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Periodicity of publication: Quarterly

The journal activity is driven by the following objectives:

- Broadcasting young researchers and scholars outcomes to wide scientific audience
- Fostering knowledge exchange in scientific community
- Promotion of the unification in scientific approach
- Creation of basis for innovation and new scientific approaches as well as discoveries in unknown domains

The journal purposefully acquaints the reader with the original research of authors in various fields of science, the best examples of scientific journalism.

Publications of the journal are intended for a wide readership - all those who love science. The materials published in the journal reflect current problems and affect the interests of the entire public.

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EVALUATION OF LIQUID WASTE FERMENTATION PRODUCTS OF ANIMAL ENTERPRISES UNDER ANAEROBIC CONDITIONS

ГІГІЄНІЧНА ОЦІНКА ПРОДУКТІВ ФЕРМЕНТАЦІЇ РІДКИХ ВІДХОДІВ ТВАРИННИЦЬКИХ ПІДПРИЄМСТВ ЗА АНАЕРОБНИХ УМОВ

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Abstract. *On the basis of sanitary and hygienic indicators of liquid manure processing products by mechanical processing methods and hydraulic manure removal systems, a hygienic assessment of the obtained components is given and the need for purification of the liquid fraction by biological methods is indicated.*

The optimal parameters for purification of liquid fraction of manure effluents in the process of biofermentation of wastewater organic matter by elimination of contaminants with the participation of active and symbiotic sludge are established.

Increases the yield of biogas and improves the sanitary and hygienic performance of organic fertilizers.

Pre-treatment of manure effluents in aerobic-thermophilic mode and their anaerobic fermentation under mesophilic conditions enhances biomass conversion, increases biogas yield and improves sanitary and hygienic performance of organic fertilizers.

Key words: *product, manure, biogas, sanitary, organic.*

Introduction.

Sustainable development of the livestock industry as part of the national economic complex of the state is based on the widespread use of intensive production technologies based on modern breeds and types of farm animals and new poultry crosses with high genetic productivity potential, disease resistant, easily adaptable to long-term economic use and effective use feed products [4, 10, 11, 18, 19].

Particular importance is attached not only to compliance with standards and hygiene requirements and rules for optimizing housing conditions [17, 20, 21], feeding [7, 9, 22], care and exploitation of animals and poultry, health and conservation of livestock, but also the protection of the environment from contamination by waste from livestock enterprises [8, 13, 14, 16].

Application to such enterprises for waste processing developed methods and technologies for their utilization, based on biological methods ne pollution recovery is not always effective, especially in the conditions of artificially created zooecosystems that operate in a closed mode. Accumulation in small areas of large amounts of waste from livestock enterprises, namely manure, manure and process effluents, manure contaminates soils, water bodies and the air basin with harmful gases, microorganisms, dust and other products of decomposition of organic waste, which is a major problem on the way creation of large complexes for the production of livestock products.

Review of literature sources.

The main role in the conversion of organic matter in livestock waste belongs to various species of bacteria, microalgae and fungi. Microorganisms of manure or manure drains belong to different groups, but depending on the need for oxygen they are divided into aerobes and anaerobes [2, 6]. biomass of activated sludge and biofilm is formed. Morphologically, such a community consists of representatives of many systematic groups - bacteria, actinomycetes, fungi and algae. Bacteria form the basis of community biomass. [15]

The most numerous species in the microflora of aerobic systems are Pseudomonas, gram-negative rod-shaped bacteria. The order of Pseudomonas includes 50-80% of the biomass of activated sludge bacteria formed by aerobic methods of wastewater treatment. This order includes bacteria that oxidize nitrites (Nitrosomonas), sulfur compounds (Sulfomonas, Thiobasilus). Many species of Bacterium are found in effluents. These include ammonifiers Bact.mycoides, which are involved in the destruction of organic nitrogen-containing compounds, namely: proteins, urea, amino acids with the formation of ammonium ions or free ammonia. The composition of microorganisms in activated sludge and biofilm is capable of changes in a wide range and depends on the fermentation conditions, the process temperature. The influence of mutagenic waste factors on the composition of the microflora of sewage treatment plants has been noted. [12] The most studied microorganism that oxidizes ammonium nitrogen to nitrites - phase I nitrification - is Nitrosomonas europaea [3].

Actuality of theme.

The development of the livestock industry is closely linked to the introduction of the latest production technologies, which, in addition to economic benefits, exacerbates the environmental problems associated with the concentration of livestock and the accumulation of significant excrement and technological effluents in limited areas. the amount of animal excrement and waste from enterprises with intensive technologies of livestock production in many cases exceeds the conversion capacity of soils and water, pollutes the air with toxic substances, microorganisms, dust, increases the environmental pressure of livestock facilities on the environment.

The purpose and objectives of the study.

The aim of the work was to develop theoretical aspects (provisions) of biotechnologies for waste disposal of livestock enterprises in a closed zooecosystem by determining the physicochemical properties of fecal masses of animals and manure effluents of livestock enterprises, the main parameters of biofermentation of waste under ana- and aerobic conditions and sanitation.

The goal set in the work was achieved by studying the sanitary and hygienic indicators of fecal masses of cows, pigs and laying hens for different types of feeding and intensive production technologies.

Research methods.

For research of sanitary and hygienic indicators the laboratory installation which was characterized by three-stage process without intermediate removal of a deposit (activated sludge) from system was used (fig. 1).

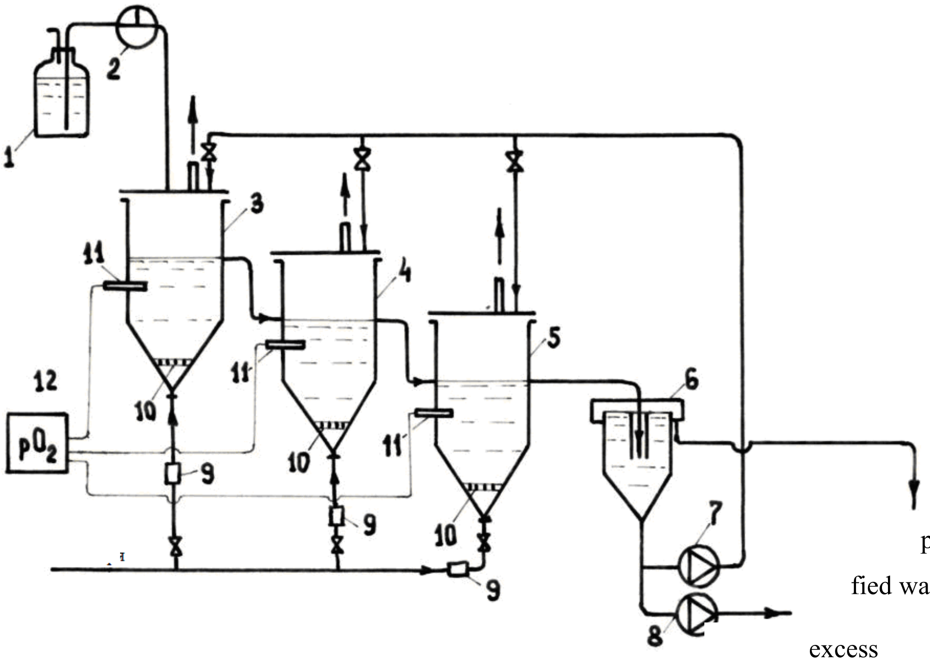

Fig. 1. Schematic diagram of the installation of three-section treatment of manure effluents under aerobic conditions (flow regime).

In this series of studies, three experiments were conducted. In the first experiment, the sanitary and hygienic parameters of manure effluents after biofermentation without return of activated sludge at the rate of their dilution at D1 = 0.09 h-1 and D2 = 0.07 h-1 were studied. The second experiment studied the same indicators of manure effluents after biofermentation, but at 150% recirculation of activated sludge in the third stage of the bioreactor at a dilution rate of D1 = 0.09 h-1 and D2 = 0.07 h-1. To compare the data obtained in the first and second experiments, similar studies were performed on an aeration tank mixer. Cultivation of manure effluents under these conditions was performed at a dilution rate of D1 = 0.09 h-1 and D2 = 0.07 h-1.

In the samples of manure effluents before and after biofermentation at different hydrodynamic regimes and dilution rates without recirculation and with recirculation of activated sludge (sludge) in the system investigated the degree of removal (conversion) of OP (contaminants) and inorganic components, as well as physiological groups of microorganisms.

The third stage of research was devoted to the study of the processes of transformation of PR (contamination) of manure effluents and sanitary and hygienic indicators of the obtained products of biofermentation under the action of microalgae. The experiments were performed using a special laboratory installation for growing polyculture of microalgae (Fig. 2).

The processes of OR transformation of manure effluents from pig enterprises with the participation of microalgae were studied in different modes of aeration and pH stabilization of the mixture. For this purpose, three series of experiments were performed using native pig effluents of different degrees of dilution or liquid fraction obtained after purification of manure effluents with activated sludge.

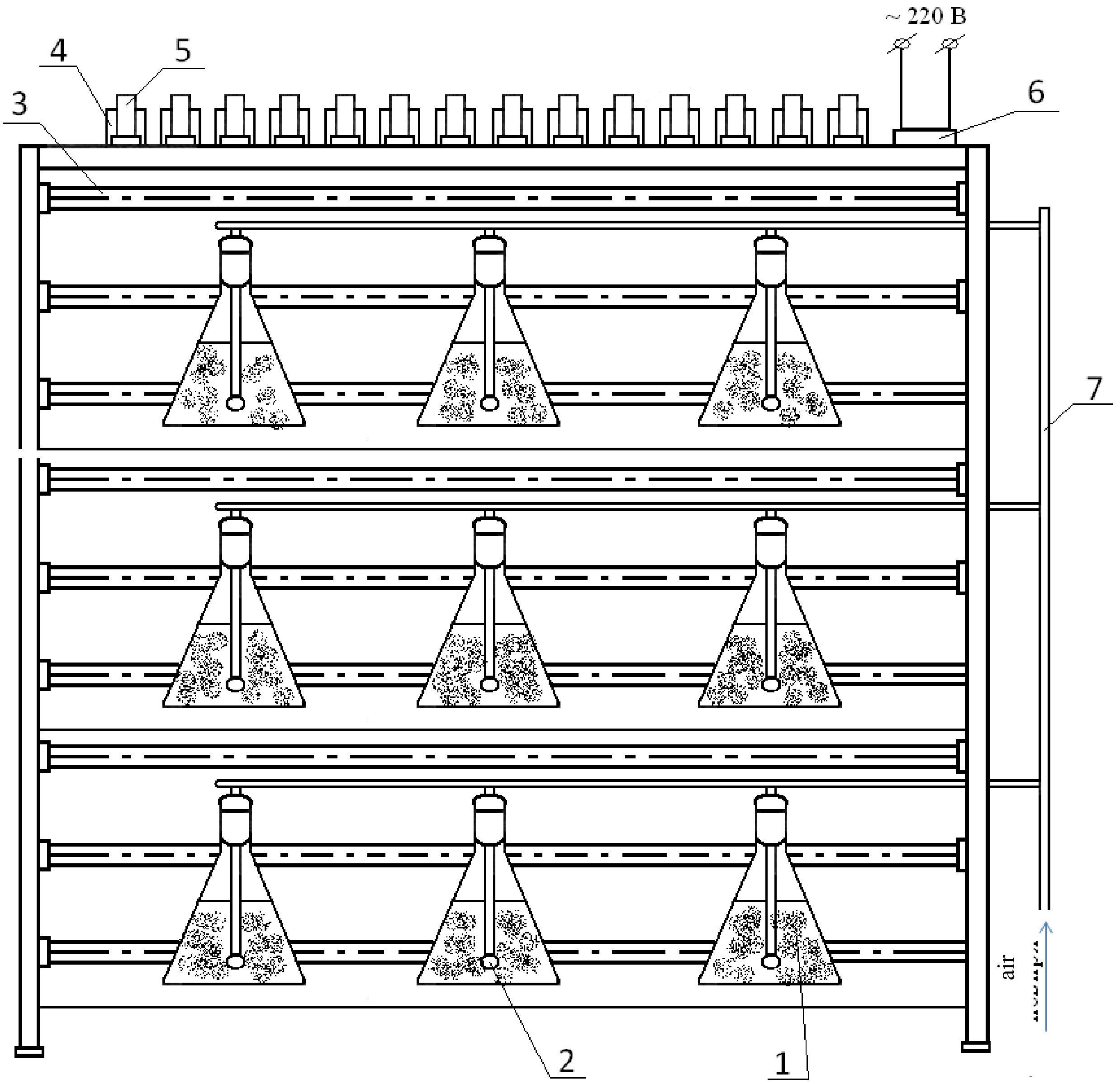

Fig. 2. Schematic diagram of the installation of manure effluent treatment with microalgae (periodic mode).
1 - bulb, 2 - bubbler, 3, 4, 5, 6 - lighting system, 7 - air distribution manifold.

Pratt's medium with the addition of manure. The polyculture of microalgae included representatives of the genera Chlorella, Scenedesmus and Ankistrodesmus with impurities Chlorella vulgaris, which was used to record biomass growth. Microalgae were added to the effluent in the amount of 6.93 ± 0.6 million cells / ml of medium in all series of the experiment. In the process of biofermentation of effluents, the optimal illumination of biomass (3000 - 5000 lux) and the temperature of the cultivation medium (20°C) were maintained. In effluents, the total microbial count and the total number of activated sludge anaerobes, coli-titer and enterococcal titer were determined [ISO 8199: 1988; ISO 9998]. Sewage samples before and after treatment, as well as activated sludge were sown on selective media. To determine the ammonifying microorganisms in the effluents, Oleynik's medium was used, Hutchinson's cellulose-destroying, Imshenetsky's anaerobic, Rubenchin's urolytic, Rushman's amylolytic and butyric acid, I and II - Vinogradsky I and II axiomycetes, nitrifiers I and II. The number of microorganisms in the samples on liquid media was controlled by the McCready method, and on solid - by counting the number of colonies grown in Petri dishes. The number of anaerobes and the total microbial count of effluents were calculated after incubation of samples at a temperature of 27 0C on Wilson-Blair medium [1, 5, 14]. agar with the addition of triphenyltetrazolium chloride and crystalline violet. Aickman's medium from TTX was used to isolate Escherichia coli. By repeated inoculations on solid and liquid nutrient media, algologically pure cultures of microalgae were obtained, which were counted in Goryaev's chamber.

Research results. Unlike aerobic, in anaerobic conditions biofermentation can not provide deep removal of organic contaminants from waste. The depth of destruction (fermentation) of OR components of contaminants in the anaerobic process of biofermentation of manure effluents is limited by bioenergy laws and has well-defined limits that depend on the chemical composition of the components and their ratio. Therefore, the purpose of this stage was to study the degree of destruction of organic matter from pig waste by anaerobic biofermentation and to determine a number of kinetic constants of this process. Manure effluents after filtration through a 3 mm sieve were used for the studies. For this purpose, native liquid manure from pork enterprises was used, which was previously freed from impurities. As shown by research, the filtration of liquid manure had little effect on the chemical composition of the obtained manure effluents, table. 1.

Table 1

Chemical composition of liquid pig manure,%, M ± m, n = 3

Indicator	Concentration
Humidity	94,2±2,10
Dry matter	5,8±0,46
Ash, % ACP	21,4±0,90
Crude fat	3,4±0,90
Crude protein	11,9±2,40
Total carbon, g / l	14,8±2,80
Total nitrogen, g / l	2,9±0,40
LJK, g / l	0,2±0,05

The research results show that the depth of fermentation of PR for different components of waste is different. Thus, for protein it is 54-60%, and for fats - 45-90%. Studies have shown that the maximum depth of fermentation of OP is not a constant value for each of these classes of compounds, but varies depending on the composition of raw materials, the ratio of components and the presence of other compounds involved in redox processes. In each case, the maximum depth of fermentation of the OP raw material depends on the ratio of donors and electron acceptors. The maximum depth of fermentation of total carbon, which reaches 60% of its initial concentration, is relatively constant for the studied objects.

It is known that the process of fermentation of liquid manure under anaerobic conditions includes two stages: acidic and alkaline. - 5 days). During this period, there is a high concentration of acetic, propionic and butyric acids in a mixture subjected to anaerobic biofermentation. First, the maximum level is reached by acetic acid - 1.2 g / l, and then propionic and butyric 0.61 g / l and 0.19 g / l, respectively. From 5 to 10 days there is a sharp decrease in the total content of LH in the biomass and each of the acids, which correlates with an increase in the volume of biogas produced and a change in the ratio of methane and carbon dioxide in the gas mixture.

Important for optimizing the system, ie the process of biofermentation, is the calculation of the process under flow conditions, which includes the determination of kinetic constants for dissolved and suspended components of the feedstock. This is due to the fact that the calculated volume of the biofermenter significantly depends on the hydrodynamic characteristics of the interaction conditions of the substrate and biomass.

The high rate of utilization of raw materials at the beginning of the biofermentation process is due to the decomposition of dissolved and fine components, after depletion of which it is determined by hydrolysis of more complex compounds until complete cessation of the process.

In this regard, the development of new and improvement of existing technologies for processing animal waste, including anaerobic biofermentation of biomass in anaerobic conditions is an important element of modern technologies for livestock production. At the same time, the issue of sanitary and hygienic assessment of biofermentation products of livestock waste obtained during the operation of biogas plants becomes especially important.

Achieve high efficiency of biogas plants and obtain processed products safe in sanitary and epidemiological terms is possible by optimizing the technological parameters of the fermentation of organic matter of waste, the impact on the life of microorganisms and pathogens of invasive diseases. Therefore, the main purpose of this stage was to investigate the parameters of the process of anaerobic biofermentation of liquid manure and sanitary and hygienic parameters of the fermented product at different fermentation times and biomass temperature.

The resulting biomass was loaded into the fermenter 2 times a day. The volume of the original biomass was 6 liters, to which was added 1 liter of fermented substrate (yeast). fermentation time of 5 or 10 days, the specific yield of biogas per unit volume of biomass reached 2.2 - 1.9 m3 / m3 (Table 2). The degree of conversion of organic matter of manure was 20.0 and 26.6%, respectively, and the specific yield of biogas from 1 kg of fermented mass - 0.55 - 0.65 m3.

This is due to the fact that low-molecular-weight organic compounds of liquid manure, which are in soluble form in the form of a fine phase, are first fermented.That is, the energy potential of the organic matter of liquid manure under anaerobic conditions of biofermentation is not fully used. Reducing the loading dose of the bioreactor to 0.07 or 0.05 days-1 and, accordingly, increasing the biofermentation time to 15 or 20 days reduces the specific yield of biogas per unit volume by 1.6 and 1.7 times compared to the loading dose D = 0 , 07 days-1 and 1.4 and 1.6 times compared with D = 0.05 days-1.

The specific yield of biogas from 1 kg of fermented raw materials increased by 1.3 and 1.1 times and 1.4 and 1.4 times, respectively, at the above levels of loading and biofermentation time of the fermenter.

Table 2

Milk production and specific biogas yield depending on the loading dose of the bioreactor under anaerobic conditions

Dilution rate, (D), days-1	Fermentation period, days	The degree of destruction of the OP, %	Specific yield of biogas, m^3 / kg OR
0,2	5	20,0	0,55
0,1	10	26,6	0,65
0,07	15	30,0	0,70
0,05	20	35,0	0,89
0,04	25	38,0	0,92
0,033	30	40,0	0,89

A further increase in the fermentation time of liquid manure biomass to 25-30 days and loading the fermenter at D = 0.04-0.033 days-1 does not cause a significant increase in biogas yield. However, increasing the degree of destruction of organic matter to 38 - 40% brings it closer to the limit of technical fermentation. Thus, the energy potential inherent in the chemical bonds of organic matter of manure of livestock enterprises under such conditions is used almost completely. However, extending the biofermentation time of liquid manure by a factor of 1.5 leads to an increase in the volume of the bioreactor, which in turn increases capital and operating costs. Thus, the degree of destruction of the OP of liquid manure at D = 0.1 dB-1 was even lower by 4.6% compared with similar data obtained without mixing the substrate, and remained unchanged when diluting the mixture D = 0.05 days-1 (Table 3).

Table 3

Chemical composition of liquid manure of enterprises for the production of milk and products of its processing at different loads of the bioreactor, M ± m, n = 4

Biomass	Indicator				
	Humidity,%	Ash,%	ACP, g / kg	OR, g / kg	LJK, g / kg
Source	92,58±0,48	23,78±0,98	74,20±4,80	56,55±1,98	5,31±0,64
Fermented, D = 0.1 days-1	93,64±0,17	30,58±0,51*	63,57±1,70	44,14±1,33*	8,35±1,14
Fermented, D = 0.05 days-1	94,56±0,68	32,39±0,34*	54,32±6,80	36,67±2,42*	4,01±0,65

** - p≤0.05 compared to the original biomass*

The processes of biofermentation and the efficiency of destruction of organic matter of biomass are significantly affected by the temperature in the reactor. It is established that the increase of biomass temperature at the beginning of the anaerobic biofermentation process from 22 to 52°C reduces by 6.5 - 7 times the period of plant start - up and its output to the optimal mode. The degree of destruction of organic matter of manure biomass within the specified temperature limits increased from 8.37 to 61.82%, ie 7.4 times, and the methane content in biogas increased by 24.21% and amounted to 71.4%.

The yield of biogas under anaerobic conditions depended on the biomass temperature and was exponential. The same dependence was found on the methane content in biogas, although it had certain features. At a biomass temperature of 15 °C in the process of biofermentation, a relatively constant yield of biogas and methane content was observed. At the stage of starting the fermentation process and in the channel, the biogas yield practically did not exceed 0.4 m^3 / m^3 of biomass, and the methane content in it was at the level of 17%.

The decrease in biomass temperature under anaerobic conditions of biofermentation significantly increased the concentration of LW in the mixture, which correlates with a decrease in the methane content in the biogas.

Studies have shown that the total microbial count of the product obtained in the process of biofermentation of liquid manure is reduced by two orders of magnitude in both thermophilic and mesophilic regimes.

Under the mesophilic regime of biofermentation and anaerobic conditions, the number of acid-forming bacteria in the biomass increases from 7.1 • 104 to 2.45 • 106 microbial cells / g, and spore-forming remains unchanged. Under these conditions, cellulose-destroying aerobes in the biomass disappear completely, and the number of anaerobic cellulose-destroying bacteria increases significantly, which correlates with an increase in the content of LHL.

Under the thermophilic regime and anaerobic conditions of biomassation of biomass, the species composition of the microflora changes more dynamically. Thus, the number of acid-forming bacteria is reduced in biomass from 106 to 103 microbial bodies / g, spore-forming - from 105 to 103 and proteolytic - from 105 to 103. Fungi, including yeast and actinomycetes under thermophilic conditions disappear completely in biomass.

It is important from a sanitary point of view that salmonella and staphylococci were not detected in the tested samples of liquid obtained after fermentation under the thermophilic regime. Bacteria of the Escherichia coli group in biomass after fermentation in the thermophilic regime are also virtually absent, and in the mesophilic - are found in small quantities. Increasing the fermentation time of biomass in the reactor under thermophilic conditions significantly reduces the total number of viable bacteria. It is established that the maximum disinfection of biomass in reactors under anaerobic conditions occurs at a temperature of 52 °C and a process duration of 10 days, which corresponds to a flow rate D = 0.1 days-1.

Fermented under anaerobic conditions and thermophilic regime, biomass can be used without restrictions as an organic fertilizer.

Characterization of biomass in terms of value as an organic fertilizer showed that the nitrogen content in it under the mesophilic regime is almost no different from the original effluent, and the loss of this element did not exceed 6.0% of the total level. Under the thermophilic regime of fermentation of manure effluents, nitrogen losses reach 30% of the total content. m3 of bioreactor at D = 0.2 days-1, and the value of specific gas formation decreases, which can be explained by the deterioration of the process of methanogenesis.

According to sanitary and hygienic indicators, biomass fermented under anaerobic conditions and thermophilic regime predominates over similarly obtained products (organic fertilizers) in mesophilic process parameters. It turned out to be important that in the processes of intensification of the biofermentation reactions of waste OP under the mesophilic regime lies its phase separation and control of the stage preceding methane fermentation. That is, one of the requirements of this technology of organic waste processing is a combination of aerobic-thermophilic fermentation of OP in the first stage (acidogenic phase) and anaerobic-mesophilic fermentation in the second stage (methanogenesis phase).

Studies have shown that increasing the temperature of liquid manure under anaerobic conditions of biofermentation from 15 to 22°C did not affect the content of moisture, ash, ACP and OP (Table 4). did not affect the moisture level in the biomass, but increased the ash content by 3.9% and reduced the ACP content by 34% compared to native effluents.

Table 4

Chemical composition of native effluents and products of their processing at different temperatures, M ± m, n = 4

Temperature, ° C	Indicator				
	Humidity,%	Humidity,%	Humidity,%	Humidity,%	Humidity,%
15	89,30±0,15	22,10±0,54	107,0±1,5	83,35±1,84	3,77±0,91
	90,65±0,18	23,05±1,08	93,5±1,8	71,94±2,04	11,20±1,63*
22	89,70±0,48	21,58±0,96	103,0±4,8	80,77±3,44	3,76±0,54
	90,50±0,21	22,09±0,49	95,0±2,1	74,01±2,40	7,20±0,87*
27	89,30±1,02	21,45±1,06	107,0±10,2	84,05±3,58	3,77±0,68
	92,70±0,63	25,35±0,39*	73,0±6,3*	54,49±1,25*	6,98±0,48*
32	88,73±1,19	22,63±0,45	112,7±11,9	87,19±3,50	3,44±0,50
	93,50±0,24*	25,26±0,68*	65,0±2,4*	48,58±1,20*	5,68±0,17*
52	89,40±0,71	21,54±1,09	106,0±7,1	83,16±2,48	3,48±0,40
	95,60±1,24*	27,84±1,20*	44,0±12,4*	31,75±3,40*	3,11±0,14

*In the numerator the data of native effluents, in the denominator - after biofermentation; * - p≤0.05 compared to native effluents*

Increasing the biomass temperature to 32° C under anaerobic fermentation conditions contributed to an increase in moisture content by 4.8%, ash - by 2.6% and a decrease in the level of ACP and SR, respectively, 1.7 and 1.8 times compared with native effluents. A similar pattern of changes in the above indicators was registered under the conditions of the thermophilic regime of the biofermentation process, which in turn affected the species composition of bacteria, and hence the cleavage of waste OP.

At a temperature of 52 °C, the humidity of biomass increased by 6.2, ash content - by 6.3%, and the content of OP and ACP decreased by 2.6 and 2.4 times, respectively, compared to native effluents.

Therefore, based on the obtained results, it can be concluded that the chemical composition of the products of processing manure effluents of the pig complex after biofermentation depends on the ambient temperature and determines the yield of biogas and its composition. This is indicated by significant changes in the concentration of LH in biofermentation products compared to their content in native effluents.

It is shown that at the temperature of the mixture in the bioenzyme 15°C the amount of LV in the obtained biomass, compared with the initial level increased 3 times, at 22°C - in 1.9, at 27°C - in 1, 8, at 32°C - 1.6 times, and at 52°C - did not change. Therefore, with increasing temperature of the mixture, the rate of formation of LVH under anaerobic conditions of biofermentation of manure effluents decreases significantly. Probably, this fact can be associated with a significant reduction in the period of the process to the optimal mode, or the inhibitory effect of high temperatures on the physiological activity of acid-forming bacteria. This is consistent with the previously given data on their amount and in wastewater fermentation of manure effluents of the dairy complex under anaerobic conditions. (Table 5).

Table 5

Specific yield of biogas by anaerobic biofermentation of manure effluents of the pig complex at different temperatures, M ± m, n = 4

Temperature, ° C	Indicators		
	Optimal yield, days	Specific biogas yield, m^3 / kg OP	The composition of biogas, % CO2 / CH4
15			83,30±0,60
		0,4	16,70±0,60
22	21-26		52,81±4,32
		5,6	47,19±4,32
27	15-18		51,88±8,88
		9,9	48,12±8,88
32	8-9		43,46±3,43
		14,2	56,54±3,43
52	3-4		28,60±2,51
		21,4	71,40±2,51

It was found that the specific yield of biogas during fermentation of manure effluents of the pig complex under anaerobic conditions with increasing temperature from 15 to 32°C, ie for every 5°C increased by 14.0; 1.8; 1.5 times, and at a temperature of 52°C, ie in the thermophilic regime - 53.5 times compared to similar data at 15°C.

It is also important that with increasing biomass temperature in the bioreactor changes the ratio of gases in the mixture, which is formed in the process of biofermentation under anaerobic conditions, by increasing the amount of methane and reducing the CO2 content. Thus, at 15°C the ratio of CO2 and CH4 was 5: 1, at 22°C - 1: 1, at 27°C - 1: 1.3 and at 52 °C - 1: 2.5.

Therefore, ensuring the optimal temperature regime in the biofermentation of manure effluents of the pig complex under anaerobic conditions is the basis for obtaining a high specific yield of biogas, including methane.

Especially important in this regard were the parameters of the process to the optimal mode. It is proved that the shortest time of the process to reach the optimal mode at a temperature of 52 °C, ie thermophilic mode. The gradual decrease in the biomass temperature in the reactors increased, and to a large extent the time of the process reaching the optimal regime, which at a temperature of 15 °C averaged 21 - 26 days against 8 - 9 days in the mesophilic and 3 - 4 days - in the thermophilic regime.

On the basis of the conducted researches it is possible to draw a conclusion about dependence of a course of biofermentation of manure drains of a pig complex on temperature of environment under anaerobic conditions.

The processes of biofermentation of organic matter from animal waste under anaerobic conditions are known to occur under the action of microorganisms that are capable of destroying high molecular weight organic compounds with the formation of simple substances, including organic acids and carbon dioxide and methane. The rate of biofermentation reactions depends on the chemical composition, physical properties of the manure, the parameters of the processing process and, as previous studies have shown, almost do not depend on the level of humidity.

The efficiency of the biofermentation process of manure, which leads to the formation of methane, is also affected by the residence time of biomass in the reactor and the associated degree of biodegradation of organic matter (bioconversion). The maximum specific productivity of a bioreactor depends on its working volume. However, this does not always provide a complete decomposition of the OP manure. The main parameter that affects the efficiency of the process of methane fermentation of manure is its chemical composition and physical properties.

It is known that increasing the content of OP per unit volume of bioenzyme increases the yield of biogas, but impairs the processes of heat and mass transfer, which reduces the depth of its destruction. Reducing the content of OP in biomass, on the contrary, requires additional energy to maintain the process of methanogenesis at an optimal level. As for the changes in the content of individual components of organic matter in the process of anaerobic biofermentation of manure, they have been studied to a much lesser extent and require additional research.

Studies have shown that the physical properties of native manure of laying hens of an industrial herd is a heterogeneous dark mass of semi-liquid consistency, consisting of different particle size of gray-green color.

The study of the main parameters of the process of biofermentation of manure under anaerobic conditions showed that it proceeds according to a known scheme, which includes acidic and alkaline phases at an initial humidity of 91.0%.

It is proved that under these conditions the maximum amount of gas is formed in the bioreactor on the 4th, 9th, 14th and 23rd days. During this period, there is an increase in the degree of biofermentation of organic matter of manure, which is respectively 31.4; 40.05; 47.13 and 57.14% of its initial level. A similar pattern of changes in the content of PR was obtained by other authors in developing a model of bacterial decomposition of solid substrates in the periodic regime under anaerobic conditions.

It was found that from 1 to 6 days of fermentation the rate of formation of other gases from the OP manure exceeds the release of methane. This is due to the fact that in the beginning there is an activation of the hydrolysis reactions of macromolecular organic compounds of manure with the formation of LVH. Thus, the content of OP in the manure of laying hens after the biofermentation process reached the optimal regime on the first day, compared with baseline, decreased by 12.4%, on the second - by 22.5%, on the third - by 27.4%, on the fourth - by 31.4%, on the fifth - by 29.3%, staying at this level until the 11th day. From the 14th to the 28th day, the content of OP in the biomass of manure in the process of biofermentation under anaerobic conditions varied, but to a much lesser extent. Its further decrease within 47.1% on the 14th day and 55.8% - on the 28th day, compared with the initial value, although it indicates a deepening of the destruction of organic matter, but to a much lesser extent than during the first 9 - 11 days.

In the period from the 35th to the 65th day, the content of OP in the biomass of manure did not change, but decreased compared to its initial level by 2.8 times. Therefore, based on the obtained results, it can be concluded that the highest intensity of biofermentation processes of diluted manure of laying hens under anaerobic conditions is observed in the first 6 - 7 days of the process.

This conclusion is confirmed by the results of research on the formation of various gases in the process of biofermentation of manure and indicators of the degree of its biofermentation and the amount of fermented OR.

During this period, there is an intense release of carbon dioxide. Thus, on the third day of the experiment, its content in biomass reaches 78 - 80% of the total amount of biogas. On the sixth day of fermentation the ratio of carbon dioxide and methane is 1: 1, but on day 7-8 the intensity of methane formation in biomass significantly exceeds the process of carbon dioxide evolution and on the tenth day the ratio of these gases in biomass is - 7: 3. day, the intensity of gas formation in the reactor decreases, and the composition of biogas is characterized by the ratio CH_4: CO_2 = 6: 4.

It is established that the process of biofermentation of organic matter in chicken manure is almost completed on the 46th day, as evidenced by a decrease in biogas 45-65 ml / day and for 20 days did not change.

It was found that the amount of fermented manure in the process of its biofermentation for 65 days varied significantly, but without a certain pattern. The largest amount of fermented OP manure of laying hens under anaerobic fermentation conditions is observed during the first 4 days of the process, then it decreases slightly, gradually increasing on the 7th and especially on the 9th and 14th day. Subsequently, from the 14th to the 21st day, the amount of fermented OP manure decreases slightly compared to the previous period, and then decreases sharply from the 23rd to the 60th day (Table 6).

The obtained results on the amount of fermented OP manure of laying hens are closely correlated with its total content and degree of biodegradation.

Decreases in the organic matter content of biomass during fermentation are closely related to the conversion of individual components of manure - carbohydrates, fats and proteins. Moreover, in the process of long-term biofermentation, this pattern changes.

Of particular interest were studies to study the carbon content in the biomass of laying hen manure in the process of biofermentation under anaerobic conditions. This indicator primarily characterizes not only the intensity of conversion of organic matter, but also the formation of carbon dioxide. The decrease in carbon content in biomass in the first 6 days of its fermentation by 9.4 g/kg, or 36.0% compared with similar data of raw materials.

Table 6

Degree of destruction of organic matter of manure of laying hens at different term of biofermentation (anaerobic conditions), M ± m, n = 3

Fermentation period, days	Indicators		
	OR, g / l	Degree of destruction of OR, %	Number of fermented OR, g / l • day
Raw materials	67,9 ± 0,05	-	-
1	59,5 ± 0,25	12,37± 0,15	8,4 ± 0,34
2	52,6 ± 0,44	22,53 ± 0,25	6,9 ± 0,25
3	49,3 ± 0,31	27,39 ± 0,18	3,3 ± 0,14
5	47,7 ± 0,25	29,8 ± 0,15	-
9	40,4 ± 0,5	40,05 ± 0,28	4,4 ± 0,15
14	35,9 ± 0,87	47,13 ± 0,53	6,9 ± 0,28
21	29,2 ± 0,13	56,99 ± 0,18	4,5 ± 0,15
28	30,0 ± 0,15	55,81 ± 1,2	-
35	25,9 ± 0,13	61,8 ± 0,94	0,41 ± 0,02
40	24,8 ± 0,13	63,47 ± 0,15	1,1 ± 0,1
60	23,8 ± 0,25	64,9 ± 0,25	0,1 ± 0,01
65	24,2 ± 0,25	64,35 ± 1,25	-

In direct dependence on the content of the main components of biomass formed from the manure of laying hens, there was also the content of LHL - the main intermediate product of anaerobic fermentation of organic matter. Thus, on the first day the level of LHL in biomass, compared to their initial level, increased 1.3 times, on the 2nd - 2.5 times, on the 3rd - 3 times, on the 4th, on 5th and 6th - 3.6 times. That is, the highest intensity of LVL formation in the process of biofermentation of laying hen manure was observed in the first 3-4 days, and then was at this level for another 2-3 days and began to decline sharply in the next period of the biofermentation process.

Thus, already on the 7th day of fermentation the content of LH in biomass decreased 1.3 times, on the 9th - 2.2 times, on the 14th - 2.4 times, on the 17th - 3 times, 4 times, on the 21st - 6.5 times and on the 23rd - 18.9 times compared to similar indicators on the 6th day, when this indicator had the highest value. As can be seen from Table 3.58, the pH of biomass by anaerobic biofermentation of manure was closely correlated with the content of LH in the mixture. In the first 6 days of the process, the pH of the mixture shifted from 7.6 to 7.2.

In parallel with a significant decrease in the content of LH in the biomass during anaerobic biofermentation from the 7th to the 28th day, a decrease in the content of proteins, fats, carbohydrates and carbon was registered. Thus, during this period of biofermentation, the fat content in biomass under anaerobic conditions decreased by

2.5 times, and these changes occurred in two periods. The first period was observed from the 7th to the 17th day, and the second - from the 21st to the 28th day, remaining virtually unchanged until the end of the biofermentation period (65th day).

A slightly different pattern was observed with respect to the protein content in the mixture during its long-term biofermentation under anaerobic conditions. In the period from 7 to 28 days, the protein content in the mixture decreased 1.4 times, and then on the 40th day - 2.3 times, on the 50th - 2.9 times, on the 60th - 3.5 times compared to the original data.

Similar changes have been registered in the content of carbohydrates and carbon in the biomass from the manure of laying hens in the process of its biofermentation. Like the lipid content, the level of carbohydrates in the biomass of manure from 7 to 28 days decreased by 42.7%, and then until the end of the biofermentation process remained unchanged. This indicates the completion of the process of breaking down carbohydrates at earlier stages under the action of microorganisms.

The carbon content in the dynamics of the process of biofermentation of manure changed in a similar way, because it largely depended on the amount of carbohydrates and fats in the biomass. Thus, in the period from 7 to 28 days, the carbon content in the fermentation mixture decreased by 1.5 times, and then until the 65th day did not undergo special changes.

A significant decrease in the intensity of the conversion of organic matter in the manure of laying hens in the process of biofermentation was accompanied not only by a decrease in the content of LHL, but also contributed to a shift in the pH of biomass towards alkaline values. It is shown that from the 7th to the 28th day the pH of the mixture in the bioenzymeter gradually increased from 7.4 to 8.7. Moreover, the increase of this indicator towards alkaline values was gradual and correlated with a decrease in the content of LHL and an increase in the ash content of the mixture. However, significant changes in the pH of the mixture adversely affected the activity of saprophytic microorganisms and did not affect Escherichia coli. From the 14th day of the biofermentation process until the end of the experiment, the pH of the biomass did not change.

Thus, on the basis of the conducted researches it is established that the most intensive processes of OP cleavage by anaerobic biofermentation of diluted manure of laying hens take place in the first 5 - 6 days, and the formation of LHC - in the first 2 - 3 days.

To improve the sanitary safety of chicken manure processing products, it is necessary to carry out pre-treatment under conditions of aerobic-thermophilic stabilization of raw materials in the process of biofermentation under anaerobic conditions. This technique, as shown by previous studies, is an effective means of improving the sanitary and hygienic performance of the fermented product.

The decrease in carbon content in biomass during the whole period of fermentation of laying hen biomass is consistent with an increase in the total amount of biogas produced.

The research has established the peculiarities of manure decomposition, the degree of its destruction at different terms of biomass fermentation and the intensity of biogas formation.

The degree of decomposition of the OP manure, which was fermented in a fermenter for 46 days at a temperature of 320C, was 64.8%. The degree of destruction of fats reached 62%, proteins - 57.2%, carbohydrates - 81.2% and carbon 64.4%. However, with such a high degree of fermentation of OP manure, the efficiency of the process as a whole decreases, as this leads to a significant increase in the term of biofermentation. The results of research show that the most intensive process of biofermentation under the mesophilic regime occurs during the first 7-9 days. In the future, up to 20 days, this process slows down.

During 20 days of biofermentation, the degree of decomposition of OP manure reaches 57%, and the fermented biomass has no unpleasant odor, acquires a dark gray color, is well divided into fractions. It was found that the fermentation of 1 g of OP manure makes it possible to obtain 1.1 - 1.2 liters of biogas, which consists of 64% methane and 36% carbon dioxide.

The study of sanitary and hygienic indicators of the original and fermented manure of chickens showed that there is a significant reduction in the total number of heterotrophic microorganisms. Thus, on the 9th day, the NMR of biomass was 11 • 106 cells / g, which was 17% of its initial value. Subsequently, almost until the end of fermentation, a significant decrease in the value of this indicator was not observed. Thus, the SMC on the 17th day was equal to 9 • 106, and on the 40th - 6 • 106 cells / h. The number of anaerobic microorganisms increased from 11 • 102 to 13 • 104 cells / l. At the same time, the number of Escherichia coli bacteria, which is an indicator of the sanitary condition of biomass, did not change. The coli-titer of biomass ranged from 10-4 to 10-3, as in the raw material.

It was found that the specific yield of biogas from 1 m3 of fermenter capacity ranged from 0.7 to 1.2 m^3 per day, increasing proportionally with increasing loading dose based on organic matter. In this case, the specific output of biogas from the fermenter in terms of organic matter was inversely proportional to the volumetric dose of the plant.

As the volume load of the bioenzyme increases, the degree of destruction of organic matter decreases. At a constant dose of loading the fermenter on the organic matter, the degree of its destruction varies according to the humidity of the original manure.

Thus, the increase in biomass humidity from 88% to 91% and even up to 94% leads to a decrease in the degree of destruction of organic matter by 47%, 42.8% and 40.31%, respectively. Studies have also shown that the specific yield of biogas from biomass at a humidity of 88% for 60 days, after the process went to a stable mode with a volume load of 2.5% did not change and ranged from 1.99 to 2.17 liters per day (Table 7). However, with a reduction in reactor capacity from 2.5 to 2.1%, the specific biogas yield decreased by an average of 12.4% in all study periods.

As in the first case, no significant changes were registered in the dynamics of research in the study of the specific volume of biogas extracted from the fermenter at its volume loading at the level of 2.1%. Compared with the specific yield of biogas at a volumetric load of the fermenter of 2.5%, this figure for the first 10 days at a load of 2.1% decreased by 11.1%, for 20 - by 11.7, for 30 - by 22.6, for 40 - by 11.9, for 50 - by 13.5, for 60 - by 7.0%, and on average for the whole period - by 12.4%. The specific yield of biogas from the fermenter at its volumetric load at the level of 1.6% decreased by an average of 21.8% compared to similar data when loading the fermenter within 2.1% and 31.6% compared with the loading by 2, 5%. Moreover, a similar pattern of reducing the biogas yield with a decrease in the volume load of the reactor was observed throughout the study period, ie for 60 days. Thus, the specific yield of biogas on the 10th day of fermentation when loading the bioreactor 1.6%, compared with similar data at 2.1%, decreased by 22.6%, on the 20th - by 21.8, by 30- that and the 40th - by 20.8, on the 50th - by 15.5 and on the 60th - by 27.8%. Comparing the data obtained when loading the bioreactor at the level of 1.6% with similar results in the volume of 2.5%, it should be noted that on the 10th day this difference was 31.1%, on the 20th - 31.0, on the 30th - 38.7, and on the 40th - 30.2, on the 50th - 26.5 and on the 60th - 32.9%.

Table 7

Specific yield of biogas in the process of fermentation of manure of laying hens at different loads of the fermenter (manure humidity 88%), l / day, M ± m, n = 10

Process time, days	Volume load, %		
	2,5	2,1	1,6
10	1,99 ± 0,05	1,77 ± 0,03*	1,37 ± 0,03*
20	2,13 ± 0,04	1,88 ± 0,08*	1,47 ± 0,04*
40	2,02 ± 0,01	1,78 ± 0,03*	1,41 ± 0,02*
60	2,13 ± 0,02	1,98 ± 0,02*	1,43 ±0,01*
In the middle	2,09 ± 0,03	1,83 ± 0,03*	1,43 ± 0,04*

** - p ≤ 0.05 compared to the volumetric load of the fermenter 2.5%.*

Therefore, based on the obtained results, it can be concluded that reducing the volume load of the bioreactor with diluted manure of laying hens reduces the specific yield of biogas. Moreover, this pattern is seen in different indicators of manure humidity.

A significant decrease in the volume of biogas from the fermenter was registered at a moisture content of 91% (Table 8).

Table 8

Specific yield of biogas in the process of fermentation of manure of laying hens at different volumetric loads of the fermenter (humidity 91%), l / day, M ± m, n = 10

Process time, days	Volume load, %		
	3,3	2,8	2,2
10	1,99 ± 0,05	1,66 ± 0,06*	1,38 ± 0,05*
20	2,19 ± 0,03	1,76 ± 0,06*	1,48 ± 0,03*
40	2,07 ± 0,05	1,67 ± 0,08*	1,42 ± 0,04*
60	2,23 ± 0,03	1,92 ±0,03*	1,65 ± 0,04*
In the middle	2,1 ± 0,03	1,72 ± 0,06*	1,46 ± 0,05*

** - p ≤ 0.05 compared to the volumetric load of the fermenter 3.3%.*

As established by previous studies, the specific output of biogas from the reactor in the dynamics for 60 days at humidity 91% of laying hen droppings did not change. However, this figure largely depended on the volumetric loading of the bioreactor with the diluted manure of the laying hens. Thus, with a decrease in the volume load of the biofermenter from 3.3 to 2.8%, the biogas yield for the first 10 days decreased by 16.6%, for 20 - by 19.6, for 30 - by 21.9, for 40 - by 19.3, for 50 - by 19.1, for 60 - by 13.9% and on average for the whole period - by 18.1% (see Table 8).

With a reactor volumetric load of 2.2%, the biogas yield decreased by an average of 30.5% over the entire period compared to similar data with a volumetric load of 3.3%. Comparing the results of studies of the specific yield of biogas at a volume load of 2.2% with data at a load level of 3.3%, it should be noted that the intensity of the biofermentation of waste in the first option compared to the second, as evidenced by a significant reduction in anaerobic digestion products laying hen. So, on the 10th day this indicator decreased by 30.6%, on the 20th - by 32.4, on the 30th - by 31.3, on the 40th - by 31.4, on the 50th - by 30.4 and on the 60th - by 26.0%.

Of particular practical interest are the data on the output of biogas from the fermenter when the humidity of the manure increases to 94% and at a volume load of 5.0; 4.1 and 3.3%. Studies have shown that despite the significant difference in the volumetric load of the biofermenter, even at different manure humidity, a probable difference in biogas yield within 60 days of the biofermentation process has not been established.

As in previous versions of the experiment, biogas yield from the fermenter at a manure humidity of 94% with a decrease in volume load from 5.0 to 4.1% decreased by an average of 16.1%, and from 5.0 to 3.3% - by 28.1%.

The obtained data reproduce the similar nature of changes in the specific yield of biogas from the fermenter and at certain intervals of the biofermentation process, ie during 60 days of the experiment (Table 9). reducing the volume load of the bioreactor from 5.0 to 4.1% decreased by 16.1%, on the 20th - by 17.7, on the 30th - by 13.7, on the 40th - by 14, 6, on the 50th - by 19.6 and on the 60th - by 10.3%.

Table 9

Specific yield of biogas during fermentation of laying hen manure at different volumetric loading of the fermenter (humidity 94%), l / day, M ± m, n = 10

Process time, days	Volume load, %		
	5,0	4,1	3,3
10	1,86 ± 0,08	1,56 ± 0,07*	1,35 ± 0,05*
20	2,03 ± 0,05	1,67 ± 0,02*	1,46 ± 0,04*
40	2,05 ± 0,03	1,75 ± 0,01*	1,41 ± 0,03*
60	2,04 ± 0,02	1,83 ± 0,03*	1,59 ± 0,02*
In the middle	1,99 ± 0,06	1,67 ± 0,03*	1,43 ±0,05*

** - $p \leq 0.05$ compared to the volume load of the fermenter 5.0%.*

A further decrease in the volume load of the bioreactor from 4.1 to 3.3% led to an even greater decrease in the volume specific yield of biogas from the manure of laying hens. Compared with the volume load of 4.1%, the specific yield of biogas on the 10th day with a volume load of 3.3% decreased by 13.4%, on the 20th - by 12.6, on the 30th - by 15.2, on the 40th - by 19.4, on the 50th and on the 60th - by 13.1%.

The decrease in the volume load of the bioreactor from 5.0% to 3.3% caused a decrease in the specific yield of biogas from the manure of laying hens on the 10th day by 27.4%, on the 20th - by 28.1, on the 30th that - by 26.9, on the 40th - by 31.2, on the 50th - by 30.3 and on the 60th - by 22.1%.

Therefore, based on the research to conclude that the conversion of organic matter in the manure of laying hens largely depends on anaerobic conditions and volumetric loading of the fermenter, to a lesser extent changes during the biofermentation process, does not depend on biomass moisture and organic matter content in the fermentation broth.

The changes in the content and degree of destruction of such components of manure as fiber, fat-like substances and proteins are identical to the changes in dry ashless matter and are closely related to the general patterns of destruction of organic components of manure.

The process of biofermentation of the mixture under anaerobic conditions is not inhibited by the concentration of the substrate despite the change in humidity from 88 to 94%, and the yield of biogas and the degree of destruction of organic matter depend on the rate of dilution of biomass by solids.

Conclusions.

On the basis of complex researches of sanitary and hygienic indicators of fecal masses of cows, pigs and manure of laying hens, liquid manure and sewage of the enterprises with intensive technologies of production of livestock products the expediency of application of biological methods of their processing is proved.

1. Manure effluents of livestock enterprises with intensive production technologies are characterized by significant bacterial contamination, high colitis, enterococcal titer, moisture, high content of OP, crude protein, crude fiber, calcium and phosphorus, have low density and viscosity, contain antibacterial residues , anthelmintics and hormones.

2. The use of hydraulic manure removal methods when keeping pigs leads to the formation of a significant amount of manure effluents with high humidity, low CP content, high levels of total and ammonium nitrogen, ash and a significant amount of contamination by HSC and BSC5.

3. Treatment of liquid manure of the pig complex on arc sieves does not provide complete removal of contaminants, its combination with settling of the liquid fraction in the tanks-settlers is a more effective way of cleaning liquid waste, as evidenced by a decrease in LVD by 1.8, CL - by 2.1, N total. - y 1,3, Пзаг. - 1.7 times, HSC - 2.7 and BSC5 - 2.0 times.

4. Purification of manure effluents of the pig complex with the help of three-section aeration tank without and with recirculation of activated sludge increases the degree of removal of contaminants to 81.4 and 85.3% by OP, reduces ammonium and total nitrogen and total phosphorus, increases coli-titer and enterococcal titer the total microbial amount of wastewater, and in the biomass of activated sludge - the number of uro- and cellulosolytic and denitrifying bacteria, reduces the number of nitrifying, ammonifying bacteria and anaerobes.

Offers to production.

Production is offered a complex technology of processing manure effluents from livestock production, which includes preparation of waste for biofermentation by fractionation, aerobic-thermophilic stabilization of biomass, anaerobic fermentation of products, processing of solid fraction into compost and humic substances, the use of liquids.

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