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Ways to Intensify the Process of Anaerobic Digestion of Poultry Manure in a Bioreactor.

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ABSTRACT

This article discusses the possibility of increasing the productivity of equipment for processing of manure and improve the quality of the useful products - organic fertilizers. Discusses how to optimize the process of anaerobic digestion of poultry manure in a bioreactor. The experimental data of influence of loading dose of poultry manure on the biogas yield of thermophilic anaerobic digestion mode. A condition to optimize the process of anaerobic digestion in a bioreactor - the separation of the process of anaerobic digestion in the two modes. It revealed a way that promotes intensification - an initial stage of fermentation in a separate container - storage. This article will be useful to scientists engaged in the processing of organic waste anaerobic digestion.

Keywords: anaerobic digestion, thermophilic regime, poultry manure, bioreactor, dung-yard.

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INTRODUCTION

Anaerobic digestion of poultry manure, is one of the most effective ways of poultry waste, allowing not only to disinfect them from pathogenic microflora and get a renewable source of energy - biogas, but also to prepare them for further processing to produce useful products (granular organic fertilizers, biologically active substances and protein and vitamin supplements) [1, 15]. Important in terms of the efficiency of the process of processing of poultry manure and improving the equipment is to accelerate the process of anaerobic digestion. This will enhance productivity without increasing the working volume bioreactors.

MATERIALS AND METHODS

For research were use poultry manure, manure from cattle and hog-raising fattening complex (HFC) with agricultural enterprises of Stavropol Territory.

Chemical analysis of the composition of of poultry manure in comparison with other types of dung (cattle and pigs) is presented in table 1. Poultry manure significantly different nutrient content, as well as indicators such as the VFA (volatile fatty acids), N_{am} (ammonia nitrogen), of H_2S (hydrogen sulphide). They are several times higher than the maximum permissible concentrations of these substances for the conduct of the process of anaerobic digestion [1].

Table 1: Comparative characteristics of poultry manure, dung of cattle and pigs

Indicators	Poultry manure	Dung		Valid values
		Cattles	Pigs	
Humidity, %	89-91	93-96	95-98	92-97
N_{tot}, g/l	5-8	1-3	2-5	-
N_{am}, g/l	1-2	0,2-0,3	0,1-0,3	0,05-1,2
P_2O_5, g/l	4-6	1-3	1,5-3,5	-
H_2S, mg/l	170-280	-	-	0,1-0,2
VFA, mg·eq/l	75-90	-	-	10-50

Since the concentration of N_{am} and H_2S exceeding limits and have a negative impact on the biocenosis of the bioreactor, so the technological parameters of the fermentation of poultry manure will also differ from similar parameters of other animal waste. In connection with this study were identified objectives:

- Determine the optimum process parameters of the process of anaerobic digestion of poultry manure;
- Identify ways to intensify the process of digestion of of poultry manure in a bioreactor.

In thermophilic mode (51-53 °C) [2, 14] has been investigated as a fermentation temperature, which characterizes the higher intensity in comparison with others. Loading doses are 5, 8, 11, 14 and 17%. (0,3; 0,48; 0,66; 0,84 and 1,02 tonn). Poultry manure charged into the bioreactor with preheating and maintained for 72 hours. Stirring of poultry manure was carried out by a mechanical device in the automatic mode, four times a day in the bioreactor and in the tank of thermostatic storage. In the tank-storage during aging developed acid-forming type of microflora. From of poultry manure releases carbon dioxide (CO_2) in large volumes. Carbon dioxide and biogas (CH_4 + CO_2) was measured in a wet type gas holders. As the end of the heating and holding poultry manure reloaded into the main bioreactor using a pump impeller. The bioreactor is operated continuously.

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RESULTS AND DISCUSSION

The results studies are presented in Table 2. The analysis of data showed that the depth of the decay of organic matter and the amount of generated biogas depend on the duration of the fermentation feedstock and loading dose.

Table 2: Results of study mode thermophilic digestion of poultry manure

Indicators	Doses making of poultry manure in a bioreactor, %					
	parent	5	8	11	14	17
Humidity, %	88-91	90-92	91-93	91-93	91-93	90-93
Ash content, %	21-23	28-31	29-32	29-31	29-31	28-32
VFA, mg·eq/l	80-100	60-80	70-90	70-80	80-90	70-80
TA, mg·eq/l	170-220	180-230	200-230	200-220	200-220	200-230
N_{am}, g/l	1-2	2-3	2-3	2-3	2-3	2-3
Yield of gas, l/l	-	24-26	25-28	26-30	24-27	18-22

Loss biogenic elements in any of the modes were observed. This indicates the superiority of the anaerobic digestion process in comparison with other methods of biological treatment of poultry manure. This high concentration in the original poultry manure N_{am} and H_2S does not have inhibitory effect on the biocoenosis of the bioreactor, which can be explained by the presence in the poultry litter large amounts of potassium and calcium, which are antagonistic compounds of nitrogen and hydrogen sulfide [3, 13].

Figure 1 shows the dependence amount released of biogas from loading dose or duration of fermentation. The graph is divided into sections. Analysis AB portion showed that the biochemical processes take place in the dynamic equilibrium conditions (balance between the activity of microorganisms and the concentration of the feedstock, between the growth of the bacterial mass, and removing it from the fermented mass).

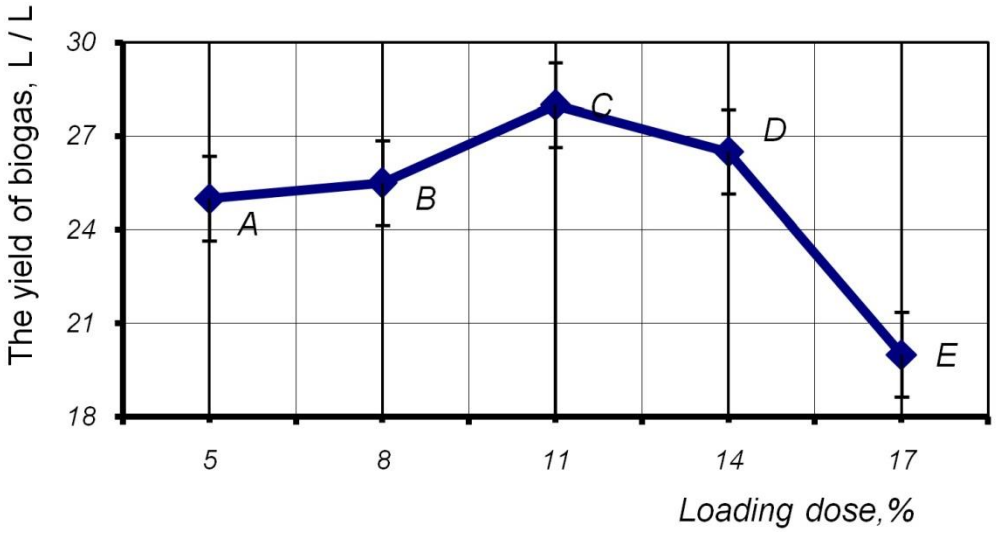

Figure 1: Influence of the dose of fresh manure loading on the biogas yield of thermophilic anaerobic digestion mode

Increasing the loading dose of up to 8% does not stop the process of decomposition of organic matter and beneficial impact on it. Thanks to a considerable length of fermentation bioreactors biocenose successfully developed, increasing the concentration of microbial biomass. This allows you to keep the rate of organic matter decomposition at the same level. Thus, the loading dose regimens with 8% or less can be attributed to a stable regime digestion of poultry manure.

With increasing doses of loading up to 11% (segment BC) activity of anaerobic microorganisms increases. Also increases the biogas yield (by 28 l/l), increases the rate of decay of organic matter of poultry manure. It can be concluded that there is an increase in the bioreactor more number microorganisms and must be greater amount of feedstock. It can be argued that the fermentation of poultry manure mode is stable, and the resulting data are in good agreement with the results of many researchers [4, 7, 12].

The increase of fresh raw materials entering the bioreactor in the amount of loading dose 14% (CD sections in Figure 1) slightly reduces the rate of digestion process. Yield of biogas Output declined to 25,5 l/l. This is due to the increase in the load of organic matter on the active part of the microorganisms. However, this mode can also recommend loading for bioreactors, but to stabilize the fermentation regime the daily dose is recommended to serve by portions load that will enable more active biocenosis bioreactor to process organic matter.

Further increases of fresh manure up to 17% already significantly reduces reaction rate. Biogas yield was 20 l/l. This is due to a greater load of organic matter on the active part of the microorganisms. Also in this case there is an opportunity to «overshoot» fresh manure in the bioreactor that makes processed substrate dangerous to use it in the plant. Also, the processing period is increased two days, which reduces the productivity of the bioreactor doubled. Consequently, the operation of bioreactors with a loading dose is not recommended.

We have also studied the work of reactors with turn sour feedstock. Quality indicators such raw materials are shown in Table 3. For the storage time in the poultry manure there were changes of chemical properties, which cause instability derived output parameters. Thus, it is possible to recommend a raw material which was stored is not more than 4 days (pH is 7.1-7.6) for bioreactors. However, the operation of the bioreactor with the use of poultry manure with a shelf life of more than 16 days passed without any problems.

Table 3: Change the quality of the original of poultry manure during storage

ndicators	pH	N_{am}	VFA, mg·eq/l
Fresh poultry manure	7,6	1,2	70
Storage: 1 day	7,3	1,8	117
4 days	7,1	2,6	144
8 days	6,8	3,4	163
12 days	6,6	4,0	182
16 days	6,4	4,3	218

When conducting research we studied indicators characterizing the activity of biocoenosis, its ability to ferment difficult oxidized organic matter, limiting factors affecting the process of decomposition of organic matter. It was found that none of the indicators from Table 3, taken separately, is not exhaustive carries information and can not serve as a criterion for the normal operation of the bioreactor. It is necessary to consider any matter as constituting the entire system, in conjunction inhibiting substances and their antagonists, and in accordance with the measures applied in the case of violation of the system equilibrium. For example, VFA concentration itself nothing says, because it's content in the original poultry manure exceeds

ten times traditionally acceptable values. But the ratio of VFA to TA (total alkalinity) can be regarded as an indication of the ratio between acidic and alkaline bacteria stages of anaerobic digestion process, and accordingly adjust the load of organic matter on the bioreactor. It has been found that the optimum ratio is equal to 0,25-0,40. An increase of this ratio leads to acidification of the fermentation process of the mass in the bioreactor and thus reduce the load required dose. The reduction indicates the prevalence of the bacteria in the system alkaline stage, and a possible increase in the load on the bioreactor. In these ratios are all substances included in the system. Search the links between them, it is one of the promising areas of research on ways to manage the process of anaerobic digestion, like bird droppings and other waste.

We have identified two of the most promising ways to intensify the digestion of poultry manure. The first - the separation process of anaerobic digestion in two stages - acid and alkaline, and the implementation of each of them in an independent capacity or cell bioreactor under optimal for each of the stages of conditions. The second - the accumulation of activated sludge in anaerobic bioreactor volume.

Studies have shown that the specific design of bioreactors are required for digestion of poultry manure with high dry matter content, with powerful mixing devices, tailored raw material humidity 80% or less. The use for the fermentation of poultry manure humidity 88-94% of special materials for the accumulation of activated sludge is not possible due to their silting sticky particles [5, 9, 11, 16]. More promising, in our opinion, it is the accumulation of anaerobic bacteria in a bioreactor by recycling parts and prevent washout of bacteria from the bioreactor.

The most simple and, at the same time, is technologically the most complex path of intensification - the separation of the process of anaerobic digestion in the acidic and alkaline stage. Specialists from Finland [6, 8, 10] were designed bioreactors that allow the process of anaerobic digestion stages. In this form of the bioreactor had a horizontally disposed cylindrical container, in which there were several partitions. Raw materials flowed through the walls of the bioreactor in which the fermentation of raw materials was carried out in stages: acid, acetate and the methane phase. However, as shown by further studies, the relationship between the bacteria involved in the anaerobic decomposition of organic matter, which is closely related. Simple mechanical release of acidic digestion phase does not allow to intensify the process.

At the same time, maintaining and preheating the feedstock in a special container (thermostating) under anaerobic conditions, has a positive impact on the reliability and efficiency of the subsequent fermentation process in bioreactor. Therefore, we have also carried out studies on 2-step fermentation. The volume capacity for storage with temperature control was selected based feedstock daily dose loading.

Heating and maintaining the feedstock in the thermophilic mode for 1-3 days loading dose which increased mostly bioreactor operating at T = 51-53 °C, up to 11-14%. Biogas output losses do not exceed 10%. They are explained by the fact that biogas is eye-catching in the first stage was not considered because of the low content of methane. Preferably it contains CO_2 (carbon dioxide). Therefore, we can say that the preliminary storage bird droppings occurs mainly sour fermentation. The source substrate becomes more accessible to its decomposition by bacteria in mainly bioreactor. Most importantly in this method is that it is during the first day of the main part is formed of ammonia and hydrogen sulfide, which reacts with the enzymes of microorganisms of the first stage. Then they fall in the bioreactor in the main biologically bound form. In addition, a positive effect on the methane fermentation process provides that the organic material is decomposed at the first stage of the process and methanogenic bacteria in the second stage receive more simple organic substance.

CONCLUSION

Thus, we have recommended to accelerate the process of anaerobic digestion of poultry manure fermentation of a two-phase, ie, separation in two phases: acidic and alkaline. Wherein the acid phase must be carried out in a separate - capacity with heating for three days. Volume capacity with heating is 11 to 14% by volume in the fermentation bioreactor. Humidity fermented manure is 88-92%, loading dose in the main bioreactor is 15%.

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