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CLOSED ECOLOGICAL SYSTEM STABILITY AND HUMAN CONTROL LIMITATIONS

Abstract

The idea of Closed Ecological Systems (CES) as systems functioning on the basis of internal material recirculation was generated by the works of V. Vernadsky in early 20th century. At the same time, this idea was applied to the concept of man-made CES for long-term Life Support (LS) in space by K. Tsiolkovsky. Since that time different configurations and scale schematics have been suggested for experimental testing of this approach, and up to date we have three 'long-term' human rated experiments accomplished in this area:

1. Biosphere of the Earth (lasting for millions of years);
2. Biosphere-2 (USA, Arizona, 2 year closure test);
3. BIOS-3 (USSR, Siberia, 6 months of uninterrupted closure, 2 years of total of closure tests)

The importance of long-lasting 'functional stability' in CES is obvious for all of the aforementioned experiments. Human Control (HC) capabilities to provide the required level of 'stability' are also of key importance. It is easy to see that principles of 'functional stability' control vary for all three CES, and HC is also represented by different mechanisms:

1. Biosphere of the Earth, principle of 'statistical regulation' buffered by huge amounts of accumulated system materials;
2. BIOS-3, principle of 'purposeful human intervention' into the system's processes to keep it running under required life support rates;
3. Biosphere-2, combination for above mentioned two principles of regulation.

This analytical research examines in detail the principles of CES 'functional stability' control, identifies system 'stability' limits, and outlines human (placed inside the system) regulation capabilities, depending on system scale and rates of material circulation, from a common position based on identical math modeling approaches. The results of the math model analysis are compared with results of experimental testing for all three systems.