



## The Ecological Status of Livestock and Poultry in the Border Regions of Russia and South-East Finland

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**Abstract.** Intensification of agricultural production increases the burden on the environment. Modern management and planning of agricultural activity requires a comprehensive assessment of the environmental status of the industry. (*Research purpose*) To develop recommendations for improving the environmental safety of agricultural production based on the implementation of the best available technologies, methods for monitoring and controlling technological processes for the disposal of organic animal waste. (*Materials and methods*) The authors studied agricultural enterprises, their specialization and production capacities, technologies for manure and litter utilization. The studies included an assessment of enterprises according to the criteria approved in the recommendations of Helsinki Commission for the Baltic Sea. The authors used standard methods for processing statistical, field and personal data. (*Results and discussion*) The authors conducted a state analysis of the agro-industrial complex of Leningrad Region in terms of the organic waste formation from animal husbandry and poultry farming, and evaluated the potential for their use. They studied 142 large complexes, which produce more than 90 percent of livestock and poultry products. The average livestock density in Leningrad Region is 2.2 conventional heads per hectare of cultivated agricultural land. They showed that there are 22,200 households in southern Finland, 79 percent of which are plant growing enterprises that are engaged in small-scale production. They took into account the specific features of the studied territories in terms of nutrient load and proposed a system of environmental impact regulation. (*Conclusions*) The authors developed 4 main recommendation sections to reduce the risks of biogenic environmental pollution: the development of an industrial environmental control system based on technological regulations; mastering the system of regional monitoring and coordination of work with organic fertilizers; adoption and implementation of a program of livestock enterprises technological and technical modernization in terms of the organic waste disposal; creation of demonstration platforms for environmental specialists advanced training in the implementation of modern technological solutions.

**Keywords:** environmental assessment, processing technologies, nutrient loading, manure, litter, animal husbandry, Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area.

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## Экологическое состояние животноводства и птицеводства в приграничных районах России и Юго-Восточной Финляндии

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**Реферат.** Интенсификация аграрного производства увеличивает нагрузку на окружающую среду. Современное управление и планирование сельскохозяйственной деятельности требует комплексной оценки экологического состояния отрасли. (*Цель исследования*) Разработать рекомендации для повышения экологической безопасности сельхозпроизводства на основе внедрения наилучших доступных технологий, методов мониторинга и управления технологическими процессами утилизации органических отходов животноводства. (*Материалы и методы*) Изучили сельскохозяйственные предприятия, их специализацию и производственные мощности, технологии утилизации навоза и помета. Включили в исследования оценку предприятий по критериям, утвержденным в рекомендациях Хельсинской комиссии по Балтийскому морю. Применили стандартные методы обработки статистических, натурных и анкетных данных. (*Результаты и обсуждение*) Провели анализ состояния агропромышленного комплекса Ленинградской области в части образования органических отходов животноводства и птицеводства, оценили потенциал их использования. Исследовали 142 крупных комплекса, на которых производится более 90 процентов продукции животноводства и птицеводства. Средняя плотность поголовья животных в Ленинградской области составляет 2,2 условной головы на один гектар обрабатываемых сельскохозяйственных земель. Показали, что в Южной Финляндии насчитывается 22200 хозяйств, из них 79 процентов – растениеводческие, которые занимаются мелкотоварным производством. Учили особенности исследуемых территорий по биогенной нагрузке и предложили систему регулирования воздействия на окружающую среду (*Выводы*) Разработали 4 основных раздела рекомендаций по снижению рисков биогенного загрязнения окружающей среды: освоение системы производственного экологического контроля на основе технологических регламентов; освоение системы регионального мониторинга и координации работы с органическими удобрениями; принятие и выполнение программы технологической и технической модернизации животноводческих предприятий в части утилизации органических отходов; создание демонстрационных площадок для повышения квалификации специалистов по экологическим вопросам внедрения современных технологических решений.

**Ключевые слова:** экологическая оценка, технологии переработки, биогенная нагрузка, навоз, помет, животноводство, Хельсинская конвенция по Балтийскому морю.

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Intensification of agricultural production increases the environmental load on the environment. Poor development of appropriate infrastructure and insufficient use of innovative technologies for processing livestock and poultry waste can negatively affect the environmental situation [1-3]. Of particular concern is the pollution of water facilities. In particular, the territory of the Baltic Sea drainage basin falls under both Russian environmental legislation and the Helsinki Convention, according to which special attention is paid to measures to reduce the supply of nutrients to water facilities, including from agricultural enterprises [4-7]. While carrying out research in the framework of one of the main directions of VIM and with the assistance of the international project EcoAgRAS, the Institute for Engineering and Environmental Problems in Agricultural Production – branch of Federal Scientific Agroengineering Center VIM organized studies to assess the ecological state of animal husbandry and poultry farming in the border regions of Russia and South-Eastern Finland. The studies were carried out by analyzing the number of agricultural enterprises, their specialization and production capacities, studying the technologies for processing and using manure and litter as organic fertilizers [8-9]. Agricultural activities assessment was carried out in accordance with the criteria approved in the recommendations

of the Helsinki Commission for the Baltic Sea (HELCOM).

**RESEARCH PURPOSE** is to work out recommendations for improving the environmental safety of agricultural production based on the introduction of the best available technologies, methods for monitoring and managing technological processes for the disposal of organic animal waste.

**MATERIALS AND METHODS.** To collect the initial information, the authors used the statistical reporting data of the Committee on the agro-industrial and fishery complex of Leningrad Region, the Institute of Natural Resources of Finland and the data obtained from the agricultural enterprises survey.

The questionnaire included the collection of the following information:

- enterprise type (crop, livestock, poultry, mixed);
- activity area (for pig enterprises – fattening, reproduction, the finished cycle; for poultry enterprises – egg or broiler production; for complexes of cattle – dairy direction or fattening);
- livestock of animals/birds;
- sown area (by crop), ha;
- use of mineral fertilizers, t/year;
- use of organic fertilizers, t/year;
- transfer of organic fertilizer to other enterprises, t/year.

When obtaining environmental information, the authors used previously developed methods, used field surveys of typical agricultural enterprises and took into account satellite data from the agricultural territories of Leningrad Region.

**RESULTS AND DISCUSSION.** In southern Finland (as of November 2019) there are 22,200 households in total. Of these 79% are purely crop farms. Dairy cattle farms account for 7% of the total; 2.5% of farms specialize in raising pigs, 4.5% - in beef cattle breeding. The share of poultry farms is only 2%. The average farm size in the southern Finland region ranges from 40-60 ha of cultivated land per farm.

In 2018 there were more than 6,200 dairy farms in Finland, 145 of which were organic. Only 1/3 of all dairy farms are located in southern Finland. Over the past 5 years, their total number has decreased by 29%. The size of such farms has a wide range. Farms with a livestock of less than 100 animals account for approximately 25% of the total number (453 farms), 55% of all dairy cows are raised on farms with a livestock of over 50 cows. In total, there are 263,600 dairy cows in Finland.

Considering that the production structure and farm capacity in the Russian part of the Baltic Sea region and in Southern Finland are completely different, problems with manure and nutrients are slightly different from those that exist in Leningrad Region. Compared to large and numerous livestock enterprises in Leningrad Region, Finnish production is represented by small-scale farming (family) farms.

The number of pig farms is approaching 1000, with half of them located in southern Finland, with a concentration in the southwest. In recent years, every year they become less by 7-10%. 50% of pigs for rearing and fattening are kept in farms for 1000 animals and more.

In the country there are 171 poultry farms for the broilers production and 54 turkey breeding. The egg direction is represented by 4 million laying hens, 607 thousand young hens. Moreover, 86% of all laying hens are reared 133 farms with a livestock of over 10 thousand. However, almost 2/3 of the farms have a livestock of less than 50 hens.

An assessment of the nutrient load on water bodies shows that 60% of the total annual phosphorus load and less than 50% of the nitrogen load in Finland are in agriculture and livestock/poultry farming. 9 kg of total phosphorus in the composition of manure and 6 kg of phosphorus in the composition of mineral fertilizers are annually contributed as fertilizer per 1 ha of land.

The load share on nutrients (nitrogen and phosphorus) from agriculture in the Archipelago region and the southern coastal zone is above average, and 90% of the total load on nutrients is noted outside the growing season. Climate change, including an increase in the amount of precipitation in the autumn-winter period, causes ever greater erosion and nutrient loading. The concentration of livestock/poul-

try farms leads to an excess of manure brought into the fields as organic fertilizer.

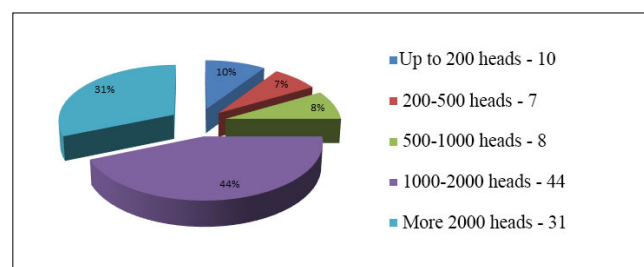
The main problem is phosphorus. The total volume of manure/litter reaches 15.5 million tons per year. In addition, during this period, 230 thousand tons of mineral fertilizers are applied. Manure and slurry from sewage treatment are 40% of the total nitrogen feed, the rest comes in the form of mineral fertilizers. Feeding with phosphorus is 33 thousand tons per year, 60% of which is manure and slurry. Fertilizing with nitrogen averages 70 kg/ha, feeding with phosphorus – 6 kg/ha.

According to the agricultural producers register of Leningrad Region, there are 831 farms operating on its territory (as of August 2019), however, more than 90% of livestock and poultry products are produced by 142 large complexes, of which 94 are cattle, 8 are pig-breeding, 12 poultry farms, 2 mixed-type enterprises (cattle and pig breeding) and 26 plant growing enterprises. In all municipal districts of Leningrad Region, 116 livestock and poultry enterprises are located, in which they contain 159.783 thousand cattle, 184.867 thousand pigs and almost 29 million birds. The poultry stock is concentrated mainly in the Kirov and Vyborg districts.

There is an intensification of livestock and poultry industries, new complexes are being built, the existing ones are increasing their production capacities in Leningrad region. This fact is confirmed by the localization of a large number of animals at separate production sites (*Fig. 1*).

Large complexes (1000 cattle and more) account for 70%. 42 enterprises from 96 (94 cattle and 2 mixed ones – cattle and pig breeding) have 1000-2000 cattle. And only in 9 farms the livestock does not exceed 500 heads.

The number of pigs in Leningrad Region is unevenly distributed. More than 65% of all pigs (120.577 thousand animals) are housed in two pig farms in the Tosno district.



*Fig. 1. The share of enterprises with various cattle in Leningrad region*

A similar imbalance is observed in poultry farming: 66% of the total number of poultry in the Kirov districts is concentrated in the two largest poultry farms – almost 19 million cattle [10].

Further animal husbandry and poultry farming intensification is impossible without the scientific substantiation of environmental safety issues in the disposal of manure and litter. If they are not used as organic fertilizer, processing technologies are not followed, then they become



a source of environmental pollution and are considered as production waste with the ensuing consequences [11-13].

To identify risks during biogenic load from livestock and poultry complexes, the mass of nitrogen formed in organic fertilizer in each district of Leningrad Region was calculated.

In total, about 5300 thousand tons of manure and litter are formed annually in the region. Using the existing recommendations of HELCOM (170 kg/ha of nitrogen) and RD-APK 1.10.15.02-17 “Methodological recommendations for the technological systems design for the removal and preparation for use of manure and litter”, the authors calculated the maximum dose for each type of organic fertilizer based on manure cattle, pigs and poultry. Having calculated application doses (t/ha), knowing the total agricultural land in each district and cultivated crops, the authors determined the potential for the full use of manure and litter in the districts of Leningrad Region (table).

Calculations indicate an uneven nutrient load. Most of the regions have the potential to add additional nitrogen with organic fertilizer to agricultural land. Only 2 districts – Vyborg and Kirov – have a shortage of land, which means an excess of nitrogen of 2172.9 and 8433.2 tons per year, respectively, which can lead to environmental risks. However, they can be unloaded by redistributing the excess to the land of neighboring regions, as evidenced by the total positive (+8769.2 tons of nitrogen per year) potential in the region.

In the countries of the Baltic region a conditionally safe value of the animals density was adopted as 1.5 head

per 1 ha of agricultural land [14, 15]. Exceeding the range of values of 1.5–1.7 head/ha may lead to the risk of accumulation of excessive amounts of nutrients in the soil and a significant increase in emissions and discharges [16]. The average density of livestock of animals and poultry per unit of cultivated land for Leningrad Region is 2.2 head/ha.

When choosing machine technologies for the disposal of manure and litter it is necessary to apply the principles of the best available technologies (BAT) considering the complexes’ size. The regulation system of negative environmental impact on the basis of BAT is based on the introduction of modern technologies and appropriate monitoring systems and the adoption of optimization decisions based on its results [17-20].

The phased development of BAT for the utilization of organic waste in agricultural production can be represented as a sequence of actions (Fig. 2).

The first stage – «Assessment of the current level of technologies and management» – allows to assess the real technical condition of agricultural facilities and the quality of accounting for the treatment of organic waste. Based on the analysis and the results of the assessment, a technological modernization plan should be prepared with a reasonable list of recommended BAT and methods for monitoring the functioning of the technologies.

The second stage – «Transition to state-of-the-art technologies of organic waste handling» – provides the implementation of a technological modernization plan based on the list of recommended BAT. Given the high

Districts	Agricultural land area, ha	Estimated nitrogen, which could be applied on available agricultural land, t/year	Nitrogen generated in the fertilizer produced, t/year	Balance (Estimated additional nitrogen, which could be applied on available agricultural land, t/ha)
Boksitogorskiy	350.0	59.5	29.8	+29.7
Volosovskiyy	36547.0	6213.0	1458.1	+4755.0
Volkhovskiy	11584.0	1969.3	907.9	+1061.4
Vsevolozhskiy	9513.0	1617.2	935.9	+681.3
<b>Vyborgskiy</b>	<b>8374.0</b>	<b>1423.7</b>	<b>3596.6</b>	<b>-2172.9</b>
Gatchinskiy	26299.0	4471.0	2587.9	+1883.1
Kingiseppskiy	10263.0	1744.7	519.3	+1225.4
Kirishskiy	8678.0	1475.3	366.0	+1109.3
<b>Kirovskiy</b>	<b>2016.0</b>	<b>342.9</b>	<b>8776.1</b>	<b>-8433.2</b>
Lodeinopolskiy	2683.0	456.1	137.0	+319.1
Lomonosovskiyy	13010.0	2211.7	872.1	+1339.6
Luzhskiy	21571.0	3667.3	1339.2	+2328.1
Priozerskiy	19690.0	3347.2	1529.2	+1818.0
Slantsevskiy	6948.0	1181.2	294.5	+886.7
Tikhvinskiy	5478.0	931.3	306.0	+625.3
Tosnenskiy	16105.0	2738.0	1689.2	+1048.8
<b>Total in Leningrad Region</b>	<b>–</b>	<b>–</b>	<b>–</b>	<b>+8508.1</b>

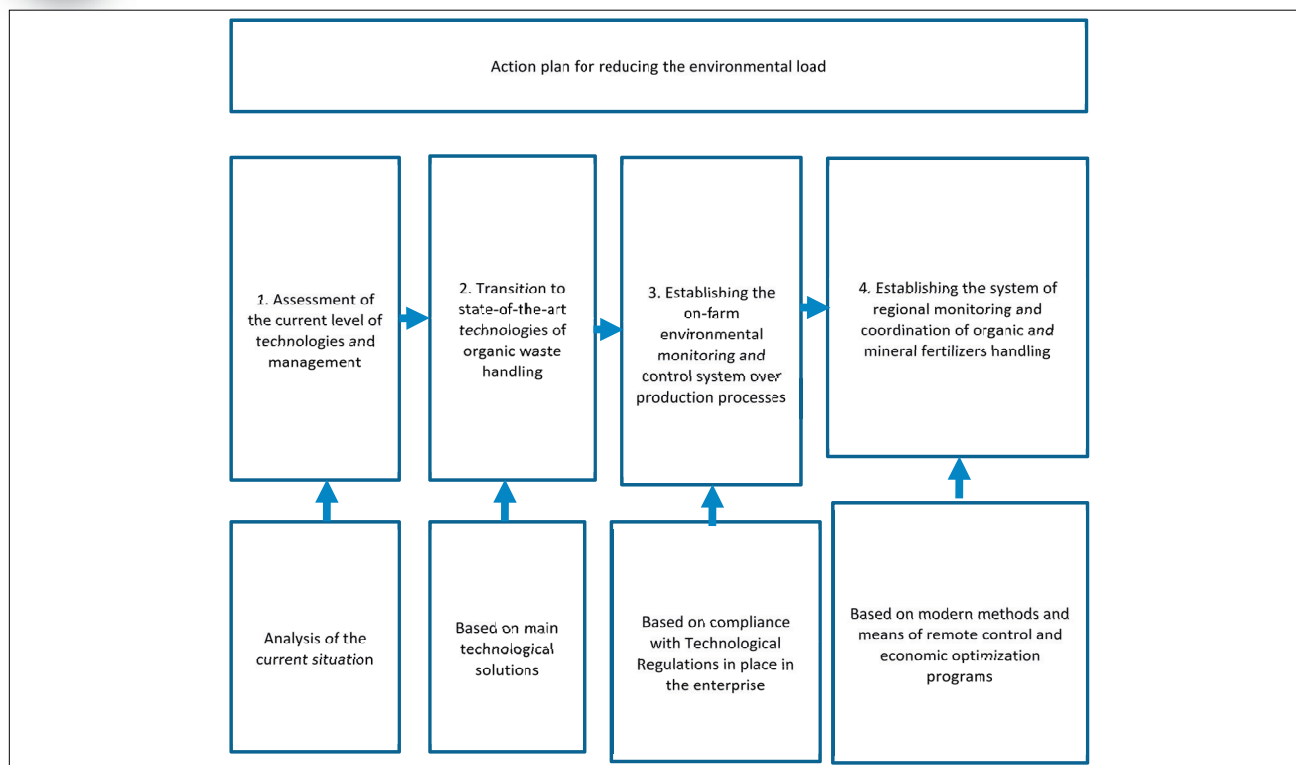


Fig. 2. The action plan for reducing the environmental load

cost and duration of the modernization plan implementation, its order should be determined, providing for priority in the areas, condition and specialization of agricultural enterprises. First of all, enterprises that create the greatest risk of diffuse pollution of water bodies should be modernized.

The third stage – «Establishing the on-farm environmental monitoring and control system over production processes» – includes the introduction of tools for internal environmental control of agricultural enterprises, which can be implemented in the development and compliance with local technological regulations (enterprise standards).

The fourth stage – «Establishing the system of regional monitoring and coordination of organic and mineral fertilizers handling» – is the most important for the subsequent assessment of the diffuse load from agricultural production.

This system allows to work with updated data online, which increases the accuracy of the environmental load assessment, including the effect of BAT.

**CONCLUSIONS.** The authors assessed the state of agricultural enterprises of Leningrad Region in terms of their environmental impact and prepared proposals to improve the environmental safety of agricultural production. Reducing the risks of negative environmental impact from agricultural enterprises can be achieved by performing the following interrelated measures:

1. Development and monitoring of the recommendations

implementation for the development of industrial environmental control system at the enterprise level. This system involves the adoption and observance of local regulations, such as the technological regulations. The technological regulation is the main tool of the on-farm organization of the manure / litter management system, which should be taken into account when moving to the system of the best available technologies.

2. Development of recommendations for the exploration of a regional monitoring system and coordination of work with organic and mineral fertilizers. Recommendations can be used by authorities to assess the environmental situation, to establish relationships between agricultural enterprises regarding the effective use of organic fertilizers in predicting the development and functioning of agricultural production.

3. Development and adoption of technological and technical modernization of livestock and poultry enterprises program in terms of the organic waste disposal, taking into account international requirements and the principles of BAT. The implementation of the program should include the creation of demonstration sites at pilot enterprises with modern and appropriate BAT technological solutions for the management of organic waste. Demonstration sites will become operational facilities where it is possible to train employees of all agricultural enterprises in order to improve their qualifications in environmental issues and further introduce modern technological solutions.

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