Closing the mineral cycles at farm level

Good practices to reduce nutrient loss in the Wielkopolskie region (Poland)
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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 Poland, with a specific focus on the Wielkopolskie region. The leaflet also provides practical information to farmers on how resource use efficiency can be maximised through good practices at farm level.

Strongly overfertilised mid-field pond
Agricultural structure in Wielkopolskie

Approximately 1.7 million hectares were dedicated to agriculture in Wielkopolskie in 2013, representing 57% of the total area. Arable land accounted for 81% of the total agricultural land in the region, with cereals, sugar beets and vegetables representing the dominant crops. Cereal production occurred on 73% of the arable land (mainly wheat and maize).

Livestock production includes pigs, poultry and cattle. The largest number of pigs in the country (3.9 million in 2013) is housed in Wielkopolskie. The region also holds the second highest number of cattle (860,000 in 2013) in Poland. The regional livestock density is relatively moderate, however, with an average of 0.7 livestock animals per ha in 2008-2011.

Figure 1 - Map of Europe (Poland in green) and map of Poland showing the Wielkopolskie 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 Wielkopolskie region and what are the causes?

The Wielkopolskie region faces a number of pressures from nutrient surpluses, largely due to agricultural production as well as industrial and municipal waste. (1) Restructuring and intensification of farms, large and concentrated livestock production with poor farm infrastructure, lack of implementation and accuracy of fertilisation management plans, very few examples of collective action between farmers, and dense drainage networks have contributed to nutrient losses in the region. Wielkopolskie’s light, acidic, and highly erodible soil also contributes to nutrient losses, causing regional as well as transboundary effects. Eutrophication of lakes, lagoons, and the Baltic Sea has partly resulted from N and P surpluses from agriculture in the region, which has impacted recreation and tourism opportunities as well as biodiversity due to the development of algae blooms. More than 80% of surface water sources frequently exceed the legal standards for drinking water, leading to high treatment costs.
What has already been done to address the problem in the region?

Since 1996, the Polish government has issued policy guidelines to integrate environmental concerns into agricultural processes. The Polish Code of Agricultural Good Practices was developed in 2004, prioritising the “sustainable balance of mineral nutrients” and creating a monitoring programme to track the mineral nitrogen content in soil. The programme aimed to determine the right nutrient doses for crops and assess how to prevent nitrogen leaching from soil to water. Research has also been conducted on how to streamline fertiliser uptake in vegetable production through integrated and organic production methods.

Poland has co-coordinated (along with Finland) the Priority Area “Nutri” of the EU Strategy for the Baltic Sea Region, aimed at reducing nutrient inputs to the Baltic Sea. (2) Three river basins in the Wielkopolskie Vovoidship developed water management plans to improve the surface water quality as well as reduce the nutrient load transported to the Baltic Sea. The Wielkopolska Agriculture Advisory Centre in Poznań offers trainings and workshops for farmers and advisors. It has also implemented a network of demonstration farms in the context of the Baltic Deal project. (3) Additionally, a project founded by BalticSea2020 on “Self-evaluation concerning nutrients by farmers in Poland” was also launched in 2013. The three-year project is aimed at training farm advisors and engaging with farmers in order to propose measures to reduce nutrient run-off based on their experiences. In 2013, the project led to the publication of a guide to improve nutrient management for both advisors and farmers. (4)
**Set of region-specific good practices**

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

<table>
<thead>
<tr>
<th>Driver</th>
<th>Problem</th>
<th>Good Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>High livestock density</td>
<td>Large ammonia emissions from manure</td>
<td>Composting manure</td>
</tr>
<tr>
<td>Inefficient use of fertiliser</td>
<td>Excessive application of fertiliser</td>
<td>Cooling manure or slurry</td>
</tr>
<tr>
<td></td>
<td>Nutrient losses by leaching and run-off</td>
<td>Improving fertilisation management plans for all agricultural sites</td>
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<td></td>
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<td>Using appropriate application technique</td>
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<td></td>
<td></td>
<td>Using catch/cover crops</td>
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<tr>
<td></td>
<td></td>
<td>Constructing sediment ponds to retain nutrients</td>
</tr>
</tbody>
</table>
## Composting manure

### Definition of the measure
Composting solid manure transforms nitrogen into ammonia and reduces the volume of the original material. Composting can be easily implemented on-farm and generates a product that is easy to export off-farm.

### Technical implementation
Manure can be composted in containers; it requires regular aeration by pushing or pulling air through the compost piles; the use of closed systems as well as modifying the C:N ratio helps reduce ammonia emissions (up to 40% of N losses are in ammonia form), but it can also enhance nitrous oxide emissions.

### Technical requirements
Composting is preferably applied to solid pig/cattle manure and to pig/cattle/poultry deep litter; regular aeration of the compost may require specific machinery; the quality of compost produced as well as the gaseous N lost due to denitrification during composting depend on: moisture content, porosity, C:N ratio of the raw manure, temperature, pH, and forced aeration/mechanical turning; optimal composting occurs when there is a C:N ratio between 20 and 30. For pig manure, straw needs to be added to obtain the C:N ratio required for optimal microorganism activity.

### Effects, benefits and costs

#### Benefits for farming business
Composting facilitates easier storage and use of manure. Using compost as a fertiliser also increases nutrient assimilation by crops, thereby reducing the need for chemical fertilisers.

#### Costs for farming business
The cost of an aerator for use in domestic production is estimated at 0.15 EUR/tonne of processed manure; thus, investment costs are around 7,200 EUR in Poland. (5)

#### Co-benefits and trade-offs
Composted manure can be stored or spread with little odour, pathogens and weed seeds. Additionally, increased availability of some N for plants (ammonium) may result in fewer losses to water or air after spreading. Rain or snow falling on uncovered compost piles results in water percolation through the piles that can transfer nutrients to water bodies by run-off or leaching. However, ammonia volatilisation, more than nitrate run-off and leaching losses, may reduce compost’s potential as a plant nutrient source.

#### Environmental effects
**Air:** Decreased ammonia emissions (depending on the C:N ratio) leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems).

**Water:** Reduced leaching and run-off of nutrients (N, and P to a lesser extent) through higher content of ammonium and storage in soil organic matter, 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.
**Cooling manure or slurry**

<table>
<thead>
<tr>
<th><strong>Definition of the measure</strong></th>
<th>Temperature control of the stored manure or slurry to decrease the volatilisation rate and thus ammonia emissions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical implementation</strong></td>
<td>Properly insulate the storage units to avoid temperature changes resulting from the exterior temperature; Install cooling plates and pipes; Regularly control the temperature.</td>
</tr>
<tr>
<td><strong>Technical requirements</strong></td>
<td>This measure requires slurry to be stored in a tank. It may require infrastructure changes at farm level, e.g. placing slurry tanks under the housing units may warm the manure by its proximity to the livestock. Cooling slurry could also be connected to a system of heat recovery.</td>
</tr>
</tbody>
</table>

**Effects, benefits and costs**

**Benefits for farming business**
Decrease in the amount of fertiliser purchased, as the manure contains more ammonium; cost-savings through less labour due to fewer applications; possible on-farm energy savings through installation of heat exchangers that allow for recuperation of energy to heat homes, livestock buildings, water, or to dry crops.

**Costs for farming business**
Installation and materials for slurry tanks; costs may vary depending on whether the farmer is able to construct or change the storage infrastructure independently or if a contractor needs to be hired.

**Co-benefits and trade-offs**
The N content of manure is higher as less is lost through volatilisation and may require less overall application with targeted matching of the nutrient content to the plants’ needs. Thus, the nutrient content of the manure must be taken into account during application to avoid excess fertilisation that can lead to leaching and run-off.

**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, nitrous oxide and carbon dioxide), thereby decreasing the impact on climate.
- **Soil**: Improved soil fertility and health through reduced potential for soil acidification.
- **Biodiversity**: Positive effects from reduced N deposition in natural ecosystems.
# Improving fertilisation management plans for all agricultural sites

<table>
<thead>
<tr>
<th>Definition of the measure</th>
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</thead>
<tbody>
<tr>
<td>Preparation of basic fertiliser management plans could be expanded to cover the whole territory rather than just large farms (&gt; 100 ha) in nitrate vulnerable zones (NVZs) and pig and poultry farms with more than 100 livestock units. Additionally, larger farms could include more detailed calculations in their plans than simply determining the basic nutrient balance. For instance, more detailed fertilisation management plans 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 specific plot conditions (soil type, crop demand, and remaining nutrients). Basing organic and inorganic fertiliser application rates on a calculated nutrient balance can considerably reduce nutrient losses.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical implementation</th>
</tr>
</thead>
</table>
| 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. |

<table>
<thead>
<tr>
<th>Technical requirements</th>
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<tbody>
<tr>
<td>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 ($N_{\text{beg}}$), which also serve as a monitoring element of this measure. Nutrient application is fine-tuned according to the crop type and the local conditions. Appropriate tools are required to calculate the necessary fertiliser levels, which may be accessible through advisory services.</td>
</tr>
</tbody>
</table>

## 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 use 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 decreases and consequently, the amount of nitrogen utilised by the crops is improved. Even distribution of manure can also improve the utilisation of nutrients. When manure is incorporate immediately after spreading or directly through injection, nutrient run-off 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. (6)

**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);
- **Water**: Reduced greenhouse gas emissions (carbon dioxide – reduced production of mineral fertiliser), thereby decreasing the impact on climate.
- **Soil**: Improved soil fertility and health through reduced potential for acidification.
- **Biodiversity**: Positive effects from reduced N deposition in natural ecosystems.
## Using catch/cover crops

**Definition of the measure**
Integrating catch crops into the crop rotation reduces nutrient leaching and run-off and decreases the need to add organic and mineral fertilisers. This is particularly relevant to farms in NVZs, where nitrogen leaching risk must be reduced by using catch/cover crops or other suitable measures included the Code of Good Agricultural Practice. (7)

**Technical implementation**
Crop rotation (with catch crops in winter) should account for the characteristics of each type of catch crop in order to maintain good soil structure and soil organic matter. Catch crops should be incorporated mechanically only to avoid additional chemical application and further pollution risks.

**Technical requirements**
Integrating catch crops is particularly suited to the region due to the soil type; catch crops are more effective on sandy soils than on clay soils, which is the case in Wielkopolskie. Consideration of the appropriate time for seeding and ploughing under the catch crop is required, but low technical and knowledge requirements are necessary. The choice of the catch crops should be adapted to the territory and the other crops of the rotation to optimise their nutrient catching function. Legumes mixed with cereals are already used by Polish farmers, which contribute to the N surplus in the region due to biological fixation.

### Effects, benefits and costs

**Benefits for farming business**
Improved soil fertility and availability of nutrients after the crop has been ploughed in as the residues release nutrients which are available to nourish the following crop, thus reducing the need for additional fertiliser purchase and application costs.

**Costs for farming business**
Additional seeding and ploughing costs but overall, low implementation/running costs.

**Co-benefits and trade-offs**
Catch crops (and cover crops in general) are a means to combat weeds. Consider legumes for soils with poor nutrient content or which are subject to high nutrient losses due to their capacity for N-fixation. One drawback of legume-rich swards is the high risk of nitrate leaching and increased nitrous oxide emissions after ploughing.

**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 during fallow crop periods, decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
- **Air**: Reduced greenhouse gas emissions (nitrous oxide), thereby decreasing the impact on climate.
- **Biodiversity**: Positive effects due to the catch/cover crops providing additional wildlife and pollinator habitats.
Constructing sediment ponds to retain nutrients

<table>
<thead>
<tr>
<th>Definition of the measure</th>
<th>Small shallow sediment basins retain soil particles and nutrients, especially P, from run-off water. This measure could help decrease the nutrient concentration in surface water.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical implementation</td>
<td>A sediment pond is composed of a shallow sediment basin and wetland covered with typical wetland plants, which act as a filter. Ponds can be constructed by widening a section of a ditch or assessing the most appropriate location to create a shallow basin based on the natural drainage of the area. The size of the drainage area and the soil type will influence the size of the sediment pond and the suitability of the measure (e.g., basins in sandy soils would not retain high structural integrity compared to other soil types). The flow of run-off may need to be slowed down by increasing soil heights along ponds to block the pathway of the water. If the area is highly sloping, a second wetland can be added to increase the sedimentation efficiency.</td>
</tr>
<tr>
<td>Technical requirements</td>
<td>The measure does not require significant investments or technical knowledge, but the measure does require some substantial planning before implementation and additional labour to create the pond. This measure can be combined with conservation tillage and buffer strips at the end of the field to reduce soil erosion and nutrient losses.</td>
</tr>
</tbody>
</table>

Effects, benefits and costs

**Benefits for farming business**

Once established, sediment ponds require little maintenance and cleaning out the built-up sediment allows farmers to recover organic matter and nutrients to re-apply onto the field. This reduces the need to purchase and apply additional fertilisers. Additionally, farms practicing irrigation can create sediment ponds to catch the irrigation run-off and re-use it for increased water use efficiency.

**Costs for farming business**

Costs for labour to implement technical requirements, such as increasing soil heights, creating shallow basins, or widening a section of a ditch. Costs may vary depending on the area taken out of production and the opportunity costs from not harvesting crops there.

**Co-benefits and trade-offs**

Soil and water quality is improved by slowing floodwaters and rainwater run-off and retaining the nutrients in the sediment (mainly P), which are caught by the plants. Pesticides may be caught in addition to N, P, and K bound to soil particles. Possible risk of plant death and fungi development in the ponds if the ponds stay wet for a long period of time. As constructed wetlands, sedimentation ponds produce varying levels of N and methane emissions to air, which negatively impact climate change. However, wetlands can store large amounts of carbon, which has a positive impact on climate change. (8)

**Environmental effects**

**Water**: Reduced risk of eutrophication through storage and sedimentation of run-off water containing soil particles and nutrients (especially P as well as N and K) and improving surface water quality, thereby lowering risks to human health and biodiversity.

**Biodiversity**: Benefits from creation or restoration of semi-natural habitats.
Further good practices to reduce nutrient losses

**Increasing the height of manure heaps to increase manure compaction**

Increasing the height of temporary manure heaps is a simple measure that reduces ammonia emissions through compaction of the manure under its own weight. Increasing heap height to 4-6 m would require proper equipment, such as a telescopic loader. This method is a less effective alternative to manure cover, but it is easier and cheaper to implement.

**Using an impermeable floor for manure storage**

Since a significant share of the manure is stored in heaps, using an impermeable floor (e.g., concrete) would avoid nutrient losses by run-off and leaching. Programmes have been implemented to help increase the use of impermeable floors for the temporary storage of solid manure and tanks for liquid manure and slurry. In particular, the Polish Rural Development Programme 2014-2020 under the EU Common Agricultural Policy provides subsidies for the modernisation of buildings and storage facilities.

**Conservation tillage techniques**

Wielkopolskie is affected by tillage-induced erosion, both from water and wind. Tillage-induced erosion is responsible for soil loss (> 20 t/ha) and thereby nutrient loss, in particular P. Favouring conservation tillage or no-till would help reduce the loss of nutrients due to tillage. Conservation tillage also decreases the decomposition of residues and thus increases the available nitrogen for crops. However, due to the type of soil in Wielkopolskie, which is mostly sandy, tillage would likely have only a limited effect on nutrient losses from leaching or emissions. This technique is mostly appropriate for large or intensive farms and holdings with few or no livestock. No-till can only be implemented in holdings with livestock production if the slurry is injected into the soil as slurry needs to be incorporated. While implementation may result in some labour cost-savings, both reduced till and no-till may require significant investments for the purchase of specialist machinery and/or result in an increased use of herbicides and pesticides. Yield loss may also potentially result due to weeds, leading to further costs.

**Incorporating crop residues**

Incorporating crop residues or mulching enriches soil organic matter and has a positive impact on soil structure and water retention capacity, which in turn reduces the risk of nutrient leaching. Residues such as straw have a high carbon to nitrogen ratio and help fix nitrogen that is slowly released. Combining fertilisers with straw and liming increases soil organic matter content. This measure can have a high effect on the overall regional nutrient loss since 84% of the land in the region is arable land. In Poland, ploughing under is the most common solution for utilising harvest residues. Farmers apply this type of practice in order to enrich their soils and due to a lack of alternative uses for the straw (e.g., insufficient quantities compared to the size of the cattle and breeding systems, or since a high quantity of pig operations do not use straw for bedding).
Aberdeen Angus and Simmental heifers in organic farm in Przybỳ region of Wielkopolskie.
Further relevant links

Further information (links) on the issue of reducing nutrient losses in agriculture which are relevant for the Wielkopolskie 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:

EU Strategy for the Baltic Sea Region:

Contacts:

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

**National and regional level**

Ministry of Agriculture and Rural Development:

Rural Development Programme for 2014-2020:

Ministry of the Environment:

Agency for Restructuring and Modernisation of Agriculture (ARMA):

Agricultural Market Agency (ARR):

Agricultural Social Insurance Fund:

Agricultural Property Agency
[http://www.anrgov.pl/web/guest](http://www.anrgov.pl/web/guest)

[http://www.ieep.eu/assets/74/seminar1countryreportpoland.pdf](http://www.ieep.eu/assets/74/seminar1countryreportpoland.pdf)

Wielkopolskie Region:

Statistical Office in Poznań:
Studies and projects


The Baltic Manure project – Business Opportunities: http://www.balticmanure.eu/

Baltic Deal: http://www.balticdeal.eu/ (links for buffer strips and compost from solid manure)


Pietrzak, S. (2012) Priority measures for reducing nitrogen and phosphorus losses from agriculture and water protection, Institute of Technology and Life Sciences in Falenty (ITP), Poland: www.balticdeal.eu/measure/adapted-feeding/?aid=4507&sa=1

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(3) Baltic Deal (2012) Putting best agricultural practises into work - How can 48 Polish farms reach 3,000 advisors and 1,600,000 farmers.


(5) Baltic Deal (2013) Production of aerobic compost from solid manure, available at https://www.google.com/url?q=http://www.balticdeal.eu/measure/compost-from-solid-manure%3Faid%3D5017%26sa%3DU&ei=dFOEVaffCgGsvQGStoPiBg&ved=0CAQQFjAA&client=internal-uds-cse&usg=AFQjCNFlgYqdH8TY0I51kHGiw2UyY0kOQ.


(7) Nitrates Directive 91/676/EEC.

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Cover page: Field crops in Raszków in the region of Wielkopolskie where cereal production occurred on 73% of the arable land (mainly wheat and maize) © Jacek Halicki - P3: Strongly overfertilised mid-field pond © Aneta Kozłowska - P5: Effects of crop rotation and monoculture at the Swojec Experimental Farm, Wroclaw University of Environmental and Life Sciences ©: Leslaw Zimny - P6 top & bottom: unusual example of a buffer zone between arable land and a lake. Water flows from a stream into the ditch and then into the shore of the lake overgrown by reeds by a siphon system intended to filter out sedimentation and nutrient loads © Zygmunt Miatkowski - P8: Composting is a natural process that transforms manure into a valuable organic fertiliser which is easier to handle and transport than fresh manure © Marek Krysztoforski - P9: Slurry cooling © Frank-Bondgaard - 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 Hutchinson / Alamy - P11: Equipment that allows direct incorporation of slurry and a uniform distribution of nutrients © Giorgio Provolo - P12: White mustard grown as catch crop in Poland © Leslaw Zimny - P13: This sedimentation pond was established by widening a section of a ditch. In the foreground, right after the inlet, is the deeper sedimentation basin © S. Owienius, Water Revival Systems Uppsala (WRS) - P15: Aberdeen Angus and Simmental heifers in organic farm in Pyzdry, region of Wielkopolskie © Edyta and Janina Saacke.

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