

# Are electric scooters the answer to improve air quality in cities?

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## ABSTRACT

There are 6 common types of air pollutants: particulate matter, ground-level ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide and lead. These particulates are said to be harmful to public health and can potentially cause lung cancer due to the toxic chemicals contained within them. The most damaging particulates are under PM<sub>10</sub> (diameter of under 10 micrometres) as these particulates can irritate the lungs and can cause people with previous respiratory and cardiac problems to be more likely to be admitted into hospital.

Recently a new legislation has come out which has made the e-scooter legal on roads in the UK to ease pressure on public transport amid the COVID 19 crisis however people have concerns over how safe e-scooters are for both the users and other members of the public as they can be dangerous if misused. One of these concerns is that at night the e-scooters may not be as visible which may lead to an increase in cars accidents. The scooters may be good for the environment but the factories used to produce them may produce more overall greenhouse emissions than if we just used regular bikes which leads the public to question if there is a need for e-scooters. Another problem is that they can only be used for shorter distances as traveling further would be inconvenient, also with so many other modes of transport why would people give this mode priority.

In regard to the public's concern to help make them safer the government has put rules and regulations in place such as not being allowed to use them on pavements as well as the speed limit being limited to 15.5mph. They also recommend that you wear a helmet when riding them for safety. Another advantage of having an e-scooter is that you won't need insurance to ride a scooter so it will be cheaper but you would require a licence before you could ride it to stop young children misusing them or using them dangerously.

This project looks at researching the growing use of electric scooters within cities and how they are impacting the overall air quality. It will investigate the advantages and disadvantages of this mode of transport and an online survey will be created to find out the public's opinion on this topic. It will be distributed online to the public and then the data will be analysed to form an overall public opinion. Also an air quality sensor will be built at home and the data gathered from it will be used to compare the rates of pollution across cities in the UK and globally.

From the research conducted it is seen that overall the public believe that e-scooters come at a higher cost than benefit to cities and that they believe there is a need to change our mode of transport for the betterment of the environment and overall health as it is agreed that air pollution can cause long term complications however the public don't necessarily believe that e-scooters are the best solution. E-scooters would need to be used by a large number of people and used to travel large distances in order to make an impact on air quality however that doesn't seem like a likely option and the design of having to stand on these scooters makes it more uncomfortable to travel further with them. There was also a lot of confusion with their safety and use as many people were concerned that they would still be misused on the pavements and could be more of a hazard to other road users.

E-bikes are another alternative mode of transport which can help to reduce air pollution but unlike e-scooters they are seen as safer to use by the public as there are already cycle lanes and laws in place; the government has also announced a £2 billion active travel fund to create pop-up bike lanes in cities and wider pavements. They are also a healthier/ active form of transport as you can pedal the bike if you wish therefore the e-bike helps both the environment and the users overall health. People are also more inclined to use these to travel longer distances, e.g. take them to school/ work therefore more people are willing to consider buying them.

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## 1. INTRODUCTION

This project is researching the current impacts of air quality both globally and locally and whether electric scooters are a possible alternative mode of transport which could help reduce the currently rapidly increasing air pollution levels.

Air pollution is a growing issue which is resulting in global warming and climate change. Over the past few years there has been a large increase in wildfires, floods, extreme heat waves etc which are felt globally as a result of global warming therefore countries all around the world are trying to reduce their air pollution levels. One method is the use of alternative modes of transport e.g. walking, cycling, using more public transport and the use of electric transport.

E-scooters are a new electric mode of transport which is used in other European countries and is being introduced to the UK as an alternative distanced form of transport due to the coronavirus pandemic. This is a current topic which has a lot of controversy around it therefore this project is aiming to see whether the benefits of e-scooters truly out way the costs.

## 2. Scope

The project looks at researching the growing use of electric scooters within cities and how they are impacting the overall air quality. It will be investigating the advantages and disadvantages of this mode of transport and presenting an overall conclusion which answers the research question 'Are electric scooters the answer to improve air quality in cities?'

An online survey will be created to find out the public's opinion on this topic e.g. how much they know about electric scooters and overall air quality. It will be distributed online to the public and then the data will be analysed to form an overall public opinion.

Also an air quality sensor will be built at home and the data gathered from it about Nottingham's air quality will be used to compare the rates of pollution across the UK and globally.

## 3. Background research

### 3.1 Types of air pollution

There are 6 common air pollutants: particulate matter, ground-level ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide and lead [1].

-Particulate matter (PM) is a mix between solids and liquids suspended in the air (eg carbon, complex organic chemicals, sulphates, nitrates, mineral dust, and water) and different types of PM vary in size. Some particles such as dust, soot, dirt or smoke are large/ dark enough to be seen but the most damaging particles are the smaller PM<sub>10</sub> and PM<sub>2.5</sub> particles. PM<sub>10</sub> refers to particles with a diameter smaller than 10 micrometres (10µm) and these particles can come from natural sources (e.g. volcanoes, pollen, soil) or manmade sources (eg diesel, petrol engines, industry) [2].

-NO<sub>2</sub> comes from man-made sources, e.g. power stations, heating, vehicles [2], cooking with gas (indoor) and high levels can be found near busy roadsides [3].

-Ozone is a gas composed of 3 atoms of oxygen in the upper level of the Earth's atmosphere and it absorbs harmful UV radiation. It is made by a chemical reaction between the sun's rays and organic gases/ oxides of nitrogen emitted by cars, power plants, chemical plants and other sources [2].

-SO<sub>2</sub> is highly reactive gas which is formed by fossil fuel combustion at power plants and other industrial facilities. Also some natural processes that release sulphur gases include decomposition and combustion of organic matter, spray from the sea, and volcanic eruptions [3].

### 3.2 Effect of particulates on our health

Air pollution is believed to cause lung cancer and respiratory conditions because we breathe in different sized particulate matter- larger particles can become trapped in your nose, PM<sub>10</sub> can reach your airways and fine particles (PM<sub>2.5</sub>) may reach the breathing sacs deep in your lungs.

These particles can also carry toxic chemicals that are linked to cancer and PM irritates your nose/ throat and may be associated with more severe symptoms in people with asthma. It results in more people with lung conditions (COPD, asthma, bronchitis) and heart conditions (heart attacks, strokes) being admitted to hospital. There is also evidence that long-term exposure to particulate matter can contribute to the development of lung cancer and possibly asthma [2].

People with previous lung/ heart conditions, children and elderly people are most at risk and exposure to harmful particles can cause:

- premature death in people with heart or lung disease
- nonfatal heart attacks
- irregular heartbeat
- aggravated asthma
- decreased lung function
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing. [7]

Indoor air pollution is also dangerous if you have a lung condition as you may spend more time indoors due to it therefore this means you need clean indoor air to breathe in. Indoor pollutants could include cigarette smoke, cleaning materials or mould [4].



The combined effects of ambient (outdoor) and household air pollution cause about seven million premature deaths every year- around 4.2 million deaths occur due to outdoor air pollution and 3.8 million due to indoor pollution every year. Around 91% of the world's population live in places where air quality levels exceed WHO limits and low/ middle-income countries are suffering from the highest exposures (both indoors and outdoors pollution) [15].

### 3.3 E-scooters

E-scooters are 2 wheeled electric scooters and a new legislation has been passed so rental e-scooters are becoming legal on roads in Great Britain in hopes to ease pressure on public transport amid the coronavirus crisis. The Department for Transport (DfT) has published a guidance for e-scooters for hire and the vehicles are banned on pavements (will be limited to 15.5mph) and it is recommended that riders wear helmets.

Some people are concerned that rental e-scooters will cause unnecessary travel obstructions and are hazardous because there have been close call cases where people have carelessly driven the scooters and almost hit pedestrians at crossings. Disability awareness campaigner Deborah Farley-Persaud believes they are "frightening because you can't hear them and you can't see them" and David Davies, executive director of PACTS is convinced that they will be used on pavements despite the regulation and the police don't have the time to regulate that behaviour. Therefore these e-scooters are hazardous for the general public especially for people who are registered as blind [8].

The safety of the use of these e-scooters by the general public is being questioned as people have seen parents delivering their children to school with the child standing at the front of the scooter and their parents steering. This is an easy way to get to places but it's not a safe way and many children treat them like toys and use them without any protection [9].

Scooters are only useful for short distance commutes of 1-3 miles however a healthier alternative would be to ride bikes instead. Bikes (or walking) are also a good form of physical activity and convenient to use as there are already cycle lanes and laws to use them safely. Researchers at North Carolina State University found that traveling by scooter produces more greenhouse gas emissions per mile than traveling by bus, bicycle, moped or on foot. While the scooters themselves were not particularly environmentally unfriendly, the materials it took to manufacture the frame, wheels and battery, as well as the companies' efforts at the end of each day to round up the scooters, charge them and then return them to the streets, had significant impact when it came to greenhouse gas emissions [14]. Scooters may be useful in some cities however in many urban cities there are already a range of modes of transport therefore e-scooter may only add more congestion to the traffic or obstruct the pavement. For example in Nottingham there are already cars, buses, trams, cycle lanes and a train station therefore there is no need to add e-scooters to the city as there would be no large benefit.

Alternatively, supporters of the vehicles say they are better for the environment than current alternatives because cars, busses etc produce lots of air pollution and leave a large carbon footprint. E-scooters would help people to travel around cities as lockdown restrictions are eased and the vehicles offer a convenient alternative to public transport as they are ridden out independently in the open air where there is less risk of coronavirus transmission and they produce less air pollution than current modes of transport (cars, buses, trams). People are excited to use scooters as they will help "reduce congestion which will improve people's commute and therefore quality of life" [8].

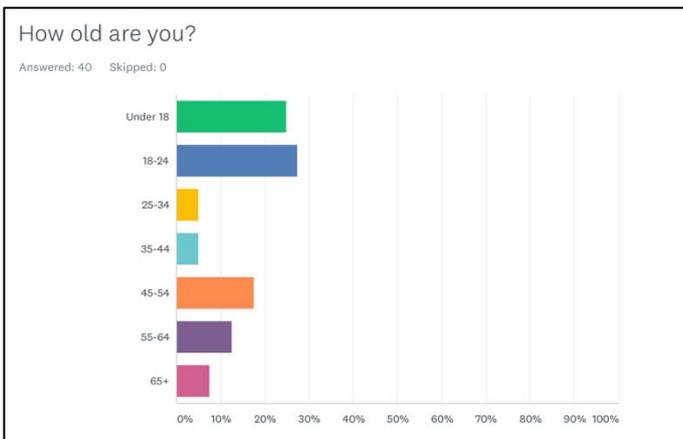


Also the government are suggesting that riders wouldn't need to take out their own insurance to hire an e-scooter but they would need a driving licence or at least provisional one to use an e-scooter in public [16]. This will help make the use of e-scooters safer as younger children won't be able to miss use them or play with them in public.

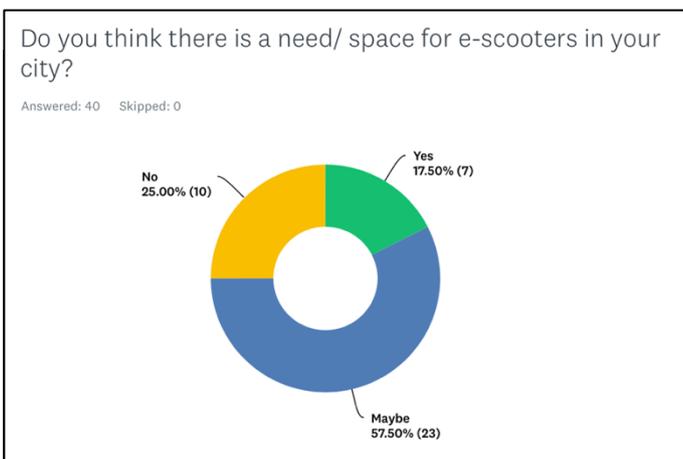
## 4. METHOD

### 4.1 Survey

For this project a survey was made and distributed out to various people in the public in order to get a large number of responses for primary research. Originally there was a broad range of questions which were too open to interpretation but in the end the survey sent out contained specific questions which related directly to the research topic and it was made sure that each person could only answer the survey once so that a range of unbiased answers/ data could be acquired. The survey was also anonymous so that more people would be likely to complete it ensuring that the maximum number of responses were gathered making the data more accurate.

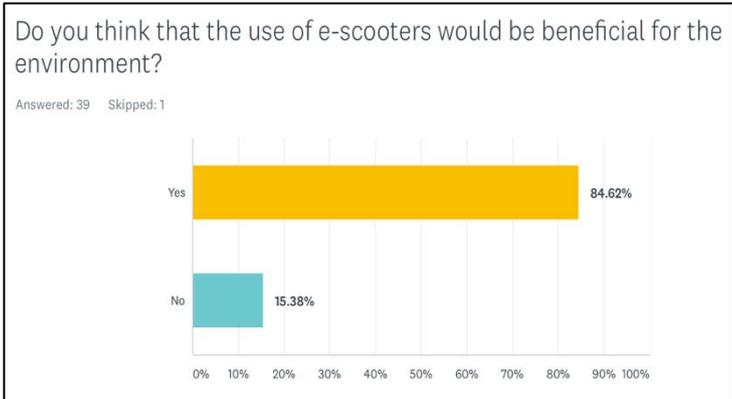


The survey contains responses from people of a range of ages therefore ensuring that the responses aren't biased to a view that 1 particular age group holds. Most of the respondents also had a medium amount of knowledge on the subject of air pollution and e-scooters therefore were able to properly respond to the survey as they had knowledge about the subject area.

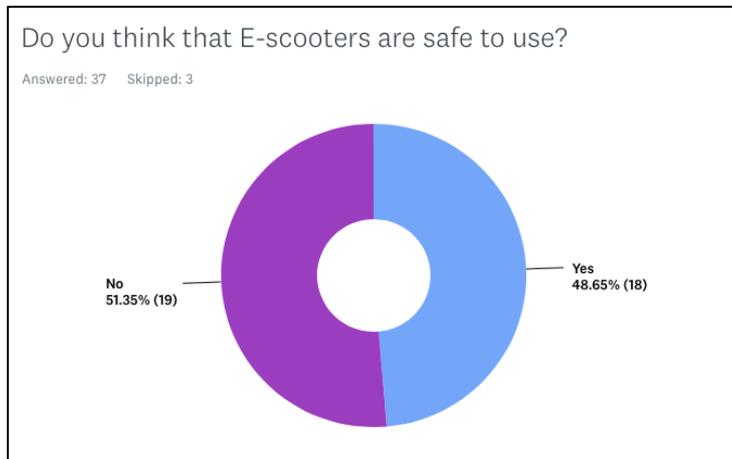


From the survey it was found that 35% of respondents would get an e-bike and 27.5% would consider getting a form of electric transport. This shows that e-bikes seem to be more popular than e-scooters and overall many people would consider buying them. This might be due to normal bikes already being used so e-bikes seem more accessible also people commented that being they liked being sit down on a seat unlike scooters. Also 51% of the respondents believe that e-scooters are unsafe however this data isn't conclusive as the sample size is still quite small.

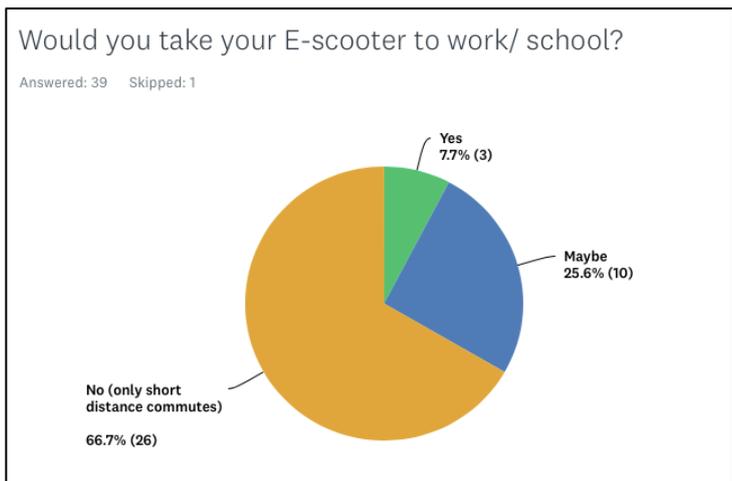
When asked if there was a need for/ space for e-scooters in their cities 57.3% of respondents said maybe and 25% said No as there are "already so many other modes of transport like trams, electric buses, bikes". There were concerns that even though w-scooters are good for the environment they would be dangerous for pedestrians if used on pavements.



84.62% of respondents believe that e-scooters would be beneficial to the environment as some talked about how they could help reduce carbon emission and be good for global warming. However those who voted no stated that it in order to have a large scale impact on improving the environment a lot of people would need to use them and they would need to be used over larger distances which isn't practical with its design.

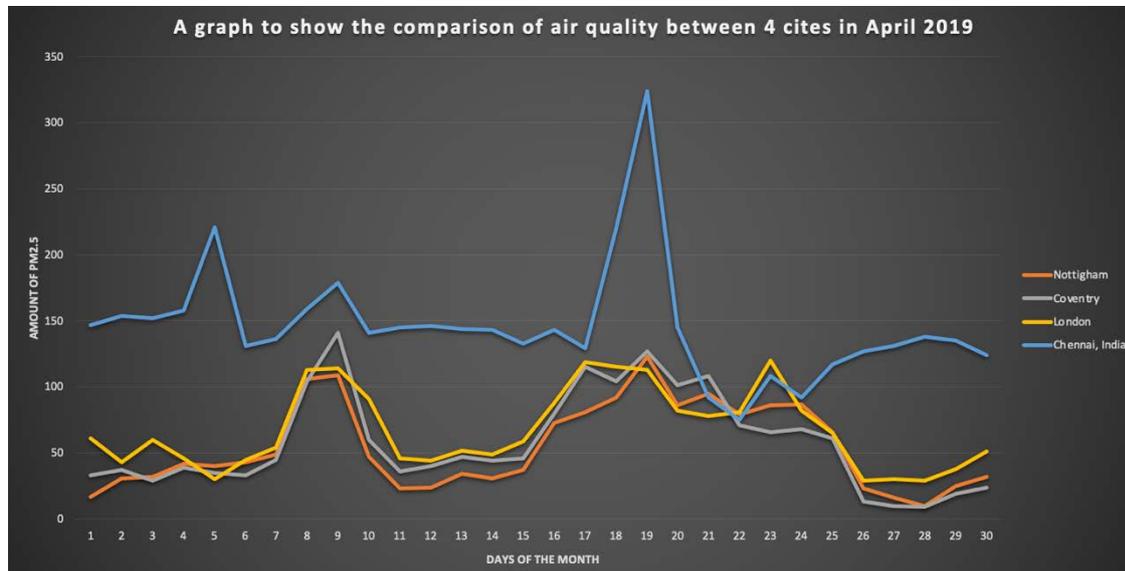


The respondents had mixed views on if e-scooters are safe to use. Some concerns that the public had were that a speed limit would be required to help prevent accidents also that they should be licenced to ensure people use them safely. Another concern was that they look quite "flimsy and poorly designed" for the speed they go at also it would be hard to see them at night especially on the road.



66.7% of the respondents wouldn't take an e-scooter to work/ school as they are too far away to make it there by e-scooter at a reasonable time therefore it is seen to be a good investment. But they would use it for shorter commutes eg to go around the city centre. 25.6% of people said maybe and their main concerns were about weather conditions eg on a rainy-day people will be less inclined to use e-scooters.

## 4.2 Comparing emissions in different cities



Data was collected, put into a table and analysed [18] to compare the air quality between different national and international cities during April 2019.

The data for Nottingham suggests that they have a good level of air quality, the highest value during April 2019 was 123 and on average the median value across the month was 54.6. The Nottingham sensor is in the town centre (next to Victoria centre) therefore it is in a higher area of pollution and as there is only 1 sensor in Nottingham this is the only data on air quality received. This could impact the data giving slightly higher values of air quality due to the sensor only being in the city centre where there is generally more pollution.

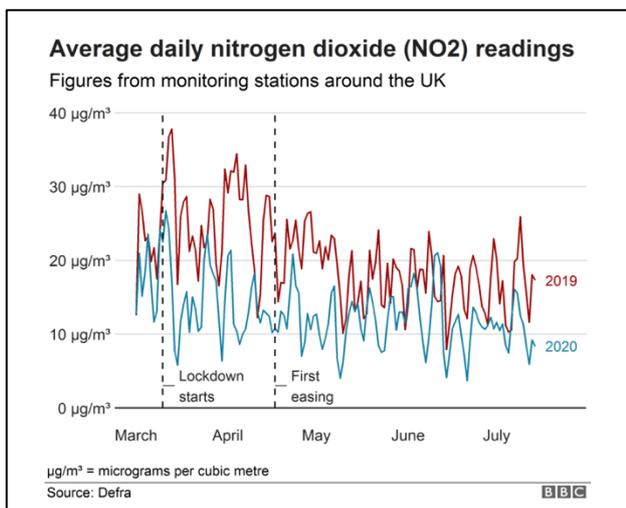
Coventry had a highest value of 141 and an average value of 58.2 during April 2019 but it only has one sensor in place to detect levels of air pollution like in Nottingham. In cities such as Coventry there are climate change protests occurring because public health England released a report saying 168 deaths per year have occurred due to particulate pollution. Campaigner Merle Gering criticised Coventry's current air pollution plans as "very minimal" however a department for Environment, Food & Rural Affairs spokesman said "urgent action" was being taken to lower air pollution further through its £3.6bn plans to tackle pollution [12]. When comparing Nottingham and Coventry they are both cities of the same size so we are able to see that they have similar air pollution levels with their averages being 54.6 and 58.2 respectively. Another similarity is the fact that they each have only one air pollution sensor as well as their geographical locations being very close to one another which could explain why their results are so similar on the graph above.

London had the highest value of 120 and a median value of 67.6 therefore it has the highest average monthly values out of the UK cities analysed. This could be because London is the capital city therefore is heavily populated with more transport links than the other cities. In London there are 14 sensors which means that in comparison to Nottingham which only has 1 sensor we get more accurate data as we get more values to work with which reduces the impact that any anomalies will have. Also, this means that you get fed data from various locations so you are able to get a broad picture of the city rather than only getting the data from one place.

In Chennai, India there are very high and unhealthy levels of air pollution due to it still being a developing country so there are lots of industries trying to grow which require factory work. These are very big and produce a lot of pollution which can make their air quality levels significantly worse and this can be visually seen when the moisture in the air mixes with the particles which cause pollution to create a visible haze/ fog in the air. Chennai's has 4 air quality sensors and its highest value was 324; there was an average value of 146.3 which when compared to the UK is more than double on average.

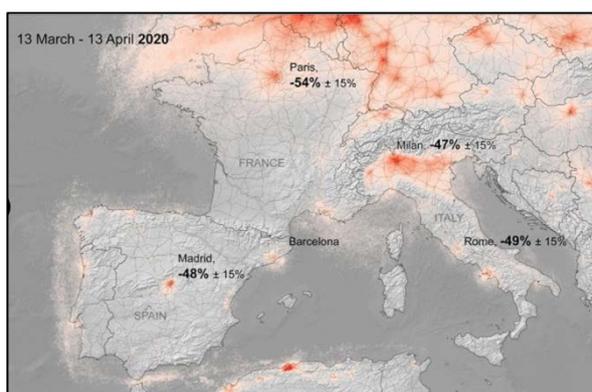
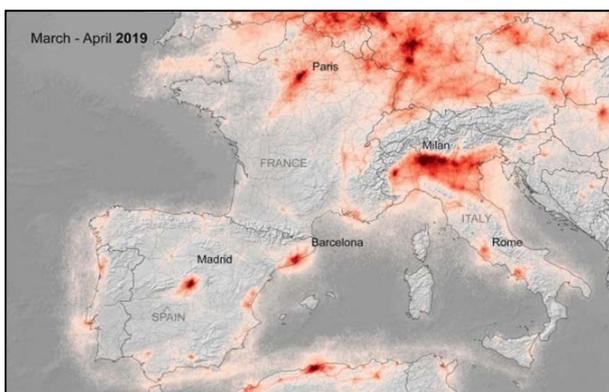
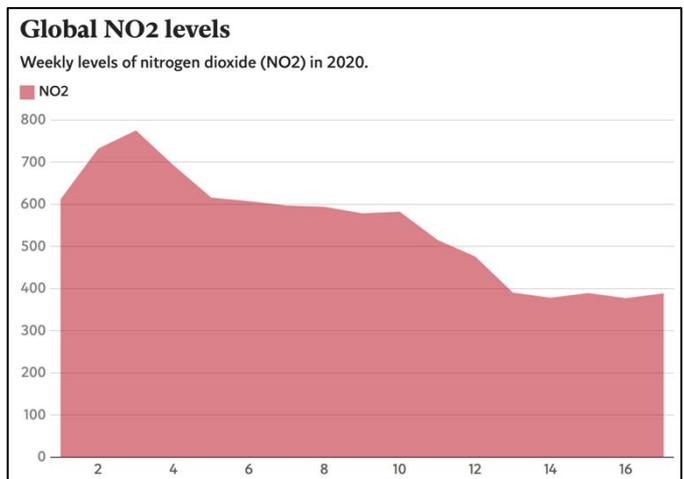
### 4.3 General effects of lockdown on air quality

Lockdown has reduced air pollution and improved air quality all around the world due to less people going out and using transport (eg cars/ trains/ buses), factories and roads closing etc therefore less particulate matter is being released into the air via roadside pollution.



Average readings of nitrogen dioxide, one of the main pollutants from vehicles, were lower throughout lockdown than on equivalent days of the week in 2019 but the gap narrowed after restrictions started to ease in May and most people were able to travel further [13].

There has also been a drop in global NO<sub>2</sub> levels because the coronavirus pandemic resulted in a worldwide lockdown occurring so outdoor pollution caused by vehicles dropped suddenly [5].



The images above were gathered by the European Space Agency's (ESA) Copernicus Sentinel-5P satellite and they capture ground-level concentrations of NO<sub>2</sub>. This is another direct visual comparison of the change in air pollution in Europe between the years of 2019 and 2020. In France, Germany, Italy, Spain and the UK car use fell by over 50% during lockdown [5]. Overall lockdown has globally helped to reduce the amount of air pollution produced by various forms of transportation

## 4.4 Measuring particulates

Measurements of the concentration of particulate matter in air are made by recording the mass of particulate matter in one cubic metre of air using the units micrograms per cubic metre ( $\mu\text{g m}^{-3}$ ). Particulate matter is classified according to its size and this classification is used in concentration measurements, for example PM<sub>10</sub> is – to a good approximation – the concentration of particles that are less than or equal to 10  $\mu\text{m}$  in diameter and PM<sub>2.5</sub> describes the concentration of particles that are less than or equal to 2.5  $\mu\text{m}$  in diameter [10]. The measurement is characterized by various parameters eg particle mass, number, size distribution, surface, etc [11].

For countries committed to reducing their PM emissions it is essential to have models that accurately estimate and predict PM<sub>10</sub> concentrations for reporting and monitoring purposes. The Kyoto Protocol is an international agreement that aimed to reduce carbon dioxide (CO<sub>2</sub>) emissions and the presence of greenhouse gases (GHG) in the atmosphere and requires a lot of large-scale air quality monitoring. The Protocol was adopted in Kyoto, Japan in 1997 when greenhouse gases were rapidly threatening our climate and the planet. Now there are 192 developed countries part of this agreement and if a country emits more than its assigned CO<sub>2</sub> limit then it will be penalized by receiving a lower emissions limit in the following period. Developing countries are encouraged to voluntarily follow the rules of the agreement however aren't forced to be [17].

## 4.5 Building a sensor

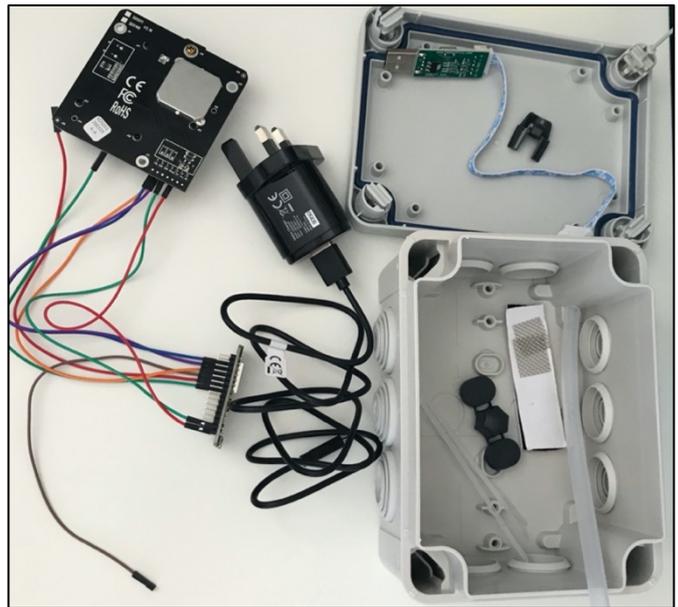
For this project a sensor was built to try and collect more primary air quality data for Nottingham.

The sensor box contained the components:

- ESP8266 v2 Arduino NodeMCU with WIFI  
This connects the sensor to WIFI allowing all of the data to be transmitted online and accessed on the Luftdaten sensor community website
- BME280 Temperature, Pressure and Humidity Sensor  
This detects the temperature, pressure and humidity of the surrounding area and transmits the data online



- SDS011 Laser Particle Counter  
This detects the air particles in the inlet feed pipe and provides this data to the NodeMCU unit, it actively sucks in air every measurement cycle and only measures what it sucks in (not the air in the surrounding area).
- Connecting Cables  
These join the 3 electrical components together (ESP8266 v2 Arduino NodeMCU with WIFI and BME280 Temperature, Pressure and Humidity Sensor are joined to the SDS011 Laser Particle Counter)
- Weatherproof Box  
This protects the electrical components inside from getting damaged
- Ties, Velcro and Metal Grid, and plastic tube  
These are used to secure the parts together, to secure them within the waterproof box and to prevent anything extra getting in (e.g. insects)
- Micro USB and power supply  
This is used to charge and power on the ESP8266 v2 Arduino NodeMCU with WIFI



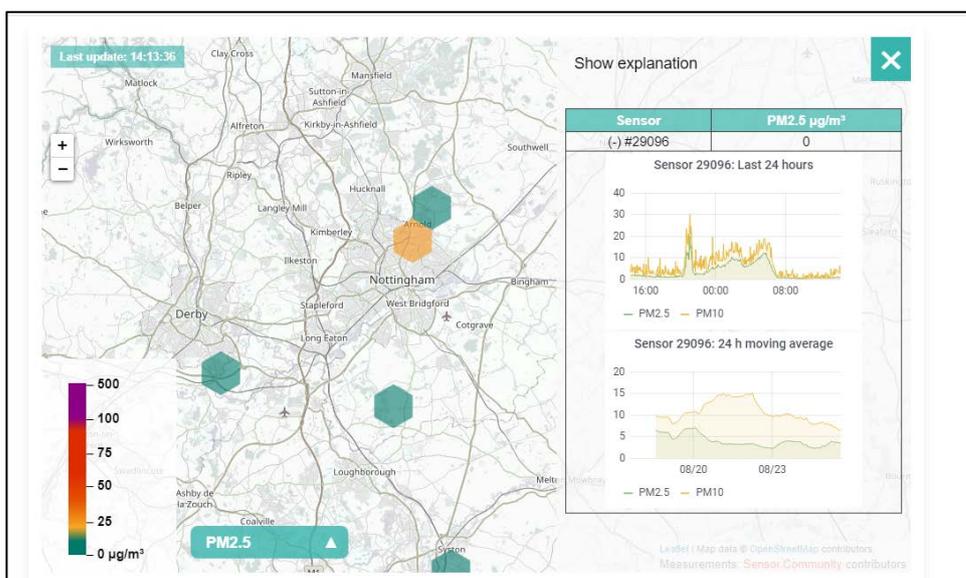
The sensor was built in accordance to the instructions on the Luftdaten website:  
<https://sensor.community/en/>



When the sensor is connected to the WiFi the data can be checked on the [madavi](https://madavi.com) website using the unique chip number. The sensor records PM2.5, PM10, temperature and humidity. The output from a typical sensor is shown here.



The sensor can be registered with luftdaten with a location so it will display continuous monitoring on the luftdaten map giving access to all the sensors across the world. <https://sensor.community/en/>



## 5. RESULTS AND DISCUSSION

From the research conducted overall it is seen that most people believe that e-scooters come at a higher cost than benefit to cities. The public opinion survey showed that most people believed there is a need to change our mode of transport for the betterment of the environment and overall health as it is agreed that air pollution is dangerous/ can cause long term complications however the public don't necessarily believe that e-scooters are the best solution. E-scooters would need to be used by a large number of people and used to travel large distances in order to make an impact on air quality however that doesn't seem like a likely option and the design of having to stand on these scooters (no seat) makes it harder/ more uncomfortable to travel further with them. There was also a lot of confusion with their safety and use as many people were concerned that they would be misused on the pavements and could be more of a hazard to other road users.

E-bikes are another alternative mode of transport which can help to reduce air pollution but unlike e-scooters they are seen as safer to use by the public as there are already cycle lanes and laws in place. They are also a healthier/ active form of transport as you can pedal the bike if you wish/ need therefore the e-bike helps both the environment and the users overall health. People are also more inclined to use these to travel longer distances, e.g. take them to school/ work therefore more people are willing to consider buying/ using them.

In a poll carried out by YouGov on behalf of Cycling UK, 63 per cent of people said they want to see traffic free cycle tracks and 36 per cent said they would use their cars less after lockdown. The government announced a £2 billion active travel fund to create pop-up bike lanes in cities and wider pavements. Plans in Greater Manchester include 150 miles of protected cycle track and in London, Transport for London will create a 'bike Tube' network above Underground lines [6].

## 6. EVALUATION

Throughout this project the topic idea was able to change as new research was done and discussed with other ambassadors allowing my report to constantly develop and for me to gain more knowledge in this subject area. Due to social distancing we were unable to directly come in contact with the general public however we were still able to collect primary research via an online survey and by building an air quality sensor which can be set up within the local community. The online survey allowed us to be able to contact people from different areas of the UK giving us a wider scope of data which may not have otherwise been collected if we had simply gone into a public space and handed out questionnaires therefore in the future when conducting other primary research I would consider doing this again.

During the course of this project there were a few technical restrictions and difficulties which slowed down the project, e.g. when evaluating data some data sets were too large to be sent across between me and my project co-ordinator therefore we had difficulties gathering smaller sets of data which were also still accurate. It was also difficult setting up meetings and getting notifications at the start of the project as google classroom wasn't always completely reliable. However due to these setbacks I was able to learn how to effectively use a range of new online softwares and a webcam for online meetings which are key skills that will also benefit me in the future.

If there was more time we would've liked to also have been able to research the carbon footprint of various modes of transports and to see how the air pollution produced when

making them compared to the amount produced when using them. Because this would've allowed us to look at another aspect of air quality and helped us to see if the carbon footprint of producing e-scooters was impacting how environmentally friendly they are.

Overall, I was also able to develop a range of IT and communication skills whilst completing an enjoyable independent research project and we were able to gather a large amount of relevant/ accurate research on both air quality and e-scooters which was backed up by a range of data allowing us to answer our initial project question well.

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