DIGESTATE PLUS CHLORELLA IS IMPORTANT ALTERNATIVE BIOTECHNOLOGY FOR SOILS AND AGRICULTURAL PRODUCTION IN THE CONDITIONS OF CLIMATE CHANGE

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Abstract: During the last decade, the topic of climate change has become an inseparable part of our everyday life. The significant anthropogenic impact on the environment contributes to the acceleration of this process and leads to catastrophic consequences in some regions. This directs the views of scientists in many branches to develop and implement environmentally friendly technologies, waste-free production and use of non-traditional approaches to the ecology of production, including agriculture. One of the areas that has recently attracted the attention of scientists in many countries is the use of microalgae, among which Chlorella vulgaris is gaining popularity, and has a wide range of uses. The research presents the results of treatment with a suspension culture of living cells of microalgae Chlorella vulgaris, as well as a suspension preparation of Chlorella vulgaris, grown on digestate, on changes in the parameters of the chemical composition of sand and on the sowing quality of winter wheat seeds of the Shestopalivka variety. A high positive correlation is established between the length of roots and the coleoptile of winter wheat seedlings of the Shestopalivka variety (r = 0.86) in the variant with the aqueous concentration of the Chlorella plus Digestate suspension.

Keywords: Absheron, *Malus*, introduction, diseases, pests.

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Introduction:

As advanced to long-term observations, climatic zones are shifting to the north and west, heat and droughts are becoming more catastrophic, and many extreme weather events that were previously rare are often repeated in unusual seasons and in unusual areas. This is related to climate change, which affects crop production, the condition of forests and water facilities, livestock and fish farming, etc. Almost all the agricultural areas in Ukraine are in the zone of risky farming (the area with a natural deficit of rainfall), where there is a constant risk of loss of crop volumes in the too-dry year or loss of crop quality in the over-rainy year.

The fluctuations in wheat yield in the south of the country are among the highest in the world: The actual yield can be up to 30% lower than planned. This is a consequence of increasingly difficult conditions, fewer precipitations, reduced soil moisture, and lower soil water levels.

However, agriculture, in turn, also has a significant impact on climate change. Thus, in 2018, the share of greenhouse gas emissions from the agro-industry in Ukraine reached 12% and now shows the highest growth trend among all sectors. By 2030, emissions from the sector could increase by 64%.

Agriculture also has a significant impact on the binding (accumulation) of carbon in soil and carbon dioxide emissions because of land use change. For example, the introduction of organic components of soil on the eagle lands and pastors, the conversion of forest lands into agricultural use.

Therefore, to prevent future soil fertility losses, complex measures should be developed and implemented that will reduce risks from climate change, and will also contribute to the accumulation of organic matter in soil and increase plant stability to adverse conditions of cultivation.

The way to climate neutrality means the development and use of a whole range of new clean technologies throughout the economy: In transport, construction, production, energy and agriculture. In the next decades will be the greatest industrial transformation of our time. And those who develop and produce technologies that will be the foundation of tomorrow's economy will have the greatest competitive advantage. The scope of this opportunity is obvious to all. The International Energy Agency (IEA) estimates that by 2030, the market for clean energy technologies will be about $650 billion a year, more than three times the level of today. Moreover, climate change is already associated with huge costs, and we have no time to move to a clean economy. The EU is preparing a major transition to clean technology to achieve climate neutrality by 2050. Net technology is now the investment sector in Europe, which is growing most rapidly: In 2020 – 2021 it doubled. We have an urgent need to make this energy transition without creating new dependencies. We have a Green Deal Industrial Plan - a plan to make Europe a centre of clean technologies and industrial innovations on the way to climate neutrality.

Such measures can be attributed to the use in agriculture of microalgae of the Chlorella vulgaris family.

Micro fluidity stands at the beginning of trophic systems, playing the most important role of the functioning of the entire biosphere. But lately, their industrial production is becoming more and more important, as they are being used in different spheres of the national economy. This is also the production of food, feed, fertilizer, and a new promising direction – biofuel production.

The idea of cultivation of microalgae on an industrial scale arose in Germany in the middle of the last century, when they tried to obtain food oils from atomized algae (however, selected cultures were characterized by low productivity). Soon green microalgae from the birth of Chlorella and Scenedesmus, which were mainly cultivated in the following years, attracted the attention of scientists. However, at that time the technological features of microalgae growth were still weak, so their interest in them was temporarily reduced. The renewal of research in the field of industrial cultivation of microalgae has begun since the end of the 60-ies, and interest in them does not reach today (Sharilo & ets, 2020; Onishchenko, 2013; Bodnar, 2017).

The industrial growth of microalgae has a half-century history. The obtained biomass is used in agriculture, food industry, perfumery, pharmacology, medicine and other sectors of the national economy. The world Algora has about 40 thousand species (in Ukraine – more than 5 thousand species), but the most perspective are the representatives of the families of Chlorella, Dunaliella, Scenedesmus, and Spirulina. The most productive were diatomic (silicon) algae (Diatoms) and green algae (Chlorophyceae) (Bilyavtseva, 6).

Literature review

Directions of application of Chlorella

Many substances contained in chloride are accumulated in its cultural environments – simply put, in the water in which it grows. Thus, according to the Bulgarian scientist P.I.Stancheva, a cellular mass contains up to 350 different substances, and a culture environment up to 310! These are various carbohydrates, proteins, organic and fatty acids, carbohydrates, spirits and air, carbon compounds, vitamins, stubble and other substances with high biological activity, which can be successfully used in medicine and agriculture (Muzafarov & Taubayev, 1984; Muzzafarov & Milogradova, 1965; Muzzafarov & Taubaev, 1974)

Microalgae are considered a promising raw material for bio-diesel fuel. The development of microalgae in culture is a way of mitigating the effects of climatic and seasonal factors of growth, while the formation of strain and productivity enables biomass to be obtained throughout the year. The leaders in this field are the Netherlands, Germany, South Africa, the USA and Australia. Experts from China and Japan are actively searching. Scientists are working on the optimization of parameters of biocultivators and bioreactors for active cultivation of biomass of algae and processing of raw materials, the search for productive species and strains of algae. (Muzzafarov & Taubaev, 1984; Golub & Levtun, 2016; Harwood & Callow, 1989; Krienitz & Wirth, 2006; Nakamura, 1964)

Chlorela (Fig. 1) in agriculture is a 100% organic highly effective natural biostimulator of plant growth, which accelerates root formation, growth, development and flowering. These algae increase the protective properties of plants, and antistress resistance to adverse external influences, including drought, acclimatization, and transplantation (Kravets & ets, 1968; Rakhimov & Yakubov, 1978).

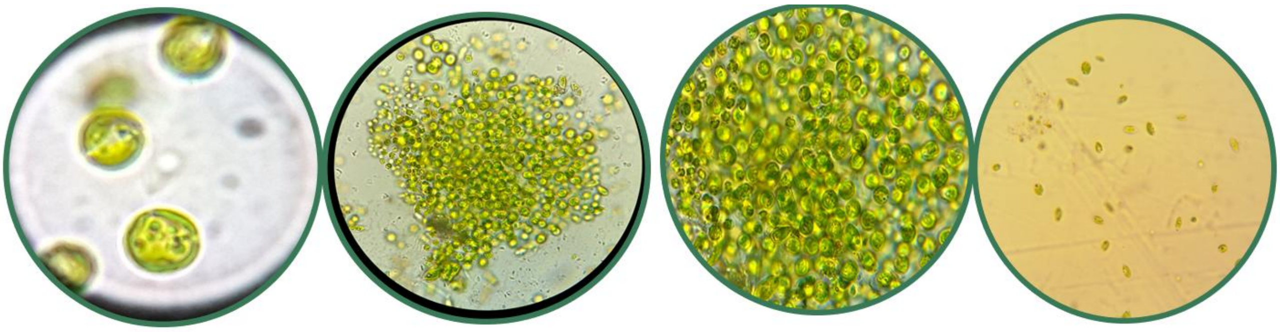

Fig. 1. Chlorela under microscope.

Chlorella is a wonderful green fertilizer. By applying it to watering plants, it is possible to reduce the cost of mineral and organic fertilizers. Algae produce a huge mass of organic matter, enrich water and air with oxygen, and are the basis of nutrition for many water and soil animals. A person uses the food, uses it as food for cattle, organic fertilizer and raw materials for the production of various chemical substances and medicinal preparations. Algae participate in the formation of sediment and soil formation. Algae in soil composition allocate oxygen to the environment. Organic matter of soil is formed from its dead lattice, which increases its fertility. Therefore, mass reproduction of soil algae – "flowering" of soil, which is observed most often in spring or autumn, is considered the purpose of good harvest (Onishchenko & Dvoretsky, 2013; Bilyavtseva, 2020; Rakhimov & Yakubov, 1978; Ryabov & Kirilenko, 1968; Gorda & ets, 2010).

Agronomically useful soil algae are not only because they actively capture air nitrogen, but also because they can produce biologically active substances, including phytohormones and amino acids. They provide optimization of the hormonal state and amino acid composition of plants, which positively influences the production process of crops (Onishchenko & Dvoretsky, 2013; Bilyavtseva, 2020; Zolotareva & ets, 2008; Vasigov, 1966).

Chlorela is an organic, highly effective natural biostimulator of plant growth, which accelerates root formation, growth, development and flowering. For animal and poultry production, Chlorine is an alternative source of protein, vitamins and amino acids. It contains 40–55% of protein and exceeds even alfalfa. In terms of 1 ha, algae yield 20-30 tons of pure protein, and alfalfa – 2-3,5 tons. Chlorella increases the protective properties of plants, and antistress resistance at adverse external influences, including drought, aclimatization, and transplantation (Onishchenko & Dvoretsky, 2013; Bilyavtseva, 2020; Vasigov, 1966).

The expediency of the application of Chlorella vulgaris is based on the very high content of biologically valuable substances in it. The dry biomass of Chlorella vulgaris contains more than 45% of crude protein, including irreplaceable amino acids, 30–35% of carbohydrates, and 7 –10% of fat. In the composition of the green cell contains irreplaceable in nutrition of animals amino acids: Lysine (10 %), methionine (1 %), tryptophan (2 %), arginine (15 %), histidine (3 %), leucin (~6%), jesolycin (~3%), fenilane (~2%), treonin (~2%), valine (~5%), as well as chlorophyll (2%). Vitamins of groups A, B1, B2, B5, B6, are on the share of vitamins in Chlorella vulgaris biomass. Q9, Q12, C, D, E, K, PP); minerals and micronutrients (Ca, N, P, Mg, K, Cu, Fe, S, Zn, Co, Mn, Zr, Rb, I), каротин. Wild strains in native form contain microelements – iodine, bromine, arsenic, cobalt, potassium, phosphorus, iron, magnesium, and antibiotics. The cultural environment of chlorides contains a wide number of physiologically active substances, among which are: Growth and development regulators (auxins and hybrids, phenol compounds, natural steroids, vitamins, amino acids); active cell divesters (cytokinina); natural antibiotics "chlorelin", which destroys pathogenic microflora.

The main advantages of microalgae as organic fertilizers for increasing soil fertility:

– high conversion efficiency of photons (approximately 3-8% against 0.5% for terrestrial plants), which allows to receive higher crops of biomass per hectare), high growth of microalgae cells;

– high carbon dioxide absorption capacity;

– microalgae do not demand the quality of water for growth, therefore, sewage, polluted, salty and other waters can be used for their cultivation;

– microalgae can use nitrogen and phosphorus from different sources of wastewater (for example, agricultural effluents, industrial and municipal wastewater) in the process of life, providing an additional benefit of biological wastewater treatment; - for the cultivation of microalgae, it is possible to use arable, desert and saline lands, which are not suitable for agricultural production of food products;

– production is non-seasonal, raw materials can be obtained in batches almost all year round;

– microalgae can be raw materials for a wide range of products (proteins, polysaccharides, pigments, biopolymers, feeds, fertilizers);

– the organization of microalgae biomass production does not require complex equipment and a high level of production automation.

According to O.K. Zolotareva, until recently, microalgae, photosynthetic organisms with a high growth rate, were considered as a source of vitamins, polyunsaturated fatty acids, natural dyes and other valuable biologically active compounds and were cultivated mainly for the needs of pharmacology, medicine, as well as for the enrichment of human and animal diets. With the deepening of the energy crisis, the rapid negative impact on the environment and the actualization of the search for alternative renewable energy technologies, attention to microalgae as energy raw materials and cells with resource-renewing and pathogen-suppressing potential is rapidly increasing (Gorda & ets, 2010).

Microalgae cultivation technology

Microalgae can be grown on an industrial scale in phytobioreactors, which are closed, controlled, automated continuous cycle systems that allow for the least costly maintenance of culture hygiene (Figure 2). Due to the modular design of the equipment, production space is saved (Bilyavtseva, 2020; Muzafarov & Taubayev, 1984); Muzzafarov & Milogradova, 1965; Muzzafarov & Milogradova, 1965; Muzzafarov & Taubaev, 1974; Muzzafarov & Taubaev, 1984; Golub & Levtun, 2016; Vasigov, 1966).

Among the main elements of microalgae cultivation technology are:

CO_2 supply: algal biomass contains about 50% carbon on a dry mass, which is asymmetric from carbon dioxide. For the production of 100 tons of algae biomass, it is necessary to bind about 180 tons of CO_2, which should be received continuously during the light day. Openly, the absorption of carbon dioxide comes from the atmosphere. For the active growth of microalgae, it is necessary to enrich the matte solution with a mixture of air and CO_2 and remove O_2. Carbon dioxide can be obtained from a CO_2 tank or produced from the exhaust gases of the diesel generator after their previous purification (Muzafarov & Taubayev, 1984; Muzzafarov & Milogradova, 1965; Muzzafarov & Taubaev, 1974).

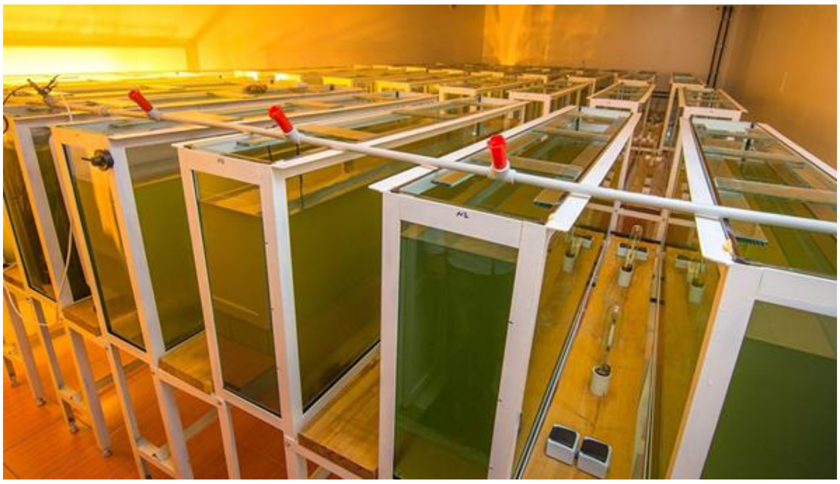

Fig. 2. Scientific and production complex of biotechnology company "Zhyva Chlorella", Ukraine (Vasigov, 1966).

Growing algae in reservoirs is ineffective because in ordinary reservoirs surface algae cover the rays of the sun, which are located in the depth. Also, there are problems with water evaporation and the appearance of algae-weeds. Therefore, now the settings envisage the vertical positioning of algae.

Elements of nutrients: as a rule, a mother liquor solution of nutrients is prepared and added to the water every 10 hours. Burrelli, Chu-13, Tamiya, Bolda and other nutrient media are used (Muzafarov & Taubayev, 1984; Muzzafarov & Milogradova, 1965; Muzzafarov & Taubaev, 1974).

Temperature: most algae develop in water bodies at a temperature of 35-40 °C, as the temperature rises, their number drops sharply.

Periodically, the culture medium is sent to the filtration line, which is a set of hydro cyclones, where the primary separation of algal biomass from the liquid takes place. The filtrate is returned to the mother tank to prepare the nutrient solution. The algae biomass concentrate is sent to microwave drying for drying and then used for various industries (Muzafarov & Taubayev, 1984; Muzzafarov & Milogradova, 1965; Muzzafarov & Taubaev, 1974; Vasigov, 1966).

Digestate and directions when use

Digestate is a product of the bioconversion of organic materials in the process of methane fermentation, as a result of which complex organic substance is dissolved into more simple organic compounds, mineralized substances, microbial biomass and biogas, consisting mainly of methane (55-70%) and carbon dioxide (30-45%). The methane content in biogas largely depends on the raw materials used (corn silage, beet pulp, post-alcohol bard, molasses, cattle manure, chicken manure, etc.) and the fermentation technology

Renewable sources in general, and bioenergy in particular, are growing steadily, outpacing the use of all other fuels. With the right energy policy, Ukraine will have a similar result. At the end of 2020, the share of renewables in the EU was 22%: 12.5% - bioenergy and 9.5% - other RES. This means that today bioenergy is the largest (after nuclear energy) energy sector in the EU with a steady positive development trend. The EU's legally enshrined goal is to reach 45% of energy from

RES in 2030, with bioenergy accounting for about half of it.

For example, Oudon Biogas, which has 72 farms in the Laura region of France, is launching an agricultural biogas project. In April 2022, Oudon Biogas laid the first brick of the plant, which will be built using anaerobic digestion technology and will start operating in 2023. More than 140,000 tons of manure produced on its 72 farms will be recovered. 85 % of the raw materials are agricultural by-products such as manure and straw. Grain waste and local agricultural by-products can also be used to feed the plant. As a result, 55 GWh of biomethane will be produced per year, which is equivalent to the green energy consumption of 9,000 families in the Craon region. The biogas produced will be fed into the French national grid and will avoid emissions of approximately 14,000 tons of CO2 into the atmosphere, which is equivalent to the greenhouse gas emissions generated by 5,500 cars (with an average distance of 20,000 km per year). The resulting digestate will be used on 7,700 hectares of Oudon Biogaz farms, which will reduce the use of chemical fertilizers.

The project will provide farmers with access to digestate, a natural fertilizer with agronomic characteristics that can replace chemical fertilizers.

A typical technology for the production of biogas from agricultural raw materials (manure, litter, corn silage, pulp, crop residues, etc.) is methane fermentation in semi-flow bioreactors (Figure 3).

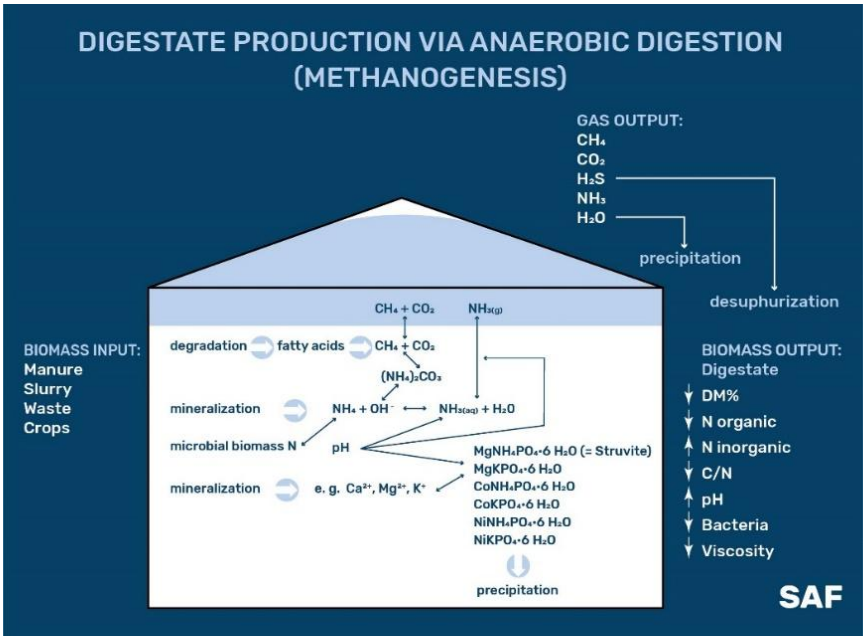

Fig. 3. Production of digestate in the process of methane fermentation.

As a result of the breakdown of organic matter, mineralisation processes, and the release of biogas, the digestate produced is lower in moisture compared to the feedstock:

– The content of dry matter is reduced, humidity is increased accordingly, and the level of strength is reduced. The humidity of the digestate is usually 94-96%, although it can vary in the range of 92-99%.

– The content of ammonia nitrogen (directly available for plant nutrition) increases by 10-70%. The increase in the proportion of ammonia nitrogen depends on its initial content in the feedstock - a smaller increase during fermentation is typical for pig and cattle manure, and a larger increase for food waste and plant material.

– The C/N ratio decreases due to the release of part of the carbon with biogas. The optimal C/N ratio for methane fermentation is 20-30, which is also considered optimal for soil biocenosis.

– The content of pathogenic microflora and viable weed seeds is reduced because of simultaneous exposure to temperature (usually 38-40°C) and acidity in the bioreactor for a long time (at least 25-30 days).

In the process of methane fermentation, part of the organic matter is transformed into biogas, which reduces the content of carbon (C), hydrogen (H), oxygen (O), sulfur (S), and nitrogen (N) in the feedstock. With each 1 m3 of biogas produced, the feedstock loses an average of 502 g of carbon, 114 g of hydrogen, 517 g of oxygen, 5 g of sulfur, and only 0.06 g of nitrogen (Fig. 4).

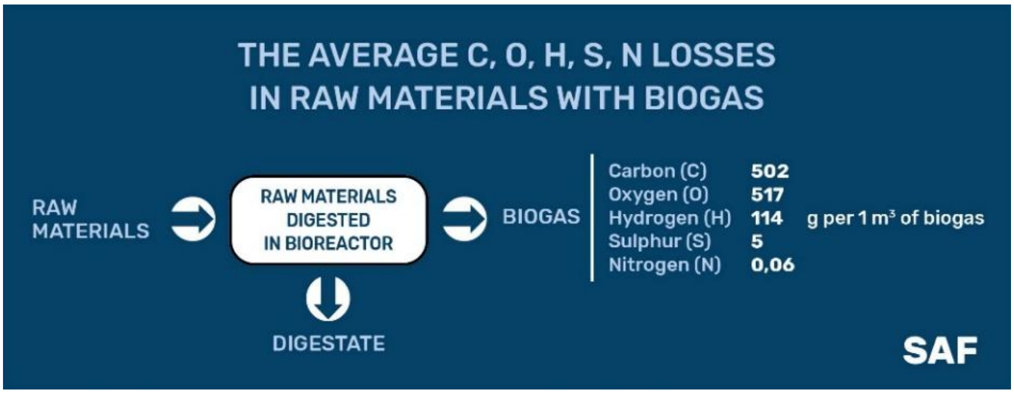

Fig. 4. Average output C, O, H, S, N with selected biogas.

A significant portion of the sulfur can be returned to the digestate if hydrogen sulfide removal is provided in the bioreactor's sub-dome space. If biogas desulphurization takes place in a separate facility, the efficiency of hydrogen sulfide removal is much higher, and the resulting sulfur-containing product (in solid or liquid form) can be a marketable product, for example, for the production of complex mineral or organo-mineral fertilizers.

All other input macro- and microelements are contained in the digestate as part of native or converted compounds. Therefore, the chemical composition of the digestate is determined mainly by the mixture of components entering the bioreactor, including raw materials for biogas production and various additives (enzymes, micro-nutrients, reagents, water, etc.).

Thus, digestate has the following characteristics that are important for soils and agricultural production:

It contains a complex of macro- and micronutrients necessary for plant growth (N, P, K, S, Co, Mo, Zn, Fe, Mn and others).

It has a high content of readily available nitrogen for plants (60-80% of the total nitrogen content).

It has a balanced C/N ratio (20-30).

It has a pH level close to neutral (6.5-8.0).

It doesn't contain (minimum content of) viable weed seeds and pathogenic microflora (subject to the required duration and temperature of the process).

2.4. Utilization of digestate from biogas plants by cultivation of microalgae

Digestate from biogas plants is also an organic fertilizer that can contain all of the above types of organic materials in a converted form.

Recycling organic materials back into the soil is considered in most cases the best environmental approach to close the natural nutrient and carbon cycles. Organic materials are a valuable source of essential nutrients (such as nitrogen (N), phosphorus (P_2O_5), potassium (K_2O) and sulfur (SO_3)) that are essential for plant growth and thus sustainable crop production. Organic materials are also a valuable source of organic matter that contributes to soil water saturation, facilitates mechanical processing and soil erosion resistance, etc.

At the same time, the return of organic material to the soil should be controlled in terms of both the agrotechnical effect (application should be balanced according to the type and condition of the soil, crops, etc.) and the environmental effect (application should not lead to deterioration of the sanitary and epidemiological situation, soil and groundwater pollution, etc.) Therefore, the use of pretreatment technologies for organic materials is appropriate and, in some cases, necessary.

Anaerobic digestion technology is one of the most efficient ways to bioconvert various types of organic materials, including those of agricultural origin.

Digestate application reduces the potential for soil erosion and improves soil productivity by increasing the organic matter content of the soil and improving its fertility, including through the supply of nutrients. Anaerobic digestion technology is essentially an important link in the recycling of organic raw materials in agriculture.

Digestate is commonly used as a fertilizer for crops without additional processing, thus replacing industrial mineral fertilizers. However, the need for efficient nutrient management, given the limited manure application options in areas with high animal density, as well as the depletion of the world's natural phosphorus and potassium reserves, makes the recovery and recycling of nutrients from manure and other waste streams increasingly important to farmers, technology providers, investors, and decision-makers.

Materials and Methods:

Object, subject, and methods of research

For the study, a suspension of Chlorella microalgae (TS U 03.0-37613791-001:2017), was used, which meets the requirements of the Organic Standard (certificate No. 21-1088-04) and is suitable for use in organic agriculture by the Standard of International Accredited Certification Bodies for organic production and processing, which is equivalent to European Union Regulations No. 834/2007 and 889/2008 .

The biotechnology company RPC Zhyva Chlorella (U Samvela Farm, Ukraine) grew Chlorella microalgae in the form of a suspension on the digestate of biogas plants produced in Moldova and produced a new type of organic fertilizer - Chlorella Suspension PLUS Digestate. The product was tested in the laboratory and in the field on cereals, green vegetables (sorrel, dill, parsley, coriander, spinach, and radish) and nut crops (almonds, hazelnuts)

To establish the effect of using the microalgae Chlorella, which was growing on digestate, we conducted an experiment that included the following stages:

The first stage involved several sand treatments to determine the best accumulation of organic matter in the sand, followed by the determination of nitrogen, phosphorus, potassium, organic matter, pH, and sulfur:

1st Variant - without treatment (control)

2nd Variant - water treatment

3rdVariant - Chlorella Start treatment

4th Variant - Chlorella Plus treatment (digestate)

The determination of nitrogen, phosphorus, potassium, organic matter, pH and sulfur in the respective samples was carried out at the laboratory of the testing centre of the Odesa branch of the State Institution "Institute of Soil Protection of Ukraine".

The second stage involved the treatment of winter wheat seeds with a suspension of chlorella microalgae, followed by their germination:

1st Variant - water treatment (control)

2nd Variant - treatment with Chlorella Start

3rd Variant- treatment with Chlorella Plus (digestate)

The object of research: germination processes of soft winter wheat seeds depending on the treatment of seeds with Chlorella suspension on different nutrient media (Fig. 5).

a *b* *c*

Fig. 5. *a)* Digestate *b)* The microalgae *Chlorella vulgaris's* Subcellular culture of living cells *c)* Suspension Chlorella plus digestate.

Subject of research: winter wheat variety Shestopalivka, germination energy, laboratory germination of seeds, root length and colloid of winter wheat seedlings

Laboratory studies were conducted in the laboratory of the Department of Field and Vegetable Crops of Odesa State Agrarian University. Both well-known scientific methods (experiment, analysis, hypotheses) and special methods (laboratory, comparative, calculation and statistical) were used in the research.

Results and discussions:

The Odesa branch of the State Institution "Institute of Soil Protection of Ukraine", the testing centre, conducted a study of the effect of the suspension culture of live cells of microalgae Chlorella vulgaris on sand, which was taken as a zero substrate (Table 1).

The pH value of the control variant was 7.1, compared to the experimental variant, where a suspension of Chlorella was introduced, which had a pH of 7.7 during the growing season.

The data of the research results obtained in the course of the work convincingly proved the uniqueness of the properties of the microalgae Chlorella as a natural biostimulant of plant growth and development.

Therefore, another form of chemical action of microalgae on the soil is changes in its pH. It is known that algae, assimilating carbon dioxide in the course of their life, alkalize the environment, which is observed in natural water bodies, in culture, and in soils. Since microalgae are unevenly distributed in the soil, significant soil alkalization by microalgae occurs in places where they accumulate, where conditions are particularly favourable for their development.

Table 1. Influence of the treatment of suspended culture of living cells of microalgae Chlorella vulgaris on the change of the chemical composition of the sand

	Indicator, determined, od. see	In fact				Marking of the normative document on the test method
		№ 1 sand control	№2 water control	№3 Chlorella Start	№ 4 Chlorella Plus Digestate	
1	Nitrogen, mg/kg	3,02	2,42	0,85	2,36	MU QINAO.M.-2984*
2	Phosphorus, mg/kg	24,04	19,52	75,39	31,68	GSTU 4114-2002
3	Potassium, mg/kg	111,8	59,52	125,2	135,3	GSTU 4114-2002
4	Organic matter, %	0,57	0,39	0,39	0,39	GSTU 4289:2004
5	pH	7,1	7,5	7,6	7,7	GSTU ISO 10390:2007
6	Sulfur, mg/kg	47,84	49,47	12,99	55,66	GSTU 8347:2015
7	Moisture, %	2,38	0,76	1,94	3,22	GSTU 12536-79

*Methodical guidelines for the determination of heavy metals in agricultural soils and crop production (1992).

Table 2. Influence of processing of winter wheat seeds of the Shestopalevka variety by suspension culture of living cells of microalgae Chlorella vulgaris on native quality in laboratory conditions, 2022.

Options for investi-gation	*Energy of germination of seeds, %*	*Simi-larity of seeds, %*	*Length of prophets*		*Length of roots*		*Number of roots*	
			sm	*% before control*	*sm*	*% before control*	pcs	*% before control*
1 Monitoring (Wa-ter)	*12,0*	*86,0*	*4,5*	*100,0*	*5,0*	*100,0*	*3,0*	*100,0*
2. Chlorella START®	*46,0*	*100,0*	*11,0*	*244,0*	*15,5*	*310,0*	*4,5*	*150,0*
3. Chlorella plus Digestate®	*44,0*	*100,0*	*9,5*	*211,0*	*13,0*	*260,0*	*5,0*	*166,6*

In the second stage, the germination of winter wheat seeds of the Shestopalivka variety was carried out. After treatment with a suspension culture of live cells of microalgae Chlorella vulgaris, seed germination was determined according to GSTU 41382002 "Seeds of agricultural crops. Methods of quality determination" (Table 2, Fig. 6, 7).

The stimulating effect of an aqueous solution of chlorella suspension on the germination energy and laboratory germination of winter wheat seeds of Shestopalivka variety was established

Under the influence of an aqueous solution of chlorella suspension Start, the length of winter wheat roots increased by 3.7-40.5% depending on the variety.

A high positive correlation between the length of roots and coleoptile of winter wheat seedlings of the Shestopalivka variety (r = 0.86) in the variant with an aqueous concentration of Chlorella Plus Digestate suspension was established.

In order to stimulate the germination of soft winter wheat seeds of the Shestopalivka variety, it is necessary to carry out pre-sowing treatment of seeds with a solution of chlorella suspension plus digestate.

Fig. 6. The holding of long castles of the wheat collection of soft winter variety Shestopalovka.

Fig. 7. Effect of the processing of the seeds of the suspension of chlorine on the length of wheat collection of soft winter variety Shestopalovka, (on the left – variant with the processing of chloride plus digestate, on the right - control).

Conclusıon:

Ukraine's developed agricultural sector with a large amount of agricultural land requires significant volumes of fertilizers. Over the years of Ukraine's independence, the forms of management and land ownership have hurt soil fertility. This is manifested in the loss of a significant portion of humus, imbalanced nutrient content, acidification and alkalization of soils, and a deficit of mobile forms of phosphorus, potassium, and several trace elements. Over-compaction, chemical and radiation contamination, and various types of erosion are also detected. The reasons for this state of the soil are, in particular, intensive production with the dominant use of mineral fertilizers and a critical drop in the use of organic fertilizers. All of these phenomena require immediate intervention and efforts to restore soil fertility, so the effective use of organic materials, in particular, chlorella suspension and digestate based on them, is extremely relevant in Ukraine.

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