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The Technology of Producing Biohumus and the Study of its Qualitative Indicators

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Abstract

This article presents the results from the development of a technology for producing biohumus from the feces of cattle and winter wheat straw in a biodynamic fermenter. Nitrifying agents are important for soil fertility, which is dependent on the intensity of the nitrification process. This group includes aerobic cellulose-destroying microorganisms, denitrifiers and sulfate-reducing bacteria. The ratio of these groups and their composition are changing. Therefore, the study of the quantitative ratio of microbial communities involved in the formation of biohumus was of considerable scientific interest. During the microbiological analyses, a large number of microorganisms were found to be involved in the decomposition of the organic compounds. Aminoautotrophic microorganisms represented the largest physiological group of microorganisms in the biohumus. The chemical composition of the biohumus was determined during the study and a sanitary microbiological analysis was performed. The content of gross forms of elements in the humic extract was also examined. The humic extract from the biohumus was a brown liquid with 15 g / l of humic acids, 5.0 g / l of fulvic acids, and gross forms of elements (potassium, phosphorus, nitrogen). The dry matter in the biohumus was 1.0% of the total composition and contained 0.1% nitrogen, 0.03% phosphorus P_2O_5 and 0.01% potassium K_2O. It was found that high-quality organic fertilizer can be obtained using this technology.

Keywords: biohumus, humic extract, chemical composition, sanitary-microbiological analysis, organic fertilizer

1. Introduction

The amount of livestock waste exceeds the volume of the entire household waste, which is more than five times in many countries. Livestock waste contains a large number of organic substances, mineral compounds of nitrogen, phosphorus, potassium, etc. Thousands of hectares of the agricultural land are used to store manure and litter.

Storage of manure and litter near large livestock complexes and poultry farms leads to environmental pollution [1-3].

Modern energy-saving technologies are needed in order to effectively use manure and get high-quality organic fertilizers from it. The main requirement for the processing of animal waste technology is the preservation of their biological activity. The main requirement is the maximum preservation of compounds of nitrogen, phosphorus and other elements with the subsequent receipt of biological fertilizers from them [4-6].

The valuable organic fertilizer can be obtained using microorganisms as a result of biofermentation of litter and manure at 70... 85 ° C.

With proper management of the biotechnological process of waste fermentation, more intensive mineralization of the initial substrate occurs. Also, biosynthesis activity of the novel compounds increased. The nutritional properties of the final products are improved. Processing of organic matter can be regulated by various methods: physical, chemical and biological. Microorganisms are activated by the biological method, by their enzyme systems to accelerate the decay of organic compounds and microbial synthesis [7-10].

The trophic structure of the microbial community is determined by the interactions between the functional groups of microorganisms that have specialized sets of enzymes that enable them to use certain substances. The process of decomposition of plant residues in the form of biopolymers (cellulose, etc.) is started by hydrolytic microorganisms, which, by isolating hydrolytic exoenzymes, decompose biopolymers into monomers. It, accumulating in the substrate, on the principle of feedback causes repression of the synthesis of exohydrolases, which causes the transition of hydrolytic microorganisms to a resting state. The monomers formed in this process are used by another group - copyiotrophs, the intensive development of which leads to a sharp decrease in the content of monomers. Copyiotrophs become inactive as a result of depletion of the pool of monomers in the soil. Then oligotrophs, which use monomers in extremely low amounts, appear in the active phase. In this case, the catabolic repression of the synthesis of hydrolases is removed, and the cycle of decomposition of the biopolymer is repeated. Thus, the activity of each of the above groups of microorganisms is of pulsating character [11-13].

An urgent task is the development of biotechnological methods for producing organic preparations based on humic compounds with a wide range of biological effects, which will contribute to increasing crop yields and ensuring biological protection of the soil [14-16].

The purpose of the work was to develop a technology for producing biohumus and study its quality and sanitary-microbiological indicators.

To achieve this goal, the following tasks were solved:

1. to develop a technology for producing biohumus from feces of cattle and straw of winter wheat in the biodynamic fermenter;

2. to determine the chemical composition of biohumus;

3. to conduct a sanitary-microbiological analysis of biohumus;

4. to study the content of the gross forms of elements in the humic extract of biohumus.

2. Methods and Equipment

In order to extract humic compounds from the obtained extract, we carried out its treatment with sodium hydroxide at the rate of 40 g of NaOH per 1 liter of extract. With alkaline pH, the growth and development of microorganisms stop. In addition, water-soluble salts of all the main bioactive elements (sodium, potassium, ammonium) contained in biohumus are formed. Alkaline treatment of the humic extract allows one to obtain a more concentrated product, to enhance the activity of humic acids, to increase the quality and shelf life of biohumate.

To determine the chemical composition of biohumus and the humic extract obtained from it, we carried out a chemical analysis of two samples of biohumus and two samples of humic extract in triplicate. According to I. Tyurin's method, in the studied samples, we determined: carbon of humic acids, carbon of fulvic acids, mass fraction of dry matter according to GOST 26713-85, mass fraction of moisture according to GOST 26713-85, mass fraction of organic substances according to GOST 27980-88, the mass fraction of ash substances according to GOST 26714-85, the activity of hydrogen ions according to GOST 27979-88, the mass fraction of total nitrogen of dry matter according to GOST 26715-85, the mass fraction of total phosphorus in recalculation of P_2O_5 by dry matter according to GOST 26717-85, the mass fraction of calcium in terms of dry matter according to GOST 26487-85.

3. Results and Discussion

We received biohumus according to the technology developed by us from cattle manure and winter wheat straw in a $12 \times 4 \times 2.5$ m biodynamic fermenter equipped with a system

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of gutters in the bottom that ensure fluid outflow. To obtain biohumus, we prepared a mixture of 72 tons of cattle manure and 9 tons of straw chopped to a fraction of 1–20 centimeters, moistened to a relative humidity of 65% (total 81 tons), which was placed in a fermenter. We periodically mixed the mixture and monitored a change in its temperature under the influence of indigenous microorganisms. After 125 hours, we heated the mixture to 75 ° C and started collecting the humic extract, which was collected in a gutter system in a collection tank. The moisture content of the mass in the biodynamic fermenter was maintained at 65%. The process of isolating the humic extract lasted for 72–90 h and ended when the temperature of the biohumus mass was reduced to 50 °C. As a result of one cycle of biodegradation of 81 tons of organic matter in the biofermenter, 4000 L of humic extract was obtained.

At the initial stage of composting, manure had a bright brown color, a pungent smell of ammonia, and humidity up to 75%. To prepare the compost mixture, straw cutting was mixed with manure on a concrete site. At the bottom of the biodynamic fermenter, chopped straw in the form of a pillow 0.2 m high was placed and then the fermenter was fully loaded. The volume of the fermenter was 80 m^3. After loading the fermenter, the compost mixture was spilled with water in a volume of 2-3 m^3, depending on the initial humidity. Throughout the cycle, we recorded the following technologically important indicators: temperature, humidity, density, acidity. On the second day of fermentation, aeration was carried out automatically for 1 hour under a pressure of 10 atmospheres. As a result of an increase in the number of thermophilic microorganisms, on the sixth day of the experiment, the temperature in the organic matter increased to 70 ° C. After 10 days, the fermenter was restarted.

Compost from the fermenter was laid out on a concrete platform, mixed and again placed in the fermenter, previously prepared according to the same scheme as it was at the beginning of fermentation. At this stage, biohumus acquires a dark color, and the smell of ammonia is lost. The fermented mass was unloaded from the fermenter in the form of a ready biohumus after 12 days. During this time, biohumus acquired an even more saturated black color, and a tangible smell of soil. The finished product was unloaded on a concrete site, where it was dried to a moisture content of 55%.

The use of straw slices is necessary for the use of a filler, which prevents the adhesion of manure and ensures optimal aeration. Analysis of the chemical composition of biohumus is presented in Table 1.

The biohumus obtained was found to contain a high content of organic matter - up to 50%, humic substances - 20%, total nitrogen - 1.8%, total phosphorus - 2.1%, total potassium - 2.5%, amino acids - 32 g / l. All these biologically active compounds, when used as biofertilizers, can fruitfully affect the growth and development of crops, and the quality of products.

Table 1: The chemical composition of biohumus

Indicators	Content
Mass fraction of organic matter, %	50.0
Humic substances, %	20.0
Ash substances, %	30.0
Total nitrogen, %	1.8
Total phosphorus, %	2.1
Total potassium, %	2.5
Humidity, %	54.0
pH	6.7–7.8
Amino acids, g / l	32.0

The vital activity of microorganisms plays an important role in the composting process. Microorganisms contribute to the intensive decomposition of organic matter, which include various groups of microbial cenosis. First of all, these are ammonifiers, which cause the breakdown of protein residues. The next group includes microorganisms that decompose plant debris and contribute to the formation of humus compounds enriched in products of microbial autolysates (α-humates). This group includes bacteria, fungi, actinomycetes. The next group is the so-called “scattering microbes”, which processes residual amounts of organic substances. This is a group of oligotrophic (oligonitrophilic and oligocarbophilic) microorganisms. In the process of biodegradation of organics and the formation of biohumus, autotrophs play a significant role, using the final products of microbial decay and mineralize α-humates. Among them, nitrifying agents are of particular importance, since soil fertility is most dependent on the intensity of the nitrification process. Also this group includes aerobic cellulose-destroying microorganisms, denitrifiers, sulfate-reducing bacteria. The ratio of these groups and their composition is changing, therefore, the study of the quantitative ratio of microbial communities involved in the formation of biohumus was of significant scientific interest.

A large number of microorganisms involved in the decomposition of organic compounds were detected in biohumus during microbiological analysis

The largest physiological group of microorganisms in biohumus is represented by aminoautotrophic microorganisms, the number of which was 231.6×10^6 CFU / g. This, apparently, is associated with the predominance of plant-origin organic matter in the processed mass. The number of ammonifiers was 1.8 times lower compared to that of aminoautotrophs and amounted to 130.33×10^6 CFU / g. The predominance of the group of aminoautotrophs over ammonifiers indicates a rather high degree of compost mineralization.

The number of cellulose-destroying actinomycetes in the studied biohumus was 0.93×10^3 CFU / g. This is a fairly large microbial community for this class of microorganisms, which is of fundamental importance for humification and for self-cleaning of compost from conditionally pathogenic microorganisms. The latter circumstance is confirmed by the results of microbiological analysis of biohumus for the presence of sanitary-indicative microorganisms and helminth eggs (Table 2).

TABLE 2: The results of sanitary-microbiological analysis of biohumus

Indicators	Analysis result	Allowed Levels
BGKP index	are absent	1–10
Enterococci index	are absent	1–10
Pathogenic, including salmonella	are absent	not allowed
Eggs and larvae of geohelminthes (viable), ind./kg	are absent	not allowed

The humic extract from biohumus is a brown liquid with a content of humic acids of 15 g / l, fulvic acids - 5.0 g / l. The content of the gross forms of elements in the humic extract (potassium, phosphorus, nitrogen) is presented in table 3.

TABLE 3: The content of the gross forms elements in the humic extract

Index	Content in terms of initial humidity	Dry matter content
Dry matter, %	1.0	–
Total nitrogen, %	0.1	10.0
Phosphorus, P_2O_5, %	0.03	2.9
Potassium, K_2O, %	0.01	1.1

It was found that biohumus contains dry matter in an amount of 1.0%, total nitrogen - 0.1%, phosphorus P_2O_5 - 0.03%, potassium K_2O - 0.01%, which is quite acceptable for organic fertilizers.

4. Conclusion

As a result of the research, it has been established that the chemical composition, phytosanitary condition and the content of the gross forms of elements in the humic extract of the developed biohumus sample allow us to recommend its use for soil treatment as an organic fertilizer.

Conflict of Interest

The authors have no conflict of interest to declare.

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