European Commission

Closing the mineral cycles at farm level

Good practices to reduce nutrient loss in the **Weser-Ems** region (Germany)

Content

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 Germany, with a specific focus on the Weser-Ems region. The leaflet also provides practical information to farmers on how resource use efficiency can be maximised through good practices at farm level.

Aerial photo taken between Nordholz-Spieka Cuxhaven airfield and Wilhelmshaven, region of Weser-Ems

Agricultural structure in Weser-Ems

With an average of around two livestock units per hectare (and thirteen communities with more than three livestock units/ha), Weser-Ems has the highest livestock density in Germany. The area particularly includes dairy cattle and beef farming in the north and poultry farming and pork production in the central part of the region. As of 2012, more than half of the broiler chickens, around one-third of the pigs and laying hens, and one-fifth of the cattle in Germany were located in Lower-Saxony, with the focus of production in the Weser-Ems region. Furthermore, regional maize production supplies biogas plants, which contribute a significant portion of the total installed electrical power.

Figure 1 - Map of Europe (Germany in green) and map of Germany showing the Weser-Ems 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 Weser-Ems region and what are the causes?

The Weser-Ems region faces a number of pressures to water bodies, the majority of which arise from nitrogen losses from livestock and crop production as well as organic soils. Nitrate leaching can threaten groundwater used for human consumption. In addition, eutrophication and algae blooms caused by nitrogen loss can occur downstream in marine waters, threatening biodiversity and negatively impacting tourism and fisheries activities. High ammonia emissions also pose threats to human health due to higher levels of particulate matter in the air and N deposition can acidify agricultural soils, which requires liming to counteract the effects.

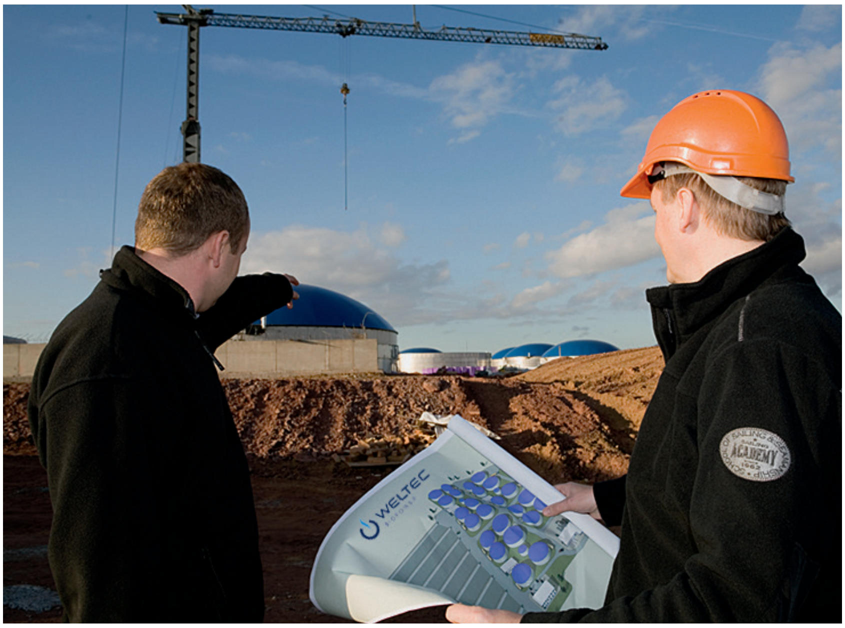
Herd of cattle grazing in field, Westerstede, Ammerland, Lower Saxony, Germany

What has already been done to address the problem in the region?

A combination of mandatory and voluntary measures has been adopted to address nutrient loss in the Weser-Ems region. In addition to measures stemming from European obligations and the EU Common Agricultural Policy, the latter of which has provided financial support for specific measures (adopting new technology, updating equipment, changing crop rotations, ploughing using different methods, etc.), additional voluntary measures have been implemented within the region. Many of these measures focused on cropland, such as the use of cover crops and the reduction of bare fallow as well as avoiding legumes as cover crops.

Advisory services for farmers about site-specific fertilisation, crop needs, and environmental conditions have been utilised on around 30% of the total area of Weser-Ems under the Water Framework Directive and 12 % within voluntary 'water co-operations'. Both were intended to maintain or restore high water quality through land management measures in order to avoid expensive water treatment facilities. Furthermore, in 2012, several agricultural actors in Lower-Saxony established a manure transfer system. In the period between July 2012 and June 2013, 1.8 million tonnes of organic fertiliser were traded between producers and applicants inside and outside of the Weser-Ems region

A wind farm. The wind turbines are manufactured by Enercon. Aerial photo taken between Braunschweig and Hildesheim in Lower Saxony



250kW biogas plant in Löningen, region of Weser-Ems

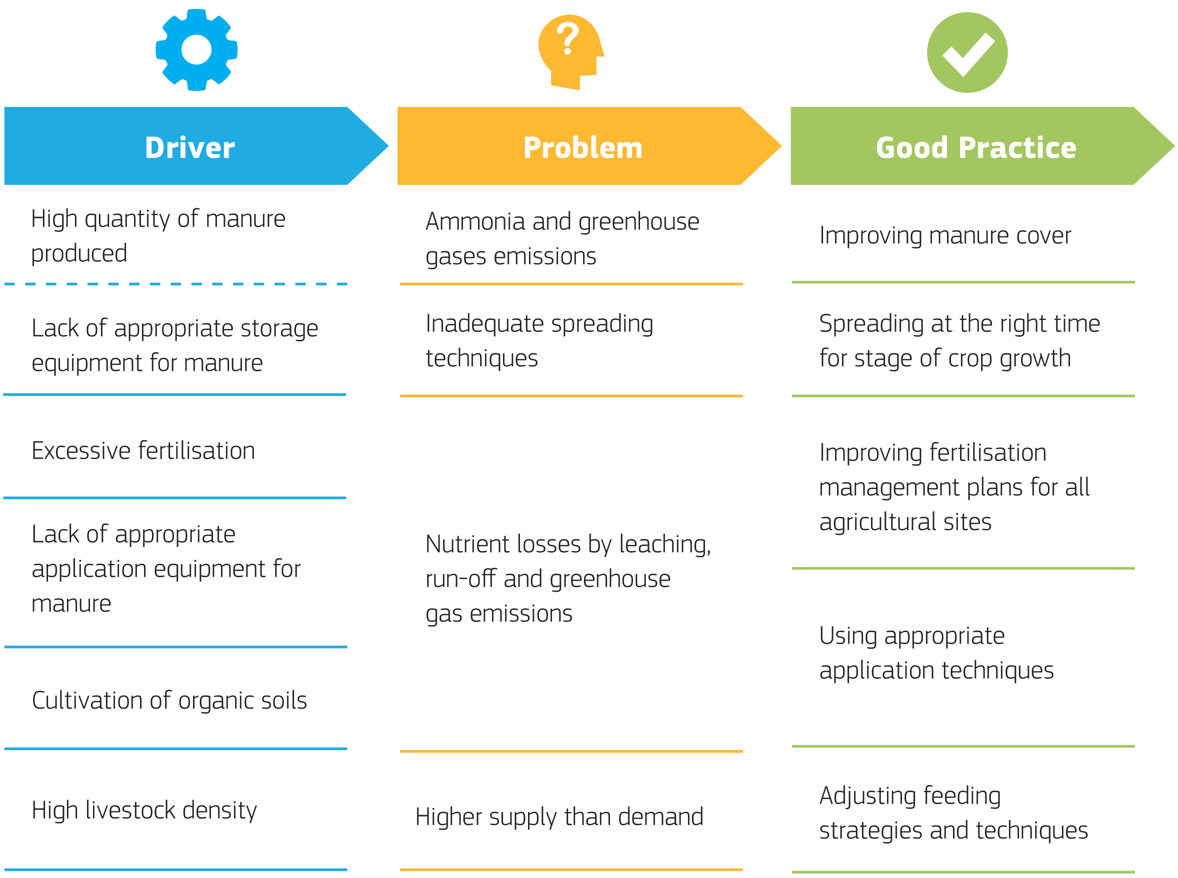
[1] To reduce nitrate concentrations in drinking water, nitrate input levels and resulting losses to groundwater systems are managed cooperatively between water users and farmers on 300,000 ha in the Weser-Ems region. Farmers contractually agree with the water company to limit their application of nitrogen fertiliser, and the water consumers pay the compensation to the farmers through their water bills.

Set of region-specific good practices

Several examples of 'good practice' measures to reduce nutrient loss and increase resource efficiency in the Weser-Ems 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 Weser-Ems 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 Weser-Ems 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 Weser-Ems region



Improving manure cover

Definition of the measure	Reducing nutrient losses from manure storage by covering manure. Manure coverage decreases the surface area from which emissions (ammonia and methane) can occur and avoids an increase of the volume of manure that needs to be stored and applied due to rainwater dilution.
Technical implementation	To decide on the type of cover and/or controlled subsurface, the percentage of dry matter that the manure contains needs to be considered as well as the amount of precipitation (see table below (3)). Fixed covers are more efficient in achieving emission reductions and diverting rainwater collection. Flexible covers can be implemented in different ways, e.g., straw, clay, fleece, and foils are some possible covers. Cattle manure forms a natural crust, which lowers the amount of ammonia emissions. Pig manure requires the addition of straw or other materials (clay or plastic elements).

Dry matter	Measure	Up to 500 mm precipitation	500-1000 mm precipitation	> 1000 mm precipitation
<25%	Cover	Straw (useful but not necessary)	Fleece	Fleece or foils after self-heating
	Controlled subsurface[2]	Useful	Necessary	Necessary[1]
>25%	Cover	Straw (useful but not necessary)	Straw or fleece	Fleece
	Controlled subsurface[2]	Not necessary	Useful	Necessary

[1] plus: pre-composting on a concrete slab [2] e.g. straw or clay minerals like bentonite

Technical requirements	High initial investments are needed for fixed covers. Flexible covers have lower associated costs. Fixed coverage may be impractical for solid manure, as the regular addition of manure to the storage structure (daily, twice weekly) requires removal of the cover. Nevertheless, solid manure emits a higher amount of greenhouse gases than separated slurry. Thus, since the emission reduction potential is high, adoption of this measure should be considered where feasible.

Effects, benefits and costs

Benefits for farming business	Cost-savings from reduced mineral fertiliser purchase and application due to higher nutrient content of stored manure (obtained by covering with a semi-permeable or impermeable cover). Cost-savings from reduced storage capacity requirements and transport volumes if impermeable covers are used, which reduces rainwater dilution.
Costs for farming business	Construction and increased operating costs for maintenance and handling of the covered manure storage facilities. Fixed covers are more expensive than flexible covers, especially if not foreseen in the storage design. On cattle farms, a solid cover on the storage facility will cause additional costs for removal of sediments that accumulate at the bottom of the tank.
Co-benefits and trade-offs	Manure nutrient levels need to be calculated to match the crop needs; otherwise, application of the same quantity of manure would result in higher nutrient levels and potential losses.
Environmental effects	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); decreased ammonia emissions will also result in benefits to water and natural ecosystems. Reduced greenhouse gas emissions (methane), thereby decreasing the impact on climate.

Spreading at the right time for stage of crop growth

Definition of the measure	In order to decrease the loss of nutrients to the environment, manure application should be planned based on the crop development stage and environmental conditions (temperature, wind, solar radiation, precipitation, and soil conditions). For this, application timing management systems (ATMS) could be used. ATMS are mainly computer-based models that calculate the amount of nutrients lost during and following application for the average regional environmental conditions. ATMS encourage farmers to spread manure in cool, windless and humid conditions, on flat land, away from surface waterways and ideally in the evening, when wind speed and air temperature are lower. When spreading on tilled land, application on freshly cultivated soils allows for more rapid infiltration.
Technical implementation	Identify plant-specific needs via yield potential maps, (optical) sensor technology, and the use of plant growth models and artificial neural networks; Determine the appropriate site-specific amount of fertiliser through farm data analysis and testing of soil and farmyard manure samples; Use controlled-release fertilisers to improve matching of plant needs with nutrient provision. (1)
Technical requirements	Knowledge of environmental conditions, crop growth stages and the corresponding nutrient requirements. Environmental data is needed to evaluate the proper timing for manure application and to manage ATMS.

Effects, benefits and costs

Benefits for farming business	Cost-savings from lower amounts and less purchase of additional fertiliser. The least costly option to increase the value of nitrogen is to change the timing of the application.
Costs for farming business	Potential increase of the volume of manure storage facilities; increased need for labour due to repeated applications.
Co-benefits and trade-offs	When implementing the measure, manure might have to be stored longer while waiting for the proper application time and release more ammonia emissions. If manure is applied on several occasions, multiple passes of machinery over the soil may increase soil compaction.
Environmental effects	**Water**: Reduced risk of leaching and run-off of nutrients (N, P, and K), 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, though potential compaction may result. **Air**: Reduced greenhouse gas emissions (nitrous oxide), thereby decreasing the impact on climate; Potential increase in ammonia emissions if manure stored for longer periods of time.

Improving fertilisation management plans for all agricultural sites

Definition of the measure	Basing organic and inorganic fertiliser application rates on a calculated nutrient balance can considerably reduce nutrient losses. More effective nutrient management plans (considering additional factors in the nutrient balance) can be devised beyond the basic legislative requirements. These could be developed using specific tools (e.g., soil analysis) and accounting for all relevant inputs and outputs (e.g., deposition, fertilisation, crop residues), which would allow the amount of nutrients applied to be optimised to the conditions of the land (soil type, crop demand, and remaining nutrients). (2)
Technical implementation	Calculate and interpret the site-specific nutrient balance: Analyse the parcel-specific remaining nutrient content in the soil considering the soil type and mineralised crop residues; Determine the crop nutrient requirements for the desired yield under the given environmental circumstances; Analyse the nutrient content of organic fertilisers, establish the ratio to mineral fertilisers to fully satisfy crop needs, and consider the time lapse between the application and the assimilation of nutrients by crops.
Technical requirements	The measure involves the calculation of N, P and K leftover in the soil and adjustment of the amount of fertiliser to be applied in the next growth period. This is based on soil samples taken in the spring and autumn (N_{min}), which also serve as a monitoring element of this measure. Nutrient application is fine-tuned according to the crop type and the local conditions.

Effects, benefits and costs

Benefits for farming business	Cost-savings from reduced purchase and less application of additional fertiliser
Costs for farming business	Soil analyses, increased management efforts when applied to all sites, and potentially additional technical support to balance the N, P and K budget (e.g., consideration of remaining nutrient content).
Co-benefits and trade-offs	The reduction of applied nutrients positively affects nutrient loss provided that the application takes place under suitable conditions (including weather conditions). A further benefit is the reduction of greenhouse gas emissions during the production of fertilisers if less additional inorganic fertiliser is applied.
Environmental effects	**Water**: Reduced leaching and run-off of nutrients (N, P, and K), 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. **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 carbon dioxide), thereby decreasing the impact on climate. **Biodiversity**: Positive effects from reduced N deposition in natural ecosystems.

Using appropriate application techniques

Definition of the measure	The choice of an appropriate manure application technique, such as band application or injection, can reduce the volatilisation of ammonia by decreasing the surface area of manure in contact with the air. Thereby, the potential for ammonia emissions is decreased and as a consequence, the amount of nitrogen utilised by the crops is improved. When manure is incorporated immediately after spreading or directly through injection, nutrient runoff can also be decreased.
Technical implementation	Immediately incorporate urea-containing fertiliser (e.g. via injection of slurry, ploughing in solids), which significantly reduces ammonia emissions; Calibrate fertiliser spreaders to reduce N losses; Broadcast spreading techniques should be replaced by more accurate ones, e.g., trailing hoses/shoes. (1)
Technical requirements	The appropriate application technique may vary according to soil type and crop. When the manure is applied before seeding, band spreaders (followed by incorporation) or injectors (open or closed slot) can be used. Band spreaders drag perforated hoses behind them, from which slurry is applied close to the ground. Injection systems slit the soil open and inject the fertiliser at different depths. On grassland, using a trailing shoe spreader helps provide uniformity of spreading and lowers emissions. Some band spreading or closed slot slurry injection machines for top dressing applications are also available. Distribution of slurries mixed with irrigation water can also be a suitable technique provided that the irrigation water does not leave the fields. Some of these types of equipment, like a band spreader or an injector connected to an umbilical system, can also improve the timing of application as well as lead to more efficient use of nutrients.

Effects, benefits and costs

Benefits for farming business	Cost-savings from reduced purchase and application of additional fertilisers. Consistent and even application promotes better yields as all crops are fertilised.
Costs for farming business	Purchase or rental costs of specific equipment and potential costs from reduced field capacity of the machinery (use of contractors could be a possible solution to reduce expenses); higher labour intensity. Collective action could be a way for smaller farms to invest in such techniques.
Co-benefits and trade-offs	Accurate application avoids fertiliser waste, which in turn reduces the use of supplemental manufactured N fertilisers. Through application close to the soil, odour emissions are reduced, but in order to avoid an increase in the nitrate leaching potential, injection must be timed appropriately in terms of crop needs and climate conditions. Furthermore, shallow injection may increase the potential for nitrous oxide emissions; thus, deep injection is preferable. By incorporating or injecting manure, nutrient run-off is reduced. Trailing shoe equipment may increase the potential for soil compaction due to the weight of the attachment. Slurry is best applied in spring when soils are often wetter, thereby threatening compaction damage. Umbilical slurry handling systems can be used to alleviate this, but they are expensive.
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 (carbon dioxide – reduced production of mineral fertiliser), 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. **Soil**: Improved soil fertility and health through reduced potential for acidification. **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 of feed to animals' needs in order to reduce P and/or N levels in manure. Generally, the use of N-reduced feed is already well established in the region.
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; 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 according to sex, age and production stage as feed requirements differ according to these categories. By keeping animals separated, feed levels can better be adjusted. Regular adjustment and maintenance of feeders, bunks, and drinking troughs 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 and avoidance of excess fodder purchase and/or use.
Costs for farming business	Initial labour to re-group animals for feeding; regular analyses of fodder.
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 will be released into the atmosphere and reduce N-deposition, which also affects remote ecosystems.
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 on biodiversity from reduced N deposition in natural ecosystems.

Further good practices to reduce nutrient losses

Improving manure processing: Slurry separation

The Weser-Ems region has a high livestock density in the south and a high percentage of tillage systems in the north, which include a large amount of maize production for biogas plants. Treatment of manure with separators results in a solid portion that is rich in phosphorus as well as a liquid portion with a high amount of ammonium. The solid portion has a high potential for energy production in biogas plants. In order to reduce the nutrient surplus in high livestock density areas, the solid substrate could be traded in the regional manure stock exchange and be used as digestion substrate in the northern part of the region. Treatment with manure separators has been tested in Lower-Saxony, aimed at producing N-P-K fertiliser from the manure.

Rewetting organic soils and establishing paludicultures

Utilising the region's organic soils for agricultural purposes requires them to be drained and ventilated. These processes induce mineralisation, which in turn causes greenhouse gas emissions and nutrient leaching into water bodies. By dismantling drainage mechanisms and allowing the water table in moors to rise close to the soil surface, greenhouse gas emissions and nutrient leaching are reduced in proportion to the increase of the water table. In Weser-Ems, the mitigation potential of this measure is large given the region's abundance of former wetlands used for agricultural production. Depending on the degree of restoration, the costs for rewetting may involve high initial investments for the use of machinery and labour, dismantling of drainage systems or excavation, and differences in crop production/output. However, depending on the specific peatland context, rewetting may require low-cost investments.

Possible uses of the peatland include extensive grazing, permanent grassland (in line with nature conservation requirements), ribbon grass culture, and alder tree or reed cultivation (sorted in accordance with their need for low to high water tables). After the harvest, reed and wood from the alder trees can be used as construction material, for thermal combustion in combined heat and power plants, as "biomass to liquid" (reed), or in biogas digesters. Subsidies for complying with nature conservation programmes can compensate for opportunity costs associated with adopting the measure. The measure provides co-benefits for nature conservation through the restoration of habitats for rare birds and plant species in the threatened ecosystems. The measure has been implemented through pilot projects to demonstrate its feasibility and economical viability, for example, in Lower Saxony, Brandenburg and Mecklenburg-Vorpommern. (4) Furthermore, paludiculture can provide a possibility to mitigate greenhouse gas emissions. (5)

Converting arable land to grassland in areas of high soil risk

Land use change from arable production to grassland reduces the intensity of use and the potential for nutrient losses. Although this is less favourable than rewetting peatlands, it still delivers considerable improvements in terms of nutrient losses. To reduce nutrient leaching and the risk of soil erosion, the grassland sward needs to be seeded at an appropriate density rate (20 kg per ha is generally recommended) and then rolled in order to ensure productivity, prevent weed establishment, and encourage seed consolidation. The costs to the farm are high due to the loss of arable crop production, but such costs can potentially be counter-balanced with financial support, such as incentives provided by the regional Rural Development Programme under the EU Common Agricultural Policy.

Participation in advisory and education programmes

Enhanced resource efficiency at farm level is crucially dependent on the right information and farm-specific adaptation. Especially for innovative practices, this requires a certain amount of know-how and practical experience with the implementation of these practices. Furthermore, programmes by the Chamber of Agriculture of Lower-Saxony and the advisory councils provide services for grant applications, legal questions, business and socio-economic consultancies. For the implementation of the EU Water Framework Directive, special advisory programmes for farmers are in place that aim to enhance nutrient efficiency, providing information on ammonium /nutrient management, feed ration management, stable planning, grant application for water conservation, and agri-environment-climate measures and assistance in implementation.

Further relevant links

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

EU level

DG Environment - Nitrates Directive:
http://ec.europa.eu/environment/water/water-nitrates/index_en.html

The study "Resource Efficiency in Practice - Closing Mineral Cycles" is available at the following link:
http://ec.europa.eu/environment/water/water-nitrates/studies.html

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

German Federal Ministry of Food and Agriculture (BMEL):
http://www.bmel.de/EN/Ministry/ministry_node.html

German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB):
http://www.bmub.bund.de/en/

German Federal Environment Agency (UBA):
http://www.umweltbundesamt.de/en

Chamber of Agriculture, Lower-Saxony:
http://www.lwk-niedersachsen.de/

Ministry of Food, Agriculture, and Consumer Protection, Lower-Saxony:
http://www.ml.niedersachsen.de/portal/live.php?navigation_id=1312&_psmand=7

State Department for Waterway, Coastal and Nature Conservation, Lower-Saxony:
http://www.nlwkn.niedersachsen.de/portal/live.php?navigation_id=7892&_psmand=26

Studies and projects

DLG e.V, 2014. Bilanzierung der Nährstoffausscheidungen landwirtschaftlicher Nutztiere, 2nd ed. DLG-Verlag, Frankfurt am Main (German Agriculture Association - Farm animal nutrient excretion amounts. Second Edition, DLG Publishing, Frankfurt am Main, Germany) ISBN 978-3-7690-3166-9

Empfehlungen für die Stickstoffdüngung (recommendations for nitrogen fertilisation):
http://www.lwk-niedersachsen.de/index.cfm/portal/2/nav/341/article/14022.html

Farm consulting service of the Chamber of Agriculture, Lower-Saxony:
http://www.lwk-niedersachsen.de/index.cfm/portal/48/nav/0/article/11969.html

N-Injektionsdüngung zahlt sich aus (N-injection fertilisation pays off), LAND & Forst, No. 14, 5 April 2013:
http://www.dettmer-agrarservice.de/wp-content/uploads/2013/04/n-injektionsdungung.pdf

Minimum values for the effect of nitrogen in organic fertilisers:
http://www.lwk-niedersachsen.de/index.cfm/portal/2/nav/341/article/15868.html

CULTAN – Injektionsdüngung - ein Düngeverfahren mit Zukunft! (A fertilisation process with a future!):
http://www.jki.bund.de/index.php?id=1187&no_cache=1&press_id=58

KLIMZUG-NORD Project of the month – October 2009: Evaluation of climate change impacts on the emission of nitrogen in soil and assessment of an adapted fertilisation management:
http://klimzug-nord.de/index.php/page/2009-09-30-Projekt-des-Monats-Oktober-2009

KLIMZUG-Nord: Part 4 – Water saving in tillage systems:
http://www.lwk-niedersachsen.de/index.cfm/portal/6/nav/203/article/24920.html

References

(1) Frelih-Larsen, A. et al. (2014) Fiche M3: Improved N efficiency and Fiche M4: Precise N-application. Technical fiches for Mainstreaming climate change into rural development policy post 2013 project, DG Climate Action.

(2) Düngeverordnung in der Fassung der Bekanntmachung vom 27. Februar 2007 (BGBl. I S. 221), die zuletzt durch Artikel 5 Absatz 36 des Gesetzes vom 24. Februar 2012 (BGBl. I S. 212) geändert worden ist (Fertilisation Act in the version of the notice of February 27, 2007 (BGBl. I S. 221), amended through article 5 section 36 of the law of February 2012 (BGBl. I S. 212)).

(3) Stein-Bachinger, K., Reckling, M., Hufnagel, J. and Granstedt, A. (eds.) (2013) Ecologic Recycling Agriculture: Farming Guidelines (1st ed., Vol. 1, p. 136). Berlin: BERAS - Baltic Ecologic Recycling Agriculture and Society.

(4) Flessa, H., Müller, D., Plassmann, K., Osterburg, B. and Techen, A.-K. (2012) Studie zur Vorbereitung einer effizienten und gut abgestimmten Klimaschutzpolitik für den Agrarsektor (Preparation study for an an efficient and well-coordinated policy on climate change for the agricultural sector). VTI, Braunschweig.

(5) European Parliament and European Council (21 May 2012) Decision on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities. Decision No 529/2013/EU.

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Image sources:
Cover page: Dairy cattle on grazing land, lutten, goldenstedt, vechta district, oldenburger münsterland, lower saxony, Germany © Premium Stock Photography GmbH / Alamy - P3: Aerial photo taken between Nordholz-Spieka Cuxhaven airfield and Wilhelmshaven, region of Weser-Ems © Martina Nolte - P5: Herd of cows in field, Westerstede, Ammerland, Lower Saxony, Germany © F1online digitale Bildagentur GmbH / Alamy - P6 top: A Wind farm. The wind turbines are manufactured by Enercon. This photo was taken up from air. During a flight from Braunschweig to Hildesheim in Lower Saxony © Philip May - P6 bottom: 250kW plant in Löningen, region of Weser-Ems © www.weltec-biopower.de - P8: Bottom plate for manure coverage © Landwirtschaftskammer Niedersachsen - P9: Farmyard manure, recycled and spread as a nutrient resource © Paul Murphy and Ger Shortle (Teagasc) - P10: Farmer taking soil samples out of ploughed field. Matching crop requirements and nutrient content of soil and fertilisers can minimize nutrients losses and reduce expenses © Wayne Hatchinson / Alamy - P11: Equipment that allows direct incorporation of slurry and a uniform distribution of nutrients © Giorgio Provolo - P12: Market hogs at feeder © Grant Heilman Photography / Alamy

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