SCHOOL OF CONSTRUCTION AND THE ENVIRONMENT

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# Influence of Living Walls on Indoor Environmental Quality

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## Introduction

### Living Wall

There has been an increasing interest in installing interior living walls (ILW) due to their beauty, the ability to facilitate interactions between people and nature, and the belief in their contribution to indoor environmental quality (Figure 1). engineered living wall systems consists of three components; the manufactured carrier, the substrate, and the plants (Figure 2). However, there is little understanding of their impact on indoor air quality (IAQ) and the acoustical environmental indoors.

Figure 1: Interior living wall. From www.gsky.com

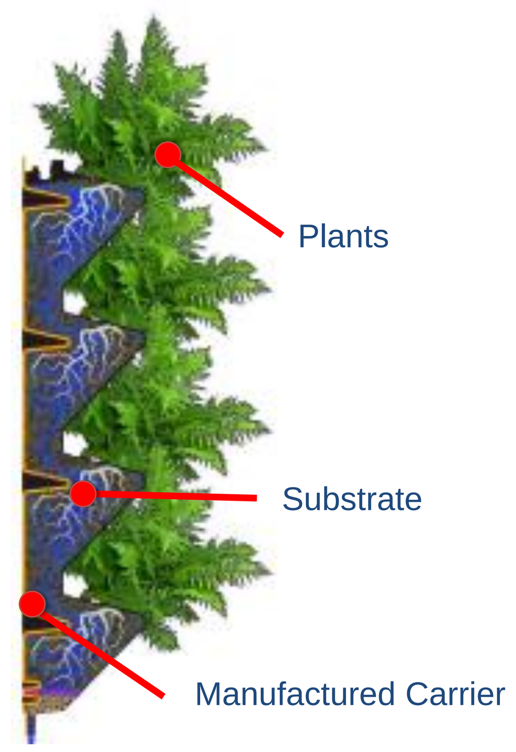


Figure 2: ILW System`s Components

### Indoor Air Quality

Many living wall installers touted the ILW as filters for volatile organic compounds (VOCs), carbon dioxide ($CO_2$), and other gaseous contaminants in the air that may cause sick building syndrome (SBS). While ornamental pot plants is effective in the removal of many gaseous contaminants in controlled settings, little is known about the ILW's impact in a building on VOCs and $CO_2$, which is expected to be less effective than what has been found in controlled settings. These factors may allow the building to have a lower ventilation rate to provide adequate IAQ.

At the same time, ILW may produce unintended IAQ effects. Plants increase the relative humidity (RH) indoors and facilitate the microbial growth on building materials. The substrate can become another source of indoor bacteria and fungi. Spores and metabolites produced by microbes (most notably endotoxin) may also be found in the air as well, which have been implicated in respiratory symptoms in SBS, and may be associated with the exacerbation of asthma. On the other hand, these factors may require the building to have a higher ventilation rate to provide adequate IAQ.

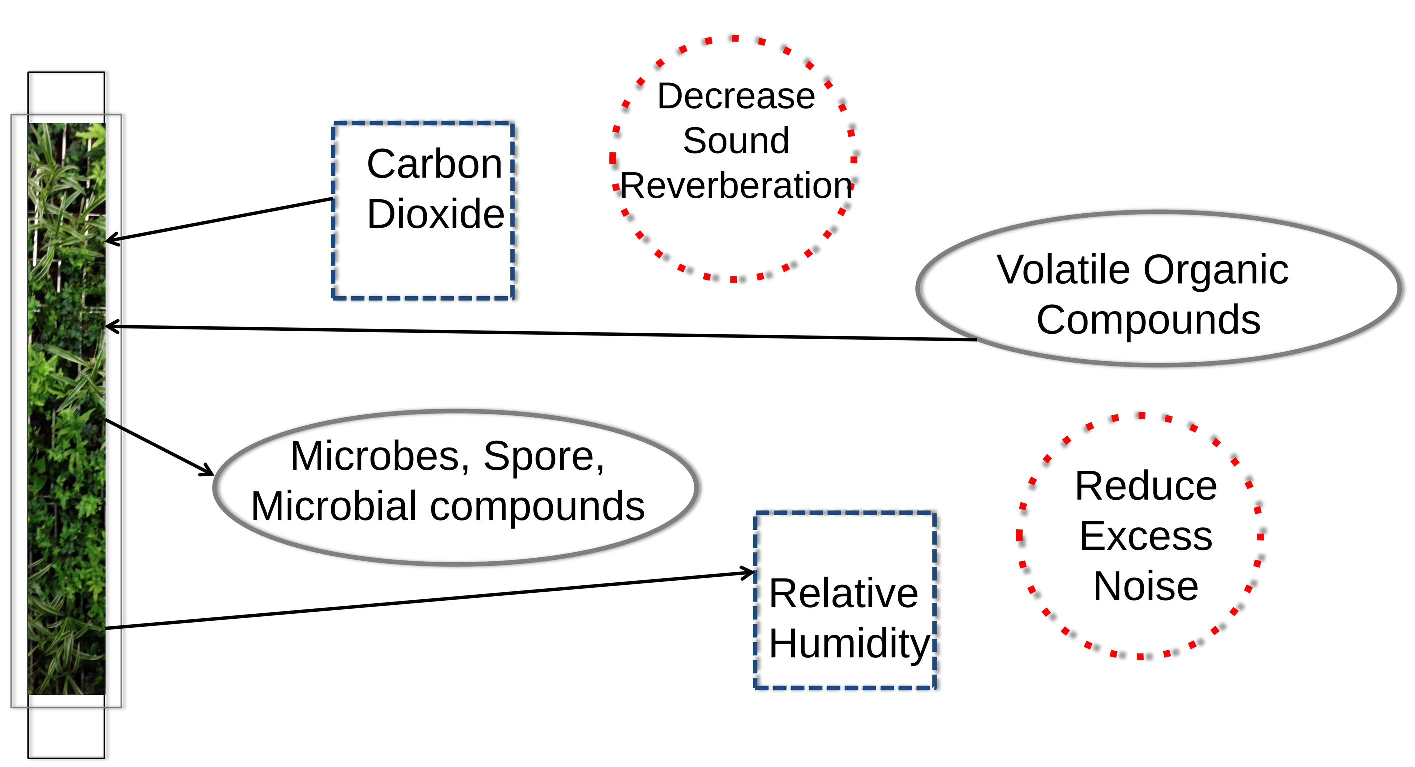


Figure 3: Proposed IEQ effects of an interior living wall.

### Acoustics

Research literature identifies the acoustical characteristics of green roof and living walls and validates their contribution to exterior acoustical environment. However, there is very little discussion on the effect of interior living walls (ILW) on room acoustics.

In this research ILW are under investigation to understand their acoustical characteristics, and to determine if and how ILW positively benefit room acoustics by reducing excess noise and reverberation, which is distracting and interferes with speech intelligibility.

Each component of ILW plays different roles in absorbing and scattering sound. Therefore, it is necessary to define and characterize systematically each component and combination of components. The acoustic characteristics is quantified in terms of absorption and scattering to first, determine the impact of each components of the ILW and second, to model the acoustical impact of living walls in rooms. The modeled impact of ILW will be validated with field measurements of background noise level, reverberation time (RT), and Speech Intelligibility Index in campus lecture / meeting rooms.


Figure 4: The growing area for the living wall

Figure 5: Three living wall carriers used in the study.


Figure 6: The six species used in the study

## Hypothesis

Interior living walls will be an alternative as a sustainable building material to meet IEQ criteria.

The living wall would decrease VOC and $CO_2$, but increase RH relative to the amount of plant matter in the room.

Relative to the organic matter of the substrate, the living wall would:
- Increase airborne bacteria and fungi, and
- Increase airborne endotoxin.

It is expected that:
- ILW will decrease the reverberation time in a room
- The substrate is the most significant component in terms of absorption
- The plants are the most significant component in terms of scattering
- The plant coverage/ density is important in terms of both absorption and scattering
- The modeling of room reverberation time will improve with the inclusion of the scattering coefficient

## Methodology

### Indoor Air Quality

A test room (Figure 6) is constructed to simulate human occupancy in a lobby of similar occupant density, following the ventilation rate in ASHRAE 62.1-2010. Several sources of VOC and $CO_2$ are released into the room to establish a baseline level of contaminants associated with human occupancy.

- For VOC and $CO_2$: Compare the mean steady state concentration with ILW with the mean from the baseline mentioned above.
- For bacteria, fungi, endotoxin, and RH: Compare the mean concentration with ILW with mean concentration in the empty test room.

These six IAQ factors are also compared with the effects from the living walls with only one plant species to determine if there are synergistic effects of species on these IAQ factors.

Plant quantifiers (the leaf area index, the plant depth, the dry weight and biomass of the shoots and roots, the volume of the living wall and the mass of soil) is measured to determine the relationship with IAQ factors and acoustic characteristics.

Figure 6: Test room for IAQ (left) and reverberation chamber (right).

### Acoustics

A series of measurements are being carried out in a reverberation chamber (Figure 6) to examine random-incidence absorption and scattering coefficients, by considering various parameters such as carrier type, vegetation type and vegetation coverage.

*Absorption coefficient of panel systems*
- Carrier panel, as manufactured
- Fully established panel

*Absorption and scattering coefficient of substrates and plants with substrate*
- Three compositions of substrate
- Six plant species characterized by leaf size, leaf length, plant height, stem diameter and LAI.

In order to provide a sufficient database, plants will be measured growing over a six-month period to account for variance in plant structure, character and overall coverage.

The empirical data will then be applied in numerical models (for RT) to explore the room effects of the ILW, using 7 known algorithms which only requires the absorption coefficient, and ODEON acoustic software (which uses ray and mirror image reflection theories).

The final objective is to validate the predictive model with the measured laboratory data by evaluating acoustical criteria in a standard BCIT classroom with and without a fully established interior living wall.