Closing the mineral cycles at farm level

Good practices to reduce nutrient loss in the North-Brabant region (Netherlands)
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Nutrient loss – Why does it matter?

Nitrogen, phosphorus and potassium are essential for agricultural production as they nourish the crops and support soil productivity. However, if these nutrients are not taken up by plants, they run the risk of being lost in various ways (e.g., leaching, run-off, emissions) and causing unnecessary costs for the farming business. Finding the right amount required by the plants and optimising the timing and application of the nutrients to match these needs can result in an economic gain and a positive effect on human health and the environment, including soil health and fertility.

This leaflet was developed in the framework of the project “Resource Efficiency in Practice – Closing Mineral Cycles”. It aims at providing practical information to farmers on how the risk of nutrient loss can best be minimised or prevented. In particular, the leaflet addresses the effects of nutrient loss in the Netherlands, with a specific focus on the North-Brabant region. The leaflet also provides practical information to farmers on how resource use efficiency can be maximised through good practices at farm level.
Agricultural structure in North-Brabant

Livestock production is the main type of agriculture in North-Brabant, totalling about 30% of the intensive, landless livestock production in the Netherlands. In 2014, the regional Utilised Agricultural Area (UAA) was 244,670 ha, which consisted of grassland and fodder crops (65%), arable land (27%), and horticulture (8%). (1) North-Brabant has a high share of intensive livestock production, with farms in the region holding over 5.7 million pigs, which is 47% of all pigs in the Netherlands. Additionally, 33% (146,000) of all goats and 27% (27.4 million) of all chickens in the Netherlands are located in North-Brabant. Finally, there are over 670,000 head of cattle, which accounts for 16.5% of all cattle in the Netherlands. (2)

Figure 1- Map of Europe (the Netherlands in green) and map of the Netherlands showing the North-Brabant region in dark green
How does nutrient loss affect farming business?

Nutrients are valuable and vital resources, which can nourish productive grazing lands and crops. From an economical point of view, it therefore makes sense to match the nutrient application to the grassland and crop requirements, thus limiting nutrient loss as much as possible. This in turn could limit the additional costs (e.g., tractor fuel, spreading equipment, labour, etc.) incurred when nutrients are applied beyond the crop and grass requirements. In addition, nutrient loss can create other costs for the farmer; for instance, in order to prevent soil acidification (which can increase with the application of fertilisers), farmers may have to lime their soils. Avoiding the impacts that may result from nutrient loss provides benefits to farming businesses, such as maintaining soil health and fertility and crop yields.

How does nutrient loss affect the North-Brabant region and what are the causes?

In North-Brabant, nutrient losses are a concern, particularly nitrogen and phosphorus losses contributing to overloads in freshwater bodies ranging from ditches to lakes. (3) Over-fertilisation and run-off are the main causes and occur predominantly due to nutrient application exceeding crops’ or grasslands’ nutrient needs. In 2013, the amount of N produced in animal manure within the region (excluding N emissions to air) was measured at 93,820 tonnes (380 kg N/ha) and P levels were 39,410 tonnes (160 kg P/ha UAA). Upstream waters with poor quality from Belgium (which are negatively affected by agriculture) also contribute to excess nutrients in the area, as does the local soil texture. Sandy soils cover a large part of the North-Brabant region and they do not have a high capacity to retain water and nutrients, resulting in further leaching to freshwater. Consequently, the nitrogen and phosphorus concentrations of regional waters are high and in most cases exceed the maximum levels allowed for drinking waters.

The intensive livestock rearing in the region also produces high levels of ammonia emissions, contributing to air pollution (particulate matter) which can affect human health. Natural resources and biodiversity are also affected (e.g., Natura 2000 areas) by nutrient losses in the region, including ammonia emissions and nitrogen deposition. Emissions of the greenhouse gas nitrous oxide are also partially caused by agriculture and particularly by the use of chemical fertilisers, manure storage, and manure application.
What has already been done to address the problem in the region?

Maximum application levels for nitrogen and phosphorus are among the measures in place under the Dutch Fertiliser Act and the Soil Protection Act, taking into account the type of crop and soil. The Dutch Nitrates Action Programme 2014-2017 applies to the whole territory of the Netherlands and, in compliance with the Programme, the Dutch Fertiliser Act has restricted manure application on grasslands and arable land to direct injection of manure into the soil. This technique reduces not only nutrient losses from run-off but also ammonia emissions released from manure application.

Appropriate design of livestock stables is obligatory within the region in order to reduce greenhouse gases and ammonia emissions. Newly built stables must fulfil low-emission requirements and the target was set for all intensive livestock housing to be low-emission stables by 2020.

Manure transfer has been common practice in the North-Brabant region as well as the Netherlands as a whole for over 25 years. Nutrients are redistributed from farms or regions where the production of nutrients in manure exceeds the on-site need for nutrients to a nutrient-deficit location. (4)

The Dutch Fertiliser Act also obiliges farms with a manure surplus to process a share of their surplus. Manure processing involves export as well as incineration or gasification to the point that the ashes contain a maximum of 10% organic matter. Farmers with manure surpluses in North-Brabant were required to process 30% of their manure surplus in 2014 and 50% in 2015.
Set of region-specific good practices

Several examples of ‘good practice’ measures to reduce nutrient loss and increase resource efficiency in the North-Brabant region have been identified (see Figure 2) and will be described in more detail in the following tables. The measures were selected based on their impacts on the agro-ecosystem in terms of reduced losses through improved nutrient utilisation. Thus, the selected measures provide some economic advantages for the farmer and at the same time reduce nutrient loss from the farming system, benefitting both the environment and society. Emphasis was placed on measures that have not yet been exploited to their full potential within the North-Brabant region. Further selection criteria were whether the measure might be feasibly implemented and whether the measure offers benefits which balance (or outweigh) the costs. The graphic below highlights various drivers of nutrient loss which exist in the North-Brabant region and problems related to those drivers. The final column presents the good practices that were identified as ways to potentially solve the problems associated with nutrient loss.

![Figure 2: Selection of good practice measures for the North-Brabant region](image)

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## Improving manure processing

**Definition of the measure**
Manure processing is defined under the Dutch Fertiliser Act as: 1) export of manure or 2) incineration or gasification to the point that the ashes contain a maximum of 10% organic matter. Thus, manure processing is a way to convert surplus manure into products of higher value and/or products which are easier to transport. Due to the obligation for farmers with manure surpluses to process a percentage of their surplus, the most appropriate techniques should be used to minimise nutrient loss. Two possibilities include: 1) separation of the manure into liquid and solid fractions or 2) combustion following biogas production from manure, which could be used for energy production.

**Technical implementation**
Separation of manure into liquid and solid fractions can be done by screening (mechanical process) or sedimentation (gravity process), among other techniques. For combustion, more energy can be recovered from manure with higher dry matter content (dry matter content should be >50%).

**Technical requirements**
Manure processing requires technical knowledge to understand the process and equipment (e.g., bioreactors, phase separators, etc.) and to more appropriately use the products (e.g., account for a higher quantity of available N in digested manure). Most processes require large quantities of manure and are generally not suitable for single on-farm implementation, except for separation. Collective solutions might be useful to overcome economic and manure supply barriers.

### Effects, benefits and costs

#### Benefits for farming business
Processed manure can allow for easier use of the manure, improve plant nutrient uptake, potentially reduce the input of chemical fertiliser, and provide energy (biogas combustion for heat and electricity), creating long-term positive economic impacts.

#### Costs for farming business
High implementation and maintenance costs for machinery. Renting or collectively purchasing the machinery can help reduce costs for individual farmers. Costs for total manure processing in the Netherlands are in the range of 20 to 25 EUR per tonne of liquid manure, which is higher than the price of manure transfer. For separation only, the costs range from 2 to 8 EUR per tonne. (5)

#### Co-benefits and trade-offs
Processing manure allows for optimal use of the available nitrogen and phosphorus in manure and the digested manure (produced from the anaerobic treatment in biogas plants) is more efficiently taken up by crops, which could potentially result in cost-savings due to improved fertilisation. Application should be matched with the plant needs and soil type, however, to avoid losses of the remaining nutrients. Other substrates, such as crop residues, are needed for the digestion process and may result in an increasing share of intensively produced energy crops, such as maize. Processes should be closely controlled to avoid excessive emissions and toxicity (metal concentration, etc.). Processed manure with high carbon content should be preferred in areas with low levels of soil organic matter.

#### Environmental effects
- **Air:** Decreased ammonia emissions leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems); Reduced greenhouse gas emissions (nitrous oxide – and methane if biogas is installed too), thereby decreasing the impact on climate.
- **Soil:** Reduced soil acidification from less N deposition and potential improvements to soil fertility and health, but excessive emissions and toxicity may cause soil impacts if the processes are not closely controlled.
- **Water:** Potentially reduced leaching and run-off of nutrients (N and P – transformed to immobile forms through digestion), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
- **Biodiversity:** Positive effects from reduced N deposition in natural ecosystems.
# Adjusting feeding strategies and techniques

## Definition of the measure
The quantity of nutrients in manure is directly related to the quantity and quality of the nutrients in animal feed. Feeding livestock is often not optimal in the sense that animals may get more nutrients than they actually need, and as a result, the digestion process of the animal is inefficient. Adapt the amount and composition of feed to animals’ needs in order to increase the efficiency of their assimilation of nutrients and reduce P and/or N levels in manure. (1)

## Technical implementation
- Test or assess the nutrient content of non-manufactured animal feeds, especially forages;
- Consider animal nutritional advice and group feeding to plan animals’ rations as part of an overall nutrient management plan;
- Adapt fodder amount for bovine animals as well as the composition of the fodder (more carbohydrates);
- Provide fodder with lower protein content to pigs, but match with the animals’ needs to avoid decreasing growth rate;
- Use feeders that can deliver different diets within the same building if necessary.

## Technical requirements
Calculate the animals’ nutrient needs and the nutrient value of the feed to design a feeding strategy and adjust the diet composition if necessary during a single production phase. Group animals if necessary to facilitate diverse feeding strategies and obtain assistance from animal dieticians. Knowledge of the appropriate levels for feed combinations, substitutions, and/or overall amounts is required to implement this measure effectively.

## Effects, benefits and costs
### Benefits for farming business
Cost-savings from reduced feed quantity due to improved use efficiency. (3) Lower levels of excess manure may result in lower costs for manure transfer (livestock farmers often have to pay arable farmers for accepting manure).

### Costs for farming business
Regular analyses of fodder; purchase of fodder with lower protein content, which may result in extra costs per unit; potential labour to group animals.

### Co-benefits and trade-offs
Feed waste is avoided and the costs of feed are reduced. When the nutrient content of animal manure is reduced, less nitrous oxide will result, for example, when it is applied as fertiliser. Also, a lower amount of ammonia and nitrous oxide will be released into the atmosphere and reduce N deposition, which also affects remote ecosystems. Uncertainty must be taken into consideration regarding the calculation of the animals’ needs as well.

### Environmental effects
- **Air**: Decreased ammonia emissions leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems);
- **Reduced greenhouse gas emissions (methane and nitrous oxide)**, thereby decreasing the impact on climate.
- **Water**: Reduced leaching and run-off of nutrients (N and P), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
- **Soil**: Improved soil fertility and health through reduced potential for acidification.
- **Biodiversity**: Positive effects from reduced N deposition in natural ecosystems.
### Adjusting drainage systems

**Definition of the measure**
A controlled drainage system allows the farmer to manage the groundwater table at plot level in response to changing precipitation levels, such as floods or droughts. By keeping the groundwater table at a higher level with a controlled drainage system, the soil can be used as a buffer to store water. As a consequence, the nutrient run-off is reduced and nutrients can be used more efficiently by crops. Nutrient leaching could be reduced as well since nutrients are partially collected in the drainage basins.

**Technical implementation**
The controlled drainage system differs from a regular drainage system because the drains are installed deeper underground, the system of drains is denser, and the drains are connected to a drainage basin. The sandy soils in North-Brabant are suitable for controlled drainage systems, but their effectiveness largely depends on the management of the system.

**Technical requirements**
If a farmer has no drainage system yet, investment in a new drainage system will be necessary. Drains from previously installed regular drainage systems can be used, but additional drains must be installed deeper in the ground. Also, a drainage basin is required for optimal management of the groundwater table, and consequently the nutrient run-off.

### Effects, benefits and costs

**Benefits for farming business**
Slightly reduced irrigation and fertiliser costs; potential yield increase due to the prevention of water-logging and reduced damage from water shortages.

**Costs for farming business**
Investments for installation and maintenance of a controlled drainage system are significantly more expensive than for regular systems.

**Co-benefits and trade-offs**
By reducing the potential for waterlogged soils, which prevent the salts introduced by irrigation water to leach, controlled drainage systems may help prevent soil salinisation.

**Environmental effects**
- **Soil**: Improved soil fertility and health through reduced potential for soil salinisation.
- **Air**: Reduced greenhouse gas emissions (nitrous oxide through avoiding anoxic conditions in soils), thereby decreasing the impact on climate.
- **Water**: Reduced run-off of nutrients (N and P), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
### Definition of the measure
The input of too much water can leach nutrients in the soil to water bodies. Systems like drip irrigation are able to control the amount of water provided and limit the losses of both water and nutrients.

### Technical implementation
A drip irrigation system requires a:
- Water pressurisation system;
- Filter station;
- Distribution system;
- Drip line (usually installed when plants have 5-10 leaves at a depth of 0-15 cm by using special machinery).

### Technical requirements
A change in crop management and special equipment for more accurate input of water to the crops are necessary. Distribution of manure with the irrigation water is possible ("fertigation"), but it requires specific equipment for filtration and dosage optimisation.

### Effects, benefits and costs

#### Benefits for farming business
Reduction of additional fertiliser purchase and application as well as soil compaction and erosion. Often the use of drip irrigation increases crop yields and improves the quality of the harvested products (e.g., less mycotoxins).

#### Costs for farming business
High costs for equipment and distribution systems. In practice, this measure is particularly relevant for high-value horticultural crops. Though horticulture is a relatively small sector in terms of land area and number of firms in North-Brabant, its economic and environmental impact is quite large. For arable crops, the use of drip irrigation systems is expensive, but the costs are partially compensated for by the lower labour requirements to irrigate.

#### Co-benefits and trade-offs
Some devices may limit tillage operation and some herbicides and top-dressed fertilisers require distribution on the soil (and thus cannot use the drip irrigation system). Additionally, the water distribution network (delivered on fixed days) might not be suitable to continuous low-flow-rate systems.

#### Environmental effects
**Water:** Reduced leaching and run-off of nutrients (N and P), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.

**Soil:** Improved soil fertility and health through reduced risk of water-logging from excess irrigation water.

**Air:** Decreased ammonia emissions (when liquid manure is applied in fertigation) leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems);

- Reduced greenhouse gas emissions (nitrous oxide – due to less soil anaerobic conditions), thereby decreasing the impact on climate.

**Biodiversity:** Positive effects from reduced N deposition in natural ecosystems.
Improving the establishment of buffer zones

**Definition of the measure**
Buffer zones are areas of land with permanent or non-permanent vegetation on the edge of agricultural land and adjacent to surface water. On this land, nutrients and pesticides are prohibited. Buffer strips trap sediments and filter nutrients and pesticides bound to soil particles by slowing run-off water from arable land that could enter the local surface waters. In the eastern part of North-Brabant, 62 ha of agricultural land have been converted to buffer zones in accordance with the measures of the River Basin Management Plan under the Water Framework Directive (WFD). Improving the implementation of the buffer zones could reduce nutrient loads from run-off by approximately 3%. (6)

**Technical implementation**
Buffer zones are voluntary measures under the WFD. A subsidy scheme has been put in place for the establishment of buffer zones in North-Brabant, which requires them to be 3-12 metres wide. The subsidy scheme has not been well utilised, however, and buffer zones are not common practice.

**Technical requirements**
Depending on the type of crop, different machinery may be required.

**Effects, benefits and costs**

**Benefits for farming business**
Biomass may be harvested from buffer strips, which can be used as fodder or as a renewable energy input.

**Costs for farming business**
Costs include planting vegetation, labour to remove weeds, and potential opportunity costs from taking land out of production.

**Co-benefits and trade-offs**
Loss of land under production, but they often help preserve the natural resource base of the farm due to reduced soil losses. Buffer zones can be combined with on-farm water storage, but their effectiveness will be negligible if controlled drainage systems are also used.

**Environmental effects**
**Water**: Reduced risk of leaching and run-off of nutrients (N and P), decreasing eutrophication and improving water quality, thereby lowering risks to human health and biodiversity.

**Biodiversity**: Positive effects due to buffer zones reducing nutrient losses to water bodies, which can negatively impact aquatic biodiversity, as well as providing additional wildlife and pollinator habitats.
Further good practices to reduce nutrient losses

**Manure transfer**

Dutch legislation restricts the quantities of nitrogen and phosphorus that may be applied on the land, thereby limiting manure application. The on-farm surplus of manure exceeding this maximum level may be transferred to farms in nutrient-deficient regions. These regions generally are not close to North-Brabant; often manure must be transferred more than 200 km. As the distance increases, the costs associated with manure transfer rise, in which case manure processing might be an interesting alternative. Through manure processing, the nutrients in manure are mineralised and changed into a form which allows for easier assimilation by plants. The volume of the obtained processed manure is also much lower than that of raw manure and therefore the transport costs per kg for processed manure products are lower. Since 2014, farmers with manure surpluses have been obliged to process part of their manure in order to export manure products or produce energy by manure combustion under the Dutch Fertiliser Act.

**Cooperative actions to increase uptake of nutrient management practices**

Deltaplan Agricultural Water Management (in Dutch – “Deltaplan Agrarisch Waterbeheer” (DAW)) is a promising initiative of LTO Nederland (the Dutch Federation of Agriculture and Horticulture), an agricultural entrepreneurs’ and employers’ organisation. Its objective is to contribute to resolving water issues in agricultural areas and to promote an economically sound and sustainable agricultural sector. Given these objectives, agricultural entrepreneurs and water boards work closely together on local water issues to improve water quality and quantity for groundwater and surface water. Farmers implement measures to reduce nutrient emissions (e.g., buffer zones, controlled drainage systems, and drip irrigation) and water boards guarantee the supply of fresh water in times of drought.
Further relevant links

Further information (links) on the issue of reducing nutrient losses in agriculture which are relevant for the North-Brabant region can be found below. This information entails links to legal documents, programmes, initiatives, institutions and studies.

**EU level**

DG Environment - Nitrates Directive:  

The study ‘Resource Efficiency in Practice - Closing Mineral Cycles’ is available at the following link:  

DG Environment - Sustainable use of phosphorus:  
http://ec.europa.eu/environment/natres/phosphorus.htm

Contacts:  
ENV-NITRATES@ec.europa.eu;  
ENV-USE-OF-PHOSPHORUS@ec.europa.eu

**National and regional level**

National government information regarding manure:  
http://www.rijksoverheid.nl/onderwerpen/mest/

National government Small Business Innovation Research (SBIR) programme for reducing ammonia emissions (adjusting management and feeding of animals):  

Small Business Innovation Research (SBIR) programme:  
www.rvo.nl/subsidies-regelingen/sbir-reductie-ammoniakemissie

Integral sustainable stables programme:  
miijn.rvo.nl/investeringen-in-integraal-duurzame-stallen-glb-2014

Deltaplan Agricultural Water Management:  
www.agrarischwaterbeheer.nl

**Studies and projects**

University of Wageningen, Alles over mestverwerking en energie uit biomassa (Everything about manure processing and energy from biomass):  
http://www.mestverwerken.wur.nl/

LEI-Wageningen UR. Gerichte bemesting via druppelsystemen e.d. (Targeted fertilisation via drip irrigation):  

LEI-Wageningen UR. Aanleg en beheer van droge en natte bufferstroken (Construction and management of dry and wet buffer strips):  
http://www3.lei.wur.nl/LTO_PDF/BOOT_34_bufferstroken.pdf
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(2) Statistics Netherlands (2014) Landbouw; gewassen, dieren en grondgebruik naar hoofdbedrijfstype, regio (Agriculture; crops, animals and land use according to region). Available at: http://statline.cbs.nl/StatWeb/publication/default.aspx?DM=SLNL&PA=80783ned&D1=a&D2=0&D3=0%2c15%2c125-134&D4=0%2c5%2c10%2c12-13&HDR=G2%2cG3&STB=T%2cG1&VW=T.

(3) Statistics Netherlands (2014) Landbouw; gewassen, dieren en grondgebruik naar regio (Agriculture; crops, animals and land use according to region). Available at: http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=80780ned&D1=a&D2=0,15&D3=0,5,10-13&HDR=G1,G2&STB=T&VW=T.


(5) PBL Netherlands Environmental Assessment Agency (2010) Verkenning van aanvullende maatregelen in het kader van de Programmatische Aanpak Stikstof: Een verkenning van de gevolgen voor milieu en economie (Assessment of additional measures in the context of the Programmed Approach to Nitrogen: an assessment of the consequences for the environment and the economy), Bilthoven (the Netherlands).

(6) Van Boekel, E. et al. (2011) Ex-ante evaluatie landbouw en KRW: bijdrage van het voorgenomen beleid en aanvullende (landbouwkundige) maatregelen op de realisatie van de KRW nutriëntendoelstelling (Ex-ante evaluation agriculture and water framework directive (WFD); contribution of the proposed policy and additional (agricultural) measures to the realisation of the WFD nutrient objective), Wageningen.