NEW GENERATION OF BIOREACTORS: THE BAREHOLE BIOREACTOR

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Abstract. *Biogas reactors are a huge technical and technological installation that operates mainly as a result of the solar heat on earth and serves to produce biogas, but in areas where air temperatures are meant to vary (although in Uzbekistan, where there are four seasons), sunlight cannot heat the bioreactor enough during 12 months. Therefore, for the purpose of producing and storing biogas, the drilling hole's diameter is as wide as possible (1600-2000 mm), and the depth of the drilling hole is calculated normally (based on geothermic conditions) for the formation of biogas We drill wells of up to 1700 to 2500 m and strengthen the side walls through special preservation and build a biogas storage and harvesting reactor.The geothermal gradient of the underground does not depend on the sharp change in weather on earth based on its depth, so enough temperatures (+30^o, +40^o) to produce biogas are provided by selecting the required depth for biomass.The difference and advantage of technology over other types of bioreactors is: the length of service life of the wells produced, the low human factor in the course of the process, and the low likelihood of problems resulting from external influences in the environment, as well as one of the most positive indicators of it, is that the process of biogas separation does not slow down due to the likelihood of cooling air.*

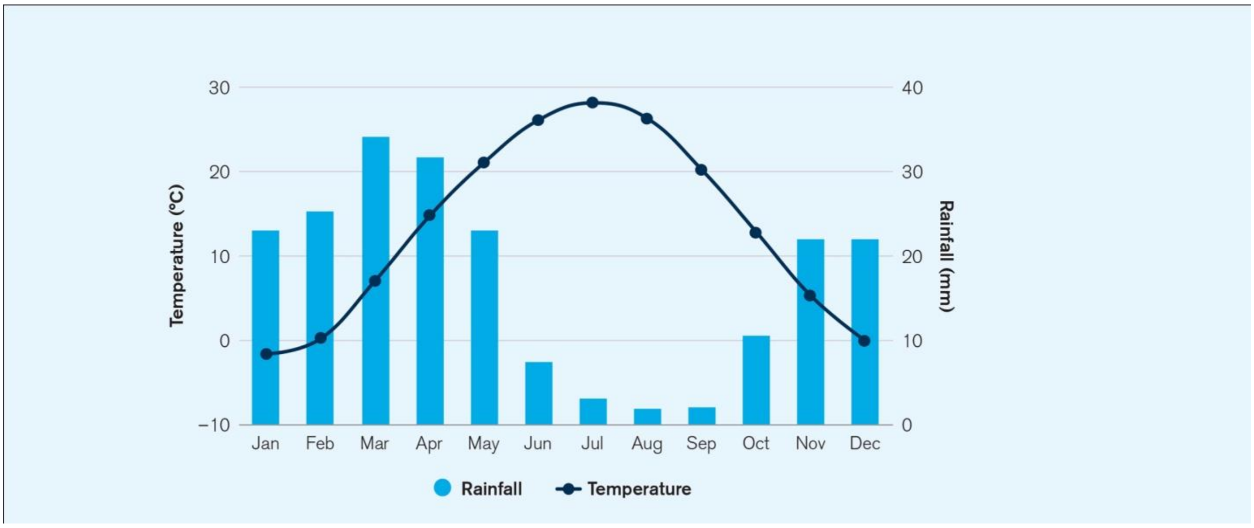
Keywords: *biomass, temperature, biogass, biodigester, well, anaerobic decomposition, bactery, mesophil, pathogen microorganisms, hydrothermal gradient, biofuel, groundwater, biofertilizer.*

INTRODUCTION

It is known that the demand for biofugradation is now increasing day by day.It is noteworthy that global biogas production reached 59 billion m^3 between 2000 and 2014 [1]. Naturally, this indicator demonstrates how high the demand for renewable energy is. Currently, the main working principle of large bioreactors in operation is based on natural heat energy and sunlight therefore, in countries with warm climate, the efficiency indicator is higher. But in many countries with temperate temperatures, the efficiency indicator of this technology is relatively low.However, the average daily temperature in Uzbekistan for June 1991-2020 was +27.2^o and in some cities (Kharshi, Termiz) was +35^o C, while between December and February of winter the temperature was -1^o and -3°C. (Figure 1) [2].

Figure 1.

(1991-2020) Average monthly temperature and precipitation indicators for Uzbekistan.



In the case of the Republic of Uzbekistan, if we consider 4-5 months of summer and spring to be hot (conditions favorable for bioreactors), the efficiency of biogas reactors will decrease as a result of moderate and cold air for the remaining 7-8 months.It is noteworthy that the anaerobic breakdown process in the bioreactor is divided into three types of thermal stages: psychrophilic (below 25°C), mesophilic (+25°C , + 45°C), and thermophilic (+45°C, + 70°C) (Table 1) [3].

Table 1.

Influencers of thermal phases on biogas separation times.

Thermal stage	Process temperatures	Minimum retention time
psychrophilic	< 20 °C	70 to 80 days
mesophilic	30 to 42 °C	30 to 40 days
thermophilic	43 to 55 °C	15 to 20 days

It is known from the above table that if the effect of heat on the bioreactor decreases, the process of biogas release also decreases respectively, and even the production of biogas due to the absolute stoppage of the activity of biofermenting bacteria caused by cold weather also becomes zero.

In 1875, in the experience of Russian scientist Popov, an increase in temperature did not affect the biogas structure, accelerating its separation process. [4] In the experiment, it was found that temperature is a big factor for biogas. Most methane-producing bacteria of this type achieve optimal growth in the mesophilic temperature range from +37° to +42°. Biogas plants operating in the mesophilic range are the most common in practice, because in this temperature range high gas yields and good process stability are achieved [5].

Anaerobic microbes in the bioreactor generally break down organic matter in order to obtain energy and nutrients for growth and reproduction, and due to this process, biogas is released (which is mainly composed of CH_4-methane) [6].For almost all types of biogas installations, the heat source is of great importance, and the effectiveness of solar heat is not always as beneficial as noted above because in some regions seasonal temperature cooling takes a lot of time (up to 5-8 months in Central Asia), resulting in a decrease in the activity of biogas-producing mesophiles (bacteria), and the process also slows down. For this reason, we need to choose and improve suitable conditions for bioreactors in such a way that we need to control not only temperature, but also pressure changes in the process.

Currently, biofugradation using public methods is carried out using the following processes:the creation of a bioreactor, the placement of biomass in it, and, of course, the temperature, the emptyim, and the biomass that break down biomass (Table 2). However, in rural farms, bioreactor and biogas systems also include mechanical and biological processes to work together or in a whole system [7].

Table 2.

Factors that contribute to the formation of biogas in bioreactors using a common method.

HUMAN'S FACTOR	NATURAL FACTOR
Making biodigester	Temperature
Placing biomass	Preasure
	Bactery

However, it is also true that through human influences, pressure, temperature, and even bakeries are possible to control, and in this case the process is an intellectual factor, not a tablet, but we should not forget the golden rule that "as human factor increases, efficiency decreases." That is, in order to increase the biogas process, we need to raise the temperature in various unnatural ways, which leads to a violation of the efficiency balance.

Taking into account all the above issues and problems, we introduce unusual technology to create bioreactors of an unusual style for generating and storing biogas, maintaining a moderate balance of natural temperature for biogas and serving for a longer period of time than conventional bioreactors: on-site hydrothermal, geologic and after exploring the hydrological environment, drilling boreholes suitable for use as bioreactors in the earth's crust and using them as bioreactors is the basis of the technology

METHODOLOGY

The technology of using it as biogas reactors by producing a known-sized drilling hole in the earth's surface includes three main stages:

1. Choosing an environment acceptable by studying and researching geothermal, geological, and hydrological conditions.

2. In the selected place, form a drilling hole with a diameter of an average of 1500-2000 mm and a depth of 1.7-2.5 km.

3. Fill a certain part of the harvested environment with biomass and hide the drilling hole for a certain period of time.

1st stage.

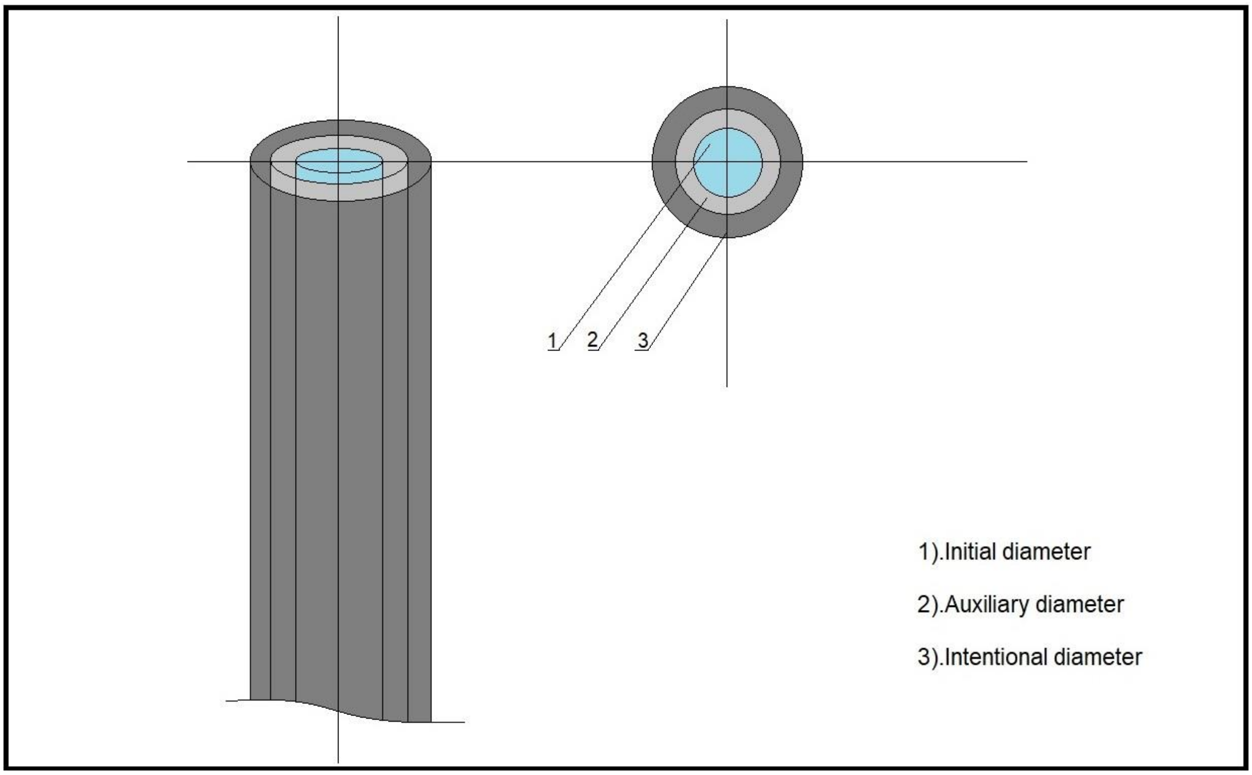
In order to create underground bioreactors in a convenient and necessary environment, the first thing to be done is to choose the location of the surface of the area in a geographical and hydrologically favorable relief and thereby create a situation that does not harm the objects of the population. In general, the lithosphere of the earth is quite favorable, which allows to study up to 11-15 km with boreholes [8]. After choosing a suitable terrain, the following are determined by conducting a small borehole for analysis: the amount of ground water (moisture), the level of impact of technology on underground water, the increase of the internal heat of the earth with increasing depth, namely the indicators of the geothermal gradient and geological conditions are also studied. After the research results return to a positive indicator, the second main stage will be passed.

2nd stage.

The average increase in temperature in the lithosphere by +25^o, +30^o degrees per 1 km is called geothermal gradient [9], and the geothermal stage is below the constant temperature region indicates the depth corresponding to an increase in temperature by 1 degree [10]. Taking into account this geothermal gradient, a normal depth should be chosen for the decomposition of biomass components and the release of biogas through it. After carrying out studies based on the above information, a well with a small diameter (120 mm) will be drilled with an average length of 1.7-2 km relying on the geothermal conditions, the main reason for drilling a small-diameter well is to achieve the target (for example, 1700 mm) diameter on the drilling well, namely it is very difficult to create or work with a 1700 mm diameter well-drilling device in just one step and due to high labor cost of large-sized drilling tools, the required size is achieved by increasing the drilling diameter step-by-step in the process.

Figure 2.

Step-by-step drilling to achieve target size.



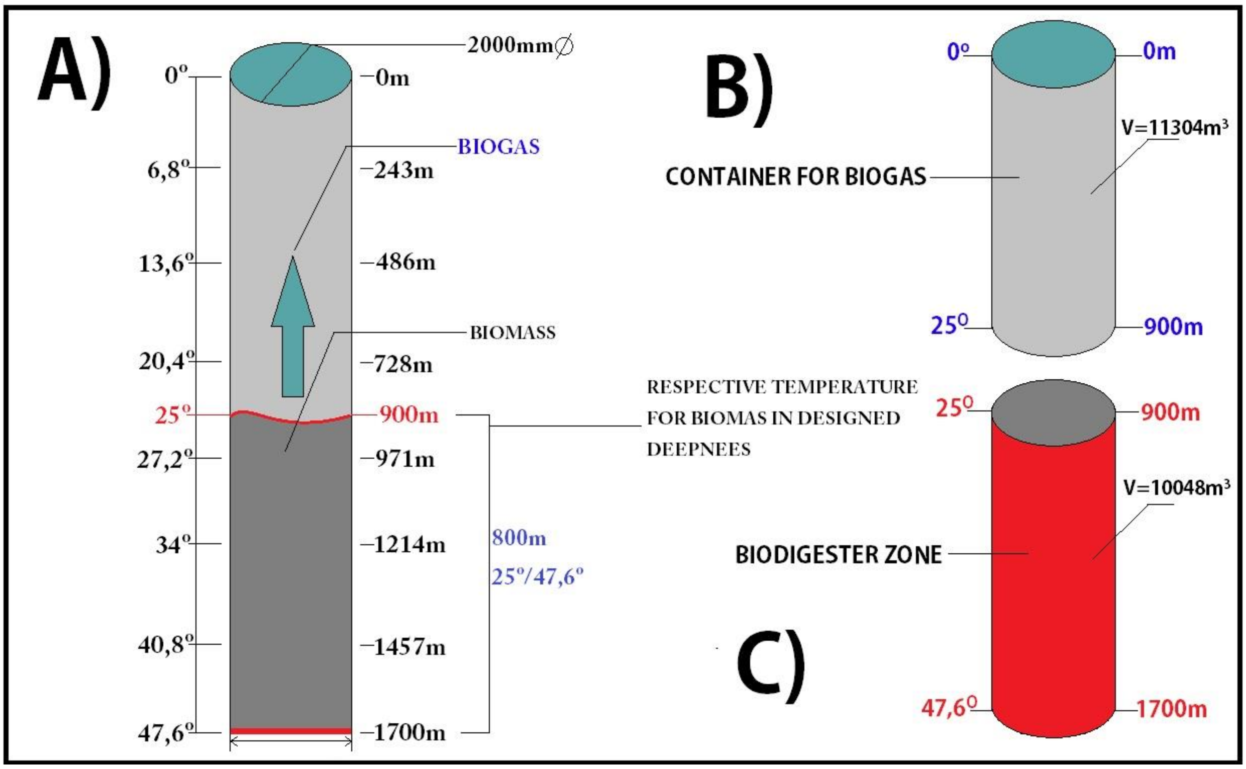
Considering the location of that environment, the different distribution of underground heat along its layers, it can be determined the depth of the well differently, for example, the geothermal gradient in the Baltic Shield (Kola and Gravberg) is very low and returned to +16^o C/km, while in the bathalites of South West England, this indicator was a very high +35^{o}C. [10]. In addition, the world's deepest ultrawell dug by the USSR (Kazlovsky-1984) was 12226 m in depth, and the main reason for the suspension of drilling in 1995 was the sharp rise in geothermal temperature (above than +200^o) [11]. On average, the temperature of the normal area at a depth of 1.7-2 km can be defined as +40^o, +50^o, which is a very favorable environment for the decomposition of biomass and the activity of mesophiles.

3rd stage.

The main part of the last stage is to fill the known amount of the well with biomass, based on the exact values of the temperature in the created well. The initial doing that should be done in this process is to measure the temperature and pressure in different parts of the well. Of course, after all accounting work is carried out through the initial well of a small diameter, auxiliary and main wells are conducted, biomass is placed based on the pressure exerted on the bottom of the borehole with an average depth of 2000 meters and a diameter of 1.7 meters, taken as an example above, and the temperature at different points. Due to the temperature is various at different points of the depth, the biomass is placed in the interval from the central point where the average temperature of the well returns +25°C to the bottom where the average temperature returns +45 °C, +47°C (Figure 3).

Figure 3.

Distinctions of the volume and temperature at depth as an alternative for biomass. (B-respectively, the volume of the reserve space for biogas. C-the part of the well used as a bioreactor.)



RESULT

The lower part of the well serves as a bioreactor, and its upper part serves as a storage block for collecting the produced biogas (Fig. 3 situations B and C.). After the biomass is placed in the specified part of the well, the upper part (lid) of the well is closed, and the biogas produced as a result of biomass decomposition is collected in the upper reserve section of the well. After the main mechanical processes (selecting a favorable environment for the constructing of a well, creating a well based on its geological, hydrological and geothermal conditions, analyzing the hydrothermal gradient of the created environment and placing biomass in a certain part of it), biogas is released in a natural stage.

If we take local and industrial waste as the main composition of biomass for process, we can reduce environmental pollution as a result. The main composition of local waste is depicted in Table , and the amount of biogas released from these substances and methane storage properties are also shown[12]. (For instance Cow dung can be, and is, directly burnt as fuel after drying it. But the conversion efficiency to heat is only 8%. Much better (25%) energy efficiency is achieved in the conversion of biogas to electricity. The most energy-efficient utilization of cow dung, however, is as heat via combustion of biogas (efficiency 55%) (Table 4) [13].

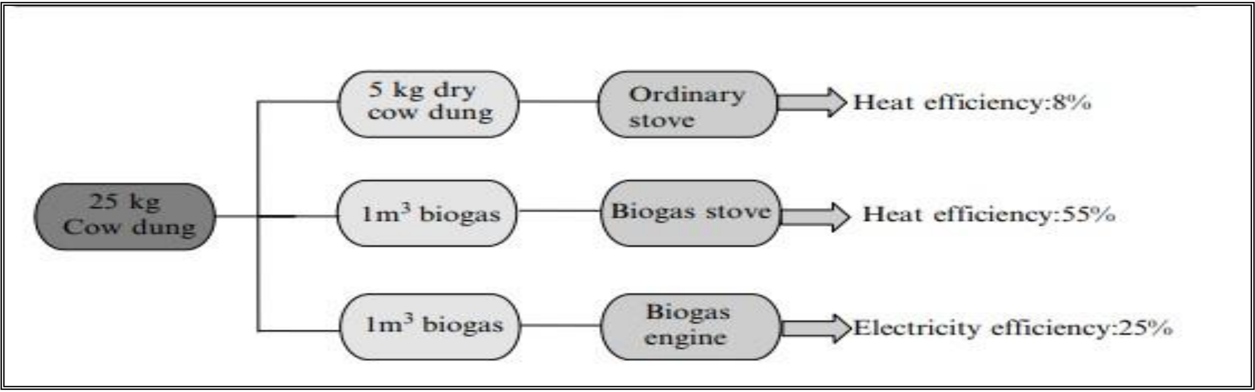
Table 3.

Indicators of methane storage and release of organic waste.

Organic substance (garbage)	**The amount of gas released from 1 kg of product (m^3)**	**Methane storage property (%)**
Fertilizer for domestic animals	0,4-0,5	64-65 %
Vegetable waste	0,35-0,4	55-65 %
Plants	0,33-0,4	60 %
Waste water	0,3-0,7	70 %

Table 4.

Efficiency of energy conversion from cattle dung



According to the data, on average, 1 kilogram of organic matter is separated 0.18 kg of methane, 0.32 kilograms of carbonic anhydrite and 0.3 kilograms of other non-degradable residues when 70% biological decomposition occurs [12, 14]. Preliminary calculations show that 350 m^3 of gas (methane, hydrogen) can be obtained from 1 ton of natural (plants) biomass mixed with waste[12]. The volume of the bioreactor portion of the borehole shown in Figure 5(C) above is approximately 1050 m^3, and this medium is composed of 30% wastewater, 30% vegetable and plant waste, 20% animal manure, and 20% other is filled with various types of waste, and biomass with a density of about 1300 kg/m^3 is formed. As a result, the total weight of biomass in the specified part of the well ($1300 kg/m^3$ * $1050 m^3$) is 1 365 000 kg. Taking into account the conversion of 1t of natural (plants) biomass into 350 m^3 of gas, it is possible to obtain 477 750 m^3 of biogas on average from 1 365 000 kg of biomass. These indicators constitute only one cycle of bioreactor use, and we can further increase the result by adding additional well bioreactors to the process.

DISCUSSION AND PROBLEMS

Although the main advantages of well bioreactors are fundamentally different from conventional bioreactors, there are main considerations and controversial points that arise in the process of implementing this technology, whereas in the process of creating a well bioreactor, increasing the depth is not a problem, the process of increasing its diameter to 2 meters is the main sensitive point. In order to solve this problem, we can achieve the result with the aid of small-sized boreholes before directly drilling a 2 meter diameter borehole. In addition, another main controversial issue is the problems of installing additional structures for mixing the biomass placed at the bottom of the well, the depth of the well is inconvenient for the special mixing devices that need to be installed, but in this case, based on the natural conditions, we can emphasize that one of the solutions to the problem is this environment itself, ie, the main purpose of mixing biomass is accelerating the process, and another advantage is to prevent the formation of sediment. In order to speed up the process the ambient temperature that higher than conventional bioreactors can be effective instead of mixers. Another drawback of the technology that should be highlighted is the difficulty in obtaining the resulting sediment for use as a biofertilizer, a very small part of them may accumulate at the bottom of the well during the years and cause its volume to decrease.

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