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Indoor Environmental Parameters: Considering Measures of Microbial Ecology in the Characterization of Indoor Air Quality

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ABSTRACT

Urbanization has led to systemic environmental factors that degrade air quality and microbial diversity, negatively impacting human health and wellbeing. Conventional building Heating, Ventilation and Air Conditioning (HVAC) units that filter airborne pollutants and support Indoor Air Quality (IAQ), are often energy intensive, decrease indoor microbial diversity, and are still unable to address specific pollutants or seasonal psychrometric profiles. Although HVAC performance, IAQ, and human health have long been correlated, emerging fields of study such as metagenomics may enable more inclusive metrics in the characterization of these co-relationships. As part of a rapidly expanding field of research, metagenomic analyses of human and indoor microbiomes have begun to demonstrate how patterns of urban development can impact microbial diversity and interrelated human health indicators, many of which are similar to health impacts associated with urban air pollutants, such as immune health and response. However, measures of microbial ecology have yet to be systematically included in the characterization of IAQ. A review of literature including both air quality and microbiome metrics reveals significant interrelated factors and impacts on human health and wellbeing, implying potentially confounding/compounding variables. While many design decisions impact indoor microbiomes, some do so with potentially larger impacts, such as building-integrated plant-based systems, which may significantly affect indoor microbial ecologies in unexplored ways. However, assessing their impact on urban health and wellbeing, building energy use, and outdoor and indoor air quality requires more systematic integration of emerging knowledge in the fields of both air quality and metagenomics. Further, the integration of measures of microbial metabolism and metagenomic analyses could enable more precise and specific evaluations of the potential for pollutant degrading processes in the design of urban green infrastructure and Indoor Environmental Quality (IEQ), such as the incorporation of bioremediation processes into urban air treatment programs.

INTRODUCTION

To date, fifty-five percent of humans live in cities, a proportion projected to grow to two thirds by 2050 [1]. Within this context, air pollution has been identified by the World Health Organization as "the biggest environmental risk to [human] health" [2]. While the majority of air-pollution related deaths are strongly associated with a person's age and their country of origin's economic status, poor indoor air quality (IAQ) in urban areas has been correlated with health impacts ranging from transient symptoms such as difficulty concentrating, and headaches [3-5], to chronic, more serious symptoms such as asthma and cancer [4, 6, 7] in both developing and developed nations. IAQ diminishes as levels of carbon dioxide (CO2), volatile organic compounds (VOCs) and particulate matter (PM) increase, each with measurable impacts to human health [8-23] and often compounded seasonally through either low or high humidity [24-26] or confounded by pathogen transmission through air handling systems [27].

Since the 1990s, literature investigating urban impacts on human health has made clear that IAQ measures, while complex, are not the only abiotic factors with impacts to human health metrics, and a new more inclusive term arose: Indoor Environmental Quality (IEQ) [28]. While a

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