

Four Disciplines, One Blindspot: How Plant Science, Materials, Comfort Engineering and IAQ Never Talked

Plant science, materials, comfort engineering, and IAQ never shared a table. [4]

At a Glance

Plant scientists study transpiration and photosynthesis. Materials engineers study thermal mass and heat transfer. Comfort engineers follow ASHRAE Standard 55 for temperature and humidity. IAQ researchers track VOC removal. [7] NASA studied plants for air filtration in sealed chambers. [4] No discipline combined all four into a single indoor system until Biothermal Microconditioning.

Deep Dive

Science advances within disciplines. Plant physiologists study transpiration rates and stomatal conductance. Materials engineers study thermal mass, specific heat capacity, and thermal conductivity. HVAC engineers follow ASHRAE Standard 55 (2023), which defines six thermal comfort factors: metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity. [7] IAQ researchers track formaldehyde, benzene, and toluene concentrations, governed by WHO guidelines (2010) setting exposure limits. [4]

Each discipline publishes in its own journals, attends its own conferences, and speaks its own vocabulary. This is the blindspot.

NASA's Clean Air Study (Wolverton, Johnson, and Bounds, 1989) demonstrated that interior landscape plants removed benzene, formaldehyde, and trichloroethylene from sealed plexiglass chambers, achieving up to 90 percent reduction in 24 hours. [4] The study was groundbreaking, but it was designed for space stations: sealed environments with no natural ventilation.

Cummings and Waring (2020) systematically reviewed 196 experiments from 12 published studies in the Journal of Exposure Science and Environmental Epidemiology. Their conclusion: potted plants do not improve indoor air quality at practical densities. Natural building ventilation already removes VOCs at rates that would require 10 to 1,000 plants per square metre to match. [5] The NASA findings, real in sealed chambers, do not transfer to ventilated offices. Plant science studied air purification. Building science studied ventilation. Neither designed a system combining both.

ASHRAE Standard 55 addresses thermal comfort through air temperature, radiant temperature, and air speed. Its adaptive model, adopted since 2004, recognises that occupants interact with their environment, adapting behaviourally and physiologically. [7] But the standard was written for mechanical systems. Plants are absent from the framework. No ASHRAE committee has evaluated managed plant clusters as personal comfort devices.

He, Yu, Ozaki, Dong, and Zheng (2020) reviewed bio-inspired cooling technologies for buildings in Energy and Buildings. They documented heat transfer mechanisms used by animals and plants, noting the potential for creating harmony between buildings and nature while enhancing indoor environmental quality and energy efficiency. Yet their review found these mechanisms remain academic. [16]

A 2024 systematic review in Intelligent Buildings International examined 74 peer-reviewed papers on biophilic design in workplaces. The findings: significant psychological, physiological, and cognitive benefits with varying effect sizes. [14] Plants improve wellbeing. But no study in the review integrated thermal cooling, humidity correction, air quality improvement, and cognitive benefit into a single deployable system.

Four disciplines. Four evidence bases. One blindspot. Biothermal Microconditioning occupies the intersection: managed indoor plant clusters that cool the person (comfort engineering), buffer heat through substrate (materials science), transpire humidity into dry air (plant science), and filter airborne compounds at the breathing zone (IAQ). The category was hidden because no discipline had reason to look across all four. Easy Retrofit. 1 day.

Summary

Four disciplines each hold a piece. Plant science measures transpiration. Materials engineering quantifies thermal mass. Comfort engineering, governed by ASHRAE Standard 55, defines six factors of thermal satisfaction. [7] IAQ research tracks VOCs, with WHO guidelines setting exposure limits. [4]

The blindspot: these never converged on a single indoor system. NASA's 1989 study demonstrated plant VOC removal in sealed chambers. [4] Cummings and Waring (2020) showed those results do not scale: 10 to 1,000 plants per square metre needed to match ventilation rates. [5]

He et al. (2020) reviewed bio-inspired cooling for buildings in Energy and Buildings, finding plant mechanisms remain underexploited. [16] A 2024 systematic review of 74 biophilic studies confirmed measurable benefits, yet none integrated thermal, humidity, IAQ, and wellbeing into one system. [14]

Biothermal Microconditioning sits at the intersection. One system: cooling, humidity, air filtration, cognitive benefit. The category was hidden because no discipline looked across all four.