

# Control system and optimization of parameters of a closed biosystem the size of a pico-satellite

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**Abstract.** The paper researched the sustainable functioning of the closed self-regulating biological system based on macrophytes *Fucus vesiculosus*, *Fucus inflatus*, *Laminaria saccharina* and *Chlorella vulgaris*. The authors describe the methods and apparatus for monitoring the composition and control of biological experiments with such a system, which is offered to spend on board the International Space Station (ISS). We also consider the option of the experiment on board the small satellite. The main task of automatically controlled experiment is to ensure the long-term functioning of the isolated biological system under conditions of weightlessness. Based on the analysis of the interaction structure of the main components of biological systems under study was developed a mathematical model of a closed biological system on the basis of aquatic organisms and holds its computer simulation, with which defined the conditions for the forecast can be carried out and state control investigated the conditions of maintaining it stable life. We consider the automated control system of a biological system, providing its stable operation. The main indicator of the functioning of biological systems encouraged to use the amount of oxygen in the air section and dissolved in water. As a biological control system parameters used by the lighting level and temperature of the water environment. In the experiment on autonomous spacecraft (microsatellite) proposed to manage the dampers in the heat-insulating sheath. The dependencies for defining the threshold oxygen concentration at which a correction of the control parameters.

## 1. Introduction

The study of self-regulating functioning of biological systems is the basis for evaluation of their adaptation capacity in normal and emergency situations. The relevance of the work in this direction is not only terrestrial and marine ecosystems, but also systems in space on the environmental and organismic levels [1]. A special role here belongs to biosystems of phytoplankton (algae), which in space can be a source of renewable oxygen and food [2]. In the future, they can be art organic production complexes producing medicines, dyes, composite materials, etc. The main advantage of algae to higher plants consist in the fact that they are better adapted to weightlessness as live in an aqueous medium, they need less light can be transported in a frozen form along with the water.



The task of utmost importance is the "diagnosis" of the normal functioning of biological systems, focused on the choice of biochemical parameters as indicators of a balanced state of biosystems [3]. It is interesting to compare the results of the transformation of the chemical component of living matter of marine ecosystems, which has accumulated a large amount of factual material, and ecosystems in space exposure, for which there is very little experimental data. According to the 30 - year study of aquatic organisms of the White and Barents Seas authors found that those macrophytes like *Fucus vesiculosus*, *Fucus inflatus*, *Laminaria saccharina*, can be effectively used in a space laboratory to evaluate the adaptation mechanisms of aquatic organisms and rhythm of their life. By maintaining certain micronutrients ratios set optimum concentration of elements such as Fe, Mn, Cu, Ni, biocatalysts perform important functions in the synthesis of the protein substance. Obviously, maintaining stable enough quantities of trace elements may be indicative ratios Biosystems balance [4]. But the main criterion for aquatic life activity on the basis of the amount of phytoplankton is produced by them in the process of photosynthesis, oxygen.

The authors have developed a method of and apparatus for monitoring the composition and management of the biological experiment, which is offered to spend on board the International Space Station (ISS) [5]. Home experiment management task is to ensure the long-term (a few tens of days) closed biosystem functioning in conditions of weightlessness. To determine the control parameters biosystem authors developed an autonomous experimental setup equipped with a system of registration of the air flow parameters of water environment [1, 6] and biochemical parameters of the biosystem.

## 2. Problem formulation

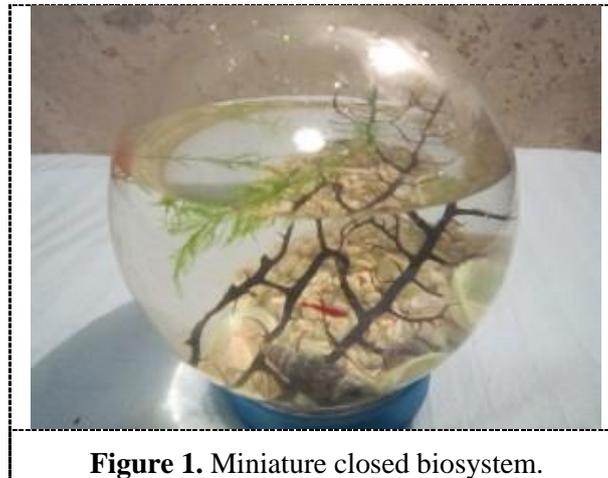
### 2.1 Description of research

Investigated ecosystem is a sealed glass container volume of about 2 liters, in which 2/3 to 1/3 contained water and air [7]. The basis of the ecosystem makes up aquatic plants - phytoplankton and microalgae (producers). During photosynthesis microalgae to light, oxygen, carbon dioxide absorption occurs and the creation of reserves of organic substances necessary for the nutrition of living organisms - by consumers (bacteria and micro-crustaceans).

Particles of aquatic plants serve as food for bacteria and micro-crustaceans, which in turn provide the biochemical reduction (i.e. regeneration) habitat. In the course of their livelihoods, they emit into the water complex organic substances. Their accumulation in the closed environment is dangerous for its functioning. Without bacteria, the allocation would have poisoned all life. Bacteria (decomposers) feed on these substances and change their nature, making simple security components that can be reused by plants. Bacteria have a further important property. Their number varies according to the amount of harmful substances. The number of body fluids - becomes more bacteria. With a decrease in the number of microorganisms is a reduced secretion.

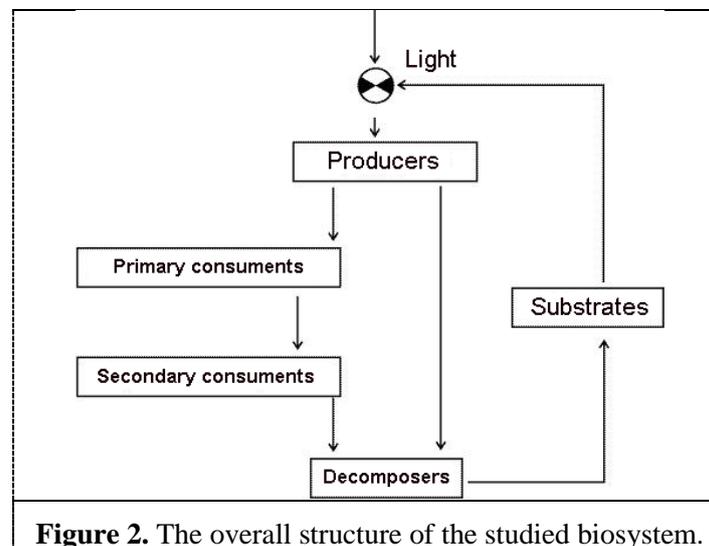
This miniature ecosystem allows us to study the laws of functioning of these natural communities. Her counterparts participated in the experiments on board the American "Space Shuttle" and the Russian space station "Mir" (see figure 1).

To assess the capacity of the closed ecosystem and to optimize control of a mathematical model based on kinetic coefficients obtained in experimental studies.

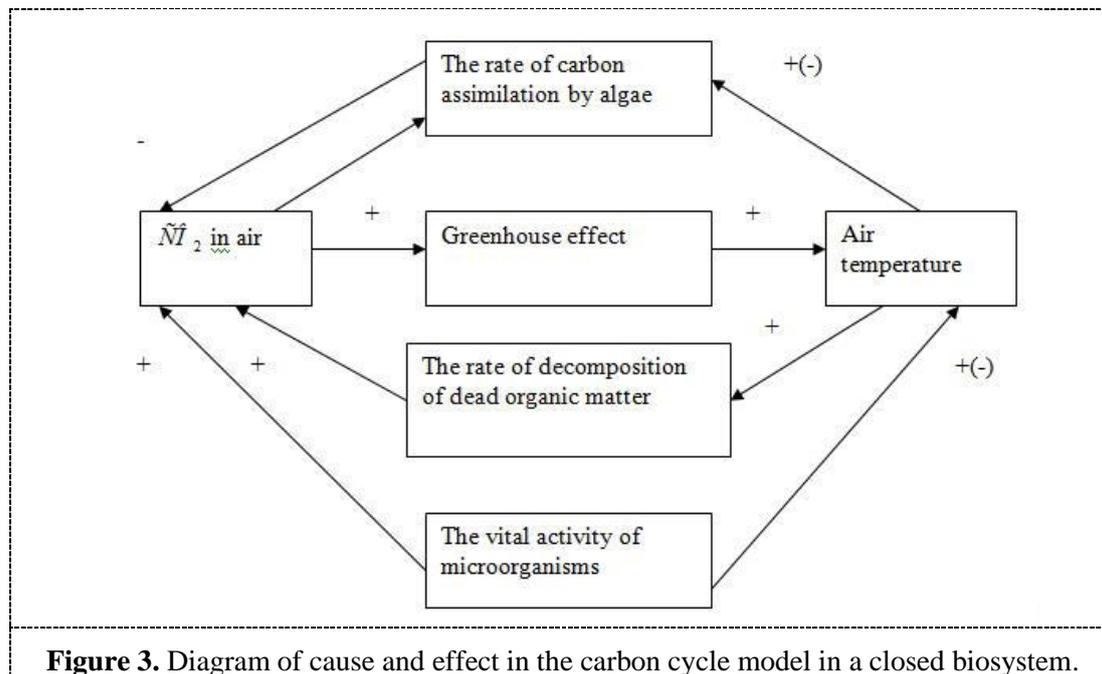


## 2.2 Development of a mathematical model of a closed biosystems

To investigate the mechanisms of biological systems considered by the author's shows the structure of the interaction of the main components of biological systems under study (see figure 2). In this structure, there is inevitably a negative feedback loop. Decomposers (decomposers) - bacteria, fungi, bacteria - throughout his life cleave the complex organic compounds (excrement and dead organic matter) into simpler minerals required producers. Organic biomass formation occurs during photosynthesis using sunlight from carbon dioxide and water, and also necessary elements coming from the soil: nitrogen, phosphorus, potassium, magnesium, iron and many other minerals.



Proceeding to the description of the mathematical model, depicting the effects of a short circuit, taken in the cybernetic model with feedback (see figure 3). The scheme sign of an arrow indicates the direction of the variable, which is addressed to the arrow, with the increase of the variable, or under the influence of factors from which the arrow starts. For example, the amount of  $\text{CO}_2$  in the air causes a temperature increase in growth.



In consideration, biosystem means that its productivity is not so much of the weight of ecological community, as determined phytocenosis surface area. The reason for this is the fact that the annual production of natural phytosystems located in similar climatic conditions the same. At constant humidity mode efficiency of various ecosystems (BGC) with increasing temperature can both increase and decrease. Therefore, in the model are considered growth factors corresponding to those observed for different values of the BGC  $\alpha_2$ ,  $\alpha_5$ :  $\alpha_2 \geq -4$ ,  $\alpha_5 \leq 15$ .

The classical mathematical techniques in the construction of models are considered biological apparatus of differential equations. The development of such models and their modifications presents in many papers. An example of use of the system of differential equations in partial derivatives can serve as a model of the pelagic ecosystem of the ocean [8].

In the paper of Lyapunov is only qualitative study of its proposed system of equations. The numerical solution of this system of equations for the specific case of observations carried out in the works M.E. Vinogradov, V.V. Menshutkin, E.A. Shushkina [9]. On their basis it was drawn below the system of equations describing the operation of a closed biosystem for space experiment.

Where A - the rate of photosynthesis, L - the intensity of solar radiation, CN - concentration of mineral nitrogen, CP - the concentration of the mineral phosphorus,  $\varphi_1$  - phytoplankton biomass,  $\varphi_2$  - zooplankton biomass,  $\psi$  - the mass of detritus (dead organic matter), k - coefficient of vertical turbulent diffusion, t - time, z - depth. All other characters in the system of equations - are empirical coefficients.

For a reasonable prediction of the kinetics of environmental components in the mathematical modeling can make the following assumptions.

$$\left. \begin{aligned}
 A &= \min(b_1, Lb_2, C_n b_3, C_p b_4) \\
 \frac{\partial L}{\partial t} &= -L(a_0 + a_1 \cdot \varphi_1 + a_2 \cdot \varphi_2 + a_3 \cdot \phi) \\
 \frac{\partial C_N}{\partial t} &= -h_N \cdot A \cdot \varphi_1 + v_N \cdot \phi + \frac{\partial}{\partial z} \left( k \frac{\partial C_N}{\partial z} \right) \\
 \frac{\partial C_P}{\partial t} &= -h_P \cdot A \cdot \varphi_1 + v_P \cdot \phi + \frac{\partial}{\partial z} \left( k \frac{\partial C_P}{\partial z} \right) \\
 \frac{\partial \varphi_1}{\partial t} &= \alpha \cdot A \cdot \varphi_1 - \beta \cdot \varphi_1 \cdot \varphi_2 + \frac{\partial}{\partial z} \cdot \left( k \frac{\partial \varphi_1}{\partial z} \right) - \frac{\partial}{\partial z} (\omega_1 \varphi_1) \\
 \frac{\partial \varphi_2}{\partial t} &= \gamma_1 \cdot \varphi_1 \cdot \varphi_2 + \gamma_2 \cdot \varphi_1 \cdot \phi + \frac{\partial}{\partial z} \cdot \left( k \frac{\partial \varphi_2}{\partial z} \right) - \frac{\partial}{\partial z} (\omega_2 \varphi_2) \\
 \frac{\partial \phi}{\partial t} &= v \cdot \varphi_2 - \mu \cdot \phi + \theta_1 \cdot \varphi_1 \cdot \varphi_2 + \theta_2 \cdot \phi \cdot \varphi_2 + \frac{\partial}{\partial z} \left( k \frac{\partial \phi}{\partial z} \right) - \frac{\partial}{\partial z} (\omega_3 \phi)
 \end{aligned} \right\} \quad (1)$$

1) Biological characteristics biosystem Components unchanged, as well as the relationships between them. The system is considered to be homogenous in space. We study the changes in the number of times (biomass) system components.

2) While maintaining homogeneity hypothesis introduces the assumption of a regular change of the system of relations between the components of biological systems. This can be either the laws of change of external conditions (e.g. seasonal) or given the nature of the evolution of forms that make up the system. At the same time it continues to study the kinetics of the number of components.

Apparatus for the study of these two classes of problems are the system of ordinary differential and differential-difference equations with constant (A) and variable (B) coefficients.

We form the equation, showing the mass balance for each of the components of biological systems:

$$\begin{aligned}
 dx_i/dt &= (F_x^i - D_x^i) \cdot x_i - \sum_{j=1}^n v_{ij} - y_i + R_x, \quad i=1, \dots, m, \\
 dy_j/dt &= (F_y^j - D_y^j) \cdot y_j - \sum_{r=1}^n v_{jr} + R_y, \quad j=1, \dots, n, \\
 dc_k/dt &= \sum_{j=1}^n U_{kj} y_j - \sum_{i=1}^m W_{ki} x_i + R_c, \quad k=1, \dots, p
 \end{aligned} \quad (2)$$

here  $F_i$ ,  $D_i$  - function of fertility and mortality producers and consumers;  $V_{ij}$  - predation function describing biomass consumption rate of i-type-producing unit of biomass j-th type-consumer;  $v_{jr}$  - predation function of j-type r-th (among of consumers);  $U_{kj}$  - intensity of production of k-th substrate j-th of consumers;  $W_{ki}$  - intensity use of k-th substrate i-th producer;  $R_x = R_y = R_c$  - sum of the input and output streams of the corresponding components. In general, all of these functions are dependent on environmental parameters. By converting the system variables can be written in a form similar to the equations of Voltaire.

To create an adequate mathematical model should take into account that all biological systems in varying degrees, affected by recurrent and occasional geophysical influences their biological components possess endogenous biological rhythms (biological clock). There are now also solved the problem of communication between the vibrational modes in the local (point) systems and space-time structures in ecological systems. As in the physical and chemical systems, a crucial role is played by the

character of non-linear interactions that determine the way mass and energy in a complex system. Modern mathematical tool allows you to find these issues, as well as to link the local population dynamics with large-scale spatial structures and long-term adaptability of species and species communities. In earlier studies [4] periodic dependence, allowing considering the empirical coefficients of the system of differential equations (1) in the form of a periodic function of  $k$  time ( $t$ ) have been installed.

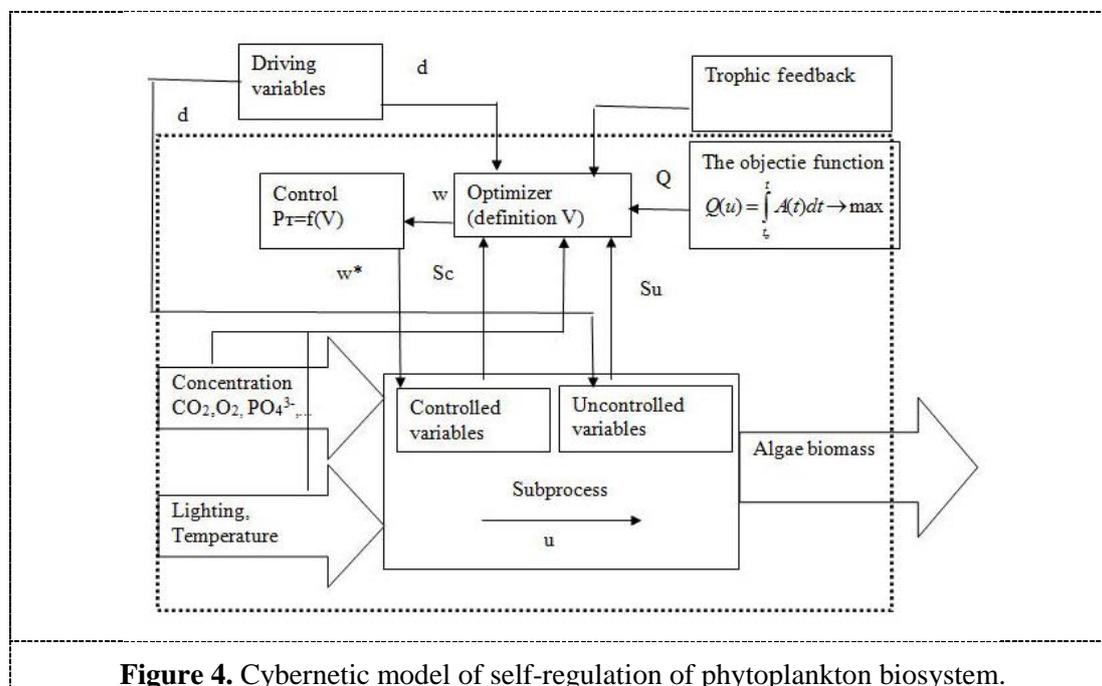
### 3. Control circuit for sustainable functioning of biosystems

Model description of closed self-regulating biological systems is closely linked to the control [10]. All information about the processes taking place in it, as well as qualitative data on the composition and condition of its individual parts and the environment are the sources of information for the control system [11]. For example, temperature and lighting informative play a role for the biological model block, because it gives important information on the characteristics of the environment, and controlling the intensity of different processes. The streams of energy and mass in the biosystem define a set of mechanisms for feedback, where each individual transfer of energy and mass causes a counter-flow.

In figure 4 shows a schematic representation of the concept of self-regulation of the closed biological system. The objective functions  $Q(u)$  are characterized genetically fixed ability of organisms to survive. As noted above, it is determined by the rate of oxygen production by photosynthesis  $A(t)$ .

Control of such a system is being realized at two levels. First, information about the biological system is processed by disturbing variables and subsystems is compared with the target function and then transmitted as a control signal of the signal  $w$ . This signal determines which activity of living organisms is optimal for a given length of time. This layer acts as a control optimizer entire system.

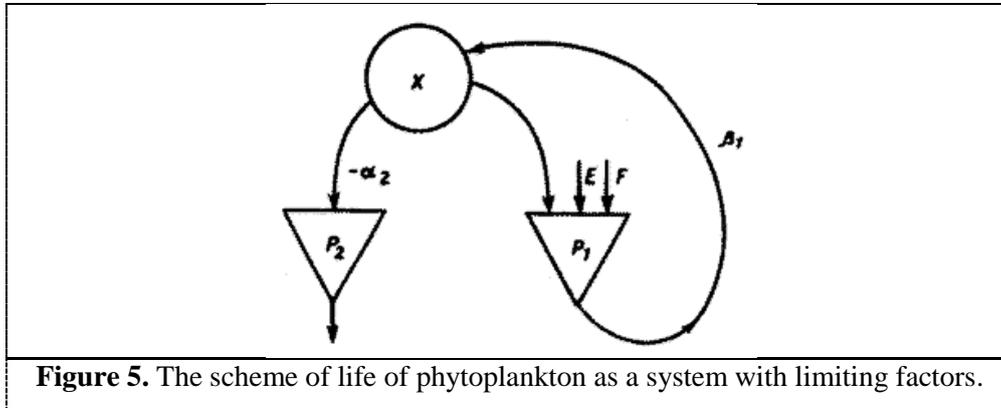
Controlled biological system has a number of options for implementing the signal  $w$ . One of them relates to the choice of appropriate values of the control parameters. This level is defined as the control element, as it affects the controlled system  $w^*$  signal.



**Figure 4.** Cybernetic model of self-regulation of phytoplankton biosystem.

The main external control parameter, which is very sensitive to changes in the growth rate of phytoplankton is the level of lighting. As is known, the basic processes of transformation of matter and phytoplankton energy is - biomass increase process (growth) going by photosynthesis and the absorption of substances from the air and water, as well as the process of basal metabolism (respiration), supplying

free energy of the biomass of life due to the partial consumption of the substance contained in the biomass itself. A block diagram of this process is shown in figure 5.



**Figure 5.** The scheme of life of phytoplankton as a system with limiting factors.

In this diagram, a circle denotes the stock material - biomass, and triangles - the processes. The arrows indicate the flow direction of the substance; process  $P_1$  uses external light  $E$  and some substance  $F$ , gives biomass growth  $x$ ;  $P_2$  breathing process consumes a portion of the biomass by providing free energy for the life of the rest, and identifies products that this model does not take into account. The process of growth of phytoplankton biomass is described by the equation:

$$\frac{dx}{dt} = \beta_1 P_1 - \alpha_2 P_2 \quad (3)$$

where  $x(t)$  - value of the biomass at time  $t$ . For the purposes of this problem it is continuous and has a derivative. Let  $P_1$  and  $P_2$  be two non-negative real variables - intensity of growth and respiration. Then the process  $P_j$  intensity value at time  $t$  is determined by the system input limiting component, i.e. one that provides the lowest intensity  $P_j$ . All other components which exceed the minimum flow are in excess and only partly consumed. The limiting factor of  $j$ -th process varies in magnitude with time, along with its corresponding intensity  $P_j$ . Due to changes over time the system state component  $i^*$  limiting process at the time  $t_1$ , it can be to stop the passage of time. Then, starting from the time  $t_2$  becomes the limiting is another component  $i^{**}$ . The model processes the intensity of the plant  $P_1, P_2$  can be written as:

$$P_1 = \min[x, E, F], \quad P_2 = \min(x) \quad (4)$$

The magnitude component input stream  $i$  for  $j$  at time  $t$  of the process depends on a number of existing components of the system  $X$ , while the component  $(E, F)$  coming from outside - the condition of the environment. The flow of external components (water, solutes) can be considered constant, proportional to the presence of this component in the external environment. Feed light is supposed to be proportional to the product of the intensity of light on the value of  $E_0$  defined by the absorbing surface area of phytoplankton (can be regarded as proportional to the square of the cube root of the value of the biomass). Thus, the light flux can be written as:

$$E = E_0 k(x) x^{2/3} \quad (5)$$

where  $k(x)$  - empirical coefficient.

Depending on the ratio values and system parameters  $\beta_1, \alpha_1, E_0, F$  value  $P_1$  may be equal to the lowest of the three values. Consequently, the solution is divided into three areas, each of which growth is limited by a factor.

#### 4. Development of a research module in CubeSat format

Speaking about the CubeSat design, it is worth noting that at this stage, not a full-fledged orbital module is being developed, but a layout for short-term flight to high altitude [12]. Moreover, the launch of the cubesat layout is planned to be carried out in a balloon at a height of up to 25 km. For the layout under consideration, it will be necessary to maintain a normal, positive temperature inside the microsatellite layout. To ensure the stable functioning of the biosystem, it is important to maintain the temperature in the inhabited part within 22-25 °C. The essence of maintaining the temperature is to use an infrared film and Peltier elements.

As a phytoplankton, the single-celled green algae *Chlorella* is well suited. *Chlorella*, like other green algae, is able to synthesize organic substances during photosynthesis. This requires only water, carbon dioxide, and sufficient illumination. Also, algae of this group have a need for a small amount of minerals for reproduction.

As zooplankton and at the same time filters, you should choose the simplest microorganisms-*Daphnia*. These are small crustaceans that are undemanding to the conditions of functioning, and their growth, with a sufficient amount of nutrients, continues throughout life.[13].

In nature, *Daphnia* closely interact with phytoplankton, including *Chlorella*. This interaction is determined by the fact that the quality characteristics of the water in which *Daphnia* lives depend on the *Chlorella* population, and the number of *Chlorella* depends on the *Daphnia* population, since *Daphnia* feeds on it [14, 15]. As a result, we have a stable scheme of relationships between the considered organisms.

As part of the described research, it is planned to conduct an experiment with the placement of a closed biosystem as part of a small spacecraft corresponding to the Sansat format. Based on the fact that the experiment involves a biological object, the task of the researcher is to control and manage the components of its life activity, achieving an optimal ratio between the volume of phyto - and zooplankton, ensuring their joint sustainable functioning. At the same time, the controlled parameters are: temperature and light level, when analyzing the life of the biosystem, the value of dissolved oxygen, carbon dioxide, hydrogen pH, and water density are estimated [16]. It is also important to be able to assess the density of phytoplankton biomass (by measuring the water turbidity level with an optical sensor) and the density of zooplankton biomass (using a video camera and a vision system). The composition of the instrument equipment is shown in figure 6.

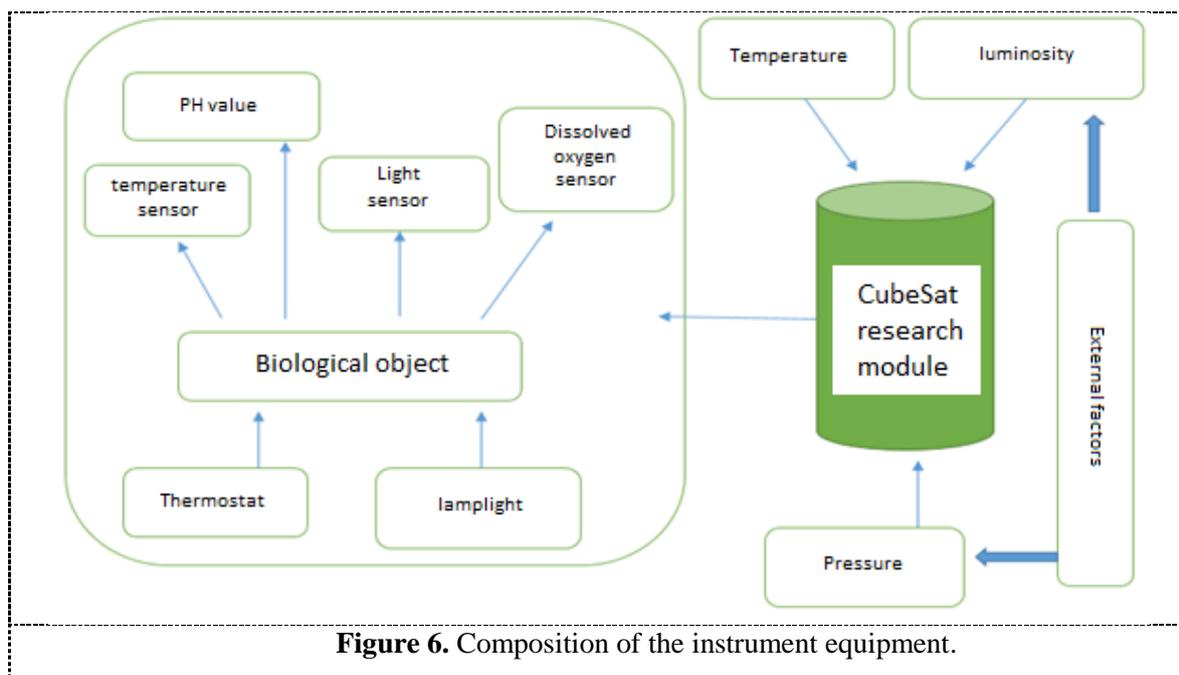
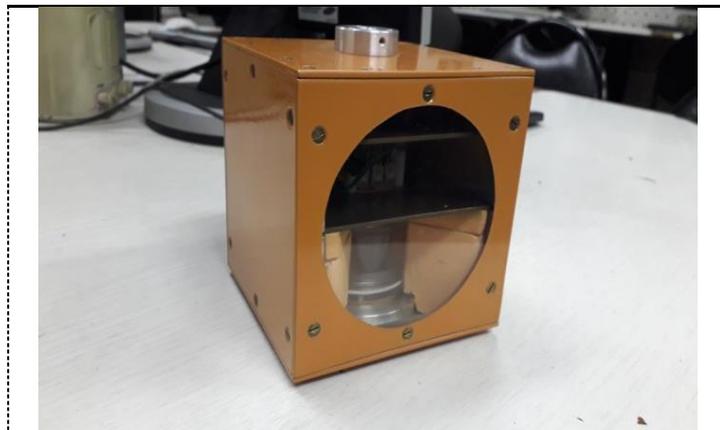


Figure 6. Composition of the instrument equipment.

Energy consumption in this design requires about 2A per hour. If you take regular batteries of 12 volts 7A / H-2 PCs, then their full charge will last for 7-8 hours, then depending on the charging dynamics. That is, the system at the height of the experiment will be fully Autonomous with a temperature difference at the boundary of the media (heated and cooled parts) up to 150-200 degrees. But even so, the charge dynamics will be higher than the consumption, so it will definitely be active for 12 hours.

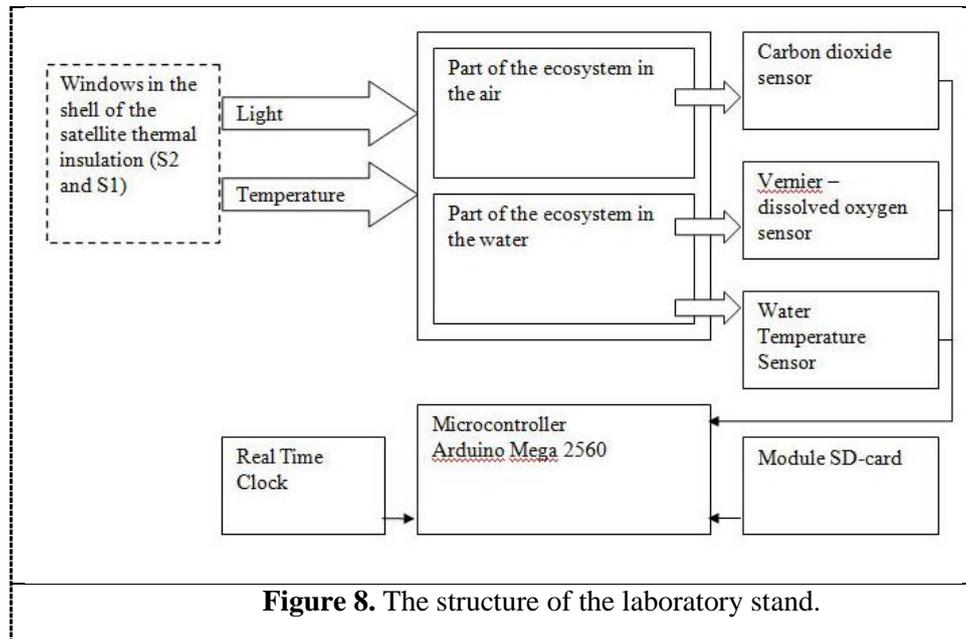
The resulting model will make it possible to study and evaluate the current stability of specific ecological systems through biological observations and mathematical calculations of the rate of biomass consumption, illumination, and temperature between the levels of the trophic pyramid between bio-and zooplankton, which will allow us to conclude that it is possible to maintain stable functioning conditions and ways to regulate Biosystems by changing the temperature and illumination level.

To conduct the experiment in orbit, it is planned to place a closed biosystem or as part of scientific equipment on Board a separate module (1Unit) of the Cubesat format of a composite microsatellite (3Unit – 6Unit). Thus, the minimum size of a research module with a closed biosystem will be 10x10x10cm with a weight of less than 1 kg (see figure 7).



**Figure 7.** Model of the CubeSat research module.

To resolve the biosystem management mechanism and the experimental determination of the values of the coefficients of a mathematical model laboratory stand were designed, the structure of which (see figure 8).

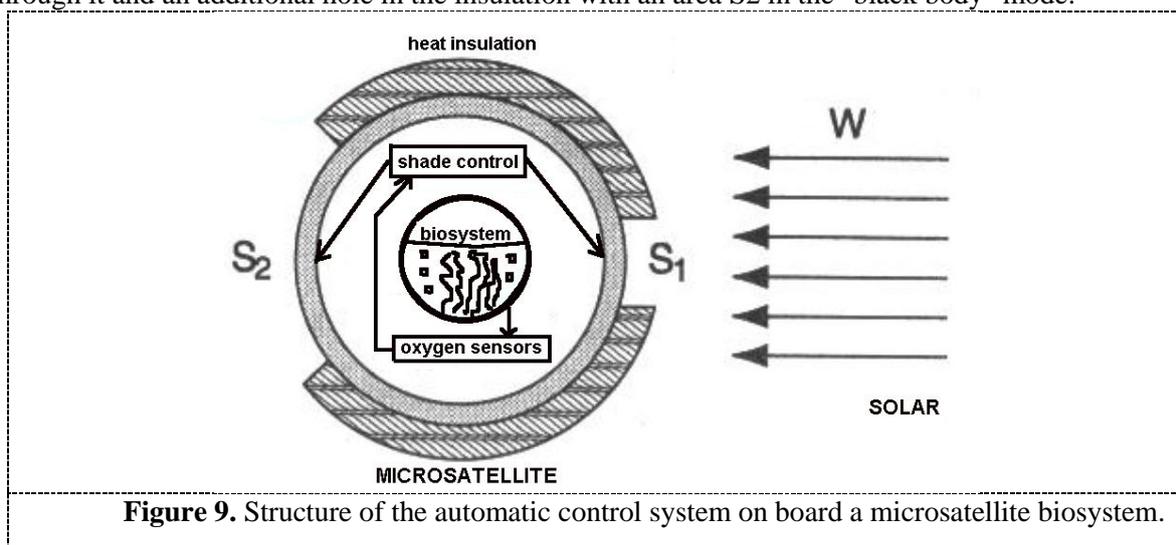


**Figure 8.** The structure of the laboratory stand.

This installation, designed for ground experiment using a core set of monitoring parameters of the biosystem of sensors (CO<sub>2</sub>, O<sub>2</sub>, temperature) [17, 18]. Processing system used Arduino microcontroller platform with the external real-time clock module and data storage module to the micro SD- card. As an external control parameters used upravlemye sources of light and heat.

After ground testing cycle biological systems to be installed on board the spacecraft. Figure.9 shows the structure of a control system biosystem in the case of the experiment on board the microsatellite.

There insulated spacecraft orbiting the Earth has on board an electric power tools, which can be changed during operation from N1 to N2). In order to ensure a predictable thermal regime in the insulation area made hole S1, which falls on the solar energy flux W. The energy emitted by the device through it and an additional hole in the insulation with an area S2 in the "black body" mode.



**Figure 9.** Structure of the automatic control system on board a microsatellite biosystem.

Consider what should be the square holes, if the allowable temperature range for the biosystem is 20-30°C.

Minimum temperature corresponds to the minimum of heat. In this case the incoming power  $Q1 = W * S1 + N1$ . radiated power:

$$Q_2 = \sigma T_1^4 (S_1 + S_2),$$

where  $T_1$ -minimum allowable temperature in degrees Kelvin. In these conditions, the heat balance of power should be equal.

Maximum heat mode corresponds to the maximum temperature of the equipment. In this case:

$$W * S_1 + N_2 = \sigma T_2^4 (S_1 + S_2)$$

Using the two resulting equations, we get:

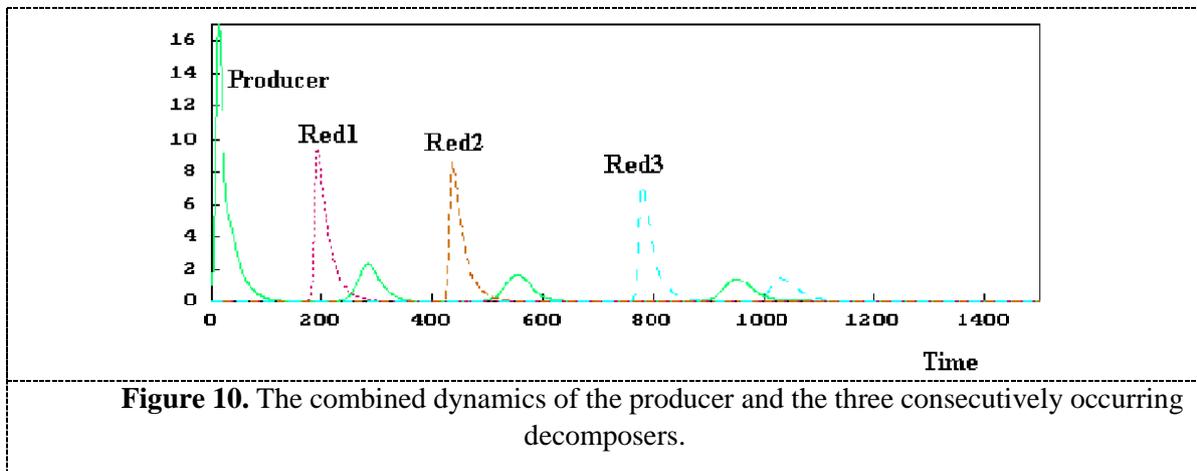
$$S_1 = \frac{(N_2 T_1^4 - N_1 T_2^4)}{W \cdot (T_2^4 - T_1^4)}, \quad S_2 = \frac{W \cdot (N_2 - N_1) - \sigma \cdot (N_2 T_1^4 - N_1 T_2^4)}{\sigma W \cdot (T_2^4 - T_1^4)}$$

where  $\sigma$  - Stefan - Boltzmann constant

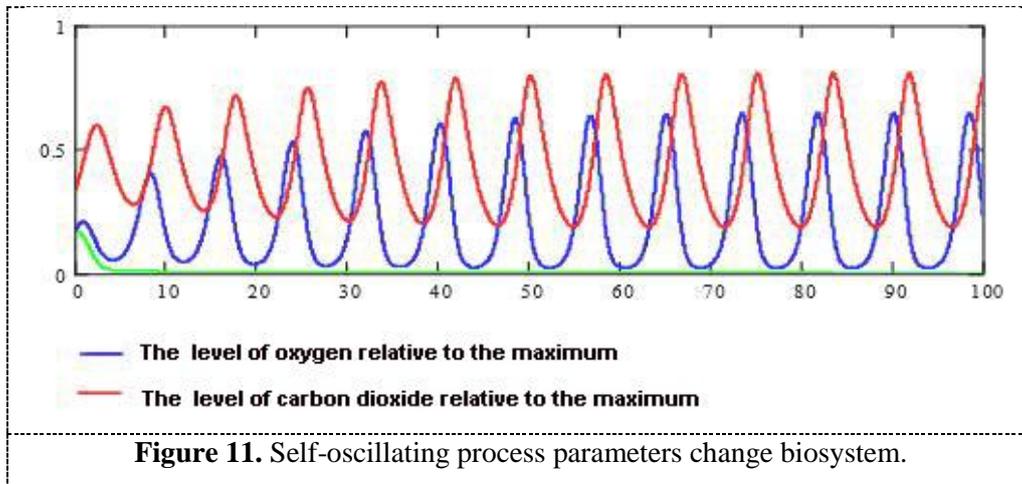
$$\sigma = 5,67 * 10^{-8} \quad (\text{Watt}/(\text{m}^2 * \text{K}))$$

Long-term (duration of 1400 hours, or 60 days) experiments with phytoplankton biosystem possible to estimate the time periods and the change of generations, producing three series occurring decomposers, which is equivalent to the results of computer simulation based on a mathematical model described above (see figure10).

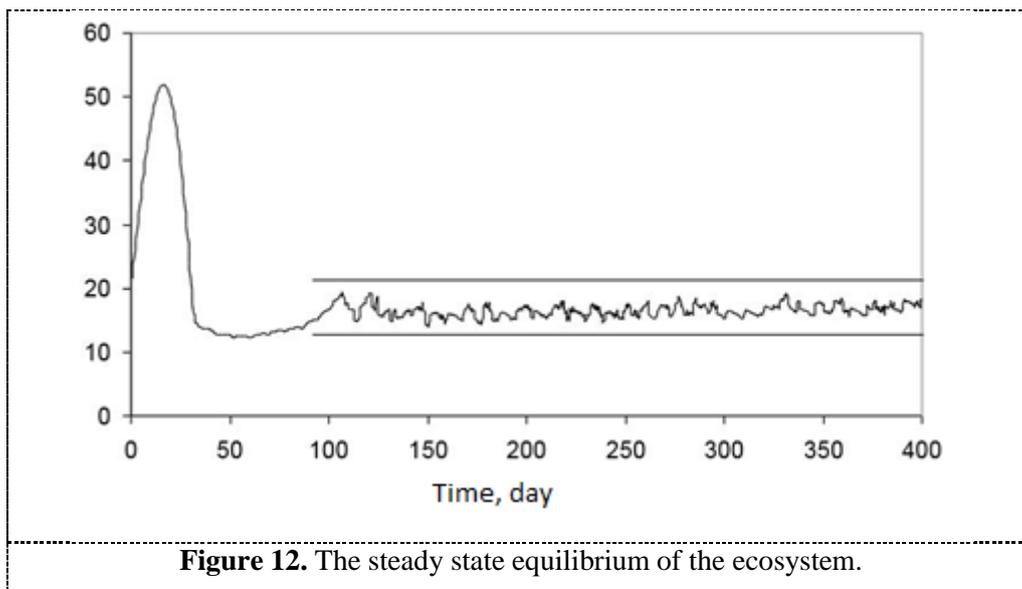
Similarly, self-oscillating processes have been obtained, reflects the process of change of the oxygen concentration and carbon dioxide in a closed biosystem (see. figure 11).



Such vibrational modes are well known both in the laboratory studies and from field observations and good investigated theoretically [19, 20]. Biological systems are affected by the periodic and irregular geophysical influences their biological components possess endogenous biological rhythms [21]. This is biological clock.



Ensure the sustainability of bio-system necessary to keep the controlled variable (the percentage of dissolved oxygen) within certain limits. Figure 12 shows a calculation model of the dynamics percent of dissolved oxygen in a biological system. The lines marked the boundaries of permissible range of experimental values that have to be maintained by changing the level of illumination of the biosystem.



Calculation of the oxygen concentration is calculated by the formula:

$$P_{O_2} = P_{C_w} = \frac{C_{O_2}}{V_{O_2}} \quad (6)$$

where  $P_{C_w}$  - the oxygen concentration in the algae (%);  $C_{O_2}$  of carbon dioxide in the air of the biosystem (%);  $V_{O_2}$  oxygen volume ( $m^3$ ).

$$P_{O_2}(T) = P_{O_2}(t_0) + \int_0^T K_1 * F(t) dt + \int_0^T (K_2(t) \times C_R(t) + K_3 \times C_B) dt$$

$$K_1 = a_1 \times PC_W + a_2 \times T_{O_2} + a_3 \times P_{O_2} + a_4 \times P_{O_2}$$

$$K_2 = a_5 \times PC_R + a_6 \times T_{O_2} + a_7 \times PC_W$$

$$K_3 = a_8 \times PC_B + a_9 \times T_{O_2} + a_{10} \times PC_R + a_{11} \times PC_W$$

where  $K_1, K_2, K_3$  - constants determined experimentally.

The calculation of the carbon dioxide concentration is calculated using the formula:

$$P_{CO_2}(T) = P_{CO_2}(t_0) + \int_0^T K_1 * C_R(t) + \int_0^T K_2 * C_W(t) + \int_0^T K_3 \times C_B(t) \quad (7)$$

where  $C_R$  - consumers,  $C_W$  - producers,  $C_B$  - decomposers.

$$K_1 = b_1 \times PC_R + b_2 \times T_{O_2} + b_3 \times P_{O_2} + b_4 \times PC_W$$

$$K_2 = b_5 \times PC_W + b_6 \times T_{O_2} + b_7 \times P_{O_2} + b_8 \times PC_R$$

$$K_3 = b_9 \times F(t) \times PC_W$$

## 5. Conclusion

These experiments allow preparing the space experiment with a closed biosystem. However, the inability to reproduce weightlessness in terrestrial conditions, which likely to have a significant impact on the life of phytoplankton, requires clarification of values obtained coefficients developed performance management system registration parameters of its operation and comparison with terrestrial experiment.

The results of computer modeling carried out within the framework of these studies, carried out under the RFBR grant N 18-08-00234-a. and using the Lotka - Volterra model [6], confirmed that the considered closed biosystem can self-organize and maintain its state for a long period of time (more than 90 days). The main scientific task was to "diagnose" the normal functioning of such Biosystems, focused on the selection of biochemical parameters as indicators of the balanced state of Biosystems, which can be the concentration of dissolved oxygen and carbon dioxide. In the case of an experiment on an orbiting microsatellite, it is assumed to implement an automatic system for temperature stabilization and control of the light level of the biological system using controlled dampers in the thermal insulation holes of the microsatellite body.

The chemical elemental composition for selected aquatic organisms before and after the experiment in space can be determined by standard methods [19]. The parameters characterizing the habitat conditions (dissolved oxygen, salinity, active reaction (pH), biogenic elements cycle etc.) can be specifically evaluated using ion-selective electrodes and atomic absorption spectral analysis directly in the space experiment on the ISS. However, it is obvious that the main difficulty in the development and testing of the proposed research is the need for deep technical study on the use of devices in conditions of weightlessness. It is also planned expansion of controlled ecosystem parameters in comparison with the proposed structure of terrestrial laboratory stand [3].

In the case of the experiment on autonomous spacecraft (microsatellite) implementation of an automated system level temperature and lighting control system of biological stabilization via controlled shutters in the thermal insulation holes microsatellite housing.

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