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Original article

PROSPECTS FOR CREATION OF AUTONOMOUS LIFE SUPPORT COMPLEXES USING BIOLOGICAL SYSTEMS FOR ARCTIC AND FAR NORTH CONDITIONS

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Abstract. *The purpose of the study* is a comparative analysis of the implemented projects of closed ecological systems and the creation on their basis of own scheme of autonomous life-support complex for the conditions of the Arctic and the Far North. *Materials and methods of research.* The object of the study is implemented projects of closed ecological systems. The subject of the study is the principles of configuration of such projects, their main components and the relationship between them. *Research results and their analysis.* The support systems created at different times, with the purpose to be used in long-duration space flights or to carry out fundamental ecological research, were analyzed. Such projects were based on the use of biological systems, which opens the possibility of their use to ensure the autonomy of infrastructure in the Arctic and Far North. The scheme of the complex planned for development is proposed. This complex allows to recycle waste products, meets human nutritional needs and produces biofuel of the third generation.

Key words: *Arctic and Far North areas, biofuel, BIOSPHERA-2 project, life support systems, MELISSA project, microalgae, project, proposed life support system BIOS project*

Conflict of interest. The authors declare no conflict of interest

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Оригинальная статья

ПЕРСПЕКТИВЫ СОЗДАНИЯ АВТОНОМНЫХ КОМПЛЕКСОВ ЖИЗНЕОБЕСПЕЧЕНИЯ С ИСПОЛЬЗОВАНИЕМ БИОЛОГИЧЕСКИХ СИСТЕМ ДЛЯ УСЛОВИЙ АРКТИКИ И КРАЙНЕГО СЕВЕРА

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Резюме. *Цель исследования* – сравнительный анализ реализованных проектов замкнутых экологических систем и создание на их основе собственной схемы автономного комплекса жизнеобеспечения для условий Арктики и Крайнего Севера.

Материалы и методы исследования. Объект исследования – реализованные проекты замкнутых экологических систем. Предмет исследования – принципы конфигурации подобных проектов, их основные компоненты и взаимосвязь между ними.

Результаты исследования и их анализ. Проанализированы созданные в разное время системы жизнеобеспечения, назначением которых являлось использование в длительных космических полетах или проведение фундаментальных экологических исследований. Показано, что подобные проекты были основаны на использовании биологических систем, что говорит о возможности их применения для обеспечения автономности инфраструктуры в районах Арктики и Крайнего Севера. Предложена схема планируемого к разработке комплекса, позволяющего перерабатывать отходы жизнедеятельности, удовлетворять потребности людей в питании, производить биотопливо третьего поколения.

Ключевые слова: *биотопливо, микроводоросли, предлагаемый проект системы жизнеобеспечения, проект БИОС, проект БИОСФЕРА-2, проект МЕЛИССА, районы Арктики и Крайнего Севера, системы жизнеобеспечения*

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The Arctic Zone of the Russian Federation (hereinafter — the Arctic Zone, the Arctic) plays a major role in the development of the country: it generates 12-15% of the gross domestic product of Russia, it provides about a quarter of its total exports [1].

The Strategy for the Development of the Arctic Zone of the Russian Federation and Ensuring National Security for the period up to 2035 indicates the reasons for the importance of the Arctic Zone:

- The region's share of natural gas and oil production in the Russian Federation is 80 and 17%, respectively;
- The Arctic zone is a platform for major investment projects and ensures the demand for high-tech products;
- The continental shelf of the Russian Federation in the Arctic is a strategic reserve for the development of Russia's mineral resource base;
- The facilities of the strategic deterrence forces are located in the Arctic zone in order to prevent aggression against the Russian Federation and its allies*.

It should be noted that the Arctic, being a valuable resource and raw material base, is a possible area of conflict of interests of different countries. This leads to the need to establish military bases there and to strengthen the presence of the Armed Forces of the Russian Federation. The military infrastructure of the region serves not only to protect civilian structures, but also as a reference point for their deployment.

The development of the Arctic and the solution of military tasks is associated with certain difficulties [2]. They arise because of its harsh climate, limited transport accessibility, and low population density. Among the main factors are:

- lack of state support for delivery of fuel, food and other vital goods to remote settlements, low level of development of transport infrastructure;
- high share of local power generation based on economically inefficient and environmentally unsafe diesel fuel;
- weak interaction of the research and development sector with the real sector of the economy, openness of the innovation cycle;
- increasing conflict potential in the Arctic, which requires a constant increase in the combat capabilities of groups of troops of the Armed Forces of the Russian Federation, other troops, military formations and bodies in the Arctic zone.

Taking into account the problems outlined above, it can be assumed that biological life support systems could be a promising tool for the development of the Arctic and Far North territories. Such systems can produce food and fuel, provide comfortable living conditions for personnel at military bases, and, as a knowledge-intensive project, contribute to the development of the innovation sector of the economy. The importance of using such technologies in the development of the Arctic is emphasized by many Russian scientists, in particular, by the president of the Kurchatov Institute Research Center M.V. Kovalchuk [3]. Let us consider in more detail their types, characteristics and properties, which are useful for ensuring continuous work of people in the Arctic and Far North zones.

The purpose of the study is a comparative analysis of the implemented projects of closed ecological systems and the creation on their basis of own scheme of autonomous life-support complex for the conditions of the Arctic and the Far North.

Materials and methods of research. The object of the study is implemented projects of closed ecological systems. The subject of the study is the principles of configuration of such projects, their main components and the relationship between them.

Research results and their analysis.

General characteristics of life support systems

Life support systems are a set of equipment designed to ensure human survival in a hostile environment. For example, in space, underwater, underground or in desert areas [4].

Autonomous complexes that provide regeneration of vital resources are called closed-loop systems. When they are used, the initial supply of resources is placed in the system, after which there is a continuous process of their regeneration [5].

Depending on the processes underlying closed-loop systems, they are divided into physical-chemical and biological, as well as hybrid ones that include features of the former and the latter. Physical-chemical processes include the use of filters, methods of physical or chemical separation of substances, concentration processes, etc. Biological processes are based on the use of the ability of living organisms such as plants or bacteria to create or to break down various organic molecules. The first life support systems used were based on the use of physicochemical methods. This was due to the high degree of knowledge of such methods, to the small size of the devices, to the possibility of precise control of their work. On the other hand, they require large amounts of expensive energy and are not able to replenish food supplies, which must be delivered from outside. Biological processes are less well understood and more difficult to control. But the main advantages of closed-loop biological systems are: lower energy costs; possibility of recycling carbon dioxide, waste water and regeneration of oxygen and water; obtaining biofuel; possible replenishment of provisions — growing grain and vegetable crops, breeding some livestock and fish species, obtaining food additives, particularly protein and vitamin complexes with a radioprotective effect) [6-9].

Since the 1960s, such properties of these systems have led to increased interest in them on the part of scientists. The largest research works in this area were the projects BIOSPHERA-2, MELiSSA, BIOS-3. Let us carry out a comparative analysis of the structure and functioning features of each of these projects.

Project BIOSPHERA-2

The largest artificial ecosystem created to date is the BIOSPHERA-2 project. Its design was aimed at getting as

* On the Strategies of development of the Arctic zone of the Russian Federation and ensuring national security for the period up to 2035: Decree of the President of the Russian Federation of October 26, 2020 No. 645

close as possible to the complex structure and diversity of the Earth's ecosystem. For this purpose, models of many biomes were created, including tropical forest, savannah, ocean, desert. The purpose of the creation of the complex was to provide life support for 8 participants of the experiment for two years [10].

BIOSPHERA-2 contained 7 biomes, 2 of which represented anthropogenic ecosystems (human habitation and agricultural zone); the remaining 5 simulated natural zones: tropical forest, desert, savannah, swamp, and ocean [11].

The preset temperature in each biome was maintained by air conditioning systems installed in the basement of the complex. The ventilation system allowed controlling the flow of conditioned air back to the complex, depending on the simulated time of day or season [12].

The oxygen content in the atmosphere of BIOSPHERA-2 decreased during two years of the experiment. Studies have shown that some of the oxygen in the form of CO_2 molecules was absorbed by the concrete used in the construction of the complex, by sea water and by loose carbonate soils [13].

Soil reactor technology was used for air purification instead of traditional energy- and resource-consuming filtration and catalytic oxidation methods. The air was blown through a soil layer in which an active microbial community functioned to purify it from various gases, including CO, H_2S, SO_2, NH_3, etc. [13].

A complete hydrological cycle functioned in the complex. Water vapor was released into the atmosphere by evaporation from the surface of the soil and ocean, as well as by transpiration of plants. The condensate formed on the cooling coils of the air conditioners was collected in the troughs. From the troughs it was pumped into storage tanks. After collection, condensed water was distributed for the needs of the complex. Waste generated by humans and farm animals was treated with the participation of microbial and plant communities [10].

The BIOSPHERA-2 agricultural biome included beds for cultivating plants, several flooded areas for growing fish and rice, an orchard, and containers located on the balcony and in the basement. Disease- and pest-resistant plant varieties were pre-selected for use in BIOSPHERA-2. A total of 86 varieties of crops grew in the complex.

BIOSPHERA-2 was the first project that used farm animals and birds — goats, pigs, chickens. They fed on parts of plants that are inedible to humans. They performed several functions in a complex: they gave milk, eggs and meat, which served as an important component of the staff's diet, and they also took part in the cycle of substances, consuming inedible plant residues [13].

MELiSSA Project

The purpose of the Melissa project (Micro-Ecological Life Support System Alternative) is to study the mechanisms of functioning of regenerative life support systems for their application in long-term space missions. The concept of the project was first developed by Professor Mergeay in 1987 and has remained virtually unchanged since then [14].

The idea of the project is based on duplicating the functions of the Earth's biosphere without using the reserves of its resources. In contrast to the BIOSPHERA-2 project, the MELiSSA project does not create miniature copies of biomes already existing in nature. On the contrary, its biosphere is so reduced that it is only capable of carrying out the basic biological processes that support global ecological functions. MELiSSA consists of 5 compartments connected to each other and forming a single closed regenerative system — Fig. 1 [14].

In the first compartment, which is an anaerobic thermophilic bioreactor, decomposition of biological waste such as inedible plant parts, personnel waste, etc. takes place. The microbial community in this reactor is quite diverse. It includes various anaerobic thermophilic bacteria and microbiota contained in fecal matter.

The products of anaerobic fermentation are volatile fatty acids, mineral salts and ammonium, which are sent to the second compartment. There, under the influence of sunlight, photoheterotrophic bacteria Rhodospirillum rubrum decompose volatile fatty acids into carbon dioxide. After that, the obtained substances enter the third compartment.

The third compartment is an aerobic bioreactor in which nitrifying bacteria of the genera Nitrosomonas and Nitrobacter immobilized on special beads are co-cultivated. It is designed to convert ammonium nitrogen into the oxidized form of nitrate, because in this form it can be assimilated by higher plants and cyanobacteria.

The fourth compartment consists of two parts. The first part contains a photobioreactor with a culture of the photoautotrophic cyanobacterium Arthrospira platensis, intended mainly for oxygen regeneration and CO_2 absorption. In the second part, several cultures of higher plants (wheat, lettuce, beets) are grown, which are a source of nutrition and participate in oxygen enrichment of the air. In addition, the higher plants are able to regenerate drinking water by transpiration.

Finally, the fifth compartment represents the staff of the complex itself, whose basic needs are provided by the other components of the system. Currently, this role is played by laboratory animals.

BIOS Project

The first attempt to create a bioregenerative life support system was made in the 1960s in the USSR at the Institute of Biophysics of the Russian Academy of Sciences in Krasnoyarsk. The goal of the project was to create a closed system that would allow to simulate Earth conditions during long-lasting space flights for a long time. BIOS-1 was a system of two connected chambers. The first one — with a volume of 12 m^3 — was designed for human habitation. The second one contained an 18-liter photobioreactor in which Chlorella vulgaris microalgae were cultivated [15].

Рис. 1. Схема функционирования и взаимосвязи отдельных компартментов системы MELiSSA

Fig. 1. Scheme of functioning and interconnection of individual compartments of MELiSSA system

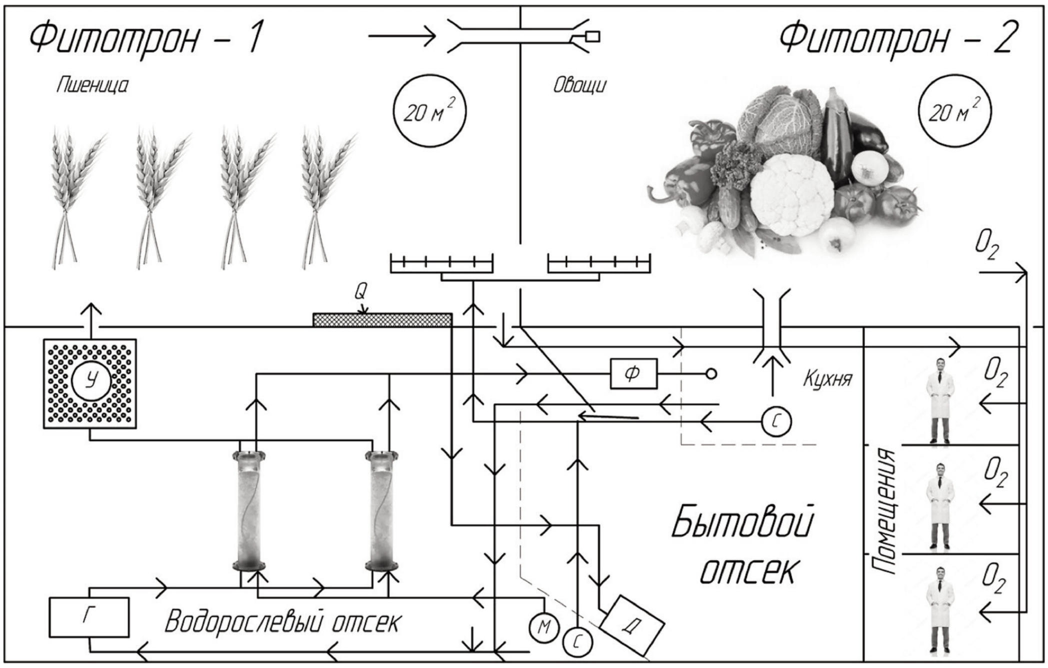

Рис. 2. Схема проекта БИОС-3: В - фотобиореактор, Г – газодувка, У – угольный фильтр, С – сборники сточной воды, Q – коллектор конденсата влаги, Д – емкость для кипячения и хранения питьевой воды, М – коллектор мочи, Ф – узел доочистки питьевой воды

Fig. 2. Schematic diagram of the project BIOS-3: C – photobioreactor, D – gas blower, U – carbon filter, C – waste water collectors, Q – moisture condensate collector, E – potable water boiling and storage tank, M – urine collector, F – potable water additional treatment unit

By conducting a series of 7 experiments, the scientists managed to achieve complete air closure of the system and 80-85% water closure. In addition, they managed to provide up to 20% of the daily human food [17]. In 1968, it was decided to attach an additional module to the BIOS-1, the so-called phytotron. It was intended for growing higher plants; the created unit was called BIOS-2.

In 1972, a fundamentally new artificial ecosystem — BIOS-3 (Fig. 2) was created. The hermetic construction was divided into 4 compartments. The first one was designed for the accommodation of 3 personnel and included sleeping quarters, a toilet, a kitchen, a control room and a working area. The second compartment contained a photobioreactor with microalgae which provided sufficient air regeneration

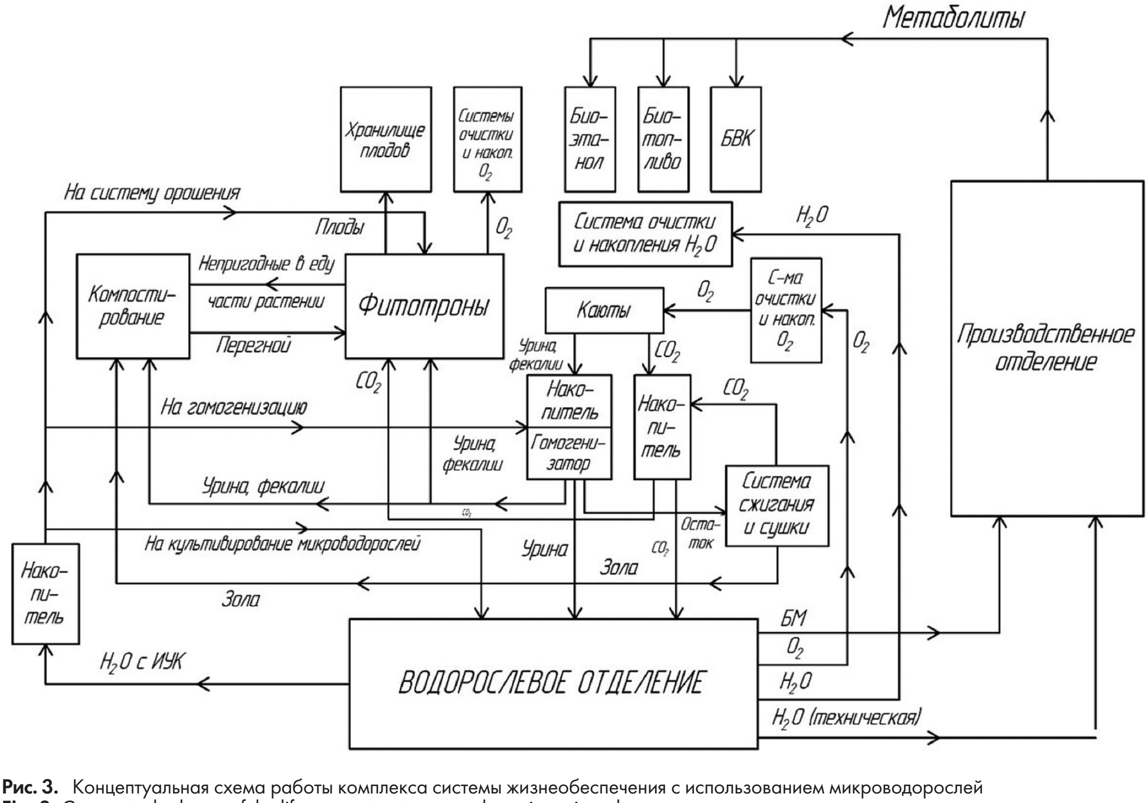

Рис. 3. Концептуальная схема работы комплекса системы жизнеобеспечения с использованием микроводорослей
Fig. 3. Conceptual scheme of the life support system complex using microalgae

Таблица / Table

Сравнительная характеристика существующих и проекта предлагаемой системы жизнеобеспечения

Comparative characteristics of existing and proposed life-support system design

Характе-ристика Charac-teristics	БИОС-1,2,3 – СССР 1963-1977 BIOS-1,2,3–USSR 1964–1977	БИОСФЕРА –США 1991-1994 BIOSPHERE –USA 1991–1994	MELISSA –Испания 2009 – наст. время MELISSA –Spain 2009 - present	CEEF –Япония 1998–2007 CEEF –Japan 1998-2007	Лунный дворец – Китай 2014 Lunar Palace – China 2014	Предлагаемый проект Proposed Project
Цель	Создание замкнутой системы, позволяющей в течение большого отрезка времени имитировать земные условия при длительных космических полетах	Создание модели земной биосферы для изучения фундаментальных экологических процессов	Изучение механизмов функционирования регенеративных систем жизнеобеспечения для их применения в длительных космических миссиях	Сбор экспериментальных данных для моделирования потоков углерода в биосфере	Создание замкнутой биорегенеративной системы жизнеобеспечения	Создание системы жизнеобеспечения для применения в условиях Арктики и Крайнего Севера
Goal	Creation of a closed system that allows to simulate Earth conditions during long-duration spaceflight within a long period of time	Creation of a model of the Earth's biosphere to study fundamental ecological processes	Study of mechanisms of regenerative life support systems functioning for their application in long-term space missions	Collection of experimental data for modeling carbon fluxes in the biosphere	Creation of a closed bioregenerative life support system	Creation of a life support system for use in the Arctic and Far North
Регенерация воздуха	Выделение O_2, поглощение CO_2 микроводорослями и высшими растениями; дополнительная очистка термокаталитическими фильтрами	Выделение O_2, поглощение CO_2 высшими растениями; контроль уровня CO_2 при помощи газоочистительного фильтра; дополнительная очистка с использованием технологии почвенного реактора	Выделение O_2, поглощение CO_2 высшими растениями и цианобактериями	Выделение O_2, поглощение CO_2 высшими растениями; обмен CO_2 и O_2 между отдельными модулями через систему обработки газов	Выделение O_2, поглощение CO_2 высшими растениями; наличие специальной системы очистки, удаляющей следовые газы	Выделение O_2, поглощение CO_2 высшими растениями и микроводоросля ми; использование фильтров и других механизмов дополнительной очистки
Air regeneration	O_2 release, absorption of CO_2 by microalgae and higher plants; additional purification by thermocatalytic filters	O_2 release, absorption of CO_2 by higher plants; controlling CO_2 levels with a gas filter; additional cleaning using soil reactor technology	O_2 release, absorption of CO_2 by higher plants and cyanobacteria	O_2 release, absorption of CO_2 by higher plants; exchange of CO_2 and O_2 between individual modules through the gas treatment system	O_2 release,, absorption of CO_2 by higher plants; special cleaning system removing trace gases	O_2 release, absorption of CO_2 by higher plants and microalgae; use of filters and other mechanisms of additional purification
Очистка воды	Получение конденсата, его кипячение и очистка ионно-обменными фильтрами	Сбор конденсата, его использование для работы дождевой системы и орошения полей; очистка фильтрами и УФ- излучениями для получения питьевой воды	Сбор конденсата, образуемого при транспирации растений, и его дальнейшая очистка	Сбор конденсата и его использование для приготовления питательного раствора для растений и в качестве питьевой воды	Сбор конденсата из воздуха с его дальнейшей очисткой при помощи мембранных реакторов	Часть воды, очищенной в водорослевом фотобиореакторе, подвергается фильтрации и обеззараживанию для использования в качестве питьевой; другая часть применяется для полива растений в фитотроне
Water treatment	Collection of condensate, boiling and purifying it with ion-exchange filters	Collection of condensate, its use to run the rainwater system and to irrigate the fields; treatment with filters and UV-radiation for drinking water	Collection of condensate formed during transpiration of plants and its further cleaning	Collection of condensate and its use for preparing nutrient solution for plants and as drinking water	Collection of condensate with its further purification using membrane reactors	Part of the water purified in the algae photobioreactor is filtered and disinfected for use as drinking water; the other part is used to water plants in the phytotron

Характеристика Characteristics	БИОС-1,2,3 – СССР 1963 –1977 BIOS-1,2,3– USSR 1964– 1977	БИОСФЕРА –США 1991–1994 BIOSPHERE – USA 1991–1994	MELISSA – Испания 2009 – наст. время MELISSA –Spain 2009 - present	CEEF – Япония 1998–2007 CEEF – Japan 1998-2007	Лунный дворец – Китай 2014 Lunar Palace – China 2014	Предлагаемый проект Proposed Project
Обработка отходов	Высушивание и хранение твердых человеческих отходов, использование мочи для полива пшеницы, сжигание несъедобных частей растений	Компостирование несъедобных частей растений и навоза животных; обработка отходов человеческой жизнедеятельности при помощи анаэробных баков и аэробных лагун	Разложение отходов в биореакторе с термофильным режимом работы; потребление промежуточных продуктов разложения фотогетеротрофными и нитрифицирующим и бактериями	Обработка отходов при помощи реактора мокрого сжигания наряду с системой химической фиксации азота из атмосферы; пиролиз отходов человеческой жизнедеятельности	Разложение фекалий и несъедобных частей растений в микробном биореакторе; дистилляция мочи и удаление её сухого остатка из системы	Обработка отходов человеческой жизнедеятельности путем очистки микроводорослями, компостирования, сжигания в муфельной печи. Несъедобные части растений подвергаются компостированию
Waste treatment	Drying and storing solid human waste, using urine to irrigate wheat, burning inedible plant parts	Composting of inedible plant parts and animal manure; treatment of human waste using anaerobic tanks and aerobic lagoons	Waste decomposition in a bioreactor with a thermophilic mode of operation; consumption of intermediate decomposition products by photoheterotrophic and nitrifying bacteria	Waste treatment using a wet combustion reactor along with a system of chemical fixation of nitrogen from the atmosphere; pyrolysis of human waste	Decomposition of feces and inedible plant parts in a microbial bioreactor; distillation of urine and removal of its dry residue from the system	Treatment of human waste by cleaning with microalgae, composting, incineration in a muffle furnace. Inedible plant parts are composted
Культивирование растений	Выращивание пшеницы, чуфы, овощей в фитотронах на искусственном субстрате с применением методов гидропоники	Выращивание растений на грядках, затопленных участках рисовых плантаций, фруктовый сад; всего 86 разновидностей культур	Выращивание пшеницы, салата-латука, свеклы и других культур как на твердом субстрате, так и методом гидропоники	Выращивание методом гидропоники 23 овощных культур, включая рис и соевые бобы	Выращивание 5 видов злаков, 15 видов овощей, одного вида ягод в почвоподобных субстратах	Предлагается выращивание в почве специально отобранных злаковых и овощных культур; использование экзометаболитов микроводорослей в качестве стимуляторов роста
Cultivation of plants	Cultivation of wheat, chufa, vegetables in phytotrons on artificial substrate using hydroponic methods	Cultivation of plants on beds, flooded areas for rice plantations, orchard; a total of 86 varieties of crops	Cultivation of wheat, lettuce, beets, and other crops both on solid substrate and hydroponics	Hydroponic cultivation of 23 vegetable crops, including rice and soybeans	Cultivation of 5 types of cereals, 15 types of vegetables, one type of berries in soil-like substrates	It is proposed to grow specially selected cereals and vegetable crops in the soil; to use exometabolites of microalgae as growth stimulators
Разведение животных	Не осуществлялось	Выращивание коз, кур, свиней и рыбы. Яйца, молоко и мясо служили важным источником питания персонала	Не осуществлялось; использовались лабораторные животные	Две козы	Мучные черви, использующиеся в качестве дополнительного источника белка	Не планируется
Animal breeding	Not carried out	Raising goats, chickens, pigs and fish. Eggs, milk and meat were an important source of food for the staff	Not carried out; laboratory animals were used	Two goats	Flour worms used as an additional source of protein	Not carried out

for three experiment participants. The remaining 2 compartments were occupied by phytotrons where wheat, chufa, and vegetables were grown [17].

The air was purified with a thermocatalytic filter that oxidized various organic impurities to carbon dioxide and water. The evaporated water was condensed and recirculated and used to prepare nutrient solutions for higher plants. Part of this water was boiled and used for household purposes and as drinking water. For this purpose, it was preliminarily passed through ion-exchange filters.

Faeces were dried and stored in a separate container, and the resulting water vapor was returned to the system; the urine entered the algae compartment and was used in the cultivation of microalgae. To close the system even more completely, a furnace designed to burn the inedible parts of the plant biomass was added [18].

Proposed life support system project

Based on the projects presented above, it is proposed to create a life support complex based on microalgae, whose metabolic features allow them to be used for various life support functions.

Due to their high protein content, microalgae are a promising source of valuable dietary protein [19]. The amino acid composition of the protein obtained from microalgae is balanced and meets the criteria established by the World Health Organization (WHO). It contains sufficient amounts of most essential amino acids. Microalgae cells are also rich in B and E vitamins, contain minerals and components with antioxidant, anti-inflammatory and immune-stimulating properties [20, 21].

The high percentage of lipids contained in microalgae biomass determines its potential for use as a source of 3rd generation biofuel.

Advantages of microalgae biomass compared to traditional raw materials used for biofuel production:

1. Microalgae are able to grow year-round, and as a result, their lipid productivity is much higher than that of the best oilseed varieties [22].

2. Cultivation takes place in an aqueous environment, but water consumption is less than that required to grow plants. This reduces the pressure on fresh water sources, which are in short supply in many regions [23].

3. Microalgae have a high growth rate and high lipid content. Lipids account for 20-50% of their dry biomass [24].

4. Nutrients for the cultivation of microalgae, in particular nitrogen and phosphorus, can be obtained from waste water. Thus, it is possible to combine the production of biofuel and waste treatment [25].

5. After lipid extraction from microalgae, valuable products such as protein and residual biomass can be obtained. They are used as fertilizer or livestock feed, and can also be fermented to produce ethanol or methane [26, 27].

6. The composition of microalgae biomass depends on the cultivation conditions. Thanks to this, the lipid yield can be significantly increased [28].

The fact that microalgae release phytohormones that can affect both the cells themselves and higher plants was established quite a long time ago. Semenenko's research showed the presence of indolyl-3-acetic acid in the growth medium of Chlorella sp. This acid causes stimulation of cell growth of both the algae themselves on agarized nutrient medium and wheat coleoptiles [29]. The positive effect of microalgae culture medium and extracts obtained from them on seed germination and plant growth (root length, stem height, branching, leaf and flower size) has been demonstrated in the works of many scientists [30-33]. This fact can be used in the cultivation of crops in biological life support systems.

Fig. 3 shows the conceptual scheme of the life support system complex using microalgae. Carbon dioxide that accumulates in the working and living spaces enters the algae compartment and phytotrons. There it is consumed by microalgae and higher plants.

The oxygen generated by photosynthesis is sent to the living space, the higher plants are used as a food source, and the algae biomass is used to produce protein-vitamin concentrate, bioethanol and biofuel. Human waste is purified with the help of microalgae. Some of it goes into compost or a muffle furnace. The wastewater treated by the microalgae is further filtered and disinfected. It is then used to supply the drinking water needs of personnel. The water that is not disinfected is used for technical purposes. The microalgae culture fluid containing growth stimulants is supplied to the plant watering system of the phytotron.

Comparative characteristics of the existing and the proposed life-support system project are presented in the table.

Conclusion

1.The use of life support systems based on biological systems will significantly increase the autonomy of infrastructure facilities located in the Arctic zone.

2. A comparative analysis showed that the most promising is the creation of life support complexes based on microalgae. Their metabolic traits make it possible to solve several important autonomy tasks simultaneously.

3. The implementation of the proposed project will provide staff with food, recycling waste, biofuel and valuable nutritional supplements.

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