
# WORKING MODEL OF A CLOSED ECOSYSTEM FOR TESTING BTLSS TECHNOLOGIES

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# Appropriateness of the experimental models of closed ecosystems' creation

The experimental models of closed ecosystems (EMCES) allow solution of the following tasks :

1. To determine an imperfection degree of the technologies under tests meant for stability sustainment and for high closure of matter turnover processes in a future full-scale biological-technical life support system (BTLSS) including a human.

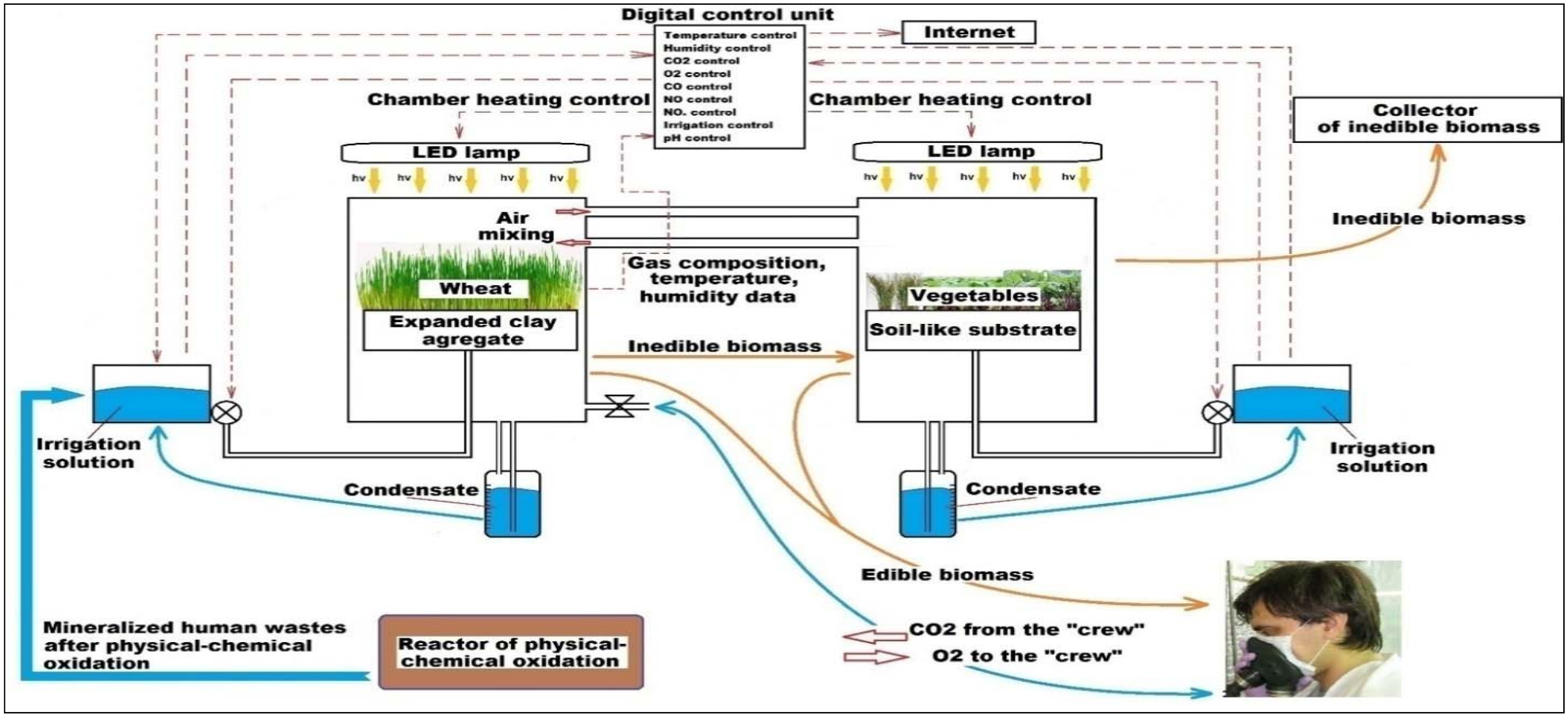
2. To save time and financial resources in comparison with these technologies testing in a full-scale BTLSS.

3. To minimize risks associated with human health under testing of those technologies in the full-scale BTLSS including a human.

4. To avoid necessity of costly experiments' stoppage in the full-scale BTLSS in the event of imperfection of the technologies under tests.

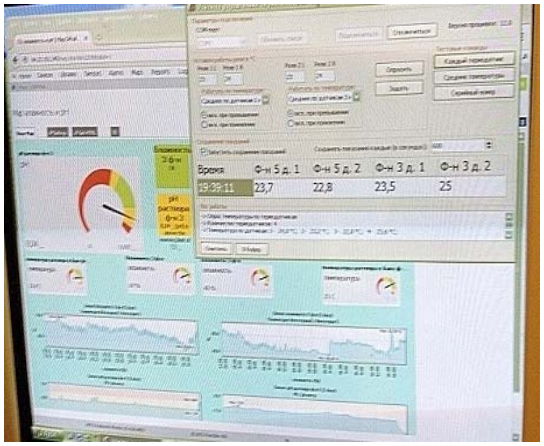
5. To use the experimental models under study for assessment of stability degree of future BTLSS to different perturbation actions both for space and terrestrial application since implementation of direct experiments in the BTLSS including a human will be absolutely unacceptable.

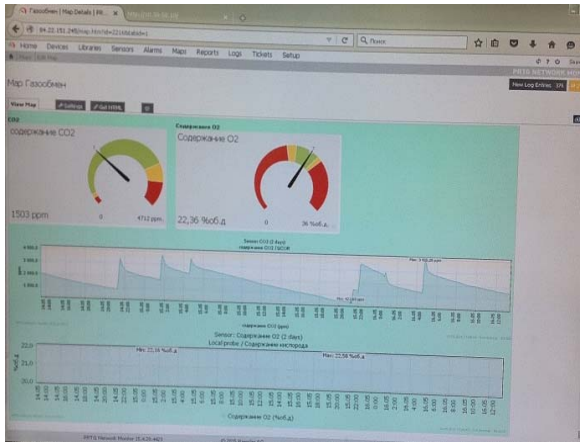
# Structure chart of the experimental model of closed ecosystem (EMCES) with designed quantity of a human

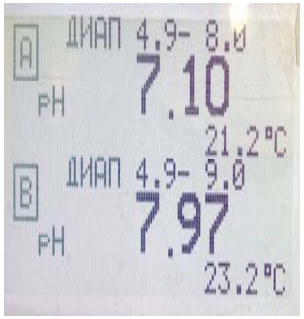


# Engineering units of EMCES control

Computerized automatic system of survey and environment parameters' control in EMCES  with data access via Internet.

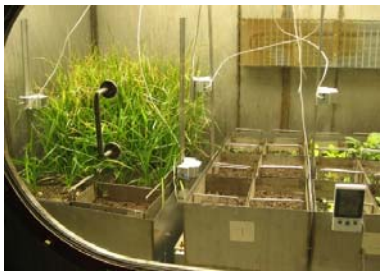
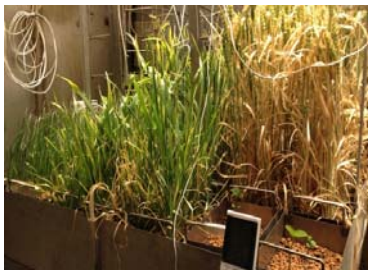







Interface of network access to the system of data acquisition on the example of separate online displays of the information registered.

# Photosynthesizing unit of EMCES

Sown areas' distribution between plant cenosis

| Culture | $m^2$ | % |
|---|---|---|
| Wheat | 0.64 | 34.5 |
| Chufa | 0.26 | 13.8 |
| Vegetables | 0.896 | 48.3 |
| Soya | 0.064 | 3.4 |
| Total | 1.86 | 100 |

# CO2 dynamics in the system

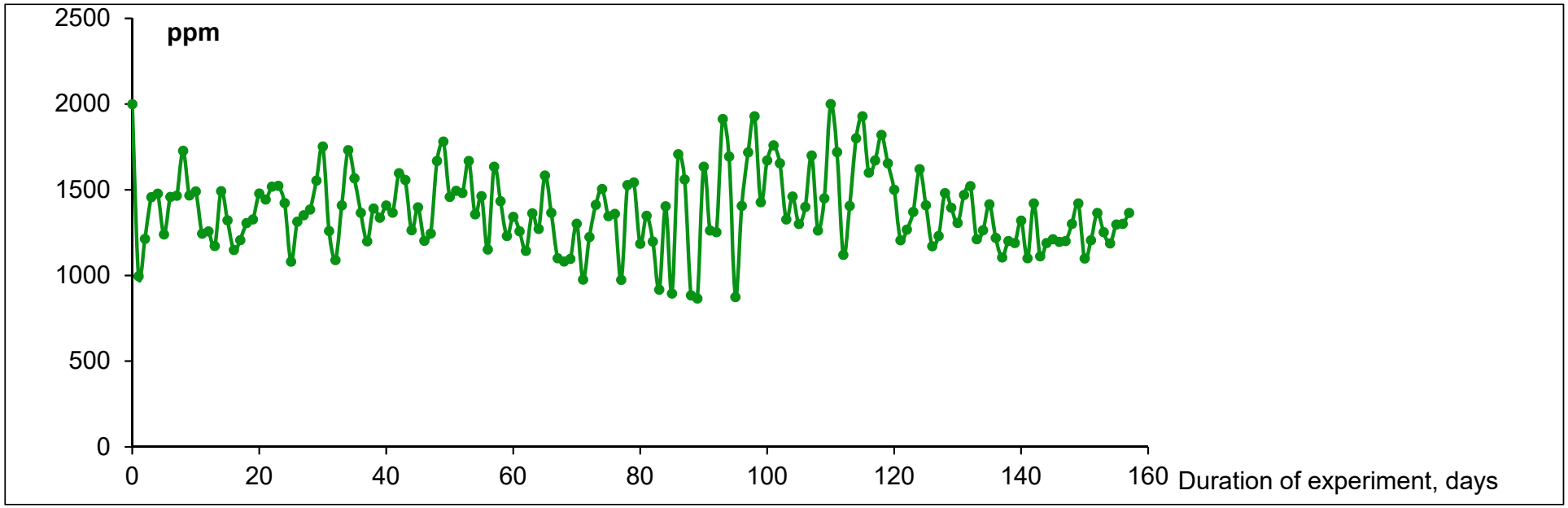
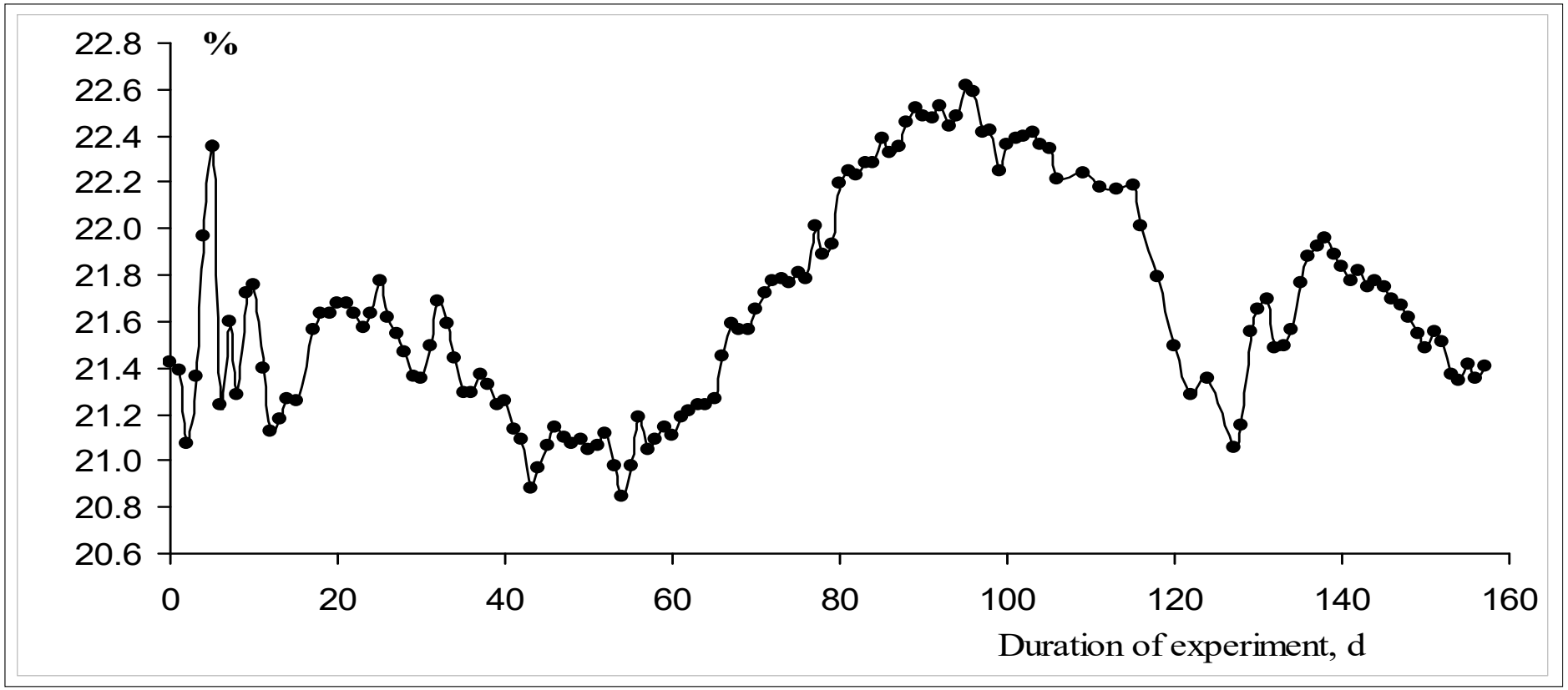



**Fig. CO2 average daily concentration in EMCES**

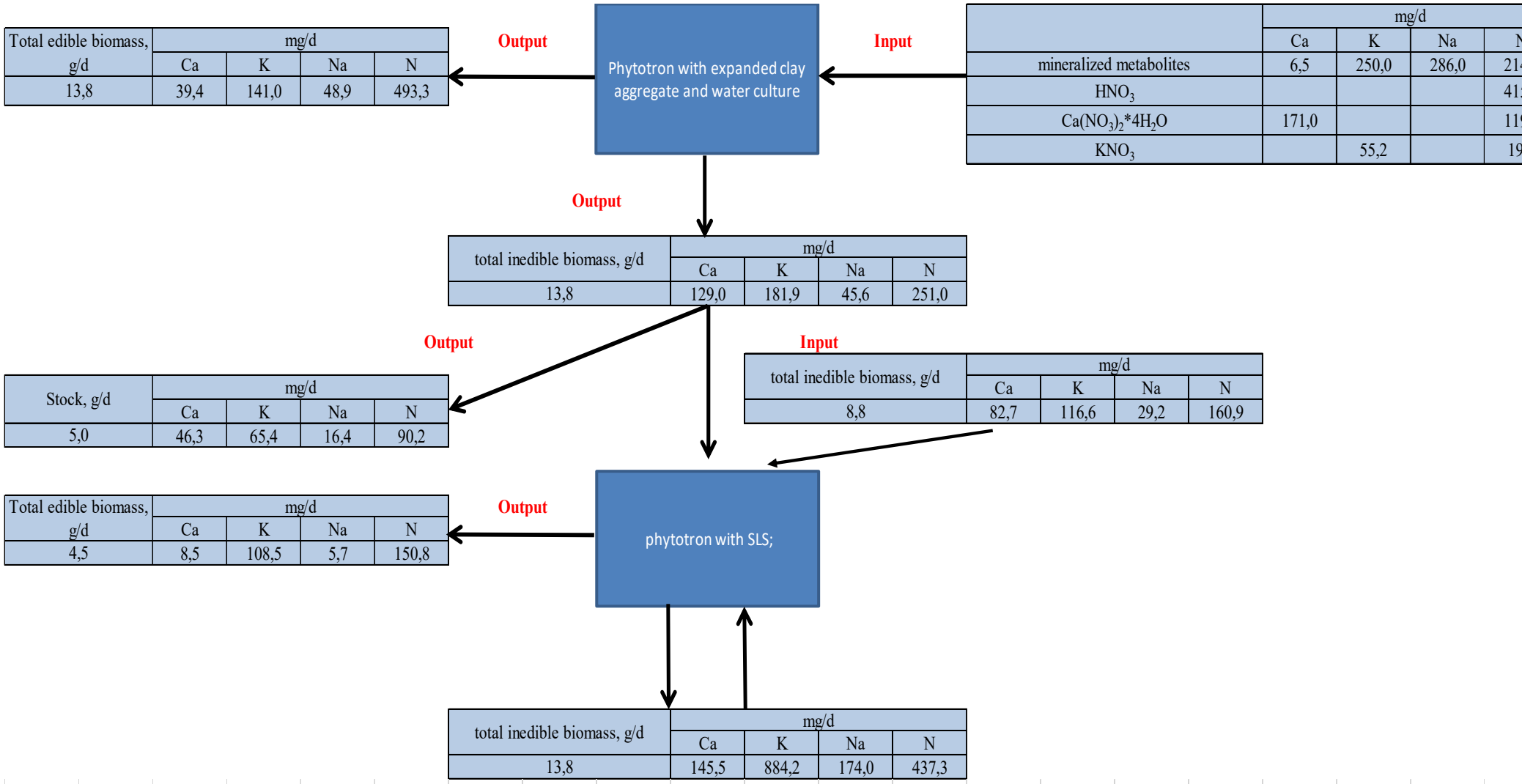
**Main CO2 consumer– higher plants**

# $O_2$ dynamics in EMCES




**Higher plants- O2 main source in EMCES**

# Recycling of plant biomass and chemical compounds




| | mg/d | | | |
|---|---|---|---|---|
| | Ca | K | Na | N |
| mineralized metabolites | 6,5 | 250,0 | 286,0 | 21 |
| $HNO_3$ | | | | 41 |
| $Ca(NO_3)_2*4H_2O$ | 171,0 | | | 11 |
| $KNO_3$ | | 55,2 | | 19 |

| Total edible biomass, | mg/d | | | |
|---|---|---|---|---|
| g/d | Ca | K | Na | N |
| 13,8 | 39,4 | 141,0 | 48,9 | 493,3 |

| total inedible biomass, g/d | mg/d | | | |
|---|---|---|---|---|
| | Ca | K | Na | N |
| 13,8 | 129,0 | 181,9 | 45,6 | 251,0 |

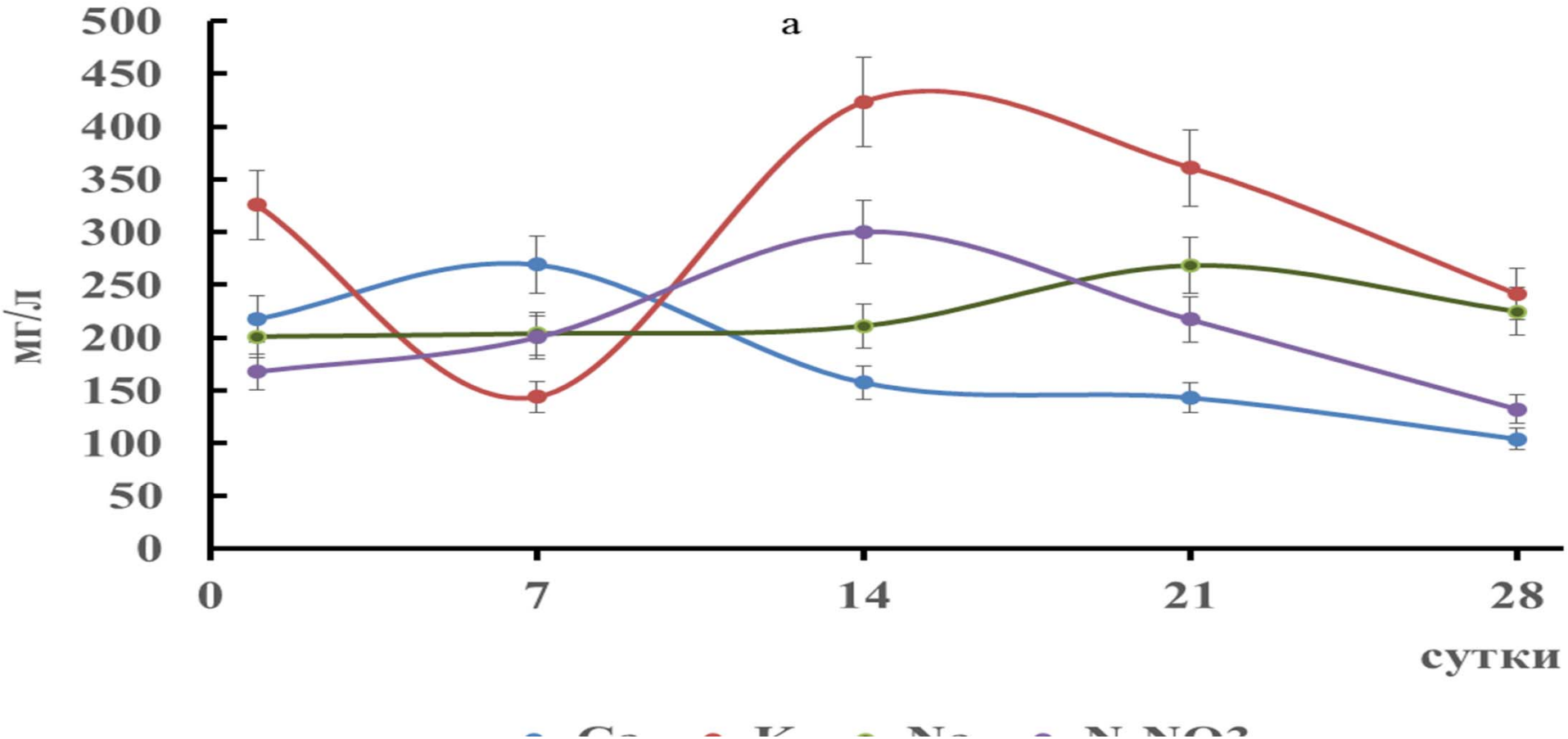
| Stock, g/d | mg/d | | | |
|---|---|---|---|---|
| | Ca | K | Na | N |
| 5,0 | 46,3 | 65,4 | 16,4 | 90,2 |

| total inedible biomass, g/d | mg/d | | | |
|---|---|---|---|---|
| | Ca | K | Na | N |
| 8,8 | 82,7 | 116,6 | 29,2 | 160,9 |

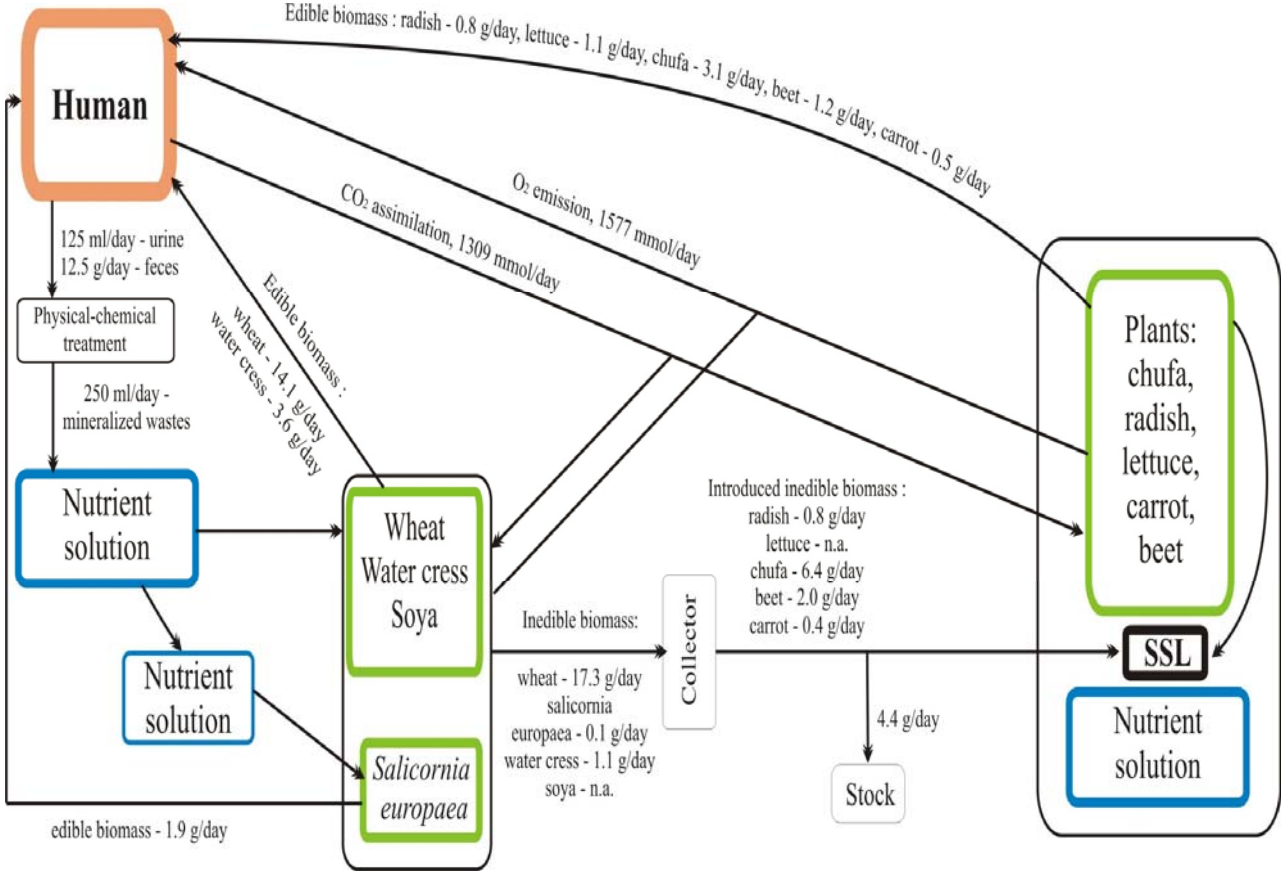
| Total edible biomass, | mg/d | | | |
|---|---|---|---|---|
| g/d | Ca | K | Na | N |
| 4,5 | 8,5 | 108,5 | 5,7 | 150,8 |

| total inedible biomass, g/d | mg/d | | | |
|---|---|---|---|---|
| | Ca | K | Na | N |
| 13,8 | 145,5 | 884,2 | 174,0 | 437,3 |

# Turnover dynamics of main biogenic elements in the system



# Organization of turnover process in EMCES




A human breathed out air into the system and inhaled air from the system sustaining $CO_2$/ $O_2$ ratio in the limits simulating 0.06 of the human breathing needs. Edible biomass was removed from the EMCES; and inedible biomass was returned in the SLS. To compensate mineral elements withdrawn from the SLS with edible biomass the inedible biomass, grown by hydroponics on expanded clay aggregate and by a water culture method, was applied in the SLS in the amount necessary to recover the potassium content. Human metabolites were mineralized in the reactor of physical-chemical oxidation; the REACTOR GAS after its purification entered the EMCE and was used to correct the nutrient solution for the plants cultivated by a hydroponics method on expanded clay aggregate restoring the nutrient elements' concentration up to a necessary level.

# Conclusion

- The automated experimental model of the biological-technical life support system designed for the calculated human part has been created.
- The system generated allows organization of turnover processes simulating basic mass exchange principles of liquid, solid and gaseous components in the BTLSS including a human.
- Feasibility to improve and/or to approbate new technologies and to study interaction peculiarities of biological and physical-chemical components of mass exchange, to disclose the factors limiting closure level regarding different elements and compounds and to find the ways of their elimination has been discovered on the base of the created system.
- Use of the given research data will allow sufficient saving of the financial and time resources at creation of real full-scale BTLSS.