MELISSA
MICRO-ECOLOGICAL
LIFE SUPPORT SYSTEM
ALTERNATIVE

CREATING
A CIRCULAR
FUTURE

The connection of physical-chemical and biological processes for future closed life support systems for space

Physical and chemical systems

Main disadvantage

There is no possibility of food regeneration

Need for repairs

Biological system

Main disadvantage

Occupy large areas/all

slow disposal of organic waste

Synthesis

Hybrid system

Complementary properties

- **Biological links – the main role in the regeneration of the environment, the synthesis of plant food**
- **Physico-chemical units – auxiliary role in the regeneration of the environment, the main role in disposal of organic waste**

TYPICAL FEATURES PHYSICO/CHEMICAL AND BIOLOGICAL LSS

Physical-chemical

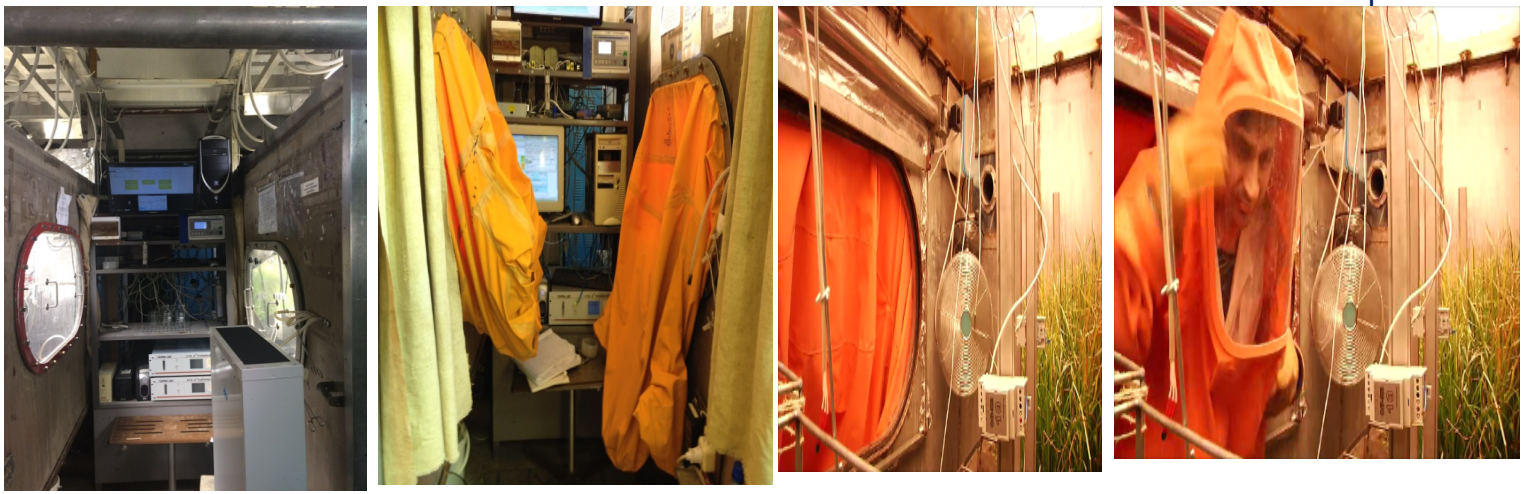
- Rapid start-up
- Fast processing rates
- Reactions (near) complete
- Predictable performance
- Can sterilize
- Can treat non-biodegradables
- Mineralization of nitrogen
- Some high T°, power, pressure
- High pre-processing needs
- Complex hardware

Biological

- Low power, T°, and pressure
- Low pre-processing requirements
- Good plant nutrient recovery
- Self-Recovery - adaptable
- Increased integration options
- Simpler hardware
- Incomplete reactions - C storage
- Slower start-up, reaction rates
- Less predictable - system upset
- Difficult process/microbial control

Using a small ecosystem to perform research

1 2 3 4



1– General view , 2 - General view after replacing transparent hatches with hatches with sealed suits, 3 – inside view (sealed curtain raised) after installing a sealed suit (video camera installed inside), 4 –an operator works inside a small ecosystem

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.

Use of water from the circular process for the operation of the physical - chemical unit

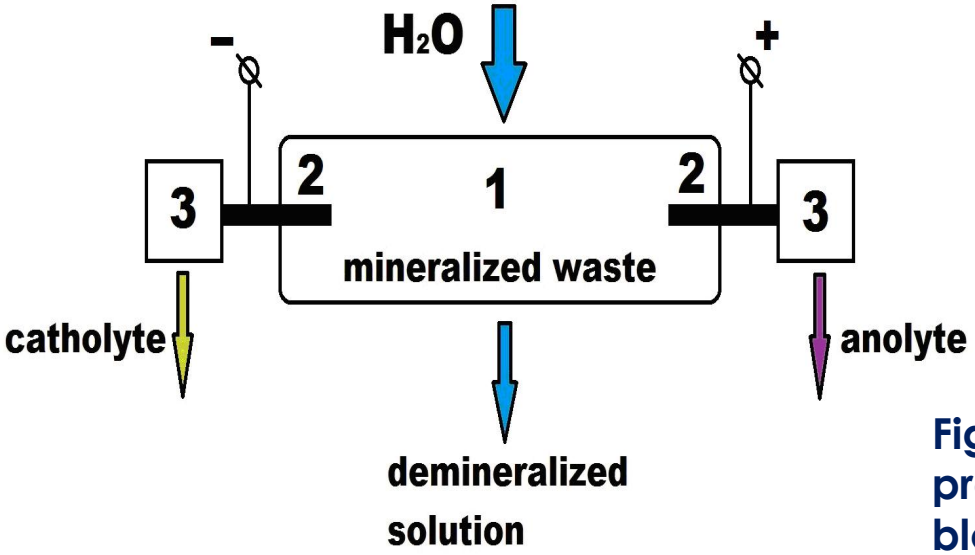


Fig. Use of water from the circular process for reactor liquid

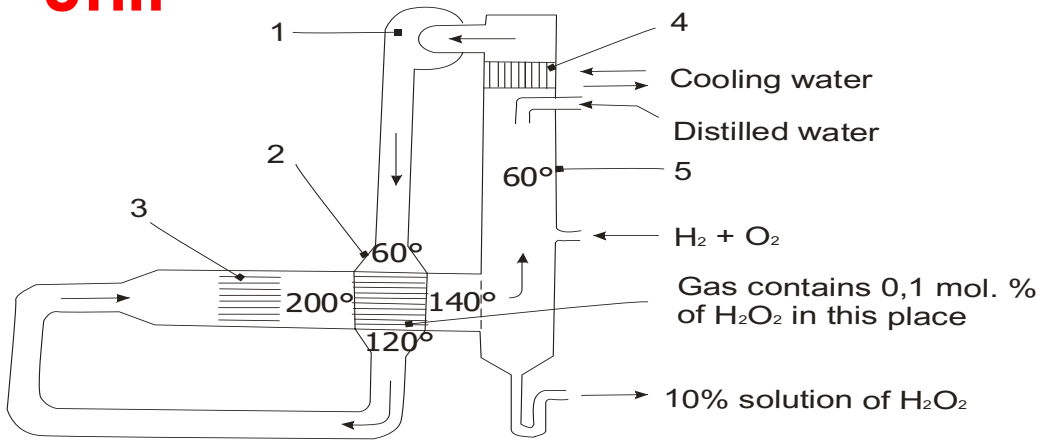
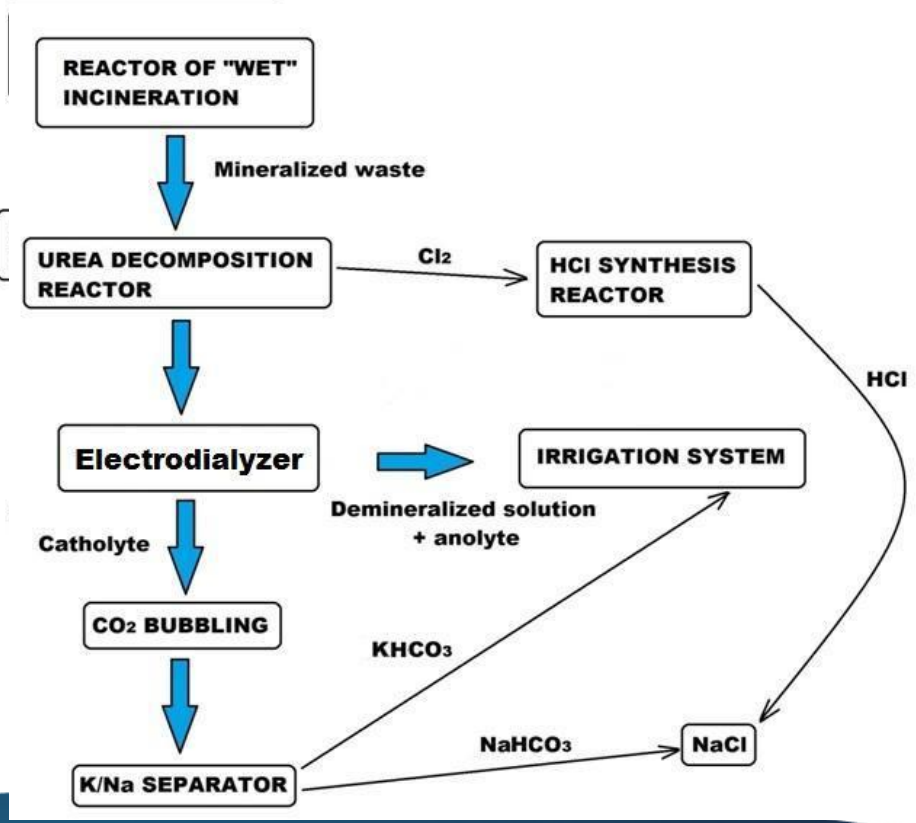
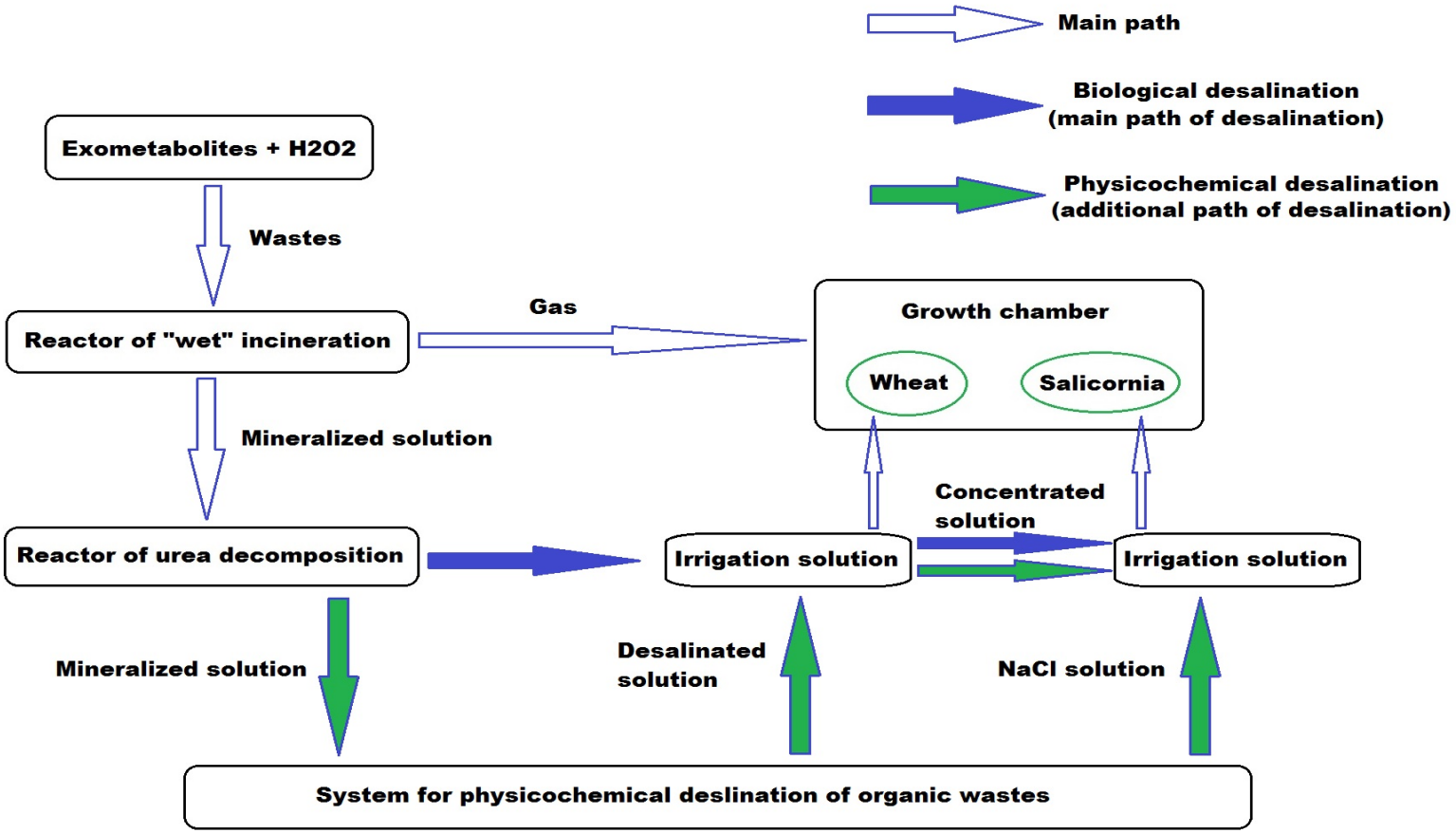


Fig. diagram of the electric discharge process for producing hydrogen peroxide by Krusch: 1 – gas blower; 2 – heat exchanger; 3 – ionization chamber; 4 – aluminum condenser; 5 – distillation column. (Walter C. Schaumb, C.N. Satterfield, R.L. Wentworth. Hydrogen Peroxide. M. 1958. (Publishing house of Inostrannaya literature (Foreign literature. 578 p. (In Russian).

Scheme of operation of the physical - chemical unit



Gas circuit as an example of interaction of physical-chemical and biological processes



Human metabolites recycling in the LSS as an example of the interaction of physical-chemical and biological processes

Faeces and urine oxidation by H_2O_2 in the wet oxidation chamber

↓

Gradual introduction of mineralized faeces and urine into irrigation water

↓

Cultivation of wheat on SLS: 70-day vegetation

9 cycles

↓

Control of NaCl concentration in irrigation water after each wheat generation (below 0.6 g/L) by electrodialysis

↓

Recycling of irrigation water

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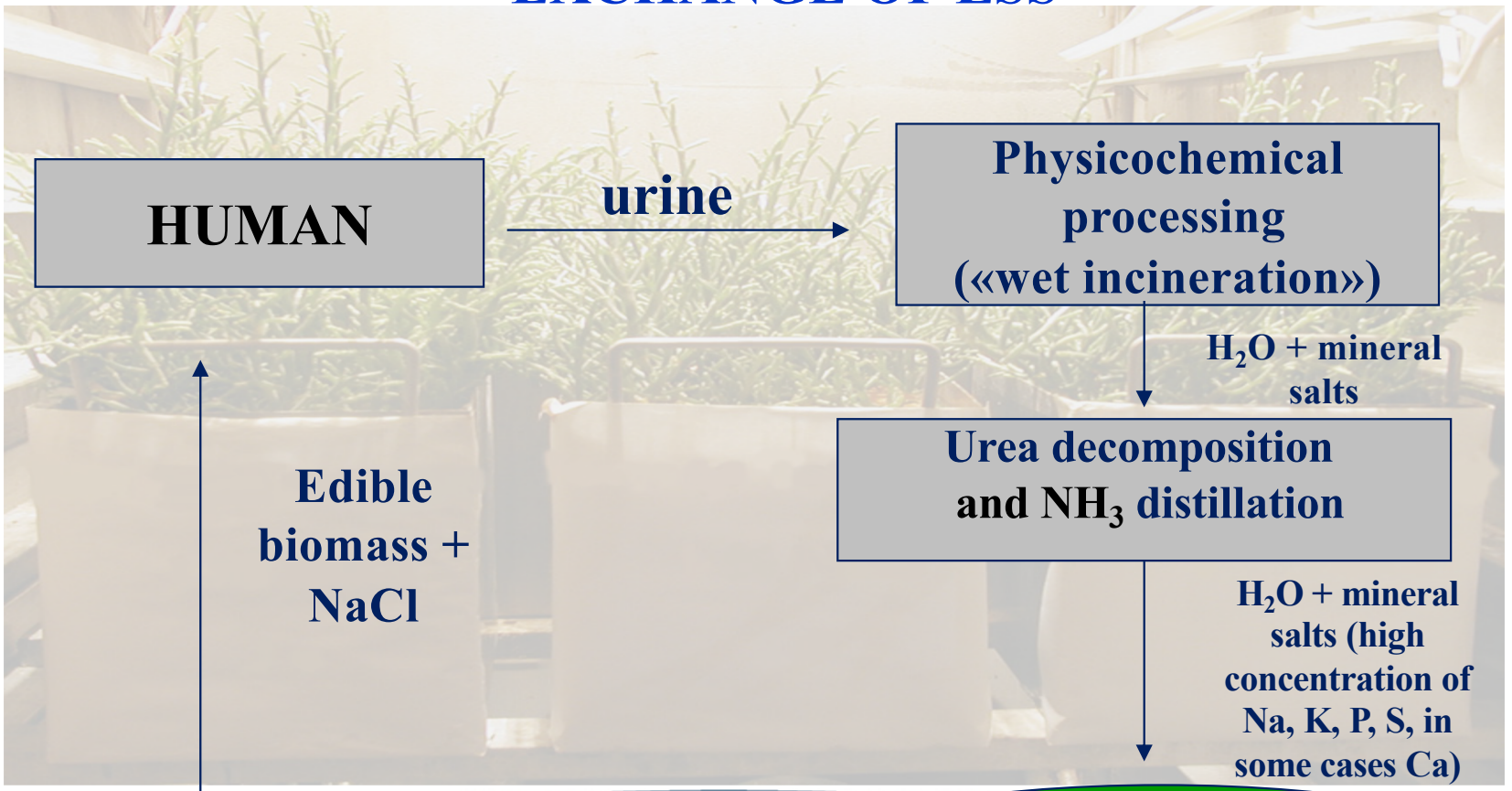
↓

Recycling of inedible biomass in SLS: straw and roots, after crushing

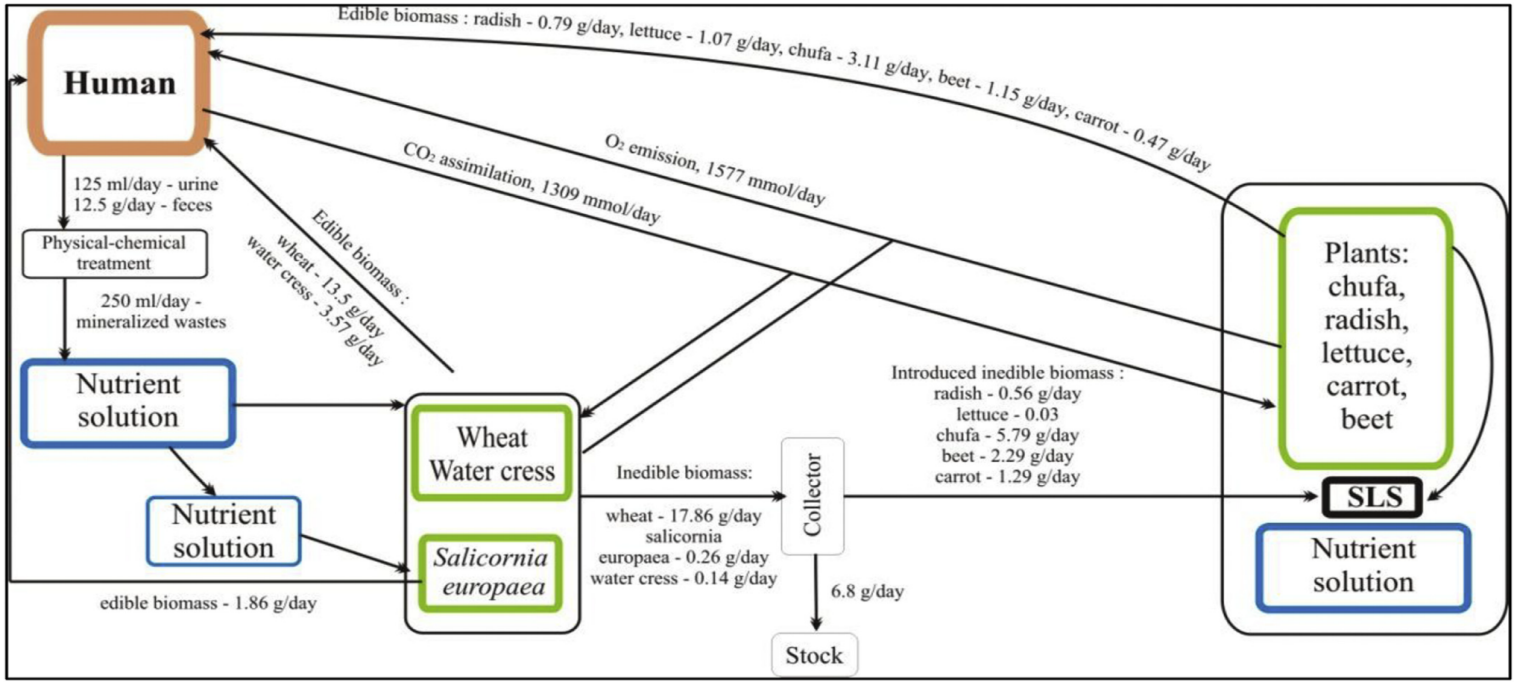
→

ONE OF THE WAYS TO INVOLVE NaCl IN THE INTRASYSTEM MASS EXCHANGE OF LSS



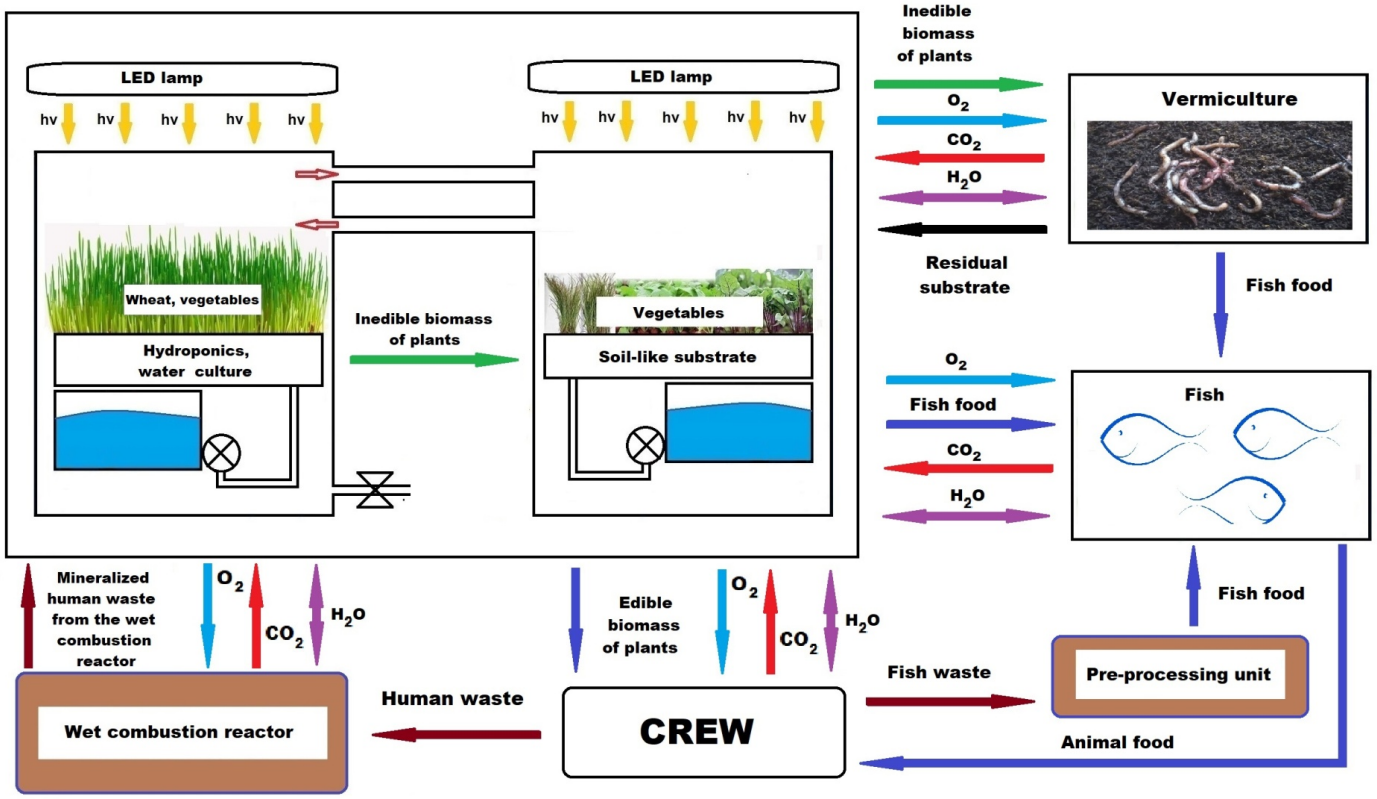
Fragments of the photosynthetic unit as a supplier of O2 and CO2 for physical - chemical processes

Organization of circular processes in the experimental model of LSS



Daily productivity of the phototrophic component (g/d) and mass exchange in the EMCE (Tikhomirov et.al., Acta Astronautica, 2020).

Further development of closed models of small hybrid ecosystems



Conclusion

- On the example of a physical model of a hybrid closed ecosystem, the features of combining biological and physical-chemical technologies for their joint functioning in the LSS are demonstrated.
- The information obtained can be used in the design of full-scale highly-closed hybrid LSS

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THANK YOU.

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