limousin Cattle Farm (Lithuania): Manure management and conservation practices yield richer harvests at this farm <https://www.wwfbaicfarmer.org/manure-management-and-conservation-practices-yield-richer-harvests-at-this-farm/>

Farm facts:

Location: Stulgiai Village, Kelmė district, Nemunas (Memel) River catchment, Lithuania

Type of farm: Organic cattle farm (72 ha)

Main production: Beef cattle and spring cereals

Key practices: Protecting soil structure from compaction, enriching soil with organic matter, buffer zones, nutrient balance and balanced fertilization, correct timing and conditions for fertilizer application, careful manure application techniques, use of manure in plant production. “Although the description of manure and slurry requirements is valid everywhere, the way they are complied with is important,” says Arūnas. The farmers feed their cattle farm-grown grains, which are crushed and combined with biological preservatives. They use an abundant amount of straw in the barn litter and, in order to reduce the emission of nitrogen and other substances during the barn period, they treat the litter with biological substances that promote the decomposition of organic matter by fixing nitrogen. For added protection of local water bodies, the farmers maintain unplowed buffer zones around the canals and along the river. Furthermore, the farm abstains from the use of herbicides, fungicides or other harmful chemicals in all their operations.

Puutsa Farm (Estonia): Manure can be both a polluter and a biodiversity starter. It all depends on how it is handled <https://www.wwfbaicfarmer.org/manure-can-be-both-a-polluter-and-a-biodiversity-starter-it-all-depends-on-how-it-is-handled>

Farm facts:

Location: Jõgevamaa, Põltsamaa parish, Tõrve village

Type of farm: Organic cattle farm (300 ha)

Main production: Beef, cereals and oilseeds

Key practices: Year-round plant cover, protecting soil structure from compaction, catch crops, enriching the soil with organic matter, buffer zones, water management, nutrient balance and balanced fertilization, correct timing and conditions for fertilizer application, careful manure application techniques, use of manure in plant production, precision farming, nutrient recycling. The manure composted on Puutsa Farm is applied to temperate and short-term grasslands on the property to improve the soil biome. By doing so, Airi has managed to enrich formerly conventional farmlands and transform them into grasslands with a biodiverse mix of seeds. Rotational grazing is employed to further improve soil biodiversity, and decrease the risk of overgrazing. Additionally, the farm's everyday management seeks to promote nature restoration. This includes efforts to maintain water bodies near the farmlands, and keep trees and natural elements on the landscape which benefit both biodiversity and the health of farm animals. And, to gain a bigger picture of the farm's climate footprint, she participated in the CAP2ER programme and mapped it out. The results revealed that her farm sequesters 2.3 kg of carbon per live weight gain.

Kowalski Farm, Poland: My grandfather and father thought that nature could handle any pest and disease well – the only condition was not to disturb her <https://www.wwfbalticfarmer.org/bsfya-poland-2018/>

Farm facts:

Location: Nasielsk in central Poland

Type of farm: Conventional crop and livestock farm (130 ha)

Main production: Pigs and various crops – including cereals, rapeseed, flax and legumes

Key practices: Nine midfield wetlands, buffer zones, midfield margins, shrubs, shelter belt, cultivation of stubble crops (peas with flax) and fabaceae plants, places for storing natural fertilizers (wall tightness checked by tests), precise fertilization, soil liming, soil testing, annual testing of fodder and water for nitrates and pesticides. Both measures such as midfield wetland construction and buffer zones, as well as good practices such as precise fertilization, soil liming and testing. The farm produces a traditional breed of pigs, and practices for environmentally friendly manure and slurry handling have been implemented. The farm retains and expands tree islands and forested buffers along the river and in between the fields which, in addition to reducing nutrient runoff, also protects wildlife and biodiversity. Helping pollinators by maintaining hives also contributes to keeping the farm in harmony with nature.

PUBLISHED IN 2025

Coalition Clean Baltic

FOR PROTECTION OF THE BALTIC SEA ENVIRONMENT

CONTACTS

ÖSTRA ÅGATAN 53
753 22 UPPSALA
SWEDEN

SECRETARIAT@CCB.SE

WWW.CCB.SE

