Innovative Technology for Processing Poultry Manure for Use in the Novgorod Region

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Abstract. With the development of poultry farming, the problem of utilizing poultry manure is becoming more and more relevant. Manure is a source of strong environmental pollution (soil, groundwater, atmospheric air); it negatively affects human health and gene pool. At the same time, manure is one of the best organic fertilizers, containing a large amount of nutrients necessary for the growth and development of plants. The article discusses the most economical and environmentally friendly biotechnological methods of manure processing, namely, processing by effective microorganisms. The article presents the technology of accelerated manure composting; it was carried out in the natural and climatic conditions of the Novgorod region and resulted in obtaining two types of products: loose and granular compost. The conditions of the composting process in the spring-summer and autumn-winter periods have been analyzed. The authors dwell upon the requirements for using compost when growing crops.

1. Introduction
Waste disposal is one of the main environmental problems caused by the high concentration of poultry in poultry farms. The limited areas of agricultural land in the structure of poultry farms do not allow using manure as fertilizer for their own needs. At the same time, the volumes of waste unused in agricultural production are increasing. For example, at one poultry farm with a livestock of up to 40 thousand laying hens, about 70 thousand tons of manure mass is formed annually [1]. A large amount of manure is stocked on the territory or near poultry farms, as a rule, at a short distance from settlements and water sources, thus creating a serious environmental hazard for people, plants and animals [2, 3].

On the other hand, poultry manure is a valuable organic fertilizer with a high content of essential nutrients that are essential for plants. The output of agricultural crops when poultry manure is applied is higher than when using mineral fertilizers [4]. In poultry manure, nutrients exist in organic form, which in the process of mineralization under the influence of soil microorganisms are converted into mineral compounds and become available for plant nutrition for a long time [5]. It increases not only the agricultural crops output, but also improves the quality of products. In crop products, the content of vitamins, sugars, proteins, starch increases, but nitrates do not accumulate.

From an environmental point of view, one of the main conditions for the safe use of poultry manure as an organic fertilizer is the absence of pathogens of invasive and infectious diseases, as well as viable weed seeds. Therefore, the technology of processing manure for its use as an organic fertilizer should be strictly regulated [6].
2. Objects and methods of research
The object of the study was the agro-industrial holding “BEZRK-Belgrankorm” which is one of the largest diversified, vertically integrated structures of the agricultural sector of the Russian Federation. The main activities of the holding are the production of poultry, pork, beef, milk, grain and animal feed. The current structure of the “BEZRK-Belgrankorm” holding comprises more than 40 subdivisions located in 6 districts of the Belgorod region and in 3 districts of the Novgorod region. They have become the basis for successful activities for the company. In the fall of 2019, the “Belgrankorm - Veliky Novgorod” enterprise put into operation the first in Russia complex for biofertilizers composting, which is successfully operating near the village of Novoye Rakhino. Manure from all poultry farms of the holding is brought to this complex, where up to 40 thousand tons of waste is processed annually. The complex for the production of organic fertilizers works according to Japanese technology using the equipment of Kohshin Engineering Co., Ltd.

3. Results and discussion
At present, the widespread methods of disinfecting manure are by influencing biological, physical and chemical processes. The most environmentally safe method is the biological method, i.e. the decomposition of manure organic matter by microorganisms [7].

The most common biological method is composting with a long period of manure holding (4 ÷ 6 months). For composting, piles of about four meters high are made, in which, under the influence of aerobic microorganisms, the mineralization of organic matter occurs. The composting process is accompanied by the release of heat and an increase in the temperature inside the pile up to 60° C; it leads to the death of pathogenic microorganisms, helminth eggs and weed seeds. The moisture content of the compost mass is 50–60% [8].

The composting process is efficient only if the optimal conditions for the vital activity of aerobic microorganisms are created by aerating the compost mixture. Aeration provides heating of the compost mixture to the temperature required for complete disinfection from pathogenic organisms. The composting product is an environmentally friendly organic fertilizer.

Currently, a technology has been developed for accelerated composting due to aeration of the compost mixture [9]. The saturation of the compost mass with oxygen is carried out mechanically and pneumatically. With the mechanical method, the compost is aerated by stirring it with turners, and with the pneumatic method, by blowing the processed material with air through the perforated bottom surface [10].

Such technologies are already being successfully used in enterprises. For example, the poultry farm of LLC “Belgrankorm – Veliky Novgorod” uses a poultry manure composting system, consisting of AC with disinfection barriers, weighing site, open composting area with concrete cover, closed composting area with concrete cover and with a monthly supply of sawdust, drying and granulation workshop, and finished goods warehouse.

This production is a technological site for making compost “BIOCOMPOST “BGK-VN”. The produced composts of grade A consist of a mixture of chicken manure without bedding and with bedding containing organic filler (sawdust, peat); the grade B composts consist of a mixture of chicken manure with bedding, a mixture of sewage sludge with excessive activated sludge, crushed shells of chicken eggs and organic filler (sawdust, peat).

The forms of the produced compost are loose and granular. Loose biocompost is produced in an open composting area using the “BACKHUS” self-propelled pile turner. Granulated biocompost is produced in the drying and granulation workshop using KOHSHIN KNLL6000SHW composting machines made in Japan by KOHSHIN.

The compost maturation time in the climatic conditions of the Novgorod region when using the “BACKHUS” turners is 1–2 months in the spring-summer period; in the autumn-winter period it is 1.5–3 months. At the same time, to accelerate the composting process, periodic turning of the compost mass over is carried out every 2–3 weeks in spring-summer time, and in winter – every 3–4 weeks. The required temperature regime is established within 3–4 days in spring and summer and 8–10 days in
winter due to the course of microbiological processes in aerobic conditions. The use of “BACKHUS” turners allows reducing the time of the mixture composting by 1.5–2 times.

The composting process takes place in 3 stages:

1) the thermophilic stage with the participation of thermophilic microflora, accompanied by the decomposition of compost mass organic matter and self-heating of the biomass to 40–70 °C within 1–3 weeks, depending on the air temperature with the turner used 3 times a week;

2) the mesophilic stage with the participation of mesophilic microflora, accompanied by the decomposition of a part of the compost mass organic matter at a temperature of 50–70 °C for 1–2 weeks, depending on the air temperature with the turner used 2 times a week;

3) the maturation stage, going on for 1–2 months at a temperature of 30–35 °C; the compost maturation is promoted when using the turner once a week.

The frequency of the turner use depends on the temperature. If the temperature in the pile is higher than 60 °C, then the number of turner’s passes is increased.

The technological process of producing grades A and B granulated biocompost on the basis of a poultry complex waste using sawdust or peat as organic fillers includes the following sequentially performed operations:

- unloading at the site of mixing production waste;
- moving from an open area and forming of pile rows (2.4 m high, 5 m wide, 60 m long) with a volume of 360 m³ on a closed composting site by an Amkodor-352 front loader;
- mixing production waste to a homogeneous mass with a self-propelled turner “BACKHUS” using sawdust (peat) as an organic filler and adding technical semi-finished products in a volume of no more than 20% of the total mass of the starting material in order to create conditions for heating the pile. The compostable mass is stored for 8-10 days in a closed area and is being turned over 2–3 times;
- controlling the compost temperature (the temperature must be above 40° C). To speed up the processing of raw materials, it is allowed to add ready-made compost to the compost mixture (up to 10%);
- loading compost into the drying and granulation workshop;
- the compost drying and granulating.

The drying workshop has four bays (tunnels) 6.2 m wide, 0.9 m – 1.5 m high and 150 m long, where two KOHSHIN KNLL6000SHW composting machines of the Japanese company “KOHSHIN” operate simultaneously.

The maximum daily feed rate for the operation of two KNLL 6000 SHW composters, which is recorded in a special log after passing the weight control, is:

- about 132 m³/100 tons when using the composter 1.5 times a day (within 6 months in winter);
- about 176 m³/130 tons when using the composter 2 times a day (within 6 months in summer).

The compost is loaded from one end of the bay and while the machine is running, the compost is being turned over and moved forward along the tunnel for a distance of up to 3 meters, making room for loading the next batch of raw materials. The composter operates in an automatic mode according to a given program, without the participation of the operator and maintenance personnel. The height of the pile under the composter is 1.2 m.

After 30–40 days of composting, the compost is moved to the end of the tunnel to the discharge opening as a fully fermented organic fertilizer (the final product in the form of granulated solid fraction compost).

A prerequisite for composting is the speed of air movement in the facility (at least 3 m/s), while the entrance gates to the workshop must be tightly closed during the operation of the composters.

Loading and removal of ready-made loose compost to temporary storage sites is carried out by specialized equipment – an Amkor 352 front-end loader and a KamAZ vehicle. The stocktaking of the organic fertilizer is carried out using truck scales with entries to a special log. The unloading of the finished granular compost is carried out daily by a self-propelled telescopic loader “Manitou”.
The volume of the finished product when using the composter 1.5 times a day (within 6 months in winter) is 30–35 tons per day; and when using a composter 2 times a day (within 6 months in the summer) it is 40–45 tons per day.

The ready-made compost is sent to the filling station to the finished goods warehouse located on the territory of the composting site.

The compost is packed in a soft container made of double polypropylene fabric with a carrying capacity of up to 1000 kg (BIG-BAG) or standard polypropylene bags for 30 and 50 kg.

In the initial components of grades A and B biocompost, before preparing the next batch, one should determine the bulk density, and in the prepared batch of compost, determine the moisture content.

On the composting site, such parameters as temperature and moisture of the compost mixture are controlled. The temperature is measured with a contact thermometer CT-5. The moisture is determined in the laboratory.

Sampling in the compost pile is carried out manually along the perimeter of the pile at 10 points at a height of 100 cm and from a depth of 50 cm in accordance with GOST R 54519-2011. The average sample is made from the selected samples in accordance with GOST 26712-94.

Each finished batch of the product undergoes test control in an accredited laboratory to determine moisture content, bulk density and quality indicators (pH, N, P, K content).

Compost “Biocompost “BGK-VN” of grades A and B is used in agriculture for growing crops. The compost introduction rate is set depending on the type of agricultural crop and the level of soil fertility [11].

The biocompost is put into the soil during tillage with general-purpose implements: plows, cultivators, disc harrows in compliance with the rules of agricultural technology.

4. Conclusion
The application of the considered technology of accelerated composting of chicken manure will allow:
- reducing the time for processing manure in comparison with passive composting;
- completely mechanizing the composting process with the help of compost turners;
- ensuring more uniform manure maturation in comparison with passive composting;
- completely destroying pathogenic microflora and pathogens, helminth eggs;
- removing an unpleasant specific odor;
- decreasing capital costs by reducing the composting area.

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