Possibilities and bottlenecks for implementing slurry acidification techniques in Russian and Belarus

Authors: Justin Casimir, Erik Sindhøj, Roman Uvarov, Alexandr Bruikhanov, Eduard Vasiliev, Natalia Oblomkova, Nikolay Kapustsin, Mikhail Ponomarev
Possibilities and bottlenecks for implementing slurry acidification techniques in the Baltic Sea Region - Report for Russia and Belarus

Möjligheter och begränsningar att införa teknik för surgörning av flytgödsel i Östersjöregionen – Rapport för Ryssland och Vitryssland

Authors: Justin Casimir, Erik Sindhöj, Roman Uvarov, Alexandr Bruikhanov, Eduard Vasiliev, Natalia Oblomkova, Nikolay Kapustsin
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1. Preface

The project “Bringing Russia and Belarus into Baltic Slurry Acidification” was a project funded by the Swedish Institute to allow partners from Russia and Belarus to participate to some activities within the EU project “Baltic Slurry Acidification” (BSA) funded by the Interreg Baltic Sea Region program. The aim of BSA was to reduce nitrogen loss from animal production by promoting the use of slurry acidification techniques in countries around the Baltic Sea.

The general aim of this project was to support partners from Russia and Belarus to take part in BSA and to spread knowledge about slurry acidification outside the EU. These countries, at least partly, are within the Baltic Sea water basins. Their participation will in the long term hopefully further reduce ammonia reduction from animal production in the Baltic Sea Region.

This report is a complement to the report “Possibilities and bottlenecks for implementing slurry acidification techniques in the Baltic Sea Region” published within BSA (RISE Report 2017:47). It includes figures, data and conclusions from Russia and Belarus which are compared with the other BSR countries. Detailed information concerning slurry acidification technologies, as well as insights from the EU countries around the Baltic Sea are also found in the RISE report 2017:47. This report focuses on Russia and Belarus.

The report was written by the Institute for Engineering and Environmental Problems in Agricultural Production (IEEP) and the Scientific and Practical Centre of National Academy of Sciences of Belarus for Agricultural Mechanisation (Belagromech) in the frame of the project “Bringing Russia and Belarus into Baltic Slurry Acidification.” The Northwest Research Institute of Agricultural Economics and Organisation (NWRIAEO) has reviewed the Russian chapter. Both contributions have been reviewed by RISE who also wrote the chapter comparing the different countries and edited the report.

The contribution from the Russian and Belarusian partners has been financed through the Swedish Institute project “Bringing Russia and Belarus into Baltic Slurry Acidification”. The coordination and contribution from RISE to this report has been financed mainly by BSA.
2. Summary

This report summarizes expert judgements on how slurry acidification technologies (SATs) could be implemented in Belarus and North West Russia. Special focus on bottlenecks for implementing SATs with existing manure management systems was considered.

In Belarus and North West Russia, a smaller proportion of manure is handled as slurry compared to EU Baltic Sea countries, but this might be due to the high poultry production in Russia since most poultry manure is solid. None the less, SATs are currently only available for slurry manure handling systems and not for solid or semi-solid manure.

Regarding the current systems used in Russia and Belarus some SATs may be easier to implement than others. For instance, due to health issues, farms do not store manure under animal houses. Further studies related to the legislation are needed to reveal if this factor is a potential bottleneck for the in-house SAT. In-storage SATs, both long term and just before spreading should be possible to implement based on the current handling practices, even in Belarus where lagoons are very commons to store slurry. In-field SATs also have a good potential for implementation, but it is worth mentioning that machine contractors in agriculture are nearly non-existent in these two countries and equipment is usually owned by each farm.

More information concerning economics and environmental impacts as well as safety issues related to acid handling are still needed to fully understand the implementation potential of SATs in Belarus and Russia.
3. Introduction

Currently, slurry acidification technologies are commercially available and commonly used only in Denmark. The technology has been developed, tested and verified effective under Danish conditions. However, manure handling techniques and practices are different in different countries and there could be technical bottlenecks that hinder the implementation of SATs in some countries. Based the current technical descriptions of available SATs, the manure handling techniques in Russia and Belarus were evaluated for possible technical bottlenecks that could hinder implementation of the SATs.

Only the North-East Federal District of Russia was included in this evaluation including the five regions: Leningrad, Kaliningrad, Novgorod, Pskov and Republic of Karelia (Figure 3.1). These were included since at least 50% of the regions are located in the Baltic Sea catchment area. Essentially all of Belarus was included in the study even though only half of the country is within the Baltic Sea catchment area.

Figure 3.1. The territory of the Russian Federation considered in BSA project.
4. Manure handling systems in countries around the Baltic Sea

Justin Casimir – RISE

The currently available SATs are described in detail in the RISE report 2017:47. These technologies were developed in Denmark for Danish conditions. The SATs were developed primarily for dairy and pig production systems and all require manure handling as slurry and will not work with solid or semi-solid manure. This chapter is an initial overview of the animal production and manure handling systems in countries around the Baltic Sea, with the aim to help evaluate the potential to implement these SATs with currently existing manure handling systems in each country. The manure management systems include animal type, housing types, storage systems, and spreading techniques. Specific definitions can be found in Appendix 1.

The results presented here are based on statistics from the Eurostat database for the EU countries, and other national sources for the Russian and Belarussian parts. As data for EU and non-EU countries come from different databases, using most likely different method for data collection, direct comparisons between countries are delicate. A more detailed analysis for Russia and Belarus is found respectively in Appendix 2. Detailed data for the EU countries is found in the RISE report 2017:47 (Appendix 2).

4.1 Livestock production

As for the EU countries, there is a clear predominance of cattle and pig production in terms of total livestock production in Belarus. In the North West Region of Russia, poultry has a larger proportion than in the other countries studied and amounts to about 40% of the total LSU. However, very little of this poultry manure is handled as slurry (Sindhøj & Rodhe, 2013) and therefore is not relevant for current SATs. Belarus has a considerable cattle production compared to most other Baltic Sea countries.
4.2 Housing systems and manure management

Cattle

In Russia and Belarus, stanchion tied stables are still very common and they typically have both solid and liquid manure handling system. However, Belarus has a high proportion of cattle kept within stanchion tied stables with slurry which is adapted to the current slurry acidification techniques.

For the housing types with “solid dung and liquid manure”, it is only the liquid manure portion that is applicable for SATs. Unfortunately, the relative portion of “liquid manure” produced in this housing type cannot be determined here however it is typically much less than when all is handled as slurry.
Russia and Belarus have some slurry and liquid manure handling, so they could implement SATs on at least a portion of their cattle production.

**Pig**

More than 80% of the pigs in Russia and Belarus are kept on slatted floors; either partially slatted or completely slatted (Figure 4.3). Housing systems with slatted floor generally handle their manure as slurry, and therefore, there is a great potential in pig farms in the BSR for the implementation of SATs.

![Figure 4.3. Pig housing in different countries, in % places (Eurostat 2010b; Unified Interdepartmental Information-Statistical System, 2017; Kangro et al., 2017b).](image)

4.3 Slurry storage systems

Russia and Belarus have a smaller share of slurry or liquid manure in comparison to the other BSR countries. Belarus only has about 40% of its manure kept as slurry or liquid manure (in term of LSU). Belarus also stands out with its higher share of slurry kept in lagoon (almost 20%).
4.4 Slurry spreading systems

Slurry injection spreading techniques have long been shown to be effective at reducing ammonia emissions compared to band spreading with trailing hoses or broadcast spreading (Rodhe & Etana, 2005; Smith et al., 2000), however, there is comparatively little slurry spread by injection compared to other methods (Table 3.1). Estonia is the exception to this where 60% of all slurry is spread by injection, due largely to strict environmental regulations. In Denmark, acidification is allowed as an equivalent method to injection and is a more often used.

Using SATs together with injection techniques would be redundant. However, using SATs with trailing hoses could effectively replace the use of injection techniques since they have been shown as equally effective in terms of reducing ammonia emissions (Seidel et al., 2017). This is the case in Denmark where there are requirements to use either injection techniques or SATs to reduce ammonia emission and the predominant method chosen is SATs.

Both broadcast and trailing hose spreading techniques have the potential to benefit from SATs. Currently SATs have only been used with trailing hose techniques; however, using it together with broadcast techniques would be a way to greatly improve the effectiveness of broadcast spreading. This could make a big
difference in countries that still rely heavily on broadcast methods for spreading slurry such as Russia and Belarus.

Table 3.1. Percentage of slurry spread by various technics in the Baltic Sea Region.
For more details and references, see national chapters in Appendix 2 and report 2017:47

<table>
<thead>
<tr>
<th>Country</th>
<th>Broadcast spreading</th>
<th>Band spreading</th>
<th>Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmarka</td>
<td>0</td>
<td>85c</td>
<td>15</td>
</tr>
<tr>
<td>Estonia</td>
<td>5</td>
<td>35</td>
<td>60</td>
</tr>
<tr>
<td>Finlandb</td>
<td>35</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>Germany</td>
<td>70</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>Latvia</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Swedenb</td>
<td>28</td>
<td>68f</td>
<td>4</td>
</tr>
<tr>
<td>Belarusd</td>
<td>95</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Russiab</td>
<td>88f</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

*a Estimation made by national experts
*b According to Statistics Sweden (2014), 24% of the surface spread manure (solid and liquid) is incorporated directly, 11% within 4 hours, and 9% within 24 hours after spreading.
*c Including 20% acidified slurry
*d Kangro et al., 2017b
*e Briukhanov A. et al., 2012; Briukhanov A., 2017; Volkov et al., 2014
*f of which 40% incorporated after spreading

References to chapter 4


Eurostat, 2013. Database available at:  


5. Conditions for implementation of SATs on a national level

In this chapter, manure handling experts from each country gave their judgement on how to implement SATs in their country. In this work, the experts also consulted national networks including for example manufactories of slurry equipment, advisor services, and farmers have been consulted. The national experts have also described the relevant slurry handling systems in their country as a background to this analysis (see Appendix 2).

For the most common manure handling systems in use, the possibility and relevance of implementing the three SAT’s were analysed as well as potential bottlenecks that might arise during implementation. Suggested implementations could differ from solutions found in Denmark, when taking into account the specific country conditions.

5.1 Russia

Roman Uvarov, Alexandr Bruikhanov, Eduard Vasiliev, Natalia Oblomkova, IEEP

In general

There is a potential to introduce SATs to Russia based on current implemented manure handling techniques. Taking into account a number of specific features of the Russian agro-industrial complex, various acidification methods can be applied. Availability of the owned machine and tractor fleet (provided it is upgraded) has an additional influence on the prospects of these technologies. However, it must be recognized that to date the main issue of concern for introduction of acidification technology is to ensure the safety when handling the acid and proper training of the personnel involved. Today it is not quite clear how the livestock enterprises will acquire the necessary acid and who will be a supplier, since the work with sulfuric acid is regulated at the state level (Safety rules for chemically hazardous industrial facilities, 2013).

In-house

In view of the regulatory documents in force, which prohibit the re-transportation of manure to animal houses, it follows that under current conditions the in-house SAT application seems somewhat difficult (Veterinary and sanitary rules, 1997). However, in some cases, e.g. when the flush system is used to remove manure from the animal house, this technique could likely be implemented.

In-storage, long term

In-storage acidification can be carried out at various technological stages: in the collecting pit, during the liquid fraction accumulation immediately after separation in the buffer tank, and directly in the manure storage. Acidification before separation could negatively increase wear and reduce the service life of commonly used separation equipment. Acidification of only the liquid fraction after separation in the buffer tank would avoid this problem.
Acidification of slurry / liquid fraction during its maturing (storing) in manure storages and lagoons may also be relevant; however, the disadvantage of this method may be a need to increase manure storage capacity due to the foam formation in the process of acidification. This leads to a higher construction and operation costs (Kai et al., 2008). This method applied to uncovered storages would reduce ammonia emissions in the summer time.

Due to specific features of the regions’ agro-industrial complex, namely substantial number of farms with large animal stock and, accordingly, big amounts of manure produced, it is advisable for some farms to purchase not a stationary but mobile equipment for SAT application.

**In-storage, before spreading**

This method may be widely used in covered storages as it allows for less frequent acid introduction compared to long-term storage of slurry. In Russian conditions due to the long period of cold weather and formation of ice on the slurry surface in uncovered storages this method may be preferred since ammonia emissions are low during winter months. It should be noted that due to the foaming, there must be free space in the storage to assure the foaming does not spill over during the treatment. A height of 0.5 to 1 m is commonly recommended (Rodhe L., 2017).

**In-field**

In-field acidification is the most technically feasible method; however, it requires a substantial modernisation of the existing machine and tractor fleet. The increased wear of the equipment associated with the increased acidity of applied slurry and the stricter requirements for the qualification of the personnel involved are also to be considered, however there are no indications from Denmark that this has been an issue. The main limiting factor for the introduction of this acidification technique may become serious safety requirements for transportation and use of corrosive acids, including sulfuric acid.

### 5.2 Belarus

*Nikolay Kapustsin, RUE "SPC of NAS of Belarus for Agriculture Mechanization”*

**In general**

Annually approximately 27 million tons of liquid manure is produced in Belarus. SAT could potentially be implemented on this resource in Belarus. In practice however, SATs are not yet applied in agricultural production in Belarus. This is due to the lack of information on SATs and machinery for its implementation. It is also needed to address issues related to safety when working with acid and training of staff to use appropriate handling methods.

**In - house**

In Belarus the implementation of SATs is technically possible in animal houses. However, this will require changes in the veterinary-sanitary rules of the maintenance of animals on the complexes approved by the resolution of the Ministry of Agriculture and Food of the Republic of Belarus №1 dated 29.01.2014.
(Popkov et al., 2004). Because of the risk of impact of harmful gases on animal and human acidification of the slurry inside the livestock buildings will be difficult to implement in agriculture of Belarus.

**In storage (effect during storage period and when spreading the slurry)**

On livestock farms of Belarus liquid manure from the livestock houses is going directly into buffer tanks with small volume (200-300 m³). These containers can be used for acidification of the slurry before pumping it to the storage into stationary storage. It gives the effect for the whole storage period.

**In storage (effect when spreading the slurry)**

Acidification of slurry can be made immediately prior to its application to fields with equipment installed on mobile devices. In Belarus there are no agricultural contractors which could provide services for acidification. Therefore, all investments in the first stage of implementation of this technology and equipment for its implementation will implement the agricultural enterprise itself. After contacting in-storage manufacturers in Denmark, they confirmed that the acidification in lagoon is possible and working practically, which is significant since most slurry storages in Belarus are lagoons.

**In field**

SAT in-field may be easy implemented by those agricultural producers in Belarus with animal production. Among native producers of such machinery is OJSC “Bobruiskagromash”. All of them have mobile tanks equipped for transporting and application in-fields of slurry. Such machinery should be refitted for using SAT as broadcast spreading represents about 95% of the slurry spreading. In Belarus there are no contractors who could provide SAT-services so the full investment would have to be on the individual farms-level.

**References to chapter 5**


6. Contact information

Justin Casimir. RISE – Agrifood and Bioscience, Box 7033, 75007 Uppsala. justin.casimir@ri.se +46 (10) 516 6903. www.ri.se

Mikhail Ponomarev. NWRIAEO – North-West Research Institute of Agricultural Economics and Organization, Department for Economic and Organizational Problems of the Development of Agricultural Sectors. Shosse Podbelskogo, 7, Pushkin, Saint-Petersburg, 196608, Russia. m.a.ponomarev@gmail.com +7 812 470 4374. www.szniesh.ru

Nikolay Kapustsin, RUE «SPC of NAS of Belarus for Agriculture Mechanization», Knorin str., 1, 220049, Minsk, Belarus. npcter@yandex.ru +375447142954. www.belagromech.by

Roman Uvarov, IEEP, 3, Filterovskoe Shosse, p.o. Tiarlevo, Saint-Petersburg, 196625, pgu-24@mail.ru, www.sznii.ru
Appendix 1. Definitions

In general, we try to use terms according to the “Glossary of terms on livestock and manure management” (KTBL, 2011).

According to the glossary, “liquid manure” and “slurry” mean essentially the same thing. “Liquid manure” is a general term that denotes manure from housed livestock that can flow under gravity and can be pumped. “Slurry” means faeces and urine produced by housed livestock, usually mixed with some bedding material and some water during management to give liquid manure with dry matter content in the range of 0-10%. In general we refer to this as slurry.

Below is defined the Livestock Unit (LSU) according to Eurostat (2013). It should be observed that there are other national definitions of LSU.

Livestock Unit (LSU)
The size of a herd is either expressed in term of head (number of animal) or Livestock Unit (LSU) where one LSU is the grazing equivalent of one adult dairy cow. LSU are used in this report in order to estimate the division between the main livestock productions. The data in Table A were used to convert from head to LSU when needed.

Table A. Conversion head to LSU, Eurostat

<table>
<thead>
<tr>
<th>Bovine animals</th>
<th>Under 1 year old</th>
<th>0.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 but less than 2 years old</td>
<td>0.7</td>
</tr>
<tr>
<td>Male, 2 years old and over</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Heifers, 2 years old and over</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Dairy cows</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other cows, 2 years old and over</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Pigs</td>
<td>Piglets having a live weight of under 20 kg</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>Breeding sows weighing 50 kg and over</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Other pigs</td>
<td>0.3</td>
</tr>
<tr>
<td>Poultry</td>
<td>Broilers</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Laying hens</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Cattle housing

**Stanchion-tied stables:** Stanchion-tied stables are animal houses where the animals are tied to their places and are not allowed to move freely.

They can contain manure in the form of solid dung and liquid manure when the floors of the stalls are on sloping concrete with bedding (e.g. straw, chopped straw, sawdust) and a shallow gutter at the rear of the animals to collect part of the faeces and the urine, whilst part is regularly removed as solid manure. In some cases the gutter is equipped with a drainage pipe to collect seepage or there can be a deeper channel instead of a gutter to collect and store the liquid fraction. The manure is normally removed mechanically outside the building as solid dung/farmyard manure.
They can also contain manure in the form of slurry when the floors of the stalls are level concrete with a channel covered by a grid at the rear of the animals or fully slatted floor to collect faeces and urine as slurry. The manure and urine drop down below the floor into a pit, where they form slurry.

**Loose-housing**: Loose housing barns are animal houses where the animals are allowed to move freely and have free access over the whole area of the building or pen (a small enclosure for livestock). Cubicle house are also included here. Cubicle housings are buildings divided into rows of individual stalls or cubicles in which animals lay when at rest but are not restrained.

Loose housing may contain manure in the form of solid dung and liquid manure when there is a concrete floor which is cleaned more frequently by scraping may be provided in the area where the animals stand to feed and/or drink. It is common for a deep layer of bedding (usually straw) to be spread over the floor that is removed from the building, typically once or twice per winter, as farmyard manure.

Loose housing may also contain manure in the form of slurry when the manure and urine drop down below the floor into a pit, where they form slurry or where it may be scraped from concrete passageways and collected in storage tanks or lagoons, along with slurry deposited on outside yards.

**Pig housing**

**Partially slatted**: part of the floor has slats where the manure and urine drop down below the floor into a pit, where they form slurry.

**Completely slatted**: the floor has slats where the manure and urine drop down below the floor into a pit, where they form slurry.

**Straw beds**: Pig housing on straw-beds (deep litter-loose housing) are animal houses where the floor is covered with a thick layer of litter (straw, peat, sawdust, or other similar material binding the manure and urine) that is removed only at intervals that may be several months apart.

**References**

Appendix 2. Manure handling systems on a national level

Russia

Authors: Roman Uvarov, Alexandr Bruikhanov, Eduard Vasiliev, Natalia Oblomkova, IEEP

Typical handling systems/handling chains in three production systems

Dairy production, slaughter pig rearing and broiler and egg poultry farming are the most widely spread animal production industries in the region (Table B). The total amount of manure produced here in 2016 was 11807.2 thousand tons, of which 50.2% originated from cattle, 35.3% - from pigs, 14.5% - from poultry, and less than 0.1% - from other animals. Around 45% of cattle farms have transferred to the loose housing systems that affected the manure moisture content: 54.9% of cattle manure is as slurry. Given the fact that all pig manure produced is slurry, the total share of slurry is 62.8% (Unified Interdepartmental Information-Statistical System, 2017; Briukhanov A. et al., 2014).
Table B. Livestock quantities in the Russian regions under consideration

| Indicator | Cattle | | | | Pigs | | | | | | Poultry* | Group | Number |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Group | Number | | | Group | Number | | | | Group | Number | | | | | |
| LSU number | <1 year old | 55 629 | | | Piglets under 20 kg | 11 027 | | | | | | | | | | |
| | 1-<2 years | 19 081 | | | 2 years and older - males | 2 115 | Breeding sows over 50 kg | 86 361 | | | | | | | | | |
| | Heifers, 2 years and older | 32 973 | | | Dairy cows | 110 670 | Fatteners and other pigs | 232 706 | | | | | | | | | |
| | Other cows, bovine, 2 years old and over | 19 003 | | | | | | | | | | | | | | | |
| Total cattle | 239 470 | | | | | | | | | | | | | | | |

| LSU number per 1000 inhabitants | Group | Number | | | Group | Number | | | | Group | Number | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | <1 year old | 11 956 | | | Piglets under 20 kg | 2.370 | | | | | | | | | | |
| | 1-<2 years | 4.101 | | | 2 years and older - males | 0.455 | Breeding sows over 50 kg | 18.560 | | | | | | | | | |
| | Heifers, 2 years and older | 7.086 | | | Dairy cows | 23.785 | Fatteners and other pigs | 50.012 | | | | | | | | | |
| | Other cows, bovine, 2 years old and over | 4.084 | | | | | | | | | | | | | | | |
| Total cattle | 51.466 | | | | | | | | | | | | | | | |

| Distribution of animal groups in the total animal stock, % | Group | % | | | Group | % | | | | Group | % | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | <1 year old | 6.131 | | | Piglets under 20 kg | 1.215 | | | | | | | | | | |
| | 1-<2 years ** | 2.103 | | | 2 years and older - males | 0.233 | Breeding sows over 50 kg | 9.518 | | | | | | | | | |
| | Heifers, 2 years and older | 3.634 | | | Dairy cows | 12.197 | Fatteners and other pigs | 25.646 | | | | | | | | | |
| | Other cows, bovine, 2 years old and over | 2.094 | | | | | | | | | | | | | | | |
| Total cattle | 26.392 | | | | | | | | | | | | | | | |

* the share of other poultry reared in agricultural enterprises is less than 0.1%, therefore it is not shown in the above table

** the table does not show the gender distinction of young cattle at the age of 1-<2 years. The national calculation methodology of the cattle herd structure does not provide for such distinction (Unified Interdepartmental Information-Statistical System, 2017; Briukhanov A. et al., 2014).

Manure is processed right on the livestock and poultry farms on specially arranged sites.

Currently the main manure processing technique is its long-term maturing (storage): above 60% of agricultural enterprises consider it the basic one. Up to 95% of slurry and liquid manure is processed by this technique (Briukhanov A. et al., 2012). It is characterized by long processing periods:

- Maturing of pig slurry must be for a minimum of 12 months, cattle manure and poultry manure for 6 months;
• Maturing of the liquid fraction of pig slurry after separation in sectional storages in spring and summer for 6 months; during the period of autumn accumulation for 9 months;
• Maturing of the liquid fraction of cattle manure after separation for at least 4 months (Management Directive for Agro-Industrial Complex 1.10.15.02-17).

The second widely spread manure processing method is its mixing with moisture absorbing material and subsequent composting. The key condition for application of this technology is compliance with the requirements to composting mix composition: moisture content below 75%, C/N ratio – between 15/1 and 20/1. This way the method is most suited for processing of poultry manure and solid animal manure.

Composting period is 3 months in winter and 2 months in summer.

The technology of manure separation into fractions with subsequent composting of the solid fraction and long-term storage (maturing) of the liquid fraction is becoming more widespread. This technology is a combination of the two above techniques (Briukhanov A. et al., 2012; Briukhanov A., 2017).

Figure A shows the main handling steps of slurry and the liquid fraction after separation. The details can be found in the text below. In general, this pattern may be applied to both cattle slurry and pig slurry.

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**Figure A. Main steps in slurry (liquid fraction of manure) handling in the Russian Federation**

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**Housing systems and manure management**

To date, the tied housing slightly prevails over the loose housing – 55% and 45%, respectively. In the tied cattle housing systems, both solid dung and slurry (semi-liquid manure) are produced. Cattle slurry is removed daily by scrapers to transverse canals, from where it is transferred to the buffer tank for temporary accumulation. In addition, in recent years, flush systems become more common, when manure is removed from the premises by flushing and suction pumps (Table C).

In pig production the most widely spread animal housing system is slated floors. The slurry produced drops down through the slats in the pits and is transported to the buffer tank either by gravity flow or with water flushes. The gravity flow
system of manure removal may be of periodic or permanent action. The pits are emptied, when they are full, but at least once every second week (Management Directive for Agro-Industrial Complex 1.10.15.02-17).

Table C. Housing systems and manure management in the Russian regions within the Baltic Sea catchment area

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Cattle</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total cattle:</td>
<td></td>
<td>% of total pigs:</td>
</tr>
<tr>
<td>• Stanchion tied stable with solid and liquid manure – 53%</td>
<td>• Partially slatted floors – 38%</td>
<td></td>
</tr>
<tr>
<td>• Stanchion tied stable with slurry – 2%</td>
<td>• Completely slatted floors – 61%</td>
<td></td>
</tr>
<tr>
<td>• Loose housing with solid and liquid manure – 39%</td>
<td>• Straw beds – 1%</td>
<td></td>
</tr>
<tr>
<td>• Loose housing with slurry – 7%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Amount of manure stored in different storage facilities in terms of LSU

<table>
<thead>
<tr>
<th>Manure storages in terms of LSU:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lagoon for slurry – 44833 LSU</td>
</tr>
<tr>
<td>• Covered storage for liquid manure and slurry – 14944 LSU</td>
</tr>
<tr>
<td>• Uncovered storage for slurry and liquid manure – 438365 LSU</td>
</tr>
<tr>
<td>• Covered storage for solid manure – 12277 LSU</td>
</tr>
<tr>
<td>• Uncovered storage for solid manure – 396944 LSU</td>
</tr>
</tbody>
</table>

Percentage of different storage facilities in terms of LSU, where 100% is the total manure produced in terms of LSU

<table>
<thead>
<tr>
<th>Manure storages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lagoon for slurry – 4.9%</td>
</tr>
<tr>
<td>• Covered storage for liquid manure and slurry – 1.6%</td>
</tr>
<tr>
<td>• Uncovered storage for slurry and liquid manure – 48.3%</td>
</tr>
<tr>
<td>• Covered storage for solid manure – 1.4%</td>
</tr>
<tr>
<td>• Uncovered storage for solid manure – 43.7%</td>
</tr>
</tbody>
</table>

Manure storage systems

Slurry is transported from the animal house to a buffer tank, from where it is either pumped or transferred by a vehicle with a tanker to a storing facility or lagoon. The buffer tank capacity should be such as to accommodate the two or three days’ volume of produced cattle manure and 14 days’ volume of produced pig manure. The buffer tank is made mainly of steel or reinforced concrete; it is equipped with a stationary electric centrifugal pump, which mixes and pumps the slurry and liquid manure to the processing place.

In the Russian Federation, four types of manure storages are used (Figure B):

- a) round precast concrete storages;
- b) cylindrical storages with metal frame and special film;
- c) lagoons with a film lining of only the base or both the base and manure surface to protect it against the rainfall;
d) metallic round storages (Briukhanov A., 2017).

![Image of manure storages](image.jpg)

*Figure B. Manure storages used in the Russian Federation*

The most common are metal round storages (around 90%); in the second place are lagoons with film lining (around 10%). The low prevalence of lagoons is explained by the difficulty to provide uniform mixing of slurry. The height of the storages is 3-5.5 meters; the depth of lagoons is 2-3 meters.

To date, the number of covered storages does not exceed 2% of the total number.

Mixing of slurry and liquid fraction in the storage allows achieving greater homogenization and lowering the silting of the storage. Slurry and liquid fraction is mixed by stationary and mobile mixing devices.

**Spreading systems**

Figure C presents statistical data on the share of various spreading technologies of slurry in the regions of the Russian Federation under consideration (Briukhanov A. et al., 2012; Briukhanov A., 2017; Volkov et al., 2014).
Figure C. Share of different spreading technologies of slurry and liquid manure in the Russian regions within the Baltic Sea catchment area

The major part of the produced liquid organic fertiliser (about 90%) the livestock enterprises apply by broadcast spreading. The share of band spreaders in the last 5 years has increased significantly from 2% to 8% of the total volume of applied liquid fertiliser. Other spreading techniques account for 3-4%. Above 60% of the applied fertiliser is used for top-dressing of perennial grasses; the remaining amount is applied with ploughing before sowing perennial and arable crops. The liquid organic fertiliser thus applied is incorporated within 1-2 hours after application (Table C).

Provided that the weight loss of slurry and liquid manure during the storing (maturing) process is about 20%, only up to 80% of the organic fertiliser produced on the basis of slurry and liquid manure is applied.
Table D. Spreading systems of slurry in the form of an organic fertiliser

<table>
<thead>
<tr>
<th>Spreading system</th>
<th>Amount of organic fertilisers* applied by the considered technique, thousand tons per year**</th>
<th>% of organic fertilisers, applied by the considered technique (in 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface distribution by broadcast spreading</td>
<td>2563.43</td>
<td>2522.40</td>
</tr>
<tr>
<td>Surface distribution by spreading with subsequent incorporation</td>
<td>1708.95</td>
<td>1674.16</td>
</tr>
<tr>
<td>Trailing hose</td>
<td>89.94</td>
<td>89.29</td>
</tr>
<tr>
<td>Band spreading</td>
<td>89.94</td>
<td>133.93</td>
</tr>
<tr>
<td>Injection</td>
<td>44.97</td>
<td>44.64</td>
</tr>
</tbody>
</table>

* by organic fertiliser is meant the slurry, which has undergone a certain processing, for example, long-term storage (maturing), because in accordance with the legislation of the Russian Federation only such manure can be applied to the soil.
** estimated value based on the amount of slurry produced and the prevalence of a specific application technology (Unified Interdepartmental Information-Statistical System, 2017; Briukhanov A. et al., 2014; Briukhanov A., 2017; Volkov et al., 2014).

References


Management Directive for Agro-Industrial Complex 1.10.15.02-17 Recommended Practice for Engineering Designing of Animal and Poultry Manure Removal Systems and the Systems of Animal and Poultry Manure Preparation for
Belarus

Author: Nikolay Kaputsin, RUE "SPC of NAS of Belarus for Agriculture Mechanization"

Typical handling systems / handling chains in three production systems

In Belarus there is no official statistical count of annually produced manure. Such information may be obtained by indirect calculation method using official statistical data of livestock (including different species and development stage) and considering the daily manure production and litter use (Kangro et al., 2017a) and national norms for technological design of livestock facilities NNTD-1-2004 approved Ministry of Agriculture and Food of Republic of Belarus on 15.10.2004 № 446 (Popkov et al., 2004).

In total 89% of the manure comes from cattle, 7% from pigs and 4% from poultry. Table E shows the repartition of manure by type and animal production.

Table E. Annual production of different manure type from cattle, pigs and chicken.

<table>
<thead>
<tr>
<th>Animal production</th>
<th>Manure type</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Solid, M t</td>
<td>Liquid, M t</td>
<td>Total, M t</td>
</tr>
<tr>
<td>Cattle</td>
<td>41,7</td>
<td>22,8</td>
<td></td>
<td>64,5</td>
</tr>
<tr>
<td>Pigs</td>
<td>0,5</td>
<td>4,3</td>
<td></td>
<td>4,8</td>
</tr>
<tr>
<td>Poultry</td>
<td>2,8</td>
<td>0,3</td>
<td></td>
<td>3,1</td>
</tr>
</tbody>
</table>

For cattle production, the proportion of liquid manure of the total amount is 35,3%, 89.6% for pigs and 9.7% for chicken.

In Belarus technologies for processing liquid manure are almost absent. Approximately 1.5 % of the manure produced annually is used in biogas plants as organic raw materials in Belarus.

Housing systems and manure management

Cattle

In Belarus, mainly large-scale industrial livestock production is carried out. In this case three systems predominate; stall-grazing system, stall-range system and year-round housing system for cattle are common. Some are used with bedding and some without bedding materials.

In stall-grazing system, cattle are kept inside animal houses during the cold season (October to April) (Figures D and E), but during grazing season cattle are outside on natural pastures (Figure F). For dairy cows, if the pasture is located near by the farm, cows are milked there, but if remote, a mobile milking and cooling system is used to milk them. There are different systems of cattle housing used in Belarus: loose-housing or tied.
Figure D. Cattle maintenance in barns during stall period (without bedding).

Figure E. Cattle maintenance in barns during stall period (on bedding).
Figure F. Cattle maintenance during pasture period.

When the stall-range system cattle are in stalls they may walk on grounds near the livestock buildings (Figure G).

In year-round housing system cattle is kept in stanchion-tied stables or in loose-housing barns.

Figure G. Stall-range system of cattle.

When cattle housing does not use bedding the animal buildings are typically equipped with slatted floor with scrapers outside of stalls. During the day slurry is periodically transported through the cross channel into a deep concrete pit (buffer tank) which is equipped with agitator and pump.
When cattle kept with bedding manure is periodically manually removed from the stalls into the aisles, from which it is removed outside the livestock building with a bulldozer. The slurry is further transported from the buffer tank into storages.

**Pig**

When pig indoor breeding are in pig houses equipped with special slatted pig pen (Figure H). As a rule, pig slurry is removed from the pig house using hydraulic flush methods and the slurry is then stored in lagoons.

![Figure H. Pig indoor breeding.](image)

**Poultry**

Because no more than 10% of the poultry manure is slurry, there is a limited interest to implement SAT in the poultry industry in Belarus. Therefore, this report will not include poultry.

**Manure storage systems**

Slurry is mostly stored in lagoons (Figure I) or cylindrical tanks (Figure J).
These storages have no hard cover or roof to reduce ammonia loses but a natural occurring crust of solid components which fulfil this role (Figure K).
Figure K. The crust on the surface of liquid manure

Slurry mixing in-storage is performed with stationary or mobile pumps before spreading in fields (Figure L), activated with the PTO shaft of the tractor or electric engine.

Figure L. Mixing and pumping of liquid manure from the lagoon.
Spreading systems

Table F. Slurry spreading technics in Belarus (Kangro et al., 2017b)

<table>
<thead>
<tr>
<th></th>
<th>Broadcast</th>
<th>Trailing hose</th>
<th>Injection</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

In Belarus slurry is applied in fields mainly by spreading from mobile tanks produced by national producers (Figure M). Recently they began use mobile tanks with trailing hoses for slurry band spreading (Figure N).

![Figure M](image-url)  
Figure M. Broadcast liquid manure application in fields by the method of splashing.

![Figure N](image-url)  
Figure N. Liquid manure band spreading in field with using ramp with trailing hoses applicators.
In Belarus in-soil injection practically isn’t used because of the lack of required equipment for agricultural producers.

References Belarusian chapter


Summary of the project

“Bringing Russia and Belarus into BSA” allow the participation of partners from outside EU but within the Baltic Sea Region to the Baltic Slurry Acidification project. Baltic Slurry Acidification project is an agro-environmental project funded by the Interreg Baltic Sea Region program in the priority area Natural Resources Focusing on Clear Waters. The aim of the project is to reduce nitrogen loss from animal production by testing, demonstrating and promoting the use of slurry acidification techniques in countries around the Baltic Sea.

Summary of the report

The aim of this report is to present the expert analysis from Russia and Belarus about the potential development of SATs on the current manure handling systems and to point out current technical bottlenecks for the implementation of SATs in the Baltic Sea Region (Russia and Belarus). The report in a complement to the RISE Report 2017:47 which looks at the EU countries around the Baltic Sea Region.

This report has been prepared as a cooperation between the following project partners: