Creative 3D Plant Optimization (C3PO) System for the eXploration Systems and Habitation (X-Hab) 2018 Academic Innovation Challenge

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Introduction
As work in space continues to progress, many different ideas are being explored to improve life for astronauts. One factor that has been extensively researched is the viability of growing plants on the international space station (ISS). As plants provide a fresh source of food and psychological benefits for the astronauts providing their care, growing plants has remained a point of interest for NASA over the years. Currently the VEGGIE system provides a platform for growing plants on the ISS; however, the system creates a large amount of waste (the substrate after use) and requires regular interaction from the astronauts, as the watering system is actively controlled.

A previous project at USU developed a 3D printed substrate system is aimed at providing an STL model of the substrate that can easily be printed in 3D printed substrates. Creative 3D Plant Optimization (C3PO) System for the eXploration Systems and Habitation (X-Hab) 2018, a project at USU, developed a 3D printed substrate system is aimed at growing plants on the ISS; however, the system creates a large amount of waste (the substrate after use) and requires regular interaction from the astronauts, as the watering system is actively controlled.

Objectives
- Develop a 3D Printed substrate that will act as a growth surface for plant life growth in microgravity.
- Provide an STL model of the substrate that can easily be printed in 3D printed substrates.
- Ceramic and tree growth of different plants in the 3D printed substrates.
- Develop a theoretical model of how the water/nutrient solution wicking effects in 3D printed substrates.
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Results
Tests were performed on the 3D printed substrates to evaluate their effects on plant growth, to provide data for modeling and to guide future design. Wicking tests were performed to assess how effective different materials were at wicking water and how triangle size influenced water uptake. A water retention test was performed to quantify how quickly water drained from the substrate. Intron crush testing was performed to test the strength of the blocks. In addition to testing the mechanical properties of the blocks, material property tests were performed to test the safety of materials on the space station. Scanning electron microscopy testing to investigate leachable chemicals. Plant growth tests were also performed. Plant growth is the primary objective of our design. Plants were germinated on the blocks or transplanted to the blocks. The substrate design was modified based on results from the plant growth tests.

Substrate Testing
Micro-Channel Design
- Highly organized internal structure
- Spatial water retention
- Excellent structural strength
- Consistent water wicking of water

Multiple-Channel Design
- Multi-material design
- Simple to add air holes
- Simple to add air holes
- Simple to add air holes

Future Work
- Testing capillary action in various substrates under microgravity environments with drops from drones and towers.
- Modelling different substrate designs to create predictive model of capillary action of fluids in substrates that would be on International Space Station.
- Developing method of seed germination for plant growth in substrates.
- Outreach final design with local schools and conferences.

Literature Cited

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