The Coronavirus, Immissions and the Combustion Engine

The coronavirus pandemic is providing unique experimental data not only for researchers but also for politicians with responsibility for the environment and transport. The lockdown measures resulted in a sudden and dramatic fall in the volume of personal and freight transport and a halving of the traffic peaks. We could have been justified in thinking that levels of air pollution in the form of carbon dioxide, nitrogen oxides and particulate matter should also have fallen. But there is no clear evidence that this is the case for nitrogen oxides and particulates.

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EMISSION REDUCTION NOT UNIFORM

A wide variety of measurement data was produced during the coronavirus crisis, some of it highly contradictory. However, we can draw some logical conclusions from it. In certain areas carbon dioxide emissions have fallen dramatically. Where smaller quantities of hydrocarbons have been burnt, less of their combustion product carbon dioxide has been produced. “In general terms we can say that if there were no more combustion engines, the air quality would improve significantly. If we reduce our diesel use by 1000 l, carbon dioxide emissions will fall by almost exactly 2650 kg. But we can’t apply the same equation to Nitrogen Oxides (NO_x) and particulate matter. The mechanisms that lead to the formation of these pollutants are highly complex and depend on a large number of factors. For example, if there were less traffic, the streets would be less congested and the vehicles would be able to travel much more quickly. The emissions they produced would then be quite different to the type of emissions at walking pace,” explains Dr.-Ing. Gennadi Zikoridse, Professor of Automotive and Powertrain Engineering at Dresden University of Applied Sciences.

The harm that NO_x and particulate matter cause to the environment and to human health is undisputed. Examples include an increase in respiratory diseases, damage to ecosystems caused by acid rain that is a consequence of sulfur dioxide emissions, and the acceleration of climate change triggered by emissions of greenhouse gases [1]. Motorized road transport produces air pollutants such as nitrogen dioxide and particulate matter, greenhouse gases such as carbon dioxide and methane and also noise, which means that it presents a risk to the health of the population and reduces people’s quality of life [2].

HUMANS ARE RESPONSIBLE FOR PARTICULATES AND NO_x

“The sources are clearly anthropogenic,” says Zikoridse. Particulate matter is also generated by volcanoes. In addition, pollen and spores can be included in the category of particulates. But in cities particulate matter is mainly the result of human activities. According to experts, the main culprits in the transport sector are diesel engines and gasoline engines with direct injection, plus dust from brakes, tires and road surfaces. Other causes include industrial plants that use combustion processes and heating systems, in particular those that burn solid fuels such as wood. According to the German Environment Agency (UBA), in 2002 the transport sector was responsible for around

50 % of the PM10 particulates in our inner cities. This includes the dust stirred up by traffic and wear debris from tires and brakes. By 2017 the Environment Agency calculated that traffic only produced 21 %. Because of the introduction of particulate filters for diesels and, since September 2017 (Euro 6d Temp), also for gasoline engines with direct injection, this source of emissions has been reduced once again by more than 90 %.

The situation is quite different in the case of NO_x. Around 90 % of the NO_x in the middle and upper troposphere of our atmosphere is produced by lightning strikes and has little impact on air quality. The main sources of NO_x in the lower troposphere are the combustion of fuel in road vehicles and in industrial plants and heating systems burning fossil energy carriers like coal, oil and natural gas as well as wood and waste. In large urban areas, NO_x (NO and NO₂) are primarily a product of combustion processes, which are responsible for up to 75 % of the emissions.

According to Zikoridse, one of the key factors that influences the measurements is the location of the measurement stations. One of the most famous pollution measurement units in Germany, on the Neckartor intersection in the center of Stuttgart, is heavily affected by the bowl-shaped valley that the city is

located in and the average of 60,000 cars that pass it each day. The measurements are also influenced by two combined heat and power plants in the vicinity.

“I wouldn’t go so far as to say that the measurement stations are not correctly positioned. But in many places they are too close to the sources or the rules on positioning them have been interpreted too narrowly,” explains Zikoridse. The legal basis for this is the EU directive 2008/50/EC on ambient air quality and its amending directive 2015/1480/EC. These state that traffic-orientated measurement stations must be no more than 10 m from the curbside and at least 25 m from major intersections. In addition, obstructions such as buildings, trees and balconies must be taken into account. “If you make the measurement 2 m further away from the edge of the road, the emissions are 10 to 20 % lower. This is why it is important to take into consideration all the factors that influence the correct recording of pollutant emissions when setting up a measuring station,” he continues.

Of course, some measuring stations have seen a fall in the levels of these emissions since mid March 2020, but others have registered a rise or have recorded figures that remain unchanged. This means that traffic is not responsible for particulate matter and NO_x to the extent previously suspected.

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Gennadi Zikoridse sees no link between the coronavirus and the changes in NO_x emissions

MEASURING STATIONS ARE HEAVILY DEPENDENT ON THE WEATHER

One cause is the fact that the fixed measuring stations are not particularly representative and are heavily dependent on the weather. In some cases they are in locations where high measurements occur naturally, for example in valleys. In addition, they do not measure in real time, but instead accumulate the measurements over a certain period of time. Another factor is the different types of model. The data is recorded on the basis of either the vector or the grid method. The two models are not in competition with one another – we need to use both [3].

The vector model is more accurate and is particularly suitable for surveying and land registry purposes, and for large-scale studies. The emissions from individual groups of emitters, such as domestic heating systems, small businesses or power plants, can be estimated and stored in a geoinformation system on a vector basis with very different spatial references [4]. By contrast, the grid model is ideal for small-scale applications. It allows for greater precision when measuring individual items of data. If you need to record the emissions and then compare them with one another and with other areas, a combination of both methods is required.

Another cause of the lower measurements is the developments made to the

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Modern engine technology has resulted in continuous falls in particulate and NO_x emissions over a period of years; this picture shows a test rig at Dresden University of Applied Sciences

cars themselves. “The differences between diesel cars that comply with the latest emissions standards, such as Euro 6d, and Euro 5 diesel models are very significant, particularly in the case of nitrogen oxides,” comments Zikoridse. The latest combustion engines with improved exhaust gas treatment systems comply with all the pollutant limits.

NO_x IS CONSTANTLY FALLING

This correlates with the data from the German Environment Agency for 2019. The air quality threshold of 40 µg of nitrogen dioxide per cubic meter of air was only exceeded in 25 German cities. The year before the figure was 57, more than twice as many. “Because of the

nature of the data, it is not possible to say that the coronavirus pandemic has had an influence on nitrogen oxide emissions. Anyone who claims that banning Euro 5 cars will improve air quality is in for a big surprise,” says Zikoridse.

The same is clear from the long-term measurement series, which have shown slight reductions in emissions at the measurement stations over a period of years. One good example of this is Berlin. All the inner-city measurement stations recorded continuous falls in NO_x emissions from 2015 to 2019. Only on the outskirts of the city and near the wooded areas of the city center did the figures remain the same or fall only slightly from an already very low level [5].

Apparent contradictions can be found not only in Berlin. In central Germany, MDR-Umschau, a program broadcast by the regional radio station Mitteldeutscher Rundfunk, reported an average of the data recorded by more than 100 traffic-orientated air measuring stations from March 22, 2020 onward, for example on Paracelsusstraße in Halle an der Saale and on Bergstraße in Erfurt. The results were clear. Despite the reduction in traffic, the air contained more particulate matter and only slightly less NO_x. Even Environmental Action Germany (DUH), one of the leading organizations calling for traffic bans, had to admit that wood-burning stoves played a major role in the figures as a result of the cool weather.

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Jörg Kachelmann,
founder of the meteorological service provider the Kachelmann Group and the kachelmannwetter.com website.

2 QUESTIONS FOR ...

What type of weather conditions influence the amount of particulate matter and NO_x emissions?

KACHELMANN _ If you listen to the discussions currently going on, you could start to believe that Germany is the global center of superstition. The weather during the coronavirus lockdown was ultimately determined by continental high pressure, which automatically makes the sky look bluer. This is not because there are fewer cars on the roads or aircraft overhead. The main driving force behind nitrogen oxides and particulate matter is meteorology. It is not possible to compare May 2020 with May 2019 because the weather conditions were different. The cause of the increase in particulates is wood-burning stoves and there are now 15 million of them in Germany. We can clearly see how the particulate matter and nitrogen oxide levels are changing depending on the time of day. In the past the peak figures were recorded during the morning and evening rush hours, but at more and more stations these peaks now occur at around 10 PM on Friday and Saturday evenings. And the measuring stations are mostly located at road intersections and not near residential areas. It is touching to see how everyone goes on believing that cars are responsible for the pollution. Anyone who has a sense of smell can tell what

the cause of the problem is in residential neighborhoods. In the evenings the air smells dreadful in German cities and this is due to the wood-burning stoves. The particulate matter concentrations are the same as those in China in the very places where people live and are breathing the air for hours at a time.

Is it possible to draw any conclusions about whether the air quality has changed during the coronavirus lockdown as a result of the reduction in traffic?

KACHELMANN _ We can come to some conclusions if we only look at the days when the emission dispersal levels are low. We need the authorities to investigate the data, but I do not think they will come up with anything positive in relation to the current policy. As a general principle, it is good to keep cars out of city centers and create pedestrian zones. However, attempts are now being made to use the measurements for political purposes, because things are going well. But it is not true to say that traffic is responsible to a significant extent. A comprehensive ban on wood-burning stoves would produce better results. We would be very unlikely to exceed the thresholds, including those for nitrogen oxides. This is why the figures are rarely above the limits in summer, because none of the wood-burners are lit.

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Natural causes such as the forest fires in Spain and Portugal in October 2017 cause increased cloud formation in Germany because of particulate matter

If we really want to use the lockdown period for comparison purposes, so that we can prove whether or not traffic is the main cause of emissions, we will need to compare the data for several years. In addition, the weather must be similar in the seasons in question.

Another look at the weather will help with interpreting the data we already have. February and early March 2020 were characterized by deep Atlantic lows which are not unusual at this time of year. Weather conditions of this kind involve a lot of precipitation and this is why the month of February was one of the wettest for some time. Low particulate matter figures are typical in rainy weather, because particles are pulled down to the ground and trapped in the drops of rain, which use them as condensation nuclei. In April by contrast, high pressure brought sunny and largely dry weather that led to an “increase” in particulates. This explains at least part of the rise in particulate pollution.

DRIVING BANS TO REMAIN IN PLACE

It is unlikely that the many driving bans will be changed. The German Federal Ministry for the Environment sees no need to amend the current regulations on air quality in cities. “This situation has made it clear that the cause of par-

ticulate matter pollution is not traffic and possibly not even industry. Instead it has natural causes,” says Matthias Klingner, Professor at the Fraunhofer Institute for Transportation and Infrastructure Systems, summing up the measurement results.

But it was the particulate matter in particular that was once used to justify the driving bans and linked to diesel cars. Since the diesel scandal and the

related discussion about particulates, the air in our cities has become a symbol of our care for the environment [6].

THE ARGUMENTS OF THE GERMAN ENVIRONMENT AGENCY ARE NOT CONVINCING

The lower figures for particulate matter and NO_x during the coronavirus crisis are genuine. The Environment Agency

In March and April 2020, air quality measuring stations showed no clear connection between the reduction in traffic volumes and falling emissions

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concedes that: "Assessments carried out by the German federal states show that the lockdown has had no or only minor positive effects on particulate matter concentrations, which confirms that road traffic is no longer the main cause."

How can we make a comparison of particulate levels? Researchers from the Leibniz Institute for Tropospheric Research in Leipzig have been operating a measurement station in the town of Melpitz bei Torgau (both Germany) which is well away from all traffic and which records natural particulate matter caused by plants or by weathering of rocks. The same rises and falls in the levels as a result of changes in the weather that we saw in the emissions in the spring of 2020 have been recorded there for years. A measuring station in the center of Leipzig is used for comparison purposes and this registers particulate emissions produced by natural sources and by cars. The rises and falls here are very similar, which makes it clear that vehicle traffic has a minor impact on particulate pollution.

Alfred Wiedensohler from the Leibniz Institute for Tropospheric Research attributes this to the improvements in engine design and, in particular, to particulate filters and the new gasoline engines with direct injection. A statement that he issued jointly with his colleagues says: "Reduced emissions during the Covid-19 lockdown do not automatically lead to lower levels of pollution, as a number of different complex factors influence pollutant concentrations in the air."

In the MDR radio program referred to above, Joachim Pfeiffer, the spokesperson on business and energy policy for the CDU/CSU party in the German parliament, came to a drastic conclusion: "Accusing these vehicles of being responsible for 80 % of the NO_x pollution is outrageous. In my view this has been comprehensively disproved. This is why I believe the existing driving bans should be lifted and there should be no new bans for Euro 5 cars under any circumstances."

CHANGING THRESHOLDS

For the traffic researcher Matthias Klingner, this is relevant from both a practical and a political perspective. His conclusion is that it is time an independent assessment of these data sets was carried out. We also

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need to negotiate with the European Commission and the European Parliament to have these thresholds abolished. Zikoridse agrees: “There are indications that the driving bans do not necessarily lead to an improvement in air quality. Despite a reduction in the amount of traffic, the pollutant emission levels have not fallen. This is due to the absolute variability of the factors, which do not allow any clear conclusions to be drawn. In addition, the other sources of emissions are very rarely taken into consideration and there are always background emissions.”

Following the driving bans for Euro 4 diesel cars that were introduced in Stuttgart in January 2019, the measurement stations showed higher nitrogen dioxide levels in February. When the ban was extended in April to include residents of Stuttgart, a further increase in NO₂ emissions was recorded in the following months.

Over recent years the air quality in our cities has continuously improved. This is not due primarily to driving bans, but to a range of factors that have a positive impact on pollution emissions. These include the introduction of new models with much more effective exhaust gas treatment systems, software updates for Euro 5 diesel cars and improvements in traffic management.

Some areas, for example around airports, have seen a significant drop in particulates during the coronavirus crisis, as shown by satellite images. The German Environment Agency also evaluated some fixed, traffic-orientated measuring stations. Here the NO_x figures fell when compared with the same period in the previous year, but not as much as might have been expected.

However, here too it is not possible to attribute the pollution only to combustion engines or jet engines, because industrial production fell during the same period, as did the use of domestic fuel when the weather became warmer. To put it in other words, the cause of greenhouse gas emissions is the burning of fossil fuels to provide energy in the form of electricity, heating or cooling. These emissions are not only caused by traffic [7].

The German Environment Agency also refers to the levels of NO_x emissions, which have fallen considerably, along with particulate matter. “During the lockdown, traffic levels in German cities fell by 30 to 50 %. During the same period, concentrations of nitrogen dioxide recorded by traffic-orientated measuring stations dropped by 15 to 40 %.”

To sum up, if we burn less fuel, then logically we also produce less emissions. It is the attribution of the amounts of pollution to different sources that is much less clear.

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WHAT DO WE THINK?

“Since the coronavirus lockdown, it has no longer been possible to assign the primary responsibility for higher particulate matter and NO_x immissions to combustion engines. Despite a considerable reduction in traffic levels, the figures recorded by many measuring stations increased, while at others they fell. Logically, they should have dropped everywhere in relation to the reduction in traffic. In fact, the weather plays a prominent role and domestic heating systems and industry are responsible for the emissions to a much greater extent than traffic. This means that driving bans are nonsensical.”

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