Proposals for the Modernization of Biogas Plants so as to Build Their Profitability

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December 5, 2019

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Abstract: In the digester, it is necessary to organize periodic mixing of the substrate, which ensures the effective and stable operation of the BSU. The purpose of mixing is the release of biogas formed, mixing of fresh substrate and bacteria (grafting), preventing the formation of crust and sediment, preventing the formation of areas of different temperatures inside the digester, ensuring uniform distribution of the bacterial population, preventing the formation of voids and clusters that reduce the effective area of the digester. When choosing a mixing method, it should be taken into account that the fermentation process is a vital process of symbiosis of various bacterial strains, and if this community is destroyed, the fermentation process will be unproductive until a new bacterial community is formed. Therefore, too frequent or prolonged mixing is harmful. Slow mixing of the substrate every 4-6 hours is recommended. Optimal mixing of the feed increases biogas yield up to 50%. A comparative analysis of the types of costs associated with the construction of the biogas plant will be carried out on the digesters of these biogas plants and facilities and equipment (devices) directly associated with them.

Keywords: Bio gas, design process of recreation, thermal effect, renewable energy.

Introduction:

With the constant increase in prices for major energy carriers, as well as the depletion of hydrocarbon resources of the Earth, an increasing number of countries are developing alternative energy sources. One of these species is biogas. In-depth studies in this area, despite the known difficulties, are carried out in the India. To a much lesser extent, this applies to India, although the full-scale development of the biogas industry in India would solve a number of important economic problems. It should be noted that the main disadvantage of biogas energy is the significant weight of specific capital costs (per unit of capacity), low profitability of projects, as well as problems with the organization of energy sales through centralized networks. Despite this, in India there is an increase in demand for biogas plants, both for small consumers (with a methane tank volume of 3 to 20 m^3) and for medium-sized (with a methane tank volume of 30 to 100 m^3). The thing is that biogas technologies properly fit into the one Doctrine of sustainable development of society. And many, in India, are committed to this idea. And they, guided by the principle "Reason is a clumsy tool of a scientist; intuition - an unmistakable leader of a seer," they try, each in their own way, to solve this problem.

Modern technology (manufacture):

If possible, they should be linked so that the *final* of one of them is the beginning of another cycle, thus achieving practically full waterlessness intensification of production and at a sufficient distance from the dynamic ecosystems stability boundaries.

According to UN experts:

It is precisely such an integrated approach, when a selection scheme is implemented for enterprises and industries that operate on one type of raw material, and waste and by-products of one production act as raw materials or semi-finished products for another, can completely solve the problem of sustainable development of society. It is known that animals do not fully absorb the energy of plant feed and more than half of it goes into manure, which is, after this or that type of processing, a valuable organic fertilizer. Keeping animals on farms and complexes has led to an increase in the concentration of manure and manure in farms. And this makes it possible to organize their processing not only into fertilizers, but also into biogas, without polluting the environment. At the same time, biogas essentially becomes a ***man-made*** renewable energy source (RES). An integrated approach to production activities, when "waste" , including organic, thermal, water, gas and air is processed in the production process chain, minimally affects the quality of the environment, the productivity of zonal ecosystems. An integrated approach, this is not something new. In general, "evolutionary" and "revolutionary" changes, including those in the energy sector, are interdependent, complement and often replace each other. Cases of a return to "old" technical solutions on a qualitatively new technological base are not excluded. Typically, a biogas plant (station) refers to a complex of engineering structures consisting of devices:

- Preparation of raw materials

- Biogas and fertilizer production

- Cleaning and storage of biogas

- Electricity and heat production

- BSU automated control system.

BSU digester:

The BSU digester should be leak-proof, there should not be oxygen access, since only in the absence of oxygen the vital activity of methane-forming bacteria is possible. The optimum temperature of methanogens depends on the type of substrate processed by the plant (organic waste). Instrumentation mounted on the digester should provide control of the substrate level in the digester, temperature and pressure inside it.

Modern technologies make it possible to process any kind of organic raw materials into biogas, however, the most efficient use of biogas technologies is for processing waste from livestock and poultry farms and wastewater, as they are characterized by a constant flow of waste over time and ease of collection. Moreover, carriage and litter must come from farms and from farms that are safe for zooanthroponic diseases common to animals (birds) and humans. Since a wide range of organic waste can serve as raw material for biogas production, many existing biogas plants use an additive to the processed waste, the so-called green mass. Of course, grinding green mass leads to additional energy costs. Active metabolism and a high rate of biochemical metabolic processes in the digester are achieved due to the maximum maintenance and continuous updating of the values of the boundary surfaces between the solid and liquid phases. Therefore, solid materials, especially those of plant origin, must be preliminarily prepared using cutting, tearing or flattening devices in order to obtain particles of the smallest possible size as a result of effective mechanical action. The proportion of solid particles suspended in a liquid largely depends on the technical means that are used to obtain thorough mixing, hydraulic transportation of the substrate and separation of biogas. The current level of development of BSU allows the processing of substrates with a dry matter content of up to 12%, BSU provide for the utilization (processing) of organic waste of hazard class 3 and 4 in accordance in the following modes:

- In psychrophilic mode, the optimum temperature in the digester is 15 - 20 ° C, but may be lower. In this mode, the waste is processed 30 to 40 days. The psychrophilic regimen is usually used in the summertime when heat and the amount of substrate (waste) is much less than usual, for example, due to grazing;

- In the mesospheric mode at a temperature of 30 - 40 ° C, organic waste is processed for 7 to 15 days, depending on the type of waste;

- In thermophiles mode at a temperature of 52 - 56 ° C, organic waste is processed in 5 - 10 days, while the quality of gas and fertilizers, according to a number of indicators, is usually lower than in the mesospheric mode. In addition, in thermophiles mode, more energy is traditionally consumed for heating. This mode is most suitable for those who have the main task - to process a large amount of waste. By optimizing the operation of the installation and the composition of the waste, it is possible to speed up the processing even up to 3 to 4 days. The benefit of working in thermophiles mode is that the cost of 1 kW of installed capacity of BSU is sharply reduced.

Requirements for the permissible limits of substrate temperature fluctuations, for optimal gas formation, the more stringent, the higher the temperature of the fermentation process: with psychrophilic temperature conditions - ± 2 ° C per hour; mesospheric - ± 1 ºC per hour; thermophiles - ± 0.5 ºC per hour. the need for a system for heating the substrate and maintaining its temperature during fermentation is obvious. According to A.A. Kovalev [1] up to 60% of the biogas received is spent on the own needs of BSU. In this case, the most energy-intensive is the process of heating the substrate, the daily dose of loading the digester, which accounts for about 95% of the energy spent on the plant's own needs.

The most common heating system is an external heating system with a water boiler (boiler plant) operating on biogas, electricity or solid fuel, where the coolant is water with a temperature of about 60 ° C. Higher coolant temperature increases the risk of sticking of suspended particles on the surface of the heat exchanger - heat exchangers are recommended to be located in the range of the mixing device. BSU should be automated. The volume of automatically performed operations of biogas plants for various purposes can be varied. The mandatory volume of automation includes:

- **For biogas plants of low power:**

When the gas detector (gas analyser) of the room is triggered, the personnel warning systems (signal lamps, electric bells, etc.) are automatically turned on and BSU systems shut down, in particular, a safety valve that shuts off the gas supply is triggered; When any thermal relay is activated in the power circuits of the circulation, water or boot pumps, emergency warning systems are activated. Directors of biogas projects at An Energy, the components of the positive cash flow of biogas projects can be as follows (table 1), with guaranteed reliability and durability of reliable operation of BSU, through the use of an enamelled steel digester for 40 years.

Component	Share in revenue structure
Selling electricity	60-75%
Sale of thermal energy	10-20%
Reduced fees for technological connection (for new and expanding enterprises)	0-50%
Power sale	0-30%
Fertilizer Sales	10-30%
Reduction of environmental charges	0-20%
Sale of carbon quotas	0-10% *
* Production of 1000 cubic meters. Biogas replaces 10 tons of CO_2 emissions. The average market price of 1 ton of CO_2 today is 800 INR.	

Table 1 - the Components of the positive cash flow of biogas projects

We will consider the traditional BSU and BSU digesters, which are located at the bottom of the solar salt pond (SSP) [2].A comparative analysis of the types of costs associated with the construction of the biogas plant will be carried out on the digesters of these biogas plants and facilities and equipment (devices) directly associated with them.

As the initial data for the analysis we accept the following.

The composition of **biogas** includes approximately 55 - 60% of bio methane and 40 - 45% of carbon dioxide. Domestic gas appliances, including gas water heaters, air heaters, and gas generators, can run on this gas. Biome thane - product obtained by purifying biogas from CO_2, is used as biofuels. Biogas is lighter than air (1.05 - 1.2 kg / m3), so it tends to go up. Regulates to which class these or those types of wastes generated as a result of raising animals and the production of livestock and poultry products belong. All production and consumption wastes are divided into 4 hazard classes: 1 - extremely hazardous, 2 - highly hazardous, 3 - moderately hazardous and 4 - low hazard. Fertilizers (effluent) obtained by thermophiles fermentation are environmentally friendly, devoid of nitrites, weed seeds, pathogenic micro flora, specific odours. For other modes, the listed fertilizer characteristics are much lower.

Equipment for the preparation and preliminary processing of raw materials for: mixing the substrate; shredding; separation of impurities at the inlet to the reactor; loading (feeding and dosing) of the fermenting suspension in the compared digesters is conventionally assumed to be the same. A set for this equipment for a traditional BSU may include a unit for defrosting raw materials (manure). In the room where the traditional digester is located, according to GOST R 53790-2010 should be:

- A set of fire fighting equipment;

- Dielectric gloves and carpets at control panels of electrical units;

- Gas analysers or gas detectors;

- Personal protective equipment;

- Explosion-proof battery lights;

- First aid kit.

It is not allowed to find workers and carry out any work in the room a digester with idle ventilation. The electrical equipment and the maintenance room of the digester should be equipped with a backup power supply to ensure the continuous operation of the fans with the required rate of air exchange.

To control the concentration of gases in the air of the room digester using gas analysers.

In the service room, a digester, electric lighting, electric motors, starting and current-feeding devices and equipment must be executed in explosion-proof design in accordance with the class of the explosion hazard zone (room category). The gas removal from the digester, the arrangement and operation of gas holders and the digester gas network must be carried out in accordance with the requirements of the Safety Rules in the gas industry and the Rules for the design and safe operation of pressure vessels.

The optimal way to accumulate biogas depends on the purpose for which biogas will be used. With direct biogas burning in boiler burners and internal combustion engines, large gas tanks are not required. In these cases, gas holders must ensure equalization of gas evolution irregularities and improve the conditions for subsequent combustion, depending on the type of gas tank and the pressure it can withstand, the volume of the gas tank is from 1/5 to 1/3 of the reactor volume. Plastic gas tanks are used to collect biogas in simple, combined installations, where an open container serving as a reactor is coated with plastic, or a separate plastic gas tank is connected to the reactor. The gas tank must contain the daily volume of biogas produced. Steel gas holders are divided into low gas holders (0.01-0.05 kgf / cm ^{2}), medium (8-10 kgf / cm ^{2}) and high (200 kgf / cm ^{2}) pressure. Steel low-pressure gas holders are justified only in the case of a large distance (at least 50-100 m) from the installation to biogas-based appliances. In other cases, the possibility of using a cheaper plastic gas holder should be considered.

In medium and high pressure gas tanks, gas is pumped using a compressor. High pressure gas holders are used for refuelling cars and cylinders. Instrumentation installed on gas holders should include a water lock, safety valve, pressure gauge and pressure reducer. Steel gas holders must be grounded. The use of biogas for flare heating of greenhouses is attractive. In addition to carbon dioxide from the gas tank, carbon dioxide is formed during the combustion of bio methane, greenhouses are illuminated and at the same time water is formed that moisturizes the air.

Another area of utilization of the constituent components of biogas is the utilization of carbon dioxide contained in it in an amount of about 40%. Removing carbon dioxide by washing (unlike bio methane, it dissolves in water), you can feed it into greenhouses, where it serves as “air fertilizer”, increasing plant productivity.

Table 2 provides a list of the main types of structures, equipment and instrumentation, depending on the type of digester in the BSU, the costs (cost) of which should be taken into account when choosing a BSU.

Table 2 - A list of the main facilities, equipment, instrumentation and control devices necessary for the placement and operation of the digester and their technical characteristics.

Type BSU	The need for the operation of the digester	Note
Methane tank		
traditional	Yes	*
c BSC	Yes	With a ring *
* climatic modification		
Building (premises) for placing a digester		
traditional	Yes	*, **
with BSC	No	
* placement category 4 (from minus 40 to +40 ºC) (operation in rooms (volumes) with artificially controlled climatic conditions, for example, in closed heated or cooled and ventilated production and other, including well-ventilated underground rooms (lack of exposure to direct solar radiation, precipitation, wind, sand and dust from outside air; absence or significant reduction of exposure to scattered solar radiation and moisture condensation)) ** Room category A - explosive and fire hazardous. Characteristics of substances and materials in the room: Flammable gases, flammable liquids with a flash point of not more than 28 ° C in such a quantity that they can form explosive vapour-gas mixtures, when ignited, the calculated overpressure in the room develops in excess of 5 kPa .		
Biogas boiler plant		
traditional	Yes	Must be in a separate room
with BSC	No	
System for heating the substrate from the coolant of a biogas boiler plant		
traditional	Yes	*
with BSC	No	**
* Indirect heating through a heat exchanger, where a heating coolant, usually hot water, heats the substrate without mixing with it.		

** A substrate heating system is required from the brine heat of a solar salt pond.		
Back-up ventilation system		
traditional	Yes	
with BSC	No	
Mechanization and automation system		
traditional	Yes	All explosion proof
with BSC	Yes	Explosion proof part
System for monitoring the concentration of gases in the room air		
traditional	Yes	
with BSC	No	*
* Leak tightness of the digester is carried out by the absence / presence of biogas bubbles rising to the surface of the SSP mirror.		
Sunny salt pond		
traditional	No	
with BSC	Yes	* Additional functions in the note to the table *
* location category 1 (from minus 10 to +40 ºC) according to GOST 15150-69 (outdoor use (exposure to a combination of climatic factors characteristic of a given macroclimatic region))		
Winter thawing equipment		
traditional	Yes	
with BSC	No	
Fire extinguishing system		
traditional	Yes	
with BSC	No	For BSU as a whole, taking into account *
Canopy (room) for the control panel		

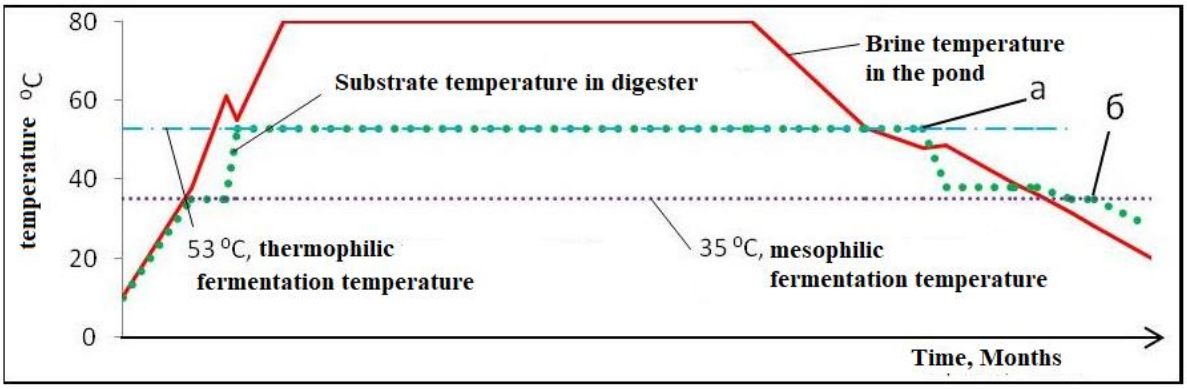
traditional	No	In the building where the digester is located
with BSC	Yes	
Compliance with the list of structures, equipment, instrumentation appointment, based on the design features of BSU		
traditional	Yes	
with BSC	Yes	

since a sunny salt pond can be a fire reservoir at the same time, a change in the need for capital investments for a biogas plant can be taken into account as the prevented expenditure of a part of the funds on a reservoir due to the use of a pond for these purposes. So to fire hazardous premises: P-II class includes low-dusty premises of mills and elevators, granaries; Class P-II an include storage facilities for the storage of combustible materials, cowsheds, pigsties and other livestock buildings during storage in the attics of hay and straw, etc.

The volume of the fire reservoir for the rural house must be such that when extinguishing the fire, the water flow should be at least 10 l / s for 3 hours. The volume of water in the pond should be more than 100 m^3. ince BSU should be located, as far as possible, closer to the sources of processed raw materials (places for keeping animals, waste storage, etc.), the thermal energy of the MTP can be used for hot water supply to farms, preventing the use of biogas for these purposes. A reliable, “Hygienic requirements for ensuring the safety of hot water supply systems”, the water temperature in the hot water supply system should be more than 60 ºC. In a cold water supply system less than 20 ºC.

Note: Legionella are bacteria that live in natural water sources. Even the most advanced water treatment system is not able to protect against their occurrence. Getting into favourable water supply conditions (temperature 25 - 45 ºC), they begin to multiply. Human infection occurs by inhalation of small drops of water containing bacteria, including, for example, when taking a shower.

This can significantly reduce the household’s daily need for biogas for cooking and heating water. Usually it is 2–3 $m^{3\ of}$ natural gas per day. This is equivalent to 3.5 - 5 m^3 and biogas. Since the substrate is heated in a digester placed at the bottom of the SSP from the heat of the brine of the pond, the fermentation regimes in it during the summer period are different. They depend on the temperature that the brine has (Figure 1).



a - The end point of fermentation in thermophiles mode at a temperature of 53 ° C,

b - The end point of fermentation in the mesospheric mode at a temperature of 35 ° C.

Figure 1 - Hypothetical change in the fermentation conditions in the digesters of a biogas plant based on a solar salt pond in India during the summer period

In the spring, when switching from the mesospheric to the thermophiles mode (the left part of Figure 1), about 420 kWh of heat is required to increase the temperature of the substrate in a 20-m3 digeste with 35 to 53 ° C. When using for this purpose the heat of the brine of a pond with an area of 78.5 m^2 (pond diameter 10 m), the temperature of the brine will decrease by about 6 ° C.

In autumn, when the temperature in the MTP decreases, in order to maintain the effective temperature regime of anaerobic treatment of livestock waste, high-energy components can be added to them to increase the exothermic heat generation during fermentation (sugar pulp, high-fat food waste, silage, clover mixture, etc. .). The position of points a and b (Fig. 1) depends on the exothermic heat of fermentation (on the activity of bacteria).

The fact that working in the thermophiles mode and using the heat of the MSC brine, instead of biogas, to maintain the fermentation temperature has its undeniable advantages, is confirmed by the results.

The tests were carried out by employees of the Kazakh Scientific Research Institute of Mechanization and Electrification of Agriculture.

Since these tests clearly reflect the above pros and cons of traditional BSU, we will give them as detailed as possible.

The bioreactor was tested in the regime of bioprocessing of liquid cattle manure fed to the barn for 40 heads. The technology of keeping animals is mixed (stall – walking) the test results and determination of the technological parameters of BSU are shown in Figures 2 and 3.

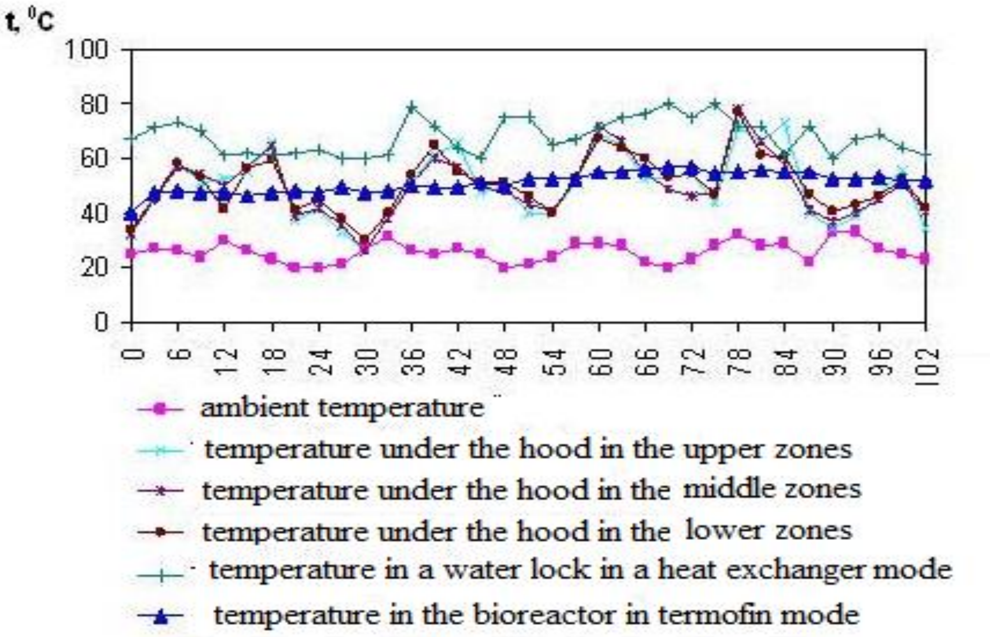


Figure 2 - Dependence of the parameters of the digester on time when heated

In thermophile mode

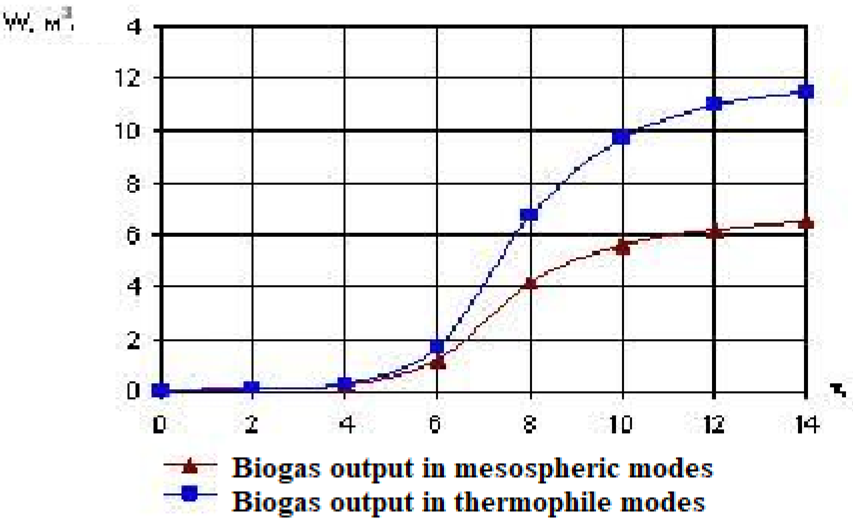


Figure 3 - Biogas output in mesospheric and thermophile modes

An analysis of the test data of the digester:

An analysis of the test data of the digester indicates that the heating time of the substrate to the mesospheric temperature is 46 hours, and to the thermophiles temperature 68 hours. The daily consumption of solid fuel (dung) is 31 kg / day. The efficiency of the fuel boiler is 78.5%. Productivity for manure is 0.5 - 0.7 tons / day. For biogas - 6.5 ... 11.5 m ^{3} / day. The biogas yield in the mesospheric mode is 6.5 m ^{3} / day, in the thermophiles mode - 11.5 m ^{3} / day. (Figures 2 and 3).

When the hydraulic lock is in the heat exchanger mode, the temperature of the heat carrier in it ranges from 49 - 65 ^{0} C, the temperature in the loading chamber is 34 - 40 ^{0} C, and in the unloading chamber - 32 - 40 ^{0} C. Studies of the dependence of biogas consumption when installing a flare and ceramic burner in a fuel boiler showed that the daily biogas consumption with a flare gas burner is 6.17 m^3 / day (0.257 m^3 / h) and 4.8 m^3 with a ceramic gas burner / day (0.2 m^3 / hour).

Chemical analysis of organic fertilizer samples taken during the operation of the biogas plant (sample No. 1 - initial manure with a humidity of 90%, sample No. 2 - finished organic fertilizer) showed a high content of nutrients (table 3).

Table 3 - Nutrient Content in Organic Fertilizer

Try	pH of the medium	Content, g / kg (%)		
		Nitrogen N_{total}	Phosphorus (P_2O_5)	Potassium (K_2O)
No. 1	7.0	21.56 (2.156%)	29.6 (2.96%)	48.0 (4.8%)
Number 2	7.2	16.52 (1,652%)	23,2 (2.32%)	21.6 (2.16%)

1 ton of dry organic fertilizer contains: 16.52 kg of nitrogen (N), 23.2 kg of phosphorus (P_2O_5), and 21.6 kg of potassium (K_2O).

Analysis of pathogenic micro flora in organic fertilizer and the effectiveness of disinfection, the presence of helminthic eggs and weed seeds are shown in table 4. The total microbial seeding of the original manure (coli index) is 10^9 CFU, after anaerobic digestion in a biogas plant, the total microbial seeding of the finished organic fertilizer decreased to 10^7 CFU, thus the degree of decontamination of manure in a biogas plant is 99%. In organic fertilizer there are no helminthic eggs, and the seeds of weeds completely lost their germination.

Table 4 - Analysis of pathogenic micro flora in organic fertilizer and the effectiveness of disinfection, the presence of helminthic eggs and weed seeds

Try	Bacterial seeded nost colonies / cm^3	If index *, bacteria / dm^3	Coli titer	The effectiveness of disinfection,%		
				by availability		
				bacterial contamination	helminthic eggs, pcs / dm^3	weed seeds, pcs / cm^3
Number 1	10^9 CFU	10^{10} CFU	3x10^5 CFU	-	Availability	Availability

Number 2	10^7 CFU	10^5 CFU	$3x10^3$ CFU	99	are absent	germination loss

* Coli index: the number of bacteria of the group of Escherichia coli in 1 dm ^{3} of water.

Based on the results, the authors concluded. As a result of tests, it was found that the biogas plant meets the requirements of GOST 31343-2007. The biogas plant's productivity is 6.5–11.5 m ^{3} / day, fertilizer 0.5–0.7 t / day, the bioreactor volume is 5 m ^{3}, and the substrate temperature in the bioreactor corresponds to the thermophiles mode — 52 - 54 ^{0} C, biogas consumption for heating - 6.2 m ^{3} / day, loading dose - 10%, the density of the fertilizer obtained - 964.9 kg / m ^{3} , the mass fraction of dry matter - 4.7%, the efficiency of manure disinfection - 99%

According to the results of the work presented in Kazakhstan, for the BSU, the digester, which is located in the SSP, to accelerate the start of the thermophiles regime in the spring and mesospheric in the fall (Figure 1), reduce the break time in biogas production, it is advisable to prepare a substrate with a colony of thermophiles (mesospheric) anaerobic bacteria. The most typical types of thermophiles bacteria are Methanobacterium soehngenii and Methanobacillus omelianskii. Thermophilic methane bacteria are usually associated with or cultured with anaerobic cellulose bacteria. The temperature boundary of their development is 45 - 69 ° C. A feature of these bacteria is their high growth rate due to the accelerated metabolism. The onset of adverse (low) temperature takes them to a stage of rest, in which they can stay indefinitely.

And mesospheric bacteria grow best (their optimum for growth) in the temperature range of 20 - 45 ° C. Free-living mesophylls inactive during the cold seasons. Below and above temperatures of 20 - 45 ° C they are at rest or death, depending on the species. Since, in accordance with Table 2, the digesters of the BSU under consideration are different, the devices (structures) directly connected with them are also different. Proceeding from this, the permits required for the operation of these various BSUs must be different, both in type (structure) and in cost. Due to the fact that BSU of both types can work both in the mesospheric and thermophile fermentation modes, the 2 types of fertilizers produced by them will be the same (table 5). The difference will be in the commodity volumes of these types of fertilizers and biogas (bio methane), since in traditional biogas plants a significant part of biogas is used to maintain the temperature of the thermophile regime, and this is not always welcomed on farms and will often force the owner of the biogas plant to switch to the mesospheric regime.

Table 5 - A list of types of products (fertilizers) produced during the operation of biogas plants, and their areas of use.

Type BSU	Fermentation mode	Fertilizer	Cost, cu / kg	Area of use
Traditional	mesospheric	Effluent *	1 cu	Only in the field *
	thermophile	Effluent disinfected	1,5 c.u.	Including home floriculture
with BSC	mesospheric	Effluent *	1 cu	Only in the field *
	thermophile	Effluent disinfected	1,5 c.u.	Including home floriculture

* Organic material decomposed as a result of fermentation during the mesospheric regime may contain harmful flora, since low temperature in the digester does not provide 100% sterility. In accordance with paragraph 2.3 of the sanitary rules of SP 1.2.1170-02 (Organic and nitrogen-containing mineral fertilizers), manure and chicken droppings used to enrich the soil with nitrogen and other nutrients must be pre-treated (thermal drying, composting, etc.). Comply with the requirements of current regulatory documents, do not contain pathogenic micro flora, incl. salmonella, and viable helminthic eggs.

One of the arguments for increasing the cost of the effluent obtained under the thermophile regime is the loss of germination of weed seeds Table 6, from GOST 31343-2007, shows the germination rate of weed seeds, and the following are examples of evaluation methods.

Germinating seed stock	Intervals of classes of abundance, thousand germinating seeds per 1 ton of fertilizer		
	Litter less manure with humidity,%		
	less than 90, semi-liquid	from 90 to 93, liquid	more than 93, manure
Low	Less than 30	Less than 20	Less than 17
Average	30-100	20-60	17-50
Tall	100-300	60-100	50-100
Very tall	More than 300	More than 100	More than 100

Table 6 - the scale of assessment of stocks germination of weed seeds

Multiple analyses of manure, composts and other fertilizers show that seed germination of the main types of weeds is from 10% to 30%. Therefore, in some cases, it is allowed to evaluate organic fertilizers by the total stock of seeds. For this, the proposed scale can be used (table 6). In this case, the obtained analysis result must be divided by 10.

EXAMPLE 1 ton of litter manure contains 5.1 million weed seeds. To assess the quality of such manure on the proposed scale, 5.1 million divided by 10, we get 510 thousand. The content of weed seeds in such manure is estimated at 3 points (high stock of seeds). Therefore, the introduction of such manure into the soil creates a strong weediness of crops. Based on this, the most important thing is the development and registration of an enterprise standard for effluent - organic fertilizer obtained as a result of anaerobic processing of organic waste in digesters. Indeed, only with the proper implementation of the effluent, the commercial success of any biogas project is possible. For the successful operation of the BSU, you must:

Conclusion of a long-term contract for the disposal of organic waste of hazard classes 3 and 4 in accordance with Resolution. Conclusion of a long-term contract with a wholesale and retail network for the purchase of organic fertilizers at prices corresponding to the price of replaced mineral fertilizers, taking into account the hazard class (hygiene certificate), incl. for indoor plants.

Based on the analysis, a more advanced use of solar energy accumulated by the solar salt pond seems to be promising compared to that given in. The energy of the solar salt ditch (a pond in the form of a ring covering the bottom side surface of the digester) can be used to heat the substrate and for large biogas plants (Figure 4).

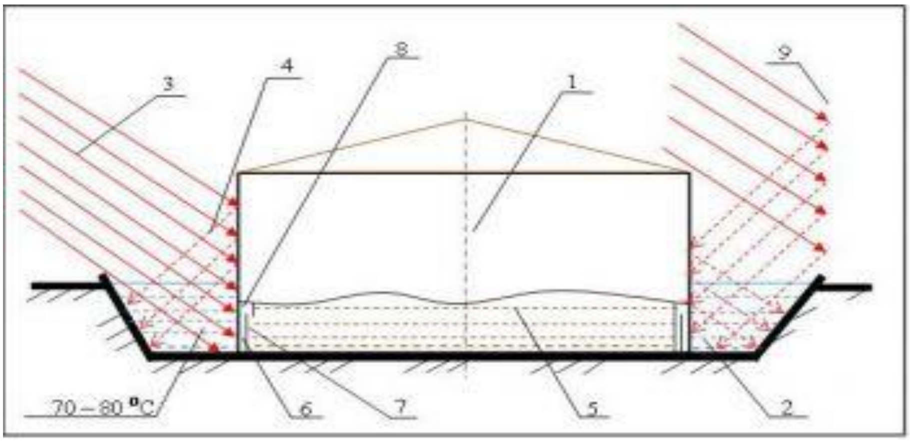


Figure 4 - Diagram of a large volume digester with a solar salt ditch

1 - digester, 2 - solar salt ditch (annular pond), 3 - direct solar radiation, 4 - reflected solar radiation, 5 - substrate, 6 - outer annular gap between the solar salt moat 2 and the internal volume of the digester 1, 7 - inner annular the gap between the solar salt moat 2 and the internal volume of the digester 1, 8 - thermal insulation digester 1, 9 - reflector of solar radiation. The digester 1 (Fig. 4) is located at the bottom of the pond 2, which receives direct solar radiation 3 and solar radiation 4 reflected from the lateral outer surface of the digester 1. Maintaining the required fermentation temperature in the digester 1, through the use of solar energy (heat of brine ditch 2) is provided as follows.

When filling the outer 6 and inner 7 annular gaps with water, the heat from the solar salt pond 2 to the substrate 5 in the digester 1 is maximum. This provides, if necessary, accelerated heating of the feed to the desired fermentation temperature. After heating the substrate to the required temperature, water is drained from the outer 6 or inner 7 gaps and drained. As a result, the rate of heat input from the solar salt pond 2 through the air gaps 6 and 7 decreases by tens to hundreds of times, compared to when they were filled with water. You can drain one of the gaps.

Further maintenance of the substrate temperature within the required limits can be achieved both by synchronously regulating the supply of "hot" raw materials and removing the effluent, and by periodically filling the gaps 6 and 7 with water and creating a low vacuum in these gaps. Such a combined installation of biogas generation can ensure the operation of the digester 1 in thermophile mode, primarily in countries with a hot climate without the cost of biogas produced for its own technological needs. This is very important if then bio methane is used as motor fuel, for brick burning, lighting, for the production of asphalt, steam production and for other technological processes where a temperature much higher than 100 ° C is needed.

In the gap 6, with the drained gap 7, during the entire summer period, water can be heated to prepare the substrate.

In addition, in the gap 6, with the drained gap 7, it is possible to heat the water in the spring, for use when watering in greenhouses and greenhouses, ensuring that they maintain an acceptable temperature not only of air but also of the ground, because, for example, in May, the **natural** monthly **average** soil temperature in the south of Omsk region at a depth of 0.4 m is 8.7 ° C, at a depth of 0.8 m - 5.1 ° C, and at a depth of 1.6 m - only 0.9 ° C. With the dried gap 6, pumping cold water through the gap 7, you can cool the substrate.

For more efficient accumulation of solar energy by the solar salt ditch, on the north side of the digester 1 (Figure 4), it is necessary to install a reflector 9 (solar energy concentrator), which will direct the reflected solar radiation to the northern part of the ditch (pond) in the sunniest, noon, before and Afternoon. The use of solar energy biogas in technological production makes it possible to ensure its summer and autumn production with the greatest efficiency, which is especially important in areas cut off from large energy centres due to river spills, impassability, etc.

Biogas plants of this type will make it possible to more effectively ensure, due to the fertilizer produced, the maintenance of soil fertility, and to prevent the free emission of bio methane into the atmosphere. The profit from operating a BSU depends on many factors, including the sale of by-products. The most significant increase in profit from the sale of bio methane can be obtained from the sale of liquid fertilizers, as these are highly liquid products that are in constant demand. There is always a demand for fertilizers, since an indispensable factor in the functioning of the agrarian bio system is the balance between the introduction of energy into the soil and the removal of energy in the form of nutrients: their introduction must be no less than the removal.

When generating biogas, the use of solar energy to heat the substrate in a large digester will allow the thermophiles fermentation mode to be applied in summer and autumn. In this case, with the same volume of digester, the biogas yield will increase by 1.5 - 2 times.

Conclusion:

The cost of a BSU with a solar salt pond is much lower than the cost of a traditional BSU, with the same volumes of digesters. At the same time, the use of the thermophiles fermentation regime in them additionally leads to a reduction in the cost of 1 kW of their installed capacity.

During the summer period of operation of a biogas plant with MTP, when working most of the time in thermophiles mode, you can get more commercial biogas, compared with traditional biogas plant.

Since the efficiency of fertilizer disinfection at BSU with MTP is higher, the income from the sale of fertilizers will also be higher.

Modernization using the BSU solar salt pond will reduce the weight of specific capital costs by 1.5 - 2 times (per unit of capacity) and increase the profitability of biogas projects.

It seems promising to use the energy of the solar salt ditch, the pond in the form of a ring, for heating and maintaining the temperature of the fermentation of the substrate in large BSU.

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