Our air 2021

New Zealand's Environmental Reporting Series

Ministry for the Environment
Manatū Mō Te Taiao
Stats NZ
Tatauranga Aotearoa

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Contents

Introduction to Our air 2021

Overlooking Dunedin.
Photo: Clare Toia-Bailey, www.image-central.co.nz

This section provides background to *Our air 2021*, including why understanding the quality of our air is important. It also provides information on the legislation and guidelines this report makes comparisons against.

About Our air 2021

This release of *Our air 2021* supersedes the earlier report *Our air 2021: preliminary data release*, released in October 2021. The earlier report was required to be published to meet statutory obligations, but due to its timing, it was not able to include evaluations of the data against the World Health Organization's 2021 air quality guidelines, and was therefore preliminary only. This updated report includes comparisons to these new guidelines, providing a more comprehensive understanding of the health impacts from air pollution based on the latest science.

Our air 2021 is the latest in a series of environmental reports produced by the Ministry for the Environment and Stats NZ. It is the third report in the series dedicated to air quality, following the 2014 and 2018 air domain reports, and is the second released under the Environmental Reporting Act 2015.

In 2019, the Parliamentary Commissioner for the Environment released his report, ***Focusing Aotearoa New Zealand's environmental reporting system***. The report identified how the environmental reporting system can be improved and recommended changes to the Environmental Reporting Act. These amendments will provide a stronger foundation to ensure we understand our environment and the impacts people are having on it.

Our air 2021 is a report in a transitional format to meet statutory requirements while we make the fundamental changes to the reporting system that have been recommended. This is a data-oriented release, with the primary focus on updating indicators. This report updates some of the indicators reported on in previous years but does not introduce new ones. Interactive graphs and maps can be found on the Stats NZ website (linked at the bottom of each indicator section of this report).

Understanding air and wellbeing

We often take the air we breathe for granted, yet clean air is essential to our wellbeing. Air can become contaminated by particulate matter (particles suspended in the air) and gaseous pollutants. This can negatively affect human health, our quality of life, and natural ecosystems. Poor air quality can become a serious public health issue, with significant costs to society. *Our air 2021* reports on the emissions generated by a range of activities in Aotearoa New Zealand.

Greenhouse gas emissions and their impacts are not reported on within *Our air 2021* but can be found in ***Our atmosphere and climate 2020***.

Standards we report against

This report evaluates monitored data against two primary standards or guidelines – one national and one international – to indicate potential impacts on human health.

The **World Health Organization guidelines** are based on an evaluation of the most recent science on health impacts from air pollution, and identify air pollution levels above which there are significant risks to human health. This is the only consideration used for setting the guideline levels. They are intended to inform air quality management, but, as international guidelines, are not legally binding.

In contrast, the **National Environmental Standards for Air Quality (NESAQ)** set legally binding levels of air pollution that must not be exceeded. The levels at which these standards are set are informed by international research and guidelines (such as the World Health Organization guidelines), but can also take into account other considerations, such as cost and feasibility of meeting the standard.

NATIONAL ENVIRONMENTAL STANDARDS FOR AIR QUALITY

The National Environmental Standards for Air Quality are regulations made under the Resource Management Act 1991. Under the standards, limits for particulate matter and gaseous pollutants are defined to protect communities against detrimental health impacts. The standards focus on short-term exposure – that is, average concentrations over hourly or 24-hour time periods. The standards allow some pollutants to be above their threshold limits (ie an exceedance) a limited number of times per year.

WORLD HEALTH ORGANIZATION AIR QUALITY GUIDELINES

While the National Environmental Standards for Air Quality have a short-term exposure focus, the World Health Organization (WHO) air quality guidelines (AQGs) also provide indicative limits to protect communities from the long-term or chronic health impacts of air pollution in addition to short-term exposure guidelines. The WHO guidelines are based on a synthesis of research on the health effects of air pollutants. Many regional councils and unitary authorities, which are responsible for monitoring and managing air quality in New Zealand, choose to report on levels of air pollutants against the WHO guidelines, in addition to the National Environmental Standards.

During the final production stages of *Our air 2021*, the WHO released updated air quality guidelines (WHO, 2021). This is the first update in 16 years and is a result of a systematic review of more than 500 publications by world experts. As such, it builds on the advances in measurement and pollution assessment from a global database as well as epidemiological studies (WHO, 2021).

In most cases the revised 2021 WHO air quality guidelines are more stringent than the 2005 ones (WHO, 2006), reflecting the large body of evidence of detrimental effects of key pollutants on human health, even at low levels (table 1).

Table 1: Comparison of recommended 2005 and 2021 World Health Organization air quality guideline levels

Pollutant	Time period	2005 air quality guideline	2021 air quality guideline	Units
Particulate matter 2.5 µm ($PM_{2.5}$)	Annual	10	5	µg/m^3
	24-hour[a]	25	15	µg/m^3
Particulate matter 10 µm (PM_{10})	Annual	20	15	µg/m^3
	24-hour[a]	50	45	µg/m^3
Ozone (O_3)	Peak season[b]	–	60	µg/m^3
	8-hour	100	100	µg/m^3
Nitrogen dioxide (NO_2)	Annual	40	10	µg/m^3
	24-hour[a]	–	25	µg/m^3
Sulphur dioxide (SO_2)	24-hour[a]	20	40	µg/m^3
Carbon monoxide (CO)	24-hour[a]	–	4	mg/m^3

Note
a: 99th percentile (ie 3–4 exceedance days per year)
b: Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration
µg/m^3: micrograms per cubic metre
mg/m^3: milligrams per cubic metre.

Our air 2021 assesses New Zealand's air quality against both the 2005 and 2021 WHO air quality guidelines. This report has included reference to the 2005 WHO air quality guidelines because these have been the reference thresholds for air quality measurements across New Zealand to date, and because this allows comparison to findings in *Our air 2018*.

We have also assessed our data against the revised 2021 WHO air quality guidelines, to enable us to evaluate New Zealand's air quality using the most up-to-date scientific understanding of good air quality.

Summary of key findings

This section provides a summary of key findings for each of the indicators included in this report: PM_{10} concentrations, $PM_{2.5}$ concentrations, nitrogen dioxide concentrations, sulphur dioxide concentrations, ground-level ozone concentrations, carbon monoxide concentrations, air pollutant emissions, and the health impacts of air pollution.

INDICATOR FINDINGS

PM_{10} (particulate matter of 10 micrometres diameter or less)

PM_{10} concentrations at most locations measured (69 percent) have improved since 2011, but sites still have high concentrations at times – 76 percent were higher than the 24-hour 2021 World Health Organization (WHO) air quality guidelines at least once between 2017 and 2020, and almost half were higher than the 2021 WHO air quality guidelines for annual PM_{10} exposure.

$PM_{2.5}$ (particulate matter of 2.5 micrometres diameter or less)

$PM_{2.5}$ concentrations at 50 percent of locations have improved since 2011. However, 95 percent of sites were higher than the 24-hour and annual 2021 WHO air quality guidelines at least once between 2017 and 2020. The sites with the highest $PM_{2.5}$ concentrations were above the guideline for around a quarter of the year. These high concentrations generally occurred during the colder months.

Nitrogen dioxide

Nitrogen dioxide concentrations at most locations (86 percent) have improved since 2011. But five of seven sites (71 percent) were higher than the 24-hour 2021 WHO air quality guidelines at least once between 2017 and 2020, and two of these sites (both in high-traffic areas) were higher than the air quality guidelines an average of 300 days and 235 days respectively per year.

Sulphur dioxide

Sulphur dioxide concentrations have improved at most locations (80 percent) since 2011. Sulphur dioxide concentrations still exceed air quality guidelines near some industrial sources.

Ground-level ozone

Ozone concentrations in New Zealand are quite low compared to levels recorded in many other countries. Trends could only be determined at one of the two sites, with the trend direction being 'indeterminate', meaning there was not enough statistical certainty to determine a trend direction. At this site, concentrations came very close to exceeding the peak season 2021 WHO air quality guidelines.

Carbon monoxide

Carbon monoxide concentrations at most locations (90 percent) have improved since 2011. Between 2017 and 2020, no sites exceeded the National Environmental Standards for Air Quality or WHO air quality guidelines.

Air pollutant emissions (sources)

Wood burning for home heating is a major source of air pollution in New Zealand. Most particulate matter from wood smoke is $PM_{2.5}$ (which is more harmful to human health than PM_{10}, due to its smaller particle size) and most is emitted in winter. Combustion in the manufacturing industries and construction is another large source of $PM_{2.5}$. Dust from unsealed roads contributes substantially to PM_{10}, although there is uncertainty around the exact magnitude of these emissions.

Motor vehicle emissions continue to contribute to poor air quality in many urban areas (primarily in the form of $PM_{2.5}$, nitrogen dioxide, and carbon monoxide). Whereas emissions of some pollutants have reduced due to improved engine technology and fuel quality, many improvements have been offset by higher traffic volumes, more distance traveled, and intensification along transport corridors. In addition, vehicles are getting heavier, with larger engines.

Health impacts

In New Zealand, poor air quality results in significant human health impacts. While the relative impacts per 100,000 people appear to have improved between 2006 and 2016, the absolute number of people affected has increased due to population growth.

Note: We anticipate that this indicator will be updated in 2022, pending an update to the Health and Air Pollution in New Zealand model.

RESEARCH FINDINGS

COVID-19 lockdown (2020) impacts on air quality

Restrictions implemented in 2020 during the COVID-19 pandemic temporarily decreased concentrations of several key pollutants across the country. Nitrogen dioxide, primarily generated by the combustion of fuel by motor vehicles, showed more of a decrease than particulate matter pollution, which comes from a range of sources. Nitrogen dioxide concentrations decreased by approximately half due to reduced vehicle traffic.

Indicator findings

Wellington traffic.
Photo: Ministry for the Environment

This section provides the key findings for each of the indicators (PM_{10} concentrations, $PM_{2.5}$ concentrations, nitrogen dioxide concentrations, sulphur dioxide concentrations, ground-level ozone concentrations, carbon monoxide concentrations, air pollutant emissions, and the health impacts of air pollution), an overview of how the data are collected and assessed, and links to more detailed information available on the Stats NZ web pages.

Particulate matter

In New Zealand and around the world, the most significant human health impacts from poor air quality are associated with exposure to particulate matter (PM) (Health Effects Institute, 2018). Particulate matter is a term used for a mixture of solid particles and liquid droplets found in the air (US EPA, 2021). This report refers to two types of particulate matter:

- PM_{10}: larger particles (but still small enough that they can be inhaled), 10 micrometres or less in diameter
- $PM_{2.5}$: finer particles, 2.5 micrometres or less in diameter. Because PM_{10} includes all particles smaller than 10 micrometres, $PM_{2.5}$ is a subset of PM_{10}.

There is considerable evidence that inhaling PM is harmful to human health, especially when of smaller particle size, such as $PM_{2.5}$ and finer. $PM_{2.5}$ can be particularly harmful because these particles can become trapped in the small airways deep in the lungs. When particles are very fine ($PM_{0.1}$) they can enter the bloodstream and penetrate organs in the body (EFCA, 2019).

Short – and long-term exposure to PM, even at low levels, can lead to a range of health impacts especially in vulnerable people (the young, the elderly, and people with existing respiratory conditions). At the less-severe end, it can cause temporary and reversible effects such as shortness of breath, coughing, or chest pain. However, there is strong evidence of more severe effects, namely, illness and premature death from heart attacks, strokes, or emphysema (where the air sacs in the lungs are damaged). Exposure to PM can also cause lung cancer and exacerbate asthma. Studies point to possible links with diabetes and atherosclerosis (the accumulation of fat, cholesterol, and other substances on artery walls, reducing blood flow) as a result of increased inflammation caused by particulate matter (WHO, 2013).

Particulate matter emissions typically result from combustion (such as burning petrol, diesel, wood, or coal) and abrasion processes (such as brake and tyre wear or road dust). Combustion tends to create fine particles ($PM_{2.5}$), whereas abrasion generates coarser particles (PM_{10}). Particulate matter can also be generated through the reaction of gases in the atmosphere (referred to as secondary particulate matter), and a proportion of particulate matter is naturally occurring, for example, sea salt.

PM_{10} concentrations

A study by Talbot et al, (2021a, b) found that during the COVID-19 lockdown (alert level 4) in 2020, PM_{10} concentrations decreased by between 11.5 and 34.1 percent across New Zealand. As the restrictions eased, concentrations of PM_{10} increased. The scale of increase was more significant in southern regions, perhaps because the burning of wood for home heating is more prevalent during the colder months.

MEASUREMENT AND ASSESSMENT

Regional councils and unitary authorities monitor PM_{10} concentrations in their regions. Data from 46 sites for state and 48 for trends, located across 14 regions, were used in this report.

In New Zealand, short-term exposure to PM_{10} is assessed against the National Environmental Standards for Air Quality (NESAQ), which allows for a 24-hour average of 50 micrograms per cubic metre ($\mu g/m^3$) (one exceedance per year is permitted under the standard). Long-term exposure is assessed against the 2005 World Health Organization (WHO) annual average air quality guidelines (AQG) of 20 $\mu g/m^3$.

We also assess against the more stringent AQGs that the WHO recommended in September 2021 for PM_{10}: a 24-hour average of 45 $\mu g/m^3$ and an annual average of 15 $\mu g/m^3$.

Trends were analysed for sites with at least six complete years of data. All trends were assessed at the 95 percent confidence level. Where a trend was 'indeterminate', there was not enough certainty to determine a trend direction.

KEY FINDINGS

In the four-year period between 2017 and 2020:

National Environmental Standards for Air Quality (NESAQ)

- Twenty-four of 46 sites (52 percent) had at least two exceedances of the 24-hour PM_{10} NESAQ (50 µg/m^3) over a 12-month period. Most exceedances were at sites classified as residential.
- Arrowtown (at 30 days), Pomona Street (Invercargill) (12 days), and Anzac Square (Timaru) (12 days) had the highest number of average daily exceedances of the 24-hour PM_{10} NESAQ per year.
- The majority of all exceedances (83 percent) recorded over this four-year period were in winter (June, July, August). Only a relatively small number (14 percent) were recorded in autumn (March, April, May).

World Health Organization (WHO)

2005 air quality guidelines

- Three of 46 sites (7 percent) were above the PM_{10} annual 2005 WHO AQG (20 µg/m^3) at least once over the four-year period. These sites were: Anzac Square (Timaru), Pomona Street (Invercargill), and Arrowtown.
- Anzac Square (Timaru) was most often above the PM_{10} annual 2005 WHO AQG, in 2017, 2019, and 2020.

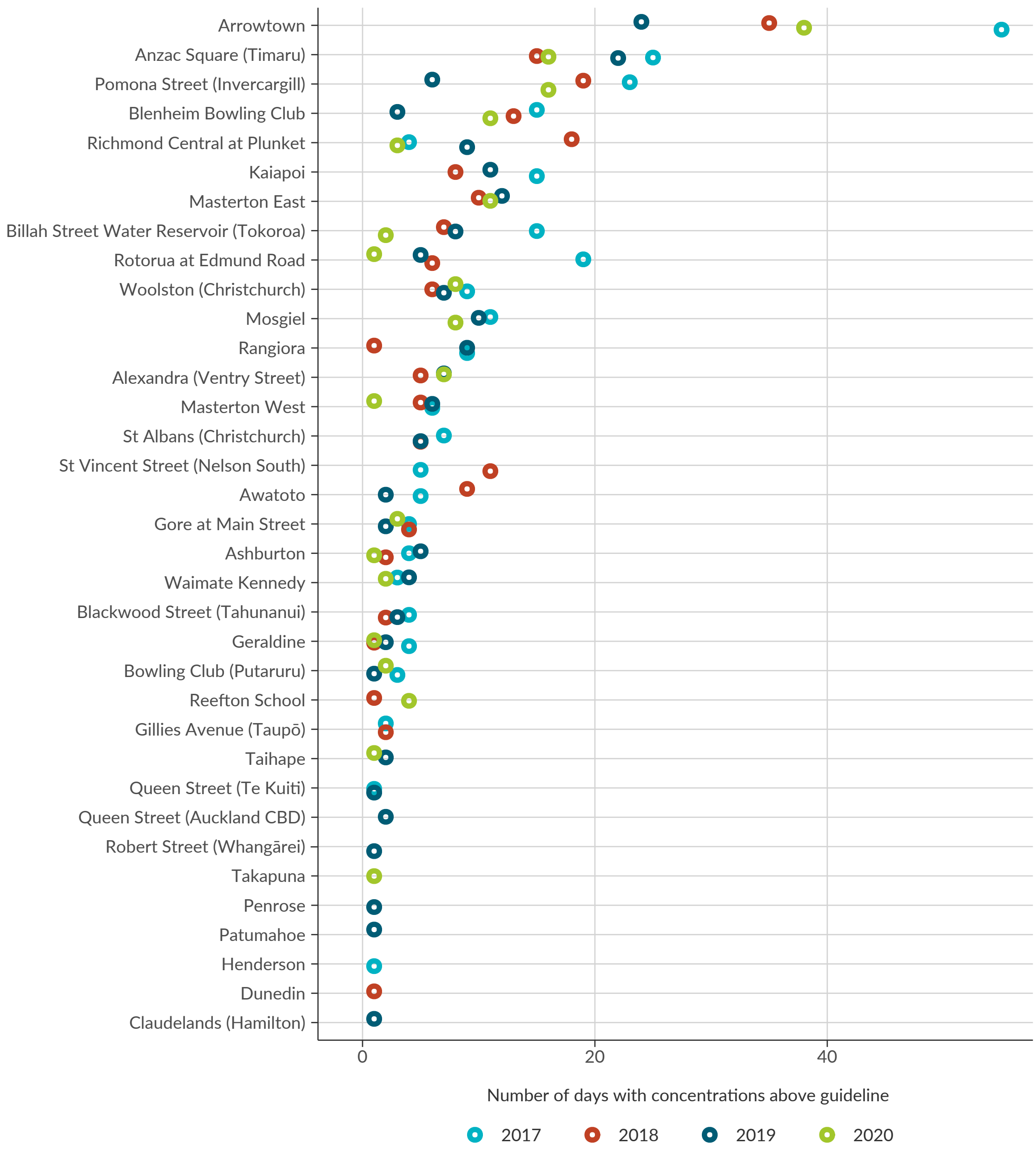
2021 air quality guidelines

- Thirty-five of 46 sites (76 percent) were above the PM_{10} 24-hour 2021 AQG (45 µg/m^3); most were at sites classified as residential.
- Arrowtown, Anzac Square (Timaru), and Pomona Street (Invercargill) were above the PM_{10} 24-hour 2021 WHO AQG most often: 24–55, 15–25, and 6–23 days per year, respectively (figure 1).
- Twenty-two of 46 sites (48 percent) were above the PM_{10} annual 2021 WHO AQG (15 µg/m^3) least once.
- Nine sites were above the PM_{10} annual 2021 WHO AQG at least once each year over this four-year period. These sites were Arrowtown, Ashburton, Blackwood St (Tahunanui), Blenheim Bowling Club, Geraldine, Gore at Main Street, Pomona Street (Invercargill), Timaru Anzac Square, and Woolston (Christchurch).

For the sites analysed for trends during the 10-year period between 2011 and 2020:

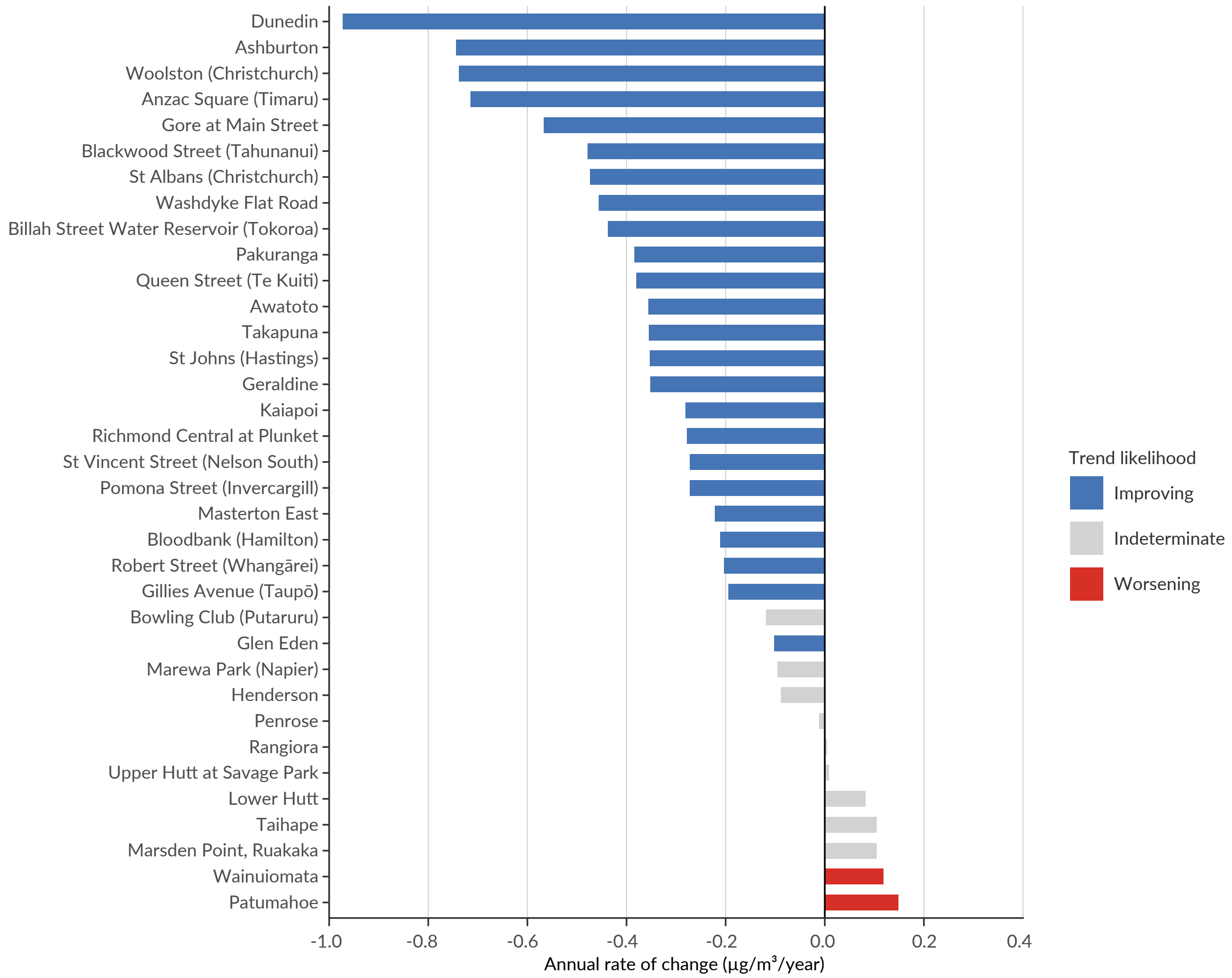
- On an annual basis, 69 percent were improving (24 of 35) and 6 percent were worsening (2 of 35) (figure 2). No trend could be determined at 26 percent of sites (9 of 35).
- Twenty-four of 48 sites (50 percent) had an improving trend in winter. The fastest rates of improvements were at Milton, Timaru Anzac Square, and Woolston (Christchurch).
- In summer, 6 of 43 sites (14 percent) had a worsening trend and 6 of 43 sites (14 percent) had an improving trend.

Figure 1: Days above 24-hour 2021 World Health Organization air quality guideline for PM_{10}, 2017–20



Data source: Regional councils, unitary authorities

Figure 2: PM$_{10}$ trends, 2011–20



Data source: Regional councils, unitary authorities

Find out more

See indicator: **PM$_{10}$ concentrations**

$PM_{2.5}$ concentrations

MEASUREMENT AND ASSESSMENT

Regional councils and unitary authorities monitor $PM_{2.5}$ concentrations in their regions. Data from 19 sites for state and 12 for trends, located across nine regions, were used in this report.

New Zealand is one of the few developed countries without a 24-hour average standard for $PM_{2.5}$. Consequently, short-term exposure to $PM_{2.5}$ has been assessed against the 2005 WHO 24-hour average guideline of 25 μg/m^3. Long-term exposure is assessed against the 2005 WHO annual average guideline of 10 μg/m^3.

We also assess against the more stringent air quality guidelines that the World Health Organization recommended in September 2021 for $PM_{2.5}$: 24-hour average of 15 μg/m^3 and an annual average of 5 μg/m^3.

KEY FINDINGS

In the four-year period between 2017 and 2020:

World Health Organization (WHO)

2005 air quality guidelines

- Sixteen of 19 sites (84 percent) were above the $PM_{2.5}$ 24-hour 2005 WHO AQG (25 μg/m^3); most of these sites are classified as residential.
- Blenheim Bowling Club, Masterton East, and Anzac Square (Timaru) were above the $PM_{2.5}$ 24-hour 2005 WHO AQG most often: 28–73, 28–43, and 23–46 days per year, respectively.
- The majority (82 percent) of days above the $PM_{2.5}$ 24-hour 2005 WHO AQG over this period occurred in winter (June, July, August), and 17 percent occurred in autumn (March, April, May).
- Seven of 19 sites (37 percent) were above the $PM_{2.5}$ annual 2005 WHO AQG (10 μg/m^3) at least once. These were Blenheim Bowling Club, Geraldine, Kaiapoi, Masterton East, Masterton West, Rotorua at Edmund Rd, and Anzac Square (Timaru).
- Blenheim Bowling Club was above the $PM_{2.5}$ annual 2005 WHO AQG each year over this four-year period.

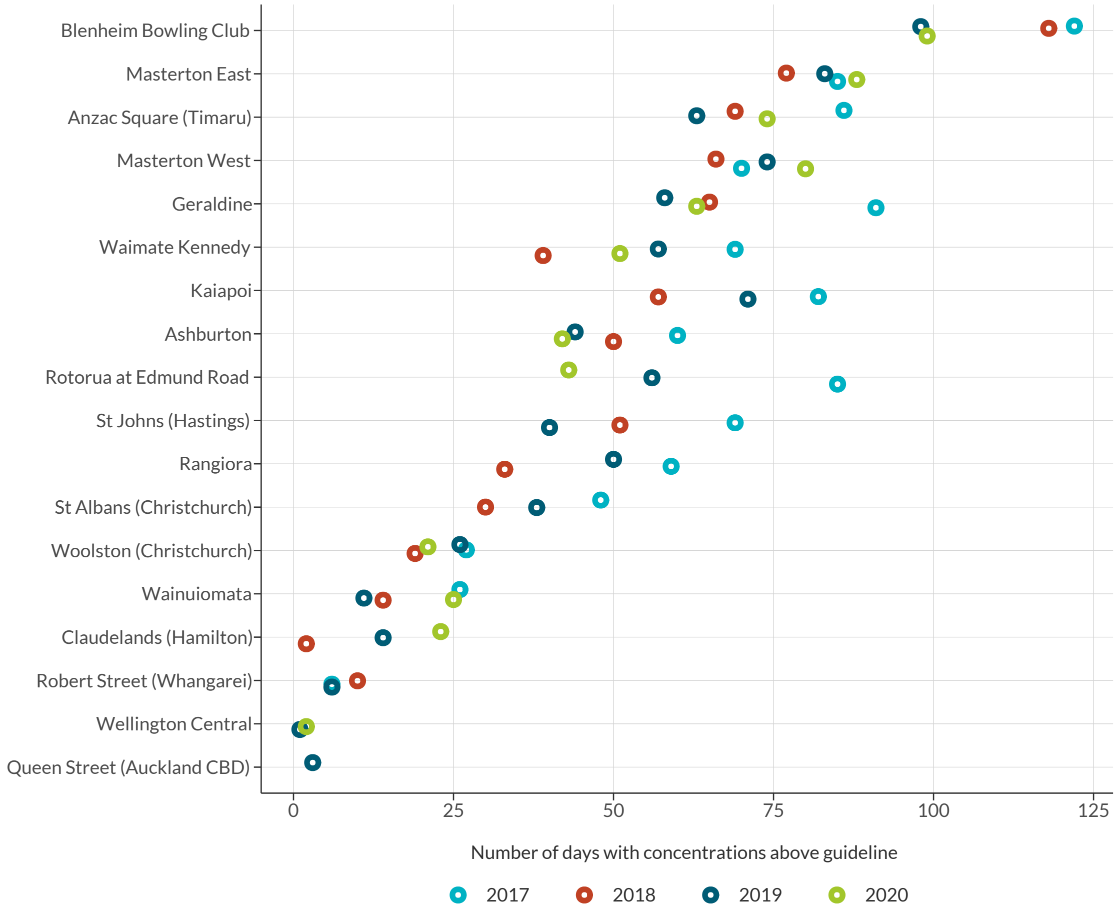
2021 air quality guidelines

- Eighteen of 19 sites (95 percent) were above the $PM_{2.5}$ 24-hour 2021 WHO AQG (15 μg/m^3); most of these sites are classified as residential.
- Blenheim Bowling Club, Masterton East, and Anzac Square (Timaru) were above the $PM_{2.5}$ 24-hour 2021 WHO AQG most often: 98–122, 77–88, and 63–86 days per year, respectively (figure 3).
- The majority (73 percent) of days above the $PM_{2.5}$ 24-hour 2021 WHO AQG over this period occurred in winter (June, July, August), and 23 percent occurred in autumn (March, April, May).
- Eighteen of 19 sites (95 percent) were above the $PM_{2.5}$ annual 2021 WHO AQG (5 μg/m^3) at least once.
- Nine sites (Ashburton, Blenheim Bowling Club, Geraldine, Masterton East, Masterton West, Anzac Square (Timaru), Waimate Kennedy, Wainuiomata, and Woolston (Christchurch)) were above the $PM_{2.5}$ annual 2021 WHO AQG each year over this four-year period.

For the sites analysed for trends in the 10-year period between 2011 and 2020:

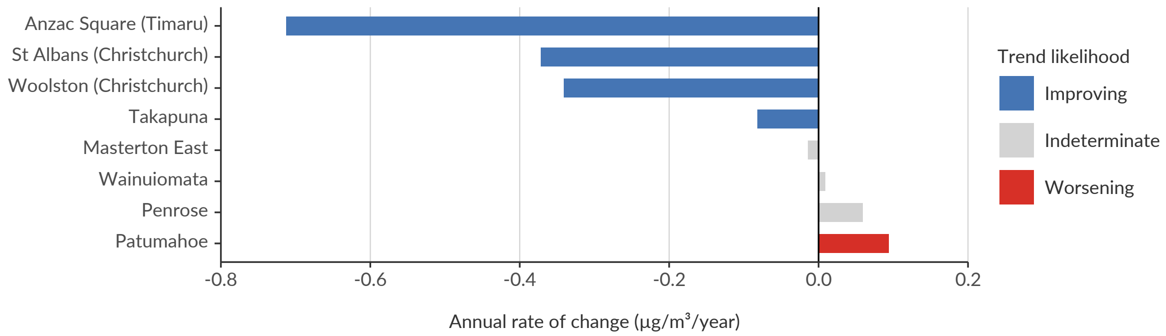
- On an annual basis, $PM_{2.5}$ concentrations improved at four out of eight sites (50 percent), worsened at one site (13 percent) (figure 4), and trends were indeterminate at three sites (38 percent).
- Concentrations in winter improved at three out of eight sites. Two sites in Auckland (Patumahoe and Penrose) had worsening concentrations in summer, with Patumahoe also having worsening concentrations in autumn. The Woolston (Christchurch) site had improving $PM_{2.5}$ concentrations across all seasons.

Figure 3: Days above 24-hour 2021 World Health Organization air quality guideline for $PM_{2.5}$, 2017–20



Data source: Regional councils, unitary authorities

Figure 4: $PM_{2.5}$ trends, 2011–20



Data source: Regional councils, unitary authorities

Find out more

See indicator: **$PM_{2.5}$ concentrations**

Nitrogen dioxide concentrations

Nitrogen dioxide (NO_2) is a gas primarily generated by burning fossil fuels, mainly by motor vehicles (particularly diesel vehicles) but also from industrial emissions and home heating. Because nitrogen dioxide concentrations are closely associated with vehicle emissions, they can be used as a proxy for other motor vehicle-related pollutants such as benzene, black carbon (a form of $PM_{2.5}$, also known as soot), and volatile organic compounds.

There are health impacts from short-term and long-term exposure to nitrogen dioxide. Short-term exposure to high concentrations of nitrogen dioxide causes inflammation of the airways and respiratory problems and can cause asthma attacks (US EPA, 2016). Short-term exposure may also trigger heart attacks and increase the risk of premature death (US EPA, 2016). Long-term exposure may cause asthma to develop and lead to decreased lung development in children. It may also increase the risk of certain forms of cancer and premature death (US EPA, 2016). Nitrogen dioxide also contributes to brown haze, which occurs in Auckland, and which is associated with an increase in hospital admissions.

Nitrogen dioxide also contributes to the formation of ground-level ozone and secondary particulate matter (when gases in the atmosphere react in the presence of sunlight), both of which can have negative health impacts.

Nitrogen dioxide can also have ecological impacts. It can cause injury to plant leaves and reduce growth in plants that are directly exposed to high levels (US EPA, 2008). In the atmosphere, nitrogen dioxide can combine with water to form nitrate, which has been shown to cause acidification and have negative effects on freshwater ecosystems. It can also affect ecosystems by acting as a nutrient (Payne et al, 2017).

New Zealand's COVID-19 response in 2020 led to a notable short-term improvement in air quality, particularly as a result of decreased nitrogen dioxide concentrations due to reduced traffic emissions (Talbot et al, 2021a, b). During the most restrictive alert level period (level 4), nitrogen dioxide concentrations reduced by 34 to 66 percent. The speed of the 'bounce-back' in concentrations varied according to location, but largely increased in line with increases in on-road vehicle volume as restrictions eased.

MEASUREMENT AND ASSESSMENT

The National Environmental Standards for Air Quality (NESAQ) for nitrogen dioxide requires regional councils and unitary authorities to undertake monitoring where nitrogen dioxide concentrations may be likely to breach the standard. Data from seven sites for state and nine for trends, located across three regions, were used in this report.

Because motor-vehicle emissions are the major source of nitrogen dioxide, the Waka Kotahi NZ Transport Agency also operates a network of passive nitrogen dioxide samplers at sites near roads, and urban background areas. These types of samplers do not meet regulatory standards but do allow for more widespread and cost-effective data collection. As such, this monitoring can provide information on concentrations but cannot be used to assess compliance with the nitrogen dioxide standard. Data from 186 sites for state and 110 for trends, located across 16 regions, were used in this report.

In New Zealand, short-term exposure to nitrogen dioxide is assessed against the NESAQ 1-hour average standard of 200 $\mu g/m^3$ (nine exceedances are allowed per year), and long-term exposure is assessed against the 2005 WHO annual average guideline of 40 $\mu g/m^3$.

We also assess against the more stringent air quality guidelines that the WHO recommended in September 2021 for NO_2: a 24-hour average of 25 $\mu g/m^3$ and an annual average of 10 $\mu g/m^3$.

KEY FINDINGS

<table>
<tr><td rowspan="3">In the four-year period between 2017 and 2020:</td><td colspan="2">

- Queen Street (Auckland) recorded the highest nitrogen dioxide concentration (41.5 µg/m³) averaged over 2017–20. Riccarton Road (Christchurch) recorded the second highest concentration (29.9 µg/m³).
- Nitrogen dioxide concentrations at monitored sites were highest in winter (June, July, August).

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National Environmental Standards for Air Quality (NESAQ)

- No site exceeded the NESAQ short-term standard (1-hour average) of 200 µg/m³.

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<tr><td>

World Health Organization (WHO)

2005 air quality guidelines

- Queen Street (Auckland) was above the NO_2 annual 2005 WHO AQG (40 µg/m³) in 2017 (43.9 µg/m³) and 2018 (43.9 µg/m³).

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2021 air quality guidelines

- Five of seven sites (71 percent) were above the 24-hour 2021 WHO AQG for nitrogen dioxide (25 µg/m³); most sites were classified as residential.
- Queen Street (Auckland), Riccarton Road (Christchurch), and Penrose were above the 24-hour 2021 WHO AQG for nitrogen dioxide most often: on 294–309, 179–271, and 51–96 days per year, respectively (figure 5).
- Five of seven sites (71 percent) were above the annual 2021 WHO AQG for nitrogen dioxide of 10 µg/m³ at least once a year.

</td></tr>
<tr><td>For the council sites analysed for trends in the 10-year period between 2011 and 2020:</td><td colspan="2">

- On an annual basis, nitrogen dioxide concentrations improved at six out of seven sites (86 percent) (figure 6).
- Concentrations in winter improved at five out of nine sites, with the rest indeterminate.

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<tr><td>For the Waka Kotahi NZ Transport Agency sites analysed for trends in the 10-year period between 2011 and 2020:</td><td colspan="2">

- Seventy-two of 110 sites (65 percent) had improving annual trends while four out of 110 (4 percent) had worsening trends.

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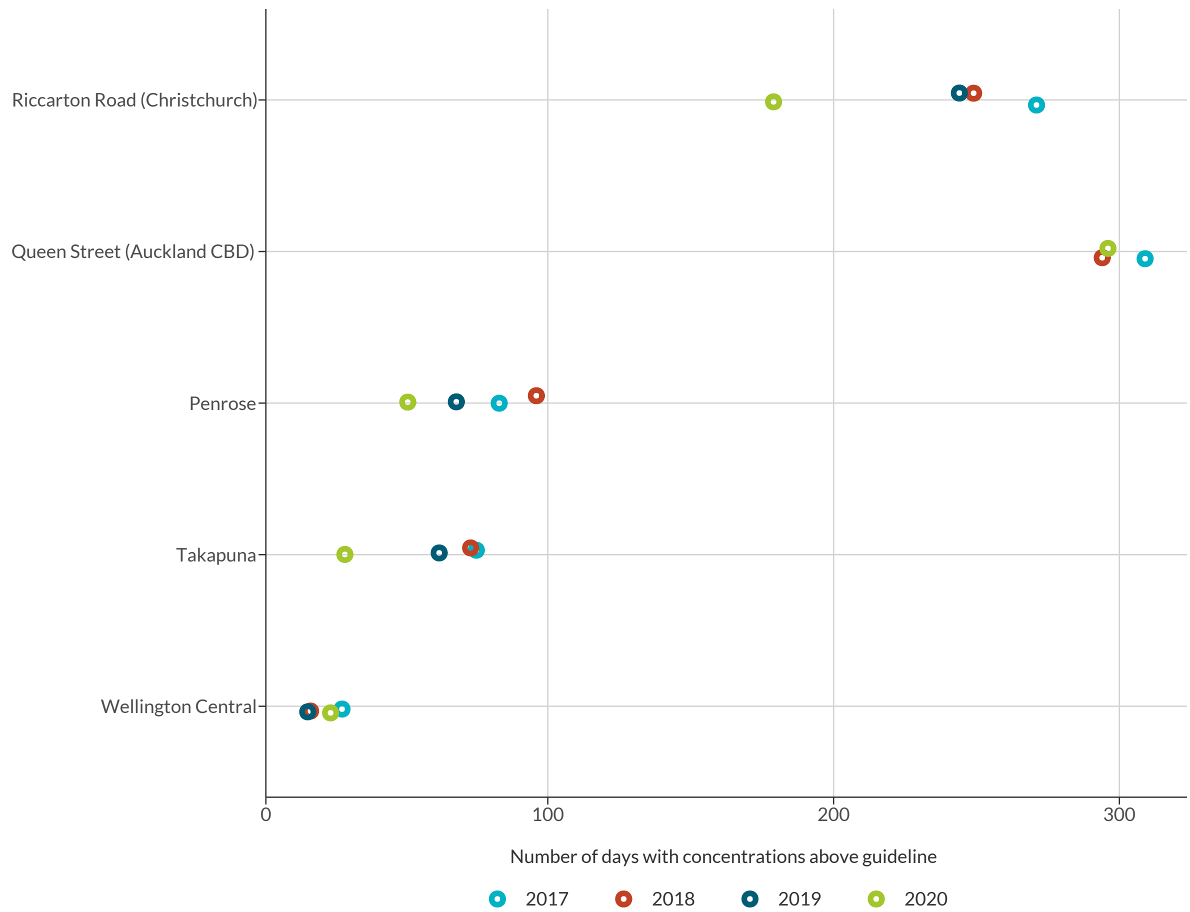
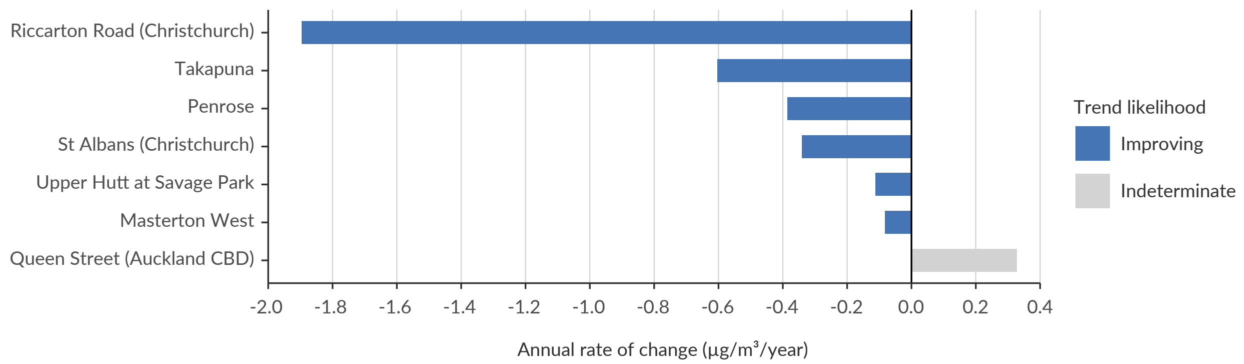
</table>

Figure 5: Days above 24-hour 2021 World Health Organization air quality guideline for nitrogen dioxide, 2017–20



Data source: Regional councils, unitary authorities

Figure 6: Nitrogen dioxide trends, 2011–20



Data source: Regional councils, unitary authorities

Find out more

See indicator: **Nitrogen dioxide concentrations**

Sulphur dioxide concentrations

Sulphur dioxide (SO_2) is a colourless gas with a sharp, irritating odour. It is associated with combustion of fossil fuels (such as coal, diesel, and heavy fuel oil used in maritime vessels) and industrial processes (such as the production of fertilisers and the smelting of mineral ores containing sulphur). Geothermal and volcanic gases are natural sources of sulphur dioxide in New Zealand.

At high levels, sulphur dioxide can have human health and ecological impacts. When inhaled, sulphur dioxide is associated with respiratory problems such as bronchitis. It can aggravate the symptoms of asthma and chronic lung disease and cause irritation to eyes.

It can also interact with other compounds in the air to form sulphate particulate matter, a secondary pollutant. Sulphate particulate matter is associated with significant health effects because of its small size and acidity. It is also a cause of haze, which impairs visibility.

In ecosystems, it can damage vegetation, acidify water and soil (US EPA, 2017), and affect biodiversity.

MEASUREMENT AND ASSESSMENT

Regional councils and unitary authorities monitor sulphur dioxide concentrations in their regions. Data from seven sites for state and six for trends, located across three regions, were used in this report.

In New Zealand, short-term exposure to sulphur dioxide is assessed against the NESAQ 1-hour average standard of 350 $\mu g/m^3$ (lower) (nine exceedances are allowed per year) and 570 $\mu g/m^3$ (upper), and the 2005 WHO 24-hour average guideline of 20 $\mu g/m^3$.

We also assess against the less stringent air quality guideline that the WHO recommended in September 2021 for sulphur dioxide: a 24-hour average of 40 $\mu g/m^3$.

KEY FINDINGS

In the four-year period between 2017 and 2020:

National Environmental Standards for Air Quality (NESAQ)

- No sites exceeded the short-term sulphur dioxide one-hour NESAQ lower threshold (350 $\mu g/m^3$) or the upper threshold (570 $\mu g/m^3$).

World Health Organization (WHO)

2005 air quality guidelines

- Four sites out of seven (57 percent) were above the 24-hour 2005 WHO AQG for sulphur dioxide (20 $\mu g/m^3$).
- Totara St, Whareroa Marae, and Tauranga Bridge Marina sites (all in Mount Maunganui) were above the 24-hour 2005 WHO AQG for sulphur dioxide most often: on 43–105, 13–51, and 6–27 days per year, respectively.
- Of all days above the 24-hour 2005 WHO AQG for sulphur dioxide recorded during this period, 32 percent were in summer (December, January, February) and 30 percent were in spring (September, October, November).

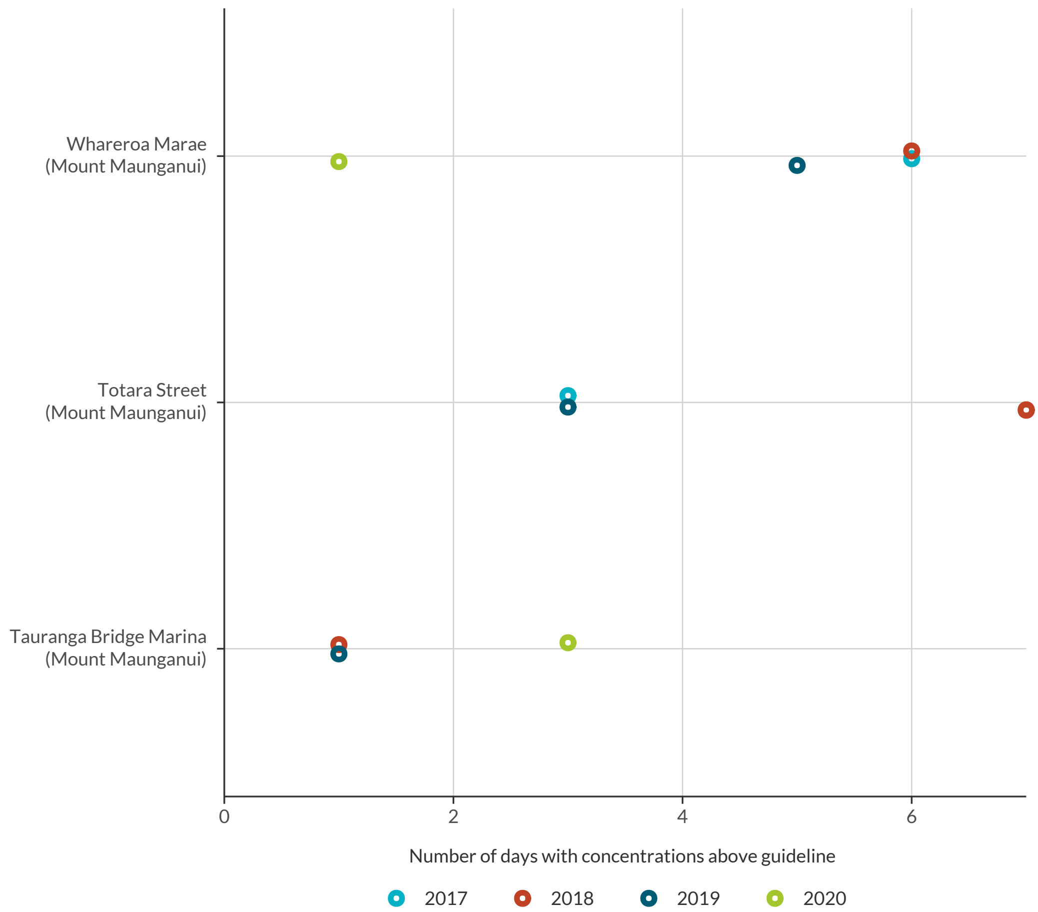
2021 air quality guidelines

- Whareroa Marae, Totara St, and Tauranga Bridge Marina sites (all in Mount Maunganui) were above the 24-hour 2021 WHO AQG for sulphur dioxide (40 $\mu g/m^3$).
- These sites were above the 24-hour 2021 WHO AQG for sulphur dioxide, on 1–6, 3–7, and 1–3 days per year, respectively (figure 7).

For the six sites analysed for trends in the 10-year period between 2011 and 2020:

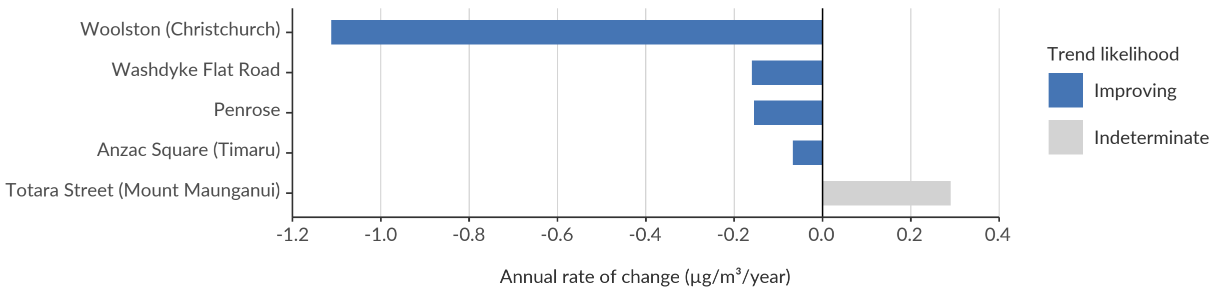
- On an annual basis, trends at four out of five (80 percent) were improving (figure 8).
- All seasonal trends were either improving or indeterminate.

Figure 7: Days above 24-hour 2021 World Health Organization air quality guidelines for sulphur dioxide, 2017–20



Data source: Regional councils, unitary authorities

Figure 8: Sulphur dioxide trends, 2011–20



Data source: Regional councils, unitary authorities

Find out more

See indicator: **Sulphur dioxide concentrations**

Ground-level ozone concentrations

Ozone (O_3) is a gas found naturally in the atmosphere. However, ozone at ground level is a pollutant primarily generated by human activity that can have harmful effects. Ground-level ozone forms when nitrogen oxides and volatile organic compounds (generated by sources such as motor vehicles and industrial processes) combine in the presence of sunlight.

Exposure to high concentrations of ground-level ozone can cause respiratory health issues and is linked to cardiovascular health problems and increased mortality. Those most at risk include children, older adults, people with asthma, and people who spend a lot of time outdoors, such as outdoor workers. Exposure to ground-level ozone may also be associated with effects on the nervous and reproductive systems, and other developmental effects (WHO, 2013).

High levels of ground-level ozone can also have harmful ecological effects: it can damage vegetation, reduce plant growth (affecting crop and forest yields), and harm sensitive ecosystems (US EPA, 2013).

MEASUREMENT AND ASSESSMENT

Two regional councils monitor ground-level ozone concentrations. Data from two sites (in Auckland and Wellington) for state and one site (in Auckland) for trends, were used in this report.

In New Zealand, short-term exposure to ground-level ozone is assessed against the NESAQ 1-hour average standard of 150 μg/m^3 and the 2005 WHO eight-hour average guideline of 100 μg/m^3.

We also assess against the air quality guidelines that the WHO recommended in September 2021 for ground-level ozone: an eight-hour average of 100 μg/m^3 (no change) and a peak season[1] eight-hour average of 60 μg/m^3.

KEY FINDINGS

In the four-year period between 2017 and 2020:

- Patumahoe (Auckland) had a higher annual average ground-level ozone concentration (40.1 μg/m^3) than Wellington Central (17.3 μg/m^3).

National Environmental Standards for Air Quality (NESAQ)

- Neither of the two monitored sites, Patumahoe (Auckland) and Wellington Central, exceeded the NESAQ one-hour average threshold (150 μg/m^3).

World Health Organization (WHO)

2005 air quality guidelines

- Neither of the two sites were above the eight-hour 2005 WHO AQG for ground-level ozone (100 μg/m^3).

2021 air quality guidelines

- No sites were above the eight-hour or peak season 2021 WHO AQGs for ground-level ozone.
- The peak season daily maximum eight-hour mean in Patumahoe was 59.3 μg/m^3 in 2019, just under the 60 μg/m^3 guideline.

For the one site analysed for trends in the 10-year period between 2011 and 2020:

- On an annual basis, Patumahoe showed an indeterminate trend.

Find out more

See indicator: **Ground-level ozone concentrations**

1 Average daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.

Carbon monoxide concentrations

Carbon monoxide (CO) is caused by the incomplete combustion of fuels, especially in petrol-fueled motor vehicles. However, exposure to carbon monoxide has been dramatically reduced since the introduction of emission standards in the year 2000, which required catalytic converters (an exhaust emission control device that converts toxic gases and pollutants into less-toxic pollutants) to be installed in most vehicles (Bluett et al, 2016).

Carbon monoxide can have a range of health effects even after short-term exposure to relatively low concentrations. When inhaled, carbon monoxide enters the blood stream and attaches to haemoglobin in red blood cells, which transport oxygen around the body. This reduces the amount of oxygen that body tissues receive and can have adverse effects on the brain, heart, and general health. Exposure to low levels can causes dizziness, weakness, nausea, confusion, and disorientation. However, higher levels can cause collapse, loss of consciousness, coma, and death (US EPA, 2010).

MEASUREMENT AND ASSESSMENT

Two regional councils monitor carbon monoxide concentrations. Data from six sites for state and 12 for trends, located across two regions (Wellington and Canterbury), were used in this report.

In New Zealand, short-term exposure to carbon monoxide is assessed against the NESAQ running 8-hour average standard of 10 mg/m^3 (one exceedance permitted per year) and the 2010 WHO 1-hour average guideline of 35 mg/m^3 (WHO, 2010).

We also assess against the air quality guidelines that the WHO recommended in September 2021 for CO: a 24-hour average of 4 mg/m^3.

KEY FINDINGS

In the four-year period between 2017 and 2020:

- Riccarton Road (Christchurch) had the highest average concentrations of carbon monoxide (0.4 mg/m^3). The rest of the sites had average concentrations of 0.2 mg/m^3 (figure 9).
- Across sites, peak concentrations of carbon monoxide occurred during morning and evening hours.
- Carbon monoxide concentrations were highest in winter (June, July, August), averaging 0.4 mg/m^3.

National Environmental Standards for Air Quality (NESAQ)

- No site exceeded the NESAQ running 8-hour average threshold (10 mg/m^3).

World Health Organization (WHO)

2010 air quality guidelines

- No site was above the 2010 one-hour WHO AQG for carbon monoxide (35 mg/m^3).

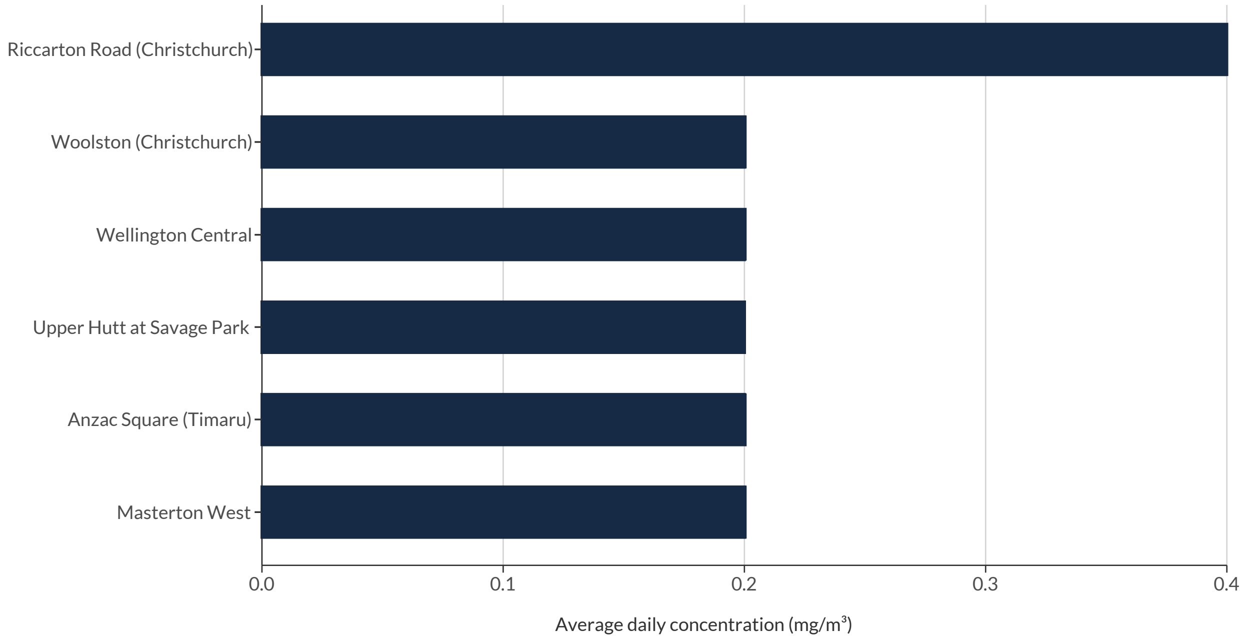
2021 air quality guidelines

- No site was above the 24-hour 2021 WHO AQG for carbon monoxide (4 mg/m^3).

For the sites analysed for trends in the 10-year period between 2011 and 2020:

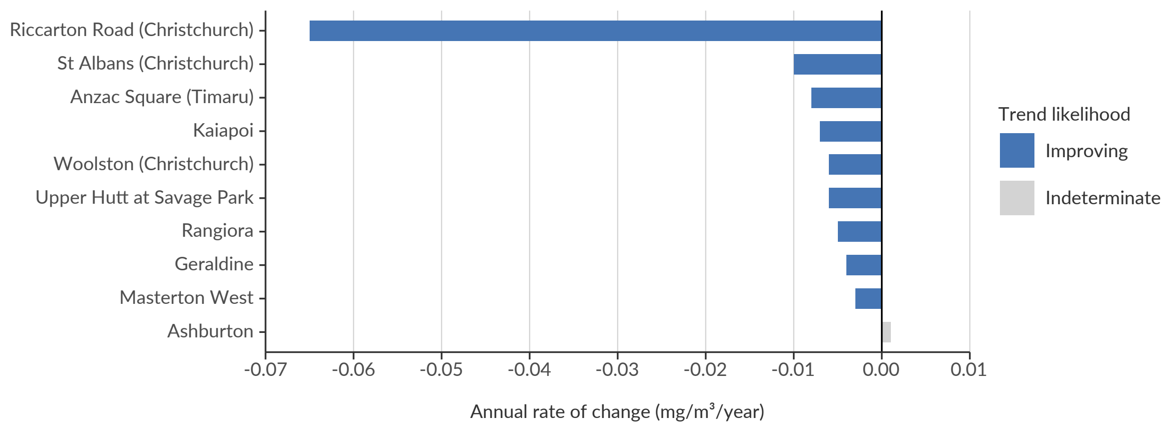
- Of the 10 sites assessed for annual trends, nine were improving and one was indeterminate (figure 10).
- During summer, two sites (Ashburton and Masterton West) were worsening, and two sites were improving (Geraldine and Riccarton Road (Christchurch)). The remaining seven sites were indeterminate.

Figure 9: Carbon monoxide average daily concentration, 2017–20



Data source: Regional councils, unitary authorities

Figure 10: Carbon monoxide trends, 2011–20



Data source: Regional councils, unitary authorities

Find out more

See indicator: **Carbon monoxide concentrations**

Sources of air pollutant emissions

Understanding the key sources of air pollutants is critical to managing and improving air quality. Emissions inventories estimate the quantities of pollutants emitted to the air by various sources over a certain time period.

Emissions inventories can provide information on the relative contributions of different sources and how they change over time, but they have a level of uncertainty in their estimates. For this report, an air pollutant emissions inventory was developed to examine sources of particulate matter and gaseous pollutants.

The primary method in the inventory is to use readily available information at a national scale (such as fuel use or production volume) and translate it into the amount of pollution emitted. This method provides national-level emission estimates that are easily updatable, consistent over time, and more complete in terms of sources.
An alternative method is direct measurement of emissions at the source, aggregated up to a national total.

MEASUREMENT AND ASSESSMENT

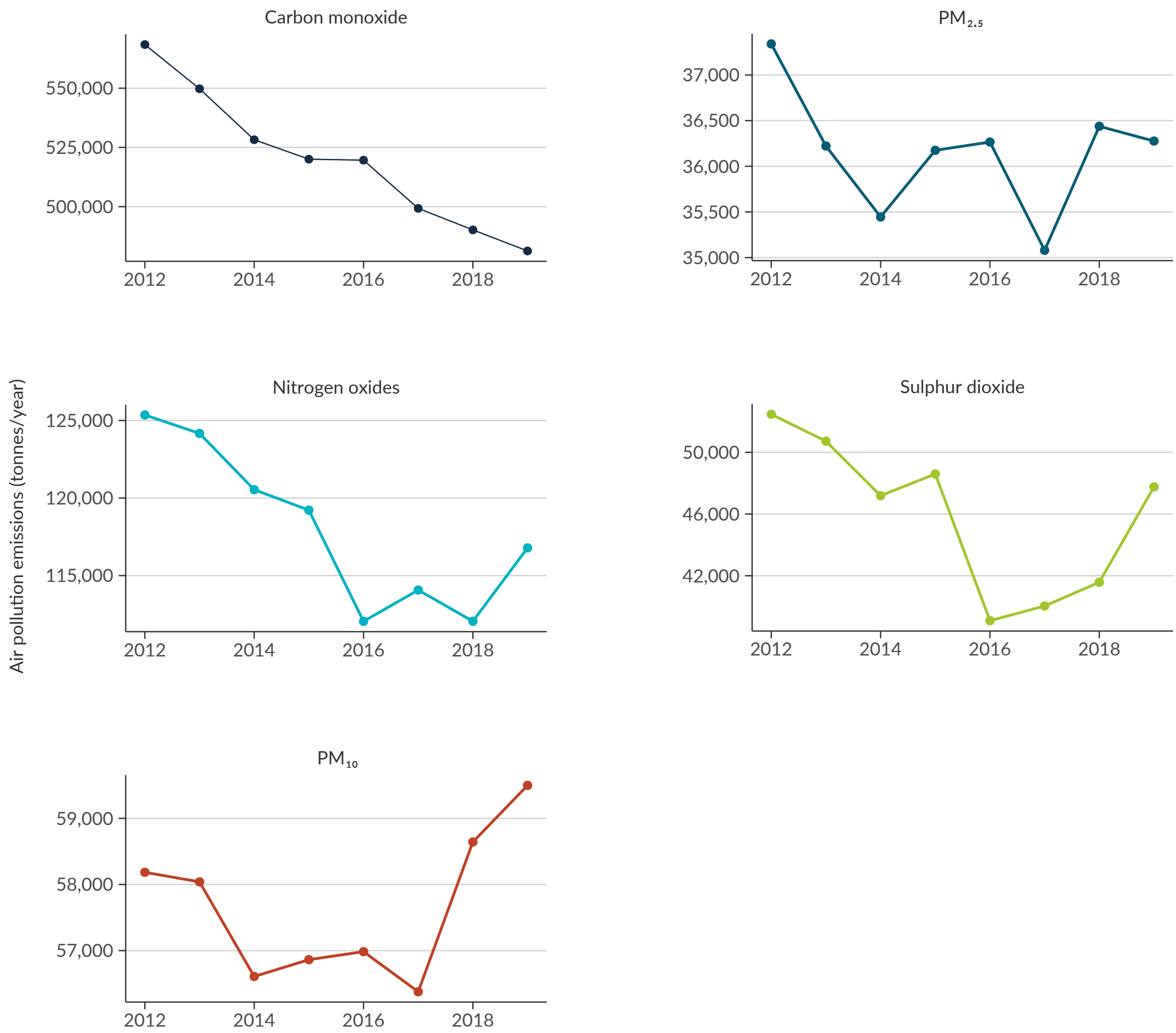
A national emissions inventory was developed for the following air pollutants in New Zealand – PM_{10}, $PM_{2.5}$, nitrogen oxides (NO_X), carbon monoxide (CO), and sulphur dioxide (SO_2).

This indicator presents data from 2012 up to and including 2019. The year covered by the Greenhouse Gas Inventory (which is a major input to the air pollutant emissions inventory) is 15 months behind the current calendar year to give countries time to collect and process the inventory data and prepare their submission (international reporting guidelines govern what the greenhouse inventory covers and when it is submitted).

KEY FINDINGS

Nationally in 2019:	▶ The residential sector (primarily burning wood for home heating) contributed 30 percent of $PM_{2.5}$ emissions and 41 percent of carbon monoxide emissions. Almost all particulate matter emissions generated by the residential sector were $PM_{2.5}$. ▶ Dust from unsealed roads was the dominant source of PM_{10} (28 percent). ▶ On-road vehicles were the dominant source of nitrogen oxides (39 percent), primarily diesel vehicles. ▶ Burning coal was a large source of sulphur dioxide emissions (41 percent), primarily from manufacturing and construction and electricity generation. Domestic shipping and aluminium production were also significant sources of sulphur dioxide, at 16 percent and 13 percent respectively.
In the eight-year period between 2012 and 2019:	▶ Total emissions were lower in 2019 than in 2012 for all pollutants except PM_{10} (figure 11). Annual emissions of carbon monoxide were down 15 percent compared to 2012 (by more than 87,000 tonnes). ▶ Transport emissions were lower in 2019 for all pollutants except sulphur dioxide, with emissions of carbon monoxide down 47 percent (by more than 85,000 tonnes) and nitrogen oxides down 12 percent (by more than 8,000 tonnes). ▶ Emissions from electricity generation were lower in 2019 across all pollutants. Most notably, sulphur dioxide emissions decreased by 40 percent (by more than 5,000 tonnes) due to lower emissions from coal burning.

Figure 11: Sources of air pollution emissions, 2012–19



Data source: Stats NZ

Find out more

See indicator: **Air pollutant emissions**

Health impacts of air pollution

Air pollution causes a wide range of health impacts. There are numerous international studies on the effects that air pollutants can have on human health, but few studies have measured the health impacts in Aotearoa New Zealand. One New Zealand-based study found that living in a neighbourhood with a higher density of wood burners was associated with an increased risk (28 percent) of non-accidental emergency department visits in children younger than three years old (Lai et al, 2017).

MEASUREMENT AND ASSESSMENT

Due to the difficulty of separating air pollution effects from other causes, modelling is commonly used to estimate health impacts from air pollution. This indicator uses a modelling methodology informed by the Health and Air Pollution in New Zealand (HAPINZ) (2012) study, which was developed in accordance with international best practice (Kuschel et al, 2012).

Note: We are anticipating that this indicator will be updated soon, pending an update to the model. Updated information will be available on the Stats NZ website. This indicator used PM_{10} as a proxy for all air pollution in New Zealand but the revision currently underway will report on $PM_{2.5}$ and nitrogen dioxide.

KEY FINDINGS

From modelling based on the current Health and Air Pollution in New Zealand (HAPINZ) model (table 2):

- Premature deaths in adults of 30 years or older linked to exposure to human-generated PM_{10} were estimated to be eight percent lower in 2016 than in 2006 (27 deaths per 100,000 people, compared to 29 in 2006).
- Total hospital admissions due to human-generated PM_{10} were estimated to be two percent lower in 2016 than in 2006 (14 admissions per 10,000 people compared to 15 in 2006).
  - For cardiac illness, admissions were estimated to be 11 percent lower (five per 100,000 people compared to six in 2006).
  - For respiratory illness, admissions were estimated to be four percent higher in 2016 than in 2006 (noting that rounding makes the admissions total the same: nine admissions per 100,000 people in both years).
- Restricted activity days, when symptoms were sufficient to prevent usual activities such as work or study, were estimated to be 12 percent lower in 2016 than 2006 (31,800 per 100,000 people compared to 36,300 in 2006).

It should be noted that the improvement in health effects from air pollution demonstrated by the data above appears to be largely due to more people living in areas with lower PM_{10} concentrations, such as Auckland, rather than a reduction in PM_{10} levels overall. While concentrations have decreased markedly in some other areas, these make only a minor contribution to health impacts calculations because of the smaller populations that are exposed.

Table 2: Modelled health effects from exposure to human-generated PM_{10} in 2006 and 2016.

		Number of cases per 100,000 people	
Health effect		**2006**	**2016**
Premature mortality (adults 30+)		29	27
Hospital admissions	**Cardiac hospital admissions**	6	5
	Respiratory hospital admissions	9	9
	Total hospital admissions	15	14
Restricted activity days		36,300	31,800

Source: HAPINZ Exposure Model (Kuschel et al, 2012), Emission Impossible Ltd

Find out more

See indicator: **Health impacts of PM_{10}**

Towards a better understanding of our air

This section provides an overview of developments underway to improve understanding of the impacts of air pollution on health and the environment.

Air quality monitoring station, Woolston, Christchurch.
Photo: Isaac Bain, Ministry for the Environment

Access to clean air is essential to health and wellbeing. But in New Zealand there are times and places when the air does not meet air quality standards or guidelines.

When air quality is poor, this can affect health, lifestyles, and natural ecosystems. The elderly, young people, and those suffering from existing health conditions are especially vulnerable to poor air quality. An improved understanding of both the state of New Zealand's air and the links to human health and environmental impacts can help decision-makers better manage these impacts.

As noted in the introduction, updated global air quality guidelines based on a new synthesis of health impacts of exposure to air pollution were published by the World Health Organization in September 2021. In most cases, guideline thresholds have been made more stringent from the previous 2005 ones, reflecting the growing evidence that air pollution can affect health even at low levels, and that for some pollutants there is likely no safe level of exposure (WHO 2021).

The analysis in this report, coupled with improved information about the health impacts of air pollution, demonstrates that, in some locations and some times of year, New Zealanders may be at risk of harm to their health from the air they breathe. This information is especially crucial for those of us that live or work near air pollution 'hotspots' outlined in this report.

Monitoring

The most significant gap in understanding air quality in New Zealand relates to its monitoring. Currently, monitoring of air pollutants is limited in its coverage over space and time. Monitoring is generally only undertaken where significant air-quality risks have already been identified. A lack of a comprehensive national monitoring network limits our understanding of air quality variations within and between regions and airsheds, populations (eg city, suburban, rural), land uses (eg residential, commercial, industrial, agricultural, natural), as well as how it might change over time.

The lack of comprehensive air-quality monitoring coverage means there is also only limited data about the state and impact of air pollutants on natural ecosystems and biodiversity in New Zealand. In addition, current monitoring is limited to outdoor air quality information, yet New Zealanders spend up to 90 percent of their time indoors.

Finally, better data are needed on key air emission sources including hazardous industry emissions, such as benzene, methyl bromide, dioxins, and heavy metals. New Zealand is the only country in the OECD (Organisation for Economic Co-operation and Development) without a pollutant release and tracking register.

Making the link to impacts

Updated information on health impacts and social costs from air pollution, utilising more recent New Zealand-specific health, population, and air-quality monitoring data, is under development. This update to the Health and Air Pollution in New Zealand model considers the effect of three pollutants, including $PM_{2.5}$ and nitrogen dioxide along with PM_{10}. This work is critical to understanding the link between poor air quality and human health for New Zealanders.

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