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Evaluating the Role of Particulate Matter as a Surrogate Index for Mould Spores in Residential Tenancy: Implications of New Legislation in Australia

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Abstract: *This paper evaluates the practical implications of recent legislative changes in Australia for residential tenancy and minimum rental housing standards, with a focus on the known risks from mould exposure to health. Specifically, the study examines the use of particulate matter (PM) measurements as a surrogate index for mould spores during residential indoor air quality assessments. The findings indicate that PM10 is a useful surrogate index for mould spores, while PM2.5 is less reliable due to size differences between PM2.5 and mould spores. The paper also investigates the relationship between particulate matter, mould spore sizes, and ambient air quality by reviewing relevant literature and presenting case studies from various Australian and international sources. Overall, the study highlights the importance of early detection during onsite inspections to minimize health hazards related to mould and dampness and to improve indoor air quality in residential tenancy spaces.*

Keywords: *Particulate matter, mould, indoor air quality, residential tenancy, onsite assessment methods*

I. INTRODUCTION

With the recent revisions to the Residential Tenancies Amendment Act 2018 [1] and Residential Tenancies Regulations 2021 (S.R. No. 3/2021) [2], the quality of indoor air in residential properties has become a significant issue for the residential tenancy market. The amendments for Victoria, highlight the significance of addressing mould and moisture issues in rented properties, placing responsibility on both tenants and landlords [3]. Changes for other States and Territories are also underway [4]-[6]. This paper examines the potential use of particulate matter (PM), such as PM2.5 and PM10, as a surrogate index for mould spores in the assessment of indoor air quality, taking into account the diameters of mould spores and their relationship to standard PM sizes.

Mould spores are ubiquitous in indoor environments and come in a wide spectrum of diameters, typically between 3 and 100 micrometers (μm). PM2.5 and PM10 are abbreviations for particles with diameters of less than 2.5 μm and 10 μm , respectively. Although mould spores can fall within the PM10 size range, they typically exceed the PM2.5 size threshold. Studies have demonstrated a correlation between elevated PM10 concentrations and the presence of mould micorganisms in indoor environments. However, the use of PM2.5 as an indicator for mould spores is restricted due to the fact that mould spore sizes frequently exceed the 2.5 μm threshold.

II. METHODS

The relationship between particulate matter, mould spore sizes, and ambient air quality was investigated through a comprehensive literature review. The review analysed research on the use of PM2.5 and PM10 as indicators of mould spores in residential and other relevant properties. In addition, the effects of recent legislative changes regarding mould and moisture on the residential rental market were examined. Papers were sourced using PubMed (<https://pubmed.ncbi.nlm.nih.gov/>), Semantic Scholar (<https://www.semanticscholar.org/>) and an AI information retrieval tool (<https://elicit.org/>).

III. RESULTS

One study [7] found a strong relationship between particulate matter (PM) sizes and the presence of mould and dampness in indoor environments. Elevated particle concentrations, including PM10, were observed in areas with dampness and mould problems, which correlated with higher concentrations of bacteria and fungi, exceeding legal limits.

Another study [8] assessed indoor air quality (IAQ) and microbiological contaminants in urban and rural school classrooms, finding that temperature, relative humidity, and bacterial colony-forming units exceeded standard limits in some cases. Airborne particulate matter was associated with the presence of common fungal species, such as *Aspergillus*, *Alternaria*, *Cladosporium*, *Penicillium*, and *Mucor*.

A more recent study [9] aimed to assess the indoor air quality of Australian residential buildings, revealing that 1 in 3 homes displays excessive dampness and mould proliferation, posing a significant threat to both physical and psychological health. Monitoring results showed a correlation between high concentrations of fungal spores and poor indoor air quality levels, marked by elevated levels of particulate matter (PM10 and PM2.5) and CO₂. Furthermore, the research indicated that extensive mould damage may go unnoticed for extended periods, increasing health risks for occupants. The findings underscore the importance of developing early detection strategies to minimize health hazards and avoid costly renovations related to mould and dampness issues.

A follow-up study by the same authors [10] further investigated the relationship between indoor air quality, particulate matter, and mould growth in Australian residential buildings. Results show that buildings with high concentrations of fungal spores are more likely to have poor IAQ levels and elevated levels of particulate matter (PM10 and PM2.5), as well as carbon dioxide (CO₂). The study emphasizes the importance of early detection strategies to minimize health hazards related to mould and dampness and prevent the need for major renovations. It also highlights the need for better building design, construction practices, and regulations to prevent mould growth and improve IAQ in residential spaces.

Earlier, the study by Jones [11] looked at the indoor living environment's impact on health, with a focus on dampness and mould as factors causing significant adverse respiratory and other health effects. That research investigated the microbiome of 100 Melbourne homes, analysing the role of fungi and other biological and inorganic airborne particulates as agents of human exposure. This paper demonstrated that PM_{2.5} and PM₁₀ are sensitive measures of mould spores in the indoor environment. It was found that understanding the relationship between PM_{2.5}, PM₁₀, and mould spores can help assess the risks related to residential housing and public health.

And even earlier study [12] calculated the population attributable fraction (PAF) of Canadian childhood asthma due to modifiable environmental exposures. It showed that Canadian exposure prevalence include PM₁₀ at 16% and PM_{2.5} at 7.1%. The study reveals that PM₁₀ and PM_{2.5} have relative risk estimates of 1.64 and 1.44 for developing physician-diagnosed asthma (PDA), respectively. The PAF estimates for incident asthma among preschool children are 11% for PM₁₀ and 1.6% for PM_{2.5}. The research suggests a contribution to childhood asthma development from exposure to particulates, while the associations for mould and moisture appear to be more variable. Further studies with objectively measured exposures are recommended to better understand these associations.

Reference [13] and [14] investigated the associations between reported common colds and home dampness, mould, and particulate matter (PM) in China among young adults without asthma or allergic rhinitis. They found that living in homes with water leakage, mould odour, indoor mould, condensation on window panes, and damp bed clothing were all associated with common colds. Furthermore, higher mean ambient temperature, PM₁₀, and PM_{2.5} were also associated with common colds. The association with particulate air pollution was stronger in southern China. The paper concludes that indoor dampness, mould, a warmer climate, and PM₁₀ and PM_{2.5} can be associated with reported common colds; while 'furry pet' ownership was also another factor but further intervention and prospective studies are needed to verify causality.

Reference [15] examined indoor air quality in 101 indoor microenvironments within 25 nursery and primary schools and found that children were exposed to high levels of PM_{2.5} and CO₂ in 69.0% and 41.3% of the classrooms, respectively, with higher levels mostly in urban sites. Multivariate linear regression models identified the main determinants of CO₂ and PM_{2.5} concentrations, including background concentrations, relative humidity, flooring material, heating, and the age group of occupants. The study recommends mitigation measures to reduce indoor air pollutant levels and prevention actions to decrease children's exposure, such as improving ventilation and cleaning actions, reducing time spent indoors, and avoiding or maintaining hardwood flooring materials and VOC-emitting materials.

IV. SAMPLE AIR QUALITY METRICS

The new laws for tenants and landlords especially in Victoria, Australia have increased the responsibility of rental providers to ensure that rented properties are free of mould and moisture resulting from or related to the building structure. Tenants, on the other hand, must provide evidence that the mould is hazardous and/or causing a health issue to support their request for immediate restorations and interventions. Table 1 shows an example from using a portable particle analyser to collect real time data from a home that has suffered water damage.

TABLE I

Particle matter counts for different rooms in a building known to have suffered water damage. rooms and areas with suspect mould were detected in real time for: bedroom 3, Bed 3 subfloor, lounge/dining room, bed 4 ensuite wall cavity and bed 4 ensuite.

Sample Location	Air Quality Score	PM1	PM2.5	PM10	VOC's
Outdoors	95	1	3.8	6.8	0.08
Bedroom Number One	95	1.3	3.3	5.4	0.07
Bedroom Number Three	85	4.5	13	22	0
Bedroom Number Three Sub Floor	53	20	53	91	0
Lounge/Dining Room	77	10	22	36	0.003
Bedroom Number Four Ensuite Wall Cavity	46	24	63	109	0.01
Bedroom Number Four Ensuite Room	76	7.7	22	39	0

V. CONCLUSION

In indoor air quality assessments, PM10 can serve as a useful surrogate index for mould spores, whereas PM2.5 is less reliable due to the size difference between PM2.5 and many mould spores. Confirmation of mould can then be verified using spore trap testing, surface tape lifts, RODAC petri plates, moisture testing using pin probe and infrared imaging if required. Recent legislative amendments have highlighted the significance of addressing mould and moisture problems in properties leased out as part of residential tenancy agreements. As a result, the use of PM10 as a surrogate index for mould spores can provide valuable, real-time insights into the indoor air quality of rented properties, aiding both tenants and landlords in complying with the new regulations.

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