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A study of indoor particle concentrations of less than 10 μ m
in Wellington office buildings.

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ABSTRACT

Indoor air pollution can have significant effects on the health of people. Indoor pollutants can exceed outdoor concentrations by 2-5 times, and occasionally more than 100 times. This is significant not only because of occupational indoor exposures, but because in general people spend over 90% of time indoors. Particles are one indoor pollutant that has been linked as a causal factor of the Sick Building Syndrome. Particles can be noxious substances or have noxious substances adsorbed on to them. Of most concern are particles that penetrate to the gas exchange region of the human body as clearance times are often in excess of months. This study explores the relationship between particle concentrations measured indoors and outdoors and the affect of occupant activity on indoor particle concentrations.

Particle concentrations were measured indoors and outdoors of four office buildings in Wellington. Indoor particle concentrations as a function of occupancy were assessed and the presence of occupants was shown to increase particle concentrations indoors for the size bands of $5\mu\text{m}$ and $3\mu\text{m}$ on a working day. Particles below $1\mu\text{m}$ were shown to generally behave independent of occupant activity. The concentrations of particles generated during a working day decreased over a period of no occupancy due to deposition and the air exchange rate of the building for the larger size bands of $5\mu\text{m}$ and $3\mu\text{m}$. However below $1\mu\text{m}$ the pattern of a reduction in particles was not apparent. Overall there was no statistically significant vertical gradient of particles between 1.2m and 1.8m for the particle sizes of $5\mu\text{m}$, $3\mu\text{m}$, $1\mu\text{m}$, $0.5\mu\text{m}$, and $0.3\mu\text{m}$.

Standard filter media were shown to be effective at reducing particle sizes of $5\mu\text{m}$ and $3\mu\text{m}$ and less effective with particles below the $1\mu\text{m}$ range. The operation of the air handling unit over a weekend period resulted in a reduction of the number of fine particles ($1\mu\text{m}$, $0.5\mu\text{m}$, $0.3\mu\text{m}$) in the indoor space. The stack effect and its influence on particle transportation throughout the four buildings studied was inconclusive with several factors capable of confounding the collected data.

Overall, the results of the study were consistent with other researchers' findings in relation to occupant influence on particle concentrations and filtering efficiency of standard media. Factors that may confound the assessment of the influence of the stack effect on particle concentrations need to be carefully monitored in future studies.

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1 INTRODUCTION

Indoor air pollution can have significant effects on the health of people. United States Environmental Protection Agency (US EPA) studies of human exposure to air pollutants indicate that indoor air levels of many pollutants may be 2-5 times, and occasionally more than 100 times, higher than outdoor levels (United States Environmental Protection Agency, 2001). High levels of indoor air pollutants are of particular concern, not only because of occupational indoor exposures (Statistics New Zealand, 2000) but because in general people spend over 90% of time indoors.

A 1984 World Health Organisation (WHO) Committee report suggests that up to 30 percent of new and remodelled buildings world-wide may be the subject of excessive complaints related to indoor air quality (IAQ) (United States Environmental Protection Agency, 2000). The term 'building related illness' (BRI) is used where symptom complaints can be clinically defined and linked to identifiable airborne building contaminants. However, there are situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. This is described as the "Sick Building Syndrome" (SBS) (World Health Organisation, 1982).

SBS symptom complaints may be localised in a particular room or zone, or may be widespread throughout a building. Occupants will experience relief of SBS symptoms soon after leaving a building. SBS problems can result when a building is operated or maintained in a manner that is inconsistent with its original design or prescribed operating procedures.

Elevated levels of indoor particles are identified as a causal factor of the SBS (Raw, 1993; Gyntelberg et al., 1994; Kemp et al., 1998). The main symptoms associated with high particle levels indoors include irritation of the nose, eyes, and throat; dry unproductive cough; fatigue; headache; and respiratory difficulties. These symptoms can occur either singularly or in combinations.

The chemical and/or biological composition of each inhaled particle in conjunction with their deposition on the human respiratory tract will determine the affect on the health of the occupant. Particles of a size less than 1 micron (μm) are part of the respirable mass fraction and easily penetrate to the gas exchange region. Penetration of particles beyond the terminal bronchioles is of concern as this region is non-ciliated and insoluble particles deposited by sedimentation and diffusion have clearance averages of a month or more.

The size, shape, density and velocity of the particle will affect the suspension time of the particle in the environment and thus occupant exposure to the particle. Particles with an aerodynamic diameter (the diameter of a unit density sphere of the same mass) greater than $1\mu\text{m}$ on average settle within hours while particles below $1\mu\text{m}$ can remain suspended for days.

Indoor particle concentrations are a mixture originated from outdoor sources and indoor sources. Particles are transported from the outdoors through unintentional pathways such as small penetrations in the building envelope, and through intentional pathways such as the heating, ventilating and air conditioning route. Occupants and visitors also introduce particles from outside as they enter the work place. Occupants then generate further particles by their daily activities and re-suspend settled indoor particles.

The measurement of particle concentrations inside and directly outside office buildings will provide an understanding of particle sources and behaviour indoors, the influence of the outdoor environment on particle concentrations indoors, and the influence of occupants on particle concentrations through generation and re-suspension of particles.

This study will develop an understanding of the influence of the activity and presence of people in the built environment on particle concentrations. The effect of intentional pathways such as the heating, ventilating, and air conditioning system and unintentional pathways such as the thermal stack effect on the transport of particles into, within and from the building will also be explored. In conjunction with above two aims a standardised procedure to ensure comparable data collection by the research will be piloted.