MODERNISATION OF MANURE MANAGEMENT TECHNOLOGIES IN LARGE PIG COMPLEXES OF LITHUANIA

Jurgita Kazakevičienė1, Sigita Marija Strusevičienė2,
1Lithuanian University of Agriculture
2Water Management Institute of Lithuanian University of Agriculture
E-mail: zenonas@water.omnitel.net

Abstract
Technologies of keeping livestock and management of manure pig complexes holdings built in the country under the Soviet regime no longer satisfy modern veterinary and environmental requirements. Conditions for the modernisation of such complexes were created as from 2000, when agricultural aid programmes (funds) appeared in Lithuania. Information about old and newly implemented manure management technologies, fertilisation value of manure, and quality of the drainage runoff from manure-fertilised fields has been collected in six large livestock companies. Analysis of collected data revealed that new livestock keeping, feeding and manure management technologies are more cost-effective in using energy and mineral resources and conform to the animal welfare, environmental protection and hygiene requirements that are becoming more and more stringent. As the traditional manure management in economic terms is quite expensive and has a significant impact on the environmental quality, academic community is looking for new manure processing methods. The global development of manure management technologies focuses on the manure processing in biogas plants. Biogas generated from liquid manure and animal waste in such plants is an alternative source of energy.

Key words: manure, fertilising value, spreader, pollutants.

Introduction
Currently, the modernization and development of large pig complexes is a top issue in the livestock sector. Due to high amounts of animal units in one place, large livestock holdings are more dangerous to the environment than the small ones. In spite of this, currently the development of livestock holdings is orientated to the increase of capacity all over the world, because in such enterprises it is much easier to implement more productive and more economical equipment, to automatize technological processes and in such way to reduce the cost price of production. Moreover, in large livestock holdings it is possible to implement advanced systems of work organization, work control, work security, and environment protection management. Therefore, the most urgent projects are those aimed at the implementation of modern cattle breeding, feeding and manure handling technologies saving energy, nature resources, and satisfying all requirements of animal welfare, environment protection and hygiene.

Since 2000, agricultural support programs (funds) have been established, which ensured perfect conditions for the modernization of livestock farms. In large pig complexes the systems of cattle breeding and shed ventilation were changed, new manure sites were constructed. No water was used to remove manure from sheds.

In 2006, in Lithuania there were 0.8 million cattle units, 1.1 million pigs, 9.4 million poultry units, and 0.2 million units of other animals (goats, sheep, horses) (Statistikos..., 2006). According to the calculations, about 560 thousand ha are needed in this country in order to spread the manure produced by animals and poultry considering all environment protection requirements. This makes up about 16% of all agricultural land use of Lithuania (3.487 mln ha) (Statistikos..., 2006). Such area of land with manure applied is not very large, therefore the country has resources for the expansion of cattle breeding in order to develop a well-balanced agricultural system. Manure is described as a product maintaining the humification process of the soil. When developing the plant growing based on mineral fertilizers it is rather difficult to maintain...
the humus of the soil. When there are no animals, fields are not fertilized with organic fertilizers, which results in reduced amounts of humus in the soil. When the same crops are grown in crop rotations, more mineral fertilizers and crop protection means are needed in order to maintain crop productivity. After some time the soil becomes exhausted, plant uptake of nutrients worsens, production is getting more expensive, and the environment pollution is increasing (Pažangaus..., 2000). As the scientist Tripolskaja L. refers in her monograph, when no organic fertilizers are applied, the amount of humus contained in the soil decreases by 19.5% within the period of 11 years (Tripolskaja, 2005). Therefore it is very important to modernize old livestock holdings, construct new ones, and encourage their vital capacity. In livestock holdings constructed during the Soviet period, cattle breeding and manure handling technologies do not meet the veterinary and environment protection requirements anymore. Only the construction of manure sites meeting the requirements of environment protection will demand about 785.3 million Lt of investments (Šileika, 2001).

The objective of the work is to analyze the tendencies of the new manure handling technologies in large pig complexes, as well as to estimate their perspectives.

Materials and methods

To carry out the study, the works of scientists from foreign countries and from Water Management Institute of Lithuanian University of Agriculture dealing with manure handling technologies were used; also the information about the new realized projects when modernizing large livestock holdings (more than 3000 pig units) was considered. The material about the implemented projects of new technologies was collected in four pig breeding companies: ‘Gražionių bekonas’ (Radviliškis district), ‘Girkalnio kiaulių kompleksas’ (Raseiniai district), ‘Sajas’ and ‘Berka’ (Kelmė district). The information for the comparison was collected from large pig-breeding complexes where old pig breeding and manure handling technologies are used, i.e., when water is used for manure removal from sheds ‘Krekenavos agrofirma’ (Panevėžys district), and ‘Litpirma’ (Radviliškis district). In those objects the technological solutions were analyzed, the comparison of data about manure composition, data about manure spreading rates during field fertilization was made, as well as pollution dynamics of drainage water released from fields with manure applied. Mathematical and statistical analysis of test study results was used for mathematical processing of data.

Results and discussion

Manure handling technologies applied in large pig complexes. During the Soviet period, in Lithuania, 33 large pig complexes were built, where the same manure removal technology – hydraulic removal of manure – was applied. In 1995, having evaluated the ecological conditions in those complexes, the Government of Lithuania prepared a program for their modernization (LR Žemės..., 1995). In all complexes, manure from sheds was removed in a hydraulic way – i.e., using subsurface or surface water. Fertilization value of manure was low due to its dilution with water. Moreover, accumulation of such diluted manure (slurry) requires very large reservoirs. In agricultural company ‘Girkalnio kiaulių kompleksas’, reservoirs of 160 thousand m³ capacity were arranged. After modernization of the complex, when no more hydraulic manure was applied, the sufficient capacity of reservoirs was reduced to 8.6 thousand m³. ‘Sajas’ had slurry reservoirs with the capacity of 140 thousand m³, but after modernization the capacity of 30 thousand m³ was enough. Figure 1 presents the dependence of manure quantity produced from one place of weight of a 20-100-kg pig on the manure moisture (dilution).
During the reconstruction of old sheds, their old floor is removed, and manure baths with self-flow collectors are arranged. The baths are covered with grating. Liquid manure from the baths is removed with the help of self-flow pipe collectors. On the bottom of the bath, a pipe for the release of manure is arranged, which is closed with a cork. The cork is taken out only when the bath is fully filled with manure. Such system is simple and comfortable to use. It is particularly efficient when manure contains about 8-12% of dry matter. Self-flow manure collectors are directed from sheds into the pumping-house. Liquid manure is accumulated in manure reservoirs of a new type – i.e., in reservoirs of cylindrical shape with metal or reinforced walls with reinforced bottom, or in lagoon-type reservoirs with two-level geomembranes (1.5 and 2.0 mm thick). In the reservoir, manure splits up into three layers: upper layer (manure crust), middle layer (slurry), and lower layer (sediment). Those layers make up 10-15%, 20-30%, and 55-70% of the capacity of the reservoir, respectively. The crust partially reduces nitrogen evaporation losses. Before starting the fertilization of fields, manure is accurately mixed in the reservoir with the help of special mixers in order nutrients (nitrogen, phosphorus, potassium, and microelements) would distribute evenly (Strusevičius, 1996).

Liquid manure has many advantages. Due to its compactness it can be properly rated, evenly spread, and can ensure better plant uptake of nutrients (~50% of nitrogen per year). Liquid manure can also be used during the whole vegetation season of plants, it can reduce nitrogen losses during the fertilization period to a maximum, because liquid manure can be inserted into the soil. The main advantage of liquid manure is that its handling can be fully mechanized and automatized.

Liquid manure is spread with the help of a spreading plate, hoses, or it is inserted into the soil.

Liquid manure spreading with the help of spreading plates is one of the simplest means. However, during the irrigation, about 20-30% of ammonia nitrogen evaporate into the environment, therefore this way of manure spreading is least suitable from the environmental point of view. Such kind of manure spreader should be used in calm, cool weather, when the soil is not sown up and is immediately ploughed up.

Surface irrigation with the help of hoses has more advantages, because nitrogen losses make up only 10-20%. According to the studies of water Management Institute of Lithuanian University of Agriculture, spreading unevenness is only 3-5%. When using the dragging hoses, liquid manure does not splash over plants, which means this way

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Fig. 2. Dependence of manure quantity produced from one place of weight of a 20-100 kg pig on manure moisture (dilution).

![Graph showing the dependence of manure quantity on manure moisture content.](image)
of manure spreading is hygienic and can be applied in the sown up soil.

Compared to other liquid manure spreading ways, manure introduction into the soil significantly reduces ammonia losses (LR Žemės..., 2000). Other advantages include less dispersion of odors, and dependence on the wind. However, the main disadvantages include small spreading area, strong tractive force, and low labour productivity.

As liquid manure can be pumped with special pumps, it can be provided to the spreader through flexible pipelines. The use of pipelines for the transportation of manure (especially when the distance to fertilization fields is rather long) may reduce work expenses much better than slurry transportation with tractor spreaders.

Z.Strusevičius, a scientist of Water Management Institute of Lithuanian University of Agriculture, after technological measurements has determined that transporting manure in a tank of 8.0 m³ capacity, the transportation of 100.0 m³ of manure at the distance of 3 km will require 37.3 l of diesel fuel, whereas pumping of the same amount of manure with diesel engine will require only 9.6 l of diesel fuel (Strusevičius, 1996).

Before spreading manure on fields, the farms investigate the composition of manure produced in their enterprises in special certified laboratories. Table 1 presents the average data of long-term research of Water Management Institute of Lithuanian University of Agriculture: the composition of manure produced on modern pig complexes and the composition of slurry produced on farms using old hydraulic manure removal system.

### Table 1

<table>
<thead>
<tr>
<th>Manure management technology</th>
<th>Organic manure</th>
<th>( N_{\text{total}}^{*} )</th>
<th>( P_{\text{total}}^{**} )</th>
<th>( K^{***} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-driven liquid manure removal system with covered livestock manure storage facility</td>
<td>Liquid manure</td>
<td>3415-4500</td>
<td>450-1000</td>
<td>1620-1800</td>
</tr>
<tr>
<td>Hydrodynamic manure removal system, fractioning into slurry and thick fraction, open slurry storage tanks</td>
<td>Slurry</td>
<td>635</td>
<td>335</td>
<td>610</td>
</tr>
<tr>
<td></td>
<td></td>
<td>548-713</td>
<td>277-459</td>
<td>522-686</td>
</tr>
</tbody>
</table>

Notes:
- \( * \) - total nitrogen;
- \( ** \) - total phosphorus;
- \( *** \) - kalium;
- \( **** \) - numerator represents the average value, and denominator – min...maximum values.

As Table 1 shows, fertilization value of slurry is 6.3 times lower than that of liquid manure. When making up plans about manure usage for field fertilization, farms are orientated towards spreading rates that would ensure nitrogen input amounts with manure no higher than 170 kg per 1 ha (LR Aplinkos..., 2005). Thus, when fertilizing fields with slurry, annual spreading rate is up to 300 m³ha⁻¹ and when fertilizing with liquid manure, annual spreading rate is up to 38 m³ha⁻¹. This means that hydraulic load of fields fertilized with slurry is much higher than that of fields fertilized with liquid manure. Table 2 presents the data of environment monitoring (drainage water outlets) collected at modern agricultural company ‘Gražionių bekonas’, and at ‘Krekenavos agrofirma’ using old manure handling technology.

As it is seen from the data in Table 2, applying slurry on fields, nutrient leaching is more intensive a applying liquid manure (according to \( N_{\text{total}}^{*} - 3.1 \) times, according to \( P_{\text{total}}^{**} - 2 \) times). This is due to more intensive hydraulic load of the fields.
Quality of the drainage runoff from manure-fertilised fields  
(environmental monitoring data, 2006)

<table>
<thead>
<tr>
<th>Company</th>
<th>Composition of the drainage runoff from organic manure-fertilised areas, mg l⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BOD*</td>
</tr>
<tr>
<td>‘Gražionių bekonas’</td>
<td>1.0</td>
</tr>
<tr>
<td>‘Krekenavos agrofirma’</td>
<td>1.8</td>
</tr>
<tr>
<td>MPC** for drainage outlets</td>
<td>23.0</td>
</tr>
</tbody>
</table>

Notes:  
* - biochemical oxygen demand;  
** - maximum permissible concentration.

Perspectives of the development of manure handling technologies. Traditional manure handling activities (accumulation transportation, spreading on fields) are successfully applied today. However, from the economical point of view, traditional manure handling is rather expensive. Besides, it results in dissatisfaction of inhabitants due to bad odor produced by manure gas (indol, mercaptan, sulphurhydrogen, ammonis). Scientists keep looking for manure handling ways seeking to deodorize it as well as reduce its amount by separating water from manure. German scientist J. Beck and British scientist C. Burton have analyzed the following manure processing and handling technologies used in European Union: mechanical separation, centrifuging, aeration, thermophylic aeration, anaerobic mesophylic fermentation, anaerobic thermophylic fermentation, treatment with acid, drying-evaporation, and osmosis (Beck and Burton, 1998). All those technologies differ in respect of their efficiency and cost price. In 2006, scientists of Water Management Institute of Lithuanian University of Agriculture started implementing the program of searching technological studies aimed at the decomposition of slurry, produced on industrial pig complexes, into solid matter and wastewater. According to this program, manure will be processed with strong acid, alkaline solutions in whirling-inductive equipment. In such way, all viruses and microbes will be destroyed, and ammonia will be bound up. As the obtained dry organic product will be used as a fertilizer, scientists suggest using sulphur acid which is rather cheap; besides, its the amount is usually insufficient in the soils of Lithuania. Heavily polluted wastewater produced after the processing of manure will be biologically treated and released into open water bodies.

Currently, the technology of manure processing in biogas reactors is being used all over the world. Biogas can be produced from animal manure in a fermentation way. Biogas has about 50% of the energetic value of natural gas (Šileika, 2001). Manure processing in biogas reactors improves the hygienic characteristics of manure; besides, a contiguous product – flammable biogas – is obtained. However, in such manure nearly all nitrogen is turned into ammonia nitrogen. In order to reduce ammonia nitrogen losses (due to evaporation) in the next stages (accumulation and fertilization), additional means are to be used. On the other hand, the arrangement of biogas power station requires particularly large investments. During the last decade, in foreign countries, biogas power stations are constructed in places with stable users of thermal energy, and with sufficient resources of grease wastes from food production and animal slaughterhouses. Such resources should make up 50% of biomass produced in the reactor; the rest 50% goes to manure. With such composition of biomass, 1 m³ of biomass may produce up to 100 m³ of biogas. If the biomass is composed only of manure, 1 m³ of biomass would produce only about 20-25 m³ of biogas. Biogas obtained in countries of European Union makes up only 2-5% of all energy demand. According to the data of scientific researches, in Lithuania biogas could meet up to 3% of all energy demand. According to the study data of all Lithuanian Energy Institute, the estimated expenses of the construction of biogas power stations with different capacity (volume of bio-reactor from 10 to 200 m³) would make up from 45 to 627 million Lt respectively. The expenses of the technologies would be covered after 10 or more years depending...
on the purpose for which where biogas will be used (for greenhouses, for house heating, etc.). Therefore, state financial support is necessary in this field. On the basis of legal, organizational and economical means, the state should support the production of alternative energy by giving preferential credits to the projects of implementation of alternative energy sources (i.e., biogas production) (Šileika, 2001).

Conclusions

1. When producing liquid manure, small spreading loads (up to 38 m³ ha⁻¹) are used due to its high fertilization value (1 m³ of liquid manure contains up to 4.5 kg of nitrogen). In farms where water is used for hydraulic removal of manure, liquid manure is diluted. This results in lower fertilization value of manure, therefore high spreading loads (up to 300 m³ ha⁻¹) are used for the fertilization of fields.

2. In agricultural company ‘Gražionių bekona’, where are newly implemented manure management technologies, the quality of drainage water released from fertilized fields satisfies the environment protection requirements. In ‘Krekenavos agrofirma’, where fields are fertilized with the rates up to 300 m³ ha⁻¹, drainage water pollution according to nitrogen is 2.1 times higher than MPC.

3. The development of manure handling technologies in the world is orientated to manure processing in biogas power stations and the use of biomass for the fertilization of fields. 1 m³ of liquid manure mixed up with wastes from foodstuff production may produce about 100 m³ of biogas. Having expanded the network of biogas power stations in Lithuania, we could satisfy up to 3 % of energy demand of the country.

References