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STUDY OF THE SIGNIFICANCE OF THE PH OF THE SUBSTRATE OF THE BIOGAS INSTALLATION DURING TREATING IT WITH A LOW-FREQUENCY ELECTROMAGNETIC FIELD

M.M. Zablodsky, Doctor of Technical Sciences, Professor

National University of Life and Environmental Sciences of Ukraine

P.B. Klendiy, Candidate of Technical Sciences, Associate Professor

SE NULES of Ukraine "Brzezany Agrotechnical Institute"

O. P. Dudar, teacher

SSE "Berezhany Professional College of NULES of Ukraine"

E-mail: pklen_@i.ua

Abstract: *The article considers the issue of studying the value of pH, substrate in the process of methane fermentation in the mesophilic regime and the influence of the electromagnetic field of industrial frequency.*

The aim is to investigate the influence of electromagnetic fields on the pH value of the substrate during fermentation.

Different types of microorganisms are involved in the process of methanogenesis, and the decisive role in it is played by methane-forming archaea, which are most sensitive to pH and should be in the range of 6.5 - 8. Therefore, it is necessary to check the effect of low frequency electromagnetic field on substrate pH. The study was performed for 25 days on two substrates, one of which was exposed to a low-frequency electromagnetic field with an electromagnetic induction of 3.5 mT. The research results show that the pH value of the substrate exposed to the electromagnetic field during the methane fermentation process was within acceptable limits, and the second substrate decreased, that is, it was acidified.

Key words: ***methane fermentation, substrate, pH value, electromagnetic field***

Topicality. From the point of view of modern scientific ideas [1-3], the process of methane fermentation is based on the results of research and study of biochemistry and microbiology of the process, as well as the study of natural anaerobic biocenoses (eg rumen ruminants) and artificial biocenoses - microbiological reactors - methane tanks. To the final products in the process of methane fermentation occurs in the following main stages - hydrolysis, acidogenesis, acetogenesis and methanogenesis.

At the first stage of anaerobic fermentation of organic substances by biochemical cleavage (hydrolysis) is the decomposition of macromolecular compounds (carbohydrates,

fats, proteins) into low molecular weight organic compounds. In the second stage, with the participation of acid-forming bacteria, further decomposition occurs with the formation of organic acids and their salts, as well as alcohols, CO_2 and H_2, and then H_2S and NH_3. The final bacterial conversion of organic matter into CO_2 and CH_4 is carried out in the third stage of the process (methane fermentation). In addition, from CO_2 and H_2 is formed in the future an additional amount of CH_4 and H_2O.

Anaerobic degradation of biopolymers is carried out by a multi-species microbial association, which is united by strong trophic bonds. Mandatory components of the community are primary anaerobes of hydrolytic microflora (hydrolyze biopolymers), fermentation microflora (ferment monomer molecules), acetogenic microflora (convert various fermentation products into substrates of methanogenesis) and secondary anaerobes - methanoforming archaes.

These reactions occur simultaneously, and methane-forming bacteria have much higher requirements for the conditions of their existence than acid-forming ones. Because they require a completely anaerobic environment and longer time to reproduce. The rate and extent of anaerobic fermentation of methane-forming bacteria depend on their metabolic activity. Since the metabolic activity and the level of reproduction of methane bacteria is lower than that of acid-forming ones, an increase in the amount of organic matter formed can result in an excess of volatile acids, which reduces the activity of methane bacteria.

Analysis of recent research and publications. It is impossible to unambiguously determine the nature of the relationship in the bacterial cenosis, which consists of more than two species. The type of relationship within the community can vary depending on many factors that affect the whole process of transformation of organic matter, so determining the optimal parameters of anaerobic decomposition of the substrate and effective management of this process is important from a theoretical and practical point of view.

The main parameters of the anaerobic process in the transformation of complex biopolymers include primarily the pH level, temperature and redox potential of the environment, which affect the course of metabolic processes. [4].

The optimal pH level for methanogen metabolism is considered to be 6.5-8. At lower pH values, non-ionized LVHs become toxic, and at pH values above 8, ammonia has a strong inhibitory effect [5,6].

The aim is to investigate the influence of electromagnetic fields on the pH value of the substrate during fermentation.

Materials and methods of research. In order to determine the effect of the electromagnetic field on the pH, electrical resistance and EMF during the fermentation of pig manure under anaerobic conditions, experimental studies were performed. Pig manure of 25 g was loaded into two fermenters of 200 ml of seed from the active bioreactor, one of which was exposed to a low-frequency electromagnetic field with an electromagnetic induction of 3.5 mT. The installation of electromagnetic radiation was turned on three times a day for 15 minutes. Measurements of pH values were performed, respectively, devices pH-301 and P 577 every 5 days of fermentation for 25 days.

The device pH-301 when measuring the electromotive force (EMF) works with the electrode system, which in aqueous solution creates an electromotive force that corresponds to the equation:

$$E=E_i+S(pH-pH_i), \quad (1)$$

where: E - EMF of the electrode system;

S - slope of the electrode system, mV / pH;

pH- is the negative decimal logarithm of the activity of hydrogen ions;

E_i- is the value of EMF at the isopotential point, mV;

pH_i - is the pH value at the isopotential point.

The device uses a silver chloride reference electrode.

To create an electromagnetic field, we use the stator of a single-phase capacitor motor type KD180-4 / 56RKA. A voltage of -28V with a frequency of 50 Hz was applied to the electric motor. The general view of the experimental installation is shown in Fig.1

Operating mode - mesophilic - t = 37-390C;

Fig.1.Experimental installation:

1 - measuring tube of biogas outlet from the bioreactor in which the electromagnetic field was exposed; 2 - measuring tube of biogas output without impact; 3 - tesla meter; 4 - laid stator with substrate; 5 - laid substrate, 6 - movable platform for mixing the substrate of experimental samples

Research results and their discussion. The most common mistake is the overfeeding of bacteria with a rapidly decomposing substrate, which leads to the accumulation of acids through acid-forming bacteria, hydrolyzing and acid-forming bacteria in an acidic environment with a pH of 4.5-6.3 reach the optimum of their activity. In this regard, there may be a very sharp drop in pH, which will not survive other bacteria. Bacteria that form acetic acid and methane can live only at neutral or slightly alkaline pH 6.5-8. The following is true for all bacteria: if the pH level exceeds the optimal level, they become slower in their life, which slows down the formation of biogas, so you need to create an optimal anaerobic biocenosis, when all microorganisms develop proportionally.

The influence of the electromagnetic field on the substrate with pig manure during methane fermentation allows to maintain a pH not lower than 6.5, which does not exceed the allowable value (Fig.2, 1), and the pH value of the substrate not affected by the electromagnetic field fell below the allowable value , 2). This is due to the fact that in the

first case, colonies of microorganisms develop proportionally and the cleavage products of each species of microorganisms are fully used by the next species, which contributes to comfortable conditions, and in the second case, acid-forming microorganisms develop faster and produce more cleavage product.

Anaerobic microorganisms belong to the magnetosensitive, which have a mechanism of magnetoreception, that is have special organelles - magnetosomes. By their structure, they are small bubbles made of a double membrane filled with nanocrystals with magnetic properties. These crystals are like small magnetic needles, most often composed of iron compounds - Fe3O4 or Fe3S4, ranging in size from 35 to 150 nm. The magnetosome maximizes the magnetic dipole moment of the cell and causes it to move along the lines of force of the magnetic field. The movement along the magnetic lines is necessary for the bacterial cell in order to find a comfortable habitat for it [7,8].

Membrane proteins of the magnetosome are encoded by magnetosome genes, which are present in the form of clusters in the genomes of all currently studied magnetotoxic bacteria (MTV) [9]. These clusters are relatively close to each other in the genomes and are surrounded or interrupted by certain types of genomic structures, suggesting that in some MTBs the magnetosome genes are organized as a magnetosomal genomic island that can be transmitted to other different bacteria through horizontal gene transfer (HGT).). Due to the improvement of genetic systems in some MTBs, the functions of several magnetosomal membrane proteins in the biomineralization of the magnetite magnetosome chain have been demonstrated, although the roles of the majority remain unknown [10]. How the genes involved in magnetotaxis common to all MTBs originated and were transmitted during evolution is still debated, although there is evidence that magnetotaxis occurred only once, regardless of the composition of the magnetosome crystal, and was then transferred independently of origin to all groups containing MTB, as well as through HGT between closely related bacteria [11]. This allows you to increase the colonies of microorganisms and, accordingly, to intensify the process of methanogenesis (Fig. 3). The increase in the colonies of microorganisms is evidenced by the change in electrical resistance and e p s of the substrate, as increased the number of iron-containing microorganisms, respectively, the electrical resistance and e p s of the substrate is less

(Fig.4, 1 and Fig. 5, 1) and vice versa with fewer microorganisms higher parameters (Fig. 4, 2 and Fig. 5, 2)

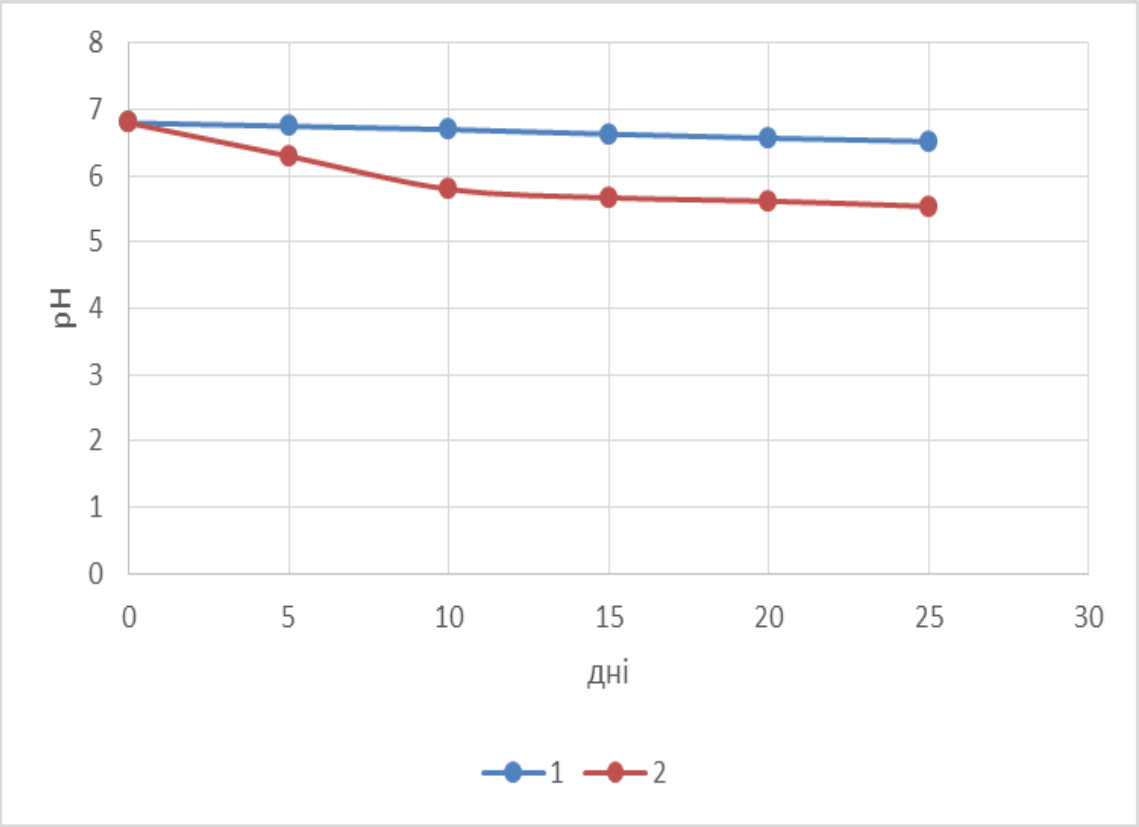

Fig.2. Change in pH value during anaerobic fermentation of pig manure:

1 - when exposed to an electromagnetic field on the substrate; 2 - without influence

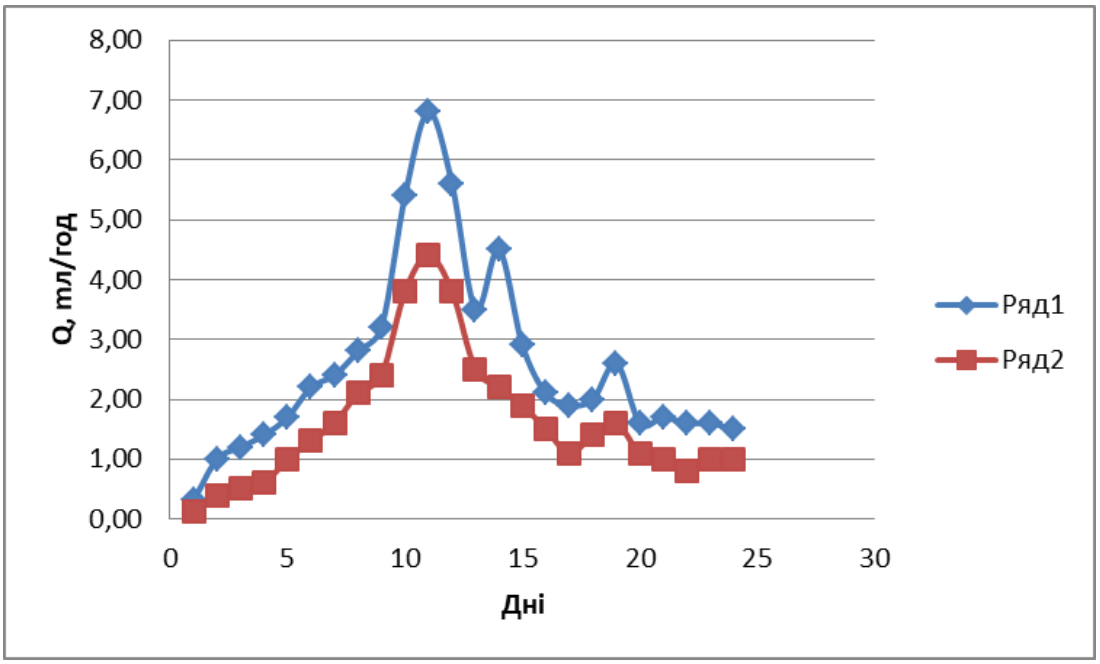

Fig.3. Biogas yield when exposed to a magnetic field on the substrate - 1 and without exposure – 2

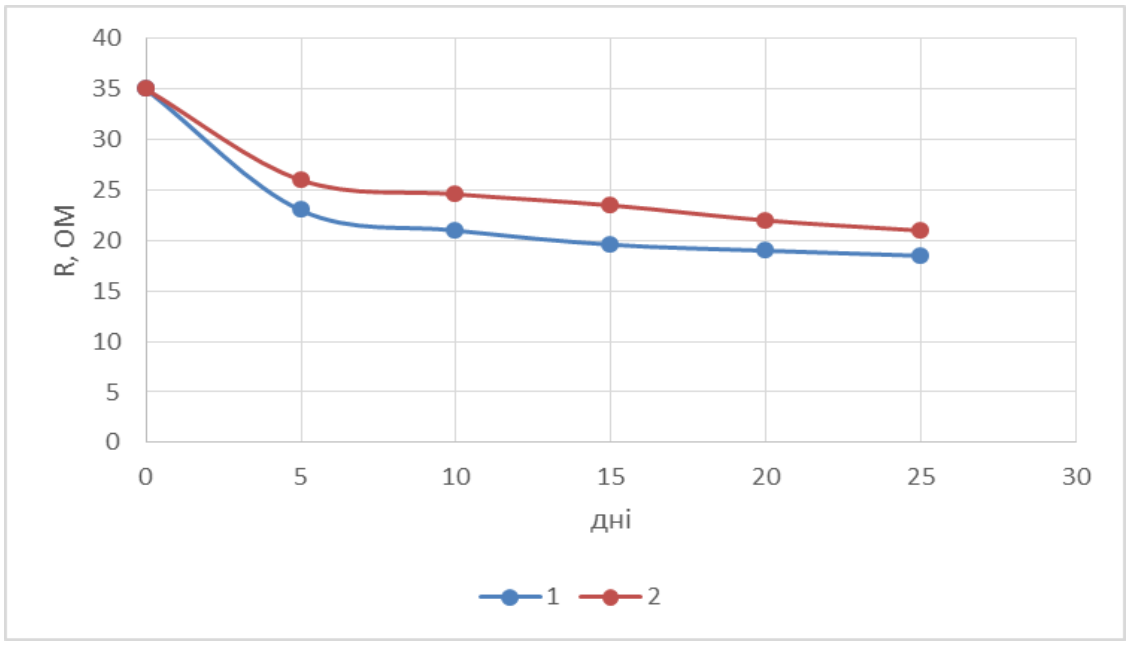

Fig.4. Change in the value of electrical resistance during anaerobic fermentation of pig manure:

1 - when exposed to an electromagnetic field on the substrate; 2 - without influence

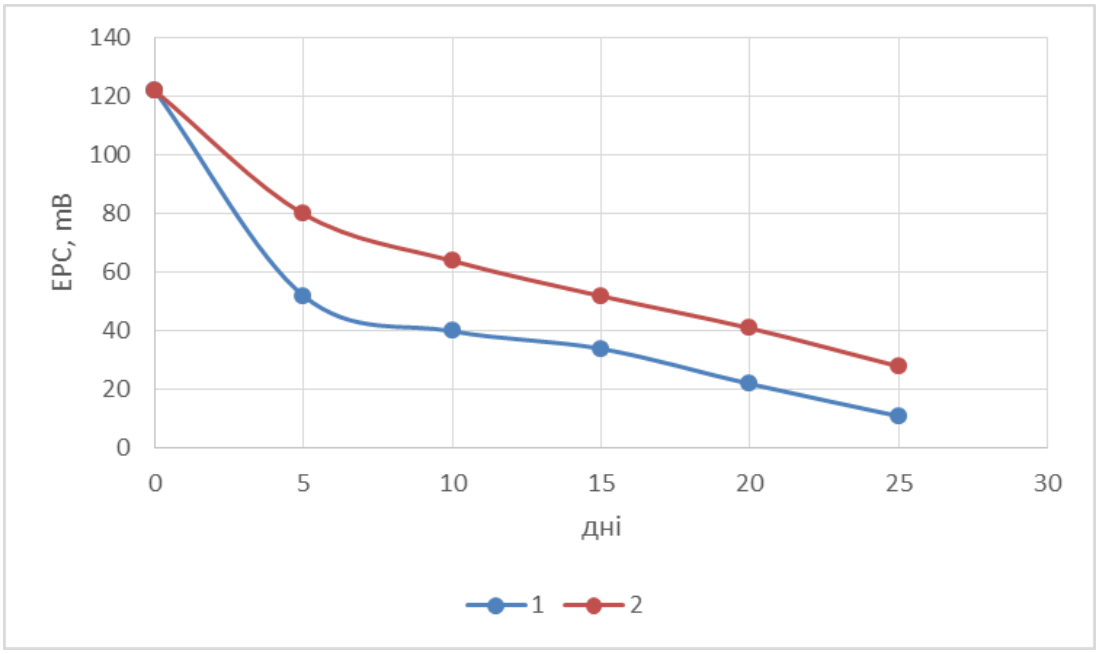

Fig.5. Change in the value of EMF during anaerobic fermentation of pig manure:

1 - when exposed to an electromagnetic field on the substrate; 2 - without influence

Conclusions and prospects. Based on the research, we can conclude that the effect of low-frequency electromagnetic field on the substrate of pig manure during anaerobic fermentation allows to maintain a pH value of not less than 6.5, which is within a

comfortable environment for microorganisms and a decrease in electrical resistance and e p s, which indicates an increase in colonies and biogas

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ДОСЛІДЖЕННЯ ЗНАЧЕННЯ РН СУБСТРАТУ БІОГАЗОВОЇ УСТАНОВКИ ПРИ ОБРОБЦІ ЙОГО НИЗЬКОЧАСТОТНИМ ЕЛЕКТРОМАГНІТНИМ ПОЛЕМ

М. М. Заблодський, П. Б. Клендій, О.П. Дудар

Анотація. *У статті розглядається питання дослідження значення pH субстрату в процесі метанового бродіння при мезофільному режимі і впливі на нього електромагнітного поля промислової частоти*.

Мета дослідження –встановити вплив електромагнітних полів на значення pH субстрату в процесі зброджування.

У процесі метаногенезу задіяні різні види мікроорганізмів, а вирішальну роль в ньому відіграють метаноутворюючі археї, які найбільш чутливі до значення pH і яке повинно знаходитись в межах 6,5 – 8. Тому потрібно перевірити вплив низькочастотного електромагнітного поля на величину pH субстрату. Дослідження проводилось протягом 25 діб на двох субстратах, один з яких піддавали впливу низькочастотного електромагнітного поля з електромагнітною індукцією 3,5 мТл. Результати досліджень показують, що значення pH субстрату який піддавався впливу електромагнітного поля впродовж процесу метанового зброджування знаходилось в допустимих межах, а другого субстрату зменшилось, тобто проходило його закислення.

Ключові слова: ***метанове бродіння, субстрат, значення pH, електромагнітне поле***

ИССЛЕДОВАНИЕ ЗНАЧЕНИЯ pH СУБСТРАТА БИОГАЗОВОЙ УСТАНОВКИ ПРИ ОБРАБОТКЕ ЕГО НИЗКОЧАСТОТНЫМ ЭЛЕКТРОМАГНИТНЫМ ПОЛЕМ

Н. Н. Заблодский, П. Б. Клендий, О. П. Дударь

Аннотация. *В статье рассматривается вопрос исследования значения pH субстрата в процессе метанового брожения при мезофильном режиме и воздействии на него электромагнитного поля промышленной частоты.*

Цель исследования – установить влияние электромагнитных полей на значение pH субстрата в процессе сбраживания.

В процессе метаногенеза задействованы различные виды микроорганизмов, а решающую роль в нем играют метанообразующие археи, наиболее чувствительные к значению pH, которое должно находиться в пределах 6,5 – 8. Поэтому нужно проверить влияние низкочастотного электромагнитного поля на pH субстрата. Исследование проводилось в течение 25 суток на двух субстратах, один из которых подвергался воздействию низкочастотного электромагнитного поля с электромагнитной индукцией 3,5 мТл. Результаты исследований показывают, что значение pH субстрата, который подвергался воздействию электромагнитного поля, на протяжении процесса метанового сбраживания находилось в допустимых пределах, а второго субстрата уменьшилось, то есть проходило его закисление.

Ключевые слова: ***метановое брожение, субстрат, значение pH, электромагнитное поле***