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# Legislation and voluntary actions regulating manure fertilization in the Baltic Sea Region

Johanna Laakso and Sari Luostarinen (eds.)

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Natural Resources Institute Finland, Helsinki 2019

*Manure Standards is co-funded by the Interreg Baltic Sea Region Programme. It is coordinated by Natural Resources Institute Finland (Luke) and includes 19 partners from 9 countries around the Baltic Sea: Finland, Sweden, Denmark, Germany, Poland, Lithuania, Latvia, Russia and Estonia. The project is a Flagship of the EU Strategy for the Baltic Sea Region. More information at [www.luke.fi/manurestandards/en](http://www.luke.fi/manurestandards/en).*



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# Foreword

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While progress has been made in reducing external nutrient inputs to the Baltic Sea, further actions are still urgently needed especially to reduce agricultural nitrogen and phosphorus inputs. All fertilization should be optimized according to the soil quality, crop produced and local conditions to maximize crop nutrient uptake and minimize losses. Manure is a major organic fertilizer from animal production and more precise manure fertilization with manure is of significance in reducing nutrient runoff from agricultural fields.

In the European Union, the Nitrates Directive and The Water Framework Directive aim to reduce water pollution caused or induced by nitrate. They are also targeted to decrease diffuse water pollution from agricultural sources to achieve good qualitative and quantitative status of all water bodies. These directives are integrated into the national legislation of each EU member state which means that even though the directives set a certain level of regulation, they are differently adopted in the different countries.

The Regulation (EC) No 2003/2003 relating to fertilisers objects safe and effective fertilizers market throughout the EU and the new Fertilizing Products Regulation (EU) 2019/1009 will open the European market for recycled nutrient products, and subsequently also for nutrient recycling technologies to produce them. Manure is the major biomass for nutrient recycling and the fertiliser regulation will affect its management in the future.

In the Russian Federation, fertilizer use of manure is based on the Federal Laws “On Protection of Environment” and “On Production and Consumption Waste”. Unprocessed manure is classified as a hazardous waste and hence its use as a fertilizer complies with the several federal laws on production and consumption waste, on protection of environment and on technical regulations. Practical solutions for manure management may still vary significantly.

This report compiles together legislation and voluntary actions regulating manure fertilization and fertilizer use in the Baltic Sea Region, in the following countries: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. Country-specific legislation on manure fertilization and fertilizer use is described in country-specific chapters.

The report has been made as part of the project “Advanced manure standards for sustainable nutrient management and reduced emissions”, Manure Standards. It produces new, transnationally equal methods for manure data collection with the aim of improving the precision of data on manure nutrient content and quantity for practical farming and policymaking purposes. This is seen as an integral step towards more precise manure management and fertilization practices and subsequently reduced manure-related emissions.

This report is one of the outputs of Manure Standards’ Work Package 5 “National and Baltic Sea Region actions for implementing new manure tools in manure policies and on farms”. A common opinion of the project partners was that legislation and regulations controlling manure fertilization use in the countries should be compiled together as this information is diverse and has not been collected earlier.

Keywords: manure, fertilization, fertilizer use, legislation, voluntary actions

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# 1. Introduction

Agricultural nutrient input into the Baltic Sea remains high with a significant risk of emissions from manure use as a fertilizer, especially in regions of intensive animal production. Agriculture contributes to over 70-90% of diffuse nitrogen and 60-80% of diffuse phosphorus inputs and almost half of total waterborne inputs to the sea, stated by HELCOM. Manure use should be enhanced, but the basis for its use both in practical farming and in regulation is not harmonized. Methods and frequency to collect information on manure nutrient content varies in the Baltic Sea countries (Luostarinen and Kaasinen, 2016) and the countries and farms are not on a level playing field with regards to the emission reduction targets.

In the European Union, the Nitrates Directive (91/676/EEC) aims to reduce water pollution caused or induced by nitrate from agricultural sources. The Water Framework Directive (2000/60/EC) has a broader approach for reducing diffuse water pollution from agricultural sources to achieve a good qualitative and quantitative status of all water bodies. These directives are integrated into the national legislation of each EU member state which means that even though the directives set a certain level of regulation, they are differently adopted in the different countries.

The Regulation (EC) No 2003/2003 relating to fertilisers objects safe and effective fertilizers market throughout the EU and the new EU Fertilizing Products Regulation (2019/1009) will open the European market for recycled nutrient products, and subsequently also for nutrient recycling technologies to produce them. Manure is the major biomass for nutrient recycling and the fertiliser regulation will affect its management in the future.

In the Russian Federation, fertilizer use of manure is based on the Federal Laws “On Protection of Environment” and “On Production and Consumption Waste”. Unprocessed manure is classified as a hazardous waste and hence its use as a fertilizer complies with the several federal laws on production and consumption waste, on protection of environment and on technical regulations. Practical solutions for manure management may still vary significantly.

In this report, the legislation and voluntary actions regulating manure management and fertilizer use are compiled for the following Baltic Sea countries: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. Due to potential changes in the regulation, it is worth noting that the situation described is for the year 2019.

## References

Luostarinen, S., and Kaasinen, S. (eds.), 2016. Manure Nutrient Content in the Baltic Sea Countries. Natural Resources and Bioeconomy Studies 40/2016. Natural Resources Institute Finland, Helsinki. Available online at: <http://urn.fi/URN:ISBN:978-952-326-272-0>

## 2. International regulation on fertilization

### 2.1. EU regulation on fertilization

**The Nitrates Directive (91/676/EEC)** was adopted by the Council of Ministers in 1991 because of environmental and health concerns over increasing nitrate concentrations in surface and ground waters in the EU, especially in intensively farmed agricultural areas. The ultimate goal of the Nitrates Directive is “reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution” (Art.1).

The Directive contains a wide spectrum of member state obligations that include the transposition of EU directive into national law and monitoring of all waters and identification of Nitrate Vulnerable Zones (NVZs). Additionally the member states are required to establish a Code of Good Agricultural Practice to be implemented on a voluntary basis and action programmes formulated and implemented for the designated NVZs based on standards contained in the Code of Good Agricultural Practice. These are binding for farmers in NVZs. The action plans must include a maximum per hectare application rate of nitrogen from animal manure of 170 kg N ha<sup>-1</sup>.

The Code of Good Agricultural Practice should contain measures relating to where and when fertilizers should be applied, how animal manure should be stored, and how manure and fertilizer should be applied. Specifically for the designated NVZs, action plans contain measures on the period when fertilizer application is prohibited, the storage capacity for animal manure, limits on the application of fertilizers to land, consideration of soil conditions, type, slope, climatic conditions, land use and crop rotation systems, and to balance nitrogen supply and crop demand.

**The EU Water Framework Directive (2000/60/EC)** was adopted in 2000. The Water Framework Directive requires the control of diffuse emissions into water bodies, the primary source of which is agriculture. The Directive aims to achieve good qualitative and quantitative status of all water bodies in the EU.

**Regulation (EC) No 2003/2003 of the European Parliament and of the Council relating to fertilizers** aims to ensure an internal EU market in fertilizers. It defines types of fertilizers which have been approved as EC fertilizers, based on three main requirements: 1) absence of adverse effects on the environment and health under normal use, 2) effectiveness, and 3) existence of sampling and analysis methods. EC fertilizers can circulate freely on the EU market but regulation allows member states to restrict the sale of a specific fertilizer if it poses a risk to safety, health or the environment. Non-EC fertilizers (also known as national fertilizers) may be placed on national markets provided they meet national requirements and can circulate in the EU market. However, current regulation has several weaknesses, in particular, it only covers a share of the fertilizer market, the member states criticize the lack of maximum limits on heavy metals in fertilizers, and it deters innovation because of complex and lengthy procedures to introduce new EC fertilizer types.

Subsequently, the European Parliament has now concluded the legislative adoption of **the new EU Fertilizing Products Regulation (2019/1009)**. This new regulation will open the EU market to recycled nutrient products, and also to nutrient recycling technologies to produce them. It covers organic, organo-mineral and mineral fertilizers, composts, digestates, food industry by-products, as well as other products, such as liming materials and fertilizer polymers. The Commission also proposes harmonized limits for heavy metals (cadmium, chromium, mercury, nickel, lead, arsenic) in CE marked fertilizers. The Regulation will be applicable across Europe without requiring member state transposition and will be fully applicable three years after publication. After implementation, any Fertilizing Product with the EU fertilizer status can be sold in any EU country. Member states will also have the



continuing possibility to authorize other products in their country as “national” fertilizers. The new regulation aims at promoting the increased use of recycled nutrients. This would further aid the development of the circular economy (European Union, 2015) and allow a more resource-efficient general use of nutrients while reducing Union dependency on nutrients from third-party countries.

## 2.2. Helsinki Convention’s regulation on fertilization

**Annex III Part II of the Helsinki Convention** (HELCOM) aims at the prevention of pollution from agriculture including regulation on, for example, plant nutrients, plant protection products and environmental permits. The Annex regulates that the amount of livestock manure applied to the land each year should not exceed the amount of manure containing 170 kg/ha nitrogen and 25 kg/ha phosphorus. The Annex also includes a six-month capacity requirement for manure storages. Concerning permits for livestock farms, the Annex states that installations for the intensive rearing of poultry, pigs and cattle with more than 40 000 places for poultry, 2 000 places for production pigs (over 30 kg), 750 places for sows or 400 animal units cattle should have a permit fully coordinated by the relevant authorities. The Annex is under revision at the time of writing this report.

### References

European Union, 2015. European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Closing the Loop—An EU Action Plan for the Circular Economy, COM(2015) 614/2. Available online: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614> (accessed on 18 November 2019).

### 3. Country-specific legislation on manure fertilization

The Baltic Sea countries that are included in this section are Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. The legislation on manure fertilization and fertilizer use is presented country-specifically. A summary is given below and in Table 1.

#### Denmark

Denmark has an advanced system for manure utilization consisting of fertilization planning, nutrient balances and documentation. Each farm must submit a fertilizer account to the Ministry of Environment and Food of Denmark (*Miljø og Fødevareministeriet*) each year. The maximum allowable fertilization rate for nitrogen in manure and organic fertilizers is 170 kg N/ha as regulated in the EU Nitrates Directive (NiD). In cattle derogation farms that have specific requests regarding crops with a long growing season and a high nutrient uptake, farms are allowed to apply up to 230 kg N/ha. The maximum rate of phosphorus for 2019/2020 is between 30-39 kg P/ha. Denmark has a number of voluntary actions for farmers to reduce the environmental impact of agricultural production.

#### Estonia

The maximum amounts for nitrogen and phosphorus with manure fertilization are 170 kg N/ha and 25 kg P/ha, respectively. There are crop specific fertilization limits for nitrogen but also for phosphorus. Registration of input of fertilizers and harvested yields is mandatory on a field level. Farms of more than 400 animal units with liquid manure are obliged to prepare three-year fertilization plans which are approved by the Environmental Board. In Estonia, there are several voluntary support schemes that promote the optimal use of fertilizers.

#### Finland

The maximum amount of nitrogen in fertilization with farm animal manure and organic fertilizer products containing manure is 170 kg N/ha per year as regulated in the NiD. The maximum crop specific soluble nitrogen application levels (from all nutrient sources) are also regulated but for phosphorus there are no regulatory limits in fertilization with manure. The nitrogen input, yield level, and spreading time of manure must be documented in field books. Nearly 90% of the cultivated area resides within the agri-environmental scheme. In these farms, more detailed documentation of production measures is needed, and the soluble nitrogen levels permitted are lower than regulated by the Nitrates Decree, and also phosphorus fertilizer use is regulated. According to the agri-environmental scheme, farmers also have to make a cultivation plan each year.

#### Germany

The maximum amount of total nitrogen application in organic and organic-mineral fertilizers including manure may not exceed 170 kg N/ha. Phosphorus application is not directly limited, but an exception is fields with a high soil phosphorus status where phosphorus fertilizers may not exceed the amount of expected phosphorus removal by the cultivated crop. Farms have to calculate the nutrient balance for nitrogen and phosphorus annually (excluded <15 ha farms). A three-year average nitrogen balance surplus is not allowed to exceed 50 kg/ha. For phosphorus, a six-year average of the balance surplus is not allowed to exceed 10 kg/ha. In Germany, farmers can commit themselves to voluntary agri-environmental and climate-protection measures. In addition, the Federal States have the possibility to implement voluntary programs, for example, to define that at least 30% of the annual amount of nitrogen is applied via manure.

Latvia

Farmers must register any applied, purchased, sold or otherwise used amount of manure and digestion residues. The amount of nitrogen applied to one ha with manure or digestion residues cannot exceed 170 kg per year. If the amount of nitrogen produced on the farm with manure and digestion residues exceeds 170 kg/ha, the farmer must prove the transfer off-farm. Phosphorus use is not limited. In the nitrate vulnerable zone, crop specific nitrogen application levels are regulated. Farmers can follow the code of good agricultural practices on a voluntary basis.

Lithuania

On farms larger than 30 ha fertilization plans have to be drawn up. The plans have to take into account manure specific and site specific conditions. Fertilization plans are based upon the results of soil tests and have to be prepared each year before the fertilization measures occur. The amount of manure applied to agricultural land is restricted to 170 kg N/ha. Phosphorus use is not regulated. Animal density is limited to 1.7 livestock units per hectare. On farms with a higher animal density, the field area has to be increased or manure surpluses have to be transported to other farms. Farmers participating in the voluntary program are obliged to calculate nutrient balances on a farm level.

Poland

Agricultural holdings with intensive animal production (40 000 poultry, 2 000 pigs > 30 kg, 750 sows) are obliged to have a fertilization plan for all fields based on soil and livestock manure analysis, and plant nutrient requirements. The utilization of 70% of livestock manure on a farm's own fields is mandatory. Large farms with an area of 100 ha or maintaining the animal density of over 60 animal units are obliged to possess a nitrogen fertilization plan for all fields. All smaller farms are obliged to calculate maximum amounts of active nitrogen from all sources. The maximum amount of nitrogen from livestock manure utilized in agricultural land may not exceed 170 kg N/ha. The use of phosphorus is limited by the maximum nitrogen dose. The voluntary program for farmers "The set of recommendations for good agricultural practice for voluntary use" aims to protect waters and the atmosphere against pollution from agricultural sources.

Russia

The maximum allowable fertilization rates depend on cultivated crops. In the Russian Federation, owners of agricultural land are required to have an agrochemical soil analysis conducted. The decision on the fertilization rates and timing (frequency per year, annual or every few years) is taken following the health of agricultural land, cultivated crops, and crop rotations. On average, the recommended amount of nitrogen introduced with organic fertilizer meets the HELCOM recommended amount of 170 kg/ha.

Sweden

The supply of nitrogen from manure and organic fertilizers may not exceed 170 kg/ha in the nitrate vulnerable zones. Within the nitrate vulnerable zones, the supply of nitrogen through fertilizers shall not exceed the amount possible for the crop to use. Therefore, farmers in the nitrate vulnerable zone are obliged to calculate the need for nitrogen for the expected yield. For phosphorus, the maximum level allowed is 22 kg/ha, counted as a five-year average, which concerns the whole country. The Swedish Board of Agriculture calculates the economic optimal nitrogen dose for different crops yearly and presents the results in the report "Recommendations for Fertilization and Liming". For manure spreading, there are different precautionary measures depending on which part of Sweden is considered. The "Focus on Nutrients" program offers a diverse range of advisory services to improve profitability on the farm and reduce its negative impact on the environment. There are also several support schemes for the farmers to apply for, with the aim to reduce nutrient losses.

**Table 1.** Selected information of regulations on manure fertilization and fertilizer use in the countries of the Baltic Sea Region.

Country	Fertilization legislation based	Fertilization plan/Nutrient field balances	Maximum amount of nutrients from manure	Crop specific N fertilization level	Voluntary measures (programme)
<b>Denmark*</b>	The Danish Livestock Manure Decree	Fertilizer account required from all farms	170 kg N/ha (230 kg N/ha in cattle derogation farms) 30-39 kg P/ha	Yes	A number of voluntary measures aiming to improve the nutrient value and reduce ammonia emission of manure. Some of these are subsidized.
<b>Estonia**</b>	Estonian Water Act	Fertilization plan is needed for slurry spreading farms >400 animal units	170 kg N/ha 25 kg P/ha	Yes	Agri-environmental support scheme with subsidies
<b>Finland*</b>	Government Decree on Limiting Certain Emissions from Agriculture (1250/2014), i.e. "Nitrates Decree", Fertilizer Product Act (539/2006) and Decree of the Ministry of Agriculture and Forestry on Fertilizer Products (2015/19/FIN)	Fertilization plan per hectare or per field	170 kg N/ha No limit for P in manure	Yes	Agri-environmental support scheme with subsidies
<b>Germany*</b>	The German Act on Fertilizing, the Material Balance Ordinance, the Fertilizers Ordinance, the Fertilizing Ordinance enacting the EU Nitrates Directive and the National Emission Ceilings Directive, the Sewage Sludge Ordinance	Nutrient balance is needed (farms >15 ha) for N and P annually. Limits: three year average for N < 60 kg/ha/year (2021: 50 kg/ha); six year average for P < 20 kg/ha/year (2024: 10 kg /ha)	170 kg N/ha No limit for P, except for high soil test P (>20 mg/100 g soil) fertilizer P may not exceed the amount of expected phosphorus removal	Yes	Agri-environment and climate-protection measures with subsidies
<b>Latvia**</b>	Law On Pollution, Cabinet Regulation No.834 "Regulation Regarding Protection of Water, Soil	Fertilization plan required in nitrate vulnerable zone from	170 kg N/ha No limit for P in manure	Yes, in nitrate vulnerable zone	Agri-environmental support scheme with subsidies

	and Air from Pollution Caused by Agricultural Activity”, Cabinet Regulation No.829 “Special Requirements for the Performance of Polluting Activities in Animal Housing”, Cabinet Regulation No.1056 “Requirements for Integrated Cultivation, Storage and Labelling of Agricultural Products and the Procedures for Control Thereof”	farms >20 ha and farms >3 ha, if farm grows vegetables, potatoes, fruit trees or fruit bushes. Farms in the whole of territory using the professional plant protection products.			
<b>Lithuania*</b>	Environmental requirements for manure management (Decree 04/04/2018 No. D1-261/3D-200)	Fertilization plan on farms >30 ha	170 kg N/ha No limit for P in manure	No	Agri-environmental support scheme with subsidies
<b>Poland*</b>	The Fertilizers and Fertilization Act, the Water Act, the Act of Waste. The Ordinance of the Council of Ministers of 5 June 2018 on the adoption of the “Action programme for the reduction of water pollution caused by nitrates from agricultural sources and prevention of further pollution” – Nitrate Program	Farms with intensive animal production (40 000 poultry, 2 000 pigs, 750 sows) a fertilization plan is needed, based on soil and manure analyses, and plant nutrient requirements. Farms >100 ha or cultivating intensive crops with high doses of fertilizers >50 ha, or with >60 AU - nitrogen fertilization plan is needed, based on a nitrogen balance. All smaller farms - maximum amounts of active nitrogen from all sources.	170 kg N/ha No limit for P in manure	Yes	“The set of recommendations for good agricultural practice for voluntary use”, the Rural Development Programme 2014-2020, with subsidies
<b>Russia</b>	Manure processing and organic fertilizer use is governed by the	In the Russian Federation, the Nutrient field	The recommended maximum application rate of	Yes	In general, no, but there are some examples of

	Federal Laws “On Protection of Environment”, “On Production and Consumption Waste” and by Management Directives for Agro-Industrial Complex. The legislation considers animal/poultry manure as waste if it is not processed and used as an organic fertilizer. The safety issues of manure processing and organic fertilizer application are governed by a local document – Standard of Organization “Technological Regulations for Animal/Poultry Manure Processing and Fertilizing Application”	balances as they are understood in the European countries, are not calculated. Each enterprise, which spreads organic fertilizers on its land, prepares an annual fertilization schedule. The rates are calculated on the basis of nutrients removed with the harvested crop yield and the soil health as determined by the agrochemical survey.	organic fertilizer (in terms of nitrogen) in the Baltic Sea region is 170 kg/ha. In some territories in Russia, however, the nitrogen amount may be increased following the agrochemical survey results in order to improve soil fertility.		cooperation between three to five agricultural enterprises on the use of organic fertilizers, mainly poultry and crop growing farms.
<b>Sweden**</b>	Environmental Code, Ordinance (1998:915) on environmental concern in agriculture, the Swedish Board of Agriculture rules, general guidance (SJVFS 2004:62) on environmental concern in agriculture as regards plant nutrients	In the nitrate vulnerable zone, N fertilizing needs to be based on the crop need	170 kg N/ha in the nitrate vulnerable zone 22 kg P/ha	In the nitrate vulnerable zone, N fertilizing needs to be based on the crop need	Agri-environmental support scheme with subsidies. Focus on Nutrients – The programme includes the establishment of farm nutrient balance and several advisory visits

\*Whole of the country defined as nitrate vulnerable zone

\*\*Parts of the country defined as nitrate vulnerable zone

## 4. Denmark: Manure fertilizing practices

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### 4.1. Legislation regulating manure management and fertilizer use

The Danish regulation related to storage, handling and utilization of manure and organic fertilizers is compiled in the Danish livestock manure decree (*Husdyrgødningsbekendtgørelsen*). The decree is updated annually by The Ministry of Environment and Food of Denmark.

The decree is founded on the following EU regulations for environmental protection: the EU Nitrates Directive, the EU fertilizer legislation, the EU water frame directive, and the decree of NEC. The decree also compiles national environmental action plans implemented in the period from 1985 till today aiming to reduce the environmental impact of livestock production. An overview of the national action plans for the reduction of nitrogen leaching can be seen in Table 2.

**Table 2.** Overview of the Danish fertilization regulation for reduction in leaching of nitrogen. (Modified from Blicher-Mathiesen et al., 2015)

Year	Action plan	Elements in the plan	Target
1985	Nitrogen-Phosphorus-Organic matter (NPO)	Ban on the direct loss of manure to drain and streams. Ban on manure spreading on frozen soils, minimum spreading area of manure per animal unit.	
1987	Water Environment Plan I	Demand for storage capacity for animal manure, ban on autumn and winter spreading on bare soils, requirement for a minimum coverage of soil with autumn and winter crops, mandatory fertiliser plans.	50% reduction of nitrogen leaching from agriculture relative to leaching in the 1980s.
1991 and 1996	Plan for sustainable agriculture	Maximum nitrogen quotas (optimal rates), minimum requirements for utilisation of nitrogen in animal manure, mandatory fertiliser accounts.	50% reduction of nitrogen leaching from agriculture relative to leaching in the 1980s.
1998	Water Environment Plan II	10% reduction in nitrogen quotas from optimal levels, mandatory minimum area with catch crops, wetlands, afforestation.	50% reduction of nitrogen leaching from agriculture relative to leaching in the 1980s.
2004	Water Environment Plan III	Increasing demand for mandatory catch crops, volunteer buffer strips.	13% reduction in nitrogen leaching relative to the leaching in 2003.
2009	Green Growth	Ban soil tillage autumn before spring sown crops, 50,000 ha mandatory buffer strips, 140,000 hectare extra cover crops in catchments to vulnerable fjords.	Reduction of loss of nitrogen with 30% relative to the outlet 2004-2008.
2016	Food and agricultural Plan	Increasing quotas of nitrogen to the optimal level with effect as from 2017. No more mandatory buffer strips and cancellation of the 140,000 hectares of extra cover crops. Wetlands, constructed wetlands, afforestation, 100,000 hectare extra voluntary catch crops in 2017 and 2018. Targeted regulation of catchment to vulnerable fjords 2018-2021 (instruments unknown).	Reduction of the loss of nitrogen by 13% until 2021 related to the loss 2010-2014 and further 9% in the period 2021-2027.

The Danish regulation of manure and fertilizer handling and utilization is comprehensive and complex. The most general and important regulations are briefly compiled below.

#### Regulation related to manure storage:

The storage capacity for manure must be sufficient to allow between six and nine months storage, depending on livestock and the crop system. The storage capacity must be high enough to allow that manure only is land applied outside the closed periods, and that a sufficient high utilization of nitrogen in the manure can be reached. Documentation for sufficient storage capacity has to be provided by fertilization accounts.



All liquid manure storage facilities must be covered by a solid cover (tent, concrete lid, or floating tarpaulin lid), if the manure surface is not covered by an artificial or natural floating crust. If the storage facility is without a solid cover, the owner has to provide a logbook note each month. The logbook note has to ensure that the floating crust has an adequate thickness and spreading to abate odour and ammonia emission. If the floating crust is not adequate, the farmer has to ensure that, for instance by supplying chopped straw.

Solid manure storage facilities without a daily addition of new material must be covered by airtight material. Only deep litter with a dry matter content higher than 30 per cent can be stored in field heaps. All other types of solid manure have to be stored at concreted areas with collection of manure leakage.

#### Application time:

The application of liquid manure and liquid organic waste is not allowed between harvest and 1<sup>st</sup> February. Due to the differences in harvest time, this means that the open window for manure application depends on the type of crop. Winter cereals and crops established in spring can only have manure applied in the spring period from 1<sup>st</sup> February till the crop is too developed or mature to be able to utilize the nutrients applied. Winter rape may additionally have manure applied in the period between crop establishment in the autumn and 1<sup>st</sup> October. Crops with a long growing season (sugar beets, grass, and maize) can have manure applied from 1<sup>st</sup> February until harvest, but not later than 1<sup>st</sup> October.

Solid manure and solid organic waste are allowed to be applied from 1<sup>st</sup> February till 15<sup>th</sup> November, given that the area is established with a winter crop. In areas without a winter grown crop, solid manure and solid waste are only allowed to be applied from 1<sup>st</sup> February till harvest and from 20<sup>th</sup> October till 15<sup>th</sup> November.

#### Application areas:

Livestock manure and organic waste must not be applied to areas that may cause risk of nutrient runoff to streams, lakes bigger than 100 m<sup>2</sup>, and coastal waters. Application of manure is not allowed in hilly areas (more than 6°) closer than 20 m to the aforementioned water types, unless the manure is injected. Application of manure is not allowed in hilly areas (more than 12°) closer than 20 m to the aforementioned water types.

Livestock manure must not be applied to soils that are frozen, covered by snow, or saturated by water.

#### Application technologies:

Liquid manure and liquid organic wastes applied to uncropped soil and fodder grass have to be injected. The only exception is if the slurry is treated by a verified technology (for example, acidification) proven to give the same ammonia reduction as injection. If applied to other established crops, liquid manure must be applied by trailing hoses or trailing shoe systems. Application by broad spreading and irrigation technologies is not allowed.

Solid manure and solid organic waste applied to uncropped soil must be incorporated within 4 hours after the application.

## 4.2. Voluntary measures regulating manure management and fertilizer use

Denmark has a number of voluntary measures aiming to produce high quality agricultural products and/or reduce the environmental impact of agricultural production. These actions are in general subsidized. Most of the voluntary actions are related to organic agricultural production, restriction on the use and input of nutrients and pesticides in agricultural land, and restrictions in crop and soil managements.

The voluntary actions do in general involve restriction in use of mineral fertilizer and pesticides, but generally the voluntary actions do not involve additional regulation on the use and handling of organic manures.

## 4.3. Manure data used for fertilizing purposes

Reduction of nitrogen and phosphorus input to agricultural land has an important role in the Danish regulation system. To ensure that farmers do not use too much nitrogen and phosphorus, each farmer must submit a fertilizer account to the ministry each year.

The fertilizer account has to document that the total amount of nutrients applied is below the nitrogen and phosphorus ceilings for the specific farm, taking into account the farm specific soil type, livestock number and production systems, and the crop systems for the coming season. The fertilization accounts also involve the calculation of the total nitrogen and phosphorus production in animal manure at the farm, and the given requirements for the minimum utilization of the nitrogen content of the animal manure.

The total farm specific production of nitrogen and phosphorus is calculated by the total number of livestock animals in different categories, and the use of standard table values for the ex-storage nutrient production (normative values). The normative values are calculated by Aarhus University annually for the different livestock types, categories, and housing and manure systems. It is a mass balance system based on the difference between the nutrient input in feed measured on a large number of farms, the nutrient output in livestock products (milk, meat, eggs and fetus), and ammonia loss from the housing system for the specific animal category.

This is the system, which has been the basis for the Calculation Tool, which has been developed in WP3.

When making the fertilizer account, the farmer has the opportunity to use the normative values as they are given, or to calculate farm specific normative values depending on the farm specific input of nutrients in feedstuff and farm specific farm production output levels (Type 2 corrections).

The farmers can use manure analyses of their manure to optimize their fertilization plans to the actual nutrient content of their manure. However, only the normative values are allowed for the calculation of the fertilization accounts submitted to the authorities, for the maximal nutrient application rates, and for the total production of manure nutrients at the farm.

## 4.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 4.4.1. Nitrogen

The total application of nitrogen in livestock manure and organic fertilizers must not exceed 170 kg nitrogen per ha per year. The only exception is cattle derogation farms. If they fulfil specific requests regarding crops with a long growing season and high nutrient uptake they are allowed to apply up to 230 kg nitrogen per ha per year in manure.

### 4.4.2. Phosphorus

The maximal phosphorus application rate to agricultural land depends on the fertilizer source and whether the application takes place in areas situated above water catchment areas for environmentally sensitive waters. The max allowed application rates are decreasing and are for the coming growing season 2019/2020 between 30 and 39 kg P/ha/year, depending on livestock type (Table 3).

If the fertilization takes place in areas above water catchment areas leading to environmental sensitive waters, the max phosphorus levels are reduced to 35 kg P at derogation cattle farms, and 30 kg P per ha for all other types of livestock farms. The total area of the environmental sensitive areas makes up about 22 per cent of the total Danish agricultural area.

**Table 3.** Overview of the maximum application of nitrogen and phosphorus to agricultural land in Denmark.

Type of manure and fertilizer	N-ceiling, kg ha <sup>-1</sup>	P-ceiling, kg ha <sup>-1</sup>				Environmental sensitive areas
		2017/18	2018/19	2019/20	2020/21	
Cattle	170	30	30	30	30	30
Cattle, derogation	230	35	35	35	35	35
Slaughter pigs	170	39	39	39	35	30
Sow and piglets	170	35	35	35	35	30
Poultry and fur	170	43	43	35	35	30
Other livestock	170	30	30	30	30	30
Organic waste	170	30	30	30	30	30
Chemical fertiliser	-	30	30	30	30	30

## 5. Estonia: Manure fertilizing practices

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### 5.1. Legislation regulating manure management and fertilizer use

According to the **Estonian Water Act (RT I, 22.02.2019, 1)**<sup>1</sup>, every arable hectare may be fertilized yearly with manure:

1. up to 170 kg nitrogen, including manure left by pastured animals;
2. up to 25 kg phosphorus, including manure left by pastured animals. The yearly amount can be adjusted so that in an average five-year period this does not exceed 25 kg per ha.

The amount of added nitrogen fertilizer cannot be more than necessary to maintain a nutrient balance according to the planned yield. Restrictions on manure spreading according to the Estonian Water Act include:

1. prohibited is to apply to the land mineral or organic fertilizer when soil is frozen, covered with snow, periodically flooded or saturated with water;
2. prohibited is to apply to the land mineral fertilizers containing nitrogen from 15<sup>th</sup> October until 20<sup>th</sup> March;
3. prohibited is to apply the land liquid manure from 1<sup>st</sup> November until 20<sup>th</sup> March;
4. the Environmental Board can vary the commencement of the break in manure spreading according to weather and growing conditions from 15<sup>th</sup> October;
5. prohibited is to apply to the land solid or deep litter manure or any other organic fertilizers from 1<sup>st</sup> December until 20<sup>th</sup> March;
6. liquid manure broadcast spreading is forbidden from 20<sup>th</sup> of September until 20<sup>th</sup> of March;
7. the manure spread on bare soil must be incorporated to soil as soon as possible, but not later than in 48 hours (within 24 h from 1.1.2021 onwards);
8. fields with plant coverage can receive manure during November only, if the manure is incorporated into the soil within 48 h (within 24 h from 1.1.2021 onwards);
9. areas with a 5-10% slope – no fertilizers from 1<sup>st</sup> October until 20<sup>th</sup> March;
10. fertilizers should not be spread on areas, where the slope exceeds 10 degrees.

There is an exception where it is possible to fertilize slopes over 10% when the next requirements apply (Ministry of the Environment Ordinance No. 11, *Maapinna kalde määramise alused põllumassivi piires ning kaldega ala väetamise erandid* [in Estonian]<sup>2</sup> – “Ground slope determination bases within the arable range and slope fertilization exceptions”; RT I, 30.04.2019, 14:

1. >10 % slopes cover less than 1/3 of the field area;
2. >10 % slopes are narrower, than 100 m;

<sup>1</sup> [https://www.riigiteataja.ee/en/eli/508102019001/consolid\\_e](https://www.riigiteataja.ee/en/eli/508102019001/consolid_e)

<sup>2</sup> <https://www.riigiteataja.ee/akt/130042019014>

3. the slope area nearest the margin must be at least 50 m from the doline edge, located downslope;
4. the slope area nearest the margin is not bordering a water body protecting boundary;
5. the slope area nearest the margin is at least 50 m away from an open ditch, located downslope;
6. the water collection area that is located upslope of the sloped area is not bordering a protection zone;
7. the slope margin is not bordering a service zone of a downslope well;
8. the slope area nearest the margin must be at least 100 m away from the yard, marked on the Main Map Layout.

It is prohibited to use fertilizers on natural grassland, except the nitrogen and phosphorus in manure left on the land by livestock upon grazing, the amount of which shall not exceed the maximum levels of nitrogen and phosphorus.

In nitrate sensitive areas of unprotected groundwater and a soil depth of up to 2 m, and in karst areas, it is permissible to restrict the following on the basis of the protection rules:

1. nitrogen spread with mineral fertilizers during one year to an average of 100 kg per hectare of land under cultivation;
2. keeping livestock to 1.5 livestock unit per hectare of land under cultivation;
3. the use of sewage sludge.

## 5.2. Voluntary measures regulating manure management and fertilizer use

There are several support systems in Estonia that should contribute to the optimal use of fertilizers. The support scheme is a part of the EU's "Agri-environmental support in the Estonian Rural Development Plan (ERDP) 2014-2020" regulated by the Ministry of Rural Affairs. For example:

1. support for environmentally friendly management (requirements for crop rotation, legume cultivation, winter vegetation, fertilizer plan, soil samples and participating in training);
2. regional water protection support (requirements for additional winter vegetation and usage of land as grassland);
3. regional soil protection support (transfer arable land to grassland or usage of land as grassland);
4. support for environmentally friendly horticulture (requirements for soil samples and participating in trainings);
5. support of organic farming (requirements for crop rotation, legume cultivation, winter vegetation, soil samples and participating in trainings).

In addition, applicants must also comply with statutory requirements. These are so-called baseline requirements.

A more detailed overview of these supports has been published<sup>3</sup>.

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<sup>3</sup> <https://www.agri.ee/sites/default/files/content/valjaanded/2017/publication-2017-erdp-environment-support.pdf>

### 5.3. Manure data used for fertilizing purposes

According to Regulation No. 46 “Requirements for Obtaining Support for Environmentally Friendly Farming, Specific Procedure for Receipt of Support and Processing of Applications” (RT I, 25.02.2013, 13)<sup>4</sup>, regulated by the Minister of Agriculture:

Before spreading, those farmers with a manure storage facility must send manure samples to the accredited laboratory to determine the dry matter percentage of the manure and the content of total carbon, water soluble nitrogen, total potassium and phosphorus. The sample is taken from the manure, which has been standing for 4–6 months before spreading. The results of the analysis have to be available at the on-site inspection at the establishment.

In order to find the maximum permissible manure rate, the limit value for the respective nutrient element has to be divided by the amount of nutrient element given by the manure. If there is analysis data for manure, then it is used in the calculations. Otherwise, it is possible to use the data of a relevant manure type from the Regulation No. 73 of the Minister of Agriculture: “Eri tüüpi sõnniku toitainete sisalduse arvestuslikud väärtused, sõnnikuhoidlate mahu arvutamise meetodika ja põllumajandusloomade loomühikuteks ümberarvutamise koefitsiendid”<sup>5</sup> [in Estonian] (RT I, 01.10.2019, 11, Annex 3; “Estimated values of nutrient content of different types of manure, methodology for calculating the volume of manure storage facilities and coefficients of the conversion of livestock into livestock units”<sup>6</sup>, Table 4).

**Table 4.** Manure nutrient content after storage by type of manure in case of housing for the whole year.

Animal species, age or production group	Manure type, DM – dry matter content	Nutrient content, kg/t		
		N	P	K
Dairy cows	Liquid manure, DM ≤ 7.9%	4.74	1.22	4.09
	Semi-liquid manure, DM 8.0–19.9%	4.89	1.26	4.22
	Solid manure, DM 20.0–24.9%	4.36	1.37	4.09
	Deep litter manure, DM ≥ 25%	5.43	1.47	5.74
Suckler cows, beef cattle (over 24 months)	Semi-liquid manure, DM 8.0–19.9%	7.34	0.85	8.87
	Solid manure, DM 20.0–24.9%	6.27	0.82	7.41
	Deep litter manure, DM ≥ 25%	7.01	0.93	9.47
Female calves (0...6 months)	Liquid manure, DM ≤ 7.9%	5.29	0.80	6.38
	Semi-liquid manure, DM 8.0–19.9%	5.27	0.79	6.30
	Solid manure, DM 20.0–24.9%	4.96	0.80	5.55
	Deep litter manure, DM ≥ 25%	5.92	0.96	7.91
Male calves (0...6 months)	Liquid manure, DM ≤ 7.9%	4.39	0.52	3.58
	Semi-liquid manure, DM 8.0–19.9%	4.62	0.52	3.55
	Solid manure, DM 20.0–24.9%	4.35	0.54	3.28
	Deep litter manure, DM ≥ 25%	5.34	0.69	5.26
Heifers (6 months ... calving)	Liquid manure, DM ≤ 7.9%	4.44	1.00	4.39
	Semi-liquid manure, DM 8.0–19.9%	4.44	1.00	4.39
	Solid manure, DM 20.0–24.9%	3.91	0.97	3.84
	Deep litter manure, DM ≥ 25%	4.83	1.07	5.86
Young bulls (6 months ... realization)	Liquid manure, DM ≤ 7.9%	4.89	0.98	3.58
	Semi-liquid manure, DM 8.0–19.9%	5.05	0.98	3.58
	Solid manure, DM 20.0–24.9%	4.43	0.98	3.25
	Deep litter manure, DM ≥ 25%	5.40	1.08	5.10

<sup>4</sup> <https://www.riigiteataja.ee/akt/116032012005?leiaKehtiv>

<sup>5</sup> <https://www.riigiteataja.ee/akt/101102019011>

<sup>6</sup> [https://www.riigiteataja.ee/akt/1011/0201/9011/MM\\_m73\\_lisa\\_3.pdf#](https://www.riigiteataja.ee/akt/1011/0201/9011/MM_m73_lisa_3.pdf#)

Fattening pigs	Liquid manure, DM ≤ 7.9%	5.50	1.27	2.75
	Semi-liquid manure, DM 8.0–19.9%	5.17	1.31	2.52
	Solid manure, DM 20.0–24.9%	4.92	1.25	2.40
	Deep litter manure, DM ≥ 25%	5.94	1.30	4.38
Weaners	Liquid manure, DM ≤ 7.9%	8.20	1.46	2.91
	Semi-liquid manure, DM 8.0–19.9%	7.06	1.19	2.32
	Solid manure, DM 20.0–24.9%	5.11	1.37	3.58
	Deep litter manure, DM ≥ 25%	4.48	1.17	4.18
Sow with piglets	Liquid manure, DM ≤ 7.9%	5.55	1.48	2.77
	Semi-liquid manure, DM 8.0–19.9%	4.95	1.30	2.58
	Solid manure, DM 20.0–24.9%	5.41	1.35	2.83
	Deep litter manure, DM ≥ 25%	5.21	1.31	4.02
Young sows	Liquid manure, DM ≤ 7.9%	5.37	1.36	2.68
	Semi-liquid manure, DM 8.0–19.9%	5.15	1.34	2.61
	Solid manure, DM 20.0–24.9%	5.39	1.36	2.73
	Deep litter manure, DM ≥ 25%	5.33	1.25	4.01
Laying hens (100 birds)	Semi-liquid manure, DM 8.0–19.9%	13.00	3.66	5.98
	Deep litter manure, DM ≥ 25	11.27	3.32	5.97
Broilers (1000 birds)	Deep litter manure, DM ≥ 25	9.31	3.79	6.08
Young chickens (100 birds)	Deep litter manure, DM ≥ 25	8.07	3.59	4.09
Sheep with up to one year old lambs, other sheep	Deep litter manure, DM ≥ 25	6.71	1.20	12.26
Goats with up to one year old lambs, other goats	Deep litter manure, DM ≥ 25	6.84	1.24	9.31
Horses with up to 6 months old foals, other horses	Deep litter manure, DM ≥ 25	6.56	1.59	8.69
Foxes	Deep litter manure, DM ≥ 25	23.00	5.59	2.61
Mink	Semi-liquid manure, DM 8.0–19.9%	14.08	4.87	2.29

All nutrients of manure are not available for plants and some become available only by the degradation of manure. Therefore, the fertilization plan should be calculated taking into account the available nutrient elements according to Regulation No. 73 of the Minister of Agriculture: “*Eri tüüpi sõnniku toitainete sisalduse arvestuslikud väärtused, sõnnikuhoidlate mahu arvutamise meetoodika ja põllumajandusloomade loomühikuteks ümberarvutamise koefitsiendid*”<sup>7</sup> ([in Estonian]; RT I, 01.10.2019, 11, “Estimated values of nutrient content of different types of manure, methodology for calculating the volume of manure storage facilities and coefficients of conversion of livestock into livestock units”, Annex 6<sup>8</sup>; Table 5).

<sup>7</sup> <https://www.riigiteataja.ee/akt/101102019011>

<sup>8</sup> [https://www.riigiteataja.ee/akt/1011/0201/9011/MM\\_m73\\_lisa\\_6.pdf#](https://www.riigiteataja.ee/akt/1011/0201/9011/MM_m73_lisa_6.pdf#)

**Table 5.** Available nitrogen, phosphorus and potassium in plants by types of manure in case of housing for the whole year.

Animal species, age or production group	Manure type, DM – dry matter content	Available nutrients for plants, kg/t		
		N	P	K
Dairy cows	Liquid manure, DM ≤ 7.9%	2.37	0.73	3.68
	Semi-liquid manure, DM 8.0–19.9%	2.44	0.76	3.80
	Solid manure, DM 20.0–24.9%	1.75	0.96	3.68
	Deep litter manure, DM ≥ 25%	2.17	1.03	5.17
Suckler cows, beef cattle (over 24 months)	Semi-liquid manure, DM 8.0–19.9%	3.67	0.51	7.99
	Solid manure, DM 20.0–24.9%	2.51	0.88	6.67
	Deep litter manure, DM ≥ 25%	2.80	0.65	8.53
Female calves (0...6 months)	Liquid manure, DM ≤ 7.9%	2.64	0.48	5.75
	Semi-liquid manure, DM 8.0–19.9%	2.63	0.47	5.67
	Solid manure, DM 20.0–24.9%	1.98	0.56	5.00
	Deep litter manure, DM ≥ 25%	2.37	0.65	7.12
Male calves (0...6 months)	Liquid manure, DM ≤ 7.9%	2.20	0.31	3.22
	Semi-liquid manure, DM 8.0–19.9%	2.31	0.31	3.19
	Solid manure, DM 20.0–24.9%	1.74	0.38	2.95
	Deep litter manure, DM ≥ 25%	2.14	0.49	4.73
Heifers (6 months ... calving)	Liquid manure, DM ≤ 7.9%	2.22	0.60	3.95
	Semi-liquid manure, DM 8.0–19.9%	2.22	0.60	3.95
	Solid manure, DM 20.0–24.9%	1.56	0.68	3.46
	Deep litter manure, DM ≥ 25%	1.93	0.75	5.28
Young bulls (6 months ... realization)	Liquid manure, DM ≤ 7.9%	2.44	0.59	3.22
	Semi-liquid manure, DM 8.0–19.9%	2.52	0.59	3.22
	Solid manure, DM 20.0–24.9%	1.77	0.69	2.93
	Deep litter manure, DM ≥ 25%	2.16	0.76	4.59
Fattening pigs	Liquid manure, DM ≤ 7.9%	2.75	0.76	2.48
	Semi-liquid manure, DM 8.0–19.9%	2.59	0.79	2.27
	Solid manure, DM 20.0–24.9%	2.46	0.75	2.16
	Deep litter manure, DM ≥ 25%	2.38	0.91	3.94
Weaners	Liquid manure, DM ≤ 7.9%	4.10	0.87	2.62
	Semi-liquid manure, DM 8.0–19.9%	3.53	0.71	2.08
	Solid manure, DM 20.0–24.9%	2.04	0.96	3.22
	Deep litter manure, DM ≥ 25%	1.79	0.82	3.77
Sows with piglets	Liquid manure, DM ≤ 7.9%	2.77	0.89	2.49
	Semi-liquid manure, DM 8.0–19.9%	2.47	0.78	2.32
	Solid manure, DM 20.0–24.9%	2.16	0.94	2.55
	Deep litter manure, DM ≥ 25%	2.09	0.92	3.62
Young sows	Liquid manure, DM ≤ 7.9%	2.62	0.77	2.38
	Semi-liquid manure, DM 8.0–19.9%	2.50	0.79	2.29
	Solid manure, DM 20.0–24.9%	2.07	0.93	2.36
	Deep litter manure, DM ≥ 25%	2.13	0.88	3.56
Laying hens (100 birds)	Semi-liquid manure, DM 8.0–19.9%	6.53	2.19	5.38
	Deep litter manure, DM ≥ 25	5.63	2.32	5.37
Broilers (1000 birds)	Deep litter manure, DM ≥ 25	4.66	2.65	5.47
Young chickens (100 birds)	Deep litter manure, DM ≥ 25	4.03	2.51	3.68
Sheep with up to one year old lambs, other sheep	Deep litter manure, DM ≥ 25	2.68	0.84	11.04
Goats with up to one year old lambs, another goat	Deep litter manure, DM ≥ 25	2.74	0.87	8.38
Horses with up to 6 months old foals, other horses	Deep litter manure, DM ≥ 25	2.62	1.11	4.85
Foxes	Deep litter manure, DM ≥ 25	11.5	3.91	2.35
Mink	Semi-liquid manure, DM 8.0–19.9%	7.04	2.92	2.06



## 5.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 5.4.1. Nitrogen

According to the **Estonian Water Act (RT I, 22.02.2019, 1)**, the maximum allowable amount of N added with manure is 170 kg/ha per year, including the nitrogen in manure left on the land by livestock upon grazing. The amounts permitted of added nitrogen with mineral fertilizers according to crops are specified with the implementing act No. 45 of the Water Act: “*Väetise kasutamise ja hoidmise nõuded põhja- ja pinnavee kaitseks ning põllumajandustootmisest pärineva saastatuse vältimiseks ja piiramiseks*” (RT I, 04.10.2019, 4<sup>9</sup> [in Estonian]; “Requirements for the use and storage of fertilizers for the protection of ground and surface water and for the prevention and control of pollution from agricultural production”; Annex 1; Table 6). Total amounts of N over 100 kg/ha must be divided.

**Table 6.** The amounts permitted of added N according to crops’ needs<sup>10</sup>.

Crop	Planned crop yield,	Allowed amount of N,
Summer cereals		
Spring wheat	2.0	60
	3.0	80
	4.0	105
	5.0	130
	6.0	155
	7.0	180
	8.0	210
	Spring barley	2.0
3.0		65
4.0		85
5.0		100
6.0		120
7.0		150
8.0		180
Oat	2.0	50
	3.0	65
	4.0	80
	5.0	100
	6.0	120
	7.0	145
	8.0	170
Winter cereals		
Rye	in autumn	30
	2.0	55
	3.0	70
	4.0	85
	5.0	105

<sup>9</sup> <https://www.riigiteataja.ee/akt/104102019004>

<sup>10</sup> [https://www.riigiteataja.ee/akt/1041/0201/9004/Lisa\\_1.pdf#](https://www.riigiteataja.ee/akt/1041/0201/9004/Lisa_1.pdf#)

	6.0	115
	7.0	140
	8.0	165
	9.0	175
	10.0	190
Winter wheat *, Winter triticale	in autumn	30
	2.0	60
	3.0	80
	4.0	95
	5.0	115
	6.0	135
	7.0	160
	8.0	180
	9.0	200
	10.0	220
Winter barley	in autumn	30
	2.0	50
	3.0	60
	4.0	80
	5.0	100
	6.0	120
	7.0	145
	8.0	160
	9.0	180
	10.0	200
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Oil crops		
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Spring rape	2.0	100
	3.0	130
	4.0	150
	5.0	170
Winter rape	in autumn	30
	2.0	100
	3.0	120
	4.0	140
	5.0	160
	6.0	180
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Potatoes		
<hr/>		
Early potatoes		80
Middle or late ripening potato	30	100
	40	120
	50	140
	60	160
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Fodder roots		
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Fodder beet		110
Sugar beet		100
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Other crops		
<hr/>		
Pea, bean		35
Cereal mix		30
Galega		20

Maize	6.0 (in dry matter)	150
	8.0	200
	10.0	250
Fibre flax		30
Oil flax		80
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Grasses (in dry matter)		
<hr/>		
Red clover	6.0	0
Lucerne	6.0	0
Grasses	6.0	200
Grasses-rich pasture	6.0	60
Grasses-rich pasture	6.0	120

\* In order to ensure quality requirements for winter wheat for food production, the nitrogen can be additionally provided as follows: planned crop yield (2–4 t/ha) up to 10 kg/ha, planned crop yield (5–5 t/ha) up to 15 kg/ha, and planned crop yield (8–10 t/ha) up to 20 kg/ha.

In the fertilization manual for farmers “*Väetamise ABC*” (2014)<sup>11</sup> the amounts of nitrogen are somewhat different (Table 7).

**Table 7.** Nitrogen fertilization (kg/ha/a) by soil organic C content and planned crop yield according to the fertilization manual for farmers

Crop	Planned crop yield, t/ha	Soil organic C content, %		
		<1	1...2	>2
need to give the N, kg/ha				
<hr/>				
Summer cereals				
Spring wheat	3.0	90	80	70
	4.0	115	105	95
	5.0	140	130	120
	6.0	- *	- *	145
	7.0	- *	- *	190
Spring barley	3.0	70	65	60
	4.0	90	85	75
	5.0	110	100	90
	6.0	130	120	110
	7.0	160	150	140
Oat	3.0	75	65	55
	4.0	90	80	70
	5.0	110	100	90
	6.0	130	120	110
	7.0	155	145	140
<hr/>				
Winter cereals				
Rye	in autumn	30	30	20
	3.0	80	70	60
	4.0	95	85	75
	5.0	115	105	95
	6.0	125	115	105
	7.0	150	140	130

<sup>11</sup> <http://www.pria.ee/docs/resources/8899.pdf>

	8.0	175	165	155
Winter wheat,	in autumn	30	30	20
Winter triticale	3.0	90	80	70
	4.0	105	95	85
	5.0	125	115	105
	6.0	- *	135	125
	7.0	- *	160	150
	8.0	- *	190	180
Winter barley	in autumn	30	30	20
	3.0	70	60	50
	4.0	90	80	70
	5.0	110	100	90
	6.0	130	120	110
	7.0	155	145	135
<hr/>				
Oil crops				
<hr/>				
Spring rape	2.0	110	100	90
	3.0	140	130	120
	4.0	160	145	130
Winter rape,	in autumn	30	30	20
winter oilseed	3.0	130	120	110
turnip	4.0	150	140	125
	5.0	170	155	140
Spring oilseed	2.0	95	85	75
<hr/>				
Potatoes				
<hr/>				
Early potatoes		90	80	70
Middle or late	30	110	100	90
ripening potato	40	130	120	110
	50	150	140	130
<hr/>				
Fodder roots				
<hr/>				
Fodder beet		120	110	100
Sugar beet		110	100	90
<hr/>				
Other crops				
<hr/>				
Pea, bean		30	20	20
Cereal mix		40	30	25
Galega		20	20	0
Maize	6.0 (in dry matter)	155	140	125
Fibre flax		35	30	25
Oil flax		85	80	70
<hr/>				
Grasses (in dry matter)				
<hr/>				
Red clover	6.0	0	0	0
Lucerne	6.0	0	0	0
Grasses	6.0	220	220	180
Grasses-rich pastu-	6.0	60	50	40

\* in such poor soil, achieving such a yield is not realistic

According to the implementing act No. 45 of the Water Act: “Väetise kasutamise ja hoidmise nõuded põhja- ja pinnavee kaitseks ning põllumajandustootmisest pärineva saastatuse vältimiseks ja piiramiseks” (RT I, 04.10.2019, 4<sup>12</sup> [in Estonian]: “Requirements for the use and storage of fertilizers for the protection of ground and surface water and for the prevention and control of pollution from agricultural production”, Annex 3), the after-effects of organic fertilizers must also be taken into account when planning the amount of fertilizer (Table 8).

**Table 8.** Aftereffect of manure one year after application, the values are suggested to be used in the planning of fertilizing<sup>13</sup>.

Manure type	Fertilization rate,	Reduced amount of N,
	t/ha	kg/ha
Solid manure	10	5
	20	10
	30	15
	40	20
Semi liquid, liquid manure	10	-
	20	5
	30	8
	40	10

#### 5.4.2. Phosphorus

According to the **Estonian Water Act (RT I, 22.02.2019, 1)** spreading up to 25 kg phosphorus with manure is permitted, including the phosphorus in manure left on the land by livestock upon grazing per annum per hectare of land under cultivation. The yearly amount can be adjusted so that in a five-year period the average does not exceed 25 kg per ha.

According to the fertilization manual for farmers “*Väetamise ABC*” (2014)<sup>14</sup>, the amounts of phosphorus are shown in Table 9.

**Table 9.** Phosphorus use (kg/ha/a) by soil phosphorus status and planned crop yield

Crop	Planned crop yield, t/ha	Need for phosphorus				
		very high	high	moderate	low	very low
Summer cereals						
Spring wheat	3.0	26	20	13	6	-
	4.0	30	27	22	18	9
	5.0	- *	30	25	21	11
	6.0	- *	- *	28	24	14
	7.0	- *	- *	31	27	17
Spring barley	3.0	26	20	13	6	-
	4.0	30	27	22	18	5
	5.0	34	30	25	21	8
	6.0	- *	33	28	24	11
	7.0	- *	- *	31	27	14
Oat	3.0	26	20	13	6	-
	4.0	30	27	22	18	5

<sup>12</sup> <https://www.riigiteataja.ee/akt/104102019004>

<sup>13</sup> [https://www.riigiteataja.ee/akt/1041/0201/9004/Lisa\\_3.pdf#](https://www.riigiteataja.ee/akt/1041/0201/9004/Lisa_3.pdf#)

<sup>14</sup> <http://www.pria.ee/docs/resources/8899.pdf>

	5.0	33	30	25	21	8
	6.0	- *	33	28	24	11
	7.0	- *	- *	31	27	14
<b>Winter cereals</b>						
Rye	3.0	26	20	13	6	-
	4.0	30	27	19	10	-
	5.0	33	30	22	13	5
	6.0	- *	33	25	16	8
	7.0	- *	- *	29	20	11
	8.0	- *	- *	32	23	14
Winter wheat,	3.0	26	20	13	6	-
Winter triticale	4.0	30	27	18	10	-
	5.0	33	30	22	13	5
	6.0	- *	33	25	16	8
	7.0	- *	- *	29	20	11
	8.0	- *	- *	32	23	14
Winter barley	3.0	26	20	13	6	-
	4.0	29	23	15	8	-
	5.0	33	27	19	10	-
	6.0	- *	30	22	12	5
	7.0	- *	- *	26	15	8
<b>Oil crops</b>						
Spring rape	2.0	40	35	25	20	15
	3.0	50	40	30	25	20
	4.0	- *	45	35	30	25
Winter rape,	3.0	45	40	30	25	20
Winter oilseed turnip	4.0	- *	45	35	30	25
	5.0	- *	- *	40	35	30
Spring oilseed turnip	2.0	40	35	25	20	15
<b>Potatoes</b>						
Early potatoes		85	75	60	45	25
Middle or	30	85	75	60	45	25
late ripening potato	40	90	80	65	50	30
	50	- *	85	70	55	35
<b>Fodder roots</b>						
Fodder beet		70	52	35	18	9
Rutabaga		70	52	35	18	9
<b>Other crops</b>						
Pea, cereal mix		32	28	24	18	9
Galega		65	55	45	35	25
Maize	6.0 (in dry matter)	45	40	30	25	20
Flax		65	50	40	30	20
<b>Grasses (in dry matter)</b>						
Red clover	6.0	30	26	20	10	-
Lucerne	6.0	39	34	26	13	3
Grasses	6.0	27	23	18	9	2
Grasses-rich pasture (legumes <50%)	6.0	30	26	18	8	-

\* in such poor soil, achieving such a yield is not realistic

## 6. Finland: Manure fertilizing practices

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### 6.1. Legislation regulating manure management and fertilizer use

In Finland, the fertilizer use of manure and organic fertilizer products is governed via two laws enacting the EU Nitrates Directive and the EU fertilizer legislation. Nitrogen fertilization is regulated by the former and phosphorus fertilization (when fertilizing with fertilizer products) by the latter. Additional rules may apply via the environmental permitting of animal farms and other related legislation.

The **Government Decree on Limiting Certain Emissions from Agriculture (1250/2014)**, known as 'Nitrates Decree', is given to implement **the EU Nitrates Directive (91/676/EEC)**. The decree aims to reduce nitrogen emissions into surface water, ground water, soil and air caused by use, storage, processing and application of manure and fertilizer products. In the decree, the whole of Finland has been defined as a nitrate vulnerable area and thus controls nitrogen fertilizer use in all farms across the country.

The decree restricts both the total and soluble amount of nitrogen applied as fertilizers. The maximum amount of total nitrogen application in farm animal manure and organic fertilizer products containing manure may not exceed 170 kg/ha per year. In addition, soluble nitrogen in inorganic fertilizers, farm animal manure, manure generated during grazing, and organic fertilizer products is limited for application to mineral and organic soils separately and for various plants. For example, the highest maximum soluble amount of nitrogen allowed is 250 kg/ha for grass and brassica vegetables and leek in mineral soils. For autumn-sown cereals, the maximum soluble amount of nitrogen is limited for autumn (30 kg/ha) and spring separately. After September 1, the amount of soluble nitrogen in farm animal manure and organic fertilizer products spread may not exceed 35 kg/ha.

The decree does not directly limit phosphorus used as a fertilizer, but by limiting nitrogen use with manure and organic fertilizers, the amount of phosphorus is simultaneously limited.

Field application of manure and organic fertilizers is prohibited between November 1 and March 31. However, deviation is possible until November 30 if exceptional weather conditions have prevented manure fertilization during the growing season. On field parcels with vegetative cover overwinter, manure and organic fertilizer products may be incorporated after September 15 only by the means of placement fertilization, except in the case of manure application in preparation for autumn sowing. Even then, the soil must be tilled within 24 hours of the application.

The **Fertilizer Product Act (539/2006)** and **Decree of the Ministry of Agriculture and Forestry on fertilizer products (2015/19/FIN)** defines the maximum quantity of water or ammonium citrate-soluble phosphorus that is permitted to be applied to field soil. In agriculture when fertilizing with fertilizer products, 325 kg and in horticulture, 560 kg phosphorus per hectare is allowed within a five-year period.

Finland's **Environmental Protection Act (527/2014)** and **Environmental Protection Decree (713/2014)** apply to all activities that may cause environmental pollution. The act is the foundation of an integrated system for environmental permits and for a pre-approval procedure for farm animal facilities, too. Applications for permissions are processed by either the Regional State Administrative

Agency or the local municipal authority depending on the number of farm animals. The pre-approval procedure is handled by municipal authorities. In the decision, due to the local circumstances, stricter regulations can be given than, for example, in the Nitrates Decree issued. Manure handling and storages, as well as the area needed for manure spreading, are regulated. The **Guidelines for Environmental Protection in Animal Husbandry (1/2010)** by the Ministry of the Environment are given to unify the environmental permitting procedure by regional authorities. The Guidelines are currently under revision.

The **Water Framework Directive (2000/60/EC)** has a broader approach at reducing diffuse water pollution from agricultural sources. Implementation has been planned and executed in cooperation with national and regional stakeholders. For example, authorities must take into account given water quality targets when permitting process is considered, and thus manure spreading on fields with high soil phosphorus status can be restricted.

The **Industrial Emissions Directive 2010/75/EU (IED)** concerns farms with more than 40 000 places for poultry, 2000 places for production pigs or 750 places for sows.

Intensive animal farming projects with more than 85 000 chicks, 60 000 hens, 3000 pigs (>30 kg), or 900 sows are also subjected to Environmental Impact Assessment (EIA) according to the **Act on Environmental Impact Assessment Procedure (252/2017)**.

## 6.2. Voluntary measures regulating manure management and fertilizer use

The majority of Finnish farmers have committed themselves to a voluntary agri-environmental support scheme regulated by the **Ministry of Agriculture and Forestry Decree on Environment Payments (327/2015)**. This scheme is a part of the EU's Rural Development Programme for Mainland Finland 2014-2020. The terms of the scheme regulate nitrogen fertilizer use according to the cultivated plant and the soil organic matter content, and phosphorus fertilizer use depending on the cultivated plant and the soil phosphorus status. The soil phosphorus status of each field is defined by acid ammonium acetate extraction (pH 4.65) and the soil organic matter class by sensory analysis in a laboratory every five years. The scheme allows higher fertilizer use (up to nitrogen +50 kg/ha/a and phosphorus +6 kg/ha/a) in a field if higher yield than the average is harvested.

The highest nitrogen fertilizer amount allowed for grass is 200 kg/ha/a if two cuts are harvested, and 240 kg/ha/a if three cuts are harvested. This amount is also allowed for brassica vegetables. For phosphorus, for example, if the soil's phosphorus status is "good", the maximum allowance is 5 kg/ha/a for cereals, 11 kg/ha/a for grass and 40 kg/ha/a for some vegetables. In farm animal manure 100% of the phosphorus content is accounted as plant-available except in fur animal manure where 60% availability is taken into account. When using manure as a fertilizer, the phosphorus content often limits the amount of manure spread. Thus, nitrogen limits are rarely reached, and additional nitrogen needs to be applied in some other form of fertilization.

## 6.3. Manure data used for fertilizing purposes

The Nitrates Decree defines a five-year interval that farms have to conduct a laboratory analysis of manure nutrients for fertilizing purposes. Those nutrients to be analyzed include soluble nitrogen, total nitrogen, and total phosphorus. The manure sampling method is not specified in the decree, but some commercial laboratories provide instructions on how to take a representative sample of manure.



Farmers can decide whether to use the analysis result or the “table (standard) values” given in the Nitrates Decree’s Annex 2 on the farm fertilization basis. The table values are based on a large dataset of manure samples analysed in two commercial laboratories. Laboratory analyses of farm manure nutrients also provide valuable data for governmental and research purposes in the country.

Farmers have the opportunity to plan fertilization according to the accuracy per hectare or per field. They have to keep a record of the manure nutrient analyses, the amount of nitrogen fertilizers (soluble and total nitrogen concentration) used on the fields, the application dates and the crop yields.

## 6.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 6.4.1. Nitrogen

#### Regulated by legislation – The Nitrates Decree (1450/2014)

Total nitrogen application in farm animal manure and organic fertilizer products containing manure may not exceed 170 kg/ha per year. Of this amount, not more than 35 kg/ha can be applied in autumn. Derogations of the Nitrated Decree are not applied in Finland.

Soluble nitrogen in inorganic fertilizers, farm animal manure, manure generated during grazing, and organic fertilizer products are allowed for application (kg/ha) on mineral and organic soils separately and for different crops as in Table 10.

**Table 10.** Examples of the maximum amount of soluble nitrogen (kg/ha) in inorganic fertilizers, manure, and also manure generated during grazing and organic fertilizer products for application.

Crop	Mineral soils	Organic soils
	Soluble nitrogen, kg/ha	
Barley, oat and mixed grain	160	120
Spring wheat	170	130
Winter rye		
- autumn	30	30
- spring	150	120
Spring rye	160	120
Winter wheat, triticale and spelt		
- autumn	30	30
- spring	170	140
Grasses	250	210
Winter turnip rape and winter rape*	200	160
Spring turnip rape and spring rape	170	130
Flax, maize, oil hemp and sunflower	150	110
Legumes	60	40
Sugar beet	170	130
Early potatoes	100	80
Starch potatoes	130	90
Other potatoes	120	80
Root vegetables	200	170

#### Voluntary measures – The Decree of Agri-environmental Support Scheme (327/2015)

For farms committed to the voluntary agri-environmental support scheme, nitrogen fertilization is defined by a field parcel and is dependent on crop, soil organic matter status and yield expectation. Tables 11-13 show the maximum total nitrogen fertilizer amount allowed. Fertilization levels are

based on the organic matter content in the plough layer. The organic matter content is analyzed in a laboratory by sensory analysis and is included in a basic agronomy analysis of soil that the farmer has to conduct every five years.

**Table 11.** Examples of maximum levels of soluble nitrogen fertilization (kg/ha/a).

Crop, yield	Soil org. matter, %			
	<6%	6-12%	12-20%	>20%
Soluble nitrogen, kg/ha				
Barley, oat, mixed grain, 4 tons	100	90	80	60
Spring wheat, 4 tons	120	110	100	70
Winter rye, autumn	30	30	20	20
Winter rye, spring, 3 tons	100	90	80	40
Spring rye, 3 tons	90	80	70	50
Flax, maize, oil hemp and sunflower				
Winter wheat, triticale, spelt and winter barley, autumn	30	30	30	20
Winter wheat, triticale, spelt and winter barley, spring, 4 tons	120	110	100	70
Winter turnip rape and winter rape (July-August)	50	50	50	40
Spring turnip rape, spring rape, winter turnip rape, winter rape, camelina, spring, 1,75 tons	110	100	90	40
Other field crops				
Pea, broad bean, sweet lupin	45	45	45	30
Sugar beet	140	140	140	120
Other than early or starch potatoes 35 tons	85	80	75	60
Other potatoes 40 tons	100	90	80	70

**Table 12.** Allowed additional soluble nitrogen fertilizer amount (kg/ha/a) if crop yields as presented are achieved.

Soluble N addition, kg/ha	0	10	20	30	40	50
	Yield, kg/ha					
Spring rye	3000	3500	4000	4500	5000	5500
Other cereals	4000	4500	5000	5500	6000	6500
Spring sown oil plants	1750	2000	2250	2500	2750	3000
Soluble N addition, kg/ha	0	10	20	30	40	45
	Yield, kg/ha					
Spring wheat	4000	4500	5000	5500	6000	6250
Winter wheat, triticale, spelt	4000	4500	5000	5500	6000	6250
Winter rye	3000	3500	4000	4500	5000	5250
Autumn sown oil plants	1750	2000	2250	2500	2750	-

**Table 13.** Examples of maximum levels of soluble nitrogen fertilization (kg/ha/a) for grass and other crops. Allowed nitrogen fertilization for horticultural plants is also regulated but not presented here.

Crop	Time	Soil organic matter, %			
		<5,9%	6-11,9%	12-19,9%	>20%
Soluble nitrogen, kg/ha					
Grass for seed	Spring	110	100	90	60
Annual and perennial grass, one cut	Spring	120	110	100	90
Maize silage, one cut	Spring	140	130	120	100
Annual and perennial grass, green forage crop, pasture	At least two cuts, pasture	200	190	180	160
	At least three cuts	240	230	220	190

## 6.4.2. Phosphorus

Regulated by legislation – Fertilizer Product Act (539/2006); Amendment: The Decree of the Ministry of Agriculture and Forestry on fertilizer products (2015/19/FIN)

When fertilizing with fertilizer products, the maximum amount of water- or ammonium citrate-soluble phosphorus is 325 kg/ha in agriculture and 560 kg/ha in horticulture in the maximum five-year period. Per year this means the maximum amount in agriculture is 65 kg/ha, and 112 kg/ha in horticulture.

Voluntary measures - The Decree of Agri-environmental Support Scheme (327/2015)

Those farmers committed to the agri-environmental support scheme are obliged to fertilize by phosphorus levels based on the soil phosphorus status. The soil phosphorus status is determined by acid ammonium acetate extraction (pH 4.65) and by soil texture in every five years from soil samples taken by the farmer. Fertilization levels for different crops by soil phosphorus status are shown in Table 14. Of the total phosphorus in manure, 100% is considered as plant-available except in fur animal manure where 60% of total phosphorus is considered as plant-available. For organic fertilizer products, the phosphorus plant-availability taken into account varies between 40-100% of the total amount. The plant-availability is counted on the basis of the raw material of the fertilizer product having the largest share. In Table 15 so-called “manure exception” phosphorus fertilizing amounts are also shown meaning if only manure is used as phosphorus fertilizer, these amounts can be applied.

**Table 14.** Examples of maximum levels for total phosphorus fertilization (kg/ha/a) by soil phosphorus status. Values for horticultural plants are not presented.

Crop	Soil phosphorus status						
	Poor	Poorish	Tolerable	Moderate	Good	High	Extremely high
	Phosphorus fertilization, kg/ha						
Cereals, oil plants, legumes	34	26	16	10	5	0	-
Cereals, oil plants, legumes, if all P from manure	34	26	16	15	15	-	-
Maize	40	32	24	14	5	-	-
Annual and perennial grass, yield 7.5 tons dry weight/ha	46	38	30	20	11	-	-
Annual and perennial grass, if all P from manure	40	32	30	30	20	-	-
Potatoes	55	55	55	55	35	20	5
Sugar beet	63	63	60	43	26	14	5
Flax	34	26	16	5	-	-	-

**Table 15.** Allowed additional total amount of phosphorus (kg/ha/a) if crop yields as presented are achieved.

Crop	Additional P, kg/ha		
	0	3	6
	Yield, kg/ha		
Rye	3000	4000	5000
Other cereals	4000	5000	6000
Oil plants	1750	2250	2750

## 7. Germany: Manure fertilizing practices

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### 7.1. Legislation regulating manure management and fertilizer use

In Germany, the fertilizer use of manure and organic fertilizer products is governed via the German Act on Fertilizing as well as the Material Balance Ordinance, the Fertilizers Ordinance and the Fertilizing Ordinance enacting the EU Nitrates Directive and the National Emission Ceilings Directive. Furthermore, the Sewage Sludge Ordinance and the regulation on putting manure into circulation and transporting manure must be considered with regard to fertilizer use of manure and organic fertilizer products in Germany. These regulations reflect the minimum legal requirements. Some federal states aggravated these minimum standards, particularly for polluted areas. Furthermore, for habitats worthy of protection (e.g., water protection areas, nature reserves or fauna and flora habitats [FFH]), stricter regulations related to manure management can exist. Additional rules may apply via the environmental permitting of animal farms and other related legislation.

**The regulation on the application of fertilizers, soil additives, cultural substances and plant additives according to the principles of the code of good agricultural practice in fertilization (Fertilizing Ordinance)** known as the German Fertilizing Ordinance is given to implement **the EU Nitrates Directive (91/676/EEC)**. The decree regulates the code of good agricultural practice of the application of fertilizers, soil additives, cultural substances and plant additives on a utilized agricultural area and aims to reduce negative environmental impacts related to the improper application of these materials. In particular, the application of these materials must be oriented on the balance between the expected nutrient needs of plants and the nutrient supply from soil and fertilization under consideration of site conditions. The application time and amount of these materials must be chosen in such a way that nutrients are timely available according to the nutrient needs of plants, and emissions into surface water and ground water are avoided.

The Fertilizing Ordinance addresses both the total nitrogen and amount of phosphorus applied as fertilizers. The maximum amount of total nitrogen application in organic and organic-mineral fertilizers including manure may not exceed 170 kg/ha per year on average of the utilized agricultural area of the farm. For compost, the maximum amount of total nitrogen applied may not exceed 510 kg/ha in a three-year period on average of the utilized agricultural area of the farm.

The ordinance does not directly limit the amount of phosphorus application. However, the amount of phosphorus applied to fields with organic and organic-mineral fertilizers is indirectly affected by the current limit for nitrogen use with such fertilizers. An exception is fields where soil analyses show a phosphorus content exceeding on average 20 mg P/100 g soil according to the calcium acetate extraction method (CAL method), 25 mg P/100 g soil according to the double lactate method (DL method), or 3.6 mg P/100 g soil according to the electric ultrafiltration process (EUF method). Here, phosphorus fertilizers may not exceed the amount of expected phosphorus removal. If harmful changes of water bodies are determined due to the application of phosphorus fertilizers, the authority responsible can, furthermore, reduce the amount of or prohibit the application of phosphorus for a farmer.

In general, the application of fertilizers containing nitrogen or phosphorus is prohibited when the soil is flooded, waterlogged, frozen or snowcapped. Fertilizer application to fields near water bodies is

particularly regulated. Furthermore, fertilizer application with a significant content of nitrogen is prohibited in the following closed time periods depending on land-use and cultivated crop:

- for arable land: from the date at which the harvest of the last main crop is completed till January 31
- for permanent grassland and arable land with perennial forage production (sowing until May 15): between the November 1 and January 31
- for arable land with catch crops, winter rapeseed and forage (sowing until September 15) or winter barley after cereals (sowing until October 1): fertilizers with a significant amount of nitrogen can be applied up to 30 kg NH<sub>4</sub>-N or 60 kg N per ha until October 1
- for horticulture: fertilizers with a significant amount of nitrogen can be applied until December 1 according to the nitrogen need of respective crops
- application of solid manure of ungulates and compost is prohibited between December 15 and January 15

However, the authority responsible according to state law can approve a deviation of the beginning and end of these time periods up to four weeks according to regional-typical circumstances, such as weather conditions or the beginning and end of plant growth, but reducing the duration of closed periods is not allowed.

On arable land without vegetative cover, organic and organic-mineral fertilizers, including manure (except solid manure of ungulates, compost and fertilizer with a dry matter content below 2%) with a significant content of plant available nitrogen, must be immediately incorporated at least within four hours after application. This incorporation deadline is only allowed to be exceeded if unpredictable weather conditions occurring after application make fields impassable.

On arable land with vegetative cover, liquid organic and organic-mineral fertilizers, including liquid manure with a significant content of plant available nitrogen, are only allowed to be applied in strips or have to be immediately incorporated as of February 1, 2020. As of February 1, 2025, this regulation will also apply to grassland and multi-cutting forage production.

The storage capacity for manure and digestates must be larger than the capacity needed to store these fertilizers during the above mentioned time periods of the application prohibition. In addition, the minimum storage capacity for liquid manure and digestates is six months. For solid manure and compost, a minimum storage capacity of two months will be introduced as of 2020.

All mentioned regulations for nitrogen and phosphorus can also be aggravated in regions containing bodies of groundwater having poor chemical status or exceeding the threshold value for nitrate, as well as eutrophicated static and slow-moving water bodies.

In Germany, livestock production and related manure management can be further affected by environmental-related regulations. The environmental law is not codified but rather scattered across many laws. Many planning provisions can be included under the environmental law because they serve, among other objectives, the environment protection to a greater or lesser extent. Their aim is to ensure the prevention of environmental damage already during the planning phase of different actions. Examples include the **Act on Environmental Impact Assessment Procedure** and the **building law**.

According to the Act on Environmental Impact Assessment Procedure, the **Environmental Impact Assessment (EIA)** must be done for intensive animal farming projects with more than 85 000 pullets or broilers, 60 000 hens or turkeys, 3000 fattening pigs ( $\geq 30$  kg), 900 sows with piglets ( $< 30$  kg), or 9 000 piglets (10-30 kg). The same applies to plants producing fishmeal and fish oil.

The **building law** aims at a sustainable urban development, which reconciles the social, economic and environmental protection requirements also in responsibility to the next generations, and at ensuring a socially fair land use. With regard to this aim, construction in outdoor areas generally should be avoided. However, under certain conditions, certain constructions can be permitted. Among others, agricultural farms have such a privileged right to constructions in outdoor areas to enable their further development (e.g., investments in barns). However, such activities need a building permit.

The **Industrial Emissions Directive 2010/75/EU (IED)** is implemented in Germany like in other EU countries. The directive demands the use of **Best Available Techniques (BAT)** for industrial activities, as listed in Annex I of the IED. The list includes intensive animal farming projects with more than 40 000 places for poultry, 2 000 places for fattening pigs (> 30 kg) or 750 places for sows.

## 7.2. Voluntary measures regulating manure management and fertilizer use

In Germany, farmers can commit themselves to the voluntary agri-environment and climate-protection measures financed by the second pillar of the **Common Agricultural Policy (CAP)**. The main support instrument is the **European Agricultural Rural Development Fund (EAFRD)**, which is co-financed by national funds from the Federal Government, the federal states and municipalities. At least 30% of the EAFRD must be used to finance such voluntary activities. The Federal Government defines a set of development measures via the **Joint Task for the Improvement of Agricultural Structures and Coastal Protection**, and these measures are then implemented to a great extent by the federal states via their individual support programmes.

For example, the framework of the Joint Task for the Improvement of Agricultural Structures and Coastal Protection (BMEL, 2019) includes the support of low-emission and environmentally friendly nitrogen fertilization, as well as low-emission and water body protecting the application of manure. The first aims at an improvement of the efficiency of nitrogen, which should be reached by limiting the allowed nitrogen surplus of 50 kg N per hectare according to §§ 8 and 9 of the Fertilizing Ordinance to 30 kg N per hectare of utilized agricultural area. Federal states have the possibility to additionally define that at least 30% of the annual amount of nitrogen is applied via manure. The second supports application techniques for liquid manure, which significantly reduce related gaseous emissions (e.g., manure is directly incorporated in soils).

## 7.3. Manure data used for fertilizing purposes

The German Fertilizing Ordinance regulates that fertilizers are only allowed to be applied to fields if the content of total nitrogen, plant available nitrogen or ammonium nitrogen and the content of total phosphorus is

- (1) known due to the product label of fertilizer,
- (2) determined, based on the data published by the authority responsible according to federal state law, or
- (3) determined, based on scientifically proven measurement methods by the farmer or other professional samplers before application.

The manure sampling method is not specified in the ordinance, but some commercial laboratories provide instructions on how to take a representative sample of manure (e.g., VDLUFA, 2008). For the determination of nutrient contents in manure (and digestates), animal nutrient excretion values given in Annex 1 (calculated and based on the mass balance approach) corrected by gaseous losses dur-

ing housing and storage given in Annex 2 of the Fertilizing Ordinance must be used. Hence, the farmers can decide whether to use the manure sampling analysis results or the “table (standard) values” published by the authorities responsible (e.g., Chambers of Agriculture in the federal states). However, calculated values according to the Annexes 1 and 2 reflect the minimum limit.

Before the application of significant amounts of nitrogen and phosphorus via fertilizers, the farmer has to determine the fertilizer requirement of each crop for each field or each management unit (defined as two or more fields with comparable site conditions and consistent cultivation features). Furthermore, the majority of farmers has to calculate a nutrient balance for nitrogen and phosphorus annually as a comparison of in- and outputs for the utilized agricultural area in total or for each field or each management unit (for example, farms with less than 15 hectares of utilized agricultural area are excluded from this regulation). If the nutrient balance is calculated for each field or management unit, the farmer has to add up these balances to an aggregated farm balance. The three-year average of the nitrogen balance surplus is not allowed to exceed 50 kg/ha and year. For phosphorus, the six-year average of the balance surplus is not allowed to exceed 10 kg/ha and year.

## 7.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 7.4.1. Nitrogen

#### Regulated by legislation – The German Fertilizing Ordinance

The maximum amount of total nitrogen application in organic and organic-mineral fertilizers including manure and digestates may not exceed on average 170 kg per hectare of the utilized agricultural area of the farm per year.

Irrespective of this maximum amount of total organic nitrogen application, the nitrogen fertilizer requirement is calculated as the locational limit for arable land and grassland. The calculation of the nitrogen fertilizer requirement is determined by the Fertilizing Ordinance considering different nitrogen needs of crops, varying yields, the nitrogen supply of soils, as well as the nitrogen supply from the previous application of manure and catch crops. Related to this, the Fertilizing Ordinance provides default values in the annexes.

For arable land, Table 16 shows the nitrogen need for selected crops dependent on the given yield.

**Table 16.** Examples for nitrogen need of crops depended on yield level according to Annex 4, Table 2 of the German Fertilizing Ordinance.

Crop	Yield level [t/ha]	Nitrogen need [kg N/ha]
Winter rapeseed	4.0	200
Winter wheat A, B	8.0	230
Winter barley	7.0	180
Winter rye	7.0	170
Winter triticale	7.0	190
Spring barley	5.0	140
Oat	5.5	130
Corn maize	9.0	200
Maize for silage	45	200
Sugar beet	65	170
Potato	45	180

If farm-specific yields deviate from the yield level given in Table 1, the farmer can/must adjust the nitrogen need of crops according to Table 17.

**Table 17.** Surcharges and discounts for farm-specific yield deviations for selected crops according to Annex 4, Table 3 of the German Fertilizing Ordinance.

Crop	Yield difference [t/ha]	Maximum surcharge for higher yields [kg N/unit of yield difference]	Minimum discount for lower yields [kg N/unit of yield difference]
Rapeseed	0.5	10	15
Cereals and corn maize	1.0	10	15
Maize for silage	5.0	10	15
Sugar beet	10	10	15
Potato	5.0	10	10

The resulting amount of nitrogen must then be reduced by nitrogen supply of soils, additional delivery of organic or organic-mineral fertilizers of previous years (10% of total nitrogen applied), and the nitrogen supply of previous crops or catch crops.

## 7.4.2. Phosphorus

### Regulated by legislation – The German Fertilizing Ordinance

A maximum amount of the total phosphorus application in organic and organic-mineral fertilizers including manure and digestates does not exist (except for fields with soil phosphorus contents exceeding the values mentioned in 7.1). However, the farmer has to determine the fertilizer requirement of the cultivated crop for phosphorus, too. According to the Fertilizing Ordinance, the need for phosphorus of the cultivated crop must be determined considering the expected yields and qualities according to the respective site and cultivation conditions. Additionally, the phosphorus content of the soil has to be taken into account.

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*Klärschlammverordnung, 2017. Verordnung über die Verwertung von Klärschlamm, Klärschlammgemisch und Klärschlammkompost (Klärschlammverordnung – AbfKlärV). Ausfertigungsdatum: 27.09.2017.*

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## 8. Latvia: Manure fertilizing practices

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### 8.1. Legislation regulating manure management and fertilizer use

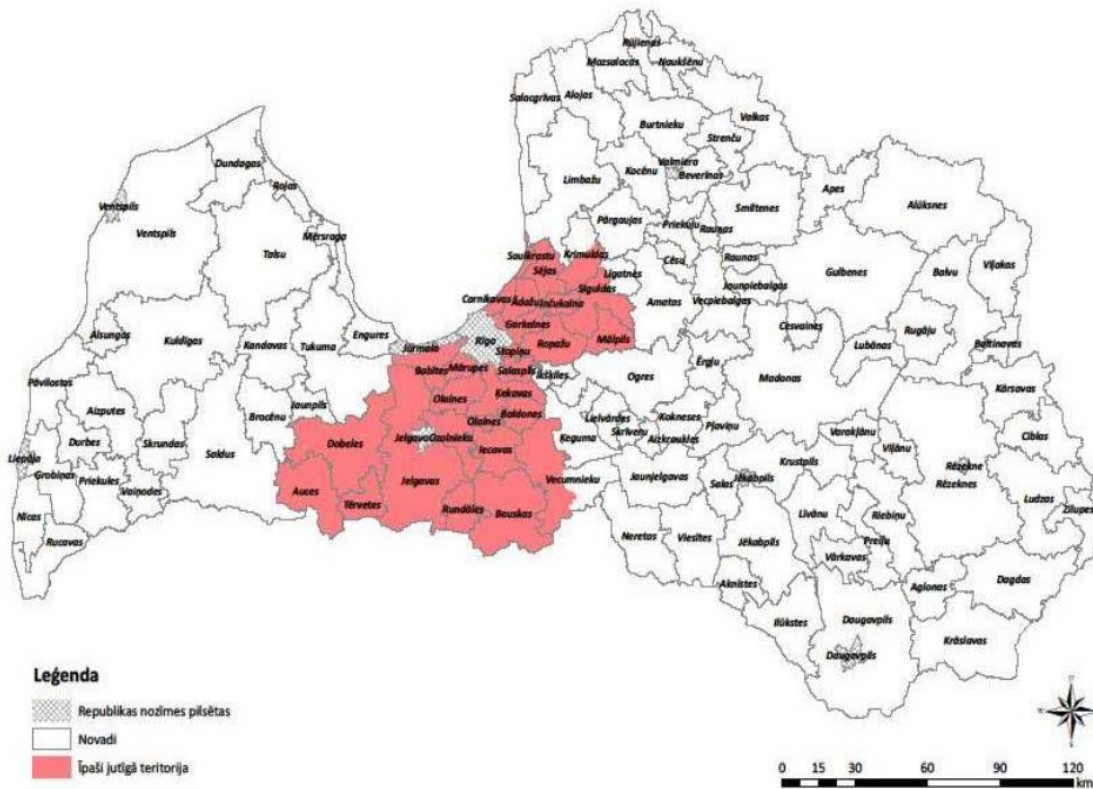
Latvia's **Law on Pollution** (2001) applies to all activities that may cause environmental pollution.

There are two regulations for fertilizers, which are issued pursuant to the Law on Pollution:

- **Cabinet Regulation No.834 “Regulation Regarding Protection of Water, Soil and Air from Pollution Caused by Agricultural Activity”** adopted on 23 December 2014 (hereafter – **Regulation No.834**) lays down requirements for the use and documentation of use of fertilizers;
- **Cabinet Regulation No.829 “Special Requirements for the Performance of Polluting Activities in Animal Housing”** adopted on 23 December 2014 (hereafter – **Regulation No.829**) lays down requirements for the storage of livestock manure.

The EU Nitrates Directive (91/676/EEC) has been implemented by both regulations. The regulations aim to reduce nitrogen emissions into surface water, ground water, soil and air caused by the use, storage and application of manure, fermentation residues and mineral fertilizers.

**Regulation No.834** defines part of Latvia as a nitrate vulnerable zone (Figure 1). The borders of the highly vulnerable zone include the administrative zone borders of the municipalities of Dobele, Auce, Tērvete, Jelgava, Ozolnieki, Bauska, Vecumnieki, Iecava, Rundāle, Babīte, Mārupe, Olaine, Īekava, Baldone, Salaspils, Stopiņi, Ropaži, Garkalne, Carnikava, Saulkrasti, Sēja, Ādaži, Inčukalns, Sigulda, Krimulda and Mālpils, except for the rural territory (or *pagasts*) of Valle and rural territory (or *pagasts*) of Kurmene of Vecumnieki municipality, the rural territory (or *pagasts*) of Lēdurga of Krimulda municipality, as well as the administrative territory borders of the cities of Jelgava, Rīga and Jūrmala). The highly vulnerable zone occupies **12.8%** of state territory. The use of nitrogen fertilizers is controlled in all farms in this territory.



**Figure 1.** Establishment of the nitrate vulnerable zone of Latvia.

In the nitrate vulnerable zone, the field application of fertilizers is prohibited in certain periods of time:

- livestock manure and fermentation residues are not allowed to be spread from 20 October until 15 March, and in respect of grasslands from 5 November until 15 March;
- mineral fertilizers containing nitrogen are not allowed to be sown from 15 October until 15 March, and in respect of other crops and grassland from 15 September until 15 March.

In nitrate vulnerable zones there are following requirements for fertilizing on slope: 1) if slant is from 5 to 7 degrees and the length of the slope exceeds 100 m in the direction of a water reservoir, fertilizers shall be applied directly in soil after dispersion of the fertilizer; 2) if slant is from 7 to 10 degrees and the length of the slope exceeds 100 ms in the direction of a watercourse or water reservoir, the soil shall be handled across the slope direction and dispersed only in case when a field is covered with plants or if fertilizer is immediately applied directly in soil; 3) where there is a bare fallow and where the slant of the slope is above 7 degrees, it is not permissible to disperse and apply fertilizers; 4) where a slant is above 10 degrees and the length of the slope exceeds 100 m towards the direction of a watercourse or water reservoir, it is not permissible to disperse and apply fertilizers.

In all territory of Latvia, the field application of fertilizers has the following restrictions: all fertilizers should not be spread on frozen, water-saturated or snow-covered ground; in lowlands and flood-endangered areas, fertilizers should be spread only after the end of the potential flood season; fertilizers should not be spread in locations where spreading is prohibited according to the normative acts of the protection zone.

Solid manure and fermentation residues in all the territory of Latvia must be incorporated into the ground within 24 hours after spreading, whereas liquid manure and urine - within 12 hours. Liquid

manure, fermentation residues and urine shall not be integrated if they are used as an additional fertilizer.

Regulation No.834 does not limit the use of phosphorus, but limits on the use of nitrogen with livestock manure and fermentation residues indirectly limits the use of phosphorus.

**Regulation No.829** prescribes special requirements for the performance of polluting activities in animal housing. Requirements for the restriction and control of pollution include: requirements for the collection, drainage and storage of livestock manure; requirements for the manure's storage facilities; requirements for the storage of silage in a trench and piles; requirements for the storage of slurry, semi-liquid manure and urine.

In accordance with Regulations No.829, if more than 10 livestock units are in the animal housing or more than 5 livestock units in the nitrate vulnerable zone, solid manure must be stored in a manure storage facility which is built of concrete, or on an area covered with concrete, or in a specially arranged area with a liquid-proof base. Urine shall be accumulated in a specially arranged storage facility (container).

Livestock manure is accumulated in a deep cattle-shed outside animal housing if the content of dry matter of at least 45 percent can be stored for no more than 24 months. In exceptional cases, this can be stored outside the animal housing for no more than five months from 1 May until 30 September, or if renovation or reconstruction of a manure storage facility is carried out. The volume of the storage facility for the storage of livestock manure must ensure the accumulation for at least eight months (referring to the storages which have been built after the adoption of Regulation No.834). If the quantity of livestock manure exceeds the volume of the storage facility, the operator shall transfer the relevant quantity which exceeds the volume of the storage facility to another person.

Use of fertilizers in the farms which uses plant protection products is regulated by **Cabinet regulation No.1056 "Requirements for Integrated Cultivation, Storage and Labelling of Agricultural Products and the Procedures for Control Thereof"** (hereafter – **Regulation No.1056**). According to Regulation No.1056 users of the plant protection products shall every seven years ensure agrochemical research of soil or sampling of analyses of soil from the agricultural land managed in the holding. Agrochemical analysis of soil shall be carried out by a laboratory which is accredited in the relevant field by the national accreditation body or another accreditation body of a European Union Member State or Member State of the European Economic Area. For agricultural land located in a highly vulnerable zone agrochemical research of soil or analyses of soil shall be ensured in accordance with the laws and regulations regarding water and soil protection from nitrate pollution caused by agricultural activity. One soil sample shall be taken from the area (field) which is not larger than six hectares by ensuring that the number or name of the specific field is indicated in the results of analyses. The user shall develop a crop fertilization plan on the basis of data obtained from the results of the agrochemical research of soil or analyses of soil. For agricultural land located in a highly vulnerable zone a fertilization plan shall be developed in accordance with the laws and regulations regarding water and soil protection from nitrate pollution caused by agricultural activity.

## 8.2. Voluntary measures regulating manure management and fertilizer use

The **Code of good agricultural practices** (hereafter – code) is prepared for Latvian farmers, which is a summary of practical advice, recommendations and laws covering the main fields of agricultural practice. The code is not obligatory and can be followed by the principle of voluntary participation. The first edition of the code was prepared by a Danish-Latvian joint project with the participation of

Swedish experts and was issued in 1999, followed by the second edition in 2008. The code covers the main topics that cause water, air and soil pollution and gives advice and recommendations which can be used to prevent or reduce pollution. The code includes recommendations on fertilization and manure management. Part of the measures included in the code were established as mandatory measures and included in national legislation.

There are several financially supported agri-environmental measures under EU's Rural Development Plan (RDP) 2014-2020 in Latvia that can contribute to the optimal use of fertilizers as, for example, requirements for crop rotation, legume cultivation, winter vegetation, conservation of perennial grasslands, construction of environmentally friendly systems in drainage systems (artificial wetlands, meandering, sedimentation ponds, two-stage ditches, controlled drainage, bottom dams), construction of manure storage facilities.

### 8.3. Manure data used for fertilizing purposes

To avoid exceeding the requirements of Regulation No.834 regarding the amount of nitrogen (170 kg/ha) in one hectare of agricultural land, the amount of livestock manure and fermentation residues permitted for application must be calculated based on the amount of nitrogen in livestock manure and fermentation residues. The area of agricultural land required for the application of livestock manure must be calculated based on animal units given in Annex 1 of Regulation No.834.

The amount of nitrogen shall be calculated in conformity with the nitrogen content in livestock manure indicated in Annex 2 of Regulation No.834 or in accordance with the analysis results of livestock manure or fermentation residues which have been issued by an accredited laboratory in the field of fertilizers. The livestock and fermentation residue samples shall be taken before the emptying of livestock manure or the fermentation residue reservoir. Livestock manure and the fermentation residues sampling method are not specified in Regulation No.834, but some accredited laboratories provide instructions on how to take a representative sample of manure and fermentation residues.

**Table 18.** Amount of acquisition of livestock manure and composition thereof\*

Livestock species, age group, type of keeping	Type of livestock manure	Acquisition per year, t*	Dry matter, %	One ton of naturally wet manure contains, kg		
				N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Dairy cow, milk yield less than 6000 kg a year	Solid manure	13.0	20	5.4	2.6	3.9
	Liquid manure	17.0	10	4.1	1.4	2.8
Dairy cow, milk yield from 6000 to 8000 kg per year	Solid manure	15.0	20	5.9	3.2	5.3
	Liquid manure	19.0	10	4.2	2.1	2.9
Dairy cow, milk yield more than 8000 kg per year	Solid manure	20.0	20	6.0	2.9	4.3
	Liquid manure	26.0	10	4.4	2.2	3.3
Suckler cow with calf	Solid manure	11.0	22	5.5	2.6	8.2
Breeding bulls	Solid manure	14.0	20	4.3	5.5	4.2
Heifer (up to the age of 6 months)	Solid manure	5.0	22	4.7	2.3	5.7
Heifer (6 months and older)	Solid manure	8.0	18	4.7	1.8	3.9
Fattening young cattle (6 months and older)	Solid manure	9.0	18	4.7	3.0	6.9
	Liquid manure	13.0	10	3.7	2.7	1.8
Separated piglets up to 30 kg	Solid manure	0.25	25	6.4	6.2	2.6

	Liquid manure	0.4	7	3.8	3.3	2.2
Sow with piglets	Solid manure	1.5	26	9.7	8.5	4.7
	Liquid manure	2.5	9.0	5.9	5.1	2.8
Sow without piglets and boar	Solid manure	1.5	22	7.1	7.6	2.3
	Liquid manure	2.5	9	4.6	3.5	2.0
Fattening pig (over 30 kg) and a gilt	Solid manure	1.0	21	6.3	4.3	3.0
	Liquid manure	2.0	8	3.4	2.3	1.6
Goat with kids	Solid manure	2.4	25	5.4	3.1	8.3
Sheep with lambs, deep cattle-shed	Solid manure	2.4	25	5.4	3.7	7.0
Horse	Solid manure	10.0	25	4.7	2.4	3.8
Laying hen	Manure without litter**	0.03	30	21.0	11.3	7.8
	Liquid manure	0.10	10	6.4	4.7	2.2
Broiler	Solid manure	0.01	55	27.6	12.1	13.8
Deer	Firm manure	1.2	26	7.8	5.5	4.8

\* It is assumed that the livestock are in the holding for 365 days.

\*\* Manure without litter - semi-solid excrements of the livestock.

The farmers can decide whether to use the analysis result or “table (standard) values” given in Annex 2 of Regulation No.834 (Table 18). The standard values were confirmed in 2008 and have been based on the results of manure samples analyses from 1997 until 2007 and the methods of calculating a fodder feed.

The farmers must register and record any applied, purchased, sold or otherwise used amount of livestock manure and fermentation residues. The registration documents must be stored for at least three years. If the amount of nitrogen produced on the farm with livestock manure and fermentation residues exceeds 170 kilograms per hectare of agricultural land in a year, the farmers must prove with documents the transfer of the residue of livestock manure and fermentation residues produced for other farms or the use thereof in a different manner.

## 8.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 8.4.1. Nitrogen

#### Regulated by legislation – Regulation No.834

The amount of nitrogen applied to one ha with livestock manure and fermentation residues in one hectare of agricultural land cannot exceed 170 kilograms per year. Derogations from this amount are not applied in Latvia.

The maximum permissible amount of nitrogen (kg/ha), which may be used for crops in one harvest period, is stated in Annex 3 of Regulation No.834 and depends on crops, planned yield level and the status of the soil organic matter. The maximum permissible amount of nitrogen (Table 19) must be observed by farmers in the nitrate vulnerable zone. Compliance is voluntary in the rest of Latvia.

**Table 19.** Maximum permissible norms of nitrogen for cultivated plants (cereals and other plants).

Cultivated plant	Harvest level, t ha <sup>-1</sup>			
	< 3.0	3-5	5-7	> 7.0
Winter wheat	80	120	150	220
Rye	65	95	130	160
Winter barley	75	105	140	185
Winter triticale	75	105	140	200
Spring wheat	80	125	160	200
Spring barley	65	100	135	170
Oats	60	90	120	-

Cultivated plant	Harvest level, t ha <sup>-1</sup>			
	Maximum permissible amount of nitrogen, kg ha <sup>-1*</sup>			
Winter rapeseed	< 2.0	2.0-4.0	4.0-5.0	> 5.0
	90	150	190	230
Summer rapeseed	< 2.0	2.0-3.0	3.0-4.0	> 4.0
	90	120	160	200
Maize, green fodder	< 40	40-60	> 60	
	110	160	200	
Potatoes	< 30	30-40	> 40	
	90	140	180	
Fodder beets, sugar beets	< 40	40-60	> 60	
	90	150	190	
Grasses of fields and meadows, hay	< 4.0	4.0-8.0	> 8.0	
	80	120	170	
Pastures, green fodder	< 20	20-30	> 30	
	100	155	240	
Cabbages	< 45	45-70	> 70	
	135	210	240	
Carrots	< 30	30-50	> 50	
	80	130	160	
Onions	< 25	25-45	> 45	
	95	170	200	
Beets	< 40	40-60	> 60	
	110	170	200	
Cauliflower	< 20	20-40	> 40	
	110	200	240	
Cucumbers	< 25	25-40	> 40	
	100	160	200	
Marrow, pumpkin	< 30	30-60	> 60	
	90	185	215	
Linseed	-			
	80			
Fibre flax	-			
	40			
Peas, beans and other pulses	-			
	40			

Fruit trees, berry bushes	- 130
Strawberries	- 120
Grassland whose papilionaceous proportion is 50 % and more	- 50

\*Soils with the content of organic substances at a layer of 0-30 cm is greater than 30 %, determining the maximum permissible norms, the amount indicated in the table shall be multiplied by a coefficient of 0.7

#### Voluntary measures – The Code of good agricultural practices

Compliance with maximum permissible norms of nitrogen for cultivated plants in accordance with Annex 3 of Regulation No.834 is voluntary for farmers in the rest of Latvia.

### 8.4.2. Phosphorus

Latvia's legislation does not have requirements for the maximum allowable phosphorus fertilization.

Most agricultural land in Latvia has a low and very low content of usable phosphorus in the soil. In accordance with agrochemical research, which was done by State Plant Protection Service in the representative set (5 000 ha) of usable agricultural land (hereafter – UA) in 2014, an average 56 % of UA has a low and very low content of usable phosphorus, but in some regions the share of such soils is 61% (Latgale region) and 69% (Vidzeme region).



## 9. Lithuania: Manure fertilizing practices

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### 9.1. Legislation regulating manure management and fertilizer use

In Lithuania, fertilizing plans are based on using animal units. Definitions of animal units for different species are described in the Environmental Requirements for Manure Management (Decree 04/04/2018 No. D1-261/3D-200) (Legislation of the Republic of Lithuania, 2018). Here one animal unit represents a source of manure with 100 kg of total N per year. Conversions of animals to animal units and the amount of land allowed for manure spreading are given in Table 20. This simplified system does not use an amount of N in manure directly and therefore there are no official table values for nutrient content.

Concerning the application periods, the legislation forbids the application of organic fertilizer on frozen soil, snow covered soil or waterlogged soil. The application of organic fertilizers is allowed during the vegetation period from 1st April until 15th November. However, from 15th June to 1st August, fertilization is only allowed on fallow, meadows, pastures or areas for winter-crop cultivation. It is also compulsory to incorporate manure within 24 hours after spreading. Furthermore, there are compulsory requirements regarding storage capacities for manure and slurry, since farmers have to ensure that slurry and manure are stored in order to prevent groundwater pollution as well as surface pollution. The storage capacity has to cover at least six months.

If organic or (and) mineral fertilizer is applied to an area larger than 30 ha, fertilization plans have to be drawn up. These plans are produced on a farm level and have to take into account manure specific and site specific conditions, as well. Fertilization-plans are based upon the results of soil tests and have to be prepared each year before fertilization. The individual fertilization plan includes the results of soil tests for nitrogen, phosphorus, potassium, and pH soil sampling has to be repeated every third year. The plan shows the planned amount of manure or slurry, and the expected nutrient demand of the specific crops. In addition, it includes a fertilization timetable (in months) and a map of fertilized fields. Fertilization plans have to be available on the farm and shown in case of control checks. Crop rotation, target yield, and additional requirements due to specific land use conditions are also referred to in preparation of fertilization plans. The records of these fertilization plans have to be kept in a "farm record book".

For certain areas, there are additional regulations to prevent nutrient losses from agricultural systems. There are, for example, additional restrictions concerning hilly areas which differ with regard to the inclination of the slope. If the slope inclination is higher than 5°, perennial grass has to cover at least 35-40 % of the total crop-rotation area. On slopes with an inclination between 5-7°, the proportion of perennial grass has to be increased up to 50 % or more. Slopes with an inclination of 7-10° demand 65-80 % coverage with perennial grasses. If the slope inclines between 10° and 15°, no crop production is allowed, although the cultivation of perennial grasses.

Slope inclination is also regarded in additional regulations for the protection of surface water. Water protection strips in general are required along rivers longer than ten kilometres or water accumulations bigger than 0.5 hectares. If the river side slope inclines more than 5°, a water protection strip of five meters is required. The width of the water protection strip has to be increased up to ten meters

if the stream side slope inclines between 5 and 10°. Side slopes inclining more than 10° require a water protection strip of 25 m.

Furthermore, it is forbidden to drain or plough natural (flooded and dry) meadows and pastures or change their condition and grassland composition by other means. With respect to the characteristic features of some Lithuanian regions, protection zones, comparable with protection strips around karst sinkholes, are legally required. The width of these protection zones varies from 5 to 10 m and depends on the type of karst sinkhole.

**Table 20.** Conversions of animals to animal units and amount of land allowed for manure spreading.

Animals	Number of animals for 1 AU	AU per one animal	Manure spreading ha
Sows (with unweaned piglets), boars	2.9	0.35	0.21
Piglets from 7 kg to 32 kg (3 months)	100	0.01	0.006
Pigs from 3 to 8 months	10	0.1	0.06
Pigs from 8 months	9.1	0.11	0.065
Cows. bulls	1	1	0.59
Calves to 1 year	4	0.25	0.15
Cattle from 1 to 2 years	1.4	0.7	0.41
Red deer	5	0.2	0.12
Fallow-deer. sika deer	9	0.11	0.06
Bison. European bison	1.7	0.6	0.4
Sheep. goats	14	0.07	0.041
Horses from 1 year	1	1	0.59
Foals till 1 year	2.5	0.4	0.24
Laying hens	140	0.007	0.0041
Laying hens (pullets)	1600	0.00063	0.00037
Broilers	2500	0.0004	0.00024
Turkeys (raised till 70 days)	157	0.0064	0.0038
Turkeys (raised till 133 days)	75	0.0133	0.0078
Ducks	116	0.0086	0.0051
Geese	63	0.016	0.009
Rabbits (bucks. does with unweaned offspring)	40	0.025	0.015
Chinchillas	714	0.0014	0.00083
Mink/martens (older than 10 months)	40	0.025	0.015
Foxes (older than 10 months)	15	0.067	0.039
Ostriches (adult)	2.5	0.4	0.24
Quails (layers)	450	0.0022	0.0013
Quails (broilers)	4800	0.000208	0.00012

## 9.2. Voluntary measures regulating manure management and fertilizer use

The Lithuanian Ministry of Agriculture signed up to a new regulation for farmers who participate in the Rural Development Program. This regulation obliges these farmers to calculate nutrient balances on a farm level. A methodology is based on the identification of input and output of nitrogen, phosphorus and potassium on the farm. The calculation-method takes specific grain production, mineral fertilizers, livestock feed and various fodder additives into account as input to the farm. A period of

twelve months is recorded. Farm- and site-specific aspects such as precipitation, nutrient content of the soil (N, P, and K) and nitrogen fixating plants are considered, as well. The farm-specific nutrient output is calculated, considering harvested crops and livestock production.

### 9.3. Manure data used for fertilizing purposes

The regulation “Environmental requirements for manure management” (Legislation of the Republic of Lithuania, 2018) describes basic manure management requirements and makes it possible for one to estimate animal units. Recommendations on how to calculate the minimum capacity of manure storage for a required period of manure accumulation are provided in “Guidelines for good agricultural practices” (Šileika A.S. et al., 2000, Šileika A.S. (ed.), 2007), but other relevant sources and farm data can be used, as well. The quantity of animal manure from different farming systems can be obtained from the “Regulation for the technological design of cattle buildings” (Lithuanian Ministry of Agriculture, 2009), the “Regulations for the technological design of poultry farms” (Lithuanian Ministry of Agriculture, 2012), and the “Regulation for technological design of pig buildings” (Lithuanian Ministry of Agriculture, 2010a). Besides these, there is the “Regulation for the technological design of wastewater and manure management buildings” (Lithuanian Ministry of Agriculture, 2010b). The nutrient content of different types of manure can be obtained from various sources; different laboratories and companies provide laboratory analyses and farmers are not restricted in their choices. However, there are manure analyses of different age and production groups of cattle and pigs (DM content, chemical composition) available based on the outcomes of the international project “Improvement of the Fertilizer Normative - Especially Manure Standards” (1998-2001) (The Danish Agricultural Advisory Centre, 1999/2001). Some results from this project are provided in the “Developing a fertilization plan” (Lithuanian Agricultural Advisory Service, 2002) published by the agricultural advisory service. Table 21 presents data taken during this project on the content of nutrients in the manure of cattle and pigs, taking into account emission losses ex-housing and ex-storage (Lithuanian Agricultural Advisory Service, 2002).

**Table 21.** Nutrient content of manure (per animal).

Animal. keeping technology, manure storing technology	Type of manure	Manure quantity, t/year	DM, %	Nutrient content, kg/t		
				N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
<b>1. Cattle manure:</b>						
Dry cow 550 kg, expected productivity 5000 kg, tie housing, open stack of bedded manure						
	solid manure	1.13	21.48	5.01	2.91	5.04
	liquid fraction	0.37	4.51	6.63	2.02	7.58
Dry cow 550 kg, expected productivity 5000 kg, loose housing, open stack of bedded manure						
	solid manure	1.60	24.28	5.53	2.49	6.49
	liquid fraction	0.06	7.36	3.25	4.67	8.61
Dairy cow 550 kg, productivity 5000 kg, tie housing, open stack of bedded manure						
	solid manure	7.32	20.87	4.46	2.56	4.54
	liquid fraction	3.06	4.16	5.30	1.16	8.47
Dairy cow 550 kg, productivity 5000 kg, loose housing, open stack of bedded manure						
	solid manure	10.60	24.00	4.94	2.24	6.81
	liquid fraction	0.68	5.90	4.43	2.77	5.28
Calf till 6 months of age, loose housing, open stack of bedded manure						
	solid manure	1.46	25.32	4.51	2.81	6.2
	liquid fraction	0.07	6.00	6.55	5.34	2.02
Dairy heifer 6-24 months of age, loose housing, open stack of bedded manure						
	solid manure	8.14	23.88	3.96	2.60	5.37
	liquid fraction	0.62	5.62	3.89	1.64	5.74

2. Pig manure:						
Pregnant sow 180 kg, on bedding, open stack of bedded manure						
	solid manure		29.77	5.08	4.12	6.36
	liquid fraction	1.97	3.69	5.37	3.91	3.44
Sow with 18 piglets till 18 kg (at weaning), farrowing crate with bedding, open stack of bedded manure						
	solid manure	0.25	30.40	5.18	5.69	2.73
	liquid fraction	1.21	3.18	8.46	3.99	3.96
Weaned piglets 18-30 kg, on bedding, open stack of bedded manure						
	solid manure	1.24	28.47	6.32	4.96	6.18
	liquid fraction	0.08	3.00	7.53	3.61	3.35
Weaned piglets 18-30 kg, on slats without washing, slurry tank						
	slurry	0.08	9.36	9.77	5.39	3.42
Weaned piglets 18-30 kg, on slats with small amount of bedding, fractionation of slurries*						
	solid fraction	0.04	18.00	6.39	4.27	2.64
	liquid fraction	0.15	3.00	3.76	2.14	1.58
Fattening pig 30-100 kg, on partially slatted floor without washing, slurry tank						
	slurry	0.53	11.69	6.72	4.72	3.48
Fattening pig 30-100 kg, on partially slatted floor, fractionation of slurries*						
	solid fraction	0.21	18.00	4.72	3.87	2.90
	liquid fraction	0.84	2.70	2.89	1.94	1.74

\*Mechanical fractionation of slurries, solid fraction stored in open stacks, liquid fraction stored in lagoon.

A more recent published national source with manure data is The Estimation of N and P in Manure, 2017 (Juška R., 2017) (Table 22).

**Table 22.** Manure amount and nutrient content.

Animals	Type of manure	Amount of manure ex house per animal place, t	DM %	N kg/t	P <sub>2</sub> O <sub>5</sub> kg/t
Dairy cows, box housing	Solid	7.9	16.4	5.2	2.5
	Liquid/slurry	4.8	6.4	3.6	0.7
Calves till 1 year	Solid	5.6	20.2	4.6	2.4
Cattle from 1 to 2 years	Solid	7.6	19.5	4.6	2.3
	Liquid/slurry	3.8	5.3	2.6	0.8
Bulls (no pasture)	Deep litter	18.9	20.5	4.8	3.1
Bulls (barn)	Deep litter	11.4	20.5	4.8	3.1
Bulls (pasture)	Excrements	6.7	8.0	3.5	1.6
Sows (with unweaned piglets)	Fresh	2.9	7.9	6.2	0.8*
	Slurry	5.5	5.4	3.5	0.6*
Boars	Fresh	1.7	8.9	7.3	1.5*
	Slurry	3.6	5.5	1.32	5.5*
Pigs 3-8 months	Fresh	1.0	9.0	7.1	1.9*
	Slurry	2.1	5.3	3.1	1.0*
Pigs from 8 months	Fresh	1.4	3.52	4.5	0.8*
	Slurry	3.0		2.4	0.75*
Laying hens	Solid	5.8**	43.1	19.5	6.6
Broilers	Solid	3.1** <sup>a</sup>	56.3	27.3	12.0
Sheep	Deep litter	0.8	30.0	6.1	3.6 (1.6*)
Goats	Solid	0.7	28.4	7.1	5.4 (2.4*)

\*P kg/t; \*\*per 100 birds; <sup>a</sup> excluded bedding

## 9.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 9.4.1. Nitrogen

The amount of manure which is applied to agricultural land is restricted, which must not exceed 170 kg nitrogen per hectare. Manure left on fields after grazing has to be considered too. The animal density on agricultural land is limited to 1.7 livestock units per hectare. On farms with a higher animal density, the area has to be increased or manure surpluses have to be transported to other farms that do not exceed this limit.

### 9.4.2. Phosphorus

Phosphorus is not considered in the official decree.

### References

- The Danish Agricultural Advisory Centre, 1999/2001. Improvement of the Fertilizer Normative - Especially Manure Standards, Phase 2, Republic of Lithuania.  
<https://www.landbrugsinfo.dk/Diverse/KA/Sider/046.pdf> (checked on 04/09/2019).
- Juška R., 2017. Estimation of manure nitrogen and phosphorus from cattle, pigs, poultry (laying hens and broilers), sheep and goats. Final report of the project. Institute of Animal Science of LUHS. 19 p. (In Lithuanian). <http://bit.ly/2IB0H7C> (checked on 04/09/2019).
- Legislation of the Republic of Lithuania, 2018. Environmental requirements for manure management. (Decree 04/04/2018 No. D1-261/3D-200). (In Lithuanian)
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- Lithuanian Ministry of Agriculture, 2009. Regulation for technological design of cattle buildings TPT 01: 2009. 45 p. (In Lithuanian)
- Lithuanian Ministry of Agriculture, 2010a. Regulation for technological design of pig buildings TPT 02:2010. 45 p. (In Lithuanian)
- Lithuanian Ministry of Agriculture, 2010b. Regulation for technological design of wastewater and manure management buildings TPT 03:2010. 26 p. (In Lithuanian)
- Lithuanian Ministry of Agriculture, 2012. Regulations for technological design of poultry farms TPT 04:2012. (In Lithuanian)
- Šileika A.S. (ed.), 2007. Guidelines for good agricultural practices. 2-nd edition. Vilainiai. 38 p. (In Lithuanian)
- Šileika A.S., Kutra G., Mašauskas V. et al., 2000. Guidelines for good agricultural practices. Kėdainiai. 64 p. (In Lithuanian)

## 10. Poland: Manure fertilizing practices

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### 10.1. Legislation regulating manure management and fertilizer use

In Poland, the rules for the use of livestock manures are regulated fundamentally by two laws: the Fertilizers and Fertilization Act, and the Water Act, which implement, inter alia, the EU Water Directive, the EU Nitrates Directive and the EU fertilizer legislation.

The **Fertilizers and Fertilization Act** of 10 June 2007 (Journal of Laws 2018 item 1259) regulates, among other things, the conditions and principles of placing fertilizers on the market, sets the rules for the use of fertilizers and plant conditioners, sewage fertilization use and prevents risks to human and animal health and the environment that may arise as a result of transport, storage and use of fertilizers. The Act also introduces the definitions of livestock manures while implementing the EU regulation 1069/2009, and defines the rules for the disposal of livestock manures and the requirements for a fertilization plan.

The **Water Act** of 20 July 2017 (Journal of Laws 2018 item 2268), contains provisions on the protection of waters against pollution by nitrates from agricultural sources. These include, among others, guidelines for the establishment of an action program in Poland and the introduction of a set of recommendations of good agricultural practice for voluntary use, as well as an assessment of effectiveness measures.

More specifically, these issues are regulated by the government and ministerial regulations. The **Ordinance of the Council of Ministers of 5 June 2018 on the adoption of the “Action programme for the reduction of water pollution caused by nitrates from agricultural sources and prevention of further pollution”** – Nitrate Program (Journal of Laws 2018 item 1339) – specifies:

- Restriction of fertilizer land application (soil and weather conditions, water bodies distance, steep terrain)
- Fertilization periods (1 March to the 15, 20, 25 and 31 October – depending on the type of manure and climate condition, solid manures – up to 30.11 on permanent and perennial crops and grasslands)
- Conditions for storage of livestock manures and leachate handling (six months capacity for liquid and five for solid manures, prevention of leaching, capacity calculation rules)
- Nitrogen fertilization rates (limitation, nitrogen fertilization plan)
- Documentation and data backup (contracts between animal fertilizer users and producers)
- Manure management system (tables, calculation methods & examples))
- Program implementation schedule

Compliance with the program is controlled by the Agency for Restructuring and Modernisation of Agriculture (ARMA) regarding cross-compliance: SMR1 Protection of waters against pollution caused by nitrates from agricultural sources, and GAEC 1 Buffer zones along watercourses. The Chief Inspectorate for Environmental Protection monitors the compliance of agricultural production with the Water Law Act.

The **Regulations from the Minister of Agriculture and Rural Development of 16 April 2008 on the specific method of application of fertilizers and conduct training on their use** (Journal of Laws 2019 item 1826) contains the recommended techniques for using livestock manures, rules for determining the dose of fertilizer, and a list of institutions authorised to conduct training on the use of fertilizers.

The **Regulations from the Minister of Environment of 23 January 2015 on the R10 recovery process** (Journal of Laws 2015 item 132) specifies the conditions in the recovery process R10 – organic waste treatment at the surface of the earth, benefiting agriculture or improving the environment, and the types of waste permitted for such recovery. It includes the conditions for the agricultural use of livestock manures and digestate.

The **Building Law of 7 July 1994** (Journal of Laws 2018 item 1202) and the **Regulation from the Minister of Agriculture and Rural Development of 7 October 1997 on the technical conditions that agricultural buildings should comply with and their location** (Journal of Laws 2014 item 81) set the conditions that must be completed in the design, construction, and maintenance of buildings and construction equipment in agriculture, with particular emphasis on protection against emissions to the environment.

The Industrial Emissions Directive 2010/75/EU (IED) is implemented in Poland in the **Environmental Protection Law of 27 April 2001** (Journal of Laws 2019 item 2166). Like in other EU countries, the Best Available Techniques (BAT) conclusions concern farms with more than 40,000 places for poultry, 2,000 places for production pigs, or 750 places for sows.

Moreover intensive animal farming projects with more than 85,000 broilers, 60,000 hens, 3,000 fattening pigs ( $\geq 30$  kg), 900 sows with piglets ( $< 30$  kg), or 9,000 piglets (10–30 kg) are also subjected to Environmental Impact Assessment (EIA) according to the **Ordinance of the Council of Ministers of 10 September 2019 on projects that may significantly affect the environment** (Journal of Laws 2019 item 1839). This ordinance is the implementation of the Environmental Impact Assessment Directive 2011/92/UE (EIA). The regulation introduces the need to obtain an integrated environmental permit for farms maintaining more than 210 LUV animals.

## 10.2. Voluntary measures regulating manure management and fertilizer use

In February 2019, an updated version of the "**The set of recommendations for good agricultural practice for voluntary use**" was published, which includes recommended practices regarding the use of fertilizers in agriculture and the management of agricultural production on the farm. The rules contained in it go beyond the law and constitute a scheme of actions aimed at even better protection of waters and the atmosphere against pollution from agricultural sources. The scope of this publication includes, among other matters: issues on the safe use of mineral fertilizers, organic fertilizers and livestock manures, fertilizer plan design, soil liming, and effective agro-technical practices to reduce nitrogen losses, fertilizer storage, transport and application techniques, modern fertilization technologies, and mitigation options of nutrient losses from agriculture.

Sustainable nutrients management is a key part of the Rural Development Program 2014-2020, which was designed on the basis of the European Union regulations regarding support for rural development by the European Agricultural Fund for Rural Development. The Agri-Environmental and Climate Scheme, Package 1 – Sustainable Agriculture included systematic nutrient and organic matter soil analyses, sustainable crop rotation, and fertilizer plan design. Section 4.1 relates to support for investment in farms, contains partial co-financing of construction or modernisation of storage tanks for liquid livestock manures.

### 10.3. Manure data used for fertilizing purposes

Agricultural holdings leading intensive animal production (40 000 poultry, 2 000 pigs > 30 kg, 750 sows) are required to design a fertilization plan based on the chemical analyses of livestock manure. Other farms, or when preparing a plan of nitrogen fertilization, or controlling the maximum rates of nitrogen from all sources, may use the table of the nitrogen content in livestock manure from the annexes of the Nitrate Program. These entities may carry out soil and livestock manure analyses, but they are not obligatory. All farms should calculate livestock manure production and storage capacity based on AU estimation according to the calculation method and tables from the annexes of the Nitrate Program.

The network of Agrochemical Stations carries out tasks related to the servicing of agriculture. In their catalogue they have accredited sampling and analytical procedures for the assessment of livestock manure. Academic laboratories, scientific institutes and commercial laboratories perform these analyses on the basis of accreditation granted by the Polish Centre for Accreditation, *Lista akredytowanych laboratoriów*.

### 10.4. Maximum allowable fertilization rates for nitrogen and phosphorus

#### 10.4.1. Nitrogen

Regulated by legislation – Nitrate Program

The maximum amount of total nitrogen from livestock manures per 1 ha of utilised agricultural land may not exceed 170 kg N.

Requirements concerning fertilization management and the determination of mineral fertilizer rates depend on the size of the farm.

Agricultural holdings (group 1) leading intensive animal production (40 000 poultry, 2 000 pigs > 30 kg, 750 sows) are obliged to have a fertilization plan for all fields, based on soil and livestock manures analysis, and plant nutrient requirements. They must obtain authorisation from the Regional Agrochemical Station and then deliver a copy of the plan together with an opinion to the head of the community (mayor, president of the city). The utilisation of 70% of livestock manure on own fields is mandatory.

Large farms with an area exceeding 100 ha of arable land, or cultivating intensive crops with high doses of fertilizers (e.g., wheat exceeding 120 kg N/ha, maize over 160 kg N/ha, rape over 150 kg N/ha) on the surface area of more than 50 ha, or maintaining the density of animals over 60 AU (group 2), are obliged to possess a nitrogen fertilization plan for all fields, based on a nitrogen balance set out in Annex No. 8 of the Program. For the calculation of expected crop yield, nitrogen uptake by plants, the content of nitrogen in the soil, and the amount of nitrogen remaining in the soil after the cultivation of leguminous plants are all taken into account. The nitrogen fertilization plans are also required from buyers of livestock manures from the fertilizer importer and agricultural holdings.

All smaller farms are obliged to comply with the so-called maximum amounts of active nitrogen from all sources. For the calculation amount of nitrogen in mineral fertilizers and livestock manures, the nitrogen content in the soil, and the amount of nitrogen remaining in the soil after the cultivation of leguminous plants are all taken into account. Examples of the maximum active amounts of nitrogen from all sources for particular crops are shown in Table 23.



**Table 23.** Examples of the maximum amount of active nitrogen from all sources for crops.

Crop	Maximum nitrogen rate [kg N/ha]
Winter rapeseed	240
Winter wheat	200
Winter barley	140
Winter rye	120
Winter triticale	180
Spring barley	140
Oat	120
Corn maize	240
Maize for silage	240
Sugar beet	180
Potato late	180

Farms from group 1 to 3 have to prove all actions related to nitrogen fertilization in the records.

Small farms with an area below 10 ha or maintaining the density of animals above 10 AU (group 4), should comply with the general rules of the Nitrate Program.

Fertilization and manure management are supported by IT tools developed by the Agricultural Advisory Centre.

#### 10.4.2. Phosphorus

The amount of phosphorus application from livestock manures is controlled to a certain extent by the nitrogen limit. The standards for the maximum amount of phosphorus doses in livestock manure are under development.

##### Voluntary measures – the Rural Development Programme 2014-2020

Farms benefiting from co-financing in Package 1 - Sustainable Agriculture are required to provide regular soil analysis and an NPK fertilization plan based on the results, taking into account organic matter content in soil and livestock manure management. The fertilization plan is also voluntary (to be chosen from other options) in the RDP 2014-2020 in activities for young farmers and the restructuring of small farms.

Information on optimal doses of macro- and microelements for plants grown under different soil conditions is available as fertilizer recommendations published by agricultural services and research institutes.

#### References

The set of recommendations for good agricultural practice for voluntary use. (in Polish) The Ministry of Agriculture and Rural Development. Online available at <https://www.gov.pl/web/rolnictwo/zbior-zalecen-dobrej-praktyki-rolniczej-do-dobrowolnego-stosowania> (checked on 01/07/2019).

##### Selected Polish legislation

*Ustawa z dnia 10 lipca 2007 r. o nawozach i nawożeniu (Dz.U. z 2018 r. poz. 1259)*

*Ustawa z dnia 20 lipca 2017 r. - Prawo wodne (Dz.U. z 2018 r. poz. 2268)*

*Rozporządzenie Rady Ministrów z dnia 5 czerwca 2018 r. w sprawie przyjęcia "Programu działań mających na celu zmniejszenie zanieczyszczenia wód azotanami pochodzącymi ze źródeł rolniczych oraz zapobieganie dalszemu zanieczyszczeniu" (Dz.U. z 2018 r. poz.1339)*

*Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 16 kwietnia 2008 r. w sprawie szczegółowego sposobu stosowania nawozów oraz prowadzenia szkoleń z zakresu ich stosowania (Dz.U. z 2019 r. poz. 1826)*

# 11. Russia: Manure fertilizing practices

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## 11.1. Legislation regulating manure management and fertilizer use

In the Russian Federation, the **Federal Waste Classification Catalogue** attributes the animal/poultry manure and derived products to Hazard Classes 3, 4, and 5 (Table 24).

**Table 24.** Categorization of animal manure according to hazardousness class.

Type of waste	Hazard Class
Cattle manure, fresh	4
Cattle manure, rotted	5
Small cattle manure, fresh	4
Small cattle manure, rotted	5
Pig manure, fresh	3
Pig manure, rotted	4
The liquid fraction of separated pig manure in case of installed gravity-flow manure removal system	4
The solid fraction separated pig manure in case of installed gravity-flow manure removal system	4
Manure-bearing waste water in case of installed flush pig manure removal system	3
Manure-bearing waste water in case of installed gravity-flow pig manure removal system	
Manure bearing wastewater sludge manure from pig houses after the settling in manure accumulation tanks	4
A mix of farm animal and poultry manure, fresh, low-hazard	4
The liquid fraction of separated pig manure in case of installed flush removal system	4
The solid fraction of separated pig manure in case of installed flush removal system	3
Poultry manure, fresh	4
Poultry manure, rotted	4
Poultry manure, stored (matured) in the storage, disinfected	

**The Federal Law of 10.01.2002 No 7-FZ “On Protection of Environment”** requires that all production and consumption waste should be made safe; accumulation and storing of production and consumption waste is allowed exclusively in the statutorily designated places.

The Federal Law of **24.06.1998 No 89-FZ “On Production and Consumption Waste”** obliges all enterprises which generate the waste of Hazard Class 1 to 5, to have a license for its collection, transportation, handling, disposal, neutralization, and placing, or to hand it over to other specially licensed organisations.

According to the **State Standard GOST R 1.4-2004 “Standards of Organisations”** and the **Federal Law of 27.12.2002 (version of 27.07.2017) No 184-FZ “On Technical Regulating”**, animal/poultry manure may be used in one’s own production process to produce organic fertilizers following the Technological Regulations of manure processing and fertilizing use, a regulatory document developed and approved by the agricultural enterprise itself.

The **Technological Regulations** (Standard of Organisation) describe the conditions and procedure of animal/poultry manure processing into an organic fertilizer, which ensure the production of the environmentally safe product with the quality indicators complying with the requirements of approved standards (specifications). The Technological Regulations establish the rules for the safe conduct of works and the ways to achieve the optimal technical and economic indicators of the particular agricultural enterprise.

The **Explanatory Statement of 23.05.2016 of the Ministry of Natural Resources and Environment of the Russian Federation to the Federal Law №219-FZ** considers the animal and poultry manure generated in the process of economic activity as not waste but a raw material. In case the agricultural enterprise has in place and observes the respective Technological Regulations, the manure may be used for its own needs as a ready product, namely an organic fertilizer. In this case, the legal requirements to the waste management, including the licensing, do not apply to animal/poultry manure.

On 01.06.2018 the two Russian information and technical reference books on Best Available Techniques (BAT) came into force: **41-17 “Intensive rearing of pigs”** and **42-17 “Intensive rearing of farm poultry”**. They contain the technological indicators of relevant BATs, serve as an element of the government BAT-based regulation and are included in the national standardization system.

Currently, the main characteristics, indicators and requirements for technologies of animal/poultry manure processing into an organic fertilizer are determined in accordance with the methodological recommendations, which are approved by the Ministry of Agriculture of the Russian Federation as the regulatory documents for the agro-industrial complex:

- **Management Directive for Agro-Industrial Complex РД-АПК 1.10.15.02-17 “Recommended Practice for Engineering Designing of Systems for Animal and Poultry Manure Removal and Pre-application Treatment”**
- **Management Directive for Agro-Industrial Complex РД-АПК 3.10.15.01-17 “Recommended Practice for Designing of Systems for Animal and Poultry Manure Removal, Treatment, Disinfection, Storage and Utilization”**
- **Management Directive for Agro-Industrial Complex РД-АПК 1.10.02.04-12 “Recommended Practice for Engineering Designing of Pig Farms and Complexes”**
- **Management Directive for Agro-Industrial Complex РД-АПК 1.10.05.04-13 “Recommended Practice for Engineering Designing of Poultry Farms”**
- **Management Directive for Agro-Industrial Complex РД-АПК 1.10.01.01-18 “Recommended Practice for Engineering Designing of Cattle Farms and Complexes”**

According to the above documents, the organic fertilizer produced from farm poultry manure, pig or cattle manure should comply with the **State Standard GOST R 53117-2008 “Organic fertilizers produced from farm animal waste. Specifications”**. In case of non-compliance, the special specifications are developed.

Organic fertilizers may be passed over to other legal entities for application. In this case, they must have an enclosed document issued by the veterinary service certifying the quality and safety compliance with the above State Standard.

## 11.2. Voluntary measures regulating manure management and fertilizer use

In the Russian Federation the voluntary measures regulating manure management and fertilizer use are not applied.

### 11.3. Manure data used for fertilizing purposes

To calculate the fertilizer application rates the nutrient content data is taken from:

- laboratory analysis protocols
- reference books
- calculations based on nutrient content in animal excrement (data from the guidance documents).

Laboratory analysis protocols include the following data:

- mass fraction of total nitrogen - % per actual moisture content
- mass fraction of total potassium in terms of  $K_2O$  - % per actual moisture content
- mass fraction of total phosphorus in terms of  $P_2O_5$  - % per actual moisture content
- mass fraction of dry matter – %.

Reference books provide indicative nutrient content in organic fertilizers. The data is given for each group of animals (cattle, pigs and poultry) without the details concerning the animal housing technologies and animal/poultry manure processing technologies into organic fertilizers.

For example, the total nitrogen content in the organic fertilizer produced from cattle manure is 0.48%, from pig manure – 0.24%, and from poultry manure – 1.4%.

To calculate the nutrient content in the organic fertilizer, the nutrient content in the animal excrement is taken as a basis; these values are specified in the guidance documents on manure management (Table 25).

**Table 25.** Calculation of the nutrient content in manure.

Nutrient content in the dry matter of excrement, %				
	Cattle	Pig	Poultry with bedding	Poultry without bedding
Total nitrogen (N)	3.2	6	3.6	6.2
Phosphorous ( $P_2O_5$ )	1.8	3.2	3.4	3.5
Potassium, ( $K_2O$ )	5.0	2.5	2.0	2.1

Estimated mass of bedding and process water which gets into the cattle manure is as follows:

Cattle farm
Tied housing (bedding) – 1.5 kg/head/day
Loose housing (bedding) – 0.5 kg/head/day
Tied housing (process water) – 5 l/head/day
Loose housing (process water) – 1.5 l/head/day
Milking parlour (process water) – 20 l/head/day

The estimated mass of the process water which gets into the pig manure is as follows:

Pig farm
Boars (process water) – 7.5 l/head/day
Mating sows and gestating sows (process water) – 7 l/head/day
Farrowing (milking) sows (process water) – 20 l/head/day
Weaners (process water) – 1.5 l/head/day
Replacement gilts (process water) - 4.5 l/head/day
Fattening pigs (process water) - 4.5 l/head/day

In an animal/poultry house, the excrement mixing with the bedding and process water result in animal/poultry manure. The total mass of manure is calculated by the following formula:

$$Q_{total} = \sum_{j=1}^m (Q_{excrements} + Q_{water} + Q_{bedding}) * nj$$

Where  $Q_{excrements}$  – is the daily output of excrements (faeces and urine), kg;

$Q_{water}$  – is the daily process water consumption, kg\*;

$Q_{bedding}$  – is the daily bedding consumption, kg;

$nj$  – is the number of animals in each category;

$m$  – is the number of animal categories.

\*In the Russian regulatory documents, the rates of process water consumption are set in l/head/day but in our calculations we use kg/head/day as the value of water density is 1.

The amount of manure nutrients is the sum of nutrients in the excrement and bedding. Manure NPK content is calculated by the following formula:

$$N_{total} = N_{excrements} + N_{bedding}$$

$$P_{total} = P_{excrements} + P_{bedding}$$

$$K_{total} = K_{excrements} + K_{bedding}$$

$N_{total}, P_{total}, K_{total}$  – is the nutrient content in manure, kg;

$N_{excrements}, P_{excrements}, K_{excrements}$  – is the nutrient content in excrement, kg;

$N_{bedding}, P_{bedding}, K_{bedding}$  – is the nutrient content in bedding, kg.

## 11.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 11.4.1. Nitrogen

The maximum allowable fertilization rates for nitrogen are regulated by the Management Directive for Agro-Industrial Complex *РД-АПК 1.10.15.02-17*: “Recommended Practice for Engineering Designing of Systems for Animal and Poultry Manure Removal and Pre-application Treatment” and depend upon the fertilized crops (Table 26).

**Table 26.** Fertilization limits for nitrogen depending on the crop.

Crops	Annual application rate		Time of application
	nitrogen, kg/ha	manure, t/ha	
1	2	3	4
1 Winter grains	120-140	30-35	Before the primary tillage (ploughing)
2 Spring grains	120-180	30-45	In autumn during fall ploughing or in spring during pre-sowing tillage
3 Table potato	120-200	38-50	In autumn during fall ploughing or in spring before spring ploughing
4 Factory beet	200-300	50-75	In autumn during fall ploughing or in spring during pre-sowing tillage
5 Fodder and sugar beet for livestock feeding	200-320	50-80	Same as above

6 Corn for green fodder and silage	200-320	50-80	Same as above
7 Perennial grains and grain legumes for hay and green fodder	200-300	50-75	Before sowing and after mowing in the form of fertilizing watering or by splashing over soil

In the Russian part of the Baltic Sea catchment area, Recommendation 28E / 4 of the Helsinki Commission, dated November 15, 2007, on the prevention of pollution from agriculture is mostly observed; the maximum amount of manure that is applied each year, including the animal excrement during the grazing, is calculated by the nitrogen and phosphorus content and should not contain more than 170 kg/ha of nitrogen.

#### 11.4.2. Phosphorus

In the Russian part of the Baltic Sea catchment area, Recommendation 28E / 4 of the Helsinki Commission, dated November 15, 2007, on the prevention of pollution from agriculture is mostly observed: the maximum amount of manure that is applied each year, including animal excrement during the grazing, is calculated by the nitrogen and phosphorus content and should not contain more than 25 kg/ha of phosphorous.

Russian legislation does not regulate the maximum amount of phosphorus applied with organic fertilizers.

## 12. Sweden: Manure fertilizing practices

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### 12.1. Legislation regulating manure management and fertilizer use

Some of the measures to reduce plant nutrient losses from agriculture are carried out via legislation. Regulations regarding the environment are gathered in the Environmental Code, and in its ordinances and regulations.

Many activities in agriculture and forestry risk harming or disturbing the environment, so particular consideration is necessary in such activities. For certain activities and measures, there are clear rules in the legislation, and for others the rules are of a more general nature. Whether or not there is detailed legislation concerning a certain measure, the Environmental Code's general rules about consideration always apply. Briefly put, they state that every person who carries out, or intends to carry out, activities must obtain the knowledge and take the measures necessary to protect human health and the environment against damage or inconvenience.

More detailed rules about the handling of plant nutrients are available in the Ordinance (1998:915) on environmental concern in agriculture, and in the Swedish Board of Agriculture rules and general guidance (SJVFS 2004:62) on environmental concern in agriculture as regards plant nutrients.

The Ordinance on environmental concern in agriculture includes rules on manure storage capacity. It also includes minimum shares of land under vegetative cover during autumn or winter (so-called green land).

The Swedish Board of Agriculture's rules and general guidance on environmental concern in agriculture includes rules on the covering of slurry stores and filling of stores under a cover, rules on spreading area and other aspects of spreading, restrictions on applied quantities of manure, as well as detailed rules on green land. Additional rules may apply via environmental permitting of animal farms and other related legislation.

#### **Restrictions on applied quantities of manure and fertilizer**

For environmental reasons, there are restrictions on how much manure and fertilizer may be applied per hectare of land. The requirement regarding land available for spreading manure is in place in order to avoid plant nutrient losses to lakes, watercourses and the sea from excessive spreading.

The spreading of manure and other organic fertilizers is limited by its content of phosphorus. The supply of phosphorus from manure and organic fertilizers may not exceed 22 kg per hectare of available land, counted as a five-year average.

Within nitrate vulnerable zones (Figure 2), there are also regulations limiting the application of manure based on its content of nitrogen. Within these areas, manure may not be applied in quantities larger than the equivalent of 170 kg of nitrogen per hectare of available land and per year. Within areas identified as being vulnerable, the supply of nitrogen via manure and fertilizers may not exceed the quantities considered necessary for the crop in the site in question.





**Figure 2.** Nitrate vulnerable zones in Sweden.

### Spreading of fertilizers

The rules on precautionary measures when spreading fertilizers are not the same in all parts of Sweden. In the nitrate vulnerable zones, the rules are more far-reaching than in the rest of the country. There are also specific rules which only apply in the counties of Blekinge, Skåne and Halland.

Mineral fertilizers based on urea that is spread on bare soil shall always be incorporated into the soil within four hours of the spreading. The purpose of this rule is to minimise ammonia losses during spreading, and applies to all of Sweden.

Outside those areas identified as being vulnerable, manure and organic fertilizers that are spread during the period 1 December - 28 February shall be incorporated into the soil within 12 hours.

In the counties of Blekinge, Skåne and Halland, manure that is spread on bare soil shall be incorporated into the soil within four hours. This applies throughout the entire year.

As regards the nitrate vulnerable zones, the following precautionary measures apply:

- Fertilizers may not be spread on water-saturated or flooded ground.
- Fertilizers may not be spread on frozen or snow-covered ground.
- Fertilizers may not be spread on agricultural land closer than two meters from an edge adjacent to a watercourse or a lake.
- Fertilizers may not be spread on agricultural land adjacent to a watercourse or a lake where the slope exceeds 10 %.

- Manure provided from animals themselves when outdoors should not be counted in the term spreading.
- No fertilizers may be spread during the period 1 November – 28 February.
- During the period 1 August – 31 October, manure and other organic fertilizers may only be spread on growing crops or before autumn sowing. Spreading in catch crops is not allowed.
- Solid manure (except from poultry) may however be spread on bare soil during the period 1 October – 31 October, even if the land is not about to be sown.
- Solid manure spread on bare soil during the period 1 October – 31 October shall be incorporated into the soil within four hours in the areas identified as vulnerable within the counties of Blekinge, Skåne and Halland. For other areas identified as vulnerable, rules apply that solid manure spread on bare soil shall be incorporated into the soil within 12 hours during this time period.

### Spreading liquid manure in growing crops

The largest part of ammonia losses due to the spreading of manure takes place in the first hours after spreading. This means that if the manure is quickly incorporated into the soil or placed directly into the ground, the losses are efficiently reduced.

However, when spreading takes place in growing crops, it is not always possible to incorporate the manure into the soil. In the counties of Blekinge, Skåne and Halland (Figure 3), the spreading of liquid manure in growing crops shall be carried out using a technology that efficiently reduces ammonia losses. Spreading in growing crops shall be carried out using one of the following options:

- A method that places the manure directly on the ground underneath the green cover, for example, band spreading.
- A liquid manure drill or a similar method that places the manure directly into the ground.
- Any method that dilutes the manure with water before spreading (1 part manure and at least ½ part water).
- Spreading followed by irrigation supplying at least 10 mm of water. The supply of water shall begin no later than four hours, and be completed within 12 hours after the spreading began. Rain counts towards the fulfilment of the 10 mm requirement.



**Figure 3.** Grey areas are the counties of Blekinge, Skåne and Halland.

## 12.2. Voluntary measures regulating manure management and fertilizer use

Within the Swedish Rural Development Programme, it is possible to get financial support for measures that reduce plant nutrient losses from agriculture. Agri-Environmental payments in the Rural Development Programme to reduce plant nutrient losses include:

- reduced nitrogen leaching (catch crops, spring tillage),
- buffer zones,
- wetlands and drainage.

There is also a possibility to apply for support when investing in equipment with the aim to reduce ammonia losses. For example, support when investing in extra storage capacity or support when investing in special equipment for the spreading or injection of manure.

### **Focus on Nutrients – *Greppa Näringen***

Focus on Nutrients (*Greppa Näringen*) offers advice, free of charge for farmers, and is a joint venture between the Swedish Board of Agriculture, the Federation of Swedish Farmers and the County Administration Boards. The purpose with Focus on Nutrients is to provide farmers and advisors with the inspiration and motivation to improve profitability on the farm, and reduce its negative impact on the environment. Through Focus on Nutrients, agriculture is to contribute to the fulfilment of the Environmental Quality Objectives Zero Eutrophication, A Non-Toxic Environment, and Reduced Climate Impact.

Advisory service within Focus on Nutrients is procured by the County Administration Boards and provided by a variety of advisory firms. Farmers can choose between about 30 different advisory visits which are divided by theme into “advice modules”.

At the initial advisory visit on the farm, the farmer and the advisor discuss the need for additional counselling and establish a nutrient balance for the farm. The nutrient balance shows the farm’s starting position, and it is followed up one or several times during future visits. The farmer also receives a plan for the continuation of advisory visits, based on his or her own interests and the needs of the individual farm.

After seven advisory visits it is time for a follow-up meeting, where the farmer and the advisor establish a new nutrient balance and evaluate actions carried out in different areas on the farm. If needed, a plan for a continuation of advisory visits is established. Focus on Nutrients emphasises that the advisor should make repeated farm visits and return to follow up changes and the progress on each farm.

More information can be found on the website [www.greppa.nu](http://www.greppa.nu). The website contains several interactive services where farmers and others who are interested can use a tool for the valuation of manure and calculate the optimal application of nitrogen. Members can also calculate a nutrient balance for their own farm.

#### *Extension services*

Focus on Nutrients also offers extension service with regional plant nutrient advisors in Alnarp, Skara, Linköping and Uppsala. The regional offices coordinate advisory service in their respective parts of Sweden.

The regional advisors spread information about results from research and trials in the area of plant nutrients to the operators in the region, as well as other important information (such as legislation). Furthermore, they shall support other advisors in their work, and take part in various regional projects and studies within their special fields.

## **12.3. Manure data used for fertilizing purposes**

The Swedish Board of Agriculture provides farmers with standard values concerning both the amount of manure produced by different animal categories and the nutrient content in the manure. These standard values are based on a barn balance with standard feeding ration. Farmers can use the standard values when calculating need of spreading area due to the phosphorus content in the manure or when making a fertilizer plan.

The farmer can also use the calculation tool VERA to make his/her own barn balance when calculating the spreading area. The nutrient content in the manure given by this balance is adjusted to the production on the farm and therefore more precise.

Results from analyses are not allowed when calculating the spreading area. However, analyses are encouraged to be used as a support when it comes to the actual spreading of the manure. It is also allowed when deciding the amount if nitrogen is accessible.

## 12.4. Maximum allowable fertilization rates for nitrogen and phosphorus

### 12.4.1. Nitrogen

Within nitrogen vulnerable zones the nitrogen level in manure is not allowed to exceed 170 kg of total nitrogen per hectare and year, counted as an average of the entire spreading area the current year.

There are also regulations limiting fertilization with accessible nitrogen in the autumn. Before the sowing of winter oilseed there is a maximum of 60 kg accessible nitrogen per hectare and before the sowing of other winter crops, such as winter wheat, there is a maximum of 40 kg per hectare. Accessible nitrogen includes nitrogen in the form of nitrate, ammonium and urea.

Within nitrogen vulnerable zones the supply of nitrogen through fertilizers shall not exceed the amount possible for the crop to use. Therefore the farmer has to calculate the need of nitrogen for the expected yield. In the calculation, consideration shall be taken to the effect of the pre-crop, long term effect of manure and humus content.

The need for nitrogen for different crops shall be decided due to production ability and economy. Every year the Swedish Board of Agriculture calculates the economical optimal nitrogen dose for different crops and presents the results in the report Recommendations for fertilization and liming. See table 27 for recommended nitrogen dose in cereals.

**Table 27.** Economical optimal nitrogen dose in kg N/ha for different cereals 2019. Mineral soils with cereals as pre-crop.

Crop	Yield (t/ha)									
	3	4	5	6	7	8	9	10	11	
Winter wheat bread, south of Götaland			120	140	160	180	200	220	240	
Winter wheat feed, south of Götaland			115	135	150	165	180	195	210	
Winter wheat bread, north of Götaland & Svealand		110	130	150	170	190	210	230	250	
Winter wheat feed, north of Götaland & Svealand		100	120	140	155	170	185	200	215	
Triticale/Winter barley, south of Götaland			110	130	145	160	175			
Triticale/Winter barley, north of Götaland & Svealand		95	115	135	150	165	180			
Rye, south of Götaland			95	115	130	135	140			
Rye, north of Götaland & Svealand		80	100	120	135	140	145			
Spring wheat		125	145	165	185	205				
Barley feed, south of Götaland		60	80	95	110	125	140			
Barley malt, south of Götaland		65	85	100	115	130	145			
Barley feed, north of Götaland & Svealand	45	65	85	100	115	130				
Barley malt, north of Götaland & Svealand		70	90	105	120	135				
Barley, Norrland	45	65	85	100						
Oats, south of Götaland		55	75	90	105					
Oats, north of Götaland & Svealand	40	60	80	95	110					

## 12.4.2. Phosphorus

The supply of phosphorus from manure and organic fertilizers may not exceed 22 kg per hectare of available land, counted as a five-year average.

As a general guidance within the Swedish Board of Agriculture rules and general guidance (SJVFS 2004:62), it is stated that storage fertilization of phosphorus ought to be avoided. For soils in P-AL-class III or higher, the amount of added phosphorus should not exceed the amount that is removed with the crop. It is also stated that soil analysis ought to be made regularly.

### References

Swedish Board of Agriculture, 2013. Actions against Plant Nutrient Losses from Agriculture. OVR125GB.

Swedish Board of Agriculture, 2018. Rekommendationer för gödsling och kalkning 2019. JO18-2018.

## 13. Conclusions

The fertilization regulation and voluntary actions within the Baltic Sea coastal countries have their similarities, but also significant differences.

The EU member states (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden) follow the maximum limit of nitrogen fertilization from manure as set by the Nitrates Directive. However, the cultivated area to which the Directive applies (nitrate vulnerable zones) differs between the countries, meaning that in some countries all fields are as NVZ and in others only some. Furthermore, Russia as a non-EU-country has its own set of regulation.

Phosphorus fertilization from manure differs significantly between the BSR countries. While all are Contracting Partners in Helsinki Commission with a set 25 kg P/ha limit, not all countries have implemented the limit. Some of the countries have no regulation for manure phosphorus use, but the amount of phosphorus contained in it is spread as the limits set for nitrogen allow. Some countries have regulation also for phosphorus.

Most of the countries subsidize more precise fertilization than allowed in legislation via different agri-environmental schemes. Such actions may include the calculation of farm specific nutrient balances to enhance nutrient utilization and reduce losses.

While the quality and frequency of manure data collection as the basis of manure fertilization regulation and the fertilization limits given differ significantly between the countries, the actual amounts spread per hectare range from very precise to rather loose quantities. The amount of nutrients added therefore also varies. The variation is not desirable from the point-of-view of efficient, equal and environmentally friendly manure fertilization.

More uniform methods for determining manure nutrient content and thus better updated and more precise manure data is one of the prerequisites for improved manure use (as developed in the project Manure Standards). Additional actions towards better unified basis for fertilization limits, certainly with consideration of the crops produced, soil types and other nationally differing conditions, should be aimed at.



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