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STUDY OF THE EFFICIENCY OF ANAEROBIC FERMENTATION OF MUNICIPAL SOLID WASTE

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ABSTRACT

Abstract. The article analyzes municipal solid waste processing methods. The process of municipal solid waste processing by anaerobic fermentation method is considered. The advantages and disadvantages of the anaerobic fermentation method have been determined. Based on the results of the experiment, the factors influencing the process of municipal solid waste processing by the anaerobic fermentation method are presented

Introduction.

The depletion of traditional fossil fuel reserves and the environmental consequences of burning them have led to a significant increase in interest in waste-free technologies based on renewable energy sources in almost all developed countries of the world in recent years. However, along with the rapid growth of the world's population, the improvement of the standard of living, the expansion of the types of consumer products and the increase in their consumption are causing a sharp increase in the amount of solid household waste, which in turn is a global threat to human development and environmental stability. Improving the efficiency of the use of energy resources, eliminating the impact of solid household waste on human health and environmental stability, and introducing energy and resource-efficient and zero-waste technologies that ensure the country's energy independence and its export potential are the main priorities for the development of the economy of Uzbekistan [1,2].

In a world with limited resources, the amount of solid waste generated is increasing significantly.

Municipal solid waste (MSW) reduction policy requires that solid waste be used as raw material as much as possible for other purposes (for example, exhaust gas recovery as renewable energy sources, heat or electricity) rather than dumping and burying. Therefore, municipal solid waste is the cheapest source of raw materials in the world [2,3].

Municipal solid waste includes all waste materials except liquid waste, atmospheric waste and hazardous waste. MSW can be divided into three main categories: municipal waste, industrial waste and agricultural waste [4].

It should be noted that food waste, paper and polyethylene waste constitute the main component of the waste container in all countries of the world.

As a result of population growth, urbanization, expansion of consumption and types of consumer products, the issue of solid household waste management, transportation, collection, disposal, disposal and processing is gaining global importance.

Methods and materials.

Especially in the poor countries of the world, scattered garbage and illegal dumping sites contribute to the spread of infectious diseases and unpleasant odors at an alarming rate and cause various damages to the environment. Most of the time, trash and other garbage is simply dumped into rivers or on farmland - causing serious damage to water, food resources and nature [5].

Recycling of MSW based on ecological requirements, as well as rational use of resources and economic criteria creates the basis for a cardinal solution to the problem of waste.

In addition, in the cities and districts of our Republic, the removal and collection of MSW from the population is unsatisfactory. Not equipped with equipment, existing waste collection and storage facilities, sanitary facilities do not meet sanitary-hygienic rules and requirements, self-formed landfills are used in a number of places [6].

The processing of organic waste (agricultural waste, food waste and organic waste in solid household waste) is carried out through various methods, among which the biological decomposition method of biological processing is very important. Under the action of various groups of microorganisms, complex organic substances are divided into simpler ones during biological decomposition [7]. The process of biological decomposition provides:

- disposal of waste by reducing its volume and mass;
- production of biodegradable products.

Production of biological decomposition products-biogas and pyrogas during anaerobic processing, bioremediation of anthropogenically damaged ecosystems during aerobic processing compost production, and production of alternative energy units provide an opportunity to solve anthropogenic problems [8].

Biodegradation:

- a complex biochemical process that consistently combines chemical, physico-chemical reactions;
- includes various types of aerobic and anaerobic microorganisms that process organic waste and produce compost when decomposed aerobically, and produce alternative energy units when processed anaerobically [9].

Anaerobic decomposition (fermentation) of organic waste:

- it includes a number of complex microbial reactions, including important raw materials and syntrophy for their substrates in the biotransformation processes of hydrolysis, acidogenesis and methanogenesis [10];
- widely used as a reliable mechanism of biochemical transformation;
- since biogas contains a large amount of methane, it shows that it is an alternative source of energy;
- to improve the use of renewable energy, to develop green energy, and at the same time, it is the most efficient method and

technology to reduce the amount of greenhouse gas emissions;

- a biological process that ensures the transformation of oxygen-free organic waste into methane and carbon dioxide;
- is a complex process in which there is a mutual exchange between solid, liquid and gas phase substrates and products;
- as a means of stabilizing the biodegradable part of organic waste is a widely developing area of biotechnology compared to other organic waste processing methods.

Summarizing the above, it can be concluded that anaerobic decomposition is a complex biochemical process that continues in an airless environment and combines chemical and physicochemical reactions, including various types of microorganisms, which in turn allows for the decomposition and stabilization of organic waste in a wide range [11].

Anaerobic decomposition of organic waste technologically proceeds in four stages - hydrolysis, acetogenesis, acidogenesis, and methanogenesis. The progress of this process is completed by the syntrophic interaction of different microorganisms.

Results and discussion.

Methane (50÷70%), carbon dioxide (34÷40%), nitrogen (up to 16%), oxygen (<1%) and other gases make up the main components of the waste gas obtained as a result of the anaerobic fermentation process. Thus, flue gas is a universal renewable energy source consisting of 50÷70% methane. The total energy potential of exhaust gas with 50÷70% methane content is 20÷25 MDj/m^3, it is possible to obtain electricity equivalent to 4÷6 kW/m^3, which is equivalent to the value of 0.5÷0.7 l of diesel fuel. The probability of the generation of waste gas is often 160÷300 m^3/t, and it depends on the morphological composition of the waste, the seasons, the climate of the area and the level of industrial development. Anaerobic processing of waste materials takes 15 to 20 days, together with waste gas extraction, it is possible to obtain high-quality local fertilizer for the agricultural sector [11].

Table 1 lists and describes the factors influencing the anaerobic fermentation process.

Table 1.
Factors affecting the anaerobic fermentation process.

Influencing factors	**Characteristic**
C/H	Anaerobic fermentation takes place under favorable conditions when C/N is between 20:1 and 30:1.
	Maintaining the synergistic effect of microbial activity by improving the balance of organic compounds in terms of the morphological composition of MSWs increases the stability of the whole process.
	The profitability of exhaust gas output increases: If the MSW is mixed with animal excrement.
Substrate/ inoculum	A substrate with a high inoculum ratio of 1.5÷2.0 leads to the accumulation of volatile fatty acids, which can lead to the failure of the waste reactor.

	Increasing the amount of organic waste to increase the anaerobic fermentation process leads to an increase in the amount of waste gas.
Temperature	The temperature range used for the processing of solid wood waste by the anaerobic fermentation method MSW for the mesophilic mode The temperature range commonly used in the anaerobic digestion of waste is 35÷42°C in the mesophilic mode and 45÷60°C in the thermophilic mode. It is more difficult to control the stability of the process in the thermophilic regime, which increases the process speed and kinetics and is sensitive to toxic substances and changes in operating parameters, thereby increasing the production of flue gas. Mesophilic mode provides reduced energy consumption for heating and process stability.
	The thermophilic regime is more sensitive to environmental changes than the mesophilic process.
	Due to a sharp decrease in temperature from 50°C to 20°C, the speed of the anaerobic fermentation process decreases on average 5-8 times.
Chemical compounds	Volatile fatty acids in the form of non-dissociated (non-ionized) acids are toxic to microorganisms due to their ability to penetrate the cell membrane. Undissociated acid molecules cross the permeable membrane to affect the intracellular pH of the bacterial cell, resulting in the restriction of microbial growth and activity.
	The ratio of total volatile fatty acids to undissociated acids should be maintained at 20 *g/l.*
	The formation of volatile fatty acids during biodegradation can lead to environmental acidification and slow down the complete conversion of organic matter into waste gas.
	There is a serious technical problem that prevents the use of municipal waste in MSW processing facilities. The anaerobic digestion process is sensitive to toxic substances, and municipal waste contains a wide range of compounds that can accelerate this process.
	Hydrolysis and methanogenesis can be the rate-limiting steps in the anaerobic digestion process due to the accumulation of unwanted volatile fatty acids. However, control and optimization of key operating parameters can improve process efficiency and ensure stable off-gas production.
	The lower the atmospheric pressure, the lower the partial pressure of CO_2 - this leads to an increase in the pH value of the medium and improves the anaerobic fermentation process. This allows the anaerobic fermentation process to resist acidification and reduce the cycle time of the plant and the processing of MSW in

	the waste reactor.
Pressure	Experiments were conducted at 20°C and 50°C. The following additives were used: MSW, sewage waste and their mixture. Conclusion: sewage waste and their mixture accelerates the process and increases the proportion of waste gas in the mixture.
Supplements	As a result of the joint decomposition of the organic fraction of MSWs and the fraction of fruits and vegetables, the total amount of exhaust gas and its content of CH_4 will decrease.
	The use of MSW and mole excrement ensures the stability of the methanogenesis phase and a small change in the pH value. Contributed to an increase in CH_4 concentration (from 45% to 60%).
	As a result of anaerobic fermentation, the organic compounds contained in MSWs with other types of organic fractions allow the production of waste gas to increase by 25% (200÷400 m^3 compared to 150÷250 m^3 of waste gas when MSW is processed by anaerobic fermentation).
	Anaerobic fermentation process is more stable when using different types of organic waste: organic fraction of MSW with sewage waste, organic fraction of MSW with agricultural waste, organic fraction of MSW with coal powder, organic fraction of MSW with activated coal briquettes, organic fraction of MSW with animal excrement and poultry the organic share of MSW with manure.
	The addition of granular activated carbon is used to improve the acidogenesis and acetogenesis phases of the anaerobic fermentation process. Due to the presence of holes on the surface of granular activated carbon, it serves to immobilize syntrophic microorganisms, adsorb inhibitors, and accelerate direct electron exchange during anaerobic fermentation.
	The addition of granular activated carbon for anaerobic fermentation of the organic fraction of MSWs leads to an increase in volatile fatty acids, an increase in exhaust gas production, and accelerates the decomposition of propionate and butyrate in organic compounds. High decomposition of volatile fatty acids with the addition of granular and granular activated carbon is syntrophic between bacteria. showed that it is related to the strengthening of relations. The addition of granular activated carbon for anaerobic fermentation of the organic fraction of MSWs accelerates the growth of bacteria and methogens and improves the decomposition of volatile fatty acids, increasing the rate of exhaust gas separation.
Ions	The concentration of CO_4^2 must be carefully controlled in anaerobic operations because it converts to H_2S, which causes problems.
	Additions of Se and Co improve the stability of the anaerobic

	fermentation process and prevent process failures. The addition of iron (Fe), Co, and nickel (Ni) to the anaerobic fermentation process of CMPs reduces volatile fatty acids and increases off-gas production and process stability. Long-term anaerobic fermentation of food waste, the addition of trace elements leads to stable processes and prevents the accumulation of volatile fatty acids. Therefore, the lack of trace elements in most substrates is caused by the accumulation of volatile fatty acids.
	ρH is a key parameter that must be carefully controlled in continuous processes. It is known that an increase in the concentration of volatile fatty acids is associated with an imbalance in the process, that is, acidogenesis occurs faster than methanogenesis.
pH	Decreasing the pH level leads to a decrease in the anaerobic fermentation process.
	The range of 6.8÷7.3 pH is the most favorable for methanogenic bacteria.
	In the process of anaerobic anaerobic fermentation, optimal performance of microorganisms is achieved at neutral pH (6.8÷7.2).
	Carbohydrate-rich wastes, such as fruit and vegetable wastes, cause rapid acid formation in the early stages of the anaerobic digestion process, which lowers the pH value in the waste reactor. If this change is not corrected, continued acid accumulation leads to a decrease in methanogenic activity.

Conclusions.

The results of the conducted research show that CH_4 values of the waste gas obtained as a result of the processing of the anaerobic fermentation method in the psychrophilic mode of the anaerobic fermentation method are slightly higher than in the mesophilic and thermophilic modes of the anaerobic fermentation method. Most importantly, in the low-temperature anaerobic fermentation process, the psychrophilic mode has lower levels of free ammonia than the mesophilic or thermophilic modes.

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