Technological line for processing animal waste

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Abstract. The accumulation of animal and poultry waste poses a serious environmental hazard to the environment. One of the ways to eliminate it is the developed technological line for processing animal waste into organic fertilizers and preparations for agriculture and plant growing. The original peat-manure mixture must meet the following requirements - humidity 65-70%, the ratio of carbon to nitrogen - 20-25: 1, pH - 6-8. Controlled modes and parameters of the fermentation process form a high-quality, environmentally friendly fermentation product, which is used as a finished organic fertilizer. It is also possible to obtain a liquid-phase biopreparation from the fermentation product, characterized by a high level of biogenicity (total microbial number of at least 1 × 10¹⁰ CFU / ml) Extraction is carried out for two days for this purpose. The sediment formed after the separation of the extracted mass is characterized by a favorable composition and can either itself, after appropriate refinement, be used as an organic fertilizer, or be used as a raw material for obtaining a liquid humic preparation (the content of humic acids is at least 5 g / l, dry matter - not less than 17 g / l, pH 8-9) and humic paste (humidity 80-85%, the content of humic acids is not less than 20%, pH 12-13). Each product of the technological line has its own function for plant growing and agriculture. The technological line is waste-free, resource-saving; it is distinguished by the relative simplicity of production, the ability to scale and use regional raw materials.

1. Introduction
The accumulation of droppings and manure is a serious environmental hazard to the entire adjacent territory of poultry and livestock complexes or farms [1, 2]. At the same time, these wastes have a high level of biogenicity; they contain a large amount of macro- and microelements, physiologically active substances. This circumstance allows us to consider poultry and livestock waste the main resource in the production of organic fertilizers.

Currently, many technological solutions are proposed for processing animal and poultry waste into organic fertilizers [3, 4]. Accelerated fermentation of organic raw materials in reactors or fermenters of various designs is a promising method. The specified technological parameters of the fermentation are aimed at ensuring the effective transformation of the initial mixture into high-quality, environmentally friendly organic fertilizer. At the same time, the loss of nutrients in the process of obtaining fertilizer is minimal, and the time of its maturation is significantly reduced. For example, in a closed reactor with a volume of 32 liters under adiabatic conditions, composting of poultry droppings lasts 14 days [5], and in chamber-type fermenters, which are separate structures, after 7-10 days of aerobic fermentation of animal waste, an organic fertilizer is formed, characterized by environmental safety, high level of biogenicity and nutritional value [6, 7]. The technology of
accelerated continuous production of organic fertilizer in a drum-type reactor, where the processing time of solid manure lasts 3-4 days is well-known [8].

However, the most progressive direction is obtaining several products on one processing line. Thus, at VNIIMZ (a branch of the Federal Research Center "V.V. Dokuchaev Soil Institute"), a technology has been developed for processing cattle manure into solid-phase fertilizers and liquid-phase preparations for agriculture.

The purpose of the work is to present the technological line for processing animal waste into organic fertilizers and preparations for agriculture and crop production.

2. Materials and methods
The initial raw material is cattle manure with a moisture content of no more than 80% and moisture-absorbing material - lowland or transitional peat. The moisture content of the peat-manure mixture should be 65-70%, the ratio of carbon to nitrogen - 20-25: 1, pH - 6-8.

The technological line includes the following main equipment:
- fermenter made of stainless steel with double walls for heating and perforated tubes for oxygen supply;
- extractors with stirrers;
- filtering centrifuge with a rotation speed of 3000 rpm;
- heated extruder;
- mixing tanks;
- packing and packaging unit.

Auxiliary equipment, for example, a compressor, flow heaters, expansion tanks, valves, pumps, pipelines, etc. are used in the technological line. All equipment is interconnected in terms of productivity. The finished products obtained on the technological line were evaluated according to a number of indicators: the total microbial number was determined by the method of limiting dilutions on mesopatämia agar, the content of humic acids - by precipitation with hydrochloric acid followed by drying, nutrients - according to methods according to GOST, pH - by the potentiometric method, dry matter - by thermogravimetric method.

3. Results and discussion
The technological process of manure recycling into various products is shown in figure 1.

![Figure 1. Scheme of the technological process of processing animal waste.](image-url)
The raw material, after thorough mixing, is loaded into the fermenter housing, where the fermentation process is carried out for five days according to the specific technology. The fermentation temperature is directionally changed from mesophilic to thermophilic and back to mesophilic. Controlled modes and parameters of the process create optimal conditions for the development of microorganisms initially present in the original mixture. Their vital activity contributes to the effective transformation of the mixture, and the pasteurization period ensures guaranteed conditions for the disinfection of the finished product. At the end of the fermentation, the fermented mass is gradually cooled, which leads to the completion of the transformation processes and stabilization of the product. The main characteristics of the finished fermentation product are presented in table 1.

Table 1. Characteristics of organic fertilizers and liquid-phase biological products.

| Name                  | pH   | Mass fraction of dry matter, % not less | Mass fraction on absolutely dry matter, % not less | Total microbial number, not less |
|-----------------------|------|----------------------------------------|---------------------------------------------------|----------------------------------|
| Fermentation product  | 7.0-7.5 | 25.0                                    | 35.0, 1.5, 1.1, 1.1                                 | $1 \times 10^7$ KOE/g          |
| Biogenic base         | 7.5-8.0 | 25.0                                    | 32.0, 1.3, 1.4, 1.5                                 | $1 \times 10^8$ KOE/g          |
| Liquid-phase biopreparation | 7.5-8.0 | 1.0                                     | 0.1, 0.1, 0.6, 0.6                                 | $1 \times 10^{10}$ KOE/ml      |

The fermentation product contains no viable eggs and larvae of helminths, pathogenic and malignant microorganisms, viable seeds of weeds. Thus, the fermentation product meets the requirements for organic fertilizers and can be used in this capacity. However, the developed technological line provides for the possibility of its further transformation into a liquid-phase biopreparation (figure 1). The fermentation product extraction is carried out for two days to obtain this. During this period, nutrient components are extracted into the solution under the influence of the extractant potassium phosphate, which simultaneously acts as an activator of microbiological activity and as a source of nutrition and energy for microorganisms. At the end of the extraction process, the suspension is centrifuged and a ready-made liquid-phase biopreparation is obtained, characterized by a high level of biogenicity (table 1).

A dense sediment with a moisture content of ~ 70% remains after centrifugalization (figure 1). It has been experimentally established that the sediment contains a large amount of agronomically useful microflora, nutrients for plants and microorganisms (table 1). However, due to the high humidity and biogenicity, during the storage of the specified sediment for more than a month, hydrolytic processes can occur, leading to spoilage of the product. To avoid this, the sediment is granulated by molding with subsequent or simultaneous drying in a gentle mode [9]. This makes it possible to obtain an independent solid-phase product - a biogenic base, which is suitable for the long-term storage and use as an organic fertilizer.

The used modes and parameters of the fermentation and extraction processes do not engage the entire internal potential of peat as the initial ingredient. Therefore, the technological line offers the second option for using the dense sediment remaining after centrifugalization - as a raw material for the production of humic products (figure 1). For this, the sediment is mixed with a solution of potassium hydroxide and alkaline extraction is carried out for 6 hours at an elevated temperature. After its completion, the extracted mass is centrifuged; mineral acid is added to the centrifuge to reduce the acidity level and create more favorable conditions for the active development of microflora. Thus, two more finished products are obtained:
• liquid humic preparation, the main indicators of which are the content of humic acids - not less than 5 g/l, dry matter - not less than 17 g/l, total microbial number - not less than 1 * 10⁹ CFU/ml, pH 8-9.
• humic paste with a moisture content of 80-85%, which has a high pH value (pH 12-13), the content of humic acids is at least 20%.
• Consequently, it is possible to obtain on the presented technological line for recycling animal waste a series of finished products for agriculture and plant growing: organic fertilizers, liquid preparations and humic paste. Each product has its own purpose:
• fermentation product and biogenic base are intended to apply as the main fertilizer, root feeding of plants, as well as to use in the preparation of garden mixtures and soil. The use of these products contributes to an increase in the yield of cultivated crops, the preservation of soil fertility, and soil structuring;
• a liquid-phase biopreparation and a liquid humic preparation are recommended for processing seed material and foliar feeding of cultivated plants. The preparations are intended to stimulate the growth and development of cultivated plants, as well as to activate soil and microbiological processes. Their use as part of general agrotechnical measures contributes to an increase in the yield of various agricultural crops, an improvement in product quality indicators, as well as microbiological and agrochemical properties of the soil;
• humic paste is intended to introduce agricultural crops into the soil before sowing and to implement recultivation measures for soil deoxidation.

It should be noted that the liquid consistency of the preparations, if necessary, allows them to be enriched with additional sources of nutrition for plants and soil biota, or combined with plant protection products. As a result, a liquid preparation of the given composition can be obtained for specific purposes, while reducing energy and economic costs to a minimum. In addition, the possibilities of using the obtained preparations are expanding not only for various crops, taking into account their biological characteristics, but also taking into account the phases of growth and development of plants. Thus, with the correct use of the products obtained on the presented technological line, it is possible to fully meet the needs of specific plants and soil throughout the season.

Another important point is the principle of substitutability of raw materials. In particular, it is allowed to replace peat with other carbon-containing raw materials available in the regions, and cattle manure - with manure or droppings of individual representatives of the fauna. In this case, it is necessary to comply with the basic conditions of the process, indicated above: the optimal ratio of carbon to nitrogen in the feedstock, humidity, acidity and biogenicity.

4. Conclusion
The presented technological line for processing animal waste into a series of environmentally friendly products for agriculture and plant growing is resource-saving and waste-free. In addition, it is distinguished by the relative simplicity of production, the ability to scale and use regional raw materials. The launch of this technological line solves the problems of utilizing animal and poultry waste, increasing the productivity of agricultural crops, preserving and increasing soil fertility, which, in general, is aimed at the sustainable development of the agro-industrial complex.

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