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To cite this article: L A Zazykina *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **274** 012009

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Promising solutions for cost-effective management in biomass processing

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Abstract. The article presents the systematization of the main technologies of biomass processing with the calculation of the result and the effect of their use both in Russia and abroad. In addition, an acute problem is indicated and promising directions in the processing and marketing of biomass are proposed. The analysis of contemporary scientific literature on this issue, which indicates the divergence of opinions on the problems of biomass processing at poultry farms. The goal set in the article is to explore promising areas in the processing of biomass. The research goal is (a) to identify problem areas in the activities of poultry enterprises and (b) to determine the economic feasibility of promising areas of management solutions to this issue, as well as in the development of an algorithm with an economic calculation. The study used statistical methods of structural and comparative analysis, structural – logical method of presenting information, economic and mathematical modeling. Conclusions are made about the economic feasibility of the use of biomass processing at poultry farms. The results obtained show new promising solutions, namely the use of the “in-house windrowing” method in the Russian poultry industry; also, a new market for biomass products was proposed. The results of the study will expand the possibilities for further study of the issue in the framework of the implementation of the Program for the Development of Biotechnology in the Russian Federation for the Period up to 2020 and the Strategy for the Development of the Forest Complex of the Russian Federation until 2030.

1. Introduction

Taking into account the experience of world countries in the production of agricultural products, including actively developing poultry farming, the problem of ensuring the environmental safety of its production, which is associated with the rational use of natural and energy resources, waste treatment, wastewater treatment, and polluted emissions, monitoring and forecasting, becomes very urgent, especially for natural objects of rural areas. First of all, this problem is associated with the disposal of large volumes of manure and litter. According to Rosstat, at the beginning of 2017, the poultry population amounted to about 5,53029.2 thousand heads, of which 512928.3 thousand heads were in all categories of farms [1, 2]. An adult chicken per day allocates 175-220 g of litter, depending on the type and age of the bird. If we round the given figure of the poultry population to 553 million heads, they allocate about 110.6 thousand tons of litter per day [2]. And this can lead to environmental pollution. Currently in the Russian legislation, fresh chicken manure is classified as a waste of the 3rd class of danger to the environment (OS) [3]. In cases when the owner of the generated waste does not recycle and does not use them as secondary resources, there is an obligation to pay a fee for a negative



impact on the fixed assets in the amount of 1,200 rubles per ton. In addition, the associated activity on the collection of transportation, treatment, disposal of waste of I-IV classes is subject to licensing in accordance with Article 16 of the Federal Law No. 458 and Part 4 of Article 1 of the Federal Law of May 4, 2011 No. 99-FZ On Licensing Certain Types of Activities [4]. The cost of such a license varies from 100 thousand rubles to 300 thousand rubles, the fine for its absence ranges from 100 thousand rubles to 250 thousand rubles for a legal entity (Article 171 of the Criminal Code of the Russian Federation).

In this regard, an extremely urgent problem is to analyze the state and prospects for the development of litter processing.

2. Literature

Theoretical and methodological aspects of rational use and processing of litter are reflected in the research of Russian scientists, such as Tarasov, S. I., Eskov, A. I., Novikov, M. N., Kocsis, I. I., Garzanov, A. L., Bryukhanov, A. Yu., Gaas, A. V., Dubrovin, A. V., etc.

3. Methods

In the process of research, the methods of structural and comparative analysis were used, along with economic and mathematical modeling.

4. Results

When fulfilling the tasks of the Food Safety Doctrine, an increase in the number of cattle, pigs, and poultry occurs, which leads to a dramatic increase in waste, so according to the research carried out by the State Institute of Energy Strategy, the amount is almost 700 million tons (260 million tons of dry matter): 350 million tons (53 million tons of dw) in livestock; 23 million tons (5.75 million tons dw) in poultry farming; 220 million tons (150 million tons of dw) in crop production; 32.5 million tons in woodworking; 86 million tons (42 million tons of agricultural waste) in MSW and waste from the processing industry [5].

From this amount of waste, one can get bioenergy annually. The main drivers in the development of the bio-fertilizers market in the world are the development of organic production, as well as the stricter environmental requirements for foodstuffs set by the government of many countries. In European countries, there is a surge in demand for bio-fertilizers in such countries as Spain, Italy, and Denmark [6]. The global market for bio-fertilizers is expected to grow at a CAGR level of 13.9%, amounting to \$1,649.7 million by 2019 [7]. In Russia, this market began its development eight years ago and increased by 2.7 times. In 2016, it amounted to 2.7 billion rubles.

Currently, there are many ways to process and obtain bioenergy, as an analysis of the main modern technologies clearly shows (Table 1).

Table 1. Economic and technological classification of litter processing.

	Technologies	Expenses	Results	Effect
Storage	Recycling on own landfill.	Expenses for the organization and maintenance of the landfill, environmental payment/	Litter not used/	Maximum environmental damage. Maximum loss.
	Recycling at a third-party landfill	Recycling costs per ton of litter		

Composting	Composting litter without using biological products – 40-50 days [8]. Tedders are used,	The cost of organizing a dedicated site. Tedding equipment.	The resulting compost can be implemented as an organic fertilizer.	Minimal environmental damage. Moderate investment. Profit from the sale of fertilizers is possible.
	Composting using biological products - 7-21 days. Used tedders on open land or special installations of accelerated composting.	The cost of organizing a dedicated site. Equipment for tedding of the shoulders and for accelerated composting in closed containers.	The resulting compost can be implemented as an organic fertilizer with improved characteristics.	
	Bunching of litter in the house (In-house windrowing).	The cost of construction of special poultry houses. Raking costs.	Compost is reused 3-4 times in the house. After can be implemented as a fertilizer.	Profit from the sale of fertilizers is possible.
	Compost with mycelium for growing mushrooms	The cost of organizing a dedicated site.	You can use the compost yourself for growing and selling by-products - mushrooms and (or) selling the compost itself.	Minimal environmental damage. Possible profit from the sale of compost and by-products.
Drying and granulation (pellets)	Drying and granulation of manure and compost is carried out using specialized process equipment.	The cost of organizing a dedicated composting site. Drying and granulation equipment – plant for the production of granular fertilizers.	The obtained granular fertilizer can be stored for a long time, safely and economically transported.	Minimal environmental damage. Moderate investment. Possible sale of goods for export.
	Drying and production of fuel pellets for solid fuel boilers.	The cost of organizing a dedicated composting site. Drying equipment and pellets		

The table shows both the well-known processing methods in Russia and the new method of composting, namely the buttering of the manure in the poultry house. This method is used in the USA for outdoor poultry housing [9].

In Russia, they are only planning to build a pilot project for the construction of poultry houses. At the moment, the technology of processing litter with biological products is widely used. However, such preparations on the market are quite expensive from 2,000 rubles per liter. For example, the composting accelerator drug “Bioelements” is intended for utilization and disinfection of litter in the

litter and cage way for keeping birds. It contains an active complex of effective bacteria and fungi, which quickly starts the process of composting litter with litter residues in piles or containers. The temperature of the substrate rises to 50 ... 70 ° C, it is disinfected. The final product is safe, does not contain pathogenic microflora, helminth eggs, weed seeds. The consumption of this drug is 2 kg per 100 tons, the cost of one kilogram is 2900 rubles, and the drug itself must be used several times within 3 weeks.

In addition, there is a known method of preparing a multi-purpose compost (patent No. 2112764). The essence of this method is layered lay-up of manure and moisture-absorbing material of organic origin, then the components are mixed while the mixture is transferred to the fermenter and subsequent aerobic composting of the mixture at its humidity is 50-60 % and periodic ventilation for 3-4 days. The oxygen concentration in the mixture is maintained within 5–12%, and the mixture loaded into the fermenter is mixed with the finished compost in a mass ratio of 9:1 [10]. This method is quite economical in comparison with other methods. Despite the variety of methods and methods of disposal and processing of litter, many poultry farms still aggravate the ecological situation in the regions. Therefore, we have invented an algorithm for making a cost-effective management decision when choosing the disposal of litter. The general scheme of the decision-making algorithm when choosing biomass utilization is shown in Figure 1. According to this algorithm, all costs associated with the utilization and processing of biomass at poultry farms are calculated, and the profit and loss of profit at the enterprise are compared.

So if the management of the company decides to keep litter at the site, then, accordingly, the costs of this activity can be represented by the following formula:

$$Z_{\text{loss}} = Z_f + Z_{(n.im.)} + Z_{tr} \quad (1)$$

where Z_{loss} – the loss of the company, Z_f – fines for environmental pollution, $Z_{n.im.}$ – payment for negative impact, Z_{tr} – transportation costs from the poultry farm to the storage site.

If the management of the poultry farm decides to recycle the litter, respectively, the company would have both additional processing costs and additional profits when selling by-products from biomass processing.

The calculation of the profit from biomass processing can be represented as the following formula:

$$P_{pf} = R_{pf} - C_{pf} \quad (2)$$

where P_{pf} is the profit received from additional products (fertilizers, pellets, biogas), R_{pf} – revenue from selling by-products, and C_{pf} – the cost of by-products [11].

Based on calculations using formulas (1) and (2), one can compare lost profits for the company.

However, many poultry farms cannot afford to invest in the processing of litter due to the inaccessibility of purchasing equipment. Thus, for example, the average cost of a plant for drying a litter starts from 14 million rubles, without installation, and lines for pelleting from 5 million rubles. Therefore, it is beneficial for many poultry farms to export litter to the municipal landfill and pay 497 rubles per ton, thereby continuing to pollute the environment in the area where the workers of the poultry factory live and work. To improve the situation, in our opinion, poultry farms need to enlist the support of local authorities to subsidize and build at least one such processing plant equidistant from each poultry farm and require everyone to bring back the raw materials for processing.

In addition to the processing of litter, there is also a burning issue with the sale of the obtained by-products. Consider another possible demand for litter. The starting point of this analysis is an estimate of the area of land in an agricultural category.

Under the purpose of the land in jurisprudence is understood as a set of environmental, biological, geological, and other characteristics, allowing to determine the individual method and order of land use. Constant monitoring of land use at the state level is carried out by the Federal Service for State

Registration, Cadastre, and Cartography (Rosreestr) [12]. Official statistics on agricultural lands of the Russian Federation as of January 2017 are presented in the table.

The table shows that there is a potential market for products of biomass processing. As one knows, one of the priority issues of the agrarian industry in Russia was the increase in acreage, the return of unused land to circulation. In 2017, for the first time in 15 years, the total acreage in Russia exceeded 80 million hectares. In 2018, the sown area should reach 80.4 million hectares [13].

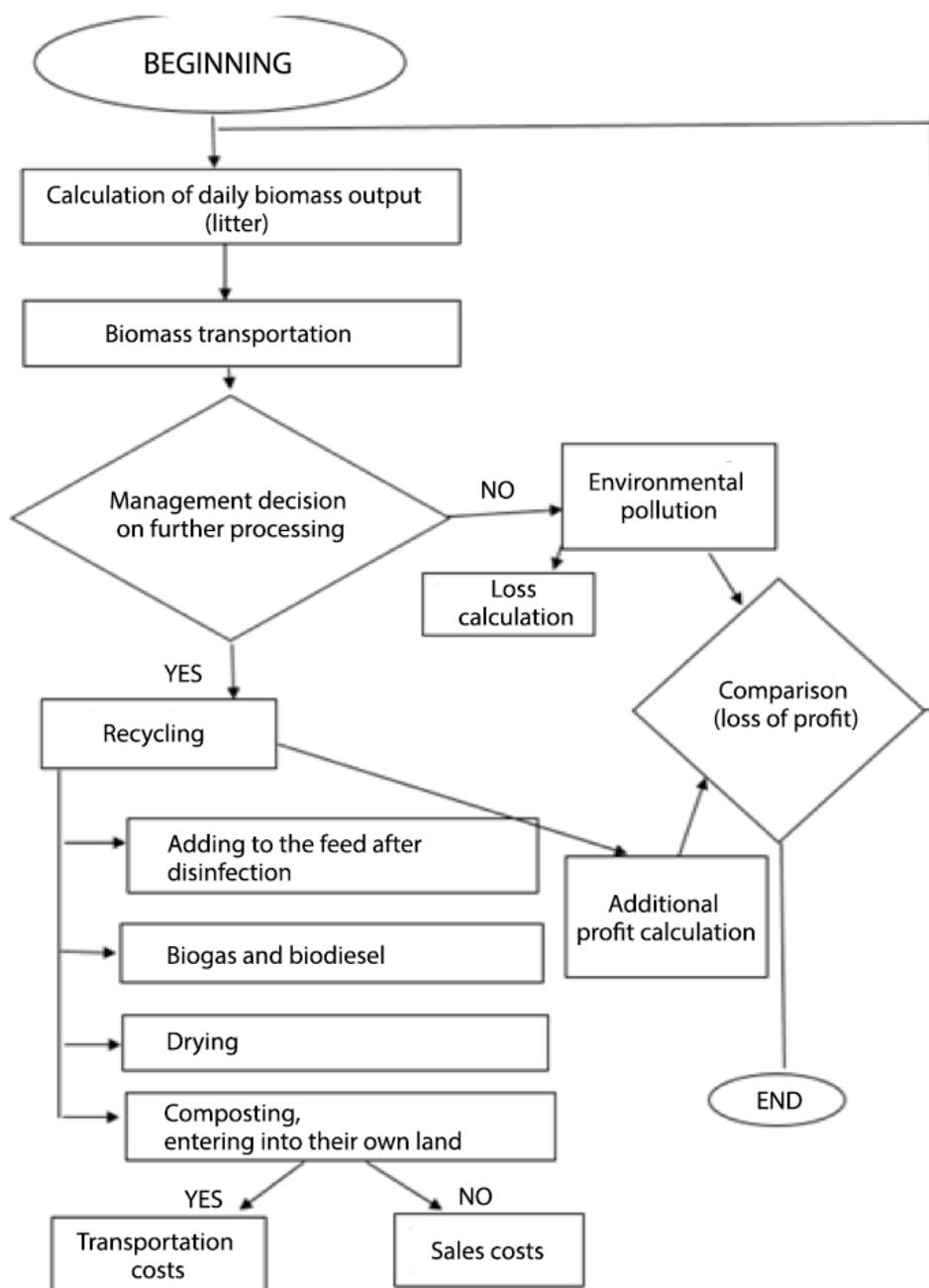


Figure 1. Decision algorithm for choosing biomass utilization.

Foreign experience shows that litter can be made on agricultural and forest lands. For example, in the United States began to use the method of making compost and in the cultivation of industrial forest. When planting forests in eastern Maryland, compost was used on an area of about 271.3

hectares and, as studies show, productivity increases [14, p. 27, 45]. In our country, about 1038 thousand hectares are allocated for reforestation by 2020 [15]; therefore, we consider it appropriate to use this method in Russia depending on the types of forest conditions and also taking into account the participation of public-private partnership (PPP). However, today for the state the priority direction is the production of mineral fertilizers for agriculture [16]. Mineral fertilizer producers are actively using the opportunities provided by the state [17, 19, 20].

In our opinion, in order to reduce environmental and economic problems in regions where there are large poultry farms, the authorities also need to subsidize the processing of biomass or give tax breaks to poultry farms that process waste.

Table 2. Data on agricultural land, thousand ha.

Land category	Total area	In the property of citizens	Owned by legal entities	In state and municipal property
Agricultural land	383612	109741.2	18238.4	255632.4
Land Redistribution Fund	43608.6	3.3	-	43605.3
Forest land	1126259	-	0.5	1126259

Source: Rosreestr (<http://rosreestr.ru/>).

5. Conclusion

Poultry farming is the leading livestock industry in Russia. Its dynamism is characterized by incremental values of the corresponding indicators for the analyzed period. For example, in January-February 2018, poultry production for slaughter in live weight in agricultural organizations amounted to 1.0 million tons, which is 7.2% more than a year earlier [18]. Accordingly, the waste of poultry farms grows every year. In this regard, we have proposed the method of litter processing, providing managers of poultry farms with an algorithm for the processing of biomass. As well as measures proposed for the sale of additional products, which consists in expanding the market for the sale of products.

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