NEW ZEALAND BUILT ENVIRONMENT RESEARCH SYMPOSIUM

Shaping future directions for collaborative built environment research and practice in New Zealand

Improving health and well-being in low decile classrooms with a solar ventilation system

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Background

Children spend the second largest proportion of their time at school. The high density of occupants in classrooms gives challenges to reach adequate ventilation (Jurelionis *et al* 2008). Nearly all New Zealand classrooms depend entirely on natural ventilation via open windows (Cutler-Welsh 2006). However, New Zealand classrooms are grossly under ventilated in cold weather and have excessively high levels of bacteria which potentially lead to adverse respiratory infections and other health effects (Bassett *et al* 1999, McIntosh 2011). Inadequate ventilation was also linked to an increase in students' absenteeism (Bartlett *et al* 2004). Conventional mechanical ventilation systems are capital and energy expensive, which is seldom for most New Zealand schools, especially as the Ministry of Education has recently introduced capped budgets for energy. However, the school day is closely aligned to the availability of solar radiation, meaning schools are ideal environments for utilising free solar heated ventilation. The proposed solar ventilation system has been pilot-tested in a dwelling in Masterton (New Zealand) during the 2010 winter and simultaneously achieved acceptable ventilation and sufficient free heat to achieve a comfortable temperature.

Aims of the primary school intervention study.

• To investigate exposure to airborne bacteria, chemical pollutants, particulate matter, temperature, relative humidity, *streptococcus sp* bacteria in students and absenteeism level in twelve classrooms and to assess the changes when the ventilation system is operating vs. not operating,

• To examine whether this intervention is sufficient to provide a healthy classroom environment in accordance with World Health Organisation (WHO) recommendations.

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Research Design and Methods

The fieldwork was undertaken from May to September (School term 2 and 3) in 2013 and in 2014. Prior to the fieldwork commencing, twelve solar heated ventilation systems were installed, on the north facing roof of twelve classrooms. Six classrooms were active while the remaining six classrooms did form a control group (ventilation system disabled). This monitoring pattern was reversed every school term. Throat swab testing was monthly performed to identify *streptococcus* infections. Total airborne bacteria load was estimated in term 3 both years using a metagenomics approach (Next Generation Sequencing). In all classrooms, every two minutes, the level of carbon dioxide, carbon monoxide, formaldehyde, temperature, relative humidity, ventilation flow rate, and heater use were monitored. Data were weekly collected on absenteeism and the absent child's parents/guardian were contacted and interviewed about absenteeism using a standard health questionnaire. For two weeks in August 2013 and August 2014, two classrooms were equipped with a particulate matter (PM) sampler to monitor PM2.5 microns and PM10 microns on an hourly time-scale. Elemental composition of the particulate matter was also measured using Ion Beam Analysis (GNS Science).

Preliminary Results

The data collection ended in October 2014. At the time of the abstract writing most of the results need to be analysed, however, some preliminary results are available from the first winter fieldwork.

At the classroom level:

- For half the time, the incoming air reached temperatures above 30˚C. Thus the solar heated ventilation system played a positive role on increasing the classroom temperature and reducing heaters usage.
- The flow rate of incoming air peaked at $83m^3/h$. At this flow rate, it will take 2.5 hours to change the whole volume of a classroom (assuming an approximate classroom volume of $200m^3$).
- For at least two thirds of the school day, all classrooms (active and control) were within the 40% - 60% relative humidity and 18˚C - 24˚C temperature range (WHO recommended level).
- To achieve a similar temperature level, the heater usage in the control classrooms was 2.5 times higher than in adjacent active classrooms. The solar heated ventilation systems contributed significantly to energy saving to the schools.
- Two thirds of active classrooms showed higher percentage of time exposure to carbon dioxide level following the recommended level (<1000ppm) than the control classroom.
- Using the metagenomics approach, the airborne bacteria results showed more dissimilarity inter-schools than intra-school (active vs. control). Each school showed its own microenvironment.
- The preliminary results of the particulate matter (PM) monitoring showed a significantly elevated PM concentrations occurred in classrooms when they are occupied by children due to re-entrained dust

(unrelated to outdoor conditions). Higher concentrations occurred in the control classrooms than in active classrooms.

At the student's level:

- First year results showed that a positive occurrence to *Group A Streptococcus* in students steadily decreasing from June to September (10.7% in June, 8.2% in July, 6.5% in August, 3.7% in August/Sept, 0.6% in September). More analysis is needed to investigate if this decrease is due to the intervention or to a medical follow up (use of medication).

Conclusion:

Preliminary results showed that the intervention had a very positive impact on the school environment (decrease of the carbon dioxide level, decrease of re-entrained dust level) and did help in saving energy (2.5 times less purchased energy). However, all these results need to be confirmed with the analysis of the second winter data.

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