An overview of indoor air contaminants in New Zealand houses

Contaminants are common in the air inside New Zealand houses, and they impact on our wellbeing and productivity. Understanding what they are and how ventilation can reduce their presence will help make New Zealand houses healthier and more comfortable to live in.

For much of New Zealand's history, our air-leaky homes and our willingness to open windows meant that most houses could easily get sufficient ventilation. New houses today are becoming much more airtight, however, trapping moisture and contaminants such as volatile organic compounds in the air. Research also indicates that many homeowners today do not regularly open windows. Indoor air quality is a matter that designers, builders and house occupants need to pay close attention to.

BRANZ and other research partners have tested New Zealand houses for moisture levels and contaminants including:

- biological contaminants such as fungi, bacteria and dust mites
- volatile organic compounds (VOCs)
- gases such as carbon dioxide (CO_2) and carbon monoxide (CO)
- particulates.

MOISTURE

Excess internal moisture is the most pressing problem, creating an environment favourable for mould and dust mites to flourish. These can lead to health issues that impact on children's schooling and adult productivity. Research has raised the possibility that damp homes are not just making asthma worse but may actually be a cause of early asthma. Excess indoor moisture can also lead to mould and fungi growth on surfaces and reduced lifespans for building materials.

There is a large body of evidence that there is too much moisture in New Zealand houses. In the BRANZ 2015 House Condition Survey, 11% of owner-occupied houses and 31% of rental houses felt damp. Assessors saw mould in almost half the houses visited. Part of the survey measured relative humidity in 66 houses. Overall, 65% of houses had at least one room with humidity over 70% for more than 20% of the time. For optimum occupant comfort, relative humidity of 40-60% is recommended.

New building materials and construction methods haven't solved the problem. Research funded by the Building Levy on two houses in Auckland - one airtight and the other not airtight - found that, without using mechanical ventilation, the more airtight house retained higher levels of internal humidity.

Sources of moisture include:

- steam from cooking or showering that is not extracted outside
- unvented clothes dryers - they can emit 5 kg of water per load into the indoor air
- occupants themselves - relative humidity in houses is often highest in bedrooms at night (over 80% in some cases) from occupant breathing
- unflued gas heaters.

Removing the source or ventilating at the source are the most effective steps in preventing moisture and contaminant build-up. House occupants should reduce indoor moisture (for example, by not using unflued gas heaters or unvented clothes dryers) and use extract ventilators to move kitchen and bathroom moisture to the outside. BRANZ research also indicates that opening windows wide for just 10-15 minutes each day can lower moisture levels - see Research Now: Indoor air quality #3 *The impact of ventilation in New Zealand houses*.

Data from BRANZ research also shows that houses heated to 18°C or above experience far fewer periods of high humidity.

A BRANZ study assessed a 1980s Wellington house with a slab floor and single-glazed aluminium windows - a very common design. The relative humidity in the lounge was over 70% for a quarter of the time and the main bedroom for 87% of the time. Humidity levels quickly fell as the bedroom was heated to different temperatures until, at 20°C, the relative humidity was over 70% for less than 1% of the time.

Installing a heat pump doesn't by itself guarantee low humidity, however, if there is no ventilation. In the BRANZ Key Energy Uses project, measurement of 134 houses around New Zealand with heat pumps found that 17% still had high humidity levels. Heating and ventilation are both key to achieving acceptable indoor humidity levels.

BIOLOGICAL CONTAMINANTS

Biological contaminants are tiny living forms that include fungi, bacteria and dust mites. They thrive in damp homes. NZS 4303:1990 *Ventilation for acceptable indoor air quality* recommends relative humidity no greater than 60% specifically to minimise levels of biological contaminants.

Some of these contaminants, like moulds and fungi, can damage building materials, but their impact on human health causes the greatest concern. The faecal waste of house dust mites in carpets and bedding is an allergen that causes problems for people with asthma. This affects a lot of people - around 600,000 New Zealanders take medication for asthma. Dust mites thrive in relative humidity of around 70-80%, and numbers reduce when humidity falls below around 50-60%. Some people with asthma are also affected by bacterial or fungal material.

VOCs

Volatile organic compounds (VOCs) are organic chemicals that are given off as gases to surrounding air and are found in many solvents and cleaning fluids, paints, coatings, adhesives and other products. VOCs are harmful to health. They can irritate eyes, nose and throat, cause headaches/nausea and potentially even damage internal organs.

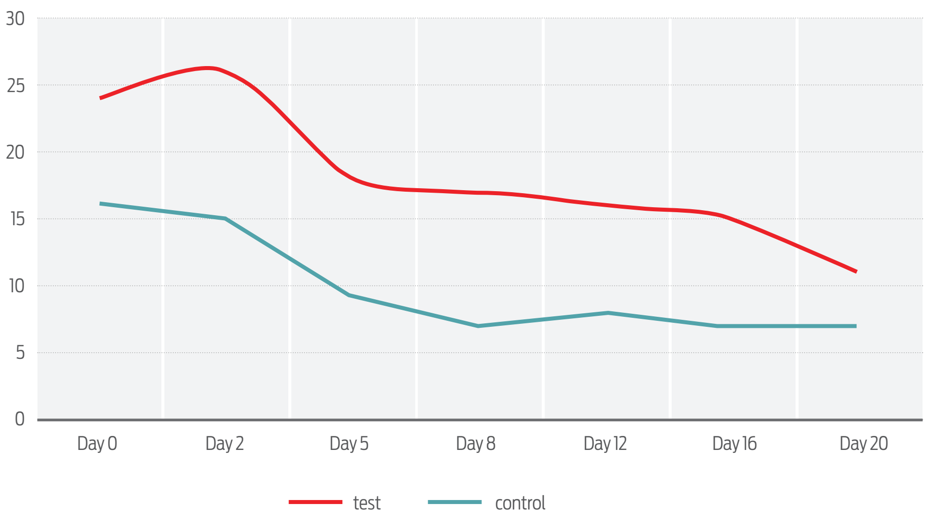

Figure 1. After an airtight test house and a less-than-airtight control house were furnished, they were measured for specific VOCs. The airtight house recorded higher levels of VOCs, and in both houses, it took 5 days before levels of the VOC measured (ethyl acetate in this graph) had fallen significantly.

In a test of occupied homes in Lower Hutt, significant one-off emissions of VOCs occurred after the use of glues and cleaning products.

In a test of an airtight and a non-airtight house in Auckland, concentrations of VOCs in both houses before they were furnished and decorated were lower than all of the current guidelines, with the exception of benzene. After furnishing and decorating (painting) the houses and without any mechanical ventilation, VOC concentrations in the more airtight house more than tripled. Both houses would exceed European and German limits for VOCs when operating without mechanical ventilation.

Five days after furnishing and painting and switching mechanical ventilation on, VOC levels had dropped significantly. This demonstrates the efficiency of ventilation in reducing VOCs but also the time it takes to bring concentrations to below international thresholds.

GASES

Breathing in high levels of carbon dioxide (CO_2) can result in headaches, tiredness and more frequent illness. Exposure to carbon monoxide (CO) in extreme cases can be fatal. Several New Zealanders have died after CO poisoning from malfunctioning or poorly maintained gas appliances.

Nitrogen oxides produced from burning gas and from car exhausts can also have an impact, irritating the airways of many people. They can cause more severe reactions in people with asthma.

NZS 4303:1990 recommends ventilation that results in CO_2 levels below 1,000 parts per million (ppm).

Tests in New Zealand houses have found higher CO_2 levels from occupant breathing in bedrooms with closed windows and doors. CO_2 concentrations in occupied spaces depend on the number of people present and the level of ventilation with fresh air. Less well-ventilated bedrooms or those with multiple occupants reached maximum concentrations of 4,000 ppm or 10 times atmospheric background concentrations. This is above the level set in NZS 4303:1990 and may cause discomfort but is unlikely to cause serious harm.

In houses with internal garages, vehicle tailpipe emissions sometimes enter the living spaces. In some houses, researchers have found that peak living room concentrations matched

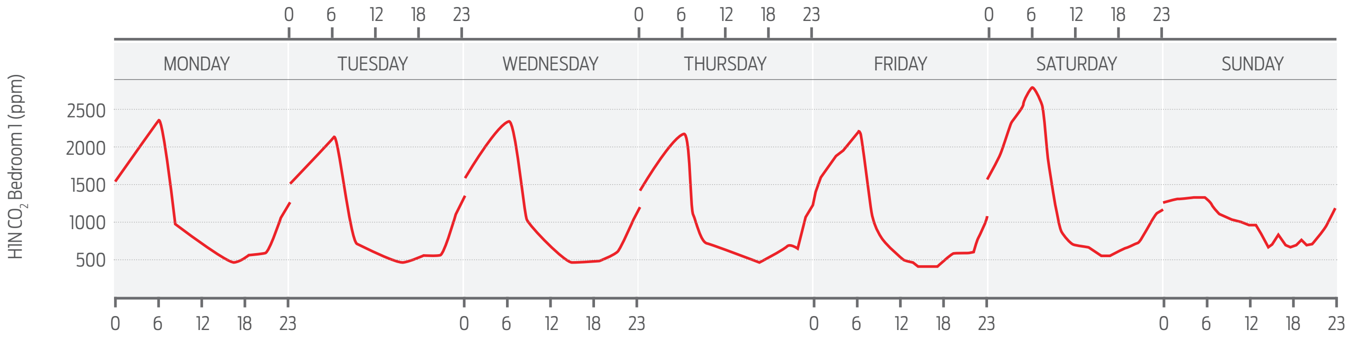

Figure 2. Carbon dioxide levels in bedrooms increase while occupants are asleep and fall when the room is empty. Levels well above 1,000 ppm are commonly reached where windows are kept closed.

the times when cars were being driven in and out of the garage.

Higher levels of carbon monoxide have been recorded in the evening in houses, produced from gas hobs and heaters and, in one house, a wood burner. The CO concentration levels found in houses were generally low and never went above health guidelines.

PARTICULATES

Particulates are tiny pieces of matter. Two sizes are commonly tested for. PM_{10} particulates (defined as coarse) are 10 micrometres or less in diameter - one-tenth the thickness of a human hair. $PM_{2.5}$ particulates (defined as fine) are less than 2.5 micrometres in diameter.

High levels of particulates in the air, especially PM_{10}, can irritate the eyes and throat. People with breathing conditions may experience an increase in symptoms. The smaller $PM_{2.5}$ particles can be a bigger threat because they can reach deep into the lungs.

The PM_{10} particulates in outdoor air in New Zealand cities in winter typically come from the emissions of solid fuel space heaters. How is this possible with National Environmental Standards (NES) for Air Quality? Consumer New Zealand says the wood used in the standards test is not typical of what New Zealanders use. Even the cleanest-burning timber in its own testing still produced three times the emissions of the NES level. Wood burners are producing far higher emissions that the NES would suggest.

Motor vehicles are a source of $PM_{2.5}$ particulates, especially in the morning and later afternoon as cars are driven to and from work. In houses close to the sea, sea salt particles are also found in the air in concentrations largely influenced by the weather.

Inside the Hutt Valley houses tested, cooking the evening meal was the chief source of PM_{10}. Toasters and frying are very strong sources of particulates and aerosols (particulates in liquid form). In a few instances, solid fuel heaters were the main source (where households do not cook) or cigarettes if the occupants smoked inside. (In a few cases, arsenic was also detected, indicating that treated timber was being used as fuel in the wood burners.)

In some houses that did not use wood burners, measurements indicated a similar level of biomass particulates (black carbon from fires) inside and outside, indicating that the particles in the house were coming from the outside air.

In the two Auckland houses (one airtight and one not) tested after furnishing and decoration and with no mechanical ventilation, concentrations in both houses exceeded the national Ambient Air Quality Guidelines for PM_{10}. With mechanical ventilation in operation, the particulate concentrations dropped significantly, demonstrating the efficiency of ventilation.

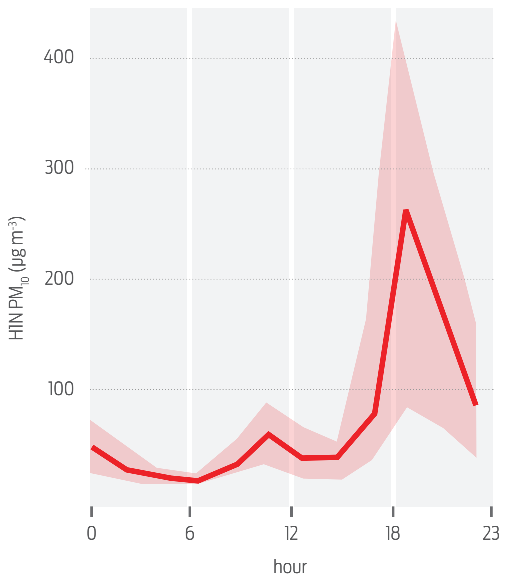

Figure 3. In Hutt Valley houses tested for particulates, PM_{10} numbers rose sharply in the late afternoon/early evening when people arrived home from work and school, cooked dinner and perhaps lit a wood burner. (The shaded area is the 95 percent confidence limits in the mean.)

VENTILATION

Ventilation with fresh outside air is the most effective means of diluting and reducing contaminants.

The Building Levy-funded research in the two Auckland houses found that the use of mechanical ventilation had a profound effect on both particulate matter and VOCs. However, in some cases, significant reductions in VOCs took days to happen. This suggests that new builds and completely renovated/redecorated homes should be well ventilated for several days before occupation. Occupants should also ensure a house is well ventilated when using strong chemicals indoors and for some time afterwards.

The fact that New Zealand houses are getting more airtight has one advantage for ventilation - it makes it more controllable than the case with older houses that have more gaps in the building envelope. But more airtight construction can lead to greater concentration of contaminants, so more thought has to be given to ventilation. To use a slogan, "build tight and ventilate right".

For more specific details about ventilation, see Research Now: Indoor air quality #3 *The impact of ventilation in New Zealand houses*.

SUMMARY

Research has found that excess moisture and contaminants such as CO_2 and VOCs exceed recommended levels in many New Zealand houses, compromising the safety and comfort of occupants. Ventilation can help but may take longer to be effective than homeowners realise. If redecorating a house has produced large amounts of VOCs, for example, it can take 4-5 days of active ventilation to reduce these contaminants to acceptable levels.

To assists in removing excess moisture and contaminants from indoor air, researchers recommend:

- ensuring effective insulation and heating systems to make rooms warmer
- installing well-sized mechanical extract ventilation in kitchens and bathrooms to expel moisture to the outside
- opening windows on a regular basis
- allowing time for VOCs to disperse after extensive redecorating.

BRANZ has a number of indoor air quality research projects currently under way. In a number of cases, these are being conducted in partnership with national and international organisations.

More information

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*

Research Now: Indoor air quality #6 *Project: Indoor air pollution at a New Zealand urban primary school*

BRANZ Bulletin 581 *Residential mechanical ventilation systems*

BRANZ Bulletin 607 *Passive ventilation*

Pollard, A. (2018). *Could damp homes be too cold/underheated?* BRANZ Study Report SR389. Judgeford, New Zealand: BRANZ Ltd.