New Technologies in the Processing of Agricultural Waste

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Abstract: The article is concerned with the need for the transition of present-day production on the example of agriculture to ecologically closed biological systems with a high level of resource and energy use. It is noted that the possibility of a deep reorganization of business processes in the agricultural sector is due to the ongoing fundamental changes in such areas as telecommunications, information technology, engineering solutions. Modern biotechnologies allow farm animal waste to be used as raw materials for the production of not only organic fertilizers, but also to obtain alternative fuels and feed from them. So, one of the examples of the effective use of organic waste as animal manure is the technology of its anaerobic fermentation with the production of gaseous fuel as biogas. Also, the development of this waste processing technology makes it possible to disinfect waste and obtain high-quality organic fertilizers that are necessary for the development of crop production industries. The regions of the Southern Federal District have great potential for the development of biogas technologies that will not only meet their fuel needs for agricultural machinery and transport, but also provide rural areas with heat and electricity.

1 INTRODUCTION

One of the most important problems of a global nature that require immediate solution is the problem of environmental protection. In accordance with the Federal Laws of the Russian Federation "On Environmental Protection" and "On Production and Consumption Waste", the efficiency of production is assessed taking into account its impact on the environment. This also applies to the agricultural sector of the economy, which has waste-intensive production and its transition to ecologically closed biological systems, with a high level of use of natural resources and energy, can be considered as an important direction in solving this problem.

Agriculture is an industry based on a large variety of rapidly changing conditions and factors, which, in turn, generate a huge amount of information necessary for efficient production and adaptation of agriculture to these and other external changes. To date, the possibility of conducting a deep reorganization of business processes in the agricultural sector of the economy is determined by the cardinal changes taking place in such related fields of activity as telecommunications, information technology, engineering solutions.

2 MATERIALS AND METHODS

In the course of this scientific research in the field of the development of advanced waste treatment technologies in agricultural production, the works of well-known Russian scientists interested in the problems of the development of highly ecological industries were used.

According to Osmonov O.M., the production of biogas during the anaerobic processing of organic agricultural waste, in addition to the energy aspect as the production of gaseous fuel, also has environmental aspects of application - the cessation of deforestation used for fuel, disinfection of waste and agrochemical – the production of organic fertilizers for the growth of soil fertility.

Golubev I.G., Shvanskaya L.Yu., Konovalenko L.Yu. and others note that in recent years, work has been actively carried out in various countries of the world, including Russia, to develop promising and environmentally friendly technologies for preparing manure for use as a raw material for biofuels.

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According to Sidorenko O.D., the technologies under consideration are environmentally friendly, since they allow transferring waste from a dangerous source of pollution into valuable raw materials needed in the production of fertilizers, combustible materials, as well as feed.

When burning biogas, according to the calculations of Zakharchenko A.N., there is a greater heat release than when burning wood waste or manure directly.

According to Kovalev A.A., the most active process of methanogenesis is observed in mesophilic conditions - 35-35 °C or thermophilic - 54-57 °C temperature modes of fermentation.

As Zavarzin G.A. notes, up to several hundred species of microorganisms are involved in the whole complicated process of converting organic substances into methane and carbon dioxide, and bacteria predominate among them.

Currently, according to Varfolomeev S.D., Moiseeva I.I., Myasoedova B.F., technologization of the use of renewable energy sources is taking place in various directions, including direct conversion of solar energy into electricity.

Pantskhava E.S.Pozharnov V.A., Shipilov M.M. believe that the process of bioenergy development, which relies on the conversion of biomass into combustible gas and its further use, corresponds to the infrastructure of modern traditional energy.

As noted by Khabibulin R.E., Yezhkova G.O., Reshetnik O.A., Russian regions differ in different potential of biomass, which can be used in the energy sector.

This work was carried out using such scientific methods as statistical analysis, comparative analysis, functional analysis, positive and normative analysis. The scientific research was carried out in accordance with the problem-chronological principle, the principles of consistency and scientific objectivity.

3 RESULTS AND DISCUSSION

The intensification of agricultural sectors in the Russian economy in accordance with the program "Accelerated development of animal husbandry" within the framework of the priority national project "Development of Agriculture" is aimed at a high level of concentration of farm animals and poultry, their maintenance using innovative technologies, reducing the volume of straw litter used, ensuring the necessary changes in the characteristics of organic waste during their disposal in new ways. The presence of untreated manure effluents near agricultural enterprises, as well as their direct introduction into the soil, can lead to various infections, biological and chemical contamination of adjacent territories, groundwater, and the air basin. Manure, animal wastes and manure effluents are not only large tonnage, but also dangerous types of agricultural waste, and the need for their neutralization becomes an important task. At the same time, farm animal waste, thanks to modern biotechnologies, makes it possible to use them as raw materials in the production of not only organic fertilizers, but also alternative energy carriers and feed.

According to various estimates, the annual amount of organic waste from agricultural production is 630-650 million tons, and the largest part of them (56%) is formed in livestock and poultry farms of various forms of ownership (Golubev, 2011). The peculiarity of animal husbandry and poultry waste is that they contain in their composition a significant number of pathogenic microorganisms - agents of infections. With large volumes of their formation, untimely collection and removal of waste to places of disposal and neutralization pose a serious threat to the environment, polluting soil, groundwater, rivers and reservoirs. According to some data, in the Russian Federation, the volume of organic waste generated on livestock farms annually amounts to 350 million tons of cattle manure, 32 million tons of pig manure and 15 million tons of poultry manure (Sidorenko, 2018).

In this regard, it is worth noting that livestock complexes as major pollutants negatively affect the environment, while agricultural land needs manure, which is a very valuable fertilizer of organic origin. So, during the year, arable lands in the Non-Chernozem zone of Russia lose organic matter in the amount of 0.5-0.7 tons per 1 hectare, 1.0-1.5 tons per 1 hectare - in the Central Chernozem region, 0.3-0.7 – in Western and Eastern Siberia, in the Far East losses reach 0.6-1.0 tons per 1 hectare. Arable lands in the country require the annual application of 840 million tons of organic fertilizers to restore soil fertility, which on average is about 6 tons per 1 hectare of land (Sidorenko, 2018).

For these reasons, the main direction of using farm animal waste in the form of manure and litter is their use as an organic fertilizer to increase the fertility of agricultural soils, since a large amount of nutrients is present in the composition of manure. The main types of organic farm animal waste are the results of the vital activity of animals and birds grown for the production of agricultural products in the form of manure and litter.

Considering animal manure as an organic fertilizer, it is always taken into account that fresh, i.e.

untreated manure contains a large number of pathogenic microorganisms (pathogens of infectious and invasive diseases of animals and humans) and weed seeds that reduce the quantity and quality of crop production. So, for one ton of fresh manure, on average, there may be from 500 thousand to 5 million different weed seeds, and therefore, when using such manure as fertilizers, with the calculation of 50 tons on the soil of the earth with a size of 1 hectare, 25-250 million weed seeds are also entered. In the future, when implementing such measures to get rid of weeds, it often becomes necessary to resort to toxic chemicals that are dangerous for both humans and animals (Osmonov, 2006).

Thus, the direct use of fresh manure as fertilizer without prior preparation (disinfection) is unacceptable, therefore, aerobic and anaerobic technologies are used to prepare manure for use. The utilization of organic waste from animal husbandry and poultry farming should provide for their effective disinfection, the use of energy and agrochemical potential of organic waste from agricultural production.

The most rational way to use organic waste from agricultural production in the form of animal manure is the technology of their anaerobic fermentation to produce gaseous fuel - biogas. In addition to the energy aspect of obtaining fuel, such aspects as environmental (waste disinfection) and agrochemical (obtaining high-quality organic fertilizers) are of great importance in the use of this waste processing technology.

The energy effect that occurs when using the technology of anaerobic fermentation of organic waste as animal manure is due to the fact that, due to incomplete absorption by animals from the plants they eat of the solar energy generated as a result of photosynthesis, more than half of it is deposited in manure. So, for example, 26% of the energy received by the cow's body from plant feeds in the process of complex biological processes is spent on its vital activity, 16% goes into dairy products, and up to 58% of all the energy noted goes into manure (Osmonov, 2011).

Thus, it can be argued that animal manure is a very valuable source of renewable energy. Also, in addition to biogas, during anaerobic fermentation during the processing of animal manure, the germination of weed seeds is lost, various pathogens and helminths are destroyed (Zakharchenko, 2005; Osmonov, 2006; Osmonov, 2011). Biogas obtained by anaerobic fermentation of organic waste consists mainly of 50-70% of a mixture of methane and 20-50% of carbon dioxide, may also contain a small amount of hydrogen sulfide - 10%, from 0 to 10% of hydrogen, 2-4% of water, up to 1% of nitrogen, even less oxygen, ammonia and other various components. Thus, the methane content in biogas is determined by its rather high value of the heat of combustion.

Biogas from liquid manure, due to anaerobic fermentation obtained from 100 heads of cattle, can provide thermal energy, which gives 0.7 tons of fuel oil, and electricity from biogas from the manure of one cow per year, presented as fuel for a thermal power plant, can be obtained up to about 900 kWh (Osmonov, 2011).

The process of anaerobic fermentation of organic animal waste is divided into two stages: the stage of maturation of methane biocenosis and the stage of methane formation. At the first stage, complex organic compounds such as fats, proteins, fiber, etc. are decomposed by various acid-forming microorganisms into such simpler primary fermentation products as lower alcohols, volatile fatty acids, carbon monoxide, acetic and formic acids, etc., presented as food sources for the second methanogenic group of bacteria carrying out the second stage, in which gases such as carbon dioxide and methane are produced (Kovalev, 1998).

The main bacteria involved in the formation of biogas in the process of anaerobic methane fermentation are methanogenic bacteria. During anaerobic fermentation, the intensity of the gas release process is determined by the conditions necessary for the vital activity of methanogenic bacteria. Methanogenic and acidogenic bacteria present during anaerobic fermentation are found in the digestive system of herbivorous animals (Zavarzin, 1986).

Thus, it is sufficient to provide them with the necessary conditions for the implementation of anaerobic methane fermentation, which consist in the fact that:

- firstly, it is necessary to achieve a complete absence of oxygen in the air in the fermentation liquid, i.e. a strictly anaerobic environment is necessary;
- secondly, we need a certain concentration of the substrate used, i.e. nutrients in the fermentation liquid and the possibility of achieving mass transfer;
- thirdly, during the fermentation process, it is necessary to maintain a constant temperature regime;
- fourth, it is also necessary to ensure the pH regime in the fermentation liquid;
- fifth, the amount of inhibitor substances in the fermented substrate should be low or absent

altogether.

When using special biogas plants with anaerobic fermentation, it is possible to achieve a strictly anaerobic environment.

During anaerobic fermentation, with the use of a biogas plant, animal manure turns into organic biofertilizer of high quality, exceeding in its fertilizing value fresh animal excrement, due to the fact that during fermentation, nutrients for plants become more accessible. In a biogas reactor, as a result of anaerobic fermentation, no more carbon is lost compared to other methods of manure stabilization, such as manure storage and composting. Also, phosphorus and potassium are almost completely preserved in fermented manure during its anaerobic processing using a biogas reactor. This is evidenced by the data obtained during periodic quality control of fermented manure on such main agronomic indicators as nitrogen, potassium, phosphorus, etc.

Ensuring the necessary concentration during fermentation of the substrate occurs by adding water to animal manure, which is prepared for methane fermentation, which leads to an increase in its initial humidity. For methane fermentation, manure from 70 to 90% of the moisture content is generally suitable, while humidity in the range from 88 to 92% is considered optimal, at which the process of the most intense gas release occurs during anaerobic fermentation.

There are three characteristic temperature regimes of fermentation, which are preferable for certain types of methane-forming microorganisms:

- psychrophilic temperature regime - 8–20 °C;
- mesophilic temperature regime - 25–40 °C;
- thermophilic temperature regime - 45–65 °C.

In fresh manure, during anaerobic fermentation of farm animal waste using a biogas reactor, weed seeds, which are rich in manure, lose their germination, and crop yields also increase when the fermented mass of manure is applied as an organic fertilizer. All this provides producers with the opportunity to grow an environmentally friendly product without the use of various types of pesticides harmful to both animals and humans for weed control. Conducting anaerobic processing of animal waste, in which pathogenic microorganisms that are the causative agents of many infectious diseases are destroyed, helps to reduce bacterial contamination of both soils and groundwater. Humus materials, which are present during the fermentation of manure, lead to an improvement in the physical qualities of the soil, and the level of assimilation of nutrients by plants also increases due to the fact that minerals for the activity of soil microorganisms are a source for their energy and nutrition.

Biofertilizers, thus, contribute to the preservation in the feedstock in an easily digestible form of all the nitrogen and other nutrients contained in it, so necessary for plants. Compared with manure that has rotted under natural conditions, most of the helminth eggs, weed seeds, and pathogenic microorganisms present in untreated manure die in biofertilizers obtained by fermenting manure using biogas reactors. Also, if mineral fertilizers are rich in nitrogen, phosphorus and potassium, then there are no chemical substitutes for protein, cellulose, lignin contained in biofertilizers obtained in biogas reactors during the anaerobic fermentation of fresh manure.

To date, Russia has a high resource potential for the production of fuel from biomass. In the country, the annual volume of organic waste reaches 750 million tons, of which 150 million tons are livestock waste, in crop production their number reaches 100 million tons (Varfolomeev, 2009; Pantskhava, 2007). The results of the assessment of the prospects for the development of renewable energy production from organic waste in the country indicate that the volume of biogas from 624 million tons organic waste can reach up to 31-75 billion m^3, from which, in turn, it is possible to simultaneously receive 150 billion kWh of electricity and 150 Gcal of thermal energy, or replace gasoline in the amount of 37 million tons when it is used in transport (Pantskhava, 2007).

Due to differences in climatic conditions and the level of development of agricultural and industrial sectors, Russian regions have different biomass potential suitable for use in the energy sector, but despite this, up to 1 billion tons of organic fertilizers are formed in all variants (Khabibullin, 2016). The Southern Federal District is among the promising ones regarding the development of biogas technologies. According to calculations, this region accounts for up to 49% of the total potential of the country, meaning that it is possible to produce from agricultural waste from 24 to 28 billion m^3 of biogas. The demand of the rural population of the region (9.7 million people) for electricity reaches 14 billion kWh per year, which will require up to 6 billion m^3 of biogas or 20-25% of the total volume of its production, 3.4 million tons are annual gasoline costs, 4.3 million tons are diesel fuel, and this is equivalent to 15.4 billion m^3 of biogas. Consequently, the district can meet its fuel needs for agricultural machinery and transport only with its own biogas, and rural territories can meet their needs for thermal and electric energy (Pantskhava, 2007).

4 CONCLUSIONS

Biogas production in the world is increasing and expanding its borders, covering more and more countries in this process. In terms of the number of operating biogas power plants, China and India are the leaders. African states accounted for 2 million biogas plants, which supplied about 10 million people with gas, while the biogas market of this continent reached 20 million installations of potential capacity. More than 150 thousand biogas plants were used in Nepal, their number in Vietnam was 25 thousand, and there are plans for the future of these countries to put these plants into operation more and more (Khabibullin, 2016).

In general, the windows of opportunity for the country consist in greater participation and leadership in various integration associations, establishing constructive and mutually beneficial cooperation with new players in the global geopolitical space, active participation in the reform of the global governance system and international economic and trade institutions, including to strengthen their positions in new international markets.

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