A new resource designed to allow primary children to investigate atmospheric pollution using Defra's Air Quality Archive

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Abstract

Air quality is an area of worldwide concern. Scientific research in this area can provide incredible stimulus to primary school children, their teachers, parents, carers and other stakeholders, and empower them and their families to make informed choices about modes of transport and reducing their exposure to pollutants. The UK Air Quality Data Archive of current and historic air pollution measurements from across the country is enormous, containing over 400,000,000 datapoints.

This paper explains how older primary children can engage with these data and even learn about the air pollution in their local area through data mining. A freely available resource has been created in collaboration between atmospheric scientists and teachers to allow this to happen and to explain the science behind it.

Keywords: Atmospheric pollutants, citizen science, air quality, data mining, numeracy

Introduction

Climate change and surface air quality are two of the most pressing global concerns as we move through the 21st century. The impact of air quality on human health is well documented, as is the disproportionate impact on the health of the very young and very old (e.g. Ruchirawat *et al*, 2007). A free resource, created by academics and teachers, will allow primary-aged children, teachers, carers and parents to interrogate the air quality archives, from which they may carry out their own research using freely available data.

The Air Quality Archive

The UK's Air Quality Archive, one of the most extensive in the world, is run by the Department for Environment, Food and Rural Affairs (Defra), a UK government department (https://uk-air.defra.gov.uk/). It contains some 400,000,000 datapoints. A project that utilises this amazing UK resource and allows primary school children, their teachers, parents and other stakeholders to learn about and carry out investigations into air pollutants is a great starting point for a citizen science project.

These data are readily accessible from the website portal and contain measurements on primary pollutants such as:

- nitrogen oxides (NO, NO_2);
- carbon monoxide (CO);
- sulfur dioxide (SO_2); and
- particulates $PM_{2.5}$ (airborne particles with a diameter less than 2.5 µm) and PM_{10} (airborne particles with a diameter less than 10 µm).

The measurements are from calibrated instruments and have much supporting information in terms of how the measurements are made, where the measurements are made (e.g. by the kerbside, in an urban background location) and the instruments used to make the measurements. These data are extensive in terms of geographical coverage, with most UK schools having some network measurements in their vicinity. The children can either interrogate their nearby data or compare them with data from other parts of the UK, perhaps from a clean air site.

The mathematical and IT requirements needed to analyse data are straightforward. At a simple level, these data can be viewed in graphical form, generated by the Air Quality Archive website or from the exemplars provided. If children, or their carers, have spreadsheet experience, more analysis can be done.

The resource

The web-hosted supporting resource (https://pstt.org.uk/resources/curriculum-materials/citizen-science-air-pollution) is freely available from the Primary Science Teaching Trust (PSTT) (Shallcross *et al*, 2015).

The website starts with an overview that introduces the project and includes suggestions of the types of investigation that can be carried out.

The 'Resource' area has a background information section for teachers on specific atmospheric pollutants and how they are measured. To support teachers in introducing atmospheric pollutants to primary-aged children, we have provided activity cards and a classroom presentation describing the source of these pollutants, with graphs showing concentrations of each pollutant measured in a city in the UK, and questions to stimulate discussion in the classroom (with answers). There is also a series of worksheets (graphs and data with question prompts) for primary-aged children to investigate yearly, monthly and weekly trends in air pollution from sites around the UK, and to allow comparison of air pollutants between an urban and a rural site. Children may then want to investigate the levels of pollutants nearer to where they live: there is a guide on how to use the data archive and pre-prepared data sets for primary teachers to use with their classes. The pre-prepared data sets (Excel spreadsheets) include data from the capitals of the four home countries and from a 'clean air' (countryside) site. Each site has yearly data extracted for every two years from 2010 to 2018 inclusive (i.e. 2010, 2012, 2014, 2016 and 2018). There is also an exemplar data set with suggestions of how these data can be manipulated and then graphed/charted. One workcard set allows each child in their class a fortnight's worth of data on one pollutant and a common blank graph grid so that they can each plot results and put them altogether to make a plot of annual data. Other workcards have pre-graphed data on daily, monthly and annual selected pollutants, with questions about patterns and site comparisons.

The resource has a section that provides profiles of climate scientists associated with the Atmospheric Chemistry Research Group (ACRG) (https://www.bristol.ac.uk/chemistry/research/acrg/) in Bristol to humanise the science of climate

research. These profiles include the scientists' thoughts on the skills needed by those scientists and a few lines about what made them engage in science the first place. Children can see that climate science research is carried out by a diverse range of people.

The last section, aimed at teachers, supports the understanding of air quality science. This contains considerable background material on climate change and atmospheric chemistry. It includes a collection of related articles originally written for teachers and secondary school students, which can, in the main, be freely accessed. An example is using aircraft for atmospheric monitoring (Leather *et al*, 2014). In addition, there are resources (PowerPoints) annotated for teacher/post-16 student use. These include a simplified mathematical treatment of the climate and a description of Stephen Pacala and Robert Socolow's theory of stabilisation wedges, a treatment of how to reduce current atmospheric carbon dioxide concentrations using existing clean energy technologies, such as wind power (Pacala & Socolow, 2004).

Apart from opportunities to report on the science research undertaken, there are additional writing activities for children. Children who work on a project based on this area of science will have many opportunities to shine in literacy and numeracy.

What sort of research can be carried out?

There are many potential and exciting investigations that can be undertaken using data from the children's own geographical area. The Atmospheric Chemistry Research Group (ACRG) at the University of Bristol has used the archive extensively with secondary school students to investigate the role of Bonfire Night on particle levels (Harrison & Shallcross, 2011). This was a project run with secondary students that later became a full academic research project (Priestley *et al*, 2018).

A much simpler starting analysis will be, for example, to look at the mean (average) value of a specific pollutant on days of the week and

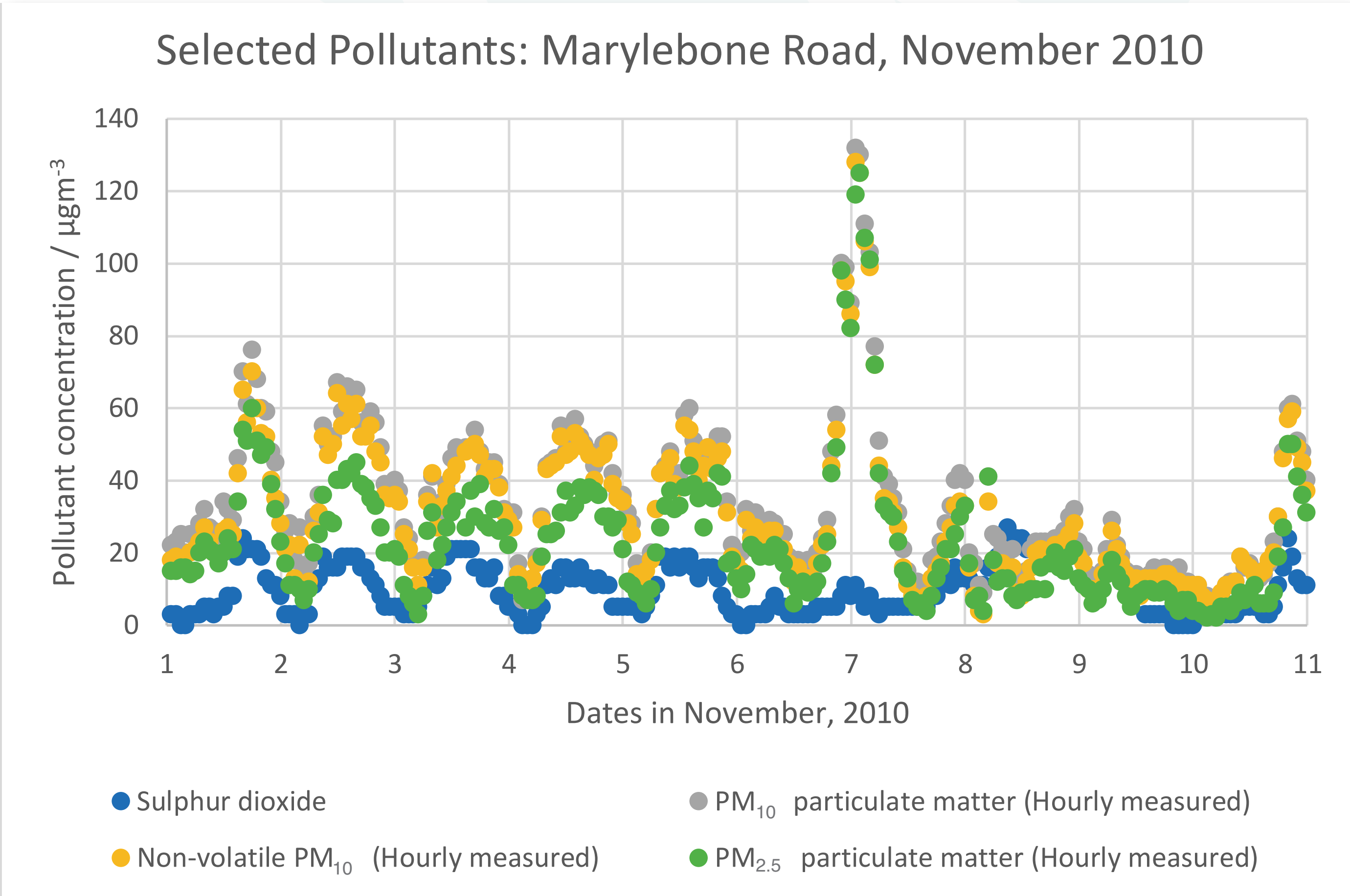

Figure 1. Pollutant data for November 2010. Note: Bonfire Night was a Friday (5th November), which would have meant most parties taking place on the Saturday evening, 6th November.

determine if there is a pattern, and why? How do these levels vary from month to month, and even year to year, or from location to location? What hypotheses do the children give before they investigate these data and for the changes they observe? What is the most polluted and cleanest day in a (named) UK city? We have asked this question with primary school children on many occasions and they predict a wide range of days for both, with excellent reasons. When they look at these data and see that the most polluted is usually around Bonfire Night (5th November) and the cleanest is Christmas Day (25th December), they make some excellent connections. The children can look at these data on an hourly scale and determine when in the day is the highest level of pollution and how this varies with month and year. These are just some of the possible investigations, and some data derived with Year 5 and 6 (ages 10/11) students from primary schools are shown in Figure 1, which illustrate how particle levels vary in the week of Bonfire Night. Data sets can be mined and pre-prepared so that teachers can use these to show to their children and for the children to investigate and explore, and avoids issues to do with using the Internet. By encouraging parents and children to investigate together, parents then have ownership of safeguarding.

For the more adventurous, or as a follow-on activity, or for an activity for children to carry out with their parents and carers, more open exploration of the database is possible. Here is a way to challenge children with an opportunity for families to carry out meaningful science investigations and for adults to engage and understand about pollutant levels in their area, and more widespread across the UK. This citizen science opportunity is not just limited to students of primary age. For those who enjoy looking at current science research in a form written for primary children, they can delve further into the *I Bet You Didn't Know* resource library (Trew *et al*, 2019; Trew *et al*, 2020).

Example activity

A student wants to look at how the COVID-19 UK lockdown has affected air quality during March 2020, compared with March 2019, in a city location. This is possible. Let us consider nitrogen dioxide

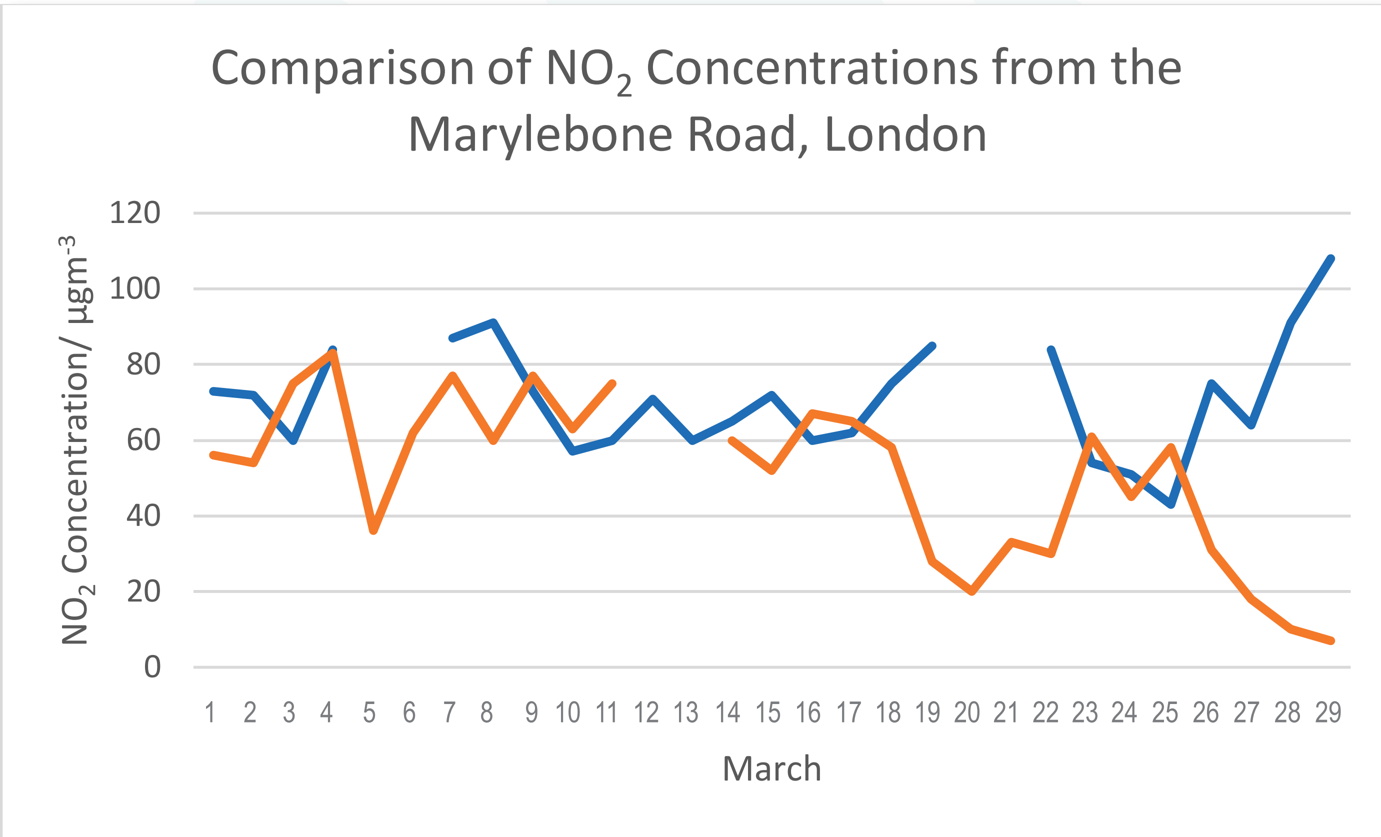

Figure 2. Nitrogen dioxide (NO_2) levels, during March 2020 (orange line) compared with March 2019 (blue line). Note the drop-off after the national lockdown mid-March 2020.

(NO_2) levels, which are associated with traffic. Let us consider a roadside location in a major city: Marylebone Road, London. The data for both months can be selected, using the *How to Use* guide on the project website. These data are extracted (copy and paste) from the tabulated data generated and pasted into a spreadsheet for manipulation.

Several questions could be asked about the levels of this pollutant from the start of March 2020 to the end of March 2020, or post the UK COVID-19 lockdown (8 pm Monday 22nd March 2020). A comparison can also be made between March 2019 and March 2020. From the spreadsheet of data, the March mean of NO_2 concentrations could also be calculated. Queries could be made in different locations and for other pollutants, and conclusions drawn.

Even if these data are not used for research, many of the graphs and other charts can be used in real life examples of the representations of data.

From graphs such as that shown in Figure 3, children can be asked many questions:

- Example 1: Why does Figure 3's caption state that 'air quality is heavily influenced by traffic, with morning and afternoon peaks associated with rush hour traffic'? From the graph, what suggests this?
- Example 2: Which of the 3 pollutants is present the most?
- Example 3: At what time in the morning is pollution the highest?

Key skills

There are many ways in which to set out the intended learning outcomes in primary science, as exemplified by the national curricula of England, Wales, Scotland and Northern Ireland. Programmes of study describing learning requirements differ. However, all share the aim

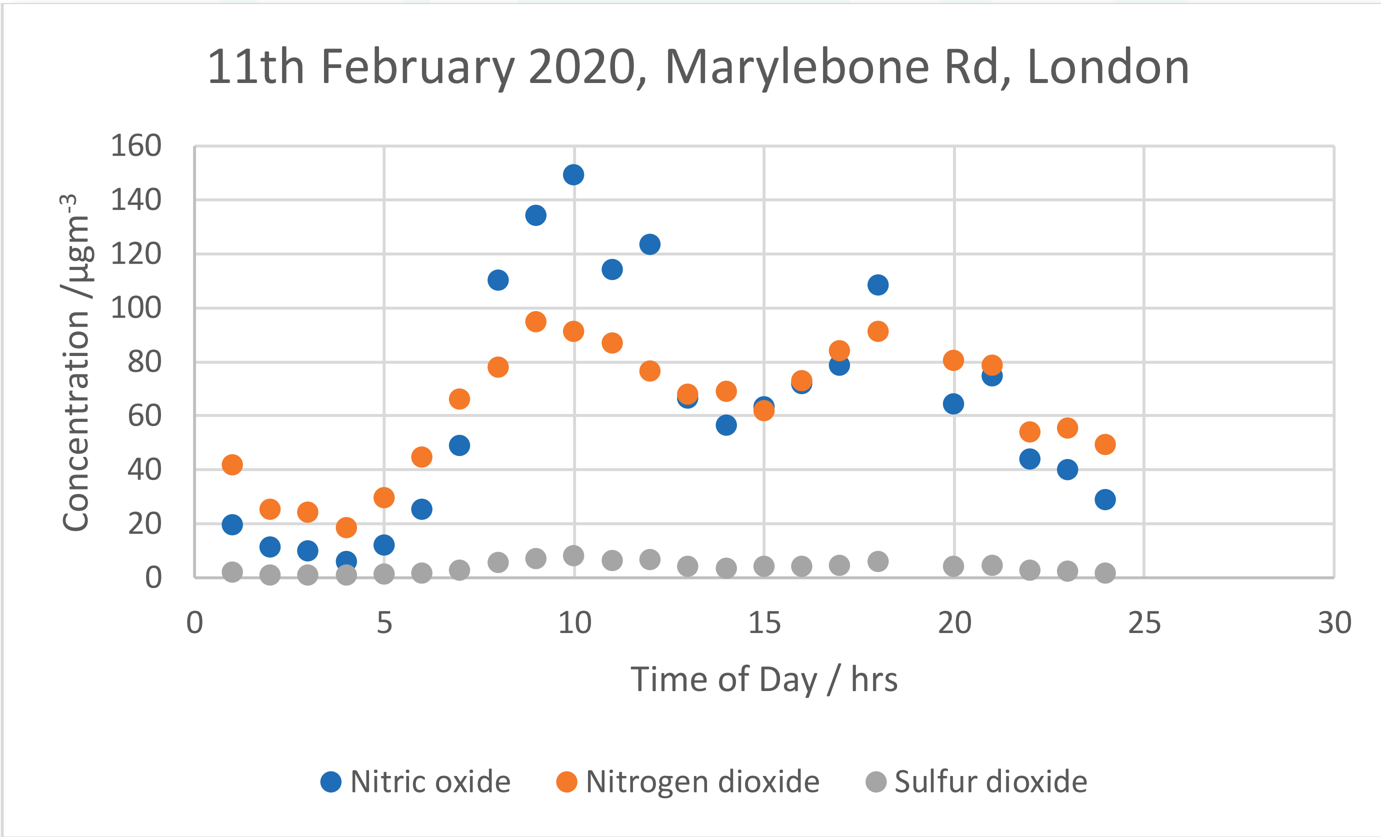

Figure 3. Nitric oxide, nitrogen dioxide and sulfur dioxide concentrations in air measured at Marylebone Road, London during Tuesday 11th February 2020, observed at the kerbside site, showing that air quality is heavily influenced by traffic, with morning and afternoon peaks associated with rush hour traffic.

of making science more relevant to children's everyday lives and of developing children's scientific enquiry skills (Harlen & Qualter, 2018). All primary children are expected to carry out practical investigations that involve setting up a range of types of enquiries (for definitions, see https://pstt.org.uk/resources/curriculum-materials/enquiry-skills), asking questions, making predictions, observing and measuring, recording and interpreting data, and evaluating (reflecting on the success of the enquiry approach). To identify questions for further enquiries and to interpret require data and this can be difficult in the primary classroom, because children's practical activities do not always generate large data sets for children to work on. Having access to the Air Quality data provides large data sets with which, with a little guidance, children can interpret and develop these skills. Children using these data will also develop their maths skills (calculating mean averages, knowing when it is appropriate to find the mean of a data set, plotting and interpreting graphs) and computing skills (using spreadsheets). Young people are increasingly aware of climate change and the challenges that this presents. The Air Quality data also provide an opportunity for children to carry out original research that is local and relevant to real life issues.

Summary

This expansive resource will allow children, teachers and their carers to use their numeracy skills to participate in science research using real atmospheric data. At a minimum, the children will be able to explain the trends and extrapolate information from pre-prepared graphs and other charts. At best, the resource will facilitate children's science curiosity and produce valid research outputs that may not have been previously explored by the older, professional scientists. The additional bonus is that these young scientists will have an increased understanding of some of the complexity of climate science, one of the world's greatest science challenges.

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