MELISSA MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

ИМБП

SPACE EXPERIMENTS TO THE INTEREST OF SPACE BIOLOGY AND MEDICINE

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ECLSS Russian activities

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THE PRIORITY AREAS OF DEVELOPMENT OF DOMESTIC SPACE BIOLOGY AND MEDICINE *IN THE NEAR FUTURE* INCLUDE:

- **Obtaining fundamental knowledge about the influence of space flight factors on biological objects (viruses, bacteria, plant and animal cells);**
- **Obtaining new biological objects** (viruses, bacteria, plant and animal cells) with the necessary properties for their use in the interests of medicine, veterinary medicine and biotechnology;
- **Research of biotechnological and other processes** *for the production of* medical and biotechnological products with the aim of developing basic technologies for obtaining bioproducts in space, as well as improving the relevant ground-based industries;
- **Feasibility study** of producing biotechnological products in space;

THE PRIORITY AREAS OF DEVELOPMENT OF DOMESTIC SPACE BIOLOGY AND MEDICINE IN THE NEAR FUTURE INCLUDE:

- **Testing scientific equipment and equipment** for research in space biotechnology;
- **Development of conditions and the necessary equipment** to ensure the conduct of biotechnological research at manned space stations in aseptic conditions;
- **Study of the biodegradable effect of microorganisms in the air of manned space stations** on the structural elements of the station and equipment located in the pressurized volume. **The most important for space biotechnological production are currently the following biological objects: hormones, interferons and lymphokines, anti-inflammatory substances, thrombolytic agents, antibiotics, monoclonal antibodies, animal treatments, highly effective plant clones, highly active producers of biopesticides, microorganisms for oil bioadsorption, biodegradation chemicals, producers of organic compounds from production wastes, enzymes, microorganisms-producers for the production of biotechnological products, food additives, vitamins;**

THE PRIORITY AREAS OF DEVELOPMENT OF DOMESTIC SPACE BIOLOGY AND MEDICINE IN THE NEAR FUTURE INCLUDE:

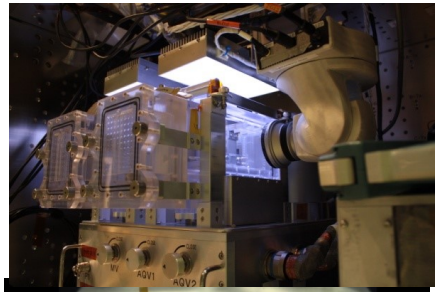
- **Determination of the permissible limits** for the development of adaptive rearrangements under conditions of weightlessness, within which all changes in the body can be adjusted, reversible and safe;
- **Increasing the information content of the diagnostic methods** used and predicting changes in health, psychoemotional status of crew members, their performance;
- **Improvement of means and methods of stabilization**, management of the state of the crew and its environment, prevention of possible violations and treatment of diseases;
- **Improving the ergonomic characteristics** of manned space objects, developing psychophysiological measures aimed at optimizing the well-being and professional activity of cosmonauts;

THE PRIORITY AREAS OF DEVELOPMENT OF DOMESTIC SPACE BIOLOGY AND MEDICINE IN THE NEAR FUTURE INCLUDE:

- **Development of fundamental problems** of space medicine, gravitational biology, ecology;
- **Solution of private medical problems** of providing interplanetary flights to the Moon, Mars and other planets;
- **The development of on-board telecommunications medicine**, associated both with the expansion of the possibilities of medical control over the state of human health in flight, and the provision of advisory diagnostics and treatment in case of diseases;
- **Introduction of the developed means, apparatus, equipment and technologies** used in cosmonautics, in health care and the national economy.

EXPERIMENT CODE: AQUARIUM

Information note: IS Aquarium AQH_IMBP_2014.doc
NPI direction: 4. Space biology and biotechnology
KNTS Section: Space Biology and Physiology
Experiment name: Study of the stability of the state of a model closed ecological system and the links included in it under microgravity conditions



The main purpose of the "AQUARIUM" experiment is **to study the influence of space flight factors on the stability of a model closed ecological system and its components** (plants and animals) under microgravity conditions.

The list of tasks that must be solved in this experiment also includes the tasks of studying the heterotrophic link of the biological life support system in the conditions of KP.

- Obtaining data on the possibility of long-term storage of dormant forms of animal organisms (eggs of lower crustaceans) and determination of their ability to reactivate after exposure in space flight.
- The joint Russian-Japanese experiment "AQUARIUM-AQH", which is a stage of the SE "AQUARIUM", makes it possible to study aquatic heterotrophic organisms in QP conditions, thereby solving part of the tasks set in the SE "AQUARIUM", including the study of the full cycle of the ontogenetic development and organogenesis in aquatic heterotrophic organisms under conditions of KP.

EXPERIMENT CODE: VITACYCLE T

Experiment name: Design development and optimization of plant cultivation modes for a space conveyor greenhouse

The main goal of the Vitacycle-T experiment is to refine the design and operation modes of the main systems of the conveyor CR, as well as the modes of plant cultivation for the subsequent design of a standard on-board CR as one of the most important links in promising life support systems for space crews.

EXPERIMENT CODE: VITACYCLE T

The objectives of the "Vitacycle-T" experiment are:

1. **Determination of the dynamics** of the performance of the spacecraft in space flight (CS);
2. **Checking the operability and testing the mode of operation** of the system of humidification and aeration of the substrate in the KO in the conditions of the KP;
3. **Determination of the duration of use of replaceable elements in KP conditions:** porous tubes and an ion-saturated substrate in the root module (CM); as well as enrichment cartridges with fertilizers;
4. **Study of the dynamics of hydrophysical properties of CM** during the growing season of plants under conditions of KM;
5. **Determination of the optimal lighting regime for plants and the duration of vegetation of salad crops** in a conveyor greenhouse under conditions of KP.
6. **Research of the technology of cultivation of plant organisms** in relation to standard greenhouse devices;
7. **Study of the effect of PCF on the growth and development of plants** that are promising for use in space vitamin greenhouses;
8. **Study of the production process in plants;**
9. **Carrying out genetic, biochemical and microbiological studies of plants grown in zero gravity.**

EXPERIMENT CODE: PHOTOBIOREACTOR

Background information: is_fotobioreaktor.doc

NPI direction: 4. Space biology and biotechnology

KNTS Section: Space Biology and Physiology

Experiment name: Photobioreactor for cultivation of microalgae in microgravity

The purpose of the experiment is to create a photobioreactor for conducting biotechnological experiments and obtaining food and oxygen by cultivating microalgae in microgravity.

EXPERIMENT CODE: QUAIL

Experiment name: study of the possibility of sustainable existence of a population of Japanese quail birds in MG conditions

The purpose of the experiment:

The study of the embryonic development of the Japanese quail with the identification of specific developmental features caused by the factors of space flight, as well as the study of the postembryonic development of birds in weightlessness with the identification of the features of their growth, development, reproduction and behavior.

Description of the experiment:

Earlier experiments on the MIR OS showed the possibility of developing a living organism from eggs delivered from Earth, and also made it possible to study the peculiarities of the development of Japanese quail embryos in a real space flight. However, the reasons that cause disturbances in the development of the embryo have not been established. In addition, Japanese quail chicks were bred aboard the Mir spacecraft, which could not independently adapt to zero gravity conditions. Studies of the embryonic development of Japanese quail under zero gravity on board the ISS RS using a new design of the incubator should answer these questions.

EXPERIMENT CODE: PLANTS

Experiment name: Study of the growth and development of higher plants in a series of generations of higher plants in space flight

The purpose of the experiment is to conduct space research in order to solve problems of fundamental biology and create advanced life support systems for space crews.

The objectives of the Plants experiment are:

1. Research of the technology of cultivation of plant organisms in relation to standard greenhouse devices;

2. Study of the peculiarities of creating a water-air regime in the roo module of the greenhouse "Lada" in microgravity conditions;

3. Study of the influence of spaceflight factors on the growth and development of tomato and wheat plants, promising for:

   - Use in space vitamin greenhouses;
   - Determination of the percentage of seed germination and viability of seedlings;
   - Study of the production process in plants;
   - Carrying out genetic, biochemical and microbiological studies of plants grown in zero gravity conditions on substrates of various compositions. They should answer these questions.

BIOUTILISATION STUDIES

THE PROBLEM OF UTILIZATION OF ORGANIC WASTE IN CONFINED HABITATS

The long terms of interplanetary expeditions and the operation of planetary bases require the creation of the most closed biological life support systems (BLSS).

Recycling of organic waste is necessary in closed BLSS.

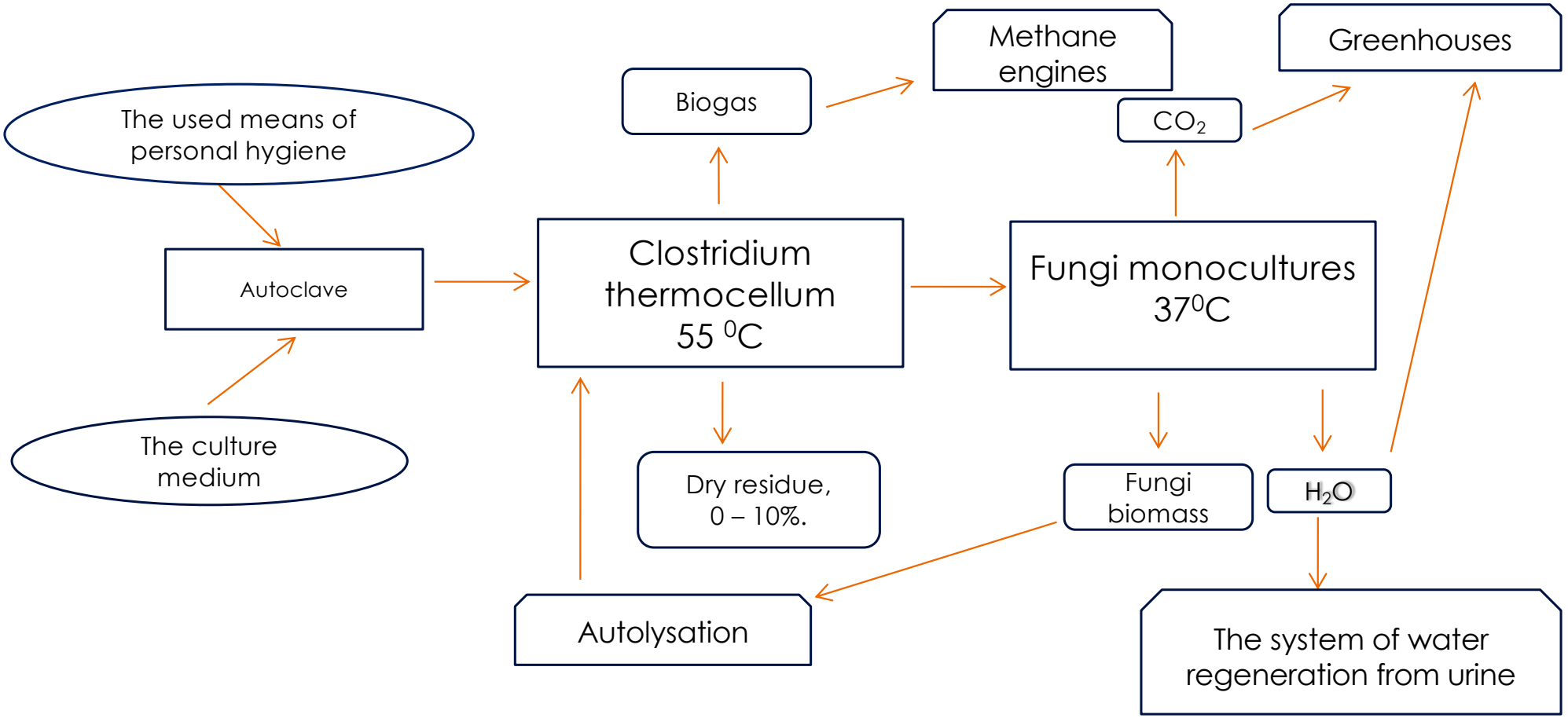
The disposal of waste beyond the limits, for example the lunar or Martian base, is unacceptable due to the presence of planetary quarantine.
Warehousing and storage of waste is unsafe in the sanitary-epidemiological aspect.

Already, a significant proportion of waste accounted for the waste of personal hygiene.

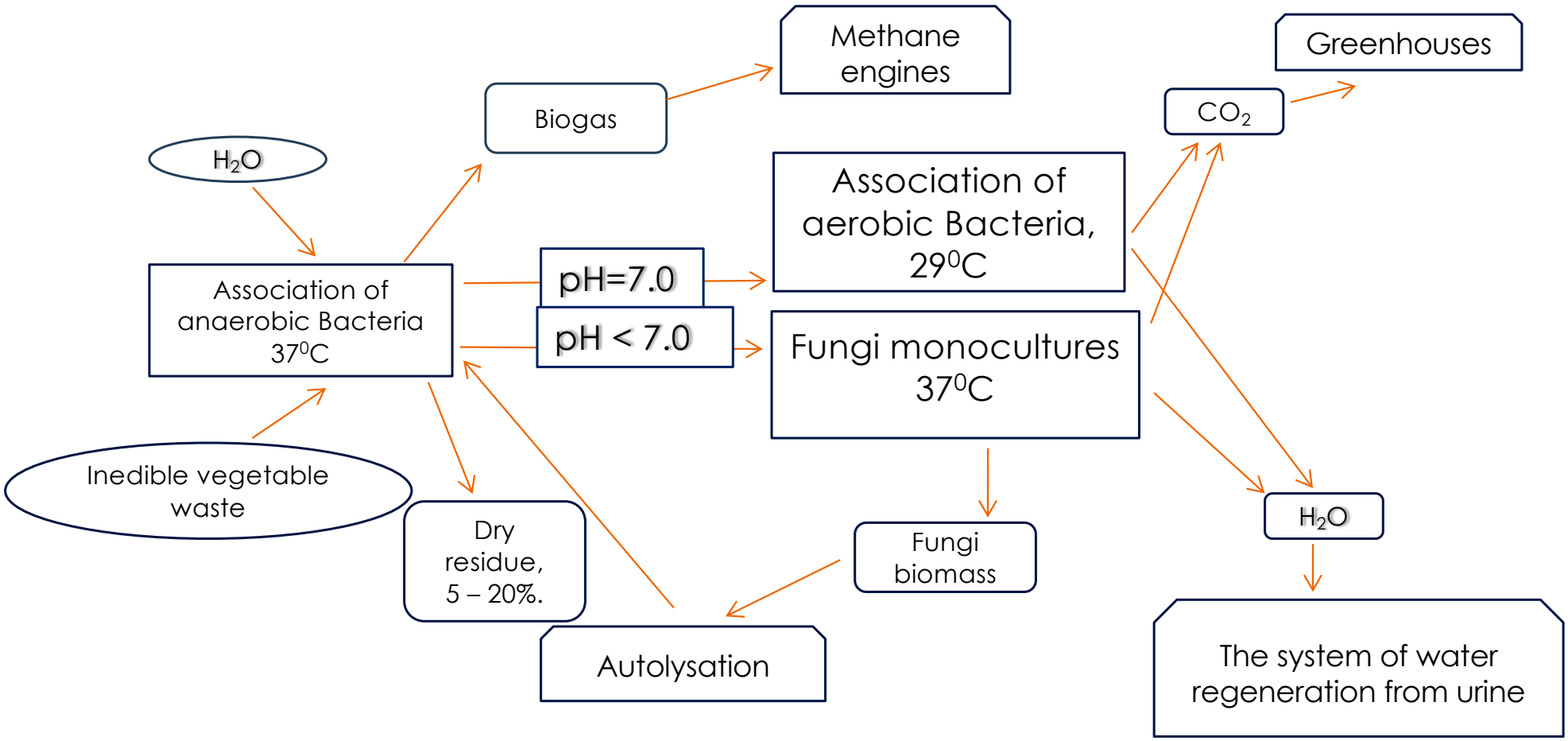
Treatment of organic wastes, especially disposed hygienic means using microbial technologies have much advantage for application in spaceflight. These advantages concerns the following categories:

- diminishing the volume of organic wastes
- the biological hazard of the wastes will be controlled
- this system may be compatible with the other biological ELSS (greenhouses)
- the biogas created during biodegradation may be used for the other needs (energy carrier).
- the water obtained in the biodegradation processes may be used for the other needs

BLOCK DIAGRAM OF TREATMENT OF DISPOSED MEANS OF PERSONAL HYGIENE



THE BLOCK SCHEME OF UTILIZATION OF PLANT WASTES



CONCLUSIONS

Disposed sanitary-hygiene wipes and towels forms significant part of wastes onboard space station.

Microbial decomposition of this substrate can be developed as an alternative to existing waste treatment procedure.

Involvement of waste decomposition technology is rather important taking under consideration future mission to Mars.

MICROBIAL FUEL CELLS

ELABORATION OF MICROBIAL FUEL CELLS

The investigations were carried out directed to create microbial fuel cells.

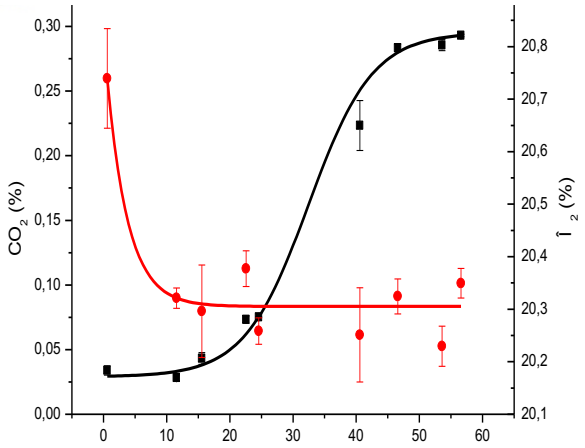
First in Russia there were elaborated 2-chambered electrochemical cells with cation-exchange membranes for microbial fuel cells for bioelectrisity/ There were determined energy characteristics of several cells type. One of such cell is acteve for over then 1 year. It consists of 6 cells..

For interactions with Microbial fuel cell the lab model of oxygen analyser was created, which was adapted to volt-amper characteristics of the battery. The obtained results are perspective for usage for application of wastewater and in life support.

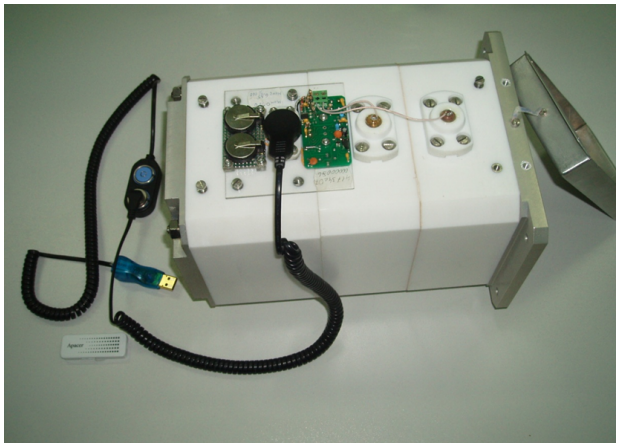
Functions of MFC containing activated sludge in the composition of the BLSS

- Fermentation of organic substances
- Removal of heavy metal ions
- Removal of nitrogen oxides formed during the decomposition of Proteins
- Power generation

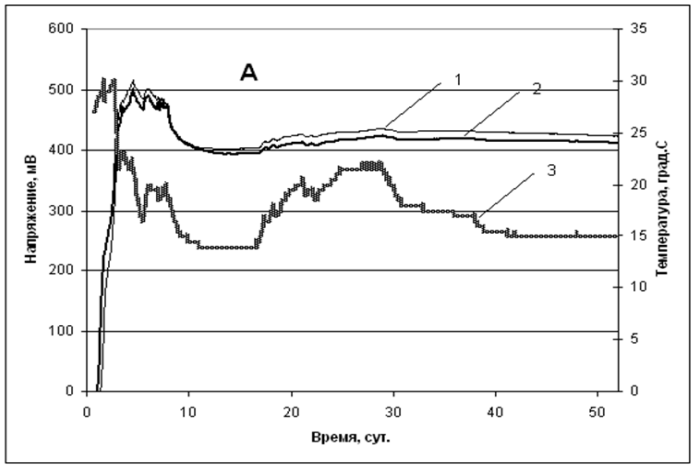
Changes in concentration of oxygen and carbon dioxide while long-term function of MFC

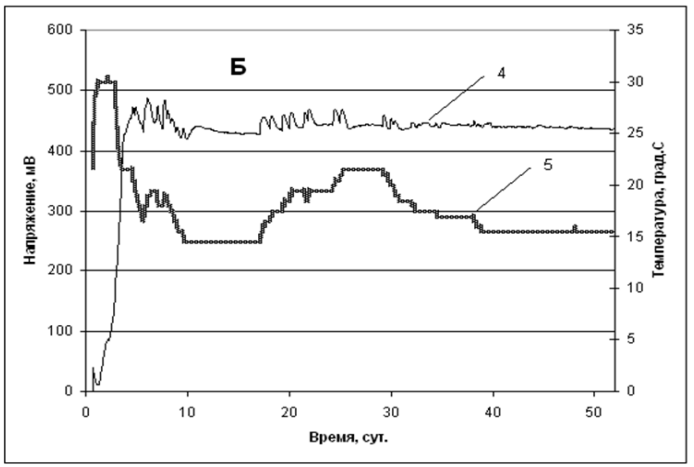


Microbial fuel cell for Bion M studies

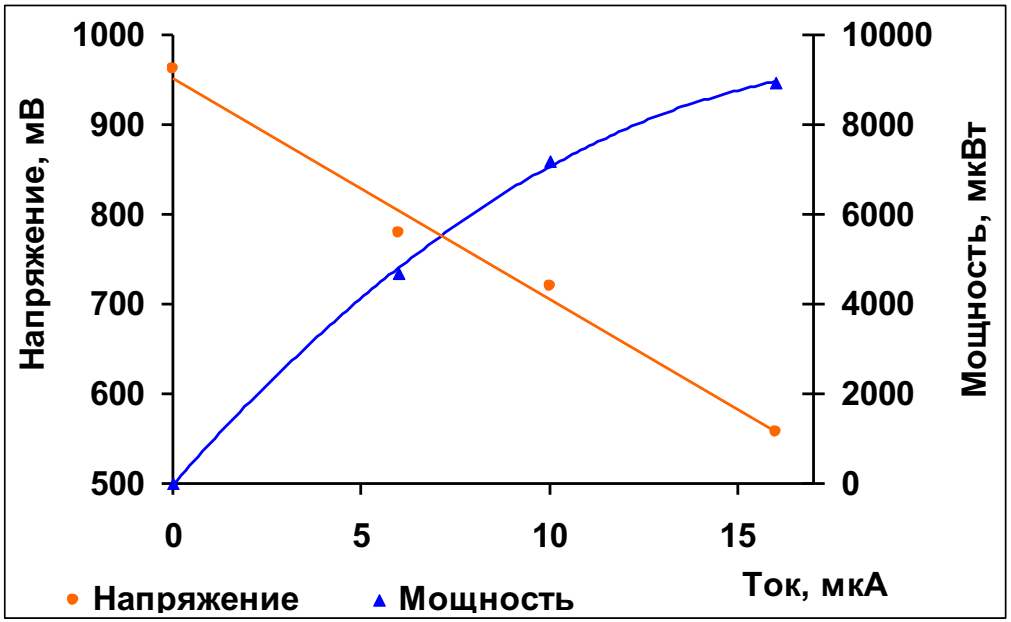


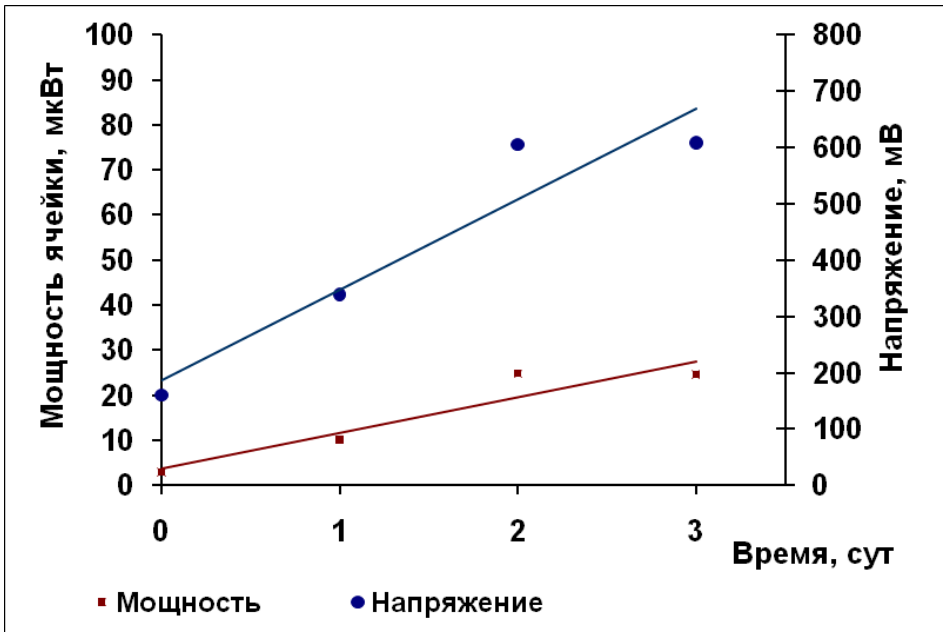
Electrical characteristics of MFC in spaceflight (A) and ground control (B)
Horizontal scale – time (days)
Vertical – voltage (mV)



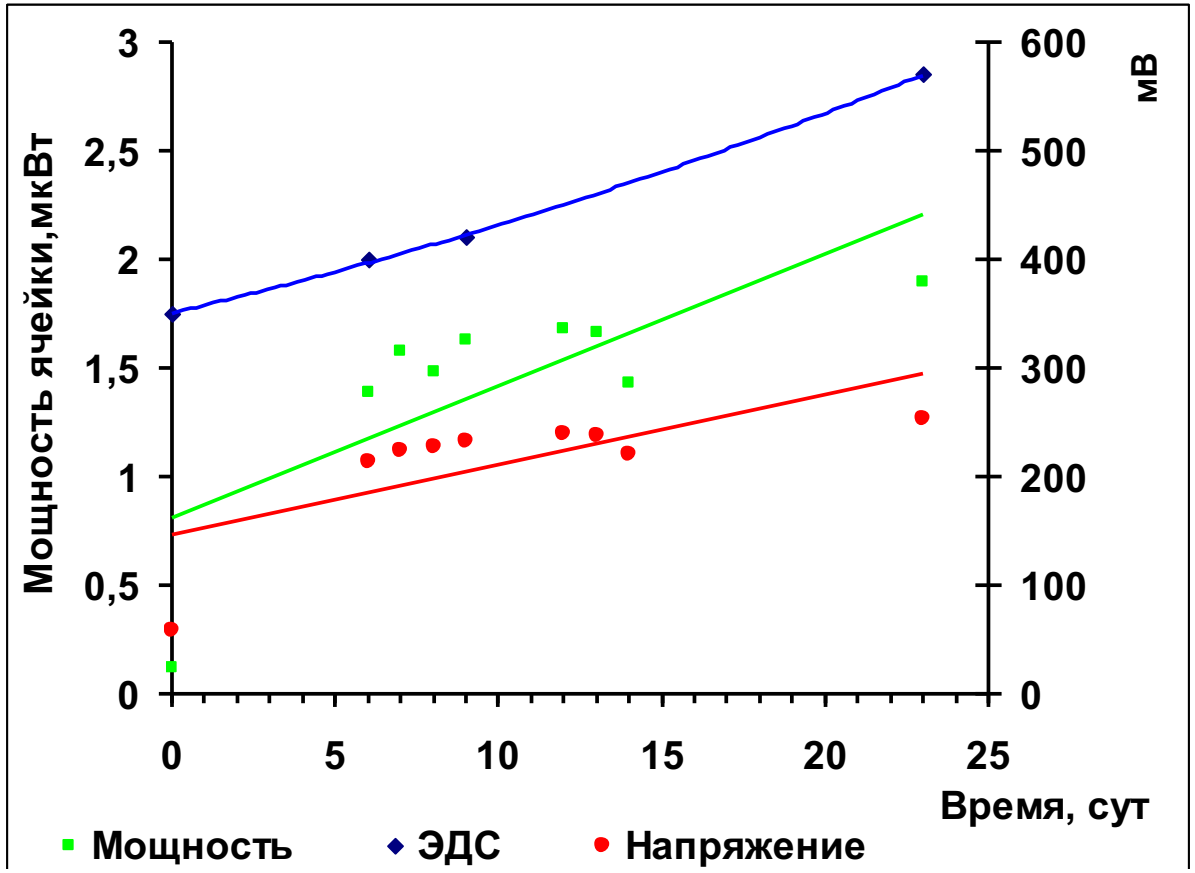


Dependence of voltage and power from time (Anode square 60 см2)





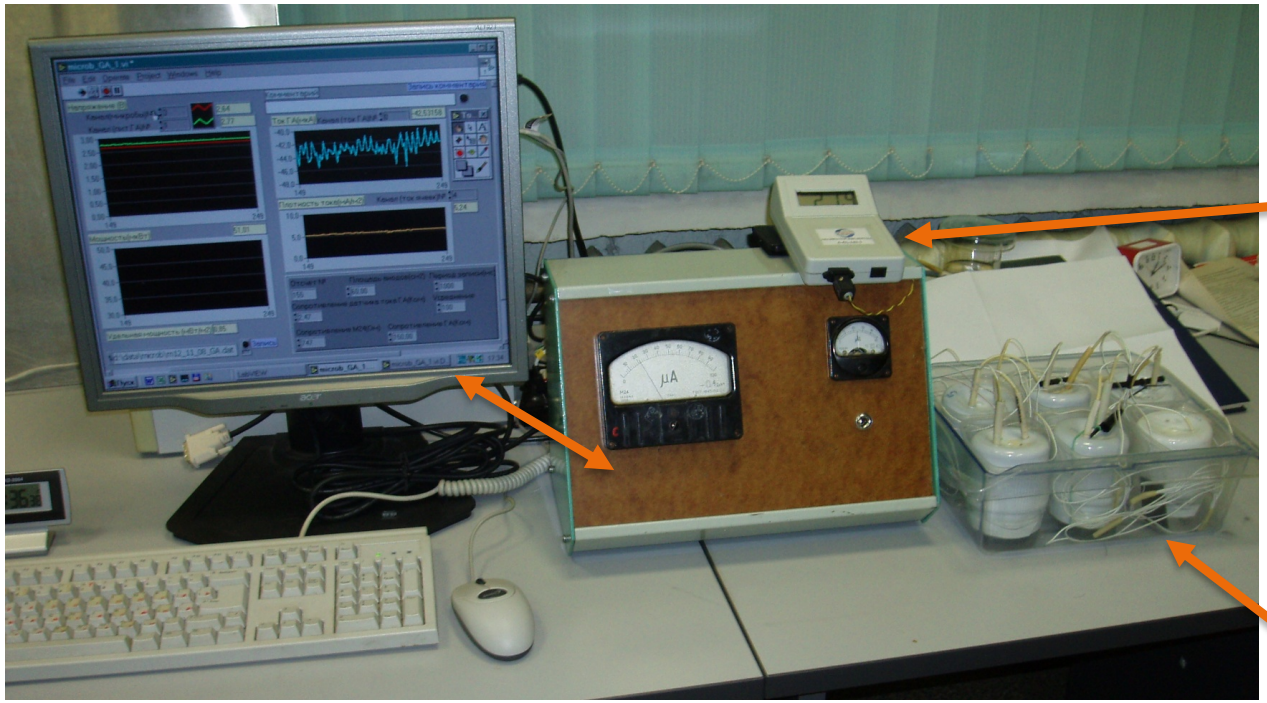
Dependence of voltage and power of MFC from current



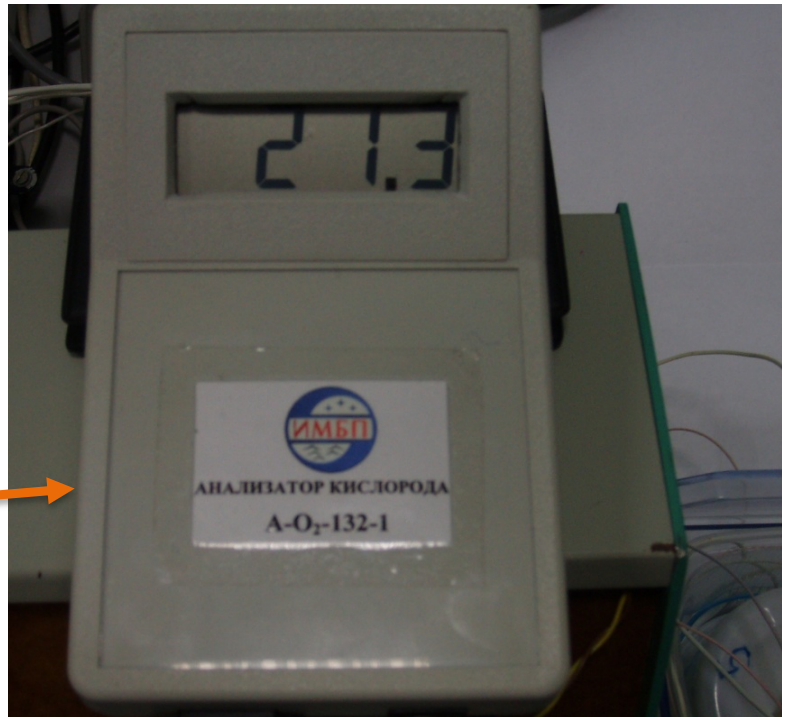
General outlook of

Dependence of electric mowing power, voltage and power of MFC from time (anode square 60 см2)

General outlook of MFC with the block of monitoring, registration and treatment of signals



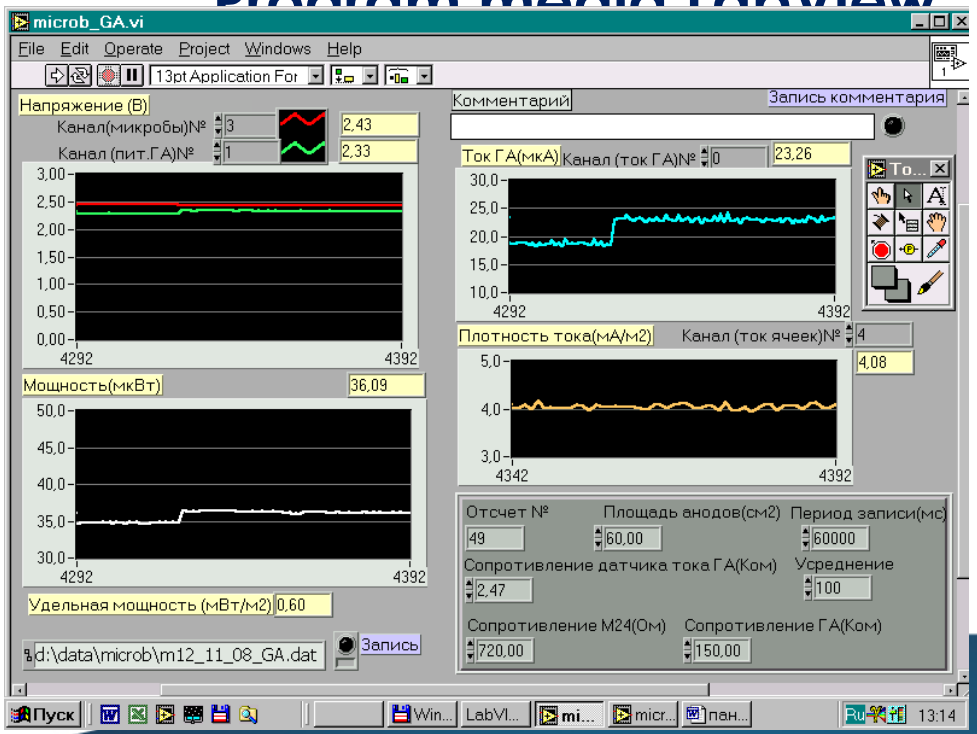
MFC Manipulation block on PC base

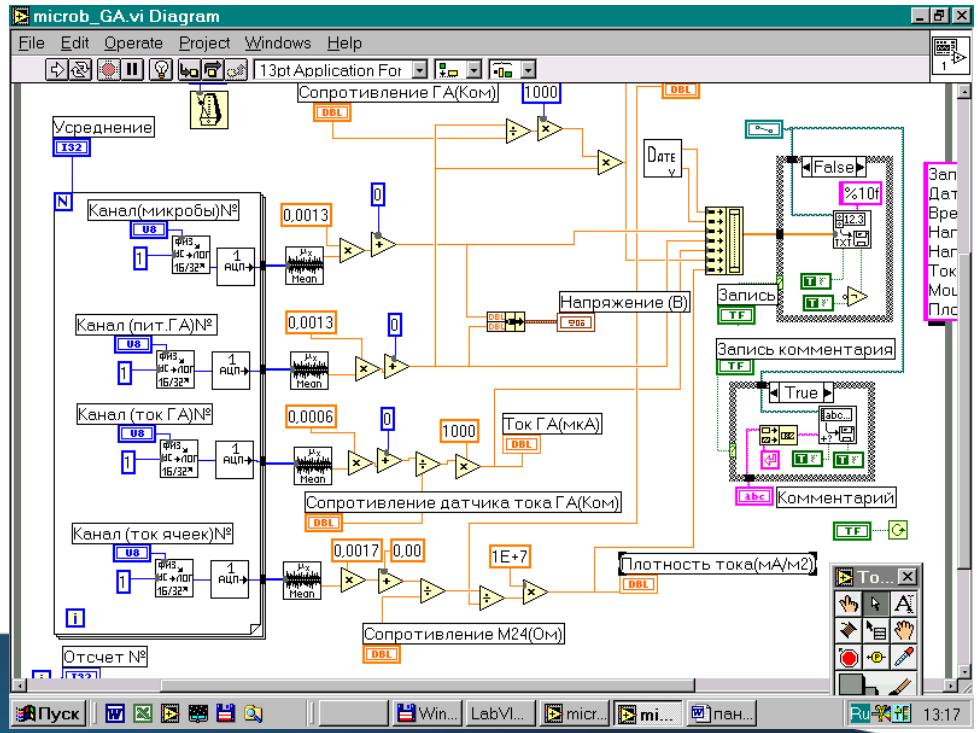


Gas analyser

6-cages battery

Interphase of electric parameters registration of MFC (left) and gas analyser (right) in Program media LabView





INVESTIGATIONS OF ELECTROGENIC BACTERIA MONOCULTURES ACTIVITY

Figure 1. Electrically conductive nanowires extend many times the length of the bacteria Shewanella oneidensis MR-1

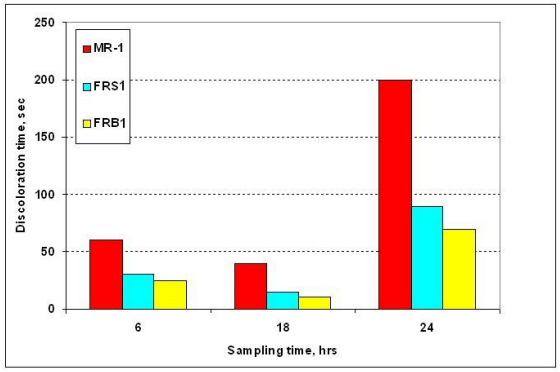


Figure 3. Dynamics of methylene blue dye discoloration (reduction) by the original strain S. oneidensis MR-1 and the mutants FRB1 and FRS1 grown in TSB medium.

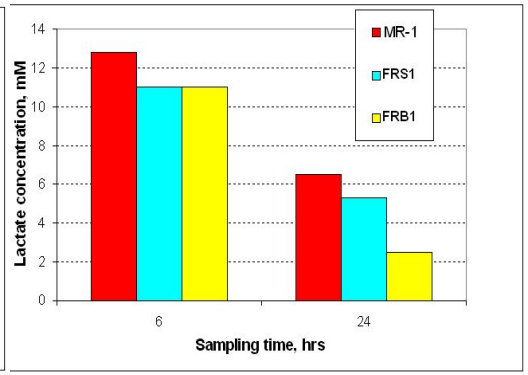


Figure 4. Dynamics of lactate consumption by the original strain S. oneidensis MR-1 and the mutants FRB1 and FRS1 grown in MM medium.

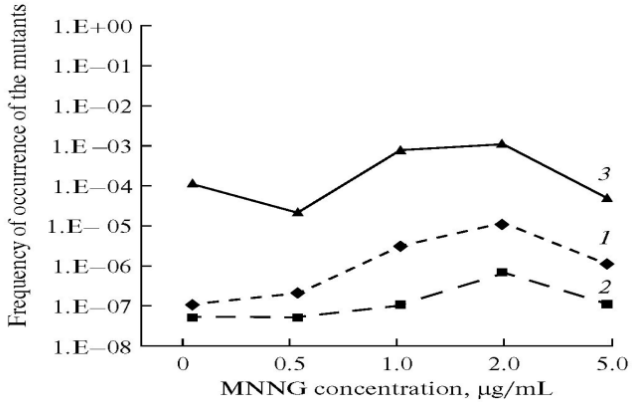
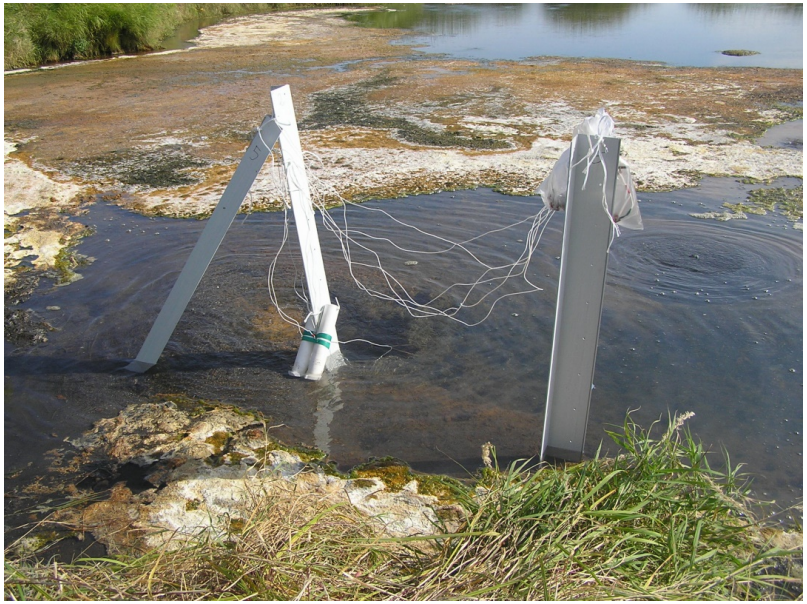


Figure 2. Frequency of occurrence of the mutants of S. oneidensis MR-1resistant to different antibiotics: streptomycin, 50 mcg/ml (1), kanamycin, 100 mcg/ml (2), fosfomycin, 1000 mcg/ml (3).



Power characteristics in MFC exposed in Kamchatka springs

Days of exposure	Sulfur spring
01	301
05	510
07,	610
11,	503
14,	218

Days of exposure	Ferrum spring
01	220
05	410
07,	530
11,	303
14,	218

Elementary content of active sludge

Chemical content of active sludge

Components	Content %
Water	93
Nitrogen	1,1
Phosphor (P_2O_5)	0,26
Potassium(K_2O)	0,22
Proteins	2,71
Lypids	1,63
Carbohydrates	1,08

Components	Content, %
Organics	0,05
Ammonial nitrogen	0,005
Non-organic phosphor	0,0015
Sulphates	0,01
Chlorides	0,01
Carbonates	0,02
Hydrocarbonates	0,01
Ca	0,007
Fe	0,001
Ca	0,001
Al	0,0001
Ars	0,0000005
Ag	0,0000001
Hg	0,000000001
Pb	0,0000008
Cdm	0,00000001
Ni	0,0000004
Cr 3+	0,000004
Mn	0,000015
Cj	0,0000002
Zn	0,00003
Cu	0,00001
Surfactents	0,0000003
Oil products	0,0000003
Water	99,88433839

Electric moving power (мВ) of electrode couples in MFC with cation-exchange membranes MK-40 using active sludge (anode part) and distilled water (cathode part) and saturation of cathode part by different gases (time of saturation 10 min/)

«+» and «-» charge of anode

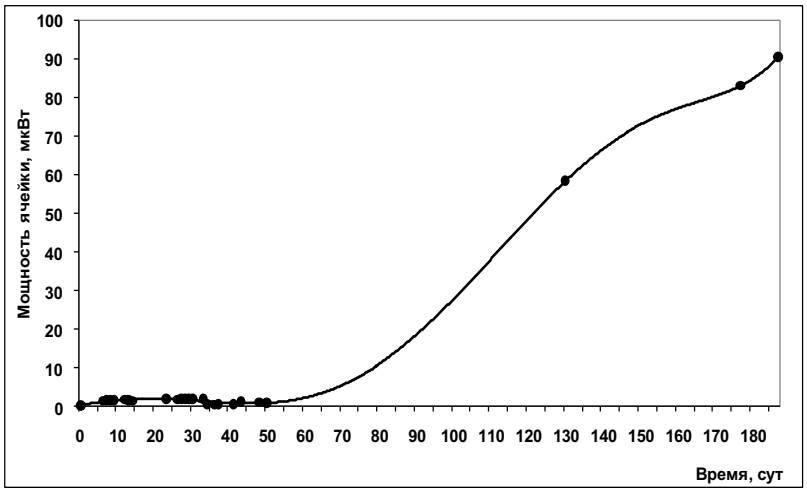
Anode	**Cathode**				
	Pb	Poric Titanium	Grafit ЭГП	Grafit МГ140	Gas
Pb	+393	+393	+605	+602	O_2
	+357	+357	+574	+533	Air
	+374	+375	+623	+612	N_2
Grafit МГ140	-259	-258	-48	-54	O_2
	-280	-281	-58	-101	Air
	-280	-280	-34	-44	N_2
Grafit ЭГП	-10	-8	+200	+185	O_2
	-26	-27	+200	+155	Air
	-45	-45	+203	+193	N_2

Electric moving power (mB) of electrode couples in MFC with cation-exchange membranes MK-40 using active sludge (anode part) and distilled water (cathode part) and saturation of cathode part by different gases (time of saturation 10min/)

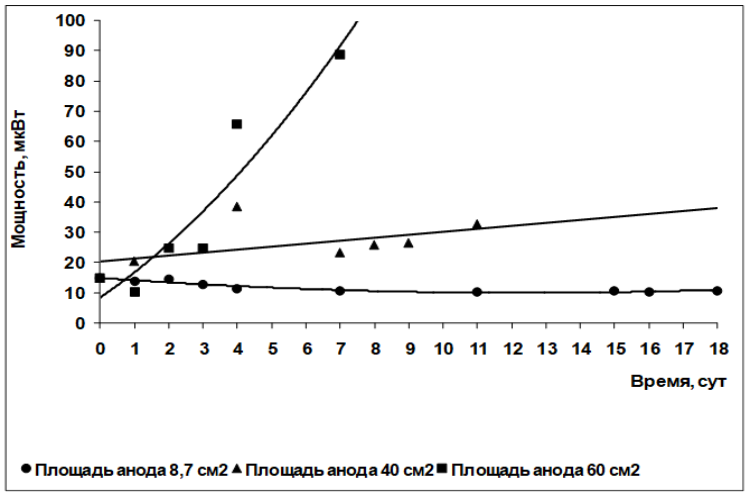
«+» and «-» charge of anode

Anod	**Cathod**				
	Pb	Poric Titanium	Grafit ЭГП	Grafit МГ140	Gas
Pb	+40	+200	+493	+200	O_2
	+66	+300	+528	+475	воздух
Grafit МГ140	-470	-222	-110	-200	O_2
	-554	-233	-200	-560	воздух
Grafit ЭГП	-270	+116	+240	+150	O_2
	-297	+106	+234	+80	воздух

Dependance of MTE power from time



MFC power under different square of anode under equivalent resistance 150 KoM

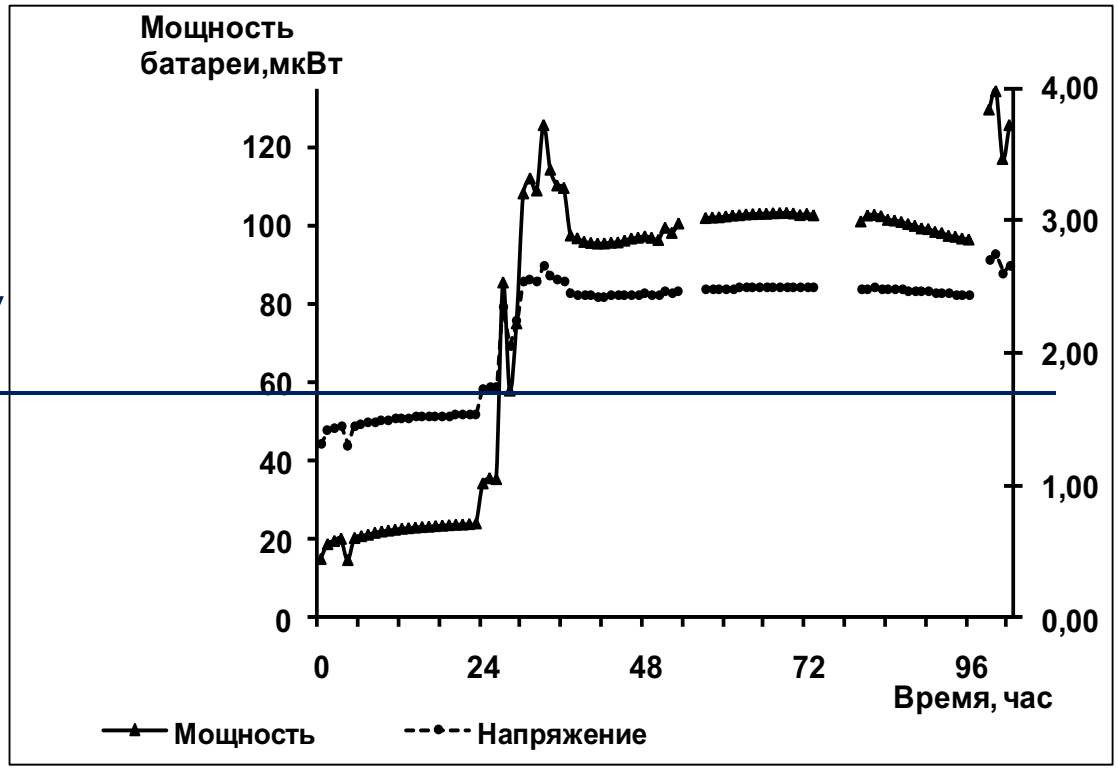


Testing of VFC with Shawanella

# testing	Data	Power, мV	Titre of Shewanella spp CFU per ml	
				катод
1	01.11.08	237	10^8	0
2	05.11.08	310	10^8	0
3	07.11.08	330	10^8	0
4	11.11.08	303	10^7	0

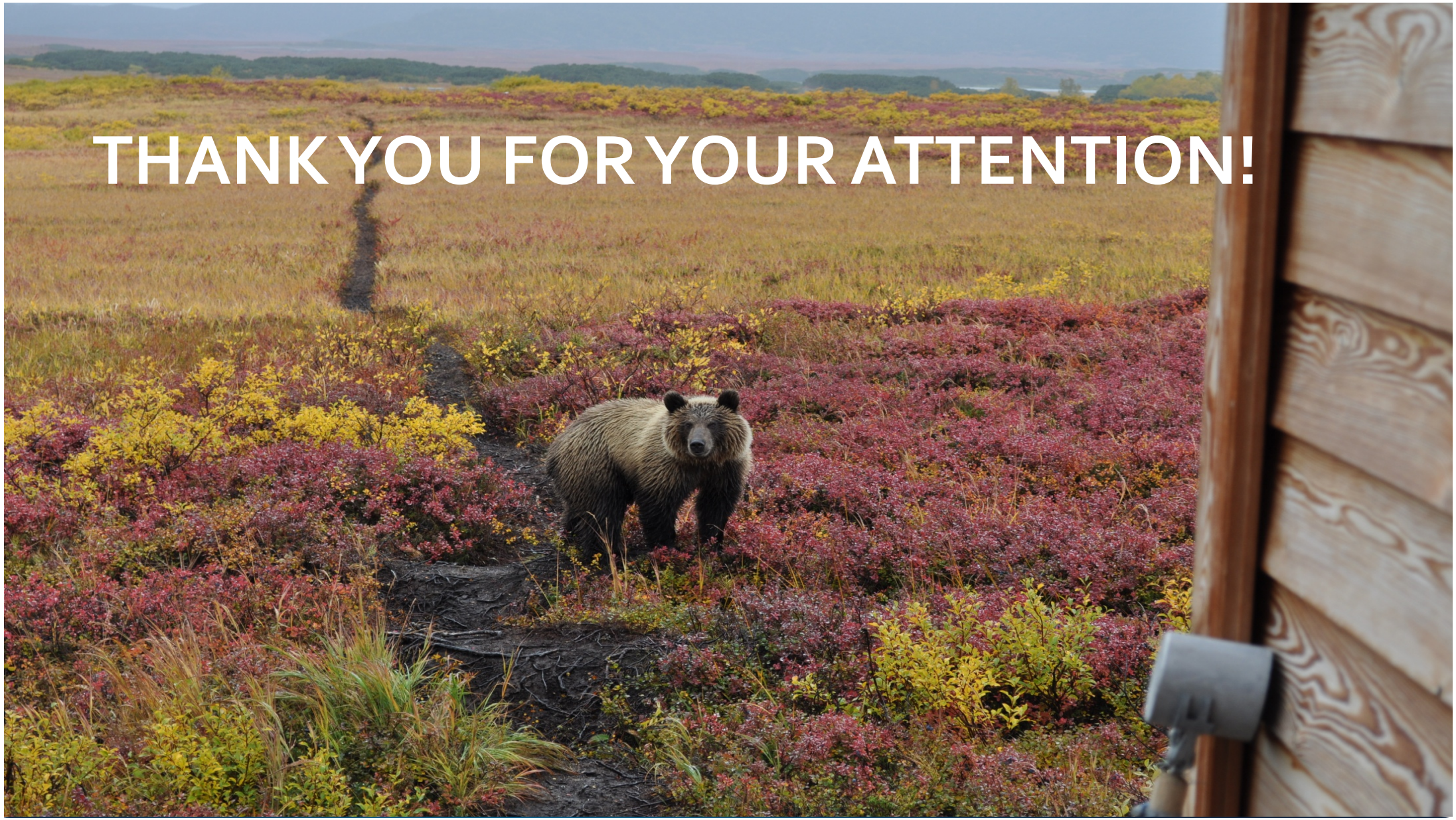
№ п.п.	Data	Power, мV	Shewanella spp CFU/ml	
			anode	kathode
1	01.11.08	237	10^8	0
2	05.11.08	310	10^8	0
3	07.11.08	330	10^8	0
4	11.11.08	303	10^7	0

Necessary voltage



PROSPECTIVES

1. To perform bioutilization scenario in spaceflight conditions (BION-M2)
2. To make bioutilization products compatible with other ELSS (watering of plants, consumption of CO2 by plants
3. To create “fitoprobiotics” – plant protection probiotics
4. To combine MFC with bioreactors
5. To optimize cathode chamber of MFC to arise bioelectricity production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