The Durability of Plant-Based Air Filtering Systems in Buildings: From an Air Quality and Energy Reduction Perspective

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1 Introduction

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), after 40 years of research and practical experiments in the field, still have a challenge to find a satisfactory solution to reduce building energy consumption while maintaining good indoor air quality. Even though HVAC filtration systems seem to be among the best solution for IAQ, they are mostly ineffective for volatile organic compounds and mostly contaminate the air instead of filtering it by infrequently changed filters (Bluyssen, 2003). There is a clear need for the design of a system that can address the IAQ concerns in the buildings and reduce the energy load from the HVAC systems at the same time.

Plants can improve IAQ by metabolizing airborne pollutants such as formaldehyde, benzene, and xylene (Wolverton, 1993; Yoo, 2006; Aydogan, 2011). The utilization of the root zone (rhizosphere) of the plant is paramount to achieving high purification ability. In continuation of earlier works of the author (Aydogan and Tardos, 2017), this paper is focusing on the durability of the prototype design, fabrication, and assembly of an alternative filtration system by utilizing plants to clean indoor air and reduce energy consumption.

2 Materials and Methods

The prototype of the plant-based air filtering system is composed of three main parts: *(1)* a cassette holding the mesh, *(2)* a mesh holding the plants and growing media, and *(3)* a structure holding the cassettes together (Figure 1).

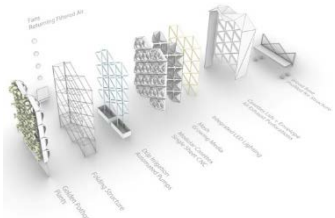

Figure 1. Exploded diagram of plant-based air filtering system.

The design of the modular system utilizes a series of cassettes that are repetitive and arranged to form a wall system. Each cassette holds the mesh containing lightweight growing media and the plants, LED lighting and drip irrigation tools. Since the prototype is double-sided, the structure is designed to be versatile with easy and fast assembly by creating pockets that cassettes settle in. A mesh that holds the plants and growing media is designed by using a three-dimensional reinforcement mat. Growing media used in this system is composed of a mixed bed of activated carbon adsorbents and porous glass stones. Golden Pothos and English Ivy are used, based on the results of the toxin removal capacity that was discovered through our previous studies (Aydogan

and Montoya, 2011). In this prototype, emphasis is placed on designing a lightweight and collapsible scissor structure, which allows the project to be easily transported and assembled. Subtractive manufacturing methods (CNC) are selected to be used to conduct the base and the cassettes of the prototype. The cassettes and mesh holders are designed to be assembled by folding technique.

3 Results

In this project, a prototype containing 68 modules was designed and fabricated. Folding technique for the structure and cassettes seemed to be a practical solution, however; due to connection problems on the corners, the fabrication technique needs to be revisited for the cassettes. Instead of HDPE, materials that are more flexible are recommended as Styrene, Vinyl or Polypyrene. The structural scissor system is a practical technique to allow the ability to open and fold easily with lighter elements that carry the cassettes and growing media. The mesh holding the plants worked very well with the media. Since the system is designed on the premise of flexibility and modularity, the mesh can be easily replaced for the maintenance without shutting the whole system, which allows the durability of the system in the long run.

4 Conclusion and Future Potentials

The durability of plant-based filtration system is investigated by exploring the design, fabrication and installation properties of the materials. The structural scissors system, mesh holding the growth media and plants has a high potential to be applied to the plant-based filtration system. The proposed system would provide crucial support to building air handling systems. The designed prototype is the first model to demonstrate the constructive feasibility of the modular, durable, easily transportable, flexible, adaptable system which can be efficiently mounted in indoor spaces.

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