Hackathon report: MAKE SENSOR SENSE

Content 1 Literature Review, 2 Air Quality Analysis Use Case, 3 Design of Citizen science initiative encourage EDI group in Environmental sciences, 4 Air Quality Citizen Science Dashboard

This dashboard is available on github: https://github.com/wegiangb/NERC_EDI

A demo version is available at: http://airnode.co.uk/NERC_EDI/index.html

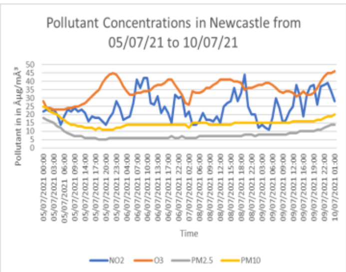
1 Literature Review

One of own team members Rob (Math Graduate) tasks was to conduct a literature review of air quality networks monitoring, analysis and applications in citizen science initiatives along with other initiatives.

This was a new field for Rob and gave him a large experience in air quality and environmental science analysis research. It allowed an objective unbiased review of the air quality domain. Rob was advised by Gordon and Hua on the domain of air quality and factors to highlight in the literature review. The literature review identified methods of monitoring, analysing and managing citizen science initiative for air quality experience analysis. Specifically it included and reviewed these categories: AQ sensors ranges, network, analysis methods, mitigations and causations.

2 Air Quality Analysis Use Case

The potential to analyse unique Air quality dataset arose through a collaboration with a leading AQ sensor manufacturer who supply AQ sensor to Urban Observatory Initiative. They provided us with AQ measurements from Newcastle city centre with 1 min sampling of NO2 and PM10, PM2.5 air pollutant from 3 AQ sensors over 6 months. These sensors were placed near Newcastle city centre and we were able to base the analysis on the experience of these school pupils. Initially we analysed the variance in the AQ measurements, seasonality and regular patterns. We were able to identify rush hours, small mid morning peaks, evening rush hours. We could further analyse irregular patterns in the AQ measurements. On unique days we were able to identify large irregular peaks. We further were able to use the AQ measurements with AirNode's existing software to predict the next two days AQ measurements. We managed to achieve this with a high level of accuracy. We managed to do this for various difficult to predict days. We were able to show that it was possible

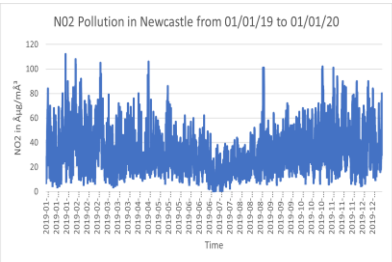


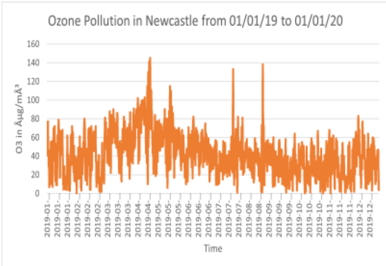
with AirNode's existing software to identify irregular patterns and predict the next two days of AQ measurements on existing AQ sensors. This irregular pattern can be used further to attribute to causes of air pollution. This would allow local school and authorities to highlight these causes and mitigate against these. It would further allow school pupils to replicate this analysis to experience air quality analysis methods and show impact on their own school experience. This shall provide a valuable tool for school to improve the school experience and for pupils to experience environmental science methods before making decisions to neglect becoming environmental scientists. Existing data can be accessed through OpenAQ.org and this section has analysed data from various time points at the DEFRA AQMS in Newcastle city centre. Conclusive data from a DEFRA AQMS located in Newcastle's city centre (N54.97825, E-1.610528) was collected between 05/07/21 and 10/07/21 in an attempt to see trends in the day to day AQ measurements. Figure 1 above graphs the results for the NO_2, O_3, $PM_{2.5}$ and PM_{10} pollutants.

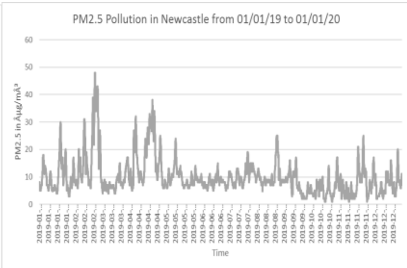
For the NO_2 pollutant levels, a clear correlation between peak traffic times and pollutant level can be observed as the large spikes always occur between 7am and 9am and 4pm and 7pm. These times are 'rush hour' times in which the vast majority of commuters travel to and from work. Therefore, the amount of traffic as an impacting factor for NO_2 emission is reinforced by this data. The O_3

pollutant level is interesting as it shows a negative correlation with the NO_2 pollutant, as the peaks in the O_3 line tend to be when the NO_2 levels are low. Obviously, this isn't a perfect fit due to the multifactorial causes of pollution but however, it is clear to observe a link between the two pollutants. Therefore, it can be reaffirmed that a lack of NO_2 in an area could cause an increase in O_3 pollution. There was little fluctuation in both of the PM pollution levels with both lines having a very small gradient which suggests that there aren't any clear daily trends for those pollutants. However, it interesting to note that both lines had an almost identical gradient at all times suggesting that the factors that impact the levels of $PM_{2.5}$ and PM_{10} are the same.

To analyse an annual seasonality we plotted the levels of each pollutant from the same sensor in Newcastle from 01/01/19 to 01/01/20. The reasoning behind using data from 2019 was to avoid using anomalous data from the COVID-19 pandemic, in which Government 'lockdowns' had a huge effect on pollution levels. Therefore data from 2019 better represents seasonality in a typical urban setting.







The seasonality of NO_2 pollution can be observed. This data reinforces claims that there is less NO_2 in warmer summer months as from the graph it can be noted that the levels of pollution is much lower in June, July and August, which are the warmest months in the UK. Also, the converse of this claim can also be observed as there is more NO_2 pollution in winter, with the levels of pollution being highest in January, February, March, November and December.

There is an uncharacteristically large spike on 25/08/2019 from 7pm to 10pm and from investigation I believe that this large spike may have been caused by an increase in people and traffic in the area. This increase in people was due to the 25th being the crux of a bank holiday weekend with multiple different events taking place in Newcastle that evening.

3 Design of Citizen Science Initiative

The aim was to increase EDI group involvement in environmental sciences and potential to choose further study. Two influential reports Aspires (10 year study) [1] and enterprising science (5year UCL study) [2] defined a measurement science capital that pupils had a various phases of education. The science capital could be measured in the 8 categories described in the appendix. The more science capital a pupil had the more likely they were to choose further science studies. This initiative aims to increase the amount of science capital for pupil through these 8 categories.

It was shown in these studies that there are effective methods to increase science capital. The 4 step method in the studies is stated in the appendix. This initiative aims to follow this method and the ability conduct their own air quality analysis on their air quality experience at school allows this initiative to be a key method to increase science capital. The initiative designed a citizen science that had a 4 step method similar to one stated in the appendix including the 4 steps below:

1 A class manual and a lesson planner was designed to allow an explainer lesson on the topic of air pollution, causes, impacts and possible mitigations through videos, storytelling and significant statistics. A second lesson planner allowed for documenting the pupils experiences of air quality and how this varied and their opinions

2 A lesson planner was designed for viewing the air quality measurements, allowing pupils to identify when they experienced these air quality levels. Another lesson planner was designed to

measure air quality and other meteorological factors with a handheld device at various locations near the school and a programme to repeat.

3 A lesson planner was designed to use the dashboard to monitor the variances of AQ measurements and find trends, irregular patterns and regular patterns. Another lesson planner was designed to hypothesis from emission sources which of these causes these peak and irregular patterns in AQ measurements and gain pupil opinions and own analysis.

4 A set of Test were designed to allow pupils to conduct their own analysis and experiments using the AQ sensors and dashboard to find causes of air pollution, variances, peak times, impacts from wind factors, impacts from traffic volumes, comparison of indoor classroom measurement to outdoor sensors. Another set of tests were designed for teachers and parents to do more accurate analysis on air quality exposure and variances. The initiative was then measured against the 8 categories of science capital to see if it had methods to advance these.

1 Scientific literacy: Pupils would gain understanding the subject air pollution which they often are not fully aware. Pupils would have had the chance to design their own experiments and analysis.

2 Science-related attitudes, values and dispositions: Pupil shall have analysed their own air quality experiences.

3 Knowledge about the transferability of science: Pupil shall have seen the results from their analysis that allowed a larger understanding of impact of air quality exposure on their experience.

4 Science media consumption: Pupil would have at least seen video explaining air pollution and if interest researched it themselves.

5 Participation in out-of-school science learning contexts: The publication of the results would be something that would be of interest to parents and other citizen and in that way they are benefiting society. It could cause pupil to have a large interest in science subject and research more.

6 Family science skills, knowledge and qualifications: This initiative gives parent access to the portal which would determine health risks of their children and be of large interest to them. It would therefor allow parent to do air quality analysis and be more informed about science analysis

7 Knowing people in science-related roles: Having provided results of interest to society the school may use this to interact with authorities or scientists to encourage pupil to take more interest in science.

8 Talking about science in everyday life: Because this is relevant to the pupils experience they are more likely to talk about it with parents and others. This design plan was designed into the making of the dashboard which is an easy to use interface for teachers, pupils and parents to use.

4 Dashboard for Citizen Science

We were able to produce a dashboard for the citizen science that would allow school pupil to monitor and conduct their own environmental science analysis on AQ measurements. We designed the dashboard to able to include many schools. The dashboard is designed to include 10 levels of analysis methods from basic targeted at primary schools to advanced targeted at University students. The first basic level seen here is made simple so that it can be used be primary schools. It shows the time and school location with a character that has 6 levels of satisfaction. These 6 levels are the international air quality index AQI levels. These are levels of AQI which is an industry used index for the main air pollutants. The dashboard includes times of day by simple images so that users can check the AQI on various times of day and the character changes their expression if the AQI changes. The map shows the location of their school to the AQ sensors. There is the ability to predict the AQ measurements for the next few days. This can be used by the users to make decision on routes to school and close windows.

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Appendix

1 Aspires Archer, L., DeWitt, J., Osborne, J., Dillon, J., Wong, B., & Willis, B. (2013). ASPIRES Report: Young people's science and career aspirations, age 10 –14. London, UK: King's College London

2 Enterprising Science [improving-science-participation-policy-overview.pdf (ucl.ac.uk)]

Science Capital

1. Scientific literacy: an individual's knowledge and understanding about science and how science works. This also includes their confidence in feeling that they know about science.
2. Science-related attitudes, values and dispositions: the extent to which an individual sees science as relevant to their everyday life.
3. Knowledge about the transferability of science: understanding the utility and broad application of scientific skills, knowledge and qualifications.
4. Science media consumption: the extent to which one engages with science-related media including television, books, magazines and internet content.
5. Participation in out-of-school science learning contexts: how often an individual participates in informal science learning contexts, such as at science museums, science clubs and fairs.
6. Family science skills, knowledge and qualifications: the extent to which a person's family have science-related skills, qualifications, jobs and interests.
7. Knowing people in science-related roles: the people an individual knows (in a meaningful way) among their wider family, friends, peers and community circles who work in science-related roles.
8. Talking about science in everyday life: how often an individual talks about science with key people in their lives (e.g., friends, family members, neighbours, community members).

Science Capitol increasing method

1 Foundation: Broadening what counts involves creating a learning environment where all feel able to offer contributions from their own experiences, interests and identities.

2 Personalising and localising means going beyond contextualising content, and instead connecting to the actual experiences, understandings, attitudes and interests of individuals, in or outside of the classroom.

3 The technique of elicit-value-link involves using questions that invite individuals to share knowledge, attitudes, experiences (eliciting), recognising these as having value in that context (valuing), and connecting back to the science content at hand (linking).

4 Building the dimensions of science capital means considering the eight dimensions when developing activities, programmes, interventions and other initiatives, whether in school or out-of-school contexts.