The biotechnological method of livestock waste disposal

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Abstract. In livestock farms, the biotechnological animal waste disposal method can be used. Almost 150 million tons of organic waste are produced by farms every year. It has a negative impact on the environment. Therefore, the livestock complex needs to utilize its production wastes. The aim of the article is to study advantages of the biotechnological method of utilization of livestock production waste. A comparative analysis of various methods was carried out. The technological and economic advantages of the biotechnological method were determined, recommendations for the implementation of this method in livestock farms were given.

1. Introduction
The Russian agriculture is developing the livestock and poultry production sectors. In addition to the meat, milk, eggs and other agricultural products, there is a downside to this production. Almost 150 million tons of organic waste are produced by these agricultural sectors every year, which has a very negative impact on the environment. Therefore, the livestock complex needs to utilize its production wastes.

Currently, there are the following methods of disposal of animal waste disposal:
- removal of manure to the fields;
- composting;
- processing of manure for feed;
- creation of fish-biological ponds near the livestock enterprises;
- bioenergy methods and innovative recycling technologies.

The research tasks are as follows:
- to carry out a comparative analysis of various methods of animal waste disposal;
- to determine technological and economic advantages of the biotechnological method;
- to give recommendations on the introduction of the biotechnological method in livestock farms.

The aim is to study the advantages of a biotechnological method of livestock waste disposal in livestock farms.

2. Results and discussion
Having analyzed the most common livestock waste disposal methods, the following conclusions can be drawn [1,2].

Removal to the fields is acceptable in cases where the number of animals is small and manure is used as a fertilizer. However, this technology is costly, while surface and underground waters and soils
are contaminated with toxic, infectious and invasive substances. This contamination results in the accumulation of zinc, copper and nitrates in grasses, grains and water sources.

**Composting.** The application of this method requires special sites, specialized equipment and a large volume of straw, peat and other moisture-absorbing materials, while 30 - 40% of valuable nutrients evaporate in gaseous form.

**Processing of manure for feed.** Due to the fact that about 40% of feed nutrients do not have time to digest and come out with droppings, it can be reused for feeding birds and animals. Manure is used in the preparation of special types of silage - navosage and westlage.

**Vermiculture** is the use of a Californian or other earthworm for the disposal of animal waste. This technique solves three problems: it utilizes waste; it produces fodder protein; it increases soil fertility. Earthworm biomass is an excellent high protein feed suitable for pigs and poultry.

**Fish-breeding ponds** function as sedimentation tanks. The solid fraction is used as fertilizer, and the liquid fraction is decomposed by specially selected zooplankton and various types of algae. The algae are removed from the pond and added to bird and animal feed. Zooplankton serves as food for fish fry.

**New recycling technologies** - processing of waste into activated carbon, which is used as an adsorbent in water treatment devices at farms, which is especially important for areas with unfavorable environmental conditions.

**Bioenergy waste disposal.** The techniques solve several problems: collection and processing of waste; capture and neutralization of harmful biological gases; production of environmentally friendly fertilizers; production of clean fuel for generating electricity and heating premises; production of gaseous fuel for automobile and tractor equipment; CFC-free cooling; production of “dry” ice, soda and [1,3].

Thus, animal waste is not a polluting harmful substance. It is a valuable raw material that can help restore land fertility, increase yields, obtain food protein (zooplankton, larvae, algae, worms). It is used to produce clean fuel [4,5].

The bioenergetic waste disposal methods are promising because they perform many tasks, including the production of biogas with a biogas plant. In terms of efficiency, 1 m3 of biogas equals 0.6 m3 of natural gas or 0.4 liters of gasoline [2].

Biogas production has a number of advantages:

1. Improvement of the ecological situation. The biogas plant acts as a wastewater treatment plant.
2. The investment for the purchase of a biogas plant pays off quickly. Its maintenance is not expensive.
3. Biogas is an alternative to traditional fuels.
4. It can be sold [6-8].

**Figure 1. The biogas production**
The types of products produced using the plant are presented in Table 1 [5,9].

**Table 1.** Types of products of biogas plants

| Types | Description |
|-------|-------------|
| 1. Biogas | Gas consisting of 50-80% methane (CH4) and 50-20% carbon dioxide (CO2). It is similar to natural gas. Calorific value of biogas is 6000-9500 kcal / m³; natural gas - 7900 kcal / m³ |
| 1.1 Heat | - heating of premises;  
- technological goals;  
- steam. |
| 1.2 Energy | Additional combined heat and power plant is required |
| Fuel | Additional biogas enrichment system (CO2 removal) is required. As a result, the gas is similar to the natural one - 90 - 95% CH4 |
| 2. Biofertilizer | 1. Acts on the plant immediately after application to the soil.  
2. Increases the productivity of plants by 2-3 times; contains active biological auxin stimulants.  
3. Increases plant resistance to adverse environmental impacts.  
4. Reduces soil acidity.  
5. Contains all the necessary components (nitrogen, phosphorus, potassium, macro- and microelements) in a dissolved form.  
6. Does not contain pathogenic microflora, helminth eggs, weed seeds, nitrates and nitrates, specific odors.  
8. 100 times more efficient than manure (1 l = 100 kg of cattle manure). |
| 3. Other positive factors | 1. Capturing methane is the best way to prevent global warming.  
2. Reducing the sanitary zone from 500 m to 150 m.  
3. Converting waste into fertilizer - waste-free production.  
4. Lack of unpleasant odor. |

Thus, biogas can be used for individual needs idents as an alternative to natural gas and by enterprises in a closed production cycle. The technological process of biogas production is shown in Figure 1.

The operation of professional biogas plants is regulated by automation [5, 10,11], and for the maintenance of several medium-sized stations, only two people are required.

To calculate the economic efficiency of the innovative method of utilizing animal waste, a dairy farm with 1000 heads was selected. The results of calculating the average daily volume of raw materials are shown in Table 2.

**Table 2.** Calculation of the average daily production of animal husbandry waste products

| Indicators | Values |
|------------|--------|
| Number of heads | 1000 |
| Raw materials | manure |
| Daily manure production per 1 head, kg | 50 |
| Volume of raw materials, t | 1000⋅50=50000 kg = 50 t |

For a given volume of raw materials, a bioreactor is required. Its technical characteristics are presented in Table 3.
Table 3. Technical characteristics of the bioreactor

| Indicators                                                                 | Value  |
|---------------------------------------------------------------------------|--------|
| Average total volume of raw materials (bioreactor productivity), t / day | 50     |
| The total volume of biogas produced, m³ / day                            | 2700   |
| Equivalent to generated energy, kW / h                                   | 270    |
| Additional heat energy, kW / h                                           | 315    |
| Amount of generated heat energy only, kW / h                             | 698    |
| Energy consumption for initial heating, kW / h                           | 350    |

Specifications

| Description                                                                 | Value  |
|----------------------------------------------------------------------------|--------|
| Bioreactor diameter, m                                                    | 4.5    |
| Bioreactor design modular, module length, m                               | 12     |
| Useful volume of the bioreactor, m³                                      | 756    |
| The total length of the zigzag bioreactor structure, m                    | 48     |
| Number of modules, pcs.                                                   | 4      |
| Fermentation time, days                                                   | 12-18  |
| Moisture content of the loaded substrate, %                               | 75     |
| Grinder pump power, kW                                                    | 4.1    |
| Excessive pressure of biogas, kPa                                         | 2      |
| Gas tank volume, m³                                                       | 312.5  |
| Fermentation temperature in the mesophilic section, °C                   | 30 - 40|
| Fermentation temperature in thermophilic section, °C                      | 45 - 57|
| The amount of outlet liquid fertilizers, t / day                          | 59     |
| Mixing frequency                                                          | 4 times / day 10 minutes each |

Fermentation process: continuous
Fermentation mode: mesophilic-thermophilic

The amount of energy generated is equivalent to heating 6980 sq. m. at -35°C. Calculation costs of the biogas plant are presented in Table 4.

Table 4. Costs of the biogas plant

| Equipment and materials            | Amount | Unit cost, rub | Total costs, rub |
|------------------------------------|--------|----------------|-----------------|
| Bioreactor                         | 2      | 3              | 4               |
| **Basic equipment**                |        |                |                 |
| Bioreactor section made of fiberglass with technological holes, pcs. | 4      | 1249137.45     | 4996549.8       |
| Strapping, pcs.                   | 3      | 749482.47      | 2,248,447.41    |
| **Total for construction**         |        |                | 7244997.21      |
| **Auxiliary equipment**            |        |                |                 |
| Manure heating and feeding system  |        |                |                 |
| Grinder pump, pcs                 | 1      | 125062.5       | 125062.5        |
| Centrifugal pump with grinder, pcs | 1      | 51000          | 51000           |
| Preheating tank, pcs              | 2      | 208189.58      | 416379.16       |
| Strapping, pcs                    | 1      | 115275.62      | 115275.62       |
| **Gas distribution system**        |        |                |                 |
| Cleaning station, pcs             | 1      | 200,000        | 200,000         |
| Moisture separator, pcs           | 1      | 200,000        | 200,000         |
| Soft gasholder, pcs               | 1      | 806250         | 806250          |
| Fermentation system               |        |                |                 |
| Stirrer-mixer, pcs | 2 | 100,000 | 200,000 |
|-------------------|---|---------|---------|
| Energy motor with a gearbox, pcs. | 2 | 40,000 | 80,000 |
| Valves, regulators, converters, pcs. | 2 | 47000 | 94000 |
| Control valves, pcs | 2 | 60,000 | 120,000 |
| Vacuum compressor, pcs. | 1 | 224000 | 224000 |
| **Total auxiliary equipment** | | | 2631967.28 |
| **Total for “Equipment”** | | | 9876964.49 |
| **Additional materials** | | | |
| Consumables, set | 1 | 132600 | 132600 |
| Elements of instrumentation, pcs. | 1 | 106080 | 106080 |
| Control cabinet with visualization for the control room, pcs | 1 | 200,000 | 200,000 |
| Power cabinet, pcs. | 1 | 150,000 | 150,000 |
| **Total for “Materials”** | | | 588680 |
| **Work** | | | 2,263,941.63 |
| **Total for the bioreactor including VAT** | | | 12729586.12 |
| **Buildings and constructions** | | | |
| Pre-fabricated building with a height of 6 m, m² | 95 | 10263 | 974985 |
| **Cogeneration station** | | | |
| AGP-100, pcs | 1.75 | 1740100 | 3045175 |
| **The total cost of a biogas plant including VAT** | | | 16749746.13 |

The calculation shows that the total cost of the biogas plant is 16.75 million rubles.

The plant generates biogas, which is converted into heat and electricity which can reduce expenses because the farm will purchase this energy less [12].

The farm can sell surplus heat and electric energy, as well as liquid fertilizers to other enterprises, receiving additional profit.

The results of calculating the economic efficiency of the biogas plant are shown in Table 5.

### Table 5. Calculation of the economic efficiency of the biogas plant

| Indicators | Value |
|------------|-------|
| **Investment** | |
| Cost of a biogas plant, thousand rubles | 16749.7 |
| **Expenses** | |
| Salary, thousand rubles | 600 |
| **Economic efficiency** | |
| Production of own heat energy, thousand rubles | 15477.5 |
| Production of own electricity, thousand rubles | 5983.9 |
| Production of biofertilizers for own needs, t | 4379 |
| Production of biofertilizers for sale, t | 17156 |
| Total savings from the use of own resources, thousand rubles | 21461.4 |
| Net profit, thousand rubles | 20861.4 |
| Payback period, months | 8 |

Consequently, the farm acquiring a biogas plant for processing waste products of dairy cows will receive a net profit in the amount of 20,861.4 rubles.
3. Conclusion

Thus, biogas is a cheap, environmentally friendly fuel that can meet energy needs of a small farm where organic waste is generated. The production of biogas and fertilizers, as well as the processing of organic waste can be the beginning of additional business activities of the farm. Agricultural producers need high-quality organic fertilizers. The main advantage of biofertilizers is that they are able to organize the transfer of all important substances through the soil to plants. That is why, after using them, harvest is 50% more than usual. The fertilizer contains all the necessary components (nitrogen, phosphorus, potassium, macro- and microelements) in a dissolved form and active biological stimulants, which increase the yield by 2 or more times depending on the type of crops, soil and climatic conditions.

But most importantly, the issue of utilizing animal waste can be resolved. Thus, the use of biogas plants solves many problems in agricultural production. After being processed, by-products are converted into the environmentally friendly gaseous fuel. The waste disposal method has a closed cycle, which makes it possible to build a closed production system in a livestock farm.

Agricultural organizations can purchase a biogas plant for processing waste products. As a result, the farms will receive net savings from using their own energy resources and biofertilizers.

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