Active and passive HVAC control through non-vegetated and hydroponically vegetated porous concrete for novel green infrastructure and controlled environment agriculture

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Bioresource Engineering

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Abstract

Green infrastructure can improve the permeability of urban surfaces, reduce the heat island effect, and ameliorate urban biodiversity, in addition to pre-filtering water, controlling stormwater runoff, and mitigating the adverse effects of urbanization. Specialized soilless systems for urban crop production can be incorporated into existing green walls and green roofs that might otherwise be less attractive due to retrofitting load, costly setup, amounts of polymeric materials used, and high carbon footprint. In this study, a novel cement-free porous concrete was cast as a hydroponic plant-growing substrate with high porosity (25%), allowing for air and water permeability. Exhibiting comparable compressive strength to provide structural support, this porous concrete was upgraded with embedded coils for temperature and humidity control of air ventilated through the substrate. When the embedded coil porous concrete system was vegetated with ryegrass (*Lolium perenne*), the grass layer showed notable interactions with its HVAC capacity. The passive cooling capacity of regular and vegetated porous concrete were further explored by developing a porous concrete evaporative cooling pad (PCECP) and a novel green wall evaporative cooling pad (GWECP) system.

These findings present porous concrete as a new prospective material in green building technology and infrastructure, with HVAC systems that can be used to actively or passively control the indoor microclimate, with the added benefit of plant production in controlled environment agriculture.

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