UNIVERSITY OF BIRMINGHAM

COVID-19 briefing series

Air quality in the West Midlands: impacts of COVID-19 restrictions, March-May 2020

MAY 2020

Executive summary

- Levels of nitrogen dioxide (NO_2) have fallen significantly in most urban regions. The data shows that that future policies to reduce vehicle emissions in individual cities, whether through lowered traffic levels or switches to cleaner vehicles, will reduce NO_2 levels.
- Changes in particulate matter (PM) levels are less directly apparent in the data we have at the moment and will require longer term analyses to quantify. This reflects the wider range of PM sources and the importance of regional, as well as local, emissions. Future reductions in PM will require coordinated, regional approaches across a range of sectors.
- Living in areas with poor air quality leads to chronic and acute health conditions. It is plausible that these increase susceptibility to Covid-19; however, the magnitude of this effect is not yet known.

Background

Air quality has received much attention since the onset of the Covid-19 pandemic, and changes in behaviour and economic activity over the past two months. Here we briefly summarise:

1. Background: what we would expect to see
2. Observed changes in air quality and their drivers
3. Implications for clean air policy and human health

There are a number of air pollutants which are known to harm human and environmental health, but the two of particular focus for the region are nitrogen dioxide gas (NO_2), and particulate matter, fine particles suspended in the air - particularly $PM_{2.5}$ (particles less than 2.5 micrometres in diameter, small enough to pass into our lungs). The key sources of NO_2 in the UK overall are high temperature combustion processes – from vehicle exhaust, power generation and heating; levels are usually higher in cities (due to the concentration of road traffic, which is the dominant source in urban areas). NO_2 levels in some urban areas of the West Midlands exceed UK air quality objectives. PM has a wider range of sources, including combustion, power generation, industry, agriculture, vegetation, heating, cooking and transportation, and a significant fraction of $PM_{2.5}$ are formed in the atmosphere. Accordingly, levels are elevated in cities, where emission sources are most concentrated, but to a lesser extent than for NO_2.

Carbon Dioxide emissions – CO_2 – are also associated with combustion sources (power generation, industry, transport) but unlike NO_2 and $PM_{2.5}$, last much longer in the atmosphere (many years, compared with hours/days). This means that CO_2 levels mix around the globe, while NO_2 and $PM_{2.5}$ are higher close to source regions and individual cities - and so local/regional changes directly affect local NO_2 and $PM_{2.5}$ levels. We do not consider CO_2, or other air pollutants – ozone, ultrafine particles, black carbon (soot) etc – further in this summary note.

COVID-19 drivers of air quality change

The Covid-19 outbreak and associated lockdown measures have caused reductions in economic activity, manufacturing, consumption, power demand and transportation. We would expect these to be associated with reductions in *emissions* of NO_2 and of $PM_{2.5}$, but the change in *the levels in air* will also depend on:

- the relative importance of different sources to levels at the location of interest, and how these have changed with lockdown etc. A roadside monitoring site on a major road will show a bigger response to traffic changes than a rural location away from busy roads.
- the weather, which affects (i) where our air comes from (e.g. Europe or the Arctic or the Atlantic), and hence levels of PM and NO_2 transported to the region from elsewhere (background levels), (ii) the mixing and dispersion of local emissions – greater

if it is windier, and (iii) if a measurement site is upwind, or downwind, of a local source (such as the nearest road) – depending on wind direction.

- other atmospheric processing, for example reactions which lead to production of PM in the air, or to the removal of NO_2. Nitrogen oxides are removed from the air by chemical processing on a timescale of 12-24 hours, while $PM_{2.5}$ persist for several days.

Behaviour changes

Levels of road traffic – the key source of NO_2 in urban centres across the West Midlands – were roughly 30% of normal levels in early April. Mean speeds were higher, by around 20% overall on roads around Birmingham, and journey times were much more consistent (due to the absence of congestion – the differences were most pronounced around evening rush hour). Wider economic activity was reduced.

The weather has been typically variable: February 2020 was the windiest Feb for several years (recall storms George, Ciara, Dennis), while we have also enjoyed several weeks of fine weather in late March / early April, and early May.

Observed changes

The combined impact of these changes is hard to see in the measured air pollution data – Figure 1 below shows NO_2 levels from Birmingham across March and April – it is relatively hard to see where the lockdown began (officially, 23 March), and day-to-day weather drives much of the variability. This highlights that it is important not to over-interpret an immediate change from one week to the next, which can reflect either emissions changes or weather changes.

We get a clearer picture by averaging more data together – this tends to average out the weather variability, to a greater extent the more data we have – but is not perfect. In Figures 2 and 3 we compare levels of NO_2 and $PM_{2.5}$ for locations around the West Midlands averaged over the lockdown period to date (23 March to 11 May) with the average of the equivalent measurements for 2017-2019 [see appendix for data from more West Midlands locations].

There is a clear reduction in NO_2 levels, particularly around the middle of the day; the difference is least in the middle of the night (when there is little traffic normally in any case). The left panel of

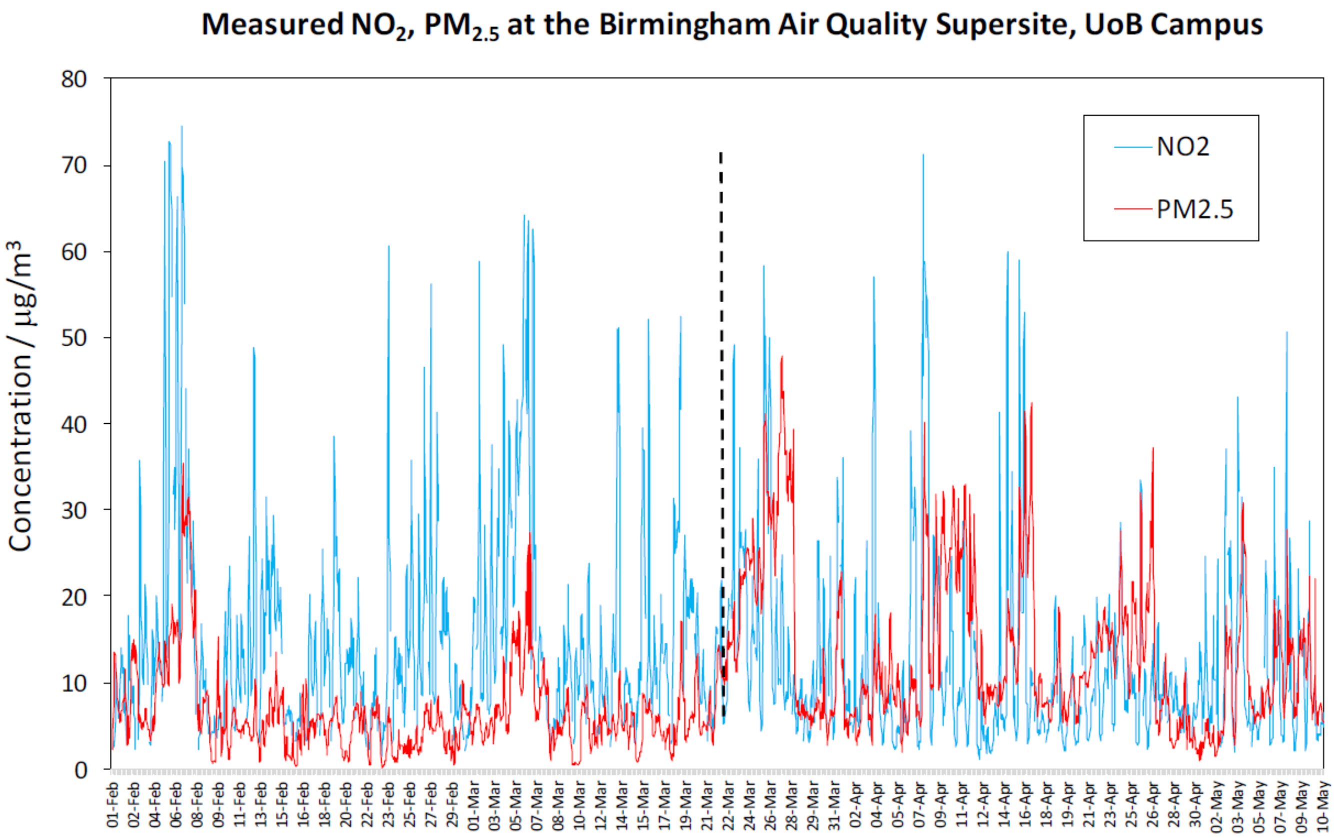

Figure 1: NO_2 (blue) and $PM_{2.5}$ (orange) levels at the ***Birmingham Air Quality Supersite****, on the University of Birmingham campus in Edgbaston, from Feb-May 2020. Dashed line indicates start of the principal restricted period (23 March)*

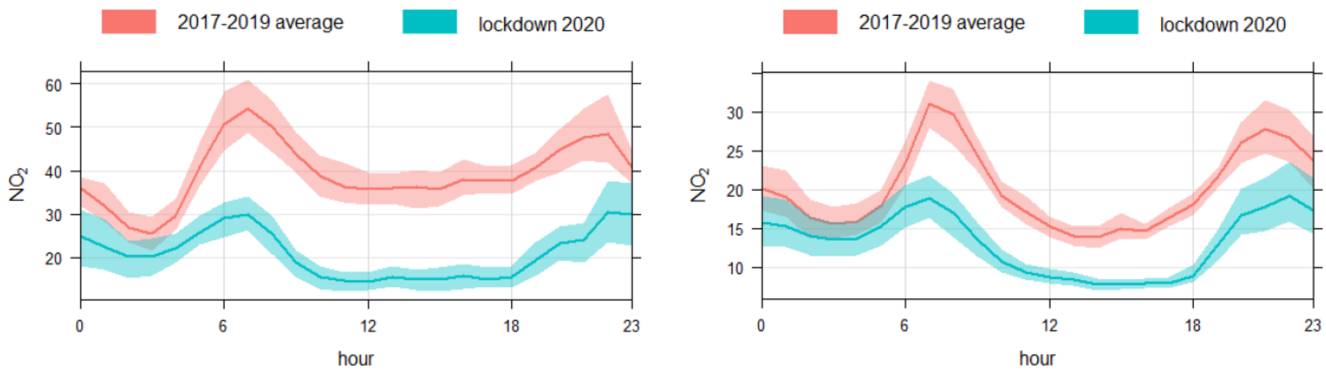

*Figure 2: NO_2 levels observed at the **Birmingham A4540 Roadside** (left) and **Birmingham Acocks Green** (right) monitoring stations during the lockdown period compared with previous years. Note different y axis scales. Red data: average of 23 March-10 May from 2017 – 2019. Green data: average of measurements from 23 March – 10 May 2020.*

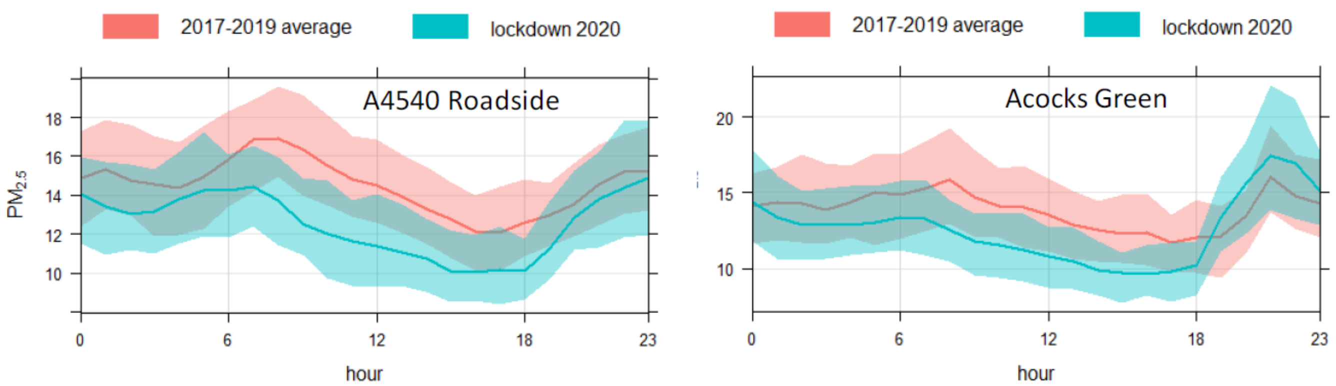

*Figure 3: $PM_{2.5}$ levels observed at the **Birmingham A4540 Roadside** (left) and **Birmingham Acocks Green** (right) monitoring stations during the lockdown period compared with previous years. Red data: average of 23 March-10 May from 2017 – 2019). Green data: average of measurements from 23 March – 10 May 2020*

Figure 2 above shows a roadside location with a big response to traffic; smaller but still significant changes in NO_2 are seen for the background (Acocks Green) location, which may be more typical of the levels most residents are exposed to – see Appendix for the equivalent plots for more locations.

For particulate matter (PM) the situation from measured data is shown in Figure 3 above – the data show a reduction in the levels of $PM_{2.5}$ during the 2020 lockdown period compared with previous years, but a smaller change than is seem for NO_2.

This reflects the much wider range of PM sources – not all of which will have changed (reduced) with the Covid-19 changes in behaviour – and the importance of long-range transport (where specific meteorological episodes bring more polluted air from elsewhere to the region) and atmospheric processing to the measured $PM_{2.5}$ abundance.

These have a greater impact upon PM levels than upon NO_2, as PM lasts longer in the atmosphere; unpicking the impact of local emissions changes will require more detailed analyses (currently ongoing).

A more sophisticated analysis can correct for the impact of meteorology by **deweathering the air quality data**. In this approach, the relationship between air quality and weather at a particular location is derived from previous years through a machine learning approach, and is then used to predict air quality during a "business as usual" 2020 – providing a benchmark for comparison with the observed levels.

This methodology has been applied by our group to quantify the success of air pollution control policies in Beijing, (Vu et al., Atmos. Chem. Phys. 19, 11303, 2019). Figure 4 below shows this analysis for NO_2; the observed levels (red line) are similar to the "BAU prediction" (blue line) before the lockdown is enacted, but are lower than BAU levels during the lockdown period – showing that NO_2 concentrations were reduced after the lockdown, above and beyond changes due to changes in the weather.

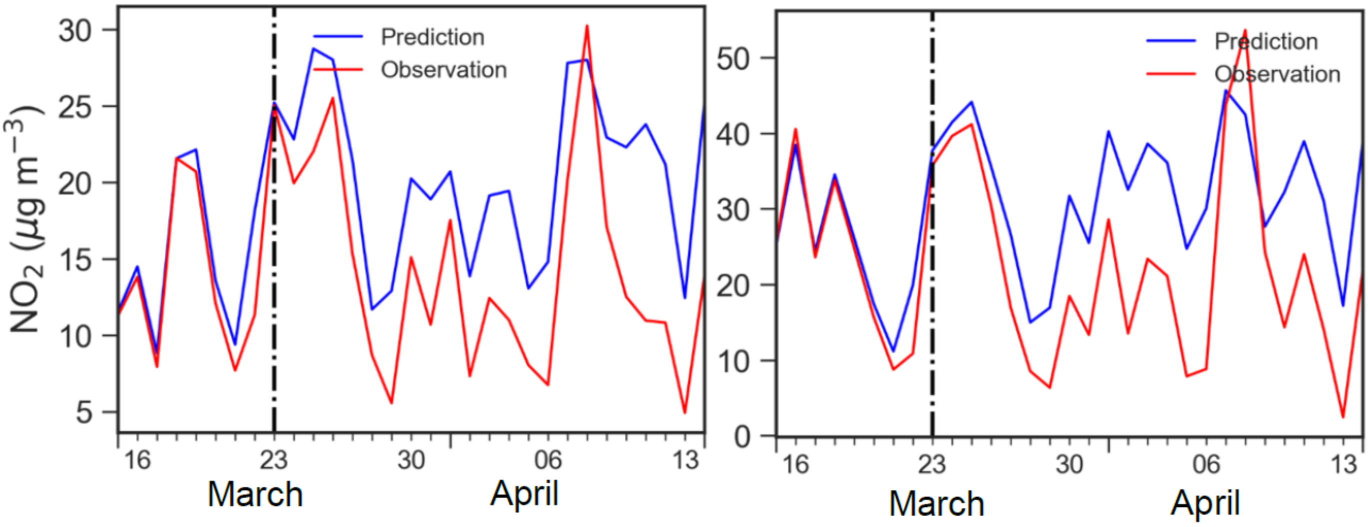

*Figure 4: NO_2 levels for **Birmingham urban background** (left) and **roadside** (right) sites. Red – actual observed levels during 2020. Blue – deweathering analysis prediction for 2020 meteorology, trained with previous years air quality & weather data. Vertical line shows 23 March (formal lockdown) point.*

Implications for Clean Air Science

Changes in behaviour and economic activity arising from the Covid-19 outbreak have improved air quality in some aspects – nitrogen dioxide (NO_2) levels have fallen significantly in most urban regions, driven by the change in emissions. Changes in PM levels are less directly apparent in the data, and will require longer term analyses to quantify – reflecting the wider range of PM sources, and importance of regional, as well as local, emissions.

The weather remains a key factor affecting public perceptions of clean air, and must be taken into account in analyses of measured levels. The changes observed give confidence that future policies to reduce vehicle emissions in individual cities – whether through lowered traffic levels or switches to cleaner vehicles – will reduce NO_2 levels. Maximising reductions in PM will require coordinated, regional approaches across a wider range of emissions sources / sectors.

What about Air Quality and Covid-19 incidence / cases?

Most of the sources NO_2 are co-located with major areas of population, i.e. towns and cities – where traffic density is greatest and industry is located. We would expect population centres to have higher numbers of Covid-19 cases, and, due to a number of factors, higher rates of infection per unit population – so seeing a spatial correlation of Covid-19 cases and air pollution is not, on the face of it, surprising and does not on its own imply any causation.

The question is, is there a relationship after we adjust for population density, industrial activity, levels of behaviour change during lockdown, and demographic factors – an analysis which will be highly complex and cannot yet be easily undertaken.

Can Air Quality affect Susceptibility to Covid-19?

This is a critical area of current research, and is hard to answer with certainty. We know that the Covid-19 virus can be transmitted through physical contact, through surfaces and through the air – but the main airborne vector from an infected person will be (relatively large) liquid droplets from coughing / breathing, so air pollution is unlikely to significantly affect transmission of the virus outdoors. However, air pollution increases the occurrence of a range of adverse health outcomes – including those affecting the respiratory and cardiovascular systems, and with mechanisms that affect the function of our airways and inflammation of lung cells. It is plausible that living in areas with poor air quality leads to chronic or acute health conditions, and that these increase susceptibility to Covid-19. The magnitude of this effect is not yet known.

University of Birmingham Clean Air Research

We are analysing air pollution data to quantify the changes in air quality associated with the Covid-19 outbreak and lockdown, in the UK and globally. In the West Midlands, this combines data from DEFRA and Local Authority monitoring stations, and from the Birmingham Air Quality Supersite on the University campus. Analysis will quantify the changes in air quality due to changes in economic activity and behaviour (e.g. traffic vs industry vs woodsmoke) during the lockdown and relaxation period. Levels of ultrafine particles, which are thought to drive many of the health effects, may show bigger changes during lockdown. We are working with colleagues in the Medical School to assess potential changes in health linked to air quality changes during the outbreak. We can use the changes observed during lockdown to assess the likely impacts of policies such as Clean Air Zones, and potential changes in travel behaviour in the future, on local NO_2 and PM levels. More widely, we are taking an interdisciplinary systems approach to develop options for air pollution reduction in developing nations, including China, India, Chile and three countries in east Africa. The WM-Air project is a NERC funded initiative, led by the University of Birmingham, to apply environmental science expertise to support improvement of air quality and health across the West Midlands.

Note on data sources

The data shown here are from the University of Birmingham Supersite, and the DEFRA Automatic Urban & Regional Network (AURN) monitors. All measurements are from non-ratified data – a quality control process typically performed over the 3-6 months following the data collection period, and there are some data gaps. Nonetheless, we do not expect significant changes in the data shown. For more information see https://uk-air.defra.gov.uk/

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Appendix: Comparison of measured levels from other West Midlands air quality stations

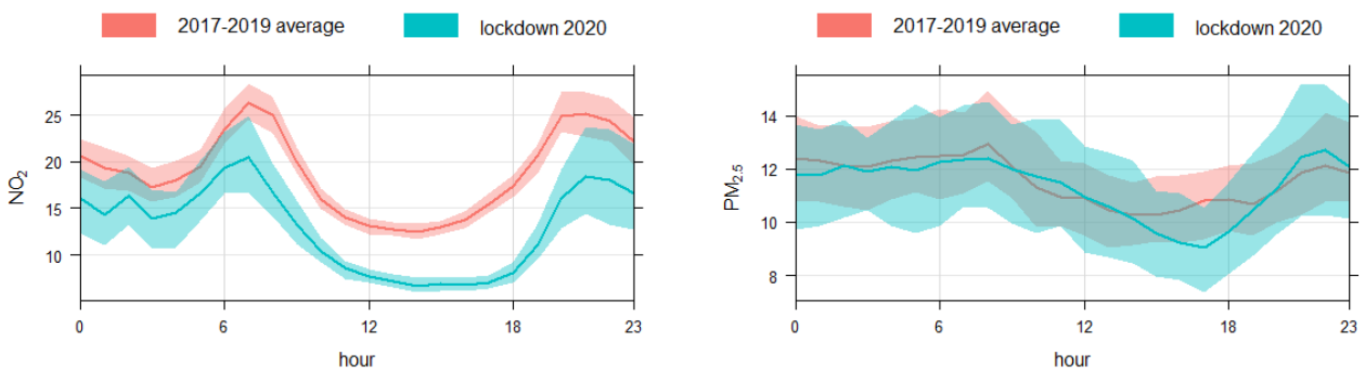

*Figure 5: NO_2 and $PM_{2.5}$ levels observed at the **Coventry Allesley** station during the lockdown period compared with previous years. Red data: average of 23 March-10 May from 2017 – 2019). Green data: average of measurements from 23 March – 10 May 2020*

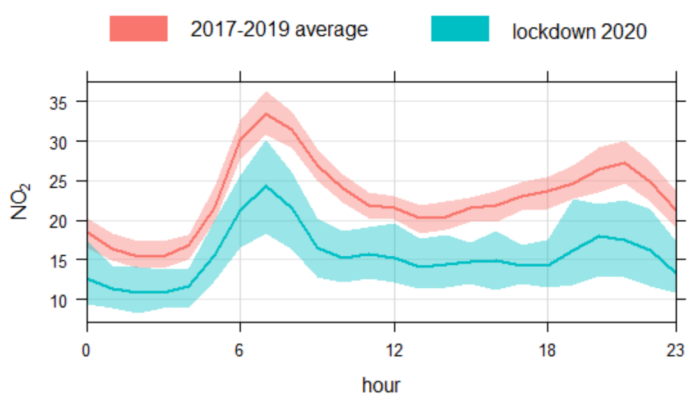

*Figure 6: NO_2 levels observed at the **Cannock roadside** station during the lockdown period compared with previous years. Red data: average of 23 March-10 May from 2017 – 2019). Green data: average of measurements from 23 March – 10 May 2020*

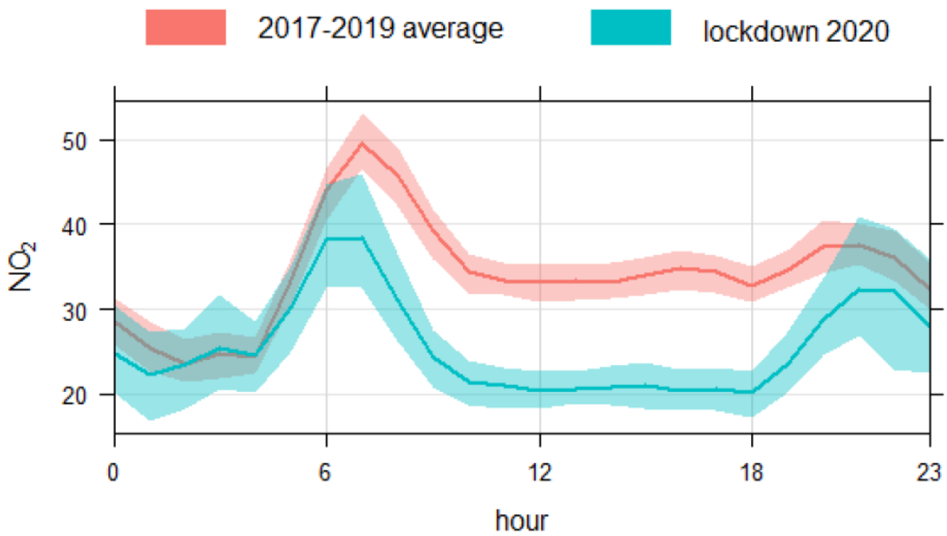

Figure 7: NO_2 levels observed at the ***Oldbury*** *monitoring station during the lockdown period compared with previous years. Red data: average of 23 March-10 May from 2017 – 2019). Green data: average of measurements from 23 March – 10 May 2020*