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C.R.O.P.® DEMONSTRATOR FOR HUMAN SPACE EXPLORATION: EXPERIMENT ANALYSIS AND SYSTEM MODEL DEVELOPMENT

Abstract

Decades have passed since the last crewed mission to a celestial body. After the Apollo era human presence in space has been limited to low Earth orbit. For long-term and far-distant human space travel the reliability and sustainability of systems are critical. Synergies must be generated between and inside different systems. Also, mass resupply has to be reduced as much as possible. These requirements imply for environmental control and life support systems not only the closure, but also the combination of material cycles. Bioregenerative ECLSS offer the advantage to simultaneously revitalize air by fixing carbon dioxide and producing oxygen, purify waste water and, generate human consumables by e.g. growing plants. The C.R.O.P.® biofilter system, developed at the Institute of Aerospace Medicine at DLR, is a sustainable concept for the improvement of wastewater in combination with plant cultivation. Therefore, two demonstrators incorporating C.R.O.P.® biofilters in combination with a closed growth chamber, have been built at ESA under the SpaceShip EAC initiative. The hydroponic growth method used in the demonstrators allow a closure of the water loop. The design, execution and analysis of experiments and, based on experimental data, the development of the simulation model of the C.R.O.P.® demonstrator at EAC are described.

Experiments with 'Micro-Tina' tomato plants proved the functionality of the demonstrators. Environmental conditions such as temperature, humidity and photoperiod inside the growth chamber, as well as pH and EC of the water are found appropriate for plant growth.

The addition of synthetic urine to the hydroponic system provide all nutrients required for tomatoes through all growth cycles. The plants' total biomass, leaf area index and total number of tomatoes are significantly lower compared to the experiment with fertilizer as additive to the system. Another experiment where lunar regolith simulant is used as growth medium instead of rockwool germinated successfully, but plants were unable to develop flowers and fruits.

In order to predict crop performance and to simulate the conditions of the controlled environment a simulation model of the C.R.O.P.® demonstrators is created based on collected data, existing crop production models and models already used in ELISSA, a software developed by the University of Stuttgart.

Simulation results and experimental results are compared in order to validate the final C.R.O.P.® demonstrator model. Modelled data could only be validated partially. The implementation of this model in ELISSA has the potential of evaluating the C.R.O.P.® demonstrators in an overall system.