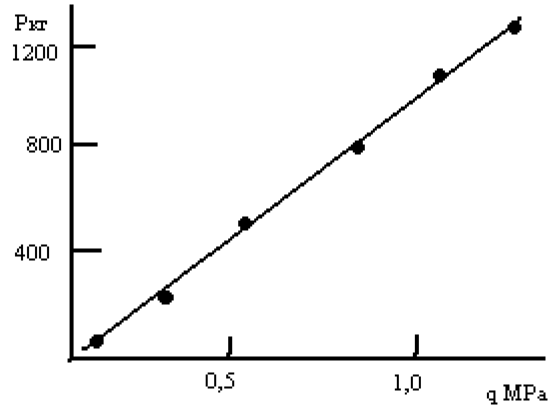


*Figure 3. Pressure on the walls of the soft container and the heavy connection of the product*

This means that small soft containers for agricultural products can be made from thin P P fabric and large bags from thicker fabric, and orders can be made according to the technical specifications of PP fabric.

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## PERSPECTIVES OF BIOGAS PRODUCTION FROM DIFFERENT TYPES OF BIOMASS AND ORGANIC WASTE

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## ПЕРСПЕКТИВЫ ПРОИЗВОДСТВА БИОГАЗА ИЗ РАЗЛИЧНЫХ ВИДОВ БИОМАССЫ И ОРГАНИЧЕСКИХ ОТХОДОВ

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**Abstract**

The present study reveals the environmental consequences of the use of conventional fuels and perspectives for the production of biogas (BG) from different types of biomass (BM) and organic waste (OW) by fermentation have been investigated. For this purpose, a comparative analysis of the effectiveness of the suitable BM and OW types is carried out. A comparative analyzes about the chemical composition of BM and OW, as well as heat transfer ability (HTA) were performed. Detailed information about the importance of the production of biogas from sewage waste is also provided.

**Аннотация**

В настоящей работе раскрываются экологические последствия использования отечественных видов топлива, рассматриваются перспективы получения биогаза (БГ) из различных видов биомассы (БМ) и органических отходов, путем сбраживания. Ведется сравнительный анализ эффективности использования подходящих, для указанной цели, видов БМ и ОО. Проводятся сопоставительные анализы о химическом составе, а также теплотворной способности (ТС). Даются также подробные информации о целесообразности получения БГ из канализационных стоков.

**Keywords:** conventional fuels, altenative fuels, heat transfer ability, biomass, organic waste, sewage waste, biogas, biomethane, carbon dioxide, fermentation.

**Ключевые слова:** отечественные виды топлива, альтернативные виды топлива, органические отходы, канализационные стоки, биогаз, биометан, способность теплопередачи, биомасса, диоксид углерода, сбраживание, ферментация.

**Introduction.**

At present, the main concern of all countries of the world is the use of environmentally friendly and inexhaustible energy sources in order to provide the next generation with sustainable and uninterrupted energy. It is known that, in most countries of the world are used convetional fuels such as oil and oil products, gas, coal, peat, firewood, etc for the production of both heat and electricity. A number of countries began to use nuclear fuel for electricity generation after the second half of the last century. However, except the firewood, the existing reserves of above mentioned fuel types on the earth may be depleted in this century. So that, if we consider that the annual rising rate of electricity and heat energy is 2,5-3,0%, it is clear that the total oil reserves in 25-48 years, gas reserves in 35-64 years, coal reserves in 228-330 years, and uranium reserves in 35-64 years will be completely depleted [1]. As for firewood, excessive deforestation can lead to major disasters, not only in terms of energy, but also in terms of ecology. So that, since it takes 40-50 years for any tree to reach the level of a wood-bearing tree, the deforestation rate should be at most 2.0-2.5% per year. Except the nuclear fuel, other conventional fuels are unambiguously used in thermal power plants, in all types of transport in the transport sector, as well as in private and public housing, factories, plants, hospitals, boarding houses, schools, kindergartens, laundries, military facilities, tourism facilities. etc. are used for hot water and heating supply which leads to the release of large amounts of gases generating thermal effects (GGTE) into the environment and causes to pollutes the atmosphere with carbon dioxide, methane, nitrogen oxides, fluorine and fluorine compounds, etc. It is sufficient to note that, about 300 million tons of CO, $CO_2$, etc., 150 million tons of ash, 100 million tons of sulfur dioxide ($SO_2$), 60 million tons of various types of nitrogen oxides ($N_2O$, $NO_x$, etc.) and much more harmful other gases, such as freons (fluorine chloride hydrocarbons such as hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)), are emitted into the Earth's atmosphere every year. The lifespan of these exhaust gases in the atmosphere is different. So that, the lifetime of $SO_2$ is 3 days, $CO_2$ is 5 days, freons are 50-70 years, and nitrogen oxides are 120 years [1-3]. The environmental consequences of these (glaciers in the oceans especially icebergs, forest fires, tsunamis, massive flooding of settlements, rivers burst banks, in some cases observation of winter in spring and spring in winter, etc. due to the increase in average global temperature) are becoming more acute every year in various countries around the world.

In addition to the above, the use of nuclear energy is also extremely dangerous. This was proved once again by the accidents at Chernobyl on April 26, 1986 and at the Fukushima nuclear power plant on March 11, 2011. So that, the tragic consequences of those accidents are known to the world. In particular, the accident at the Chernobyl nuclear power plant caused billions of dollars of damage not only to Ukraine, but also to neighboring countries such as Belarus, Poland and others. Tens of thousands of square kilometers of arable land have been permanently removed from the balance, which the restore will take 100-150 years. The share of hydropower plants (HPPs) in the energy balance of the world is very small, and the use of these energy sources is not available everywhere. Although HPPs may seem environmentally friendly at first glance, their use also leads to a number of (permanent flooding of large arable lands, degradation of the seabed, disturbance of fish and other marine life, changes in climatic conditions in the surrounding habitats and, most importantly, more dangerous consequences due to earthquakes and the explosion of high dams by the enemy) environmental complications.

All of this suggests that alternative and renewable energy sources (ARES), especially solar, wind, geothermal, wave, etc., are environmentally friendly and inexhaustible in order to provide future generations with sustainable energy and it is necessary to use these types of energy. But this is not enough. So that, since the use of ARES is not going as fast as it should be or is not possible, it may still be advisable to use such energy sources only for power supply purposes. However, if we consider that human demand for thermal energy is 2.0-2.5 times more than demand for electricity, then it becomes clear that only ARES is not enough to meet demand in the energy of the future. Thus, it is important to create new alternative fuels (AFs) in the form of liquid and gas to fully meet the growing fuel requirements of all kind of fuel consumers. Considering this, since the second half of the last century, a number of countries around the world, especially Brazil, have begun to produce methanol and ethanol from very productive plant species of sugar cane and now the transport sector in that country operates entirely on methanol. With regard to gaseous fuels, the use of different types of BM and OW, which are considered renewable raw materials in this area, is of particular importance. Considering this, the perspectives of gaseous fuels production, in particular, biogas (BG) from BM and OW have been investigated in this study.

**1. Comparative analysis of the gaseous AFs production, in particular, BG production from BM and OW.**

There are three main methods used to obtain gaseous AFs from BM and OW: pyrolysis, gasification and biochemical decomposition. High temperatures are required for these reactions to occurs, due to the endothermic character of the chemical reactions during the pyrolysis and gasification processes. Thus, the pyrolysis process is carried out at 500- $900^0$C temperature and in an oxygen-free environment. Gasification process carried out at 700-$1800^0$C and higher temperatures (up to $2000^0$C) in the thermochemical reactors with special construction, in the presence of an oxidizer.

At present, numerous gasification plants have been established and are in use in a number of countries. Most of these plants use diesel or gas-fired furnaces to maintain the required temperature, or part of the BM or combustible OW to be processed is used as fuel to heat the reactor, which is generally causes a slight decrease in the coefficient of performance (COP) of the plants. Considering this, for the first time in the world since the 70s of the last century in the Department of Radiation Research of the Academy of Sciences of the USSR (now the Institute of Radiation Problems of ANAS) several modified experimental devices were created in which parabolic concentrators with different diameters were used to ensure a high temperature regime. Thus, the implementation of this process was carried out through environmentally friendly and inexhaustible solar energy [4]. Gaseous fuel obtained by pyrolysis and gasification methods consists of a mixture of combustible gases containing $H_2 + CH_4 + CO$, which is also called a synthesis gas in the literature. The heat transfer ability (HTA) of gas with such a composition depends on the amount of hydrogen and methane gases and the HTA of that gas is higher with the higher percentage of hydrogen. In this regard, when the gasification process is carried out at high temperatures, methane is converted to water vapor, which eventually methane converts to hydrogen and produces $H_2 + CO$ content combustible gas mixture with higher HTA.

In the method of biochemical decomposition, the transformation to BG occurs by the fermentation of BM and OW. The BG consists of the combustible gas mixture of 50-70% methane and 50-30% carbon dioxide. Moreover, BG may contain up to 1% hydrogen sulfide and small amounts of nitrogen, oxygen, hydrogen and carbon monoxide. Historically, BG has been known for a long time and it has been called marsh gas or sewage gas. BG is formed by the decomposes of carbon from the substrate (a mixture of crushed BM or OW with hot water) by various types of anaerobic microorganisms and this is a multi-stage process. It is necessary to purify BG for use in vehicles. As a result, BG transforms to complete analogue of natural gas (consisting of 90% $CH_4$ and 10% $CO_2$). Another gas is carbon dioxide obtained as a result of additional processing of BG, which can be used in carbonization processes as dry ice and for other purposes (feeding vegetables grown in greenhouses and as a gasifier to production of lemonade, beer, carbonated water, champagne, etc in the field of barfomeria).

**2. Perspectives for the use of plant and animal origin BM and OW in the BG production.**

The following types of plant and animal origin BM and OW are used to obtain BG: solid and liquid wastes, sewage, sewage wastes, solid household wastes (SHW) and forest wastes belonging to the agro-industrial field. In this regard, the manure of cattle, small ruminants and other domestic animals (pigs, horses, etc.), as well as poultry manure and waste generated during the slaughter of animals (fat, suet, blood, stomach, intestines, etc.) is of particular importance. As for agro-industrial wastes, there can include corn silage, various grasses, wastes from grain production, sunflower sprouts and crowns, wastes from brewing, fruit wastes from canneries, and plant species (red and white elderberry, achillea (yarrow), fern, reed plant, grapevine and cotton swabs, etc) that are not accepted as fodder by livestock.

There are the following advantages of using fuel directly from the BM or as a raw material for new alternative fuels [5, 6]:

- natural resources can be protected due to the restoring;
- the $CO_2$ emissions problem generating the thermal effect is eliminated;
- the pollution level of the atmosphere with toxic gases such as $SO_2$, $NO_x$ and ash products is reduced;
- the cost of the produced energy is significantly reduced;
- transportation costs are minimized since the produced liquid and gaseous fuels can be transported directly through pipelines;
- uninterrupted fuel supply is possible to places with complex relief structure, including military and meteorological facilities on the mountainous areas.

In addition to all this, the following resource characteristics of existing BM types also have great importance:

- the total mass of all living matter is 2000 billion tons;
- the total mass of plants growing on the ground is 1800 billion tons;
- the total mass of forests is 1600 billion tons;
- the mass of surface BM (excluding aquatic plants) per person is 400 tons;
- the amount of energy accumulated in surface BM types is equal to 25000 EJ (1 EJ = $10^{18}$ J);
- the annual growth of the BM is 400 billion tons;

It should be noted that it is possible to provide 26% of the energy requirements of all countries at the expense of the BM (including cultivated species) if used in a planned manner. This indicator can be more than 40% also with considering animal origin BM types and OW

Another important aspect of using BM and OW (including cellulose-containing SHW) to obtain BG is that most types of BM (in particular, wood and wood products, cotton and grape twigs, etc.) contain 45-60% of cellulose, 15-35% of lignin and 15-25% of hemicellulose. The plant origin BM types contains 25% of lignin and 75% of hydrocarbons (mainly cellulose) and saccharides. Moreover, elemental analysis shows that dry wood contains a certain amount of calcium and magnesium pectates, resins, gums, oils, tannins, pigments and minerals. Dry wood contains 50% carbon, 6% hydrogen, 44% oxygen, up to 0.2% nitrogen and less than 1.0% sulfur. The amount of residual minerals (ashy substances) is 0.2-1.0%. However, the amount of ashy substances in tree branches and roots can be 2% and 5%, respectively. The ashy substances mainly consist of $Na_2CO_3$ and $K_2CO_2$, of which from 10% to 25% are soluble in water and can be used as high quality fertilizers. As for the water-insoluble part of the ash, the most important components of this part are lime, as well as carbonate, silicate and phosphate salts of iron, magnesium and manganese [6].

In addition to all these positive features, there are a number of factors that hinder the widespread use of BM:

- inaccessibility of a certain part of plant and animal origin BM types and OW resources for profitable use;
- thedifficulty of accumulation and transportation of some types of BM and OW due to their relatively small parties in nature, ie uneven distribution;
- the seasonal nature of the realization market of some types of plant origin BM;
- the inability to stored for a long time of plant origin BM types and OW;
- insufficient economical and legislative incentives in our country, as in many countries around the world.

The BG amount with $m^3$ obtained from 1kg of plant origin BM and OW, the percentage of methane in the obtained BG and the amount of carbon-nitrogen ratio are shown in Table 1.

Table 1.

**The amount of BG obtained from different types of BM and OW**

| Type of raw material | BG yield ($m^3$), per kg of dry matter | Amount of methane,% | Carbon-nitrogen ratio (C/N) |
|---|---|---|---|
| Cattle manure | 0,25-0,34 | 65 | 16,6-25,0 |
| Pig manure | 0,34-0,58 | 65-70 | 6,2-12,5 |
| Poultry manure | 0,31-0,62 | 60 | 7,3-9,65 |
| Horse manure | 0,20-0,30 | 56-60 | 25 |
| Sheep manure | 0,30-0,62 | 70 | 33 |
| Faeces and waste water | 0,31-0,74 | 70 | 6-10 |
| Wheat straw | 0,20-0,30 | 50-60 | 100-150 |
| Oat straw | 0,29-0,31 | 59 | 50 |
| Corn straw | 0,38-0,46 | 59 | 50 |
| Grass | 0,28-0,63 | 70 | 12 |
| Tree leaves | 0,21-0,29 | 58 | 50 |

As a result of the performed investigation of BG facilities have been shown that the amount of BG obtained from the unit volume or mass differs significantly from results shown in Table 1 when animal origin BM species are mixed (as a substrate) with a liquid and decomposes anaerobically. However, such a difference is not so noticeable for plant origin BM. Table 2 shows the amount of BG obtained from one ton of different types of raw materials in the form of substrates (grinded and mixed with hot water). A comparison of these two tables shows that the amount of BG obtained from 1 kg of animal origin dry mass is much higher than that obtained from the same amount of substrate. For example, this average difference is 6.33 times for cattle manure. Therefore, mixing animal origin raw materials with excessively hot water during fermentation in BG plants can show negative results. In the case of plant origin BM types, it is necessary to grind them by mixing them with hot water in order to be fermented by anaerobic microorganisms. Otherwise, the decomposition process of plant origin BM species will stop completely, and the decomposition of animal origin BM and OW will be very slow, which may create problems in meeting consumer demand.

**Table 2**

**The amount of BG obtained from a mixture (substrate) of different types of BM and OW with hot water**

| Type of raw material | BG yield, $m^3/t$ | Type of raw material | BG yield, $m^3/t$ |
|---|---|---|---|
| Cattle manure | 39-51 | Beet sprouts | 75-200 |
| Cattle-straw | 70 | Vegetable waste | 330-500 |
| Pig manure | 51-87 | Cereal seeds | 390-490 |
| Sheep manure | 70 | Grass | 290-490 |
| Poultry manure | 46-93 | Glycerin | 390-595 |
| Oily leather | 1290 | Rye waste | 165 |
| Slaughter waste | 240-510 | Linen and hemp | 360 |
| Solid household waste | 180-200 | Oat straw | 310 |
| Sewage waste | 70 | Clover | 430-490 |
| Alcohol production pulp | 45-95 | Milk serum | 50 |
| Bagasse | 115 | Corn silage | 250 |
| Silage | 210-410 | Flour bread | 539 |
| Potato sprouts | 280-490 | Fish waste | 300 |
| Beet pulp | 29-41 | | |

### 3. Ecological, energy and economical benefits of BG production

In the second part, we provided information on the perspectives, advantages and disadvantages to the production of BG using different types of plant and animal origin BM and OW. The production of BG from plant and animal origin BM and OW, as well as sewage waste has several advantages, which have been proven in world practice:

- it is a renewable energy source, as renewable raw materials are used for production;
- the use of a wide range of raw materials allows the construction of BG facilities in all regions where agriculture and technologically related industries are concentrated;
- both at production place and at any facility connected to the gas pipeline (after removal of carbon dioxide) as well as methods of use as motor fuel for cars are more universal in term of energy;
- the year-round stability of electricity generation from BG allows to supply loads with energy connected to the electrical grid during the peak hours, in particular, when combined with solar and wind power plants operating in a non-stationary mode with unstable parameters;
- the use of arable lands for the BG production is more energy efficient than liquid fuels (bioethanol, biodiesel, etc).
- it has been proved that the amount of energy produced from 1 Ha of arable land is 2 to 4 times higher than that of bioethanol and biodiesel when producing BG from energetic hybrid corn;
- numerous jobs are being created in this market from the BM provider to the BG consumer. For example, in 2011, the total number of jobs vacanies in the bioenergy sector in Germany significantly exceeded other sectors of renewable energy sources;
- negative effects on the environment are significantly reduced due to the treatment and neutralized of waste in BG reactors by fermentation, or the accumulation of BG generated at existing solid household waste landfills. Thus, BG technology is one of the most basic and more effective ways to neutralize of OW. BG production also significantly reduces the amount of GGTE released into the atmosphere;
- the application of mass fermented in the BG reactors in the arable lands leads to a significant improvement in the quality of the humus layer of the soil, as well as increase in its regeneration and productivity due to organic nutrients. The introduction of organic fertilizers produced in the BG plants to the market allows to obtain a significant amount of additional incomes.

The effectiveness of the use of BM and OW for the purpose of BG production is confirmed by the results of elemental and express analyzes of their chemical composition, heat transfer ability etc. This is obviously seen in the characteristic data of plant origin BM types and dry sewage wastes given in Table 3.

Table 3

**Characteristic data for some types of BM and dry sewage**

| Type of raw material | Elemental analysis (dry residue) | | | | | | Express analysis (dry residue) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | H | N | O | S | ash | Humidity | Volatile substances | Related carbons | HTA MJ/kg |
| **Agricultural wastes** | | | | | | | | | | |
| Wood chips | 50 | | 0,4 | | | | 7,8 | 74,0 | 25,5 | 19,3 |
| Pulp | 48 | | - | | - | 4,0 | 1,0 | 80,0 | 15,0 | 17,0 |
| Corn kernels | 49 | | 0,4 | | - | 1,0 | 5,8 | 76,5 | 15,0 | 17,0 |
| **Energy-intensive wood wastes** | | | | | | | | | | |
| Based on beech wood | | | | | 0 | 1,0 | 19,0 | 85,0 | 14,0 | 18,4 |
| **Energy-intensive origin wastes** | | | | | | | | | | |
| Straw | | | | | 0,2 | | 7,6 | 68,8 | 13,5 | 17,0 |
| **Solid household wastes** | | | | | | | | | | |
| Dry sewage wastes | | | | | 0,6 | | 4,7 | 41,6 | 2,3 | 8,0 |

As can be seen from Table 3, the main chemical elements forming the part of the BG contains from C, H and O, which the total amount is highest (99.3%) for wood chips and lowest (88%) for straw. This value is 41,2% in the dry sewage waste. This is explained by the abundance of ashy substances, which in fact is not considered a defect. Thus, although the large amount of ash eventually results in a relatively small amount of BG, in return, the amount of mineral residue increases significantly, which is considered a very positive.

The summarized data about chemical composition of the OW belonging to the solid waste category are given in Table 4.

Table 4

**Summarized data about chemical composition of the OW belonging to the solid waste category**

| Indicator | Name of substance | Amount (%) |
|---|---|---|
| Elemental composition by mass, % | Carbon | 17-20 |
| | Oxygen | 2-3 |
| | Hydrogen | 13-17 |
| | Nitrogen | 0,5-1,0 |
| | Sulfur | 0,1-0,12 |
| General properties | Ash content in the working mass, % | 10-16 |
| | Ash content in the dry mass, % | 20-32 |
| | Organic substances in dry mass, % | 68-80 |
| | Humidity, % | 45-55 |
| | Density, kq/m$^3$ | 190-200 |
| | HTA Oof working mass, kC/kq | 5000-6000 |
| Agro-chemical indicators by dry mass, % | Total nitrogen – N | 0,8-1,0 |
| | Phosphorus - $P_2O_5$ | 0,7-1,1 |
| | Potassium - $K_2O$ | 0,5-0,7 |
| | Calcium – CaO | 2,3-3,6 |

As can be seen from Table 4, the percentage of organic matter in the OW of the solid waste category is 68-80% in relation to dry mass, which is a very good result. Although the heat transfer ability is several times lower than that of plant origin BM species, this does not negative affect the importance of producting BG from these wastes.

Thus, as mentioned above, this issue, in addition to obtaining a gas AYN, also reflects a positive solution to environmental problems. Thus, as mentioned above, this issue in addition to obtaining a gaseous AFs, also give a positive solution to environmental problems. The heat transfer ability of 5000-6000 kC/kg indicates that the obtained BG is fully suitable for domestic use. On the other hand, the number of plant origin BM species, including the SHW category, are not used as a direct fuel, and even neither energy-efficient nor environmentally friendly if they are used. Thus, although the heat capacity of 1 kg of plant origin BM species (for example, in the example of straw in Table 3) is 17 MJ, it is impossible to boil a kettle of water when burning not only one kg, but even 500 kg of this type of BM. Because more than 98% of the obtained heat is released into the atmosphere as heat loss due to open combustion, and the BK burns out quickly. However, according to oat straw example in Table 2, a family of 4-5 people can fully meet its gas demand within a day in the spring-summer season including hot showers, cooking, making tea, dishes -washing, etc.

through a BG (10x0,310 = 3.1 $m^3$) obtained from 10 kg of oats.

As for the use of BG devices, it should be noted that currently India, Vietnam, Nepal and others countries are widely used small BG devices (single-family) in the home. China is the first place in the use of BG devices, as there were more than 10 million BG devices in China at the end of the last century. 7 billion $m^3$ of BG is produced in these devices a year, which is 60 mln. sufficient to meet the fuel requirement of the rural population. In 2006, the total number of BG facilities in China reached 18 million, which means that 100 million people will be provided with BG and will save about 11 million tons of conventional fuel. At present, this trend continues in China. BG plants can be used as cleaning facilities on farms, poultry factories, wineries and meat factory. One of the developed European country, in Denmark, the production and operation of BG is up to 18% of the energy balance of country. Currently, Germany is the leader in the number of BG devices with 8 million units. Up to 50% of poultry farms in Western European countries have heating systems based on BG. Volvo and Scania already produce BG based buses. This type of buses is widely used in the Swiss cities of Bern, Basel, Geneva, Lucerne, etc. [6].

As for Azerbaijan, our country is very indifferent to the application of ARES in other areas, as well as the installation and operation of BG facilities. There is almost no investigation on the production of methanol and ethanol by BM and OW fermentation. As an exception, it should be noted that the BG facility has been constructed in the Khinalig village of Guba under the direct leadership and participation of professor Fagan Aliyev. Unfortunately, this work could not be continued due to the lack of necessary financial support.

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# РАЗРАБОТКА МОБИЛЬНОГО ПРИЛОЖЕНИЯ ДЛЯ ОРГАНИЗАЦИИ СПОРТИВНЫХ СОРЕВНОВАНИЙ.


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# DEVELOPMENT OF A MOBILE APPLICATION FOR ORGANIZING SPORTS EVENTS


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