Physical-mechanical properties of organic waste reduced to bioreactor

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Abstract. The article provides detailed information on the aspects of normalization of daily organic waste loaded into bioreactors by anaerobic treatment of organic waste. The long-term experiments conducted by the authors are compared. During the operation of bioreactors, the amount of pure biomass loaded daily on moderately used bioreactors is determined to be fed to the fermentation process in the bioreactor for a certain period of time. It has been shown that this time corresponds to days 4 and 8 in the bioreactor and that the composition of the biomass fed into the bioreactor differs from each other in assessing the variable state of pH. As a result of the increase in N⁺ concentration, it was found that by loading the organic medium, it can bind the free ions in it and adjust the total amount of pH in the bioreactors. It has only been reported that the pH amount in the bioreactor begins to increase after the binding and adjusting quantities are exhausted, which has a negative effect on biogas formation.

1. Introduction
One of the most important issues in the world is to predict the impact of the daily loading of organic waste on the dynamics of loading in large and small devices and plants of renewable energy production. In this regard, the loading dose leads to a sharp change in the dynamics of anaerobic processing in small and large units and plants of renewable energy production. Of particular importance is the prevention of adverse effects of anaerobic processes on the moderate development of renewable energy sources in the absence of loading dose regulation [1,2,3,4]. The injection of biomass into a bioreactor over a period of time is called the injection rate, which in most cases is also determined by the amount per day. Practitioners claim that during the study of carotene waste tracking [5,6,7], the daily amount of biomass not only accelerates the anaerobic process in the bioreactor, but also helps to improve the quality of the biogas obtained.

In the work of some authors [4,5,6,7] it is stated that the amount of SN4 in the biogas content of the biogas obtained from a small daily loaded biomass is high. Several other authors [8,9,10,11] and devices [12,13] attribute the fact that the amount of organic waste loaded daily does not directly affect the quality of products obtained directly from bioreactors, but only with the volume of products processed. The fact that pig manure is not anaerobically processed in bioreactors in a separate composition in the world practice and their composition is very complex requires constant introduction of a certain amount into the bioreactor, which requires the introduction of complex devices for processing organic waste with such composition [17,18,19,20].
2. Materials and Methods
In many experiments [14,15], it was found that the decomposition rate of organic biomass in the bioreactor increased from 1.60 to 15.17 g / kg when the daily amount loaded on the bioreactor increased from 4% to 33% of the biomass volume in the bioreactor. However, an increase in the daily amount of biomass causes a sharp decline in the quality of the biomass obtained. Studies in a 70-liter laboratory have also shown an effect on the biogas quality of the bio fertilizer obtained from the bioreactor at large loads of the total reactor capacity. The amount of organic matter loaded is known to be due to the decomposition of dry organic matter in the biomass, but experiments show that an increase in the daily loaded amount gained from 2% to 30% affects all bioreactor products (Table 1).

| D,% | Gas output, l / day | Biogas composition, % |
|-----|---------------------|------------------------|
|     |                     | CH4 | CO2     |
| 2   | 64,42               | 67,00 | 31,74 |
| 3   | 73,36               | 67,49 | 31,03 |
| 4   | 84,40               | 67,81 | 32,89 |
| 6   | 144,72              | 68,62 | 31,57 |
| 10  | 145,72              | 70,78 | 29,41 |
| 12  | 129,64              | 70,16 | 29,43 |
| 15  | 177,88              | 66,80 | 32,88 |
| 20  | 218,08              | 61,63 | 34,14 |
| 25  | 309,7               | 57,60 | 36,3  |
| 30  | 410,07              | 53,64 | 39,4  |

Given the above, it is necessary to take into account the need to standardize biomass for bioreactors for anaerobic process, depending on the conditions of use of bioreactors and the type of biomass and to have a certain order at each stage of their normal operation [1,14,16]. In our initial experiments, we conducted experiments on multifunctional standardized laboratory equipment assembled for experiments in the laboratory of the Polytechnic University under the grant No. 2008/6 "Analysis of Korean pig manure for biogas production" with South Korea's Korea Total Chemical CO, LTD (Figure 1).
3. Results and Discussion

The results obtained on the basis of experiments were analyzed in the laboratory of KOREA TESTING & RESEARCH INSTITUTE. The obtained results and their analyses were compared with the amount of biomass in the decomposition mode in the results of experiments at 10 kg QOM / m³ / day in thermophile mode. In addition, the purity of anaerobically processed biomass and the possibility of discharging biomass into open water basins at the level required by the agreement with Korea Total Chemical CO, LTD on "Analysis of Korean pig manure for biogas production" and biochemical oxygen demand (BKKBT) were analyzed. It is referred to as BOD in international standard requirements, and the chemical oxygen demand (CCT) of organic waste changed accordingly (referred to as SOD in international standard requirements).

The analyses obtained on 20 and 26 August 2008 (Appendices 1 and 2) show that the biochemical oxygen demand and the chemical demand for oxygen decreased from 37900 mg / l to 12900 mg / l and from 13000 mg / l to 5800 mg / l, respectively. This indicates that according to the international standard, organic waste is suitable for disposal in open basins. Another indicator can be seen that the amount of floating fatty acids decreased from 29,100 to 11,300 in 6 days.

The results of the above considerations and research have led to a number of experiments on the change in the amount of load relative to the volume of devices operating in the anaerobic process. In the experiments, organic waste with a moisture content of 67% was brought from the barn in advance and stored at the level of experimental requirements [21]. The laboratory equipment was loaded with organic waste with a moisture content of 88, 92 and 96% in 3 types of cases. In the primary treatment plant, the organic waste was heated to biomass to anaerobic temperature regime. The remaining technological parameters of the process are kept unchanged in the device. Graphs of temperature change under the influence of the amount of livestock organic waste loaded into a moderately operating laboratory bioreactor were constructed, and the effect of this change on the amount of biogas released in the anaerobic process was studied (Figure 2).

![Figure 2. The effect of the amount of daily loads (ADL) on the regulator on the separation of biogas from the bioreactor: 1 - curve ADL - 10%; 2 - curve ADL - 30%; 3 - curves ADL -15%. DOM- dry organic matter](image)

It is known that small daily loads on the bioreactor slightly increase the amount of gas in the bioreactor by providing the initial amount of oxygen to the semi anaerobic bacteria and the biogas output. However, the higher the daily load, the more directly the oxygen in it affects the biogas output. G. Nikitin’s experimental results show that an excess of a certain amount leads to a sharp disruption of the anaerobic process [22]. If we pay attention to the analysis of the obtained results, we can see that when the daily load is high (30%), the biogas output accelerates in the first 10 days (Figure 2, curve 2) and then falls sharply. This can be seen not in the increase in the amount of organic waste loaded daily, but in the effect of the free oxygen in its composition. In the first curve shown in Figure 2, biogas production can be seen to be somewhat moderate at 15% of the daily loaded organic waste. However, at 10% loading dose (curve 3) it can be seen that biogas production is somewhat stabilized and the composition of the organic fertilizer obtained in such cases is also significantly stabilized. In most cases, the daily amount loaded on bioreactors has been shown to dramatically affect the pH
amount in bioreactors and cause the process to stop [24,25,26]. In conclusion, the effect of pH on biogas separation was studied in the following series of experiments (Figure 3) and the pH value was measured continuously (Figure 4).

**Figure 3.** Bioreactor device: 1-rating; 2-thermostat; 3 metering valve; 4-bioreactor.

**Figure 4.** Draining pig manure from the anaerobic process measuring the amount of pH in time

The results obtained are plotted graphically in Figure 5.

**Figure 5.** Variation of the daily loading pH in a quantitative unit of time in a metered biogas plant:
*Line 1 shows the presence of large amounts of pig urine in the organic content (organic waste moisture level 98%); Line 2 - clean manure and wastewater (tap water); Line 3 - pig manure obtained from the cleaning channel; Line 4 - organic waste from a ditch where plants grow for more than 10 days in the natural state*

In moderately used bioreactors, the analysis of Figure 5 shows that the pH of organic waste (pig manure) loaded into the bioreactor is 6.5, and at the end of the anaerobic process, pH = 7.5 [27]. It is known that the change in pH of the biomass loaded into the bioreactor per unit time indicates that this anaerobic process is properly organized. However, it is stated in the authors' work that the cleaner and fresher the organic waste loaded into the bioreactor, the higher its involvement in the anaerobic process. The main reasons for this are the presence of very small amounts of volatile fatty acids in pure manure [27,28]. Therefore, when determining the amount of biomass loading into bioreactors, it should be borne in mind that the pH content is one of the main indicators. Aging of organic waste indicates a negative impact on biogas output, and in order to prevent this, it is recommended that organic waste be placed in a bioreactor without constant and long-term storage as possible. Subsequent experiments have studied the effect of normalized organic waste on a bioreactor on the biogas produced per unit time, depending on the process temperature regime in the bioreactor. To do this, the process of loading 4 different amounts of biomass into the bioreactor was analyzed, and its results are shown graphically in Figure 6.
The process of heating the temperature accelerates the production of biogas in moderately reactive bioreactors over a period of time not within the exact limits of the complex reactions taking place in it. Figures 2-5 show that biogas production accelerates during the first 3-4 days of fermentation of organic waste in bioreactors, even at different temperatures, and lasts for 7-8 days.

The volume of biomass loaded on large bioreactor devices will also be larger. In this case, the normative loading process of the biomass requires a large amount of manual labor. As a solution to this problem, it is proposed to carry out mechanization the normative loading process of biomass. Normative mechanism (device) can also be designed for small devices. To do this, as a normative loading device, it is possible to use a screw or a blade with a helicoid surface. We control the loading norm by geometrically modeling the screw or blade surface as a working surface. Working surface determinants will be given shapes and dimensions of the surface guide curve and surface forming lines, as well as the working surface’s step. Geometrically modeled normative loading device allows one to control the geometrical parameters of its surface. As a result, the technological process that takes place in such devices will be possible to control, depending on the input and output parameters. In addition, the geometrically modeled normative loading device allows one not only to mechanization the loading process of the biomass, but also to automate and control it [29,30].

4. Conclusion
This means that the amount of pure biomass loaded daily in moderately used bioreactors during the operation of the bioreactor feeds the fermentation process in the bioreactor for a certain period of time. This time corresponds to days 4 and 8 in the bioreactor. Experiments have shown that rapidly fermenting types of organic waste are drastically reducing the pH in bioreactors. Therefore, it is necessary to require the loaders to be loaded at a limited level and slowly during the cooling period. Differences in the composition of the biomass fed into the bioreactors assess the variable state of pH. If the N+ concentration increase, the organic mode binds the free ions in it by loading, which adjusts the total amount of pH in bioreactors. Only after the binding and adjusting quantity is exhausted the pH amount in the bioreactor begins to increase, which negatively affects the formation of biogas. Although the main indicator of the anaerobic process in bioreactors is biogas from their useful volume, organic fertilizer produced by the anaerobic process, loss of weed seeds and minimization of pathogenic micro flora form the basis of renewable energy production and anaerobic processing from organic waste.

References
[1] Sze S M 1969 Physics of Semiconductor Devices (New York: Wiley–Interscience)
[2] Dorman L I 1975 Variations of Galactic Cosmic Rays (Moscow: Moscow State University Press)
[3] Caplar R and Kulisic P 1973 Proc. Int. Conf. on Nuclear Physics (Munich) vol 1 (Amsterdam: North-Holland/American Elsevier)
[4] Szytula A and Leciejewicz J 1989 *Handbook on the Physics and Chemistry of Rare Earths* vol 12, (Amsterdam: Elsevier)

[5] Kuhn T 1998 Density matrix theory of coherent ultrafast dynamics *Theory of Transport Properties of Semiconductor Nanostructures*, vol 4, (London: Chapman and Hall) chapter 6 pp 173–214.

[6] Imomov S Z 2009 Heat transfer process during phase back-and-forth motion with biomass pulse loading. *Applied Solar Energy*, **45**(2), 116–119 https://doi.org/10.3103/S0003701X09020121.

[7] Williams A, Pourkashanian M, Jones J M 2001 Combustion of pulverized coal and biomass, *Progress in Energy and Combustion Science*, **27**, 587-610.

[8] Satyanov S V, Zhakharchenko A N, Zhakharchenko A A, Rufai I 2010 Biogas in modern technologies of agriculture *Reports of the TSHA, Moscow: Publishing House of the Russian State Agricultural Academy named after K. A. Timiryazev*, **282**(1), 460-463.

[9] Shayakhmetov R G 2010 Investigation of mixing methods in methane tanks. *Young scientist*.12 (1) 43-45

[10] Wheeler B, Matuka A M (Eds.) Use of renewable energy sources. *Agricultural energy resources*. 16.02.2011.

[11] Tjurina, L E, Tabakov N A, Lefler T F, Turitsyna E G 2020 Influence of unconventional mineral complexes on the biochemical and hematological parameters of the blood of broiler chickens *IOP Conference Series: Earth and Environmental Science*, 052008

[12] Sovetov B. Ya., Yakovlev S. A. 2001. Modeling of systems. *Studies for universities (Moscow: Higher school)*.

[13] Chiarelotto M, Damaceno F M, Tonial L M S, de Mendonça Costa L A, Bustamante M A, Moral R, Marhuenda-Egea F C, Costa M S S M 2019 Reducing the composting time of broiler agro-industrial wastes: The effect of process monitoring parameters and agronomic quality *Waste Management*, **96**, 25-35.

[14] Yan M, Su H, Hantoko D, Kanchanatip E, Shahul Hamid F B, Zhang S, Wang G, Xu Z 2019 Experimental study on the energy conversion of food waste via supercritical water gasification: Improvement of hydrogen production. *International Journal of Hydrogen Energy*, **44**(10) 4664-4673.

[15] Sharma P, Gaur V K, Kim S-H, Pandey A 2020 Microbial strategies for bio-transforming food waste into resources *Bioresource Technology*, **299**, 122580.

[16] Sharipov K, Sultanov M, Usmonov K, Mamadaliyeva M, Shodieve, Kayumov T 2013 Service of biogas plants *Acta of Turin polytechnic university in Tashkent. Tashkent.*, 3, 50-51.

[17] Niu J, Shao R, Liu M, Yan Y, Dou M, Liu J, Zhang Z, Huang Y, Wang F 2019 Porous Carbons Derived from Collagen-Enriched Biomass: Tailored Design, Synthesis, and Application in Electrochemical Energy Storage and Conversion *Advanced Functional Materials* **29** (46) https://doi.org/10.1002/adfm.201905095.

[18] Imomov S, Khokhikova N, Alimova Z, Nutirov I, Temirkulova N 2019 Oil purification devices used in internal combustion engines *International Journal of Innovative Technology and Exploring Engineering*, **9**(1) 3103-3107.

[19] Auth. Certificate No. 1781549 1992 Liquid dispenser. *Bulletin of Inventions* 46

[20] L.A.Rovinskiy, S.M.Shamshurko2007 RF Patent No. 229 5490 Liquid level dispenser. *Bulletin of inventions* 8.

[21] Shodie E, Mamadaliyva Z and Imomova N 2020 Checking the reliability of biogas installations by stimulation models of markov processes on faults tree *IOP Conference Series: Materials Science and Engineering*, **883**(1), 012172.

[22] Imomov S, Sultanov M, Aynakulov S, Usmonov K, Khafizov O 2019 Mathematical Model of the Processes of Step-By-Step Processing of Organic Waste *International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISICT 2019. Institute of Electrical and Electronics Engineers Inc*.

[23] Nikitin G A 1990 Methane fermentation in biotechnology. (Kiev. Vyshch. Shkola)
[24] Matyakubov B, Begmatov I, Raimova I, Teplova G 2020 Factors for the efficient use of water distribution facilities. *CONMECHYDRO* - 2020, IOP Conf. Series: Materials Science and Engineering **883** 012050 doi:10.1088/1757-899X/883/1/012050.

[25] Willey J M, Sherwood L M, Woolverton C 2011 Prescott’s Microbiology. (McGraw-Hill Companies Inc. New York, USA: Microbial Interactions)

[26] Lamot A G W 1985 Air agitation and Pachuca tanks *Carnation Journal of Chemical Engineering*, **35**, 153-160.

[27] Rojas C, Fang S, Uhlenhut F, Borchert A, Stein I, Schlaak M 2010 Stirring and biomass starter influences the anaerobic digestion of different substrates for biogas production *Eng. Life Sci.* **10** 339-347

[28] Salimov O, Imomov S 2017. Optimization of the processes of a biogas plant on an individual order *Irrigatsiya va melioratsiya* **2** (8) 47-49.

[29] Juraev T Kh 2017 Conceptual Designing of Mold Board’s Surface by Geometrical Modeling. *American Journal of Mechanics and Applications* **5**(4) 28-33. doi: 10.11648/j.ajma. http://www.ajmechanics.org/archive/621/6210504.

[30] Juraev T.Kh 2020 Decision Maintenance Management Problems in Agriculture Engineering by Constructive Geometric Modeling Methods *Maintenance Management*. First published in London, United Kingdom, by IntechOpen, **23-37** http://dx.doi.org/10.5772/intechopen.79248.