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FINAL REPORT ON EXPERT EVALUATION OF TIER 2 ACCURACY LEVEL NATIONAL ACCOUNTING OF POLLUTANTS EMITTED INTO THE ATMOSPHERE IN AGRICULTURE SECTOR

Final report

2020

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**ACRONYMS**

|  |  |
| --- | --- |
| AAA / EPA | Environment Protection Agency (lit. *Aplinkos apsaugos agentūra*) |
| AB | Joint stock company (lit. *Akcinė bendrovė*) |
| AIVIKS | Integrated computer system for environmental information management (lit. *Aplinkos informacijos valdymo integruota kompiuterinė sistema*) |
| EMEP/EEA 2016 | EMEP / EEE technical manual on emissions 2016 |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations (lit. *Jungtinių Tautų maisto ir žemės ūkio organizacija*) |
| IFA | International Fertilizer Industry Association – IFA (lit. *Tarptautinės trąšų pramonės asociacija*) |
| IPCC | Intergovernmental Panel on Climate Change (lit. *Tarpvyriausybinė klimato kaitos komisija*) |
| PM | Particulate matter |
| LR | Republic of Lithuania |
| PAV | Environmental impact assessment (lit. *Poveikio aplinkai vertinimas*) |
| RATCA | Association of regional waste management centres (lit. *Regioninių atliekų tvarkymo centrų asociacija*) |
| GHG / ŠESD | Green-house gasses (lit. Šiltnamio efektą sukeliančios dujos) |
| TIPK | Integrated pollution prevention and control (lit. Taršos integruota prevencija ir kontrolė) |
| UAB | Limited liability company (lit. *Uždaroji akcinė bendrovė*) |
| ŽŪB | Agricultural company (lit. *Žemės ūkio bendro*vė) |
| GDPR / BDAR | General Data Protection Regulation (lit. *Bendrasis Duomenų Apsaugos Reglamentas*) |
| VAT | Value added tax |

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# Introduction

This report provides collected data and information to increase the level of accounting of emissions in the agricultural sector. The purpose of the data collection report is to separate the sources of input data, methodologies and data required and to provide all the data collected.

Part of the data on the accounting level of the agricultural sectors was collected using the Environmental Protection Agency (EPA) pollution reports and the AIVIKS database. Using the AIVIKS database, data was collected on the effectiveness of the applied air pollution abatement measures in different Lithuanian farms. Farms were divided into NFR codes based on farm activity descriptions and air pollution abatement measures. In this breakdown, the actual pollution reduction by tonnes for each NFR code is calculated. Approximately 1% of farms in these estimates were not assigned to any NFR codes due to lack of data on their activities.

In order to obtain additional information on the use of air pollution abatement measures in farms, the Chambers of Agriculture were contacted. The information provided by the Chambers of Agriculture was the outcome of the feasibility study. No systematic data on pollution abatement measures are collected, therefore, the data of the Chambers of Agriculture are not included in the report.

During the data collection process, the analysis, with the help of The Chambers of Agriculture, was distributed to 50 associations and farmers' organizations[[1]](#footnote-1) covering all the agricultural sub-sectors analyzed in this report. Given that GDPR came into force on 25-05-2018, Direct Farmer Survey became complicated, therefore, it was chosen to reach respondents through associations. However, we regard that respondents' activity was too low to objectively assess the prevalence of applied pollution abatement technologies in Lithuanian farms. The total number of respondents to the survey was 54. Considering the negative attitude of respondents to such surveys, we propose that the most effective way of collecting this type of data would be the 5-year nationally representative researches conducted by Lithuanian Statistics. Due to low response rate from survey participants it was decided not to repeat the surveys in 2020.

In order to evaluation practices of other countries in applying new regulation changes to emission calculations 35 Inventory informative reports were analyzed. All reports submitted in 2020 were analyzed as well as relevant older reports. Only legal changes in agriculture (NFR3) were analyzed. Out of 35 reports analyzed only 12 contained relevant information. To sum up:

* In most cases new legal regulation requirements were applied without questioning possibility if the some people may not follow the law (for example in Estonia (in case of manure management calculations), Germany, Hungary, Latvia, North Macedonia, Slovak Republic). Some countries additionally note that there is not data regarding breaking of the law;
* Some countries are taking additional measures in order evaluate cases where the legal regulation was not followed. Usually these measures include additional request of information sent to controlling institutions (Great Britain, Czech republic);
* In cases were legal regulation include exemptions and information about extent of said exemptions is known countries provide that information (Spain, Hungary);
* It should be noted that Estonia in 2016 emission calculations from pig manure management were done based on legal regulation stated in the order of Minister of Environment. The analysis of said IRR showed that after the legal regulation came into force it’s requirements were included in full scope same year in the IRR calculations.

Based on the analysis above, it is recommended the incase new regulation directly affecting the emission calculations, it assumption should be made that the requirements of the regulation are applied immediately, in full scope and in all farms. In case the regulation have exemptions and data about their scope is available, such information should be included in the calculations of emissions.

Data were collected and systematized on the number of livestock present in Lithuanian farms from paper document options available at the Environmental Protection Agency. Data are presented in livestock units for the period 2007-2017. During this period, the Environmental Protection Agency has accumulated some information on pollution reduction measures and their effectiveness. Analyzing paper document data, it was found that many more farms provided paper documents compared to AIVIKS.

Part of the data collected is from EIA documents, EIA selections and IPPC permits. These documents provided information on the use of air pollution abatement measures, the planned use and the number of animals that could be attributed to the instrument used. Also, the review of these environmental documents has shown that in Lithuania the data on agricultural sectors consists of many small and medium-sized farms. Only in the pig manure management sector was it possible to identify the main and largest market share, the Idavang Group. Almost all sectors of manure management have failed to identify the largest farm, as there are many small and medium-sized farms that make up the entire sector.

It has also been noted that not all farms are required to have EIA or IPPC documents according to the laws of Lithuania. New activities are also starting almost every year, some of the activities are expanding, some are running out, the number of animals is constantly changing, so it is almost impossible to trace the period and number of animals for which pollution abatement measures were used. However, this report assumed that the air pollution abatement measure had been used since the start of the planned activity until now, unless there are other data, and was applied to the planned number of livestock.

In the crop sector, more information was collected from manuals, publicly available online information, and research, as well as from national and foreign statistical databases. In addition, some sectors still lack data that is expected to be collected during the survey phase of the data collection. The data collected by the service provider from AIVIKS is specified in the attached Microsoft Office Excel document.

In 2019 a new version of the Guidebook was published. Changes in methodology[[2]](#footnote-2) were analyzed and applied in this report. However, it should be noted these changes are minor (term “building” was changed to “housing”, explanation added on the calculations of mbedding (kg fresh weight a-1) and mbedding\_N (= approximately mbedding/100) indicators, "EF\_(storage\_effluent\_N)" was removed, mmdig\_TAN and mmdig\_N are added (these indicator are calculated at chapter 5.B.2) and will not make significant changes to outcome of the calculations.

In order to evaluate if any significant changes in legal regulations have occurred since the III interim report, analysis of legal regulations[[3]](#footnote-3) was carried out. Only legal regulations that were confirmed in 2019 were analyzed. Sample of analysis was legal documents associated with these Eurovoc[[4]](#footnote-4) terms:

* MT 5206 environmental policy (576 legal documents);
* NT environmental protection (298 legal documents);
* MT 5606 agriculture policy (220 legal documents).

Out of the documents analyzed, 15 were identified as potentially relevant and analyzed in detail. It should be noted that in 2019 a regulation regarding the wellbeing of animal was issued: regulation regarding animal housing in populated areas[[5]](#footnote-5), Requirements for farm animal wellbeing as well as additional regulation regarding requirements for calves’[[6]](#footnote-6) and laying chicken[[7]](#footnote-7) wellbeing. These regulations are firstly focused on safety of the animals and servicing the basic needs of the animals, hence have no effect on the emission calculations for this sector (for example requirements of calves’ well being p. 16 “Manure and uneaten feed has be removed regularly so the bad odor would not attract rodents” regulates manure management but has no effect on the emission calculations).

LMT Benchmarking Project covered only stationary incineration in agriculture, which is classified in the NFR 1.A.4.c.i. Stationary incineration in agriculture, forestry and therefore this NFR is not analyzed in this report. Said project also recommends to use Guidebook 2016 EFs for PM2,5 from activities in the fields, since measuring country specific EF requires research of much larger scope. EF calculated in the aforementioned project can be used on emission calculations in case of cattle manure management – changes to chapters 2.4 and 2.5 are made accordingly.

**During the preparation of this report, the following main data collection activities have been carried out:**

* The analyzed pollution abatement technologies are specified in the IPPC applications and permits filed in 2019 (no new permits were issued in 2019, three permits were stopped – no new data about abatement measures was gathered);
* Data from Statistics Lithuania was updated;
* Data from international agricultural organizations (FAOSTAT and IFASTAT) was updated;
* Data provided by the Lithuanian Association of Regional Waste Management Centers was updated;
* Extrapolation of data was applied;
* Data on inorganic N-fertilizers (includes also urea application) was supplemented with data from GHG emission reports as well as research financed by Ministry of agriculture.
* Information for calculating emissions from grain elevators was added in NFR 3.D.C;
* Analysis of changes in regulatory environment was carried out;
* 35 IRR were analyzed in order to provide recommendations for applying changes in legal regulations to calculations of emissions;
* In cases where data required for Tier 2 calculations cannot be gathered recommendation regarding collection of said data is provided;
* Methodologies are updated according to changes in Guidebook 2019;
* Phone consultation with Institute of Animal Science was conducted and Recommendations regarding application of LMT benchmarking project results were provided;
* Additional disaggregation of IFASTAT data was added (classification by product).

Activity data collected with respect to the subsectors, types of economic activities, and pollution abatement technologies provided in the Technical Guide are provided in the Microsoft Office Excel document (SEE Agriculture\_Collected\_data\_1990-2019\_EN.XLSX). This document is considered an integral part of this report.

# Manure management (NFR 3.B)

## European Union legislation on manure management

**Directive 2010 / 75 / EU of the European Parliament and of the Council**[[8]](#footnote-8) **"**on industrial emissions (integrated pollution prevention and control)" states that intensive poultry farming and animal husbandry contribute significantly to increasing air and water emissions. In order to achieve the objectives set out in the Thematic Strategy on Air Pollution and Union Water Protection Law, the Commission needs to review the need for differentiated cap limits for different bird species in order to define the scope of this Directive and to review the need for the most appropriate emission control measures for livestock installations. Manure fertilization contributes significantly to air and water pollution. In order to achieve the objectives set out in the Thematic Strategy on Air Pollution and Union legislation on water protection, it is necessary for the Commission to review the need for the best available techniques for controlling these emissions.

**Directive 2016/2284 of the European Parliament and of the Council[[9]](#footnote-9)** "on the reduction of certain atmospheric pollutants in the Member States and amending Directive 2003/ 35 / EC and repealing Directive 2001/81 / EC" should contribute to the progressive reduction of air pollution based on Union air pollution legislation on the control of pollution sources, which regulates the specific emissions of a substance through reductions. The second subparagraph of Article 6 (2) of the Directive refers to emission reduction measures. Member States, taking into account the UN / ECE Code of Good Agricultural Practice for Reducing Ammonia Emissions, develops a national code of good agricultural practice related to the control of ammonia emissions, consisting of at least the following elements:

* nitrogen management, taking into account the entire nitrogen cycle;
* animal feed strategies;
* low-emission manure spreading techniques;

low-emission manure storage systems;

* low-pollution animal housing systems;
* possibilities of limiting the amount of ammonia emissions from mineral fertilizers..

Member States can reduce ammonia emissions from manure by following these methods:

* Reducing the amount of pollutant emissions from non-animal storage facilities using the following methods:
  + slurry storage facilities built after January 1st, 2002, use low-emission storage systems or methods, that reduced ammonia emissions by at least 60%, as compared to the method described in the guidance document. If current slurry storage facilities are used, ammonia emissions decrease by 40 %;
  + solid manure storage facilities are covered;
  + ensure that farms have sufficient manure storage capacity to spread manure only during periods suitable for crop growing;
* reduce pollutant emissions from livestock storage facilities, using recommended systems that have been shown to reduce ammonia emissions by at least 20% compared to the method described in the guidance document;
* reduces manure emissions by using low-protein fee that reduces ammonia by at least 10% compared to the method described in the Guide of Ammonia Emissions.

## The legislation of the Republic of Lithuania, which regulate manure management and air protection

Environmental protection of the Republic of Lithuania Act, 4th November, 1999, No VIII-1392 (latest edition 31st December 2018)**[[10]](#footnote-10)** controls air pollution management in Lithuania. In their National Environmental Protection Strategy, Lithuanian parliament[[11]](#footnote-11) established national targets for the reduction of emissions of air pollutants and also essential policies to achieve the targets regulated by EU and international law. In this strategy, air pollution management measures were decided considering the environmental air protection priorities set out in Article 3 of the Environmental Air Act. The national air pollution management plan may establish measures for limiting the environmental pollution of municipalities, especially agglomerations included in Article 2 (16) of this Law, and reducing its negative environmental and human health impacts, as well as emissions from stationary sources into the air quantity management measures.

Minister of Environment of the Republic of Lithuania and Minister of Agriculture of the Republic of Lithuania Act, 14th July, 2005, No. D1-367/3D-342**[[12]](#footnote-12)** „on the approval of a description of the environmental requirements for manure and slurry management. The act describes the requirements for handling manure and slurry. The provisions of the specification are mandatory for individual and legal entities who keep livestock and/or use manure and/or slurry for field fertilization, and for authorities controlling this activity. The manure and / or slurry must be stored in barns, manure storage, slurry storage and / or in dense manure stacks at the barn.

**Minister of Agriculture of the Republic of Lithuania Act, 14th October, 2016, No 3D-592[[13]](#footnote-13)** „on the rules for the technological design of fur farms and rabbit farms in the context of the approval of the ‘ŽŪ TPT 13:2016’. Technological design rules for fur farms and rabbit farms ‘ŽŪ TPT 13:2016’ lay down the basic technological requirements for the design and construction of new and reconstructed buildings for fur animals (minks, ferrets, foxes, nutrias and chinchillas) and rabbits; racks and other places of storage and equipment, their auxiliary facilities and other structures, implementing the most important provisions to ensure the welfare requirements of fur animals and rabbits, a production process consistent with good cultivation practices, based on producers' experience and research, environmental and occupational safety requirements.

The Rules provide the necessary information for the preparation of the technological part of the project and do not restrict the improvement of the technological process.

**Minister of Agriculture of the Republic of Lithuania Act, 21st August, No. 3D-602[[14]](#footnote-14)** „on the approval of ‘ŽŪ TPT 01:2009’ technological design rules for bovine storage buildings. Rules for the design of bovine buildings ‘ŽŪ TPT 01:2009’ lay down the basic technological requirements for the design of cattle housing and servicing buildings, premises and enables the implementation of the most important provisions guaranteeing the welfare of the cattle, efficient production, quality food, clean environment and safe work.

**Minister of Agriculture of the Republic of Lithuania Act, 14th May, 2010, No. 3D-472[[15]](#footnote-15)** „on the approval of technological design rules for manure and wastewater treatment structures. Technological design rules for manure and wastewater treatment facilities ‘ŽŪ TPT 03:2010’ lay down the basic technological requirements for the design of manure, production, household and surface wastewater disposal, storage and treatment facilities on livestock, poultry and game farms and allows for the implementation of the most important provisions guaranteeing animal welfare and clean environment; and safe work.

**Minister of Agriculture of the Republic of Lithuania Act, 27th January, 2010 No. 3D-50[[16]](#footnote-16)** „on the approval of ‘ŽŪ TPT 02:2010’ rules on technological design of pig farms. Rules for the technological design of pig farms ŽŪ TPT 02:2010’ lay down basic technological requirements for the design of pig farms, their premises and other pig farms holdings. They apply to the most important provisions that guarantee the welfare of pigs, efficient production, clean environment and safe work.

**Director of the State Food and Veterinary Service Act, 30th October, 2015, No. B1-995[[17]](#footnote-17)** „on the approval of biosecurity measures for poultry holdings. The requirements for biosecurity measures for poultry holdings lay down the rules for poultry holdings, breeding, rearing and keeping of poultry, poultry workers, visitors, vehicles and handling of animal by-products, as well as emergency biosecurity measures in case of suspected or confirmed avian influenza in poultry holdings.

**Director of the State Food and Veterinary Service Act, 11th July, 2011, No. B1-384[[18]](#footnote-18)** „on the approval of biosecurity measures for pig farms. The requirements for biosecurity measures in pig farms provide minimum biosecurity measures for pig storage and are designed to protect pigs from infectious agents, obligations for animal owners and keepers, and for persons working or visiting pig farms; and requirements for pig keeping.

## Description of the techniques used to handle livestock manure

Technologies that can be applied to manure management: dung manure with slurry tank, liquid manure, composting, thickening, biogas extraction. Pumped liquid manure can be stored in over ground, sunken tanks or lagoons. After study analysis, it was found that more abrasive and more frequent removal of manure from the barn produces less harmful gases in the premises. The release of ammonia also depends on the way the animals are kept. When stored on a grate floor, nitrogen losses can be 12-15% and higher. When the manure is open, about 15-30% nitrogen is evaporated during storage. To reduce ammonia evaporation, the tank must be covered. Low conductivity or impermeable films can be used to cover the surface. When covered with tarpaulin or film, the evaporation decreases by 60-80%, the surface of the manure is filled with non-combustible clay - 90%, the shredded straw - 40-50%. Various chemical reagents or biological agents can be used to reduce NH3 and NMML. Air purification biotechnology is capable of reducing up to 80-90% of NH3 and NMML emissions.

The most effective and inexpensive way to reduce manure odour is to install a tent cover. It can be used for at least several seasons. Straw coatings also greatly reduce ammonia evaporation. A 10-centimeter-thick layer of straw on the liquid manure surface can reduce the odour by 60%, and a layer of 30 cm - 85%.

Liquid manure handling technologies save human and technical labour costs, but are very expensive, and nitrogen losses in manure are higher than in litter and especially in litter beds.

Deep litter sheds also save on human and technical labour costs, and are the cheapest technologies (no separate manure storage; keeping loose animals can build low-cost sheds). But it is more difficult for the farmer to take care of each animal individually. With more creeping and more frequent removal of manure from the barn, less harmful gases are generated in the premises. The microclimate in the barn is highly dependent on the ventilation system[[19]](#footnote-19).

Dung manure berm. The cheapest and easiest is a manure trench on the ground triple, double-skinned or single-walled (sometimes on a small barn), when the manure pad is raised over 5-10 cm above the ground or just 50 cm above the ground. Height of support walls - up to 1.5 m. When the manure is stubble, the manure can be covered with a crane of not less than 5 cm in height instead of all or several retaining walls, which keeps the slurry in the manure and prevents rainwater from entering the farm's territory. When manure is open, slurry is mixed with rainwater when it is dripping or dropping from manure. They are equipped with a coated reinforced concrete tank with a depth of 2-4 m. The same tank is lowered and washed from the barn. For dairy cows, additional 0.3 m3 (per cow) of wastewater from milking facilities and 0.15 m3 per month per pig should be added.

Liquid manure berm. The pumped liquid manure is stored in over ground, sunken tanks or lagoons. The depth or height of the reservoirs is up to 6 meters, and when left over, reserves are left for unforeseen overflow due to abnormal rainfall. In order to reduce nitrogen losses, liquid manure must be supplied to the bottom of the hopper either individually or by means of pumps. In cattle farms, liquid manure reservoirs may not be covered because of the formation of floating fibre crust. The natural fibre crust does not form on the surface of the pig manure and water-diluted cattle manure tanks with less than 7% dry matter and must therefore be covered. Since manure and slurry in fertilization fields must be spread over a maximum of 15%, the mass of liquid manure must be homogenized by mobile or stationary means before leaving the tanks.

Flushed concrete manure is cast from concrete, mounted on reinforced concrete elements, and the overhead is concrete and metal. The manure is directed to the bottom of the manure so that the straw is up. If the manure is open, about 15-30% nitrogen is evaporated during storage. To reduce ammonia evaporation, the tank must be covered.

Lagoon-type slurry accumulators can be installed in the ground excavation when the groundwater level is below its bottom, ensuring its integrity throughout the service life (for example, by using a resistant waterproofing film or other appropriate means). Over 70 condensate-type slurry-type slurry storages must be equipped with a drainage control system with a control well. Lagoons are set up to a depth of 6 meters on the surface of the ground or, at low groundwater levels, drowned. In deepened lagoons, the groundwater level should not exceed 0.5 m from the bottom of the lagoon.

The lagoons are lined with two 1.0 - 1.5 mm layers of geomembrane films, including a 15 cm sand drainage layer. The lagoon waterproofing layer can be made of clay that is at least 0.5 m thick. The useful capacity of the lagoon is calculated from the top of the reservoir at a depth of 0.5 - 1.0 m and at least 0.5 m of sediment from the bottom. The lagoon slopes depend on the soil properties and are made at a slope of 1: 2 to 1: 3. Lagoons that do not form a natural fibre crust are coated with floating film of at least 0.75 mm thick with installed gas release valves.

In addition to the above-mentioned above-ground liquid manure storage tanks, there is a more expensive technology, where liquid manure is stored in deep ditches throughout the storage period. Such manure must not be mixed until it is homogenized by means of a special mixer prior to dispatch to the fertilization fields. Such sheds may contain dangerous amounts of toxic or even life-threatening gases during mixing and removal of the manure, therefore, during the removal of the manure there must be no animals, all ventilation systems of the stables must operate without fail, gates and windows open, and warning signs must be placed at the entrance to the premises. This way of storing liquid manure is applied when there is no room for reservoirs or lagoons at animal storage sites, or sanitary hygiene requirements are not allowed.

Semi-liquid manure berm.Semi-liquid manure (12-20% dry matter) is formed in low-shear shallow farms and can be stored in manure storages of three or four-walled manure with a wall height of at least 1.5 m. The slope of the slurry floor must be at least 1% on the open side where a grooved groove for collecting slurry is installed. The capacity of slurry tankers must be higher than the normative minimum of 30%. It is recommended to transport the manure to the berm under a piston conveyor equipped with it. Dried manure can be loaded with mobile loaders and stored in the same way as litter manure.

Farmyard manure berm.When farmyard manure contains straws, the manure can be covered with a crane of not less than 5 cm in height, instead of all or several supporting walls, which keeps the slurry in the berm and prevents rainwater from entering the farm's territory. The floor and the area around the berm are made sloping so that the slurry flows only into the pit and the rain or snow water does not run from the farm to the berm. They are more expensive to build, but are reliable, ground-based, single-walled, double-skinned, three-way, rarely quadruple with entry ramps. The height of the support walls is 1.5 m or more. Support walls are made of prefabricated blocks or cast out of monolithic concrete.

Trench type berm is a double-skinned oblong form, assembled from reinforced concrete slabs. Such berm slabs have an optimum area and allow manure to be stacked into higher loads. It is easy to load or remove manure in them, it can also be easily covered with waterproof film. The rear wall makes it possible to increase their capacity even though they become harder to operate. Trench or other types of manure can be covered with a roof. If the roof is lifted above the trench by 3.5 m or installed above the unbroken manure storage site, it is expedient to protect the walls from the side rain. Coated manure storages containing stubble manure are virtually unnecessary for slurry collecting tanks. However, covered manure berm is expensive to install and harder to operate than an open-type berm.

Farmyard manure disposal technologies. In livestock and poultry farms where no litter (shredded straw, sawdust) or very little litter is used, manure must be disposed of daily or periodically if it is accumulated in liquid manure channels. This type of manure can be disposed by using chain conveyors fitted in an open or grate-ducted manure removal path. The animal feed and manure removal paths (zones) can be removed by bulldozers or scrapers. Liquid manure can be collected under grid-coated periodic ducts and disposed of individually, by pumps or by rinsing with process water or manure flow.

In cows' walkways, manure is removed by a chain manure removal system powered by a 0.75 KW electric motor for heavy duty scrapers with a 13 mm marine chain. This system can clean up to three tracks and work with three scrapers. All trails are cleaned at the same time. The system consists of a single drive station mounted at the end of the manure runway at the corner wheel location. If there is a door at the end of the manure channel, the station can be installed between manure paths. The system is easy to adapt to sheds with different manure lengths.

In addition to the chain manure scraper, there is a wire manure removal system that can handle eight scrapers and clear up to four tracks. All trails are cleaned at the same time. The system consists of a single drive station, wrapped around one edge of the drum, and rolled off the other side by a stainless steel or stainless-steel coated plastic cable. The plastic guide wire is wrapped in a single layer on the drum. This significantly prolongs the life of the cable.

From deep stables, litter manure is removed by moving it directly to the fertilized fields with mobile loaders, spreading in manure slurry and grabbed no later than 12 hours. When the manure is removed, the barns are disinfected. Semi-deep barns are used to remove dense manure from mobile cranes or bulldozers to litter manure. During the day-to-day maintenance of shallow cattle sheds (individual storage areas, rows and stables), manure can be picked up by forks and transported to the manure by means of mobile means or by scraping, pneumatic conveyors, bulldozers or pushed into manure. When removing manure by bulldozers, during the cleaning, the animals are either expelled from the premises to the open air or separated into another part of the stall (in other barn reins), by extending the rebuilding by at least 5-10% as provided for in the regulations. Most of the time manure is removed by bulldozers, less often by scrapers.

Green or semi-liquid manure disposal technologies.In livestock and poultry sheds, with little or no litter (shredded straw, sawdust), manure must be disposed of daily or periodically every 1-2 months if it is accumulated in liquid manure channels. Green manure can be disposed of by means of chain conveyors mounted in an open or grid-covered channel for the removal of manure. Dung can be disposed of by bulldozers or scrapers from shallow livestock and manure removal paths (zones).

Liquid manure gathered under grid-coated periodic ducts is disposed of by means of pumps or rinsed with process water or manure flow. The method of a recirculation manure washing, where liquid manure is washed down from the collector, must include an effective ventilation system. From a hygienic point of view, flushing of liquid manure with slurry is not recommended as ammonia enters the barn air, and the use of slurry from the common storage facility of the barns, if undamaged and non-settled, can spread the disease agents.

Direct washing of manurewith technological water is not recommended and is not part of the sustainable use of water as a valuable natural resource. From a geochemical point of view, this technology is poor because the air humidity in the livestock housing is greatly increased. From an economic point of view, the technology is poor due to the high amount of diluted manure, which requires additional capacity, high costs of removal and spreading in the fields, and has low fertilizing value.

Green manure, accumulated through canals or trays should not be kept for more than 3 weeks, as biological processes are subsequently activated, causing manure temperatures and abundant release of harmful gases. In the case of liquid manure transport to pumping station conveyors, mixing-homogenization equipment is required in the pumping station[[20]](#footnote-20).

Manure storage tanks.The location of the liquid manure storage tank is located near the barn, where it is convenient to access. The direction of winds should be evaluated and the place from which the prevailing wind does not bring smell into the living or work areas should be selected; natural ventilation must be ensured. The bottom of the manure storage facility shall be installed 0.5 m above groundwater level, surface and ground water must not enter the territory of the storehouse; slurry must not be disposed to the environment. Drainage and control wells for groundwater level monitoring and control of the absence of slurry in the groundwater, are carried out by submerging the ground manure storage facility. Drainage pipes are laid at a distance of 1.5 to 2 m depending on the type of soil and the depth of the ground water.

For dung manure, the storage facility can also be located away from the barn, alongside the intended fertilization fields. In all cases, however, the soil must be protected by a waterproofing layer from manure and slurry.

According to the current requirements, the manure storage facility must have the capacity to contain 6 months of manure. This does not apply to semi-deep and deep littered barns where the capacity of the manure can be less than the capacity of the accumulation period. When designing a manure storage facility, it is estimated that the cow needs about 13 m3, along with falling rainfall - about 16 m3 of manure storage capacity.

The manure reservoir can be a ferro concrete, or a lagoon, with a film-resistant pit. Concrete manure slabs with coatings are less vulnerable to external factors, are more durable and often pays off sooner than the lagoon type storage facility. Likewise, ferro concrete storages can be equipped with a reliable cover and be adapted to biogas production in the future.

Concrete constructions for liquid manure berm and slurry walls must be made of 35/45 MPa, monolithic - 30/37 MPa, bottom of the same wall as concrete. Metals must have anticorrosive coatings for the entire lifetime, and other installation materials must also have a high resistance to aggressive environments. It is recommended to install a vertical deformation joint every 25 meters. Deformation joints are often excluded in warmer regions, but higher temperature fluctuations in Lithuania lead to higher stress in concrete, which usually results in faster structural wear. Reinforced concrete storage facilities are up to 6 meters high19.

Ground manurecan also be made above the ground, on the dykes. The depth of the ground berm is up to 5-6 meters. At least 2 layers of 15 cm sand layer are laid to cover the bottom. Film thickness is 1-1.5 mm. Ground berm can also be made by compacting 0.5 m thick clay layer. The surface is covered with a 1 mm floating film, which is equipped with gas release valves. The cost of installing ground manure slurries is about half that of reinforced concrete constructions, but at the same time it is more difficult to mix and suck up accumulated manure, as well as loose nitrogen in uncoated lagoons and to reduce the value of manure as fertilizer. Dredged lagoons are often filled with surface waters.

Reduction of manure odour**.** Manure odour spreading is a very big issue for livestock development, especially those close to living areas. Approximately 50% of the odours are spread by watering slurry or spreading manure in the fields. 20% of the odour entering the environment is from manure and 30% of the smell is coming from the farms. The odour has many components, the main ones being ammonia (NH3) and hydrogen sulphide (H2S).

An unpleasant smell is not only dangerous to people living close to the farms, but also reduces the productivity of the workers and the productivity of the animals. More ammonia is distinguished from the surface of manure, where there is more air, as well as urine. Therefore, if there is sufficient moisture in the barn, it is better not to improve mechanical ventilation, but to remove manure and urine. Manure storages should have a smaller surface area, and for dense manure it is better if they are built higher. The most effective and cheapest ways to reduce manure odour are tent coverings and various chemical reagents or biological agents.

Liquid manure spraying in fields**.** Scientists believe that in modern high-tech agriculture, more useful substances are taken from the soil than are recovered. The amount of humus, which can be produced by fertilizing the fields with manure, is decreasing especially fast. It is prohibited to spread manure in fields from 15th November until 1st April, as well as on frozen, soaked and snowy land. It is prohibited to spread manure and / or slurry from 15th June until 1st August, with the exception of fertilization, meadows, pastures and areas under winter crops.

Spreading manure is regulated on weekends and public holidays, with the owner's permission being required for watering less than 100 m away from the house. Spreading manure 300 m away from the settlement – required the consent of the local government. The manure on the fields can be spread by spraying, spreading evenly through the tubes as the crop grows, when slurry lines are connected to the ploughing units and the manure is inserted into the open turf through the nozzles.

There are several rules to follow to reduce odour by spreading manure:

* Insertion of manure into soil within a day from spillage;
* The smell is less diffusible on a very moist and untidy day;
* The odour is more likely to spread on a sunny windy day after the colder night.

Production of biogas from manure**.** Biogas is a valuable energy product with only one-third of the energy value falling on natural gas. The most valuable part of biogas is methane, which can contain up to 60% of biogas. The resulting gas can be used immediately in boilers after the removal of moisture; and hydrogen sulphide can be used in cogeneration power plants, or purged to pure methane supplied to the natural gas network. Liquid manure is often mixed with other methane release components such as corn silage, slaughterhouse waste.

The manure from which biogas has been removed does not lose its fertilizer properties and can continue to be used as a valuable organic fertilizer. In degassed manure, ammonium nitrogen, which is more easily absorbed by plants, is 10-15% more. Degassed manure does not damage the leaves and can be used during the vegetation period.

The same reinforced concrete manure storage tanks can be used to produce biogas. The walls and top of the tanks are heated, the inner tubes are also heated to maintain a temperature of about 40. A gas trap is installed at the top or side of the tank, from which the pumps deliver gas to the tanks. Most often there are several reservoirs for biogas production and 1-2 tanks of similar size for storage of processed manure. Different raw materials emit different amounts of gas: maize releases 200m3 / t, pig manure 35 m3 / t, grease and oil waste - 400-600 m3 / t, grass - 110 m3 / t[[21]](#footnote-21).

Removal of liquid manure from barn**.** One of the ways in which liquid manure can be disposed of is the manure channels that are washed with high pressure. The manure trail is about 1.5 meters deep. At the end of the channel, high-pressure (up to 16 atmospheres) fluid is fed through the tubes, which rinses the accumulated manure into the transverse channel. In the transverse canal, manure is pushed into the pothole in the same way. All channels must have a constant amount of water. In the appendage, the manure is mixed, leached, the part is returned to the washing system and the excess part is pumped into the main manure tank. It is also recommended to direct the liquids from the milk block to the transverse channel. If litter or non-crushed feed is used, the liquid manure must be crushed, using pumps with shredders.

Slurry pipes can be used in conjunction with self-propelled liquid manure removal technology when liquid manure is removed by periodic action. There is a threshold of about 10-15 cm to maintain a constant water level at the end of the channel. Liquid manure is pushed into the transverse channel in the middle or at the end of the barn. From here, the manure enters the primary collection tank (pothole), where it is mixed, sometimes further shredded, the part is then directed to the channel washing, and the excess is pumped into the main manure storage tank by means of the pump.

Manure removal.Currently, various organic fertilizers are harvested: bird manure, cattle and pig manure. The process is different for individual organic materials. It is very important to separate the liquid fraction from the thick fraction that can be spread mechanically. The separation of liquid and thick fractions has many advantages:

* Liquid fraction can be drained at any time without complicated drainage equipment;
* No need to mix before shipment;
* After spreading quickly absorbs into the ground and does not damage plants;
* The thick fraction (practically odourless) can be easily stored. It is a great fertilizer and can also be reused for litter.

Such fertilizers are more convenient to use, they do not emit unpleasant odours, have no pathogens, and their components are well known. Scientists have found that fertilizing agricultural plants with fresh manure is not possible, because the ammonia nitrogen contained therein burns the roots of the plants, and the plants die or become very thin, so further cultivation of such crops is cost-effective. To solve this problem, manure pelletizing technologies are being developed. In Western Europe, manure pelleting technology has been used for a long time, whereas in Lithuania it was only used a few years ago. Such manure pellets contain several times less water than fresh manure, and dry matter content depends on production technology.

The classification of livestock in Lithuania according to manure management systems is presented below (see Figure 1).

Figure 1 The classification of livestock in Lithuania according to manure management systems

|  |  |  |
| --- | --- | --- |
| NFR code | Group | Manure management system |
| 3.B.1.a | Dairy cow manure management | Liquid manure, litter manure, pasture |
| 3.B.1.b | Manure handling of non-dairy cattle | Deep litter, liquid manure, litter manure, pasture |
| 3.B.2 | Sheep manure management | Farmyard manure, pasture |
| 3.B.3 | Pig manure management | Deep litter, liquid manure, litter manure, biogas power plants |
| 3.B.4.d | Goat manure management | Farmyard manure, pasture |
| 3.B.4.e | Horse manure management | Farmyard manure, pasture |
| 3.B.4.g.i | Chicken manure management | Liquid manure, farmyard manure, green manure, pasture |
| 3.B.4.g.ii | Broiler manure management | Liquid manure, farmyard manure, green manure, pasture |
| 3.B.4.g.iii | Turkey manure management | Liquid manure, farmyard manure, green manure, pasture |
| 3.B.4.g.iv | Other birds manure management | Liquid manure, farmyard manure, green manure, pasture |
| 3.B.4.h | Other animals manure management | Liquid manure, farmyard manure |

Analysis of sources of pollution coefficients. The Technical Guide identifies many different sources for sector 3B (most sources point to other sources). Some of them:

* fmin - (9th-step step of culculatons, part N mineralizes to TAN during storage) The estimation source[[22]](#footnote-22), although available, does not indicate either the EF value or the measurement conditions. Another source[[23]](#footnote-23) from this author has a value of 10%, or 0.1 in the calculation, but does not specify what environmental conditions are used to estimate how this value was obtained. Thus, conditions are not available / not provided.
* fimm - (7th step of calculations, TAN immobilized in organic material) - sources[[24]](#footnote-24) that calculated EF based on Kirchmann and Witter[[25]](#footnote-25) data. Kirchmann and Witter's source is available, some experimental conditions for poultry manure are provided (eg at 25 degrees Celsius), but the study was conducted under laboratory conditions[[26]](#footnote-26)
* The EF assessment sources in Table 3.8 of the Technical Guide are not fully described;
* The main sources of emission factors in Table 3.9 of the Technical Manual are listed. The IPCC 2006 provides even more sources[[27]](#footnote-27), [[28]](#footnote-28), [[29]](#footnote-29), [[30]](#footnote-30), which provide values ​​for emission factors but not the environmental conditions in which they are obtained.
* In the other reference source[[31]](#footnote-31), no information about the emission factor or the measurement conditions or other source is provided although the official page is available.

A summary of the analysis of sources of pollution factors is provided in the conclusions (see Chapter 5).

## Manure management – Dairy cattle (NFR 3.B.1.a)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sector "3B1a Dairy cow manure management".

**1. Brief description of the processes:** Lithuanian black-and-white, Lithuanian Green and Lithuanian Red cattle breeds are bred in Lithuania. The Black and White Cattle population accounts for 68% of all dairy cattle kept in Lithuania. It includes various types of Black-and-White breed: Lithuanian, Dutch, German, Danish, Swedish. There are also Black and White Cattles from United Kingdom, USA and Canada. The population of Lithuanian Green and Lithuanian Grey dairy cattle is 32% of the total cow population in Lithuania. There are different manure management systems for dairy cows in Lithuania: liquid manure, litter manure and pasture. A more detailed description of the systems is given in section 2.3.

**2. Parameters used in the Tier 2 methodology:**  LMT benchmarking projects provides country specific EF estimations for the cattle manure management in Lithuania. Based on the scope and results of said research it is recommended to apply calculated EFs for Tier 2 level calculations of emissions from dairy-cattle manure management in Lithuania (the relevant EFs are provided in Table 25 of LMT report).

Given coefficients provided it is advised to use assumptions used in the national GHG reports[[32]](#footnote-32), [[33]](#footnote-33):

* Periods of grazing and staying in barns: assumption of manure fractions remaining in pastures based on the grazing period of dairy and non-dairy cattle. Bulls, partly calves and cows raised for slaughter are usually kept in barns for a year. Calves, heifers raised for breeding and milk production, and beef, are grazing on pasture for about 145 days a year, as do dairy cattle (p. 256 - 2019 report)
* Information on non-dairy cattle manure management systems in Lithuania: 36.8% of non-dairy cattle manure has been managed in solid manure management systems, 21.5% in liquid manure/sludge management systems and 10.3% in deep bedding manure management systems. Approximately 31.4% of non-dairy cattle manure is deposited in pastures (p. 267 - report 2019);

Average annual population is also needed for the calculations, this indicator is published by Lithuanian Department of Statistics. The data required for the calculations is provided in the Microsoft Office Excel document (SEE Agriculture\_Collected\_data\_1990-2019\_EN.XLSX).

**3. Effectiveness of pollution reduction methods:**under agreement with EPA, due to lack of time in this data collection phase, the data is limited to administrative, publicly available data.

**„Daukniūnų“ ŽŪB[[34]](#footnote-34), [[35]](#footnote-35).** Following the recommendations of EPA Department of Pollution and Permits in Panevėžys (AAA Taršos prevencijos ir leidimų departamentas) on modernizing dairy farms, ‘Daukniūnai’ (agriculture company) decided to keep 1050 units of dairy cows after modernization is completed. Prior-modernization there were 430 dairy cows. The liquid manure is accumulated in 2 former (2x3768 m3) and 3 new (3x4835 m3) liquid manure tanks. Liquid manure is planned to be delivered to the bottom of the tanks in order not to disrupt the naturally occurring floating crust, which reduces the emission of air pollutants. Thick manure is planned to be stored in 640 m2 and 828 m2 of manure, which is covered with polyethylene film and straw layer to reduce odours. Based on the above information, from 2015 onwards Emissions from dairy cows grown in the company must be reduced by the use of air pollution abatement measures. The efficiency of the tools is presented in section 2.3.

**ŽŪB „Vaškai“[[36]](#footnote-36)** started its activities before 2009, but there is no publicly available information when the company was founded. In 2017, the company planned to expand its activities. According to the information on the planned economic activity, 1000 units were kept before the expansion. After the expansion (from 2017-2018) - 1448 units were kept. The EIA document contains information on applied manure management systems: manure storage is kept covered, slurry storage tanks are also covered with a layer of 10 centimeters thick straw on the surface of liquid manure, which reduces the emission of pollutants and odours into the environment up to 60%.

Based on the information provided, it is proposed to take into account the effectiveness of the air pollution abatement measures applied (from the foundation of the company or at least from 2009) when calculating the emissions from dairy cows.

**„Griškabūdžio“ ŽŪB[[37]](#footnote-37)** was established in 1995. According to the 2011 edition of ‘Lietuvos Juodkalnijos galvijų veislės raida, bendrovė ir jos darbų smėliu’[[38]](#footnote-38) the company kept 734 dairy cows. Based on 2016 planned economic activity “construction of a cowshed, milking unit and two tanks for liquid manure (extension of cattle farm)" information on environmental impact assessment screening, the company planned to increase the herd from its existing 280 dairy cows to 413 cows, It is also stated that slurry and liquid manure are stored in sealed storage tanks in the complex, which is a means of reducing air pollution. Hence, the application of this company's anti-pollution measure for the production of a certain number of cows should be taken into account when calculating emissions.

**ŽŪB „Atžalynas“[[39]](#footnote-39)** was registered in 1993. According to the 2016 information (that was used for the environmental impact assessment of the milk production expansion), the capacity was planned to be 745 units of dairy cows. The number of dairy cows held by the company before the planned activity was 465. Hard manure is stored in open berm covered with straw, peat or film. The liquid manure removal channel is connected to the pumping station reservoir where liquid manure is removed. When the pump tank is filled, liquid manure is sucked into the liquid manure storage tanks. During the accumulation of liquid manure, manure is not mixed in order to automatically form a floating layer of the reservoir mass. This layer has reduced air pollution, and the tool is described in more detail in section 2.3.

**A. Andrijauskas[[40]](#footnote-40)** started his activities in 2000-2001. According to 2016 information used for the assessment of Expanding the Cattle Farm, the farmer planned to grow 310 cattle, of which 93 were dairy cows (classified in sector 3B1a). The assessment mentions that the slurry storage facility (lagoon) is operated with a rigid film, thus reducing the spread of odours. It is possible that it had been used since 2016. The effectiveness of the tool is described in section 2.3 When calculating emissions for dairy cows, the impact of air pollution abatement measures (reduction of emissions) can be estimated.

According to the Republic of Lithuania 15th August, 1996 Act on Environmental Impact Assessment of the Proposed Economic Activity No. I-1495, the environmental impact assessment must be carried out on cows and bulls where there are 250 units or more of them. Environmental impact assessment is not required by law for cows and bulls. According to the Minister of Environment 15th July, 2013 Act No. D1-528 "on the approval of rules for the issuance, replacement and revocation of integrated pollution prevention and control", The IPPC permit is mandatory for milk processing, when more than 200 tonnes of milk is processed per day (annual average). The biggest dairy producers in Lithuania in terms of the volume of milk sold in 2017[[41]](#footnote-41):

* Padovinio žemės ūkio bendrovė (Marijampolė.) – 11 389;
* Pasvalio rajono žemės ūkio bendrovė „Vaškai“ (Pasvalys.) – 11 334;
* Žemės ūkio bendrovė „Draugas“ (Radviliškis)– 11 323;
* Šakių rajono Kubilių žemės ūkio bendrovė (Šakiai) – 10 595;
* Šakių rajono Lukšių žemės ūkio bendrovė (Šakiai) – 10 082;
* Lytagros žemės ūkio bendrovė (Kaunas) – 9 303;
* Lygumų žemės ūkio bendrovė (Pakruojis) – 9 160;
* UAB Aristavos ūkis (Kėdainiai) – 9 133;
* Šakių rajono Griškabūdžio žemės ūkio bendrovė (Šakiai) – 8 368;
* Kėdainių rajono Okainių žemės ūkio bendrovė (Kėdainiai) – 8 005.

From the list of the largest milk producers presented, it can be seen that the IPPC permits are not mandatory for them because the quantities of milk are too small and the limit of 200 tonnes per day is not reached.

Information on the quantities of dairy cows and their air pollution abatement measures can only be obtained from freely available companies' websites, existing conclusions on the environmental impact assessment and IPPC permits (if applicable). Also, there are no big cow farms in Lithuania - there are a few medium sized (about 1,000 units and more) and many small farms. For this reason, there is almost no publicly available information. Small farms, dominating in the country, do not need to be sampled for EIA[[42]](#footnote-42) or IPPC permits[[43]](#footnote-43). Also, many do not provide the necessary information on their activities on their website or do not have one at all.

**Results of the survey of Lithuanian farms.** In order to find out the prevalence of manure management and pollution reduction technologies, a survey was distributed to Lithuanian farms engaged in manure management of dairy cows. The questionnaire was completed by 12 respondents. The survey collected data on manure management and pollution abatement technologies for 27.8 thousand dairy cows in the period 2005-2018 (or 1.9 thousand cows per year).

Survey data collected may be used to account for atmospheric pollutants, but we estimate that respondents' activity was too low to objectively assess the prevalence of applicable pollution abatement technologies across the country. The results of the survey are presented in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.B.1.A).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Manure management – Non-dairy cattle[[44]](#footnote-44) (NFR 3.B.1.b)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sector ‘3B1b Handling of dairy cattle manure’.

**1. Brief description of processes:** Beef cattle farming in Lithuania is the youngest branch of agriculture. The beginning of the development of beef cattle breeding in Lithuania is believed to be 1995 when 35 Šololė breed heifers and three bulls were imported from ‘Šilutės veislininkystė’ from Germany. Later, in 2000, 130 heifers and 17 bulls were brought into the country each year. In Lithuania, non-dairy cattle manure management systems: deep litter, liquid manure, litter manure and pasture. A more detailed description of the systems is given in section 2.3.

**2. Parameters used in the Tier 2 methodology:** LMT benchmarking projects provides country specific EF estimations for the cattle manure management in Lithuania. Based on the scope and results of said research it is recommended to apply calculated EFs for Tier 2 level calculations of emissions from non-dairy-cattle manure management in Lithuania (the relevant EFs are provided in Table 25 of LMT report).

Given coefficients provided it is advised to use assumptions used in the national GHG reports[[45]](#footnote-45), [[46]](#footnote-46):

* Periods of grazing and staying in barns: assumption of manure fractions remaining in pastures based on the grazing period of dairy and non-dairy cattle. Bulls, partly calves and cows raised for slaughter are usually kept in barns for a year. Calves, heifers raised for breeding and milk production, and beef, are grazing on pasture for about 145 days a year, as do dairy cattle (p. 256 - 2019 report)
* Information on non-dairy cattle manure management systems in Lithuania: 36.8% of non-dairy cattle manure has been managed in solid manure management systems, 21.5% in liquid manure/sludge management systems and 10.3% in deep bedding manure management systems. Approximately 31.4% of non-dairy cattle manure is deposited in pastures (p. 267 - report 2019);

Average annual population is also needed for the calculations, this indicator is published by Lithuanian Department of Statistics. The data required for the calculations is provided in the Microsoft Office Excel document (SEE Agriculture\_Collected\_data\_1990-2019\_EN.XLSX).

However, it has to be noted that in LMT report provides EFs not for categories on non-dairy cattle, covered by Lithuanian department of statistics[[47]](#footnote-47). It recommended to apply previously suggested methodology for non-dairy cattle categories not covered by the LMT report (bulls of less than 1 year as well as heifers,2 years or over). Methodology provided in the previous reports was updated in accordance to Guidebook 2019 and relies on following assumptions:

* Average annual population by sub-categories, thousands. (Table 5-2, 1990-2017. Table 5-2. Annual average number of livestock population per year, thousands);
* average weight, kg (1990-2017 Table 5-8. Average weight of non-dairy cattle during the period 1990-2017, kg);
* body weight and weight gain of a mature animal, kg (for the whole period 1990-2017 Table 5-9. Mature body weight and weight gain of non-dairy cattle, kg);
* Periods of grazing and staying in barns: assumption of manure fractions remaining in pastures based on the grazing period of dairy and non-dairy cattle. Bulls, partly calves and cows raised for slaughter are usually kept in barns for a year. Calves, heifers raised for breeding and milk production, and beef, are grazing on pasture for about 145 days a year, as do dairy cattle (p. 256 - 2019 report)
* All data related to the composition and amounts of fat, protein and carbohydrate nutrition (Annex VII Table A.5-5 - Table A.5-40 or ‘Gyvulininkystės žinynas’).
* Total Energy Consumption, MJ / pc / day (Table 5-19. Calculated average energy consumption and non-dairy cattle emissions);
* Information on non-dairy cattle manure management systems in Lithuania: 36.8% of non-dairy cattle manure has been managed in solid manure management systems, 21.5% in liquid manure/sludge management systems and 10.3% in deep bedding manure management systems. Approximately 31.4% of non-dairy cattle manure is deposited in pastures (p. 267 - report 2019);
* Volatile solid excretion: 1990-2017 Table 5-29. Daily VS excretions for dairy, non-dairy cattle, swine and sheep, kg-dm./day;
* defined Nexcretion indicators for 1990-2017: Table 5-40. Estimated N excretion factors for cattle, horses and swine, kg N / head / yr.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

**Other required data may only be available through surveys**:

* Part of slurry that is stored (xstore\_slurry) and part of slurry transferred to biogas production (xfeed\_slurry);
* The part of the solid manure that is stored (xstore\_FYM) and part of solid manure transferred to biogas production (xfeed\_FYM).

All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values are taken from Technical Guide or IPCC (version - 2006).

**3.Efficiency of pollution abatement measures:** underthe agreement with the EPA, due to the lack of time in this data collection phase, the data was limited to the review of administrative, publicly available data.

**„Daukniūnų“ ŽŪB[[48]](#footnote-48), [[49]](#footnote-49)** according to the 2014 EPA review on expansion and modernization of the Dairy Farm ‘Daukniūnai’ in Panevėžys, after the modernization of the company it was planned to keep 1092 units of cows of different ages, which are not attributed to dairy cattle. The number the cattle prior-modernization is unknown. The resulting liquid manure is accumulated in 2 old (2x3768 m3) and 3 new (3x4835 m3) liquid manure tanks. Liquid manure is delivered to the bottom of the reservoirs, in order not to disrupt the naturally occurring floating crust, reducing air emissions. Thick manure is stored in 640 m2 and 828 m2 berm, which is covered with polyethylene film and straw layer to reduce odours.

Based on the above information, from 2015 onwards emissions from farmed cattle must be reduced by taking into account the use of air pollution abatement measures. The efficiency of the tools is presented in section 2.3.

**ŽŪB „Vaškai“[[50]](#footnote-50)** started its activities before 2009, but there is no publicly available information on when the company was officially registered. In 2017, the company planned to expand its activities. According to information about the planned economic activity, 900 units were kept before the expansion: heifers (not included in dairy cattle) and 450 units of cattle. After the expansion (from 2017-2018), only the number of dairy cows increases but there will be no change in numbers of cattle kept in the farm. The EIA document contains information on applied manure management systems: manure storage is kept covered, slurry storage tanks are also covered with a layer of 10 centimetres thick straw on the surface of liquid manure, which reduces the emission of pollutants and odours into the environment up to 60%.

Based on the information provided, when calculating non-dairy cattle emissions, it is proposed to take into account the impact of the air pollution abatement measures applied since the launch of the company or at least from 2009.

**„Griškabūdžio“ ŽŪB[[51]](#footnote-51)** was founded in 1995. According to the publication "Development of the Lithuanian Blackbird Cattle’[[52]](#footnote-52) (‘) in 2011, the company kept 566 breeding heifers (not attributed to dairy cattle). In 2016 the company planned to expand the cow farm but did not provide the number of non-dairy cattle in the information on the environmental impact assessment of the planned economic activity "construction of cowshed, milking unit and two liquid manure storage tanks (expansion of cattle farm)". It is stated in the EIA selection that the slurry and liquid manure are accumulated in sealed storage tanks, which is an air pollution abatement measure. Thus, the calculation of emissions should take into account the application of this company 's pollution reduction measure to the increase in the non - dairy cattle population in 2011.

**ŽŪB „Atžalynas“[[53]](#footnote-53)** was registered in 1993. According to the information of 2016 for the selection for the environmental impact assessment of the expansion of milk production farm, the complex planned to grow 318 units of cattle of all ages. Before the expansion the company had 45 units of cattle younger than 2 months; 14 pieces bulls up to 1 month; 87 pieces calves 2-6 months; 98 Units heifers 6-12 months; 60 pcs. heifers 12-15 months. and 125 pcs. calf heifers 15-24 months. Hard manure is stored in open manure covered with straw, peat or film. The liquid manure removal channel is connected to the pumping station reservoir where liquid manure is removed. When the pump tank is filled, liquid manure is sucked into the liquid manure storage tanks. During the accumulation of liquid manure, manure is not mixed in order to automatically form a floating layer of the reservoir mass. This layer has reduced air pollution, and the tool is described in more detail in section 2.3.

**UAB „Agrolinija“[[54]](#footnote-54), [[55]](#footnote-55)**started to develop breeding and beef cattle business in Kaišiadorys district in 2010, importing 63 purebred Angus heifers and three bulls from Germany, Saxony - Anhalt Land Cattle Breeders Association (RSA). In 2011, the farm also brought in 15 Angus and 50 Simental purebred heifers and purchased two bulls from the Antanas Bezaro Angus farm. According to 2017 environmental impact assessment of the planned economic activity of „Agrolinija“, the company reduced the number of cattle raised from 564 units to 407. Additionally, pollution reduction measures were evaluated for pollutant and odour emissions: manure will be kept in a closed barn, resulting in a possible 80% reduction in emissions (based on CORINAIR methodology - 3.B Manure management, Table A2-2). Based on the data provided, the impact of the air pollution abatement measures used must be assessed.

**ŽŪB „Šiaurės bulius“[[56]](#footnote-56)** was registered in 2015. According to the 2018 EIA selection, the company has 480 units of cattle and planned to expand the beef cattle complex up to 1920 cattle. Cattle numbers before 2017 are required for the assessment of emissions. 480 units of cattle were kept in 2015-2018 period. The EIA also states that for manure scattering, thick manure sites are covered with a layer of 0.2 m thick straw - an air pollution abatement measure that has been adopted since the inception. There is no more available information.

**A. Leščinskas[[57]](#footnote-57), [[58]](#footnote-58), [[59]](#footnote-59)** started the livestock business in 1998, but initially only kept 8 units of cattle and expanded to 10 units later. According to the data in 2012, the farmer kept 130 units of suckler cows and 230 calf. According to the 2016 EIA data, the farmer planned to keep additional 110 suckler cows and 170 units of calf. The EIA also stated cleaning was planned in the barns and also the use of probiotic preparations (Penergetic-k), which not only reduces emissions and odours, but also has a positive effect on the destruction of pathogenic microorganisms, reducing the risk of viral diseases among animals. To reduce the amount of ammonia released into the air in the environment, manure is only mixed at the time of removal. The farmer additionally raised 60 pieces of calf and 60 units of suckler cows. However, these beef cattle are grown on the field all year round and are not kept in the farm complex area, so they (120 units) are not subject to air pollution abatement measures.

**A. Andrijauskas[[60]](#footnote-60), [[61]](#footnote-61)** started his activities in 2000-2001. According to the data in 2015, the farmer kept 112 cattle. According to 2016 A. Andrijauskas' Economic Activities and Information for Environmental Impact Assessment, the farmer planned to grow 310 cattle, of which 93 were dairy cows (classified in sector 3B1a), 31 calves, 93 calf and 93 adult cattle. The assessment mentions that the slurry storage facility (lagoon) is operated with a rigid film, thus reducing the spread of odours. It is possible that this had been used since 2016. The effectiveness of the tool is described in section 2.3. When calculating emissions for non-dairy cattle, the impact of air pollution abatement measures (reduction of emissions) can be estimated.

According to the Republic of Lithuania 15th August, 1996 Act on Environmental Impact Assessment of the Proposed Economic Activity No. I-1495, the environmental impact assessment must be carried out on cows and bulls where there are 250 units or more of them; calves up to 1 year old: 1 000 or more; and bovine animals from 1 to 2 years - 350 or more. Environmental impact assessment is not required by law for cows and non-dairy cattle. The mandatory IPPC permit for the adoption of D1-528 "on the adoption of rules for the issuance, amendment and revocation of integrated pollution prevention and control" is not related to cattle farming. Therefore, the IPPC permit for such activities is optional.

Information on the quantities of non-dairy cattle and the air pollution abatement measures applied to them can only be obtained from the web pages of freely available companies, the existing conclusions on the selection of the environmental impact assessment and the IPPC permits, if the company has it. Also, there are no big cows or dairy cattle farms in Lithuania, there are several medium sized (about 1,000 units and more) and many small farms. For this reason, there is almost no publicly available information. Small farms, dominating in the country do not need to be subject to EIA[[62]](#footnote-62) selection or IPPC permits[[63]](#footnote-63). Also, many do not provide the necessary information on their activities on their website or do not have one at all.

**Results of the survey of Lithuanian farms.** In order to find out the prevalence of manure management and pollution reduction technologies, a survey of non-dairy cattle manure management was distributed to Lithuanian farms. The questionnaire was completed by 3 respondents. The survey collected data on manure management and pollution abatement technologies for 2.6 thousand non-dairy cattle in the period 2005-2018 (or an average of 186 cattle per year).

Survey data collected may be used to account for atmospheric pollutants, but we estimate that respondents' activity was too low to objectively assess the prevalence of applicable pollution abatement technologies across the country. The results of the survey are provided in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.A.1.B).

## Manure management – Sheep (NFR 3.B.2)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sector ‘3B2 Sheep Manure‘

**1. Brief description of processes:** Most of sheep in Lithuania were kept in 1924-1926 (1.5 million for the period). Later the number of sheep decreased continuously. Until 1988 In Lithuania, only Lithuanian Blackheads and local coarse sheep were bred. Later, sheep of various breeds were imported from abroad. In 2007, even 23 breeds of sheep were reared, including 18 raised for meat. In addition, small sheep farms are dominating in the country, that usually have 1-5 sheep (about 60% of such farms); 6-20 sheep (25% of farms); 21-50 sheep (about 10%); 51-100 sheep (only 3%); and 101-500 sheep (up to 1% of such farms). Manure management systems known in Lithuania: litter manure and pasture. A more detailed description of the systems is given in section 2.3.

**2. Parameters used in the Tier 2 methodology:** there are many specific parameters that would be very expensive to set national values ​​for, therefore they are limited to default values. In addition, many data are available in the national GHG reports[[64]](#footnote-64), [[65]](#footnote-65):

* Average annual population by sub-categories, thousands (1990-2017 Table 5-3. Average annual number of livestock population per year, thousand, Table 5-5.); average weight, kg (1990-2017 „Table 5-11. The average weight of sheep during the period 1990-2017, kg“);
* all data related to the composition and amounts of fat, protein and carbohydrate nutrition (Annex VII, Table A. 5-31 - Table A. 5-36, Annex VII Table A.5-40);
* average total energy consumption, MJ / pcs / day: for subcategories "Table 5-21. Average gross energy intake and emission factors of sheep '- 2019 report;
* Periods of grazing and staying in barns: 200 days for sheep in the barn, 165 days for grazing;
* Volatile solid excretion (VS): 1990-2017 Table 5-29. Daily VS excretions for dairy, non-dairy cattle, swine and sheep, kg-dm./day;
* Information on manure management systems: 54.8% of the stock of sheep manure is stored in solid storage for the entire 1990-2017 period. (xstore\_FYM)), 45.2% settle in pastures.
* defined Nexcretion indicators: 1990-2013 and 2017 - 10.59 kg N / pc / year, in 2014-2016 - 10.60-10.62 kg N / pc / year.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

Other required data:

* The share of solid manure transferred to biogas production (xfeed\_FYM) – according to the above information, it can be assumed that sheep manure is not transferred to biogas.

All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values ​​are taken from Technical Guide or IPCC (version - 2006).

**3. Effectiveness of Reduction Measures:** Under the agreement with EPA, due to lack of time in this data collection phase, the review was limited to administrative, publicly available data.

**Jutos Vidrinskaitės farm[[66]](#footnote-66).** According to the data from 2015 on the environmental impact of the proposed economic activity, the farmer had a herd of 59 sheep. The EIA documents were prepared while planning to increase the number of sheep in 2016 to 300 units, and in 2017 up to 422 units. The documentation also states that litter is kept in the barn and that the urine is absorbed by the litter, and that the odours are minimal. Such reduction of odours using litter also reduces air pollution, so the application of the measure should be taken into account when calculating emissions.

**Kristinos Kučinskienės farm[[67]](#footnote-67)**. According to the data from 2016, the farmer planned to store 500 ewes and 600 sheep and 20 rams. Technology of litter manure (on deep litter) is used in the farm. The manure is removed twice a year from the sheep. As in the farm described above, the use of litter in sheep barns can be attributed to air pollution abatement measures. Litter absorbs urine as a result of reducing odor emissions. When calculating emissions, the use of litter must be taken into account.

**UAB „Šeduvos avininkystė“[[68]](#footnote-68),[[69]](#footnote-69)**. newly formed on 31st December, 2010. The company was restructured and re-formed from former ‘Šeduva Avininkyste’. The latter was established on 30th December, 1992 in the former Šeduva experimental farm base, which specialized in sheep breeding and raised the Lithuanian Blackhead breed genofondin sheep. According to the annual 2016 report, in 2015, 1174 units of sheep were cut, and in 2016 - 1242 units. In the absence of more precise information, the number of sheep that were cut may be compared with the number of sheep reared. However, the company website and reports do not provide any information on the use of air pollution abatement measures.

There are no large sheep farms in Lithuania, there are many medium-sized farms growing around 1000 units of sheep, and small-sized farms, producing several hundred or a few dozen of sheep. Farms of this size usually do not have a website to provide information on ongoing activities. In this way, such farms do not have an EIA selection (2 500 or more for sheep, goats), EIA documents and IPPC permits. Therefore, more information could be collected through farmers' surveys through the Lithuanian Sheep Breeders Association, but surveys are not conducted at this stage.

**Results of the survey of Lithuanian farms**. In order to find out the prevalence of manure management and pollution reduction technologies, a survey of sheep manure management companies was distributed to Lithuanian farms. The questionnaire was completed by 1 respondent who indicated that no pollution reduction measures are applied on the farm.

Respondents' activity was too low to assess the prevalence of national pollution reduction technologies. The results of the survey are provided in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.B.2).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Manure management – Swine (NFR 3.B.3)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sector 3.B.3 Management of Pig Manure.

**1. Brief description of processes:** In Lithuania, swine farming is the main source of meat production, so one of the main tasks in developing this livestock industry is to get as much growth as possible with better meat quality. In order to improve the above-mentioned characteristics of swine growth, sows and boars with high meat qualities must be used for mating. Currently boars with high breeding characteristics are brought to Lithuania from abroad, thus improving pigs reared in the Republic. Such boars are expensive, and do not always pay off. In the mating season, 100-120 pigs are inseminated with one boar per year. There are various pig manure management systems used in Lithuania: deep litter, liquid manure, litter manure, biogas power plants. A more detailed description of the systems is given in section 2.3.

**2. Parameters used in Tier 2 methodology:** there are many specific parameters that would be very expensive to set national values ​​for, therefore they are limited to default values. In addition, many data are available in the national GHG reports[[70]](#footnote-70), [[71]](#footnote-71):

* Average annual population by sub-categories, thousands (1990-2017 Table 5-3. Average annual number of livestock population per year, thousands, Table 5-4.) average weight, kg (1990-2017, Table 5-10. The average weight of swine during the period 1990-2017, kg“);
* All data relating to the composition and amounts of fat, protein and carbohydrate nutrition (Annex VII Table A.5-5 - Table A.5-40 or Livestock Manual).
* total energy consumption, MJ / pc / day (Table 5-20)
* Information on pig manure management systems in Lithuania: The most common pig manure management systems are slurry and anaerobic treatment systems (biogas production) that account for 62.0% and 26.4% respectively. About 9.7% of manure is managed in litter manure management systems and 1.9% in deep bedding manure management systems (pp. 267 - 2019 report);
* Volatile solid excretion (VS): 1990-2017 Table 5-29. Daily VS excretions for dairy, non-dairy cattle, swine and sheep, kg-dm./day;
* Defined Nexcretion Indicators for 1990-2017: Table 5-40. Estimated N excretion factors for cattle, horses and swine, kg N / head / yr.
* The part of the pig manure that is anaerobically treated is presented in the form of a graph 1990-2017: Figure 5-6. Data on manure management systems for swine (page 268 - Report 2019). However, the schedule shows that pig manure has begun to be managed in this way only in 2004. In 2012-2013, in biogas production, pig manure was not handled by anaerobic treatment.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

Other required data:

* Pigs spend the whole year (365 days) in barns in Lithuania, therefore the period of grazing and staying in enclosures is 0 days.
* part of slurry that is stored (xstore\_slurry) and part of slurry transferred to biogas production (xfeed\_slurry) can be obtained through surveys
* The part of the solid manure that is stored (xstore\_FYM) and part of solid manure transferred to biogas production (xfeed\_FYM) can be obtained through surveys.

Note: Amounts of manure treated by Anaerobic treatment (biogas production) can be derived from the GHG report, but there is no information specifically on the proportion of slurry and litter transferred to biogas production.

All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values are taken from Technical Guide or IPCC (version - 2006).

**3. Effectiveness of Reduction Measures.**Under the agreement with EPA, due to lack of time in this data collection phase, the review was limited to administrative, publicly available data.

**UAB „Idavang“** was launched in 1999. The founders of the company evaluated the deficit markets of Eastern Europe, and established the first farm in Lithuania. Over the years until 2013, Idavang (formerly known as „Saerimner", has become the biggest producer in Lithuania. ‘Idavanag’ activities are carried out by four companies:

* UAB „Idavang“, managing 7 pig farms,
* UAB „Idavang Kepaliai”, managing 3 pig farms,
* UAB „Idavang Pasodėlė”, managing 1 pig farms and 1 boar farm.

To ensure that ammonia, nitrogen, greenhouse gases and odours do not get into the environment, a group of companies has installed a closed slurry storage facility for almost all their farms. Their two-layered bottom cover protects the land under the lagoons, and the special film on the lagoons prevents the odour from escaping from the storage tanks, entering the lagoon for rainfall. In all Idavang farms, the slurry is managed in accordance with the European Union requirements for lagoons, which enter into force in 2014.

„Idavang“ group slurry management system is shown below (see Figure 2).

1. Complex;

2. The slurry travels through the underground routes to the fractionation unit;

3. Fractionation separator separating the thick fraction from the liquid;

4. the liquid part flows into the lagoon;

5. Slurry is kept in closed lagoons until fertilization season;

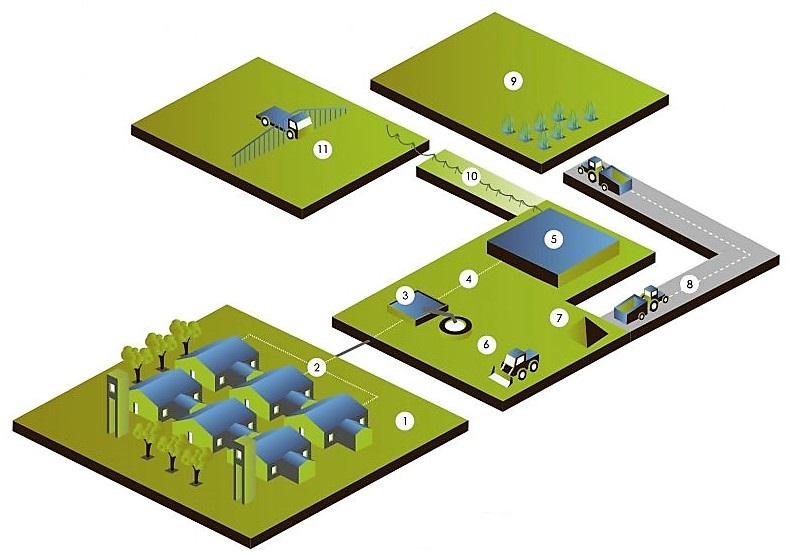
6. The solid fraction is transported to the manure storage site;

7. Spec. manure stored in the fields; 8. Field manure transport;

9. Fertilized fields;

10. The slurry is delivered to the field harvester (10 km underground); 11. Slurry is poured on the fields.

Figure 2 Group slurry management system



According to the Corporate Social Responsibility Report of the Idavang Group of 2017[[72]](#footnote-72) the group grows 0.5 million Pigs in Lithuania every year. According to the 2013 report[[73]](#footnote-73) the Group has grown on average 360,000 pigs a year, 160 thousand piglets and 17 thousand sows.

Based on the data Idavang used in 2016 for “1 999 pigs in Kalvarija pig complex (Unit 06) environmental impact’[[74]](#footnote-74) assessment, in 2006-2013, one farm raised 10,000 piglets and 15,000 pigs. Between 2015 and 2016 only 10,000 units of piglets (7-30 kg) were raised. After 2016 one farm produces only 1 999 pigs (30-110 kg).

After acquiring ‘Kalvarija’ complex in 2006, ‘Idavanag’ introduced a number of modern and GBGB-compliant pollution reduction measures in order to improve the state of the environment[[75]](#footnote-75):

* In 2006-2007, the repair of the Kalvarija complex was carried out, during which the condition of the barns was improved.
* The feed production equipment installed in the existing feed preparation workshop was analogous to the existing one; complex territory, access and internal complex roads were repaired; the area is planted with trees;
* To implement the measures of the National Emission Control (Restriction) Scheme until 2010, the company focused on modernizing the farm and replacing equipment containing ozone. Between 2007-2008 4 × 15,000 m3 of closed lagoon berms were built, which resulted in a 98% reduction in ammonia emissions from sources of unorganized pollution.
* In 2010, MILSTON 50B mobile manure separation device was purchased, which, if necessary, is used for solid fraction separation.

The above-described systems for handling slurry from a group of companies and one division 06 are subject to pollution measures: liquid and solid fraction separation, sealed transport fertilizers, closed lagoons.

According to the information provided by the Kalvarija subdivision of UAB Idavang (06) in the application for IPPC permit[[76]](#footnote-76) in 2019, a double purification unit (cyclone and sleeve filter) is planned to be installed in the Kalvarija subdivision.

The application of these measures must be assessed in the calculation of emissions.

**UAB „Merkio agrofirma“[[77]](#footnote-77), [[78]](#footnote-78)**, was granted the IPPC authorization for pig farming in 2006, it was renewed in 2011. According to the updated / amended permit for integrated pollution prevention and control, the company's production volumes are limited to 36,000 pieces of meat pigs per year or 12,000 pieces of meat pigs and 1200 units of sows. POLIFLOCK-BTS is a biostabiliser used in the company to reduce air pollution - ammonia and odour. POLIFLOCK-BTS is a product that stabilizes the ecosystems of organisms that naturally feed livestock manure, which ensures rapid mineralization of manure and slurry Due to the effect of POLIFLOCK-BTS, the ecosystems of the microorganisms in the manure become more resistant to the adverse effects of the environment, which stimulates the metabolism and mineralization and degradation of the nutrients naturally occurring in the environment (manure). One example of how POLIFLOCK-BTS works is the activation of enzymes that catalyse the degradation of uric acid. The primary product of this reaction is ammonium (NH4 +), which, in the absence of sufficient media humidity, can migrate to the gaseous form ammonia (NH3) and intensify the formation of unpleasant odours. Sufficient nitrifying and denitrifying bacteria and their activity are required for rapid ammonium (NH4 +) transformation into gaseous free nitrogen (N2). POLIFLOCK-BTS promotes the activity of these bacteria, their reproduction and prevents the formation of ammonia. POLIFLOCK-BTS contains fermented plant extracts, trace elements, vitamins, enzymes that can be freely absorbed by microorganisms that grow naturally in animal manure or in their living environment. Practical use of POLIFLOCK-BTS has shown that its use allows:

* Reduce ammonia emissions.
* Ensure faster organic degradation, faster metabolism of manure.
* Improve animal housing conditions, reduce stress and respiratory health problems
* Reduce animal mortality.
* Ensuring a healthier and safer working environment.

POLIFLOCK-BTS is a concentrated product which is diluted with water before use. The diluted solution is added to the manure or sprayed on the floor in animal housing. For maximum results, the product is used once a week by spraying the barn. The reduction in ammonia and sulphur hydrogen concentrations was found to be 65-75%. The smell around the stables is greatly reduced.

There are measures used to reduce odour dispersion from plant to plant:

* Slurry reservoirs are operated under cover of floating covers, dung – covered by dry shredded straw;
* Slurry in tanks is treated with additives that reduce pollution.
* Biostabilisers are used in barns to reduce the release of ammonia and odours.
* Optimized feed composition - low protein feed reduces the release of ammonia and odour compounds.
* Natural and artificial exhaust ventilation conditions are applied - air intake and outflow are varied according to meteorological and climatic conditions and indoor ventilation requirements.

Depending on the measures taken by the company to reduce air pollution, the emissions from this sector must be reduced for the pig farm in question.

In the pig farm complex of **UAB Takažolė** 650 sows, 3,600 fattening pigs and 2,300 weaned piglets are raised in nine barns, which are connected by a corridor system. In each barn the animals are kept in pens with grill channels. The manure is removed using a hydron wash. There is an automatic ventilation to maintain optimum temperature Equipped with state-of-the-art feeding equipment - automatic piping - dust-free, water troughs and automatic nipple drinkers for watering the animals.

The pig barn used for the prevention of ammonia and odors - Poliflock BTS biostabilizer spray. Odor biostabilizer is a product that reduces odors from animal manure, an effective means of promoting the development of naturally occurring microorganisms that break down ammonia and other pollutants. Another preventive measure is the addition of benzoic acid to animal feed. The overall efficiency of the abatement measures used is 70%.

The annual manure output for all pig groups is 11004 m3 / m. Liquid manure is transported from the barn channels by a conveyor to a closed, sealed 140 m3 tank, and from it through a pressure pipe to storage facilities. The manure also contains water for washing stalls and household sewage. The company generates a total of 13776 m3 of liquid manure per year, which is stored in airtight cylindrical tanks 2 units. after 5930 m3. The manure enters the tanks from the barns already treated with the Poliflock BTS biostabilizer. In addition, the slurry is treated with SlurryBugs, a bacterial and enzymatic mixture that traps ammonium nitrogen and transforms it into organic nitrogen forms. In tanks, a layer of peat is sprayed onto the manure surface. These complexes reduce the ammonia concentration during manure storage by 80% and the reduction of unpleasant odors by 75%. The company has long-term contracts with local farmers for an area of ​​914.15 ha (2018 data) where it can spread the resulting manure.

The company produces its own feed for pigs at about 6000 t / y. The entire feed production process is fully computerized, remotely controlled, 24/7. The production process is controlled by computer equipment, which is programmed according to the optimal physiological needs of the animal body for individual groups of animals. The feed is prepared according to 5 recipes. From feed grains and feedstocks, from the mill, pollutants are not released into the ambient air as the entire feed production process is closed in a cycle.

**Pauliukų ŽŪB[[79]](#footnote-79)**. The fattening period of pigs is 6 months. The pig farm is equipped with 1480 places for sows with piglets up to 30 kg and 6270 places for pigs for fattening. Fence No.1 has 185 places for sows and 4000 places for piglets from 8-30 kg, barn No.2 - 320 places, barn No.3 - 615 places and barn No.4 - 360 places. The fattening pigs are reared in barns No 5 and No 6. Up to 2,300 pigs can be housed in barn # 5 and 3970 pigs in barn # 6.

Liquid feeding lines in barn for fattening pigs No 6. In this barn, the animals are kept on the lattice floor. Baths with main manure collectors are connected by pipes with cork barriers. When the manure bath is full, the liquid manure flows out of the bath into the main manifold and enters the liquid manure pumping station, from the pumping station to the manure storage tanks.

Fattening pig barn No.1 is equipped with German manure removal system, filled with pigs with piglets on heated floor, equipped with German Meyer dry feeding system, computerized ventilation system. Animal excrement enters the manure baths through the grill. When the slurry is collected, it is discharged to the liquid manure pumping station and from there to the slurry storage tanks. Weaner piglet barn No.1 is equipped with a plastic floor, German Meyer liquid feeding system and computerized ventilation. Animal excrement enters the manure baths through the grill. When the slurry is collected, it is discharged to the liquid manure pumping station and from there to the slurry storage tanks. Liquid manure and slurry from Pauliukai pig farm is stored in three tanks (2 units of 4,180 m3 capacity, 1 unit of 4,200 m3 capacity).

Concrete grating floors are provided in fattening, sows and insemination barns No 2, 3, 4, 5. Equipped with German-made Meyer liquid feeding system, computerized ventilation system. The slurry removal system is the same as in other barns No.1 and 6. Automated pig feeding ensures more efficient use of feed and more accurate implementation of feeding programs. Replaced pig watering system, electrical installation and ventilation system. The working conditions of the employees have improved. The modernization includes manure removal system, floor system, stall system, heating, watering system, feeding system, electrical installation and ventilation system. The changes introduced in the technology of pig keeping and rearing comply with 1996. September 24 Indicators and measures recommended by Council Directive 96/91 / EC concerning integrated pollution prevention and control BAT for intensive livestock installations. After the implementation of all modernization measures - by installing modern technological equipment, a modern and efficiently managed pig keeping system was created, which will ensure animal welfare, application of veterinary, sanitary, hygiene and environmental requirements in pig production business.

The pig farm has three manure storage tanks No.7, No.7. 8 and No. 9. (The pig farm has built two stainless steel storage tanks of German company Duraumat in 2007, each with 4,180 m3 each. A 4200 m3 reinforced concrete storage tank was built in 2008. The monitoring wells are installed near the storage tanks. liquid manure is used to fertilize its fields.

The company uses 2348.32 hectares of land to spread manure. 592.91 acres are owned by the agricultural company, while 1755.41 acres are earmarked by the state and farmers. It is sufficient to spread manure over the land. Pauliukai ŽŪB cultivates cereals and fodder crops on its own and leased land.

**UAB "Kontvainiai"[[80]](#footnote-80)**.The pig rearing complex has 5300 units Phase I weaned piglets, 7170 units Phase II weaned piglets and 6,800 places for fattening pigs. The total stocking stock is 1450 SG. The annual projected number of fattening pigs to be reared is 50,500. Reconstruction works were carried out in the pig breeding complex in Phase I and II animal stables Nr. 1-12.

Liquid pig manure from the barns is accumulated in five slurry ponds no. 23 with a total capacity of 75 thousand m3. They currently store the company's liquid manure and the company's domestic wastewater. New covered liquid manure storage tanks are under construction. Liquid manure from the farm is sold to farmers and companies for fertilization.

**UAB "Vingininkai"[[81]](#footnote-81)**. The production activity covers an area of ​​11,3505 ha. The pig slurry's 4 slurry collectors are located 1.1 km west of the main production area. The company carries out the following economic activities: keeping a reproductive pig herd (main activity), producing heat, collecting and discharging surface water from the production area, treatment of domestic wastewater, abstraction of groundwater. Sows with piglets in the pig rearing complex. The total number of notional livestock kept is 1498 SG. Annual design capacity of weaned piglets from 7.5 to 8.0 kg: 82500 units. The activity is carried out in 17 barns. The sow cycle consists of 21 weeks: 17 weeks of gestation (119 days), 3 weeks of lactation and 1 week of insemination, can give birth to up to 2.5 litters. There are four types of premises in the company: quarantine, insemination, pregnant pigs, fattening. Slurry produced during pig rearing is stored in 4 slurry collectors and fertilization plans for slurry release are prepared annually.

**UAB "Biržų bekonas"[[82]](#footnote-82)**. UAB Biržų bekonas livestock complex has been operating for many years. The design capacity of the company is 18 645 places for pigs for fattening (over 30 kg). Weaned piglets (Phase I) are brought from other holdings for rearing to the first rearing barn no. 1-10, these barns were reconstructed. After five weeks, the piglets (phase II) are transferred to the second housing barn no. 1a-12a. The fattening pigs are moved to the last fattening stage for further rearing in fattening barns no. 1p-14p. About 41,200 m3 of liquid manure per year is produced in pig farms. The manure is accumulated in lagoons with a total volume of 160000 m3. During the watering period, liquid manure is spread in the fertilization fields. The spreading of liquid manure requires 1182 ha of fields. All fields are equipped with drainage systems.

**Results of the survey of Lithuanian farms.** In order to find out the prevalence of manure management and pollution reduction technologies, a survey of pig farms engaged in Lithuanian farms was distributed. The questionnaire was completed by 2 respondents. The survey collected data on manure management and pollution abatement technologies for 185.6 thousand pigs in 2005-2018 (or an average of 13.3 thousand pigs per year).

Survey data collected may be used to account for atmospheric pollutants, but we estimate that respondents' activity was too low to objectively assess the prevalence of applicable pollution abatement technologies across the country. The results of the survey are provided in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.B.3).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

**Actual emissions per year in the AIVIKS system** are recorded in 2011, 2014, 2015, 2016, 2017 (see MS Excel file Žemės ūkio sektorius 2019 11.xlsX, sheet 3.B.3).

* In 2011 JSC "IDAVANG" Sajas Division 04 started using biostabiliser; UAB "Merkio agrofirma" has applied new slurry pumps, pumping stations, separators, acquired geothermal heating; UAB "IDAVANG" Mūša division started using the biostabiliser Polifloc BTS.
* In 2014, UAB Dainiai started using probiotics, installed a sleeve filter; UAB "IDAVANG" Lekėčiai division 08, Mūša division, Rupinskai division 02, Sajas 04 unit, Skabeikiai division 07 started to use biostabiliser Polifloc BTS.
* In 2015, UAB "IDAVANG Kepaliai" Joniškis division started handling manure; UAB "IDAVANG" Lekėčiai subdivision, Mūša division, Saja subdivision, Skabeikiai division used biostabiliser Poliflock BTS..
* In 2016, UAB "IDAVANG Kepaliai" Joniškis division, Šeduva division, Mūša division, Saja subdivision, Skabeikiai division, Lekėčiai division 08, Pasodėlė, Rupinskai division 02 used biostabiliser Poliflock BTS.
* In 2017, UAB "IDAVANG Kepaliai" Joniškis division, Šeduva division, Mūša division, Saja subdivision, Skabeikiai division, Lekėčiai division 08, Pasodėlė, Rupinskai division 02 used biostabilizer Poliflock BTS.

The number of livestock produced by the divisions of IDAVANG UAB in the respective year is presented in the mentioned Excel document, which is an integral part of this report. The data in sector 3B3 in Excel and in the report should be taken into account when calculating national emissions.

## Manure management – Goats (NFR 3.B.4.d)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sector 3.B.4.d Goat Manure Management.

**1. Brief description of processes:** the number of goats began to rise every year in Lithuania since 1990 and goat farming started to recover. Because of enthusiastic goat keepers, a number of breeds (Czech white, Zanen, etc.) were imported to improve local breeds. Currently, dairy goat farming is developing and the variety of goat milk products (especially organic ones) is expanding. Control of goat productivity is carried out since 1992. The number of goats in comparison with 2001-2002, when it increased to 23.7 thousand, in 2003-2007 fell to 7 thousand (of which about 700 breeding animals). All goats are reared on private farms. Most often one farm has 1 or 2 goats. Only a few farms have 10-50 goats. Two goat manure management systems are used in Lithuania: litter manure and pasture [[83]](#footnote-83). A more detailed description of the systems is given in section 2.3.

**2. The parameters used in the Tier 2 methodology:** there are many specific parameters that would be very costly to set national values ​​for, therefore they are limited to default values. In addition, many data are available in the national GHG reports[[84]](#footnote-84), [[85]](#footnote-85):

* Average annual population, thousands (1990-2017 Table 5-3. Average annual number of livestock population per year, thousands);
* Average weight for the entire period is 33.84 kg (page 255 - 2019 report);
* Periods of grazing and staying in barns: 200 days of staying in bands, 165 days of grazing;
* Information on manure management systems: for the entire 1990-2017 period, 54.8% of the stock of solid manure stored (xstore\_FYM) is 45.2% deposited on pasture.
* defined Nexcretion indicators for the whole 1990-2017 period are the same: Table 5-41. Estimated N excretion rate for goats and poultry, kg N / head / yr.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

Other required data:

* the share of solid manure transferred to biogas production (xfeed\_FYM) – according to the above information, it is acceptable that goat manure is not transferred to biogas.

Note: as the contribution of the goat sector to overall emissions is very small compared to cattle categories, goat emissions in the GHG report are calculated at Tier 1 level.

All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values are taken from Technical Guide or IPCC (version - 2006).

**3. Effectiveness of pollution reduction measures:**under the agreement with EPA, due to a lack of time in this data collection phase, the review was limited to administrative, publicly accessible data.

**Dalios Emužytės goat farm[[86]](#footnote-86)** is one of the largest ecological goat farms in Lithuania, growing up to 600 goats at different times of the year. However, there is no data on the management of goat manure or air pollution abatement on either their website or other publicly available information.

The amount of goats produced in Lithuania does not change significantly during the year. There are no big goat farms, they only grow up to several hundred or tens of goats. For small farms there is no mandatory EIA selection (2,500 or more for sheep, goats), EIA documents [[87]](#footnote-87) or IPPC permits [[88]](#footnote-88), so no publicly available information is available. More information could be collected by interviewing goat farmers, but no surveys are conducted at this stage, so no more publicly available information has been collected.

**Results of the survey of Lithuanian farms.** In order to find out the prevalence of manure management and pollution reduction technologies, a survey of goat manure management farms in Lithuania was distributed. No respondents completed the questionnaire.

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Manure management – Horses (NFR 3.B.4.e)

Input data for 2000-2017 needed for emission estimation at Tier 2 level in sector 3.B.4.e Horse Manure Management.

**1. Short description of processes:** It was counted that in 2006 in Lithuania there were 63.5 thousand horses, of which 4221 were for breeding. In rural villages, there are still many heavy and large Samogitian-like crossbreeds – also called ‘working’ horses. ‘Vilniaus žirgynas’, ‘Nemuno žirgynas’, ‘Sartų žirgynas’ grow different breeds such as *Žemaitukai*, *Didieji* *Žemaitukai,* *Lietuvos Sunkieji*, *trakėnai*, *grynakraujai jojamieji*, *Lietuvos jojamieji*, Hanover, Holstein, Arab, Budionian rider, Russian, American, French and Orlovian trotter, also various breeds of ponies. Lithuanians also improted less common breed horses - achaltekin, Andalusian, Danish warm blood, Norwegian cold blood, etc. from abroad. The change in Lithuanian horse breeding has especially accelerated in Lithuania's integration into the European Uniom. Rights of developing equine breeding, keeping records of breeding horses, preparing and carring out breeding programs, horse-racing trials and assessments, keeping herd books, preserving the national breed genome fund has been granted to the recognized horse breeding institutions by the Minister of Agriculture:

* Lietuvos arklių augintojų asociacija,
* Žemaitukų arklių augintojų asociacija,
* Lietuvos trakėnų žirgų augintojų asociacija,
* Lietuvos sunkiųjų arklių veislės augintojų asociacija,
* respublikinė lenktyninių žirgų lyga,
* Baltijos hanoverių žirgų augintojų asociacija,
* Nacionalinė ristūnų sporto asociacija.

The activities of the associations are controlled by the State Animal Breeding Supervision Service under the Ministry of Agriculture of the Republic of Lithuania.

Lithuanian natural and economic conditions are more suitable for the development of beef meat breeding than horse meat breeding. In addition, the development of this branch is not favorable to the traditionally respectful attitude of Lithuania towards the horses.

In Lithuania there are two horse manure management systems: litter manure and pasture. A more detailed description of the systems is given in section 2.3.

**3. Parameters used in the Tier 2 methodology:** there are many specific parameters that would be very costly to set national values ​​for, therefore they are limited to default values. In addition, many data are available in the national GHG reports[[89]](#footnote-89), [[90]](#footnote-90):

* Average annual population, thousands (1990-2017 Table 5-3. Average annual number of livestock population per year, thousands);average weight, kg: „Table 5-12. The average weight of horses during the period 1990-2017, kg“.
* During the period 1990-2017, the average weight of horses decreased, due to the relatively fast decrease in the working horse population and the growth of the pony horses population.
* Information on manure management systems: 92% of horse manure is deposited on pasture for the entire 1990-2017 period, and 8% of manure is managed in other systems.
* Defined Nexcretion indicators for the whole 1990-2017 period: Table 5-40. Estimated N excretion factors for cattle, horses and swine, kg N / head / yr.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

Other required data:

* The period of stay in the barn according to the Technical Manual (version - 2016) is 180 days, but according to the above data, almost 92% of horse manure is in pasture. This only shows that in Lithuania the grazing period is longer and takes place almost all year.
* The share of solid manure transferred to biogas production (xfeed\_FYM) – according to the above information, it can be assumed that horse manure is not transferred to produce biogas.

Note: Since the contribution of the horse sector to overall emissions is very low compared to cattle categories, the horse emissions in the GHG report are calculated at Tier 1 level.

All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values ​​are taken from Technical Guide or IPCC (version - 2006).

**3. Effectiveness of pollution reduction measures.** There are no specific publicly available data on the number of horses, horses, manure management techniques and air pollution abatement measures. EIA selection is mandatory only if there are 250 horses grown a year (or more) and for foals up to 1 year - 500 units or more. The IPPC permit is optional, giving even less available data. On their websites, companies or horse breeders' associations do not provide the specific data required.

The Zootechnician's Guide provides information about the horse storage facilities that may be relevant to assessing emissions. Horse storage facilities must comply with the Zoohig hygiene requirements. Horses can cope with fluctuations of temperature and it is recommended not to keep the temperature in the stall stable, in order to improve thermoregulatory systems. Such stimulation is achieved if, throughout the year, the temperature of the air in the stables replicates to a certain extent the temperature of the air.

The equine breathing apparatus is extremely sensitive to dust and harmful gases, so the fresh air supply and air circulation must be ensured in the stables. Optimal concentrations of dust, microbes and harmful gases as well as relative air humidity are achieved by installing adequate ventilation, orderly rolling, and non-dusting feed. The concentration of ammonia in the stables should be <0.10 ppm.

Ceilings in shallow stables should be at a height of 2.8-3 m, when stored on deep litter - 3.3-3.5 m. The door should be 2.5-3 m wide and 2.4-2.8 m high. The floor is usually a concrete, rough surface with a ditch for running water and urine. Sand can also be used for flooring; wooden floors are not suitable. In the deep stables, the horses are kept on the manure with straw, while in shallow stables - manure is removed daily, the floor is cleaned and then covered with straw and wood chips. With more creeping and more frequent removal of manure from the barn, less harmful gases are generated in the premises. In the absence of specific data, it can be estimated that manure is more abundant in Lithuania in the period that horses spend in stables, and that they are frequently disposed of, and that these are measures to reduce air pollution that can be taken into account when calculating emissions (for all or just a certain number of horses).

**Results of the survey of Lithuanian farms.** In order to find out the prevalence of manure management and pollution reduction technologies, a survey of horse manure management companies in Lithuania was distributed. No respondents completed the questionnaire.

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Manure management – Poultry (NFR 3.B.4.g.i-3.B.4.g.iv)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sectors "3B4gi Manure handling of chickens", "3B4gii Chicken manure management", "3B4giii Handling of turkey manure", "3B4giv Manure of other poultry manure“.

**1. Brief description of the processes:** The chicken breeds are divided according to the direction of their productivity into the types of meat, re-producing and meat/eggs. In Lithuania, different breeds of turkeys differ in weight, regularity, physique and feather colour. Bronze, White Breast and North Caucasian turkeys are the most common. Goose breeds differ in their biological characteristics. Before World War I, geese bred in Lithuania were called *chickens* and *colonies*. Later geese spread more frequently in Suwalki, Samogitia and Aukštaitija. Goose farms in our country were liquidated after the development of chicken broiler industry. The geese of the breed of chickens with more fluff have remained in geese farms specially developed for the maintenance of the gene pool in Russia and Ukraine. Colonies that were bred only in the eastern part of Lithuania, with less weight and productivity, disappeared completely. In Lithuania, there are various manure management systems used for chickens, broilers, turkeys and other birds: liquid manure, litter manure, litter and grazing. A more detailed description of the systems is given in section 2.3.

**2. Parameters used in the Tier 2 methodology:** there are many specific parameters that would be very costly to set national values ​​for, therefore they are limited to default values. In addition, many data are available in the national GHG reports[[91]](#footnote-91), [[92]](#footnote-92):

* Average annual population, thousands (1990-2017 Table 5-3. Average annual number of livestock population per year, thousands), average weight, kg: „Table 5-13. The average weight of poultry categories in 1990-2017“
* Periods of grazing and stay in barns: the period of grazing of geese, ducks and other bird categories in the barn lasts about half a year, and the grazing period is also about half a year.
* Parts of bird manure for litter without litter, litter, liquid manure, and sedimentation are shown graphically: Figure 5-8. Poultry manure production per animal waste in manure management systems.
* defined Nexcretion indicators for the whole 1990-2017 period: Table 5-41. Estimated N excretion rate for goats and poultry, kg N / head / yr and Table 5-42. Default N excretion for livestock categories, kg N / head / yr.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

Other required data:

* part of slurry that is stored (xstore\_slurry) and part of slurry transferred to biogas production (xfeed\_slurry) –according to the above information, it can be assumed that no poultry manure is transferred for biogas production, no information on storage of manure is provided;
* The share of solid manure transferred to biogas production (xfeed\_FYM) – according to the above information, it can be assumed that poultry manure will not be transferred to produce biogas.

All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values ​​are taken from Technical Guide or IPCC (version - 2006).

**3. Effectiveness of pollution abatement measures.**Under the agreement with EPA, due to a lack of time in this data collection phase, the review was limited to administrative, publicly accessible data.

**„Reibinių“ ŽŪB[[93]](#footnote-93)** according to the data planned to be sampled for EIA in 2016, the number of birds (broilers) was 62,580 units. The following general preventive measures are also applied to reduce unpleasant odours:

* feed with reduced protein intake;
* Reduces the area of ​​manure surfaces on the premises;
* abundant use of litter;
* manure in the berm will be covered with straw or film;
* The PEA area will be planted with a protective strip of trees from the side of the residential building.

The use of air pollution abatement measures for the relevant amount of chickens / broilers should be taken into account when calculating emissions.

**Audronės Jagminienės Krikštonių poultry farm[[94]](#footnote-94)** was opened in 2012. According to the 2014 IPPC edition, the breeding of chickens / broilers is carried out using the technology of the Belgian company Roxel. 270 000 chickens/broilers are grown at a time. The design capacity of the farm (7 sheds) is 1.620 million broilers per year. EM probiotic is used, which allows to reduce the release of ammonia and other unpleasant odors from the barn. According to the information provided by the manufacturers, ammonia release is reduced by 56% and odorous substances by up to 96%. The IPPC permit provides for the use of probiotic preparations in combination with feed, as well as for the reduction of manure-released odors by storing manure in berms, and covering it with film. The use of air pollution abatement measures for the relevant amount of chickens/broilers should be taken into account when calculating emissions.

**UAB ,,Jondara“ poultry farm [[95]](#footnote-95),** planned to grow and market chickens / broilers on the basis of the 2016 IPPC permit. According to the project task, it was planned to construct a poultry house, which will grow 1 152 000 broilers per year, i.e. 6 lots of 192 thousand units (weight of one broiler 2kg). The IPPC permit recommends the use of raw protein diets for each feed cycle - low-protein feed that reduces ammonia release from poultry manure. It is also intended to use probiotic preparations to reduce ammonia and other unpleasant odors by at least 50%. Thus, probiotics are planned to be used both for feed and for manure treatment. When calculating emissions into the ambient air, the use of the probiotic agent must be taken into account.

**UAB „Domantonių paukštynas” poultry farm[[96]](#footnote-96)** was registered in 2004. Since its launch until 2016, when the expansion was planned, the annual capacity of the poultry farm was 1,500,000 units of broilers. In 2016, the report of the PEA for the expansion of the activity was prepared, with the aim of producing up to 302,000 units of broilers in the facility. At the same time it was planned to increase the annual capacity of the poultry house to 1,963,000 units. broilers. According to the 2017 poultry house IPPC permit, manure is transferred immediately to farmers in order to minimize odors on the site.

In exceptional cases, due to unfavorable climatic conditions or restrictions on manure spread, the manure generated is transported to an open storage area of ​​4050 m3 and 1641.64 m2 of manure on the territory of the poultry house. The bulk of the manure is empty for most of the year, but if necessary (e.g. during the fertilization period from 15 November to 1 April, i.e. 4.5 months), the capacity of the manure is sufficient to accommodate the manure produced.

It is also stated that reducing nitrogen and phosphorus inputs to manure reduces the amounts of pure protein and phosphorus in feed. In view of these air pollution abatement measures, the calculated emissions should be reduced for the relevant bird population.

Based on the revised application for the amendment of the IPPC permit[[97]](#footnote-97), **AB Vilniaus paukštynas has** implemented a cyclone for particulate matter deposition. The odorous pollutants (odorants) emitted from boilers are trapped in water tanks (50% of the amount released). Water tanks are treated as part of a technological facility.

205 040 birds are grown at the same time in 22 poultry houses of Dusinėnų site, 13 poultry houses in Kalviškės site, correspondingly grow up to 118 230 birds. The 57 poultry houses on Rudamina can house 1484200 broilers. Incubation eggs from breeding birds kept at Kalviškės and Dusinėnai sites, chickens are hatched for meat production. Chickens for fattening, grow on average at 40 days in the sheds on Rudamina site. Protein-rich vitamins, micronutrients and macronutrients are balanced by the age and weight of the bird. The manure is transported from all sites for transhipment to the Rudamina transhipment site adjacent to the sewage treatment plant. The manure collected at the site is transhipped to farmers' transport and handed over to farmers under contract.

**AB „Vilniaus paukštynas“ Vilkiškių branch[[98]](#footnote-98)** started its activities in November, 2013. The company’s activities were carried out in two poultry houses (01 and 02), each had 7,400 places for laying hens and 1,000 seats for cocks (total 16,800 units per year). In 2016, the remaining three birds were built (03, 04 and 05). According to the company's modified IPPC permit for 2017, the company keeps 37,000 units of laying hens and 5000 units of cock. The permit also states that a reduced amount of pure protein is used in feed and that the birds are fed with a reduced amount of total phosphorus. Bird manure is not kept in the territory of the company and is transported directly from the poultry house (at the end of the growing cycle) to the manure storage facility of AB Kaišiadorių paukštynas. After evaluating the use of balanced feed, which helps to reduce the release of air pollutants and the transfer of manure to another company that keeps manure in a confined space, manure emissions from the sector concerned must be reduced.

**UAB „Vilkyčių mėsa“ and UAB „Vilkyčių paukštynas“[[99]](#footnote-99)**. In accordance with the IPPC permit issued in 2015, it operates 10 poultry houses with chickens for laying (design capacity is 362,000 chickens kept at the same time) and one breeding chicken (design capacity is 38,000 chickens kept simultaneously). The total capacity of the poultry house is 400,000 units. birds kept at the same time. The permit states that berm will be covered with reinforced film or filled with straw as this method reduces the odours. Also low in protein, nitrogen and phosphorus, a protein-adjusted diet that reduces ammonia release from bird manure is used. For controlling ammonia emissions, Bio Livestock probiotics should be used, which should reduce the amount of ammonia released from poultry houses and manure by up to 69%. The use of a probiotic spray to reduce ammonia and other unpleasant odours to 96% should also be used. The bird house will also use a system of chicken-rearing and manure collection on a regular basis, with its periodic removal into a closed storage facility that, according to BAT reference documents, reduces ammonia emissions by at least 58%..

In 2019 JSC UAB Vilkyčių paukštynas application for IPPC permit[[100]](#footnote-100) change includes the following pollution reduction measures:

* Pollution-reducing technology for hen keeping and manure management
  + Cages will be equipped with a cage housing system with manure removal conveyors and intensive forced ventilation. There is a longitudinal bar between each floor of the cage, on which hen feces fall and dry. The excrement is removed every 2-3 days directly from the shed to the transport trailer and removed from the shed. 1.4 BAT for intensive livestock farming Section 4.5.1 indicates that cage-type chicken housing systems, with vertical tier cages with manure conveyors and intensive air drying, reduce ammonia release by 70% to 88%.
  + The tunnel ventilation system with very intensive ventilation is designed in the poultry houses. The amount of fans is calculated for changes in air with a maximum of 12 m3 air per hour for each bird in the building. With this intensive ventilation, the manure that accumulates under the cages on the conveyors is dried to 40% humidity. The humidity of fresh manure is> 80%. This allows a significant reduction in manure volume, weight and emissions of air pollutants and odors.
  + Each shed is equipped with nipple drinkers for chickens - called drip watering. This prevents water from entering the manure, keeping it dry.
  + Manure will be removed from the poultry farm by covered vehicles, protecting the manure from precipitation and the release of additional air pollutants from vehicles.
* Nutrition management:
  + The feed for chicken used in Vilkyčių paukšynas is ~ 4-5% lower in protein compared to standard compound feed. A 1% reduction in the protein content of manure from bird manure reduces the ammonia content by 10%, and nutritional management reduces the ammonia emission from bird manure by about 40%.
* Use of probiotics to reduce ammonia emissions:
  + Probiotics used as ammonia-reducing agent - SCD Bio Livestock with 80% ammonia reduction efficiency

In view of all the above measures, emissions from the laying hens sector must be reduced.

**V. Sadaunyko poultry farm[[101]](#footnote-101)** planned to grow 425 520 units in accordance with the 2015 IPPC permit for the production of laying hens. The permit mentions that manure is removed from barn conveyors at least twice a week. his manure removal technology meets HELCOM Recommendation 14/4, reducing ammonia emissions to the air. The farm also uses a combination of low protein feeds optimized with amino acids and mineral supplements that are purchased from ‘Kretingos grūdai’. This reduces the release of nitrogen and phosphorus into manure. In assessing air pollution abatement measures, the emissions must be reduced for the respective number of laying hens.

**UAB „Mažeikių rugelis“ Ylakių paukštyno[[102]](#footnote-102)** 2019 metų patikslintoje paraiškoje TIPK leidimui pakeisti[[103]](#footnote-103) **n**umatoma išplėsti Ylakių paukštyno eksploatacinę veiklą ir padidinti Ylakių paukštyno projektinį pajėgumą nuo 126 138 iki 910 798 dėsliųjų vištų laikomų vienu metu. Ūkinės veiklos išplėtimo metu, kaip ir dabar, bus vykdomas dėsliųjų vištų auginimas, kiaušinių gamyba ir pardavimas. Esamoje Ylakių paukštyno GP teritorijoje vienu metu bus laikoma iki 126 138 dėsliųjų vištų (883 SG) ir 50 000 prieauglio (31,5 SG) , naujai suplanuotoje Ylakių paukštyno GP teritorijoje - iki 78 4660 dėsliųjų vištų (5492,6 SG). Viso bendrai abiejuose GP - 6407,1 SG.

The following preventive measures will be applied in the poultry farm to reduce ammonia emissions:

* Emission control technology for hen keeping and manure management:
  + Cages will be equipped with a cage housing system with manure removal conveyors and intensive forced ventilation. There is a longitudinal bar between each floor of the cage, on which hen feces fall and dry. The excrement is removed every 2-3 days directly from the shed to the transport trailer and removed from the shed. 1.4 BAT for intensive livestock farming Section 4.5.1 indicates that cage-type chicken housing systems, with vertical tier cages with manure conveyors and intensive air drying, reduce ammonia release by 70% to 88%.
  + The tunnel ventilation system with very intensive ventilation is designed in the poultry houses. The amount of fans is calculated for changes in air with a maximum of 12 m3 air per hour for each bird in the building. With this intensive ventilation, the manure that accumulates under the cages on the conveyors is dried to 40% humidity. The humidity of fresh manure is> 80%. This allows a significant reduction in manure volume, weight and emissions of air pollutants and odors.
  + Each shed is equipped with nipple drinkers for chickens, which is called drip watering. This prevents water from getting on the manure, keeping it dry.
  + Each shed is equipped with nipple drinkers for chickens - called drip watering. This prevents water from getting on the manure, keeping it dry.
  + The existing manure is equipped with a closed type - the walls and roof of the manure protect the manure from precipitation and moisture, which promotes anaerobic processes that produce ammonia. Closed manure also prevents odors from spreading to the environment.
  + All manure produced will be contractually transferred to manure processors so that manure will not be spread in the fields and therefore ammonia emissions from manure application
* Nutrition management:
  + The net protein content of feed used for chickens reared for poultry is ~ 4-5% lower compared to standard compound feed. A 1% reduction in the protein content of manure from bird manure reduces the ammonia content by 10%, and nutritional management reduces the ammonia emission from bird manure by about 40%.
* Use of probiotics to reduce ammonia emissions
  + Probiotics will be used as an ammonia-reducing agent. Once the planned economic activity has started, additional measures to reduce ammonia and odor emissions will be applied to the Ylakiai poultry farm, using the Pobiotic SCD Odor Away ™, which has an 80% ammonia reduction efficiency.

In view of all the above measures, emissions from the laying hens sector must be reduced.

**Co-opeartion „Alsių paukštynas“[[104]](#footnote-104)** According to the 2015 IPPC permit, it was planned to grow up to 2.093 million broilers a year. The permit describes the use of feed (cycles) for feed containing reduced amounts of pure protein and total phosphorus. Feeding rates will be established based on absorbable / existing nutrients and the use of feed supplements to improve feed efficiency and uptake and reduce nutrient levels in the manure and also ammonia emissions. In addition, there are no manure storage facilities on the territory of the Alsiu Paukštynas, at the end of each cycle, the accumulated manure is transported for further storage and use according to the contracts. Tree spreading and / or shrubs help reducing odour spread. Depending on the air pollution abatement measures listed, the emissions must be reduced for the relevant number of broilers.

The updated application for IPPC permit[[105]](#footnote-105) by **farmer A. Tunkevic Jociūnai** poultry farm in 2019 states that the poultry farm is planned to grow 60 000 broilers (24 SG). It planns to grow 360 000 boilers per year, which corresponds to 144 SG, vol. y. 6 lots of 60,000 pcs each. broilers. The broilers will be reared in two poultry houses of 31,000 units each. and 29,000 units. broilers. Broilers will house broilers on peat litter. The manure produced at the end of each broiler rearing cycle will not be stored in the PEA, but will be transported directly from the poultry houses to a manure storage facility owned by the Agrowill Group, a manure manager. The manure will be removed from the poultry farm by covered vehicles, protecting the manure from precipitation and the spread of additional air pollutants from the vehicles.

**Farmer Leonas Rutkauskas[[106]](#footnote-106)** started turkey breeding activities in 2006. According to 2016 EIA selection documents , the farmer raised 9 850 turkeys. In 2016, it was planned to increase the number of turkeys reared to 16 000 units. Based on the assessment, the following general prevention measures have been taken to reduce emissions to the environment and at the same time unpleasant odours:

* Feeding with reduced protein content in diet;
* Reduces the area of ​​dung surfaces in the premises;
* Heavily used litter.

There is a 750 m3 manure storage facility on the farm under the roof. At the end of one bird-rearing cycle, manure is transported from poultry houses to manure storage and stored until spreading. The manure was installed in compliance with the Minister of Environment of the Republic of Lithuania and the Minister of Agriculture of the Republic of Lithuania 14th July, 2005 Act no. D1-367 / 3D-342 on Approval of the Description of Environmental Requirements for Manure and Slurry Management[[107]](#footnote-107). Evaporation from the manure storage is minimal, because the manure is under the roof, the manure surface is covered with straw up to 10 cm. Such a layer of straw reduces odour to 60%. From 2006 onwards, for calculating emissions from the turkey sector, the use of air pollution abatement measures must be assessed for the number of birds concerned.

According to the data on applications for IPPC permits or modifications, the following **poultry farms are not subject to reduction measures:**

* According to the revised application for amendment of the IPPC permit[[108]](#footnote-108) in 2019, UAB Jondara does not apply pollution abatement technologies in the poultry house. It is planned to raise up to 220 thousand boilers in Micai per rearing cycle. The birds will be reared for up to 32 days: some (70,000 units) will be fished, the remaining 150,000 will be grown for up to 40 days. The Mica Bee farm has 6 rearing cycles per year, each lasting approximately 58 days. The broiler rearing cycle begins and ends practically simultaneously in all 7 poultry houses, i. y. all sheds are either full or empty at one time.
* **Petkevicius Company "PETKUS"[[109]](#footnote-109).** Currently in the shed no. 2 cultivated 30,000 broilers. It is planned to raise 33 000 boilers in the poultry house No.1. Birds are expected to change a maximum of 7 times a year, i.e. Maximum number of birds expected to be reared for both poultry houses: 63 000 x 7 times = 441,000.
* UAB "Šilų Ūkis"**[[110]](#footnote-110)** poultry farm. Production capacity: up to 2,400,750 broiler chickens per year or 330,000 chicken broilers at a time.
* **UAB „Agvika“ poultry farm[[111]](#footnote-111).** The poultry farm is planned to grow up to 134 thousand. units of broilers per rearing cycle. The birds will be reared for up to 32 days: some (50,000 units) will be fished, the remaining 84,000 will be grown for up to 40 days. The poultry farm has 6 rearing cycles per year, each lasting approximately 58 days. The broiler rearing cycle begins and ends practically simultaneously in all 7 poultry houses, i. y. all sheds are either full or empty at one time. The broiler rearing cycle consists of the combined duration of the rearing and prevention period. The duration of broiler rearing 4 to realization weight is 32 and 40 days. The duration of the preventive period depends on the duration of the cleaning and disinfection of the shed. The preventive period is calculated from the last day of dispatch of the chickens to the date of arrival of the first day-old broilers.

In the scope of this report, UAB Ilgai Bird Farm[[112]](#footnote-112) and Rumšiškių paukštynas UAB Dovainonys[[113]](#footnote-113) and Girelė[[114]](#footnote-114) Bird Farms applications for IPPC permits were analyzed, however, sources did not anticipate changes in the applied pollution abatement technologies.

Ducks and geese are grown in small farms in Lithuania, one of which is **Marius Steponavičius bird farm**[[115]](#footnote-115). According to the farmer, the most common duck species in Lithuania are the Peking duck. Chak-Kempbel breed and others brought from abroad are also common in the country, because there is no breeding or breeding farms in Lithuania. In 2016, the farmer traded Polish goats of the Koludzka breed. All ducks and geese are brought from abroad, then grown and sold in Lithuania. However, there is no more available information, neither on the quantities produced nor on the application of air pollution abatement measures.

According to Republic of Lithuania 15th August, 1996 Act on Environmental Impact Assessment of the Proposed Economic Activity No. I-1495[[116]](#footnote-116), the environmental impact assessment must be carried out:

* For chickens less than 60,000 but more than 20,000;
* Less than 85,000 but more than 20,000 broilers
* Ducks - 12,000 or more;
* 15,000 or more for turkeys up to 70 days old;
* For turkeys up to 133 days - 7 500 or more;
* Goose - 7 500 or more;
* For quails - 20,000 or more;

Environmental Impact Assessment is required by law only if there are 85,000 or more places for storing chickens and 60,000 or more hens are kept. According to the Minister of Environment of the Republic of Lithuania, 15th July, 2013 Act No. D1-528 "on the adoption of rules for the adoption, amendment and revocation of integrated pollution prevention and control" IPPC permit for poultry farming with more than 40 000 places is mandatory.

In Lithuania, laying hens and broilers are the most popular species of hen. However, the rearing of these poultry takes place in small and medium-sized farms that are very popular in the country. Turkeys, ducks, geese, quails and other birds are also grown in small farms in Lithuania, only in very small quantities compared to chickens and broilers. It is not possible to identify specific farms in the country which are the main producers of birds, as there are many farms with similar production volumes. In addition, the number of farmed birds changes each year, IPPC documents are replaced, new bird-breeding activities are launched, EIAs are selected and so on. is very difficult to track the main grower of each bird sector in the Lithuanian market, and it is possible that it changed every year since 2000.

It is also important to take into account that the selection of IPPC and EIA for turkeys, ducks, geese and quails is only necessary for the production of relatively large quantities. In Lithuanian farms, the quantities produced by these birds do not exceed the limits set by the law, so they do not need IPPC or selection and the availability of more detailed information is not sufficient.

**Results of the survey of Lithuanian farms**. In order to find out the prevalence of manure management and pollution reduction technologies, a survey was carried out on poultry manure management to Lithuanian farms. The questionnaire was completed by 2 respondents who indicated that no pollution reduction measures are applied on the farm.

Respondents' activity was too low to assess the prevalence of national pollution reduction technologies. The results of the survey are provided in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.B.4.G.I, II, III, IV).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

**The data collected by AIVIKS** on the reduction of pollutants due to the applied pollution abatement measures are provided (see MS Excel file Žemės ūkio sektorius 2019 11.xlsX, sheet 3.B.4.g.i, ii, iii, iv). The actual decrease in tonnes of ammonia according to AIVIKS data is only in 2014 in this sector. ‘Dovainonių paukštynas’ Girelė, Morkūnai, Kairiškiai, Prozariškės and Papačiai in 2014 metais has applied ammonia reduction measures, so the actual reduction of pollutants in the sector has been recorded in AIVIKS. Applied reduction measures:

* Regular control of protein and phosphorus in feed;
* Optimization of ventilation systems.

The number of birds reared by these companies is presented in an Excel file, which is an integral part of this report. When evaluating emissions, both the data presented in this report and the AIVIKS data in the Excel appendix should be taken into account.

## Manure management – Other animals (NFR 3.B.4.h)

Input data for 2000-2017 required for emission estimation at Tier 2 level in sector 3B4h Management of other livestock manure.

**1. Brief description of the processes:** Rabbit breeds in Lithuania are classified as large (gray giants, white giants, German spotted giants, French rams), medium-sized (large light silver, big chinchillas, Mecklenburg-Vorpommern, English rams, Burgundy, Vienna, New Zealand, California, Japanese, Thuringia, White Balts), small (small chinchilla, deilinar, rion, fire), dwarf (dwarf rams, dwarfs), satin, shorthair (reed), long-haired (angora). In addition to rabbits, this sector includes fur animals and nutria in Lithuania.

Other livestock manure management systems in Lithuania: liquid manure and litter manure. A more detailed description of the systems is given in section 2.3[[117]](#footnote-117).

**2. The parameters should use in the Tier 2 methodology:** there are many specific parameters that would be very costly to set national values ​​for, therefore they are limited to default values. In addition, many data are available in the national GHG reports[[118]](#footnote-118), [[119]](#footnote-119):

* Average annual population, thousands (1990-2017 Table 5-3. Average annual number of livestock population per year, thousands; average weight, kg);
* As it is difficult to estimate the average weight of small animals (fur animals, nutrients and rabbits), the categories were marked "NA" - "not available" or data not available.
* Information on manure management systems: 100% of rabbit manure has been stored for the entire 1990-2017 period, 100% of manure was also stocked during the period 1990-2006, then distributed between storage and liquid manure management systems. Between 1990-2017 100% of nutria manure was stored. Table 5-39. Manure production per animal waste management systems,%.
* Defined Nexcretion indicators for the whole 1990-2017 period: Table 5-42. Default N excretion for livestock categories, kg N / head / yr.
* In Guidebook 2019 adds mmdig\_TAN and mmdig\_N to step 11. These indicators are calculated in NFR 5.B.2 (formulas 6 and 7 respectively);
* It should be noted in Guidebook 2019 EF\_(storage\_effluent\_N). Indicator was removed.

Other required data:

* part of the slurry transferred to biogas production (xfeed\_slurry) – according to the above information, it can be assumed that manure from other animals is not transferred for biogas production, in order to obtain more accurate information, farm surveys are needed;
* The share of solid manure transferred to biogas production (xfeed\_FYM) – according to the above information, it can be assumed that manure from other animals is not transferred to produce biogas, and farm surveys are needed for more accurate information.

Note: the contribution of the other livestock sector to total emissions is very low compared to cattle categories, so emissions from other animals in the GHG report are calculated at Tier 1 level.

From the above data, it can be understood that the grazing time of other animals is 0, and according to the Technical Manual (version - 2016) other animals in the barn spend 365 days a year, and such assumptions should be taken into account when calculating emissions. All other data and emission factors are used, as stated in the Technical Manual (version - 2016), default values ​​are taken from Technical Guide or IPCC (version - 2006).

**3. Effectiveness of pollution reduction measures:**Under the agreement with EPA, due to a lack of time in this data collection phase, the review was limited to administrative, publicly accessible data.

**UAB „Fur Farm LT“[[120]](#footnote-120)** was registered in December, 2010.According to the Environmental Impact Assessment Report of the “Existing Fur Animals Farming Farm Modernization and Development” of the Planned Economic Activity in 2015, it was planned to increase the number of minks to 200 000 animals: up to 56 000 females and up to 8 500 males. In order to reduce the spread of pollution (though not reaching the limit values) to the surrounding territories, the territory was intended to be fenced and planted with trees in order to create a natural barrier to the emitted odors. The EIA report also describes recommended measures for reducing air pollution for the company:

* PHODE Laboratories (France) product NORASYSTEM® is of organic (botanical) origin (easily degradable - biodegradable) and is really effective (more than 1000 plants / sites / cleaning plants installed in Europe). The base of the system is that the product (complex organic material set) molecules react (chemically) with bad odor molecules (chemical reaction occurs rather than masking the smell) and they mineralize within 2-3 seconds (turns into salt);
* Or probiotics could be used - microbiological means are the most effective ways to remove odors. It is a special natural microflora-probiotic composition. At the same time, the prevention of harmful odors is carried out. For example, the timely use of probiotics in agriculture, and more specifically in livestock complexes, prevents the introduction of manure and slurry into pathogenic microflora, reduces ammonia release, leading to a significant reduction in odors. Probiotics are also used for processing livestock farms and bedding, inserted into water and feed.

It is assumed that one of the proposed measures is applied in the company, in which case the use of air pollution abatement measures must be taken into account in the calculation of emissions from the sector and the emissions reduced accordingly. Precise data on the amount of minks grown before 2015 are not provided.

**UAB „Minkirta“[[121]](#footnote-121)** On the basis of 20th December, 2016 EPA tiSelecon Conclusion "on breeding and breeding activities of soft animals (minks) in Smilgaičio g. 10, Ruseiniai village, Jonava old town, Kėdainiai district, grows 22 000 of minks in a year. The animals are kept in cages without litter (mink manure is classified as dense manure). Approximately 2,400 m3 of manure is produced per year on average. The manure is stored under the cages on concrete, asphalt, sand or other, wetted base with non-woven textile material waterproofing, so in this particular case the manure formed falls on a hard-covered and environmentally insulated surface that is manually cleaned and delivered to manure in an automated way. The manure is covered and can hold up to 6 months of manure. Accumulated manure is given to farmers who use it as fertilizer for fertilizing the fields. Taking into account that manure is covered, air pollution is reduced and this has to be evaluated when calculating emissions.

**Dainius Vaškelevičius farm[[122]](#footnote-122).** In 2016, the farmer planned the establishment of a rabbit farm and, according to the environmental impact assessment, planned to produce 1200 units within five years. Selected rabbit breeds: Aries, California, Hypla - hybrid meat rabbit breed. Rabbits were planned to be kept in cages, the size of which depends on the breed of rabbits. Females that are raised for breeding are kept in one cage with two or three other females, males – separately, only one in a cage at the time. The breeding females of the rabbit are housed one by one in the maternal cages. Weaned single-family rabbits are kept in cages in groups of 6-8 for 90 days..

It is essential to maintain cleanliness at the place of storage in order to ensure the hygienic and veterinary requirements and the specificity of rabbit breeding. Planned daily maintenance of the farmer includes: cleaning of cages, removal of manure, cleaning of sticks and tumblers, monitoring of the condition of rabbits, inspection of rabbits and rabbit milk glands. Inspection of the cages for safety (no cracks, flies, protruding nails, etc.). and sanitation is carried out every ten days. Its flooring, ceilings, walls are cleaned with 3 percent. calcined soda solution, and drinkers and other small items should be stored in a solution for 1-1.5 hours. time. Food residue are planned to be collected daily and stored in a stack specially designed for manure.

The handling of faces will be carried out in accordance with the Ministry of Agriculture of the Republic of Lithuania and MoA in 14th July2005 Order no. D1-367 / 3D-342 "On the Approval of Environmental Requirements for Manure Management of Manure" (current version), the Rules and Advice of Advanced Farming of the Ministry of Agriculture of the Republic of Lithuania (current version). The stack is installed so that surface and underground (ground) water cannot enter from adjacent areas and manure is released into the environment. Anticipated odour reduction measures - cleaning and disinfection work, ventilation.

Assessing ventilation, frequent cleaning of cages, removing manure, storing it in a special stack, from which it does not come into the environment, can ensure that air pollution abatement measures are applied and when calculating emissions this must be taken into account.

Minks, nutria, foxes, rabbits, chinchillas can be attributed to the sector of 3B4h "Other livestock manure" in Lithuania. Unfortunately, information was only available on minks and rabbits. According to Lithuanian Republic 15th August, 1996 Act on Environmental Impact Assessment of the Proposed Economic Activity No. I-1495, environmental impact assessment must be carried out on rabbits of 5 000 or more; chinchillas - 25,000 or more; for weavers / pigs: 3 500 or more; foxes - 1,500 or more; for nutrias - 2,500 or more. Because apart from the minks, farmers do not keep such large quantities of fur animals, there are no EIA screening documents available for review. More detailed information could be obtained through surveys, but at this stage surveys are not conducted.

**Results of the survey of Lithuanian farms.** In order to find out the prevalence of manure management and pollution reduction technologies, a survey of sheep manure management companies was distributed to Lithuanian farms. No respondents completed the questionnaire.

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

# Crop production and agricultural soils (NFR 3.D)

## European Union legislation on fertilization

**Directive 2010/75/ EU of the European Parliament and of the Council on industrial emissions**[[123]](#footnote-123)(integrated pollution prevention and control) claims that manure application contributes significantly to air and water pollution. In order to achieve the objectives set out in the Thematic Strategy on Air Pollution and Union legislation on water protection, it is necessary for the Commission to review the need for the best available techniques for controlling these emissions.

**Eur Directive 2016/2284 of the European Parliament and of the Council**[[124]](#footnote-124) on the reduction of certain atmospheric pollutants in the Member States and amending Directive 2003/35 / EC and repealing Directive 2001/81 / EC. The second subparagraph of Article 6 (2) of the Directive refers to emission reduction measures. Member States may reduce ammonia emissions from livestock manure by applying the following methods:

* reduces the amount of pollutants emitted by arable land and grassland where slurry and solid manure is used, using methods that reduce emissions by at least 30% compared to the method described in the Guidance Document on Ammonia and meet the following conditions:
  + Manure and slurry are spread considering expected need for nutrient nitrogen and phosphorus in the fertilized crops or meadows, as well as taking into account the amount of nutrients in the soil and in the fertilization of the soil with other fertilizers;
  + Manure and slurry are not released if the fertilized land is impregnated, flooded, frozen or covered with snow;
  + In the meadow, slurry is spread by using a trailed hose, a trailed carriage or a shallow or deep injection.;
  + Manure and slurry spread on arable land is added to the soil within four hours of spreading.

**Regulation of the European Parliament and of the Council 2003/2003 on fertilizers[[125]](#footnote-125)** This Regulation applies to products placed on the market as fertilizers known as 'EC fertilizers'. The regulation is aimed at controlling the market of fertilizers so as not to endanger human health. Ammonium nitrate EC fertilizers with high nitrogen content should meet certain characteristics to ensure that the fertilizer is non-hazardous.

**European Council, 12th June, 1986 Directive no. 86/278 / EEC**[[126]](#footnote-126) „on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture". The purpose of this Directive is to regulate the use of sewage sludge in agriculture in order to prevent its harmful effects on soil, vegetation, fauna and humans and to promote its correct use.

## The legislation of the Republic of Lithuania Acts that regulate fertilization

**Minister of Environment of the Republic of Lithuania and Minister of Agriculture of the Republic of Lithuania 14th July, 2005 Act no. D1-367 / 3D-342[[127]](#footnote-127)** „on approval of a description of the environmental requirements for manure and slurry management". The act describes the requirements for the application of manure and slurry to fields.

**Minister of Agriculture of the Republic of Lithuania 16th July, 2004 Act no. 3D-431[[128]](#footnote-128)** „**on Good Farming Practice Requirements.** The requirements of good farming practice establish good farming practices for the implementation of surface water body coastal protection strips, water protection and protection against erosion, contractual stocking densities and manure management, use of plant protection products, soil quality protection, biodiversity and conservation of natural resources, meadows management requirements, farmland environment management principles, water and animal welfare standards.

**Lithuanian Fertilizer Supplied to the Market in 2018 law project[[129]](#footnote-129)**. The purpose of this law is to establish that the fertilizers placed on the market of the Republic of Lithuania comply with the requirements laid down in legal acts ensuring the quality of plants, food and environment.

**Minister of Environment of the Republic of Lithuania 29th June, 2011 Law no. 349** **[[130]](#footnote-130)** „on the approval of the normative document LAND 20-2005 requirements for the use of sewage sludge for fertilization and recultivation“.

The purpose of LAND 20-2005 for the use of sewage sludge for fertilization and recultivation is to regulate the use of sewage sludge in agriculture, forest nurseries, energy crops (fast growing plantations for direct use for biofuel production), orchards and shrub plantations, plantation forest plantations or for the cultivation of gemstones planted in former agricultural land, for the rehabilitation of damaged areas (such as quarries, depleted peatlands, landfills, roads, etc.) so as not to adversely affect groundwater, soil, vegetation, animals and humans.

**Minister of Environment of the Republic of Lithuania 18tg April, 2011 Act no. D1-327 [[131]](#footnote-131)** on the approval of a description of the interim environmental requirements for the use of biodegradable waste for fertilization. The aim of the description of the interim environmental requirements for the use of biodegradable waste for fertilization is to regulate the use of biodegradable waste for fertilization in agriculture in order to avoid adverse effects on human health and the environment.

## Inorganic N-fertilizers (includes also urea application), NFR 3.D.a.1

Input data for 2000-2018 needed for emission estimation at Tier 2 level in 3Da1 Soil fertilization with inorganic nitrogen fertilizers.

**1. Brief description of processes:** Nitrogen for plants is the most important nutritional element with the greatest impact on yield and quality**.** Nitrogen reserves in the soil lead to a deficiency of this chemical element, in some cases, surplus to the plant. Mineral nitrogen plays a major role in the majority of agricultural crops. About 90-98% of the mineral nitrogen from the soil is washed out in the form of nitrates. According to research data conducted in Lithuania, in different years and at different times of year, the losses of nitrogen in separate Lithuanian zones range from 14.4 to 126 kg ha – 1[[132]](#footnote-132). Most of the nitrogen is leached from soils with a light granulometric composition, and the least from heavy granulometry. According to research data, most of the arable soil is lost during the autumn and winter periods, as most of the precipitation in Lithuania is currently low, and the majority of soils in this period are without vegetation cover[[133]](#footnote-133). Inorganic nitrogen fertilizers are widely used in Lithuanian agriculture to improve soil quality, but only recently (after joining the European Union) have started to explore fertilization techniques to reduce emissions to the air.

**2. Parameters used in Tier 2 methodology:** Between 1990 and 2005 (inclusive) only information on total inorganic fertilizer consumption in Lithuania is available from different sources, which means that only Tier 1 method can be used. However, the effectiveness of the mitigation measures in the scientific literature for the different inorganic fertilizers is different, so it would be inappropriate to apply them during this period. It is only appropriate to apply the effectiveness of mitigation measures in the calculations from 2002 onwards. when it is possible to use Tier 2 level and data on individual inorganic fertilizer consumption in Lithuania (Table 2.3). The total amount of inorganic fertilizers consumed in Lithuania according to the data of the International Fertilizer Industry Association[[134]](#footnote-134) is presented in Table 2.1, and according to the Food and Agriculture Organization of the United Nations (FAO)[[135]](#footnote-135), [[136]](#footnote-136) (see MS Excel file Žemės ūkio sektorius 2019 11.Xlsx, sheet 3.D.a.1). It should be noted that International Fertilizer Industry Association provides data on fertilizer consumption by product, however information gaps are found in said database.

* According to the data provided in GHG report Lithuania should be attributed to wet climate condition under the boreal and temperate climate zone as provided in the 2006 IPCC Guidelines. The reason for selection of this value is that Lithuania is situated in the temperate climate zone, i.e. north of subtropics and south of subarctic area, and its climate is characterized as wet, i.e. precipitation exceeds evaporation.
* Soil pH data for agricultural areas was obtained from the Agrochemical Research Laboratory (Lithuanian Agrarian and Forestry Center). Based on their research, weighted acidity level average was calculated based on data from 6 regions (45 thousands of hectares in total). Weighted average PH=6,18. It should be noted that Guidebook 2019 soil with PH=7 or higher is considered as acidic (the analysis intervals do not match). Hence it is recommended to make an assumption that soil with PH=7 or more comprises 29.7% of total agricultural land[[137]](#footnote-137).

**3. Effectiveness of pollution abatement measures:** Information on the use of air pollution abatement measures in this sector is not registered in Lithuania. However, there are scientific articles that can be used to determine the effectiveness of mitigation measures.

Bouwmeester and other authors conducted a study [[138]](#footnote-138) in the greenhouse simulating various microclimate conditions with the aim of determining factors that affect ammonia evaporation after soil fertilization with urea. The study found that evaporation of ammonia at 7 days after fertilization for the first time of 1 cm of rainfall is about 40%, but after 4 cm of rainfall, emissions are reduced and are only 13%. This means that more rainfall reduces ammonia emissions, so it is necessary to evaluate or always fertilize with rain. In the same study, higher nitrogen losses were observed at 8% when soil moisture increased from 21% to 31%. This again indicates that fertilization is required when the soil is not too wet or after rain.

Sanz-Cobena and other authors[[139]](#footnote-139) have investigated the use of inhibitors to reduce ammonia emissions from urea fertilizers. In the course of the study, 10 mm of water was added immediately after application of the urea on the soil, in order to insert the pollution into the top layer of the soil. Total ammonia emissions during the entire observation period (36 days) were found to be 17.3 ± 0.5 kg NH3-N ha − 1 for urea fertilization and N- (n-butyl) triphosphoric tripamide (NBPT) for urea and inhibitor. 10.0 ± 2.2 kg NH3-N ha − 1. In the first case, emissions accounted for 10.1% of distributed urea-N, and in the second case 5.9%. Thus, emissions were reduced by almost half.

According to research by Jones and other authors [[140]](#footnote-140), by the introduction of 4cm of urea into the soil, urea-N emissions were 5% while it was equal to 17% when the fertilizer was spread on the soil surface.

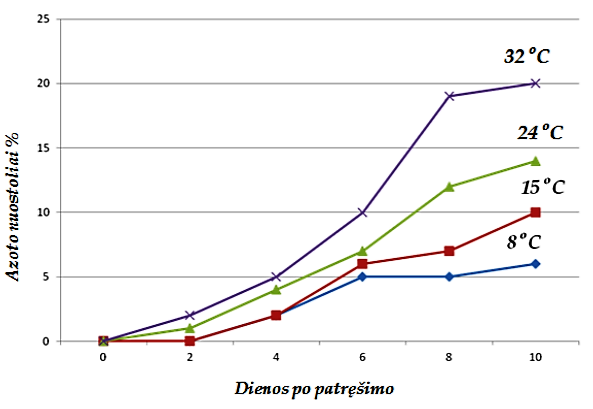
Figure 3 Nitrogen losses in soils with different granulometry composition due to denitrification (Jodaugienė 2017)

According to the data of Lithuanian scientists (Jodaugienė 2017), nitrogen loss due to evaporation is possible during the denitrification process, when nitrate nitrogen transforms into nitrogen oxides (NO; N2O) and free nitrogen (N2) at low temperature, acidic or very alkaline soil in case of excess moisture content in the soil (see Figure 3).

|  |  |
| --- | --- |
| **Soil granulometry composition** | **Nitrogen losses due to denitrification** |
| Sand | 11-25 |
| Clay | 16-31 |
| Peat | 19-40 |

Nitrogen losses can also be caused by improper use of amide nitrogen fertilizers. In all cases, plant amide nitrogen fertilizers must not be fertilized without application to soil when the ambient temperature is above 15 (Figure 4).

Figure 4 Nitrogen losses due to evaporation without urea being added to soil (Jodaugienė 2017)



In Lithuania, AB Achema produces and markets slow-acting urea fertilizers[[141]](#footnote-141). Urea Litfert StabillioN belongs to a slow-acting nitrogen fertilizer. The advantage of slow-acting nitrogen fertilizers is that their nutrients are absorbed more slowly and gradually. This improves the uptake and use of fertilizers, reduces leaching and evaporation losses, and reduces the negative impact on the environment. Urea Litfert StabillioN is a concentrated Nitrogen Fertilizer with Stabilizer that keeps urea in the soil unchanged and improves urea penetration into the plant root area and reduces nitrogen loss. Taking into account that such products are produced and sold in Lithuania, it can be concluded that there are farms using this urea and reducing air pollution compared to the use of conventional fertilizers.

**Results of the survey of Lithuanian farms.** In order to find out the conditions for the use of inorganic nitrogen fertilizers and the use of the inhibitor, a survey was distributed to Lithuanian farms. The questionnaire was completed by 10 respondents. The survey collected data on fertilizer application technologies and conditions for 31.9 thousand hectares in the period 2005-2018 (or 2.3 thousand hectares per year on average).

Survey data collected may be used to account for atmospheric pollutants, but we estimate that respondents' activity was too low to objectively assess the prevalence of applicable pollution abatement technologies across the country. The results of the survey are included in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.D.A.1).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Animal manure applied to soils (NFR 3.D.a.2.a)

Input data for 2000-2018 needed for emission estimation at Tier 2 level in sector 3.D.a.2.a Soil fertilization for livestock manure.

**1. Short description of processes:** This sector is closely related to sectors 3B, as almost all the same companies and farmers transfer manure to field fertilization. However, not all the same companies and farms provide data on used air pollution abatement measures. This section therefore provides information on the enterprises and farms described in sector 3B that provide information on the use of air pollution abatement measures in relation to emissions from manure used for fertilization.

In agriculture, the use of probiotic compositions in manure and slurry prevents the occurrence of pathogenic microflora, SRM, reduces ammonia release, resulting in a significant reduction in odours. Probiotics are used to treat livestock farms and bedding, as well as storage facilities, as well as into drinking water and feed[[142]](#footnote-142). In Lithuania, the scientific and applied research of probiotic compositions is carried out by:

* Lithuanian Veterinary Academy Baisogala Institute of Animal Science;
* Lithuanian University of Agriculture;
* Institute for Environmental Management and Audit.

The results of the research are fully correlated with the results obtained by research institutes in Japan, USA, Austria and Poland (Methodological Guidelines for Odor Management 2012).

The following NH3 abatement measures are also available for the sector:

* Insertion of manure into the soil (the efficiency of this tool for each type of manure and insertion provided)
* Time to insert manure to reduce NH3 release;
* Dilution of manure;
* Use of additives for manure;
* Favourable fertilization conditions are described which reduce the release of NH3 into the air.
* Not exceeding the amount of protein in the feed;
* Adding probiotics to manure or diet;
* Reducing manure pH;
* Reducing manure temperature;
* Separating urine from manure.

**2. Parameters used in Tier 2 methodology:** If the Tier 2 methodology is used to calculate ammonia emissions in sector 3B then in the 3Da2a sector when calculating emissions Napplied must be calculated as the sum of mapplic\_slurry\_N ir mapplic\_solid\_N (step 11) New data for this sector is not required based on the Technical Guide (version 2016) methodologies. Data and calculations for sector 3B are enough.

**3. Effectiveness of pollution abatement measures.** In Lithuania, the Idavang Group carries out pig breeding activities and services in four companies:

* „Idavang“, managing 7 pig farms,
* „Idavang Kepaliai”, managing 3 pig farms,
* „Idavang Pasodėlė”, managing one pig farm and one boar farm.

According to the Corporate Social Responsibility Report of the Idavang Group of 2017[[143]](#footnote-143) , the group of companies in Lithuania grows 0.5 million pigs. According to the 2013 report, the Group has grown on average 360,000 pigs, 160 thousand piglets and 17 thousand sows. The Group has a **fractionation unit that separates the thick slurry from the liquid** [[144]](#footnote-144), , which is means of reducing air pollution, as the fields are fertilized separately using liquid and thick fractions (Figure 1). Idavang aims to improve the state of the environment – after acquiring the Kalvarija complex in 2010 the company has purchased the mobile manure separation device MILSTON 50B, which is used for the separation of the solid fraction if necessary.

**A. Leščinskas**[[145]](#footnote-145) started a livestock business in 1998, but kept only 8 units of cattle, later increasing to 10. According to the data of 2012, the farmer kept 130 units of suckler cows and 230 units of calf. According to the 2016 EIA assessment, the farmer planned keeping 110 suckler cows and 170 calf. The EIA assessment discusses the use of probiotic preparations (Penergetic-k), which allows to reduce not only the emissions but also the formation of odours by fertilizing the soil with manure.

**Audronės Jagminienės Krikštonių poultry farm**[[146]](#footnote-146) was opened in 2012. According to the 2014 IPPC edition, the breeding of chickens/broilers is carried out using the technology of the Belgian company Roxel. 270 000 chickens / broilers are grown at a time - the designed capacity of the farm (7 sheds) is 1.620 million broilers per year. EM probiotic is used in the birdhouse, which allows to reduce the release of ammonia and other unpleasant odours from the barn. According to the information provided by the manufacturers, ammonia release is reduced by 56% and odorous substances by up to 96%. The IPPC permit provides for the use of probiotic preparations in conjunction with feed, which reduces the emission of manure by fertilization. The manure is handed over to the farmers for fertilization under the signed contracts.

**UAB ,,Jondara“ poultry farm** [[147]](#footnote-147) planned to grow and chickens/broilers on the basis of the 2016 IPPC permit. According to the project task, it was planned to construct a poultry house, that would grow 1 152 000 broilers per year, i.e. 6 lots of 192 thousand (weight of one broiler 2kg). The IPPC permit mentions the use of raw protein diets for each feed cycle - low-protein feed that reduces ammonia release from poultry manure. The use of probiotic preparations to reduce ammonia and other unpleasant odours by at least 50% is also intended. **Probiotics were designed to be used with both feed and manure treatment.** When calculating emissions to the ambient air from manure application, the use of the probiotic agent and the reduced protein diet used must be taken into account. Accumulated manure in manure is given to other operators for field fertilization.

**„Reibinių“ ŽŪB**[[148]](#footnote-148). According to 2016 information sampled for EIA, the number of birds (broilers) kept in **‘**Reibiniai**‘**  was 62,580 units. Also, in order to reduce the spread of unpleasant smells from manure spreading fields, various complex measures are envisaged in EIA selection. For example:

* Fertilization will only take place when the wind does not blow towards the nearby population. The manure is inserted immediately after spreading, but not later than 24hours;
* The best conditions for spreading manure are selected when the air swells high above the ground, especially on a sunny, windy day, which usually comes after a cloudy windy night, when the odour is quickly dispersed;
* Another good condition is a very damp and windless day or a quiet evening. Then the smell does not diffuse and does not spread towards the population;
* No more than 50 t / ha of fertilizer will be applied in the vicinity of the living environment;
* Fertilization (including insertion) will be completed by Thursday evening. The manure will not be spread on Fridays, weekends and holidays;
* Loaders will be loaded without overfilling. There will be no road contamination, and if it is not avoided - cleaned.
* Dredgers with plate spreaders are only used away from the dwelling, and manure is spread as close to the ground as possible.

These applied air pollution abatement measures must be taken into account when calculating emissions from the sector when manure is applied.

**Reibinių ŽŪB, UAB „Vilkyčių mėsa“ ir UAB „Vilkyčių paukštynas“,** **Ūkininkas Leonas Rutkauskas, AB „Vilniaus paukštynas“ Vilkiškių padalinys, Ūkininko V. Sadaunyko paukštynas, Kooperatinė bendrovė „Alsių paukštynas“** also uses a reduced protein diet - more information in section 2.7.

**Results of the survey of Lithuanian farms.** In order to find out the technologies, conditions and probiotic use of livestock manure fertilizers, a survey was distributed to Lithuanian farms. The questionnaire was completed by 7 respondents. The survey collected data on fertilizer application technologies and conditions for 798.3 thousand hectares in the period 2005-2018 (or 57.0 thousand hectares per year on average).

Survey data collected may be used to account for atmospheric pollutants, but we estimate that respondents' activity was too low to objectively assess the prevalence of applicable pollution abatement technologies across the country. The results of the survey are provided in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.D.A.2.A).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

**According to AIVIKS system**, the actual reduction of particulate matter in this sector was recorded in 2017, as farmer Audrius Juška installed cyclone. According to the Technical Manual (version - 2016), the particulate matter in 3Da2a "Soil fertilization in livestock manure" is not calculated. Only NH3 and NO emissions are assessed in this sector. In the following year, there is no reduction in emissions or no data available under the system. The data collected from the AIVIKS system are presented (see MS Excel file Žemės ūkio sektorius 2019 11.xlsX, sheet 3.D.a.2.a).

**Analysis of pollution sources.** The Tier 1 EF in the Technical Guide is based on a study by Stehfest and Bouwman[[149]](#footnote-149). However, the specified source does not provide any specific measurement data, but provides a link[[150]](#footnote-150) to the source from which the data can be downloaded, but has been removed[[151]](#footnote-151) from the specified page and is therefore not available.

At Tier 2 level, EF factors are not provided, as sector 3.B data can be used.

A summary of the analysis of sources of pollution factors is presented in the conclusions (see Chapter 5).

## Sewage sludge applied to soils (NFR 3.D.a.2.b)

Input data for 2000-2018 needed for emission estimation at Tier 2 level in 3.D.a.2.b Soil Fertilization with Sewage.

**1. Brief description of processes:** In Lithuania, municipal sewage sludge is used as a fertilizer for soil improvement. The 2019 GHG report [[152]](#footnote-152) (page 293) provides information on the amounts used and the assumptions made for improving the soil when using sludge. As there is no newer data on this sector, the same assumptions should be followed.

**2. Parameters used in Tier 2 methodology:** The amounts of sludge used for soil fertilization during the period under review are kept by the Environmental Protection Agency and are therefore not reported.

**3. Effectiveness of pollution reduction measures:** Under the agreement with EPA, due to a lack of time in this data collection phase, the review was limited to administrative, publicly accessible data.

D. King conducted a scientific study[[153]](#footnote-153), to determine the release of N emissions by spreading sewage sludge and inserting it into soil. During the 18-week observations, the scientist found that by adding sewage sludge to the soil, losses of gaseous N are 16-22%, while spreading on soil is 21-36%. Thus, emissions from sewage sludge were approximately 24-39% lower than those after spreading.

The introduction of sewage sludge into the soil is the only known air pollution abatement measure in this sector. No more data on the effectiveness or application of the measure in Lithuania were found.

**Results of the survey of Lithuanian farms.** In order to achieve the technologies and conditions for the use of sewage sludge, a survey was distributed to Lithuanian farms. No respondents completed the questionnaire.

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Other organic fertilisers applied to soils (including compost), NFR 3.D.a.2.c

Input data for 2000-2018 needed for emission estimation at Tier 2 level in sector 3.D.a.2.c Soil fertilization with other organic fertilizers (including compost).

**1. Brief description of processes:** In Lithuania organic fertilizers or compost are used for soil fertilization. An extensive historical description of this activity is provided in the GHG 2019 report[[154]](#footnote-154), page 294. Regional Waste Management Centers have only started to receive green waste from 2011, and since 2013, compost production has been started, so the amounts of compost sold as fertilizer can only be known from 2013 onwards.

**2. Parameters used in the Tier 2 methodology:** specific compost quantities for soil fertilization are needed to calculate emissions. Regional waste management centers collect information on the quantities of compost sold as fertilizers, so the data for 2013-2017 can be obtained on request (no surveys are conducted at this stage). According to publicly available data - the annual RATCA reports, in 2016, 33,218 tons of compost was produced[[155]](#footnote-155), in 2017 - 46084 tons[[156]](#footnote-156), in 2018 - 56 904 tons[[157]](#footnote-157) of compost was generated. 2013-2015 quantity of compost produced data was extrapolated based on data of quantity of composted communal waste provided in RATCA reports. . In consultation with RATCA member Algirdas Reipis, Director of Alytaus Regional Waste Management Center UAB, it turned out that the entire compost produced by RATCA is marketed or distributed during the shares. Thus, the amount of compost produced in 2016-2017 is similar to the amount of compost used for soil fertilization.

**3. Effectiveness of pollution reduction measures:** the only known air pollution abatement measure in this activity is the insertion of compost into the soil instead of spreading.

Z. He and other scientists conducted a study[[158]](#footnote-158) to determine ammonia release from calcareous soil that was fertilized with sewage sludge and coconut palm compost. The study showed that ammonia emissions from compost to soil were reduced 5 times compared to spreading, and decreased by 150 times in the case of sewage sludge. More scientific literature on compost insertion efficiency in reducing ammonia emissions has not been found.

It is also necessary to find out how much compost has been added to the soil, and how much has been spread to determine which part of the sector can be used to reduce the effectiveness of air pollution abatement measures.

**Results of the survey of Lithuanian farms.** In order to find out the technologies and conditions for the use of other organic fertilizers, a survey was distributed to Lithuanian farms. The questionnaire was completed by 2 respondents, but none indicated the areas of cultivated land where fertilizers are used.

We estimate that the activity of respondents was too low to objectively assess the prevalence of applied pollution abatement technologies across the country. The results of the survey are provided in the appendix to the report (SEE AGRICULTURE\_COLLECTED\_DATA\_1990-2019\_EN.XLSX, SHEET 3.D.A.2.C).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Urine and dung deposited by grazing animal (NFR 3.D.a.3)

Input data for 2000-2018 required for emission estimation at Tier 1 level in sector 3.D.a.3 Urine and manure for grazing animal.

**1. Brief Description of the Processes**: This sector is closely related to sectors 3.B and 3.D.a.2.a, that contain information on grazing periods, livestock numbers, and air pollution abatement measures for that stock. According to BAT[[159]](#footnote-159) the incorporation of manure in the pasture is impossible. However, there are urea suppressants that prevent urea from turning into ammonia[[160]](#footnote-160). There are three types of these substances: fosforamidai There are three types of these substances: phosphoramides (added directly to the soil); yuka extract; straw (but can also increase NH3 release)[[161]](#footnote-161). Other known air pollution abatement measures for this sector include:

* Not exceeding the protein content of the feed;
* Adding probiotics to manure or diet.

**2. Parameters used in Tier 2 methodology:** based on the Technical Manual (version - 2016) when calculating NO emissions in this sector, applied has to be equal to mgraz\_N, in step 3, if emissions in sector 3B were calculated at Tier 2 level. NH3 emissions are already calculated in sector 3B and therefore do not need to be recalculated.

**3. Effectiveness of pollution reduction measures.** Air pollution abatement measures are applied in Lithuania, as illustrated by information in sectors 3.B and 3.D.a.2.a. Information is provided on animals that graze for a part of the year with reduced protein intake and probiotics. The number of animals covered by these measures is also provided. In order to obtain more information, a farm survey is needed. The survey was not carried out at this stage.

## Farm-level agricultural operations including storage, handling and transport of agricultural products (NFR 3.D.c)

Input data for 1990-2018 needed for emission estimation at Tier 2 level in 3.D.c Agricultural Product Management.

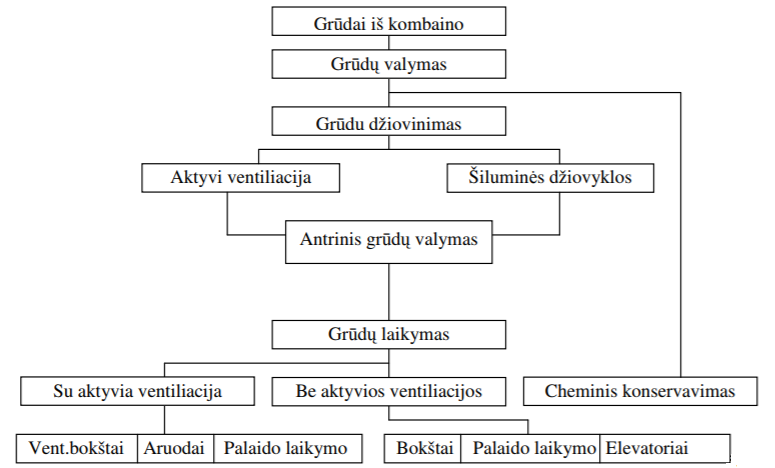
**1. Brief description of the processes:** In Lithuania, the activities discussed in this sector have been ongoing throughout the period under review and started much earlier, because the popularity of cereal is very high in the country. In many places in Lithuania, soil is suitable for agricultural production activities and climate conditions are also favourable. Winter cereals are the main cereals used to make bread; barley is often used in malt and for feed; oats are used for oatmeal and groats production and feed; winter and spring triticale are used as feed; summer cereal straw is used for feed and litter.

**2. Parameters used in the** Tier **2 methodology:**

* **Number of crops grown, units:**
  + According to the data of the Lithuanian Department of Statistics, 12 grain crops are grown in Lithuania (Winter cereals, Winter wheat, Winter triticale, Winter rye, Winter barley, Summer cereals, Summer wheat, Summer barley, Summer triticale, Summer rye, Oats, Buckwheat) and grass).
  + According to the Technical Manual 2016, cereals are not divided into winter and summer, so it can be said that there are cereals, wheat, triticale, rye, barley, oats and buckwheat - 7 grain crops and grass.
* **Area used to grow i-th cereal crops, ha.** The data of Statistics Lithuania is presented[[162]](#footnote-162) (see MS Excel file Žemės ūkio sektorius 2019 11.Xlsx, sheet 3.D.C).
* **The number of times the kth operation / action was performed with a particular (i-th cereal) a-1.** According to the 2016 Technical Manual, it is necessary to know how many years of cultivation, harvesting, grain cleaning and drying have been carried out with a particular type of cereal.
  + **Barley and oats:** cumulative prefill is followed by cultivation or ploughing; stubble and deep ploughing is required after cereals; harrowing and cultivation is completed in spring; harrowing is completed 3 or 4 days after sowing. Barley and oats are cultivated three times a year, despite the foreground, ploughing is completed in autumn and also in spring, together with harrowing (after sowing). Barley and oat are harvested once a year.
  + **Winter wheat and winter rye: prior-sowing and tillage**.
    - With fallow:
      * Black (for organic farms): intensive tillage - cultivation, harrowing and 3-4 weeks before sowing - ploughing; - (land cultivated 2 times);
      * Semi-black: tillage for late sowing, harvesting - ploughing with plough; - (land cultivated 2 times);
      * Those in use: after harvest - surface tillage, ploughing; - (cultivation 1 time)
      * Sideral: cultivation of siderate and their overgrowth. - (Land cultivated once)
    - Grass (2nd use, 1 year old): Removing the first grass - surface tillage, and 3-4 weeks before sowing - deep ploughing; - (tillage 2 times); When removing the second grass - after cutting the grass needs ploughing with a plough with an anti-slush 3-4 weeks before sowing. - (cultivation 1 time));
    - The ploughing time can be delayed using the packer during ploughing. The soil thus prepared can be sown immediately.
    - Other prior-sowing crops (early cereals, early potatoes and others): after harvesting 3-4 weeks before sowing - deep ploughing (the soil can be sown immediately after compacting the soil).
    - If potato crop was not weedy – it is enough to only suppress the soil surface. Immediately before the winter sowing, the soil is cultivated. When sowing with direct drills, this tillage can be eliminated; - (tillage 1-2 times).
    - Vowing is completed after sowing; wheat is harrowed in Spring. If harrowing is not completed, weeds can be removed by using herbicides. (cultivation of the land is completed 1-2 times) (Gatulienė and Krlepštienė, 2006).
    - Winter wheat and rye are cultivated 2-3 times a year: first cultivation is completed, ploughing is done before sowing and after sowing. Plowing is always completed before sowing and soil preparation is done after harvesting or the first tillage, not always under cultivation. Harvesting is done once a year..

The average moisture content of grain harvested in Lithuania is 20-25%. Therefore, grains should be prepared for storage. The grain delivered from the combine is first pre-treated. t is an important technological element that removes the most humid and storage-sensitive grain mass fraction - weeds, individual parts, straws and other larger impurities. After initial cleaning, the grain moisture decreases by 2-3% (Gatulienė and Krlepštienė 2006)[[163]](#footnote-163).

Figure 5 Grain Drying and Storage Scheme (Gatulienė and Krlepštienė 2006)



*Source:* Gatulienė ir Krėpštienė, 2006

Small amounts of grain can be dried in the sun - grains are spread on an even surface (best asphalted), at a thickness of 10 - 15 cm. One ton of grain requires an area of ​​about 15 m2. It has been found that by mixing these grains intensely on a sunny day, grain moisture is decreased by 4 - 6%, however it is difficult to dry many grains in the sun. This requires a lot of work, space and, most importantly, very favourable meteorological conditions. Even a little rain can turn a few days of labour into nothing (Gatulienė ir Krėpštienė 2006)179.

Thus, from the above information and the diagram in Figure 5, it can be seen that the grain is cleaned twice a year and is dried once a year.

According to the Technical Manual (version - 2016), Lithuania's climate is classified as wet (mid-latitude climate), so the calculations use Table 3.5 Tier 2 EFs for wet crop conditions and Table 3.7 Tier 2 EFs for agricultural crop operations, in kgha – 1 PM2.5, wet climate conditions tables.

**Particulate matter emissions in grain elevators.**

In order to evaluate PM emissions from grain elevators it is recommend to apply methodology provided in USA EPA AP-42[[164]](#footnote-164).

**Emission factors.** EFs depend on the type of elevator and type of transport loaded or unloaded. The emission factor provided in the aforementioned methodology were converted from imperial to metric system and shown in the table below.

Figure PM EMISSION FACTOR IN GRAIN ELEVATOR PROCESES, KG PER TONNE HANDLED

|  |  |  |
| --- | --- | --- |
| **Emission source** | **PM10** | **PM2.5** |
| Grain receiving (straight truck) | 0.0268 | 0.0045 |
| Grain receiving (hopper truck) | 0.0035 | 0.0006 |
| Grain receiving (railcar) | 0.0035 | 0.0006 |
| Grain receiving (ship) | 0.0172 | 0.0023 |
| Grain shipping (truck) | 0.0132 | 0.0022 |
| Grain shipping (railcar) | 0.0010 | 0.0002 |
| Grain shipping (ship) | 0.0054 | 0.0010 |
| Headhouse and internal handling operations | 0.0154 | 0.0026 |

Source: Compilation of Air Pollutant Emission Factors, Volume I. Stationary Point and Area Sources, Fifth Edition, 1995

It should be noted that EPA methodology states that PM10 and smaller emission on average comprise 25% of all particular matter emitted. Also, PM2.5 and smaller on average comprises 17% of total PM10 emissions.

Activity data. The recommended methodology relies on amount of grain handled (loaded or unloaded). Accordingly grain quantity disaggregation by transport type. However, the data on such detailed level is not publicly available – Lithuanian department of statistics provide data only on the grain balances. These reports show only grain quantity at the beginning and at the end of the year, but is missing the following data:

* Amount of grain stored in elevators;
* Amount of grain loaded and unloaded (this indicator is not equal to change of grain quantity change over the year);
* What type of transport is used to deliver grain to elevators;
* What type of transport loaded from the grain elevators.

Accordingly, we conclude that currently there is no possibility to apply said methodology since required data is not available. The needed data can be gathered via surveys of grain elevator operating companies or during interviews. It should be noted that farm surveys organized by Lithuanian department of statistics are not recommended since farmers operate only part of all elevators in Lithuania. The estimated budget for said survey of grain elevators operators should 20 000 euros (not incl. VAT), given the current market rates.

## Cultivated crops (NFR 3.D.e)

Input data for 2000-2018 Necessary for assessing NMVOC emissions at Tier 1 level in 3.D.e Growing Cereals.

**1. Brief Description of the Processes:** Although crop production is carried out in Lithuania, NH3 emissions from this sector are discussed in other sectors, so there is no need to re-count in this section. Based on the Technical Manual (version - 2016), this sector is given a emission factor for NMVOC emissions Tier 1 methodology. However, no clear calculation methodology is provided and it is stated that a number of assumptions have to be made in order to obtain emission factors using a specific country methodology. NMVOC emissions from this sector are related to the planted / harvested crop area, so this section contains this information. More cereal production in Lithuania is described in section 3.8.

**2. The parameters used in the Tier 2 methodology:** The information required for this sector is the area planted with a particular type of crop or the area harvested. According to the data of the Technical Manual 2016 Table 3.3 Estimation of the NMVOC Tier 1 EFs in kg ha–1a–1, the following cultivated crops are relevant: wheat, rye, rape, grass.

Statistics Lithuania[[165]](#footnote-165) provides data on wheat, rye, rape and grass harvested in 2010-2018. No previous information is available from the Department of Statistics of Lithuania for the period 1990-2009 (see MS Excel SECTOR OF AGRICULTURE 2019 11.XLSX, SHEET 3.D.E).

Instead of the harvested area, the sown area, which is reported in sector 3.Dc, can be used, except for the area sown with oilseed rape, which data are also provided by the Lithuanian Department of Statistics (see MS Excel SECTOR OF AGRICULTURE 2019 11.XLSX, SHEET 3.D.E)

**3. Effectiveness of pollution reduction measures:** In the AIVIKS system, the actual reduction in emissions in this sector was recorded in 1991, 2000-2006, 2008-2009. During other years, the data was unavailable or the reduction in pollutants was equal to 0, more information is available in the Excel document (see MS Excel file Žemės ūkio sektorius 2019 11.Xlsx, sheet 3.D.E).

* In 1991 AB "Marijampolės grūdai" increased the efficiency of fans, reconstructed ducts; AB "Pasvalio grūdai" reconstructed thermal farm, reconstructed grain dryer, changed aspiration networks; The pressure principle of the aspirating network of AB "Rokiškio grūdai" was replaced by the principle of sonic operation, as well as major repairs were carried out; AB "Šiaulių grūdai" has applied the following air pollution abatement measures: changed the cyclone, air pipe, installed the mill workshop cleaning unit and double cleaning equipment;
* In 2000, Tauragės Grūdai AB performed repairs and also applied barriers;
* In 2001 AB "Marijampolės grūdai" installed secondary particle capture; AB "Tauragės grūdai" has carried out major repairs of aspiration networks, has installed the barriers of the wagon unloading station;
* In 2002 AB "Marijampolės grūdai" performed reconstruction of the boiler house, reconstruction of the dryer; AB "Tauragės grūdai" has made major aspiration network repairs, acquired a new aspiration network (2 units), installed a new aspiration network 3;
* In 2003, Joniškio Grūdai AB reconstructed the combined feed workshop; AB "Tauragės grūdai" has been repairing aspiration networks, acquired new aspiration networks;
* In 2004, JSC "Joniškio grūdai" acquired the Tornum workshop; AB "Tauragės grūdai" has been repairing the aspiration network, reconstructing the rake truck;
* In 2005, Tauragės Grūdai AB repaired the aspiration network;
* In 2006, Kretingos Grūdai AB started using a transporter filter; AB "Tauragės grūdai" has been doing the repair and reconstruction of the aspiration network, for auto-inverter no. 5 curtain reconstruction;
* In 2008, Kretingos Grūdai AB installed a flast for the transporter;
* In 2009, Joniškio Grūdai AB modernized the elevator aspiration system.

Although these measures have actually reduced emissions per year in 3De, based on AIVIKS data, the Technical Manual (version - 2016) only calculates NMVOC emissions in this sector and relates to planted / harvested field crops. Therefore, the data collected by AIVIKS is not required for the assessment of national emissions in this sector in accordance with the Technical Manual (version - 2016). Emissions from the sector derive from the cultivation of cereals (in the 'field'), but not from the processing, planting, harvesting, etc. of the cereals, and therefore it is not possible to estimate the reduction of emissions in this sector due to the modernization and repair works of the companies.

# Agriculture other including use of pesticides (NFR 3.D.f, 3.I)

## European Union legislation

**2009 European Parliament and Council October 21 Regulation no. 1107/2009[[166]](#footnote-166)** Concerning the placing of plant protection products on the market and repealing Council Directives 79/117 / EEC and 91/414 / EEC'. The purpose of this Regulation is to ensure a high level of protection of human and animal health and the environment and to improve the functioning of the internal market by harmonizing the rules for the placing of plant protection products on the market while increasing agricultural productivity. The provisions of this Regulation should be based on the precautionary principle in order to ensure that active substances or products placed on the market do not harm human or animal health or the environment. In particular, Member States shall not be prevented from applying the precautionary principle where there is scientific uncertainty as to whether the plant protection products authorized on their territory pose a risk to human or animal health or the environment.

**2009 European Parliament and Council October 21 Directive 2009/128 / EC[[167]](#footnote-167).** Establishing a framework for Community action to achieve a sustainable use of pesticides. This Directive lays down the framework for the sustainable use of pesticides by reducing the risks and impacts of their use on human health and the environment and promoting the use of integrated pest management and alternative methods or tools such as the use of non-chemical pesticides.

**2009 European Parliament and Council November 25 Regulation no. 1185/2009[[168]](#footnote-168)** on pesticide statistics. This Regulation establishes a common framework for the systematic production and marketing of Community statistics on pesticides that are plant protection products as defined in Article 2 (a) (i). The statistics are to be compiled on: the annual amount of pesticides placed on the market in accordance with Annex I; annual pesticide use in accordance with Annex II. The statistics should be used in conjunction with other relevant data for the purposes of Articles 4 and 15 of Directive 2009/128 / EC.

**Stockholm 2001 Convention on Persistent Organic Pollutants (POPs)[[169]](#footnote-169)**. In line with Principle 15 of the Rio Environment and Development Declaration on Prevention, the objective of this Convention is to protect human health and the environment against persistent organic pollutants. The Convention prohibits the production and use of 11 specific POT products by the EU.

## Legislation of the Republic of Lithuania

**LR 1995 October 19 Act on Plant Protection I-1069 (current edition 2017-11-01**This Act establishes the activities of natural persons and legal entities established in the Republic of Lithuania or another Member State of the European Union or in another state of the European Economic Area or other organizations or their subdivisions related to the practice of testing of plant protection products, registration of plant protection products, their additives, plant protection products. the introduction of security products from non-European Union Member States and non-European Economic Area countries, import of plant protection products into the Republic of Lithuania from the Member States of the European Union and the European Economic Area, transportation, storage, use, aerial spraying of plant protection products, placing on the market, and oversight of such activities.

**Minister of Agriculture of the Republic of Lithuania December 30 Order no. 3D-564[[170]](#footnote-170)** on the approval of rules for the storage, placing on the market and use of plant protection products. Rules for the storage, placing on the market and use of plant protection products lay down requirements relating to the storage, placing on the market and use of plant protection products; the withdrawal from the market of unregistered, falsified plant protection products and / or plant protection products not registered in the Republic of Lithuania for plant protection products; submitting information to the Application Receipt Information System (hereinafter referred to as PPIS); providing information and reports to the State Plant Production Service under the Ministry of Agriculture (hereinafter referred to as the Office), organizing plant protection training courses and issuing Plant Protection Certificates. These rules also apply to actions referred to in the 2009 Guidelines. October 21 Of the European Parliament and of the Council On the placing of plant protection products on the market and repealing Council Directives 79/117 / EEC and 91/414 / EEC (OJ 2009 L 309, p. 1), as last amended by Council Regulation (EC) No. August 7 Commission Regulation (EU) 2017/1432 (OJ 2017 L 205, p. 59), Article 28 (2) and Article 53 thereof.

**Government of the Republic of Lithuania March 5 Decree no. 310[[171]](#footnote-171)** on the pesticide management program of the Republic of Lithuania 2002-2005". The purpose of this former program is to manage and eliminate pesticide waste in Lithuania, thus reducing the risk of environmental pollution and the risk of fire, ensuring the safety of the population.

## Use of pesticides (NFR 3.D.f)

Input data for 2005-2018 required for emission estimation at Tier 2 level in 3.D.e Growing Cereals.

**1. Brief description of processes:** According to the Lithuanian Department of Statistics, in 2018 May 25 Act Nr. DĮ-119, in Lithuania, statistics on pesticide[[172]](#footnote-172) use have been collected since 2014 and this study is carried out only every five years.

According to the first survey of 2014, 139 active substances were used for agricultural plant care in agricultural companies and enterprises, as well as in farm and family farms. 43% of the total amount of plant protection products used were herbicides, 29% fungicides, 26% plant growth regulators, and 2% insecticides.

59 active substances were used from the herbicide group (gifosate accounted for 20.6% of the total amount of herbicide used, MCPA - 16.8%, metazachlor - 12.3%), the fungicide group - 57 active substances (tebuconazole totaled 25.6%) used fungicides, epoxiconazole - 8.2%, prothioconazole - 8%), insecticide group - 18 active substances (thiacloprid accounted for 45.5% of total insecticide use, cypermethrin - 9.4%, alpha-cypermethrin - 7.8) %). 5 active substances were used in the plant growth regulator group, of which 84.3% of the total amount of plant growth regulators used was chlormequat.

In 2014, plant protection products were used to treat various crops: 95% of the sown beet area, 92% of maize, 90% of cereals and rape, 62% of potatoes, 56% of legumes, 26% of vegetables, 23% - fruit and berries. According to the statistical survey, on average, one hectare of treated area had 1.08 kilograms of active substance, out of which one hectare of treated fruit and berry area per hectare had - 2.83kg of sugar beet, 2.01 kg of vegetables, 1.33 kg of potato, 1.21kg of legumes, 1.08kg of rapeseed, 1.06kg cereal abd 0.38 of corn.

**2. Parameters used in Tier 2 methodology:** The data needed in this sector are the amount of pesticides consumed, which have HCB as "impurity" (chlorothalonil and clopyralid) each year since 1990. Only HCB emissions are counted in the sector as other pesticides are not included in the NFR form. According to the data of the national 2015 report in Lithuania, only two chemicals were found that are suitable for describing in this sector.

Since no data on these pesticides have been collected in Lithuania and the amounts reported in the general statistics provided by EUROSTAT and FAOSTAT are much higher than those actually present in the country, Lithuania calculated the emissions on the basis of data from other countries and national data on the area of the agricultural area.

Data collected from the 2014 survey is provided[[173]](#footnote-173) (see MS Excel file Žemės ūkio sektorius 2019 11.Xlsx, sheet 3.D.F).

As there is no more national data on the use of relevant pesticides in Lithuania, Lithuania should assess emissions in the same way as before, according to the amounts of HCB pesticides consumed in other countries and according to the areas of Lithuanian agricultural territory. Such calculations are closest to the real situation in Lithuania.

**3. Effectiveness of pollution reduction measures.** Possible mitigation measures:

* Injecting pesticides into the soil (not spraying);
* Avoid spraying pesticides in windy weather.

In Lithuania there is no collection of data on used air pollution abatement measures and the extent of their use. However, there is research in the scientific literature to detect pesticide vaporization by spraying it on the soil surface, inserting it into the soil and from the plants. Jansma and Linders, Dutch scientists, have described the percentages of evaporation of many pesticides that can be used to determine the effectiveness of the soil insertion tool (Jansma and Linders 1995). Unfortunately, there is no description of chlorothalonil or clopyralidem the formula is only available for the theoretical evaporation assessment. This and other pesticide research information can be used to assess the effectiveness of the pesticide insertion into the soil - means of reducing air pollution.

**Results of the survey of Lithuanian farms**. In order to find out the technologies and conditions for the use of other organic fertilizers, a survey was distributed to Lithuanian farms. The questionnaire was completed by 2 respondents, but none indicated the amount of pesticides used.

We estimate that the activity of respondents was too low to objectively assess the prevalence of applied pollution abatement technologies across the country. The results of the survey are included in the appendix to the report (SEE MS EXCEL FILE AGRICULTURE SECTOR 201X 11.XLSX, SHEET 3.D.F).

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

## Agriculture other (NFR 3.I)

Input data for 2000-2018 required for emission estimation at Tier 1 level in sector 3.I Other.

**1. Brief Description of Processes:** Based on the Technical Manual (version - 2016), this sector describes ammonia emitted from ammonia-saturated straw. Ammonia-saturated straw is an animal feed. The straw is treated with anhydrous ammonia or ammonia water. The straw cone is covered with polyethylene film and a special device for injecting liquid ammonia with a metal syringe every 4-5 m into a cone. Tons of straw are given about 30 l of anhydrous ammonia. After that, the edges of the film are lowered onto the ground and trapped to prevent the ammonia from evaporating. The treated cone is kept hermetically sealed for 7-14 days. The film is then removed and the straw fed for 2-3 days.

The amount of ammonia water needed to treat the straw depends on the concentration of ammonia in it. When the ammonia concentration is 25%, 100 l of straw requires 12 l of ammonia water and at 20% - 15 l. Straw can be processed by loading them into boxes, trenches or just cones. In order to process straw in boxes or trenches, about 80l of water per 100 kg of straw is required, with an ammonia content of 1.5% (on average about 6 litres with 25% ammonia). With this weak ammonia solution, the moistened straw is heated with steam or left to heat for a few days.

Straw treatment of ammonia is also an effective straw decontamination tool, as almost all mould and small worms die. Treated ammonia straw is yellowish golden in colour and cattle are more likely to eat them. The nutritional value of the straw that was treated increases by almost 1.5 to 2 times as the nitrogen compounds increase. Such treatment of straw with ammonia or its derivatives is called ammonization. Based on the theoretical material [[174]](#footnote-174), [[175]](#footnote-175) available on the Internet about this method of straw preparation, it is known and can be used in Lithuania, but there is no specific data on the amount of ammonia consumed for this purpose or what part of Lithuanian farmers use this tool.

**2. The parameters used in the Tier 1 methodology:** Ammonia annual consumption of straw for saturation is required. Such information in Lithuania is not collected, controlled, and therefore there is no available data. Farmers' surveys may be conducted to obtain more information, but they are not carried out at this stage.

**3. Effectiveness of pollution reduction measures.** 2016 The Technical Guide discusses measures to reduce air pollution in this sector:

* saturate ammonia with wet straw;
* The rate of use of NH3 must be appropriate;
* NH3 should be evenly distributed in the stack.

Neither the Technical Manual (version 2016) nor publicly available information contains data on the effectiveness of these air pollution abatement measures, nor is there any data on these measures used in Lithuanian farms. Surveys are one of the possible sources, but they are not conducted at this stage. Emissions from this sector are very low, and the process of ammonia itself is not so significant that the possibilities for reducing emissions are widely described.

**Results of the survey of Lithuanian farms.** In order to find out the technologies and conditions of straw ammonia saturation, the survey was distributed to Lithuanian farms. No respondents completed the questionnaire.

In order to gather representative information about abatement technologies applied in Lithuanian farms it is recommended involve Lithuanian department of statistics. It already carried out nationwide, representative, periodical surveys of Lithuanian farms. Taking into account very low response rate to the surveys conducted in 2019, a nationwide survey carried out by Lithuanian department of statistics is deemed as the most appropriate method.

# Conclusions

This interim data collection report contains data from freely available sources of information such as: conclusions of the environmental impact assessment selection, environmental impact assessment documents, integrated pollution prevention and control permits, online business and farmer pages, agricultural portal articles, Lithuanian and foreign statistics, animal husbandry and planting manuals and Lithuanian national reports.

**Survey of Lithuanian farms.** During the data collection, farmers 'survey was distributed through farmers' unions, with a total of 54 respondents. Given the GDPR came into force in 25-05-2018, direct farmers survey became complicated, also the low activity of respondents and the negative attitudes of respondents towards such surveys, we consider that THE MOST EFFICIENT METHOD OF DATA COLLECTION WOULD BE SURVEY PERFORMED BY THE LITHUANIAN STATISTICAL DEPARTMENT ON A 5-YEAR PERIOD. These studies would include an assessment of best practices and non-traditional practices (if any), new practices, existing pollution. All this would help to determine the real emission factors in Lithuanian agricultural sectors.

**Analysis of sources of pollution coefficients.** In conclusion, it is not possible to evaluate under what conditions the emission factors provided in the Technical Manual have been measured. Because, a large part of the emission factors are taken from scientific articles of various countries of the world, calculated by methods unknown to us or adopted as a premise. Exploring the conditions would require researching each source in the Technical Guide, but many are not available, and full source analysis would require unproportional time.

Accordingly, it is not possible to estimate how much the Lithuanian conditions differ from those of the Technical Manual, as the Technical Manual is based on Worldwide methodologies, in some sectors the emission factor determined in US studies, and in other sectors the European State methodology. Each sector is individual.

As mentioned earlier, the most effective way of collecting this type of data would be the 5-year nationally representative surveys conducted by the Lithuanian Department of Statistics, so it is not meaningful to conduct a separate study on the influence of conditions on emission factors

**General conclusions.** In Lithuania, the agricultural sector consists of a very large number of small and medium-sized farms, which necessitates the collection of data by surveying not only large farms, but also small and medium-sized farms. Emissions are made up of many individual farms. In assessing the diversity of air pollution abatement measures, animal husbandry, manure management and crop production technologies and practices in the sectors, no single trend can be identified in Lithuania. There are several aspects that can be summarized from the information found:

* In sectors 3B, the use of probiotics and the reduced use of protein in animal nutrition are widely used by Lithuanian farmers to reduce air pollution;
* In 3B sectors, manure stored in berms is either contained in sealed tanks, lagoons or covered with a film of straw;
* The manure generated in sectors 3B in Lithuania is mostly transmitted to field fertilization, less often to biogas production, but this may change in the future due to the extensive production of biogas from manure;
* From the 3D sector, it can be observed that various fertilizers are widely used in agriculture in Lithuania (less sewage sludge and specific pesticides);
* It was noticed in 3D sector, that 3Da2a and 3Da3 have been closely linked to sectors 3B and in the assessment of air pollution abatement in sectors 3B, attention needs to be paid to whether the same measures reduce emissions in the 3D sectors;
* In Lithuania there is a lack of data on the use of pesticides in agriculture and the use of ammonia to saturate the straw, so this information could be obtained by interviewing farmers.

**Data sources used in the report.** The table below (Figure 6) provides information and data collection sources to use during this phase to collect data on individual agricultural sectors.

Figure 6 Data sources amount by sector

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NFR code | Branch Title | Total quantity of data collection sources, units | | |
| II interim report (2018 m.) | III interim report (2019 m.)[[176]](#footnote-176) | IV interim report (2020 m.) |
| 3.B | Manure management[[177]](#footnote-177) | 13 | 23 | 37 |
| 3.B.1.a | Manure management – Dairy cattle | 14 | 15 | 16 |
| 3.B.1.b | Manure management – Non-dairy cattle | 20 | 21 | 22 |
| 3.B.2 | Manure management – Sheep | 9 | 10 | 11 |
| 3.B.3 | Manure management – Swine | 10 | 18 | 19 |
| 3.B.4.d | Manure management – Goats | 6 | 7 | 8 |
| 3.B.4.e | Manure management – Horses | 5 | 6 | 7 |
| 3.B.4.g.i | Manure management – Laying hens | 5 | 9 | 10 |
| 3.B.4.g.ii | Manure management – Broilers | 7 | 18 | 19 |
| 3.B.4.g.iii | Manure management – Turkeys | 3 | 4 | 5 |
| 3.B.4.g.iv | Manure management – Other poultry | 3 | 4 | 5 |
| 3.B.4.h | Manure management – Other animals | 7 | 8 | 9 |
| 3.D | Crop production and agricultural soils[[178]](#footnote-178) | 10 | 10 | 10 |
| 3.D.a.1 | Inorganic N-fertilizers applied to soils (includes also urea application | 10 | 11 | 13 |
| 3.D.a.2.a | Animal manure applied to soils | 11 | 15 | 15 |
| 3.D.a.2.b | Sewage sludge applied to soils | 2 | 3 | 3 |
| 3.D.a.2.c | Other organic fertilisers applied to soils (including compost) | 5 | 7 | 7 |
| 3.D.a.3 | Urine and dung deposited by grazing animals | 3 | 3 | 3 |
| 3.D.c | Farm-level agricultural operations including storage, handling and transport of agricultural products | 2 | 2 | 3 |
| 3.D.e | Cultivated crops | 2 | 3 | 4 |
| 3.D.f, 3.I | Other agriculture (including use of pesticides)[[179]](#footnote-179) | 7 | 7 | 8 |
| 3.D.f | Use of pesticides | 4 | 5 | 6 |
| 3.I | Agriculture other | 2 | 3 | 3 |
|  | **Total:** | **160** | **209** | **243** |

1. The Chamber of Agriculture, which unites 42 associations, distributed questionnaires to these associations. Also, questionnaires were directly sent to Lithuanian Grain Growers and Lithuanian Dairy Producers Association, Lithuanian Farmers' Association, Lithuanian Poultry Association, Lithuanian Breeding Bird Breeders Association, Lithuanian Horse Breeders Association, Lithuanian Beasts. grower association. Each association distributed questionnaires to its members. [↑](#footnote-ref-1)
2. <https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/emep-eea-guidebook-revision-log/view> [↑](#footnote-ref-2)
3. <https://www.e-tar.lt/portal/lt/legalActSearch> [↑](#footnote-ref-3)
4. <https://op.europa.eu/lt/web/eu-vocabularies/> [↑](#footnote-ref-4)
5. <https://www.e-tar.lt/portal/lt/legalAct/5e8cac706ffc11e9a13eeecaacbc653f> [↑](#footnote-ref-5)
6. <https://www.e-tar.lt/portal/lt/legalAct/da40a400ddd611e99681cd81dcdca52c> [↑](#footnote-ref-6)
7. <https://www.e-tar.lt/portal/lt/legalAct/aa8edce0ddd611e99681cd81dcdca52c> [↑](#footnote-ref-7)
8. Europos Parlamento ir Tarybos 2010 m. lapkričio 24 d. direktyva 2010/75/ES „dėl pramoninių išmetamų teršalų (taršos integruotos prevencijos ir kontrolės)“. Europos Sąjungos oficialus leidinys, L 334/17. [↑](#footnote-ref-8)
9. Europos Parlamento ir Tarybos 2016 m. gruodžio 14 d. direktyva 2016/2284 „dėl tam tikrų valstybėse narėse į atmosferą išmetamų teršalų kiekio mažinimo, kuria iš dalies keičiama Direktyva 2003/35/EB ir panaikinama Direktyva 2001/81/EB“. Europos Sąjungos oficialus leidinys, L 344/1. [↑](#footnote-ref-9)
10. LR aplinkos oro apsaugos 1999 m. lapkričio 4 d. įsakymas Nr. VIII-1392 (aktuali redakcija 2018-12-31). Valstybės žinios, 98-2813. [↑](#footnote-ref-10)
11. *Lit. Lietuvos Respublikos Seimas* [↑](#footnote-ref-11)
12. LR Aplinkos ministro ir LR Žemės ūkio ministro 2005 m. liepos 14 d. įsakymas Nr. D1-367/3D-342 „dėl mėšlo ir srutų tvarkymo aplinkosaugos reikalavimų aprašo patvirtinimo“. Valstybės žinios, 92-3434. [↑](#footnote-ref-12)
13. LR Žemės ūkio ministro 2016 m. spalio 14 d. įsakymas Nr. 3D-592 „dėl kailinės žvėrininkystės ir triušininkystės ūkių technologinio projektavimo taisyklių ŽŪ TPT 13:2016 patvirtinimo“. TAR, 25174. [↑](#footnote-ref-13)
14. LR Žemės ūkio ministro 2009 m. rugpjūčio 21 d. įsakymas Nr. 3D-602 „dėl galvijų pastatų technologinio projektavimo taisyklių ŽŪ TPT 01:2009 patvirtinimo“. Valstybės žinios, 102-4272. [↑](#footnote-ref-14)
15. LR Žemės ūkio ministro 2010 m. gegužės 14 d. įsakymas Nr. 3D-472 „dėl mėšlo ir nuotekų tvarkymo statinių technologinio projektavimo taisyklių ŽŪ TPT 03:2010 patvirtinimo“. Valstybės žinios, 59-2941. [↑](#footnote-ref-15)
16. LR Žemės ūkio ministro 2010 m. sausio 27 d. įsakymas Nr. 3D-50 „dėl kiaulidžių technologinio projektavimo taisyklių ŽŪ TPT 02:2010 patvirtinimo“. Valstybės žinios, 14-682. [↑](#footnote-ref-16)
17. Valstybinės maisto ir veterinarijos tarnybos direktoriaus 2015 m. spalio 30 d. įsakymas Nr. B1-995 „dėl biologinio saugumo priemonių reikalavimų paukštininkystės ūkiams patvirtinimo“. TAR, 17192 [↑](#footnote-ref-17)
18. Valstybinės maisto ir veterinarijos tarnybos direktoriaus 2011 m. liepos 11 d. įsakymas Nr. B1-384 [↑](#footnote-ref-18)
19. Aplinkos Apsaugos Agentūra. Pažangaus ūkininkavimo taisyklės ir patarimai 6 skyrius [interaktyvus]. Prieiga per internetą: <http://gamta.lt/files/Pazangaus\_ukininkavimo\_taisykles\_ir\_patarimai\_6skyrius.pdf>. 55-61 psl. [↑](#footnote-ref-19)
20. Vaičionis, G. Mėšlo ir srutų šalinimas iš tvartų [interaktyvus]. 2013. Prieiga per internetą: <http://www.pienoukis.lt/meslo-ir-srutu-salinimas-is-tvartu/>. [↑](#footnote-ref-20)
21. Agrožinios. Srutų talpyklos įrengimas [interaktyvus]. 2018. Prieiga per internetą: <http://www.agrozinios.lt/portal/categories/126/1/0/1/article/11638/meslo-tvarkymas-fermose>. [↑](#footnote-ref-21)
22. Dämmgen et al., 2007 [↑](#footnote-ref-22)
23. https://www.thuenen.de/media/publikationen/landbauforschung-sonderhefte/lbf\_sh324.pdf [↑](#footnote-ref-23)
24. Webb ir Misselbrook, 2004 [↑](#footnote-ref-24)
25. Kirchman ir Witter. 1989. Prieiga per internetą: <https://link.springer.com/article/10.1007/BF02220692> [↑](#footnote-ref-25)
26. Kirchman ir Witter. 1989. Prieiga per internetą: <https://link.springer.com/article/10.1007/BF02220692> [↑](#footnote-ref-26)
27. 1996 IPCC Guidelines, 1997 [↑](#footnote-ref-27)
28. European Environmental Agency, 2002 [↑](#footnote-ref-28)
29. USA EPA National NH3 Inventory. Draft Report, 2004 [↑](#footnote-ref-29)
30. GHG inventories of Annex I Parties submitted to the Secretariat UNFCCC in 2004 [↑](#footnote-ref-30)
31. Angl. European Agricultural Gaseous Emissions Inventory Researchers (EAGER) [↑](#footnote-ref-31)
32. Lithuania‘s national Inventory report 2018. Greenhouse gas emissions 1990-2016. Vilnius, 617 p. [↑](#footnote-ref-32)
33. Lithuania‘s national Inventory report 2019. Greenhouse gas emissions 1990-2017. Vilnius, 550 p. [↑](#footnote-ref-33)
34. AAA Taršos prevencijos ir leidimų departamento Panvėžio skyriaus atrankos išvada dėl „Pieno ūkio Daukniūnų k., Panevėžio sen., Panevėžio r. Išplėtimas ir modernizavimas“ poveikio aplinkai vertimo. 2014. „Daukniūnų ŽŪB“. [↑](#footnote-ref-34)
35. Sprendimas dėl planuojamos ūkinės veiklos poveikio aplinkai vertinimo. 2014. Prieiga per internetą: <https://nvsc.lrv.lt/uploads/nvsc/documents/files/sprendimas-3(1)(1).pdf>. [↑](#footnote-ref-35)
36. Informacija dėl planuojamos ūkinės veiklos „448 vietų karvidės statyba (pieninių galvijų ūkio išplėtimas)“ atrankai. 2017. ŽŪB „Vaškai“. [↑](#footnote-ref-36)
37. Planuojamos ūkinės veiklos „karvidės, melžimo bloko ir dviejų skysto mėšlo rezervuarų statyba (galvijų ūkio išplėtimas)“ informacija atrankai dėl poveikio aplinkai vertinimo. Kaunas, 2016. „Griškabūdžio“ ŽŪB. [↑](#footnote-ref-37)
38. The Development of the Lithuanian Cattle Breed in Lithuania [↑](#footnote-ref-38)
39. Informacija atrankai „dėl pieno gamybos ūkio išplėtimo poveikio aplinkai vertinimo“. 2016. ŽŪB „Atžalynas“ [↑](#footnote-ref-39)
40. A. Andrijausko ūkinės veiklos – galvijų ūkio išplėtimas – atrankos dėl poveikio aplinkai vertinimo informacija. Šiauliai, 2016. [↑](#footnote-ref-40)
41. Pieno ūkis. Pienininkų apdovanojimuose „Pienės 2018″– optimizmas [interaktyvus]. 2018. Prieiga per internetą: <http://www.pienoukis.lt/pienininku-apdovanojimuose-pienes-2018-optimizmas/>. [↑](#footnote-ref-41)
42. LR 1996 m. rugpjūčio 15 d. planuojamos ūkinės veiklos poveikio aplinkai vertinimo įstatymas Nr. I-1495. Valstybės žinios, 82-1965. [↑](#footnote-ref-42)
43. LR Aplinkos ministro 2013 m. liepos 15 d. įsakymas Nr. D1-528 „dėl taršos integruotos prevencijos ir kontrolės leidimų išdavimo, pakeitimo ir galiojimo panaikinimo taisyklių patvirtinimo“. Valstybės žinios, 77-3901. [↑](#footnote-ref-43)
44. angl. Manure management – non-dairy cattle [↑](#footnote-ref-44)
45. Lithuania‘s national Inventory report 2018. Greenhouse gas emissions 1990-2016. Vilnius, 617 p. [↑](#footnote-ref-45)
46. Lithuania‘s national Inventory report 2019. Greenhouse gas emissions 1990-2017. Vilnius, 550 p. [↑](#footnote-ref-46)
47. The report includes these categories: Cows for suckling, 2 years and over; Female calves for breeding, less than 1 year old; Heifers for slaughter, 1 to 2 years; Heifers for breeding, 1 to 2 years; Bulls, 1 to 2 years; Bulls, 2 years and over, , however, categories of bulls of less than 1 year as well as heifers,2 years or over are not included. [↑](#footnote-ref-47)
48. AAA Taršos prevencijos ir leidimų departamento Panevėžio skyriaus atrankos išvada dėl „Pieno ūkio Daukniūnų k., Panevėžio sen., Panevėžio r. Išplėtimas ir modernizavimas“ poveikio aplinkai vertimo. 2014. „Daukniūnų ŽŪB“. [↑](#footnote-ref-48)
49. Sprendimas dėl planuojamos ūkinės veiklos poveikio aplinkai vertinimo. 2014. Prieiga per internetą: <https://nvsc.lrv.lt/uploads/nvsc/documents/files/sprendimas-3(1)(1).pdf>. [↑](#footnote-ref-49)
50. Informacija dėl planuojamos ūkinės veiklos „448 vietų karvidės statyba (pieninių galvijų ūkio išplėtimas)“ atrankai. 2017. ŽŪB „Vaškai“. [↑](#footnote-ref-50)
51. Planuojamos ūkinės veiklos „karvidės, melžimo bloko ir dviejų skysto mėšlo rezervuarų statyba (galvijų ūkio išplėtimas)“ informacija atrankai dėl poveikio aplinkai vertinimo. Kaunas, 2016. „Griškabūdžio“ ŽŪB. [↑](#footnote-ref-51)
52. *Lit. Lietuvos Juodmarių galvijų veislės raida, žmonės ir jų darbai amžių sandūroje* [↑](#footnote-ref-52)
53. Informacija atrankai „dėl pieno gamybos ūkio išplėtimo poveiko aplinkai vertinimo“. 2016. ŽŪB „Atžalynas“ [↑](#footnote-ref-53)
54. UAB „Agrolinija“ planuojamos ūkinės veiklos poveikio aplinkai vertinimo atranka. Vilnius, 2017. [↑](#footnote-ref-54)
55. UAB „Agrolinija“. Apie bendrovę [interaktyvus]. 2013. Prieiga per internetą: <http://www.agrolinija.lt/lt/apie-bendrove/>. [↑](#footnote-ref-55)
56. Atrankos informacija „dėl ŽŪB „Šiaurės bulius“ mėsinių galvijų komplekso plėtros Linkuvos g. 48, 50, 54, 56, 58 Klovainiai, Pakruojo r. sav. poveikio aplinkai vertinimo“. Vilnius, 2018. [↑](#footnote-ref-56)
57. Budrikienė, V. Ūkininkas A.Leščinskas: „Mėsininkystė - perspektyviausia žemės ūkio šaka“ [interaktyvus]. 2012. Prieiga per internetą: <http://www.silutesnaujienos.lt/index.php?option=com\_content&view=article&id=2210:kininkas-aleinskas-msininkyst-perspektyviausia-ems-kio-aka&catid=60:zemes-ukis&Itemid=78>. [↑](#footnote-ref-57)
58. UAB „Ekosistema“. Ūkininko Algimanto Leščinsko planuojamos ūkinės veiklos (galvijų fermos komplekso eksploatacija Šilutės g. 76A, Užlieknių k., Šilutės sen., LT-99336 Šilutės r. rav.) poveikio aplinkai vertinimo atrankos dokumentai. Klaipėda, 2016. [↑](#footnote-ref-58)
59. Ūkininko Algimanto Leščinsko planuojamos ūkinės veiklos „Galvijų fermos komplekso eksploatacija Šilutės g. 76A, Užlieknių k., Šilutės sen., LT-99336 Šilutės r. sav.“ poveikio aplinkai vertinimo atrankos dokumentai. Klaipėda, 2016. [↑](#footnote-ref-59)
60. A. Andrijausko ūkinės veiklos – galvijų ūkio išplėtimas – atrankos dėl poveikio aplinkai vertinimo informacija. Šiauliai, 2016. [↑](#footnote-ref-60)
61. Telšių Žinios. Šernai nuniokojo ūkininko pasėlius: kas atlygins žalą? [interaktyvus]. 2015. Prieiga per internetą: <http://tzinios.lt/sernai-nuniokojo-ukininko-paselius-kas-atlygins-zala/>. [↑](#footnote-ref-61)
62. LR 1996 m. rugpjūčio 15 d. planuojamos ūkinės veiklos poveikio aplinkai vertinimo įstatymas Nr. I-1495. Valstybės žinios, 82-1965. [↑](#footnote-ref-62)
63. LR Aplinkos ministro 2013 m. liepos 15 d. įsakymas Nr. D1-528 „dėl taršos integruotos prevencijos ir kontrolės leidimų išdavimo, pakeitimo ir galiojimo panaikinimo taisyklių patvirtimo“. Valstybės žinios, 77-3901. [↑](#footnote-ref-63)
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169. Stokholmo 2001 m. konvencija dėl patvariųjų organinių teršalų (POT). Valstybės žinios, 120-4565. [↑](#footnote-ref-169)
170. LR Žemės ūkio ministro 2003 m. gruodžio 30 d. įsakymas Nr. 3D-564 „dėl augalų apsaugos produktų saugojimo, tiekimo rinkai, naudojimo taisyklių patvirtinimo“. Valstybės žinios, 15-481. [↑](#footnote-ref-170)
171. LR vyriausybės 2002 m. kovo 5 d. nutarimas Nr. 310 „dėl pesticidų tvarkymo LR 2002-2005 metų programos“. Valstybės žinios, 26-920. [↑](#footnote-ref-171)
172. Lietuvos statistikos departamento 2018 m. gegužės 25 d. įsakymas Nr. DĮ-119 „Augalų apsaugos produktų panaudojimo žemės ūkyje statistinio tyrimo metodika“. [↑](#footnote-ref-172)
173. Lietuvos statistikos departamentas. Augalų apsaugos produktų panaudojimas žemės ūkyje 2014 m. [interaktyvus]. 2015. Prieiga per internetą: <https://osp.stat.gov.lt/informaciniai-pranesimai?articleId=3975263>. [↑](#footnote-ref-173)
174. Kulpys, J. Skanius pašarus gyvuliai noriau ėda [interaktyvus]. 2006. Prieiga per internetą: <http://www.manoukis.lt/mano-ukis-zurnalas/2006/02/skanius-pasarus-gyvuliai-noriau-eda/> [↑](#footnote-ref-174)
175. Savas ūkis. Šiaudai irgi pašaras [interaktyvus]. 2010. Prieiga per internetą: <http://savasukis.old1.krienas.serveriai.lt/straipsniai/89-siaudai-irgi-pasaras.htm>. [↑](#footnote-ref-175)
176. The farm surveys are counted as 1 source.. [↑](#footnote-ref-176)
177. Analysis of national and international legislation as well as description of manure management technologies. [↑](#footnote-ref-177)
178. Analysis of national and international legislation. [↑](#footnote-ref-178)
179. Analysis of national and international legislation. [↑](#footnote-ref-179)