Determination of biogas potential of residual biomass of microalgae Chlorella Sorokiniana

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Abstract. The results of research of biodegradation processes of compositional mixture consisting of Chlorella Sorokiniana and inoculum have been presented. Compositional mixture was prepared in different ratio of the components, and biogas emission was evaluated. The results allow determining the optimal composition with maximum biogas potential.

1. Introduction

The use of microalgae for biofuel production is recognized as a forward-looking direction of modern bioenergy. The ability to capture carbon dioxide and use it to create highly productive biomass and the ability to convert it into various types of biofuels are important biological and biochemical features of microalgae [1]. The quality of biomass, which consists of carbohydrate fraction (up to 50-60%), various protein fraction (10-47%), mineral composition (7-38%), lipids (1-3%) is attractive [2], which provides the possibility of its transformation into different types of biofuels. Low cost of biofuel promotes its wide application in various power installations [3,4,5].

Biogas production from microalgae has certain difficulties such as decomposing cell walls of microalgae by hydrolytic bacteria. As a result, the amount of available organic substances for anaerobic fermentation and biogas production is decreased. Respectively, the energy potential is decreasing and the economic indicators of biogas production are worsening.

The different methods of microalgae pre-treatment are used. There are physical, chemical, enzymatic, and other methods [6,7,8]. This increases the cost of the technological process of biogas production, as it requires additional energy, economic and other costs, which can be reduced if the microalgae substrate is used as waste after extraction of valuable substances for the needs of pharmacology, food and other production.

In this case, all expensive pre-treatment of microalgae has already been carried out, but the organic matter content of the residual biomass is reduced. The task is to study the biogas potential of different types of organobearing substrates after extraction of valuable components.

The goal of the experiment is research of decomposition of composite mixture consisting of residual biomass of microalgae Chlorella Sorokiniana and inoculum for biogas production.

Chlorella Sorokiniana is a small single-celled freshwater microalgae. It is capable of intensive growth under different climatic conditions and at different sources of carbon and nitrogen. This allows it to grow with the use of various wastes arising from the processing of raw materials, wastewater treatment, etc [9].
Exposure to various physical factors also affects microalgae growth and composition [10,11]. Dry substance of microalgae C. Sorokiniana on average consists of protein – 40 %, carbohydrates – 30-38 % and lipids – 18-22 %. The methane yield from microalgae at this ratio of components can be equal to 212 ml/g of organic dry substance [12].

The residual biomass of Chlorella Sorokiniana after preliminary special treatment was used in this experiment in order to extract useful components [6].

2. The new method, experimental results and discussion

The task is evaluation of biogas potential of the composite mixture from the residual biomass of Chlorella Sorokiniana and the inoculum at their different ratios.

The equipment used for the preparation of biosubstrate samples presents in Table 1.

| №  | Name of the work Operation title                              | Equipment                                       |
|----|--------------------------------------------------------------|-------------------------------------------------|
| 1  | Weighing inoculum and substrate                             | Scales AND GR-200                               |
| 2  | Preparation of the required volume of water                | «Aquaphor Crystal» drinking water filter        |
| 3  | Moisture measurement                                        | Moisture Analyzer MB35                          |
| 4  | Determination of organic carbon                             | Oven PT200 laboratory furnace                   |
| 5  | Definition of pH                                            | pH meter Multi 340i SET2                        |

24 g of dry matter was prepared (in terms of organic carbon) (Figure 1). Organic carbon content (93%) was determined in accordance with technological regulations [11].

Fresh cow manure with a moisture content of 82 % was used as the inoculum and the organic carbon content in it was 92 % (Figure 2).

The test samples consisted of mixture of microalgae and inoculum were put into preliminary prepared 8 bioreactors with capacity 1 liter per unit.

The quantitative composition of loaded substrate (in terms of organic carbon) presents in Table 2.
The bioreactors were filled with 600 ml of filtered water and its acidity was pH=6.28.
Ritter MilliGascounters were used to measure biogas volumes. All bioreactors, counters and gas lines were purged with 99.999 % nitrogen to remove oxygen. Then the bioreactors were sealed and placed in the thermostatic box with a constant temperature of 35°C (Figure 3). The biogas was collected in special 3L plastic valve bags.

### 3. Conclusion
The experiment was conducted for 23 days. The graphs of biogas emission from bioreactors are shown in Figure 4.
The analysis of the obtained graphs shows that on the 10th day of the experiment there was an activation of biogas emission. Its average volume was: from bioreactors No.1 and No.2 – 0.1 liters, No.3 and No.4 – 0.17 liters, No.5 – 0.16 liters, No.6 – 0.35 liters, No.7 – 0.033 liters, No.8 – 0.02 liters. On the 15th day of the experiment, the average biogas emission was: bioreactors No.1 and No. 2 – 0.26 liters, No. 3 and No. 4 – 0.4 liters, No. 5 – 0.3 liters, No. 6 – 0.7 liters, No. 7 – 0.033 liters, No. 8 – 0.02 liters. On day 23: bioreactors No. 1 and No. 2 – 0.55 liters, No. 3 and No. 4 – 0.6 liters, No. 5 – 0.85 liters, No. 6 – 0.97 liters, No. 7 – 0.033 liters, No. 8 – 0.02 liters.

Values of biogas yield on day 23 (in terms of dry substance and organic carbon) are shown in Table 3.

| Bioreactor number | 10 days | 15 days | 23 days |
|-------------------|---------|---------|---------|
| 1.2               | 0.026   | 0.068   | 0.143   |
| 3.4               | 0.036   | 0.085   | 0.128   |
| 5                 | 0.025   | 0.047   | 0.134   |
| 6                 | 0.049   | 0.097   | 0.135   |
| 7                 | 0.039   | 0.039   | 0.039   |
| 8                 | 0.013   | 0.013   | 0.013   |

* - average value

The largest amount of biogas emission was obtained from bioreactors No. 1-2 (0.143 liter per gram), No. 6 (0.135 liter per gram) where amount of organic carbon of Chlorella Sorokiniana was consisted of 78%, 76%, inoculum – 22%, 24% correspondingly.

The data of the experiment (Table 3) is possible to use for preparation of optimal composition of composite mixture from residual biomass of microalgae Chlorella Sorokiniana and inoculum for biogas production and biogas potential assessment. Biogas potential depends on mixture composition with inoculum, and it is 128-143 m$^3$ per ton of organic carbon and 63-70 m$^3$ per ton of wet mass.

The data of the experiment (Table 3) show that it is possible to use composition including residual biomass of microalgae Chlorella Sorokiniana and inoculum for biogas production and biogas potential assessment.

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