

# Environmental and Economic Effectiveness of Resource-Saving Technologies in Cattle Meat Production

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## Abstract

Current situation in agriculture leads to significant environmental pollution, in particular, in cattle breeding. The storage of manure significantly worsens the sanitary and epidemiological situation. In this connection, the article proposes the use of biogas plants for cattle breeding as an environmentally safe direction for the manure utilization with high economic efficiency. Particular attention is paid to the criterion of investment efficiency after use of a biogas plant, taking into account prevented environmental damage from manure storage. The economic justification of schemes for manure utilization using both a biogas plant and without it is being carried out.

**Keywords:** Manure, Biogas Plant, Investment, Environmental Damage, Effectiveness.

## 1. Introduction

Modern agriculture is based on an extensive type of development, which provides for a high level of use of natural resources and pollution of the environment. In this regard, there is an urgent need for the transition of agricultural production to a sustainable type of development that provides for an eco-balanced approach and the development of a "green" economy.

On September 25, 2015, the member states of the UN adopted the "Agenda for Sustainable Development until 2030", which identified 17 fundamental objectives that must be achieved within 15 years.

Within the framework of this agenda, the greatest interest from the point of view of agriculture causes several objectives, including reversing the land degradation processes, taking urgent measures to combat climate change and its consequences, as well as providing universal access to affordable, reliable, sustainable and modern sources of energy for all [1].

In developed foreign countries, the environmental and economic damage from pollution is 2-7% of the gross national product (GNP), and the costs of preventing possible environmental damage are 4-6% of GNP.

In Russia, the environmental and economic damage from environmental pollution is 15-17% of GNP, while the costs of preventing damage are less than 1% of GNP [2].

It is evidenced that the damage from manure pollution in the Russian Federation until 2020 will be 622,08 million doll., and the damage from underutilization of manure is 7463,9 doll.

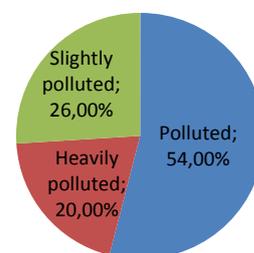
## 2. Brief Literature Review

In Russia cattle breeding takes a special place in environmental pollution in agriculture. In particular, in all categories of farms there are about 20 million head of cattle, more than 17 million of pigs, 21 million of sheep, about 450 million of poultry [3]. According to various estimates, the volume of waste from livestock enterprises and poultry farms in the form of liquid

manure, manure and sewage is about 700 million cubic meters per year.

In this case only 30% is used for fertilizer, the rest is a source of environmental pollution [4]. At present, more than 2 million hectares of land are occupied for manure burial, which is a potential source of environmental and sanitary-epidemiological catastrophe. At the same time, this kind of waste can be a good source of fertilizers and a fuel for the generation of thermal and electrical energy. It should be noted that on average 55 kg of manure per day is eliminated from one cow.

According to experts, 217 million tons of manure are produced on cattle-breeding farms in Russia. In total, the share of cattle manure is about 76% of all manure produced in the country. According to the Russian classifier, this type of manure belongs to the 4th class of danger, i.e. provides for the violation of the environmental system, with a recovery period of at least 3 years. At the same time, processing of manure on specialized installations is practically not used. The level of manure contamination is shown in the Figure 1. [5].



**Fig. 1:** Level of manure contamination after cattle breeding in the Russian Federation

In Russia the area of fields contaminated with cattle manure exceeds 2.4 million hectares, of which 20% are heavily polluted, 54% are polluted, and 26% are slightly polluted [6].

It should be noted that manure is a potential source of distribution of various infectious and invasive diseases of animals and

humans. Manure contains a large number of seeds of weed plants, which lead to significant economic damage in the crop production. Some researchers note that in concentrated doses even the smell of manure is hazardous to health due to gases that can cause asphyxiation.

### 3. Purpose

To implement all above objectives in agricultural production, it is necessary to develop a system of economic incentives for nature users to take care of the environment. It is also necessary to eliminate possible losses associated with the underdevelopment of technologies, infrastructure, etc. As a result, optimization of the interaction of agricultural production factors, their effective combination, will reduce the environmental burden and increase economic efficiency.

In order to improve the environmental and economic effectiveness of cattle breeding projects, the following problems should be solved:

assessment of the negative environmental impact of manure on the environment;

determination of possible economic damage from environmental pollution by manure

environmental and economic evaluation of projects with technological equipment for the utilization of manure and without it;

evaluation of two alternative projects for cattle breeding on the basis of an improved methodology.

### 4. Results

Nowadays, it can be stated that 30-50 m<sup>3</sup> of biogas with a methane content of 60% is produced from one ton of cattle manure. In fact, one cow produces 2.5 m<sup>3</sup> of gas per day. It is possible to produce about 2 kW of electricity from 1 m<sup>3</sup> of biogas. Additionally, an organic fertilizer is produced, that application improves the economic characteristics of the biogas plant.

According to the Figure 2, the manure produced on farms, can be successfully processed both with the output of thermal and electric energy, and for the production of highly effective fertilizers. In particular, the entire manure mass entering the biogas plant is subject to processing in thermal energy and biohumus. In the future, thermal energy is used in the energy complex of agricultural enterprises, in particular for generating electricity and heating. The rest of manure is processed for fertilizers, both for own needs, and for subsequent implementation. Emissions from the biogas plant are insignificant and not dangerous.

It should be noted that the peculiarity of using this plant is that its economic efficiency takes place when breeding at least 100 head of cattle.

According to the estimates of the Ministry of Agriculture of the Russian Federation, payments by agro-companies for placing manure and other waste on their lands reach up to 35 billion rubles per year, not including fines for environmental pollution. Now the problem of processing and utilization of liquid manure / litter is one of the most acute in Russia. A different degree of purification and processing should be subjected to more than 200 million m<sup>3</sup> of liquid manure mass per year. But not every livestock complex has modern systems for their processing and utilization. In many farms, the systems are long obsolete and do not meet environmental standards. Most existing livestock complexes were put into operation 25-30 years ago. Since then, the cleaning equipment has never changed, although it needs to be modernized every 10-15 years due to rapid wear and tear.

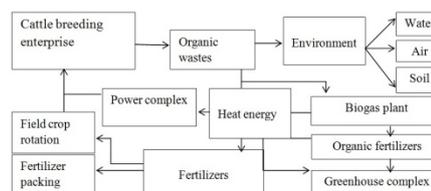


Fig. 2: Scheme of organic waste utilization at cattle breeding enterprises

According to rough estimates, almost 30% of all domestic poultry farms do not have a system for purifying manure mass. Taking into account the implementation of the national project on livestock development, the amount of manure mass to be recycled and utilized should increase by 1.5 times.

### 5. Discussion

A large number of livestock in limited areas, use of hydraulic systems for cleaning and removing animal excrement lead to the formation of huge volumes of liquid manure, as well as of significant quantities of harmful volatile chemicals, unpleasant odors, intense noise, etc.

When solving the problems of livestock complexes distribution, the choice of systems of processing and using livestock wastes, specialists proceeded from the assumption that air, soil, and water bodies are practically inexhaustible from an environmental point of view. However, the experience of operating the first livestock complexes testified to the intensive pollution of environmental objects and their unfavorable impact on the living conditions of the population.

In this regard, environmental protection from pollution, prevention of infectious, invasive and other diseases of humans and animals are based on the implementation of measures to develop efficient systems for collecting, removing, storing, decontaminating and using manure mass, as well as on the improvement and efficient operation of air purification systems, correct distribution of livestock complexes and manure handling facilities, taking into account settlements, sources of household and drinking water supply and other objects. In other words, it is connected to a set of hygienic, technological, agricultural, and architectural and construction measures.

Enterprises for animals raising, fattening and management have their own specific features:

- the predominant influence of unorganized emissions (ponds - sedimentation tanks, manure storages, treatment plants) - up to 99.5% of the total mass of emissions;

- the irregularity of separation and formation of pollutants.

The yield of liquid manure from one head of cattle is 55 kg per day.

Environmental damage from cattle manure pollution is estimated by the formula:

$$P_{edc} = P_l + P_w + P_b + P_a,$$

where  $P_l$  is payment for damage from pollution of land, dollar;

$P_w$  - payment for damages from water pollution, dollar;

$P_b$  - payment for damages from biological resources destruction, dollar;

$P_a$  - payment for damages from contamination of adjacent territories, dollar.

Amount of payment for manure placement from 1000 heads per year:

$$8,3 \text{ doll.} \cdot 55 \text{ kg} \cdot 35 \cdot 1000 \text{ heads} = 166288 \text{ doll. per year.}$$

Taking into consideration possible environmental damage and the cost for reclamation, the formula for calculating the net present value (NPV) will be as follows:

$$NPV = \sum_{t=0}^T (Rt - Ct - P_l - P_w - P_b - P_o) \cdot \frac{1}{(1 + E)^t},$$

where  $T$  is calculation step (year),

$R_t$  - effect at  $t$ -th step of calculation, dollar;

$C_t$  - costs at  $t$ -th step of calculation, dollar;

$P_l$  is payment for damage from pollution of land, dollar;

$P_w$  - payment for damages from water pollution, dollar;

$P_b$  - payment for damages from biological resources destruction, dollar;

$P_a$  - payment for damages from contamination of adjacent territories, dollar;

$E$  - discount rate.

Unfortunately, the indicator of environmental and economic damage from the cattle manure pollution is objectively difficult to calculate, due to the absence of point sources of emissions into the environment. As a result, it is rather difficult to know a real picture of the contamination, showing the degree of negative impact on individual components of the environment.

In this connection, the calculations take into account the damage caused by cattle manure contamination of the atmosphere, as well as the number of pollutants into surface and ground water, based on the distribution fee, taking into account hazard classes.

## 6. Conclusion

Indicators of environmental and economic effectiveness of cattle breeding projects are given in the table 1.

**Table 1:** Indicators of environmental and economic effectiveness of cattle breeding projects

Index of effectiveness	Project without biogas plant	Project with biogas plant
Net investment, thousand doll.	6911803,0	7649508,0
Payback, year	11,2	8,4
Rate of discount, %	11	11
Dynamic pay-back period, year	25	14,7
Net present value, thousand doll.	-898,393	1861,6
Profitability index	0,87	1,24
Internal rate of return, %	7,3	16
Environmental damage, thousand doll.	245344,2	-

Thus, based on the research presented in the article, it can be concluded that open manure storage is extremely harmful and causes irreparable damage to the environment. At the same time, the use of manure as a raw material for biogas plants will allow to use it as an alternative source of energy. The result of the closed cycle in cattle breeding and manure disposal will be possibility of significant electricity cost reduction and of fines for manure placement, and the environmental damage resulting from the implementation of this project will be minimized.

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