Closing the mineral cycles at farm level

Good practices to reduce nutrient loss in the Brittany region (France)
Content

3 Nutrient loss – Why does it matter?
4 Agricultural structure in Brittany
5 How does nutrient loss affect farming business?
5 How does nutrient loss affect the Brittany region and what are the causes?
6 What has already been done to address the problem in the region?
7 Set of region-specific good practices
8 Adjusting feeding strategies and techniques
9 Improving manure processing
10 Improving manure cover
11 Improving fertilisation management plans for all agricultural sites
12 Optimising grazing intensity – rotational grazing
13 Converting arable land to grassland in at-risk areas
14 Further good practices to reduce nutrient losses
16 Possibilities for financial support
17 Further relevant links
18 References
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 France, with a specific focus on the Brittany 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 Brittany

Approximately 1.73 million hectares were used for agriculture in Brittany in 2013, representing 63% of the total area. The region is one of France’s leading agricultural areas, accounting for 12% of the national agricultural production income in 2012 even though it only represents 6% of the national surface area. Livestock breeding is a primary activity in the region for pigs, poultry and dairy cows and arable production centres around tender wheat (1,676 kt in 2013) and maize (583 kt in 2013), which is mainly grown for feeding livestock. Brittany is also the leading region for vegetable production, which consumed 23% of the national surface area in 2013. In particular, cauliflower and artichoke production within Brittany represented 85% and 83%, respectively, of the total national production (in tonnes) in 2013.
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 Brittany region and what are the causes?

Brittany has the highest nitrogen (N) and phosphorus (P) levels in France and is one of the regions with the largest concentrations in the EU-28 due to its high livestock density, which is unevenly distributed throughout the territory. The resulting amount of phosphorus has been found to exceed the amount that can be assimilated by plants (1) and additionally, there is limited land where manure can be spread. Yet additional organic and chemical N fertiliser application is high, in particular for maize production and on pastures. Nitrates in surface waters frequently exceed the legal level. Nutrients, in particular phosphorus, impact the rivers, largely due to agricultural run-off and erosion, which contributes to freshwater and marine eutrophication. This has affected local shellfish farming as well as created algal blooms that impact human health, biodiversity, tourism and recreation. Drinking water treatment, beach and shallow water clean-up, pipe cleaning, as well as processing and spreading of the algae require significant costs. Soil and water acidification and particulate matter formation can result from the ammonia emissions produced by the manure, which pose a risk to human health.
Closing the mineral cycles at farm level

- Good practices to reduce nutrient loss in the Brittany region (France)

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

Brittany has been designated as a nitrate vulnerable zone (NVZ) in the implementation of the EU Nitrates Directive. Therefore, the region must comply with certain requirements, such as measures set forth under the French Nitrates Action Programme including nitrogen fertilisation plans for the use of manure, mandatory soil coverage, and a ban on wetland drainage. More restrictive measures have been applied to certain areas with pollution risks around drinking water catchments (in French – ZAR), e.g., a nitrogen budget lower than 50 kg N/ha. Beginning in 2011, based on the size of the farm, P fertilisation had to be balanced and the application of phosphate from organic and chemical fertilisers was limited to 80 to 95 kg P2O5/ha in areas covered by the “Scheme for planning and managing water at basin level” (SDAGE). The nitrogen to phosphorus ratio varies according to the organic matter though, so this threshold may have also limited the amount of N applied (e.g., 140 kg N/ha for pig slurry).

Brittany has largely promoted measures such as adaptation of feeding and fertilisation strategies, band spreading, immediate incorporation of manure, and improved manure management equipment and installations. The region also aims to achieve 100 MW of energy production by 2020 through anaerobic digestion of manure and other materials. Many ongoing studies are aimed at improving manure processing techniques, in particular on experimental farms in the region. In 2007, 41.6% of the excess nitrogen in Brittany was reduced by manure transfer; 25.7% through manure treatment (particularly composting and biological treatment of slurry); 23.5% with feeding practices, especially bi-phase feeding; and 8.9% by reductions in the number of livestock. Between 2000 and 2010, the amount of organic nitrogen applied decreased by 38%. Mineral fertiliser consumption of N decreased by 26% over twelve years and by 41% for P over seven years. (2) However, nutrient losses continue to occur and certain measures have a high potential for improvement, such as livestock feeding, manure cover during storage, manure processing, nitrogen and phosphorus fertilisation plans, rotational grazing, and the conversion of arable land into grassland.

Mixed use landscape with livestock, arable crop production and energy production

Agriculture has a high impact on landscapes in Brittany that include 182,500 km of hedges (survey DRAAF 2008)
Set of region-specific good practices

Several examples of ‘good practice’ measures to reduce nutrient loss and increase resource efficiency in the Brittany 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 Brittany 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 Brittany 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 Brittany region

<table>
<thead>
<tr>
<th>Driver</th>
<th>Problem</th>
<th>Good Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>High quantity of manure produced</td>
<td>Higher nutrient supply than demand: nutrient losses, greenhouse gas emissions</td>
<td>Adjusting feeding strategies and techniques</td>
</tr>
<tr>
<td>Inadequate manure storage</td>
<td>Large ammonia and greenhouse gas emissions from manure</td>
<td>Improving manure processing</td>
</tr>
<tr>
<td>Inefficient use of fertiliser</td>
<td>Nutrient losses by leaching, run-off and emissions</td>
<td>Improving fertilisation management plans for all agricultural sites</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optimising grazing intensity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Converting arable land to grassland in at-risk areas</td>
</tr>
</tbody>
</table>
## 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. Adapting feeding strategies to match the animals’ needs and to increase their assimilation of nutrients can reduce the nutrient loads in manure. In particular, replacing bi-phase feeding with multi-phase feeding and incorporating phytase into the feed could be an option for pig and poultry production in Brittany.

### 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;
- Carefully match decreases in protein content with the animals’ needs to avoid decreasing growth rate.

### 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. Increasing P assimilation by animals requires increases in feed digestibility by adding phytase. Animals may need to be grouped by gender, production stage or age to facilitate diverse feeding strategies; obtain assistance from animal dieticians if necessary to determine appropriate amounts.

### Effects, benefits and costs

#### Benefits for farming business
- Use of synthetic amino acids may reduce the need for protein feed as well as the amount of land needed to grow protein fodder.

#### Costs for farming business
- Purchase of amino acids or phytase to add to the feed; initial labour to re-group animals; regular analyses of fodder; replacement of bi-phase feeding by multi-phase feeding at similar costs.

#### Co-benefits and trade-offs
- The costs of feed are reduced due to avoided feed waste. When the nutrient content of animal manure is reduced (e.g., P excretion reduced by 60% (3)), 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. Additionally, potentially less land will be needed for fodder production.

#### 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.
## Definition of the measure

Reduce local manure surpluses through conversion into higher value products or products which are easier to use. Physico-chemical processes or biological reactions are available, including anaerobic digestion, composting manure and phase separation. For pig manure, the main treatment in the region is an activated-sludge process with a nitrification-denitrification (NDN) treatment, possibly preceded by separation of the liquid and solid fractions. For beef and dairy cattle, and solid manure in general, the main treatments in Brittany are composting and anaerobic digestion. Bio4gas and Valogreen are two examples of successful initiatives that have helped farmers implement anaerobic digestion reactors on farms with limited costs since 2012 and 2013, respectively.

## Technical implementation

<table>
<thead>
<tr>
<th>Increase ease of manure use</th>
<th>Mechanical phase separation, composting manure or increasing phosphorus concentration by centrifugation;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease the nutrient content of manure</td>
<td>NDN treatment process;</td>
</tr>
<tr>
<td>Create energy and use the residue as fertiliser</td>
<td>Anaerobic digestion on-farm or through a centralised anaerobic digestion management facility using other types of input material in addition to manure.</td>
</tr>
</tbody>
</table>

## 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. Treatment with mechanical separation and the NDN process for pig production in the region: investment costs of 450,000 EUR and running costs of 3.51 EUR/m³ for slurry (based on an operation with 140 sows). (7) Phosphorus centrifugation is highly efficient but quite expensive. For a breeding-fattening system with 150 sows, the total costs vary from 6.38 to 9.44 EUR/kg P2O5 extracted with an investment cost varying from 72,000 to 100,000 EUR (8). One example of a successful and profitable biogas plant in the region is the collective plant in Plélo.

### Co-benefits and trade-offs

Mechanical separation and NDN treatment capture or export 93% of the nitrogen and 86% of the phosphorus in the manure. Digested manure is more easily assimilated by crops, allowing for more precise use of fertiliser. Application should be matched with the plant needs and soil type, however, to avoid losses of the remaining nutrients. A further benefit is the reduction of greenhouse gas emissions during the production of fertilisers if less additional inorganic fertiliser is applied. 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, such as the northern coast of Brittany.

### 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), thereby decreasing the impact on climate.
- **Soil**: Slightly reduced soil acidification, but variable effects on soil fertility and health (e.g., high C content in the digested manure could improve soils with low organic matter levels).
- **Water**: Potentially reduced leaching (N transformed to immobile forms in digested or composted manure), 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.
## 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, which is an important factor in the Finistère.

### Technical implementation
To decide on the type of cover and/or controlled subsurface, the percentage of dry matter in the manure needs to be considered as well as the amount of precipitation received. Fixed covers are more efficient in achieving emission reductions and in diverting rainfall collection. Flexible covers can be implemented in different ways, e.g., straw, clay, fleece, and foils are some possible covers. If the manure is cooled, its N content will be higher as less is lost through volatilisation.

### Technical requirements
For cattle manure, a natural crust forms and provides a reduction in the release of ammonia and methane as long as the crust is not disturbed. Thus, tanks should be filled from the bottom to limit mixing. However, natural crusts do not protect the manure from rainfall, so an impermeable cover or certain types of semi-permeable covers (e.g., foil) would be more effective.

### 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. In Brittany, considering a manure application cost of 2 EUR per m³, tank coverage is economically profitable when more than 1,000 mm of rain are received per year.

#### 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.
# Improving fertilisation management plans for all agricultural sites

**Definition of the measure**

Improve fertilisation management plans for N and extend their coverage of P and K to the whole region to balance the nutrient budget. 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) could be devised beyond the basic requirements of the Nitrates Action Programme (4) and the requirements of the SDAGE for the whole territory. Specific tools (e.g., soil analysis) and technical advisory support could be used to match the amount of nutrients applied to the conditions of the land (soil type, crop demand, and remaining nutrients). This measure is specifically suited for maize production in Brittany.

**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. Approximately half of Brittany’s farmers account for nitrogen residues in their soil to establish their fertilisation levels.
  - 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. In 2011, 40% of the holdings performed soil analyses for solid manure compared to 25% in 2004, while 85% of the holdings performed analyses for slurry in 2011 (up from 61% in 2004).

**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 ($N_{\text{min}}$), which also serve as a monitoring element of this measure. Nutrient application is fine-tuned according to the crop type and the local conditions. Fractioned application can be an efficient technique to cater to the crops’ needs and reduce nutrient losses between applications.

## 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.
## Optimising grazing intensity – rotational grazing

### Definition of the measure
Optimising the efficiency of manure application through rotational grazing. This practice is particularly relevant for the region considering the high share of pastureland and nutrient losses resulting from uneven manure deposition by grazing animals and the excessive application of chemical fertilisers.

### Technical implementation
- Split land into grazing paddocks;
- Move cattle regularly to new paddocks;
- Vary location of drinking water within each paddock;
- Soil compaction can be avoided by removing stock from pastures during and shortly after heavy rainfall. In some areas of Brittany, this may not be possible due to frequent rainfall.

### Technical requirements
Requires farms to have land available for grazing, i.e., if a farmer decides to increase the grazing area, s/he needs more available land. If rotational grazing is applied, the pasture needs to be adapted by splitting it into paddocks with fencing. This technique also requires more labour to separate and move the livestock around regularly.

### Effects, benefits and costs

#### Benefits for farming business
- Manure deposition will be more evenly spread, improving plant uptake and reducing the need for and purchase of chemical fertilisers.

#### Costs for farming business
- May require construction of fences/paddocks and additional labour costs to move livestock around.

#### Co-benefits and trade-offs
- Soil conditions need to be considered: increasing grazing time with insufficient rotation can cause soil damage or compaction.

#### Environmental effects
- **Soil**: Improved soil fertility and structure through reduced soil compaction from livestock trampling and less de-vegetation.
- **Water**: Reduced run-off of nutrients due to less compaction (e.g., urine can better infiltrate the soil with better soil structure), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
- **Air**: Decreased ammonia emissions (due to faster absorption of urine) 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 due to less fertiliser production), thereby decreasing the impact on climate.
Converting arable land to grassland in at-risk areas

**Definition of the measure**
Land use change from arable production to grassland results in less intensive use, reducing or eliminating the use of fertilisers. These areas also act as buffer areas, reducing nutrient losses due to permanent vegetative cover. High risk areas where this would be appropriate are those lands which are prone to erosion, nutrient loss, and flooding. This measure would also be applicable to areas with high levels of precipitation, which in Brittany include the valleys and catchment areas of the river basins (e.g., Lieue-en-Greve).

**Technical implementation**
General analysis of the landscape in order to convert lands that are the most at-risk and have the highest buffer potential while considering the land productivity. Soil testing may be needed. The grassland may need to be seeded at an appropriate density rate and rolled afterwards. Natural regeneration may also be considered as a possibility for conversion.

**Technical requirements**
The measure requires additional knowledge (and materials) for the harvesting and storage of forage.

**Effects, benefits and costs**

**Benefits for farming business**
Once established, the grassland requires little maintenance and it offers economic benefits through the sale of forage and savings from reduced fertiliser purchase. Examples of gross margin increases are available in the region. (9)

**Costs for farming business**
Depending on the land price for the area taken out of production and the resulting income loss from not harvesting crops there, costs may vary. Costs required to seed and roll the grassland, test the soil to determine its nutrient status, and purchase any fertilisers that need to be added.

**Co-benefits and trade-offs**
Soil and water quality is improved by slowing floodwaters and rainwater run-off through increased soil infiltration and groundwater recharge. In soils that contain a high amount of P, soluble P leaching is reduced due to the bonding of P with soil particles.

**Environmental effects**
- **Soil**: Improved soil fertility and structure through increased soil organic matter and reduced risk of soil erosion, contributing to carbon sequestration and storage in the soil.
- **Water**: Reduced risk of leaching and run-off of nutrients (P, N and K), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
- **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), thereby decreasing the impact on climate.
- **Biodiversity**: Positive effects from reduced N deposition in natural ecosystems.
Further good practices to reduce nutrient losses

Improving the collection of manure from livestock housing units

In France, 95% of pigs are grown in buildings with slatted floors. (10) Use of a “V” scraper, a solid-liquid separation device, separates out a solid fraction containing 90% of the phosphorus and 55% of the nitrogen from the original pig manure while reducing ammonia and nitrous oxide emissions by 54% and 49%, respectively. For a breeding-fattening system with 150 sows, the investment cost for a “V” scraper is estimated to be around 88,000 EUR and the running costs are 2,800 EUR. The “V” scraper is cheaper per kg of extracted P compared to other concentration devices due to its low running cost. (8) Still experimental, the device has been tested at an experimental farm in Guernévez since 2006. Between 2010 and 2013, however, 25 to 30 pig holdings were built with this system.

The high investment cost is a barrier to implementation of this system. Currently, it is mostly implemented in new buildings. Nevertheless, the process is simple and robust and farmers asked about it have expressed satisfaction. Composting the output with 2% straw produces a material rich in phosphorus and organic nitrogen, but it still complies with French standards for organic fertiliser (e.g., NF U 42-001).

Conservation tillage techniques

In Brittany, many initiatives promote conservation techniques (“Techniques Culturales Sans Labour” (TCSL)). They include techniques such as no-till and minimum or reduced till. In 2006, 21% of the region’s maize and cereal production was carried out using conservation tillage techniques. However, no-till is not widely used compared to other techniques. In 2010, no-till was used on 35,290 ha (<2% of the arable land), while conservation tillage occurred on 197,580 ha (13% of the arable land) in the region. Conventional tillage was the main technique applied on 748,440 ha in Brittany (50% of the arable land). Hence, there is large room for improvement in the uptake of conservation tillage techniques.

Diverse crop rotations correlate with an increased use of direct seeding. For instance, in France direct seeding was used on 88% of the fields where sunflowers were planted after wheat in 2006, while the technique was only used on 30% of the fields with a wheat-wheat rotation in the same year. (11) According to a survey performed by the French agricultural statistics department, Agreste, under the Ministry of Agriculture, Agrifood and Forests in 2006, 66% of farmers do not use conservation-specific machinery. Guidance documents have been produced to advise farmers on the conversion process to conservation tillage techniques. Conservation tillage techniques offer benefits such as time savings. Nevertheless, they may represent an important reorganisation of fieldwork and possible investment in machinery. Thus, this measure may be more preferable for large farms considering the high investment in specific machinery or farms willing to explore collective options for machinery purchase and/or rental. Moreover, this technique requires some dry days before seeding, which may be a problem due to the regional climate. No-till can also reduce the possibility to incorporate manure and increase the use of herbicides. It should be avoided in highly compacted areas.

Implementing grass strips along hedgerows

The main landscape characteristic in Brittany is a patchwork of hedgerows dividing the land into many small plots. However, this mosaic landscape has been progressively changed with the development of intensive agricultural activities. Although the number of hedgerows is still decreasing, there is a growing awareness of their role in the cultural identity of Brittany and their positive effect on erosion and the reduction of nutrient run-off. In 2010, Brittany had 182,500 km of hedgerows. In areas covered by the SDAGE, maintenance and implementation of new hedgerows is mandatory. Extension of this measure would be relevant, particularly in drinking water catchments.

Consider climatic conditions before spreading manure

In addition to the periods when application of manure is forbidden (as determined under the Nitrates Action Programme), fertiliser application should be avoided before rainfall events to limit nutrient run-off. This requires accurate monitoring of the weather considering the frequent and abundant rainfall within the region. This is particularly the case in western Brittany where some soils are seasonally saturated.
Artichoke field, bay of Pleubian in Brittany
Possibilities for financial support

Agency for the Environment and Energy Management of Brittany (ADEME Bretagne): applications for funding and calls for proposals
http://www3.ademe.fr/bretagne/

Chambers of Agriculture Bretagne: financial assistance
http://www.chambre-agriculture-bretagne.fr/synagri/soutiens-financiers

Environment Plant Plan (PVE)
http://www.chambre-agriculture-bretagne.fr/synagri/plan-vegetal-environnement
Modemisation scheme for livestock buildings (PMBE); Breizh Bocage; and Watershed contracts.

DREAL Bretagne: Directive Nitrates 5ème programme d’actions en Bretagne
(French Regional Directorate for Environment, Planning and Housing of Brittany (DREAL Bretagne): Nitrate Directive, 5th Action Programme in Brittany)

Regional Council of Brittany: call for proposals “Operational Investment Plan 2014”
and regional assistance “Contract Nature”
http://www.bretagne.fr/internet/jcms/preprod_31181/contrat-nature

Regional Directorate of Food, Agriculture and Forestry: Agri-environmental measures in Brittany
and financial and technical assistance
http://draf.bretagne.agriculture.gouv.fr/Les-projets-de-territoire

National Institute for Agronomic Research (INRA) Rennes: socio-economic partnerships
http://www.rennes.inra.fr/Partenariats/Partenariats/Partenariats-socio-economiques/(key)/1

Water Agency Loire Bretagne: application for funding granted to farmers
http://www.eau-loire-bretagne.fr/agriculteurs/aide_financiere

Ministry of Agriculture, Agrifood and Forestry: call for proposals “National organisms specialized in agricultural or rural activities” 2015-2020
http://agriculture.gouv.fr/developpement-agricole-et-rural-appels-projet

Common Agricultural Policy (CAP): measures funded by CAP and related to nitrogen use (AEM, conversion to organic farming, low-input forage areas (SFEI), etc.)
http://ec.europa.eu/agriculture/cap-funding/funding-opportunities/index_en.htm
Further relevant links

Further information (links) on the issue of reducing nutrient losses in agriculture which are relevant for the Brittany region can be found below. This information entails links to legal documents, 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/naturres/phosphorus.htm

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

**National and regional level**

Ministry of Agriculture, Agrifood and Forestry:
http://agriculture.gouv.fr/

Ministry of Ecology, Sustainable Development and Energy:
http://www.developpement-durable.gouv.fr/

ADEME Bretagne:
http://www.ademe.fr/bretagne/

Regional Council of Brittany:

Regional Directorate of Food, Agriculture and Forestry:
http://draf.bretagne.agriculture.gouv.fr/

DREAL Bretagne:
http://www.bretagne.developpement-durable.gouv.fr/

INRA (National Institute for Agronomic Research) Rennes:
http://www.rennes.inra.fr/

Public Interest Group Bretagne Environment:
http://www.bretagne-environnement.org/

Water Agency Loire Bretagne:
http://www.eau-loire-bretagne.fr/

Chambers of Agriculture Bretagne:

- Chamber of Agriculture Ille-et-Vilaine:
  http://www.agriculteurs35.com/

- Chamber of Agriculture Côtes d'Armor:
  http://www.agriculteurs22.com/

- Chamber of Agriculture Finistère:
  http://www.chambre-agriculture-finistere.fr/

- Chamber of Agriculture Morbihan:
  http://www.agriculteurs56.com/

**Studies and projects**

RMT Guide de bonnes pratiques environnementales d'élevage (Good Environmental Livestock-Raising Guide):


Policy Incentives for Climate Change Mitigation Agricultural Techniques (PICCMAT):
http://climatechangeintelligence.baastel.be/piccmat/
References


(2) Fédération Départementale des Syndicats d'Exploitants Agricoles (FDSEA Bretagne) (2012) La Bretagne a relevé le défi des nitrates (French Departmental Federation of Farmer Unions - Brittany Has Taken Up the Challenge of Nitrates).


(10) Chambre d'Agriculture de Bretagne (2014) Gestion des effluents porcins (Brittany Chamber of Agriculture – Managing Liquid Manure from Pigs).
