Project: Indoor air pollution at a New Zealand urban primary school

Children spend a lot of time at school and are vulnerable to the effects of air pollution in classrooms. A study of the air quality in a Wellington primary school classroom measured temperature, humidity, carbon dioxide (CO_2), nitrogen dioxide (NO_2) and particulates. Elements in the particulates were also identified to find the source of the pullution. Fine particulates came largely from the infiltration of outdoor pollutants, particularly motor vehicle emissions from a busy nearby road. Ventilation in the classroom met the internationally recommended figure of 8 litres/second/person only 38% of the time.

Overseas studies show that children exposed to air pollution at school can have increased behavioural problems, slower cognitive development and reduced performance. Poor ventilation can affect children's ability to learn.

Classroom air quality can be affected by contaminants from indoor and outdoor sources, with indoor particulate matter (PM) concentrations in this study highly correlated with outdoor levels. This is of concern as schools and childcare facilities are often located close to roads where the air pollution peaks while children are at school.

THE SCHOOL AND THE CLASSROOM

The primary school is located in Wellington, adjacent to a busy road with approximately 16,000 vehicles passing daily. The classroom is a typical New Zealand 1970s single-storey prefabricated weatherboard building, 8 x 6 m with a volume of 168 m^3. The suspended floor is carpeted. Walls and ceiling are uninsulated. Windows can be opened on both sides for cross-ventilation. Approximately 25 children aged 8-9 years occupy the classroom. The door is often left open to let children work outside on the covered deck.

Measurements were undertaken in spring from 10-31 October 2016.

AIR QUALITY

During school hours, the average indoor temperature was 19.4°C (ranging 14.0-23.2°C), with the indoor temperature below 18.0°C for 18% of the school day.

Relative humidity averaged 60% (ranging 42-77%). This is at the top of the range of 40-60% often recommended as ideal. Above 60%, airborne pathogen numbers increase.

The average CO_2 concentration when the children were absent was 450 parts per million (ppm). Inside the classroom during school time, the CO_2 average concentration was estimated at 890 ppm (ranging 420-1,630 ppm). Breathing in high levels of CO_2 can result in headaches, tiredness and nausea. NZS 4303:1990 *Ventilation for acceptable indoor air quality* recommends ventilation sufficient to keep CO_2 levels below 1,000 ppm. In new school buildings, the Ministry of Education requires that the average CO_2 concentration should not exceed 1,500 ppm.

Most (90%) of New Zealand classrooms are designed to be ventilated by opening windows. (Note that in practice, however, windows are generally not opened.) Existing school buildings have no regulation around ventilation, but the Ministry requires a minimum ventilation of 8 litres/second/person in new buildings if mechanical ventilation is present.

The ventilation rate in the classroom, estimated from the presence of CO_2, was 6.6 litres/person/second. This is below ASHRAE's guideline of 8 litres/person/second (ASHRAE is the widely respected American Society of Heating, Refrigerating and Air-conditioning Engineers). The Wellington classroom only met the guideline 38% of the school day.

Indoor NO_2 levels were higher on weekdays than weekends. The average during school time was 56.4 µg/m³ (13.2-99.6 µg/m³). The school has no indoor sources of NO_2. Traffic-related NO_2 concentrations around major roads are well documented, and the NO_2 levels increasing from around 6 am coincided with an increase in traffic. Gases and ultrafine particles are efficient at infiltrating indoor environments. Traffic is therefore assumed to be the source of the NO_2.

PARTICULATES

Particulates are tiny pieces of matter. Two sizes are commonly tested for:

- $PM_{2.5}$ (fine) particulates less than 2.5 micrometres in diameter.
- PM_{10} (coarse) particulates 10 micrometres or less in diameter - one-tenth the thickness of a human hair.

High levels of PM_{10} can irritate the eyes and throat. Finer $PM_{2.5}$ particles may pose a greater risk because they can penetrate the deepest parts of the lung.

The World Health Organization specifies that the annual mean concentration of $PM_{2.5}$ and PM_{10} should not exceed 10 µg/m³ and 20 µg/m³. The 24-hour concentrations of $PM_{2.5}$ and PM_{10} should not exceed 25 µg/m³ and 50 µg/m³.

In school time, the indoor average for $PM_{2.5}$ was 6.9 µg/m³ (range <1.0-10.9 µg/m3) and for PM_{10} was 30.1 µg m³ (range 10.0-75.0 µg/m3). These levels were higher than outdoor concentrations. Both PM_{10} and $PM_{2.5}$ levels increased on school days around 7 am and decreased around 4 pm.

Elements in the particulates were identified to find the source. Black carbon and sulphur in certain ratios most likely came from the combustion emissions of vehicles. The main source of indoor $PM_{2.5}$ was traffic pollution, with classroom dust and sea salt also present (Figure 1).

Indoor levels of PM_{10} were significantly higher than outdoor levels. High indoor PM_{10} levels were largley due to soil being tracked in from outside on footwear and resuspended as dust during classroom activities. Other studies have reported similar findings.

IMPROVING THE AIR IN NEW ZEALAND CLASSROOMS

Measures to improve indoor air quality in classrooms may include:

- better ventilation - opening windows
- considering the location of ventilating windows or air intakes - away from roads
- improved cleaning
- replacing carpets with hard flooring
- assessing the adequacy of occupational density and promoting more class breaks
- structural measures such as the installation of air purifiers
- carefully considering the location of new schools, especially proximity to main roads.

The findings and recommendations from this study will be applicable to many other schools, early childhood learning centres and public buildings that have high foot traffic and are close to busy roads.

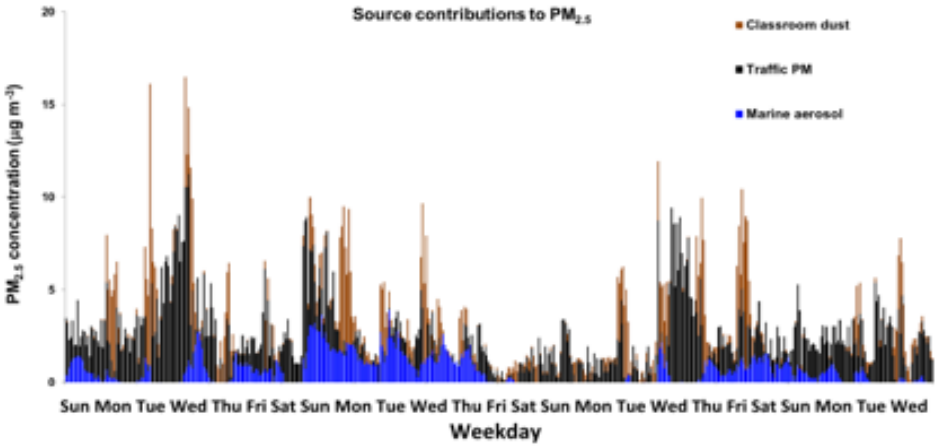

Figure 1. Traffic tailpipe emissions from a nearby road were the key contributor to fine particulates in the classroom with dust and sea salt also present.

More information

Research Now: Indoor air quality #1 *An overview of indoor air contaminants in New Zealand houses*

Research Now: Indoor air quality #2 *An overview of indoor air contaminants in New Zealand schools*

Research Now: Indoor air quality #3 *The impact of ventilation in New Zealand houses*

Research Now: Indoor air quality #4 *Project: Indoor air quality in New Zealand homes and garages*

Research Now: Indoor air quality #5 *Project: Using a low-cost sensor platform to explore the indoor environment in New Zealand schools*

This study was funded by the Building Research Levy.

Read the full report, including references:

Bennett, J., Davy, P., Trompetter, B., Wang, Y., Pierse, N., Boulic, M., Phipps, R. & Howden-Chapman, P. (2019). Sources of indoor air pollution at a New Zealand urban primary school; a case study. *Atmospheric Pollution Research*, 10(2), 435-444.