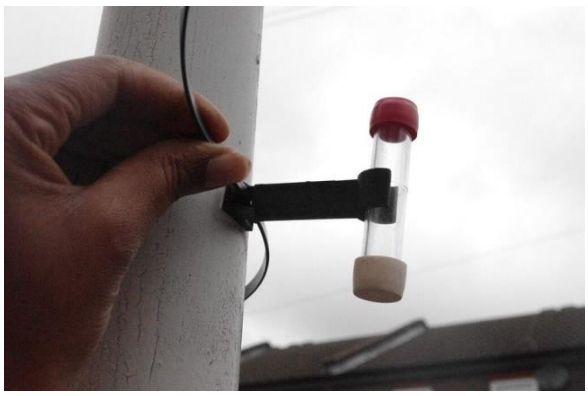
CLEANER AIR 4 COMMUNITIES: ENGLAND

Particulate Matter and NO_2 Monitoring toolkit for London



Esmée Fairbairn FOUNDATION

ROYAL SOCIETY OF CHEMISTRY | ENVIRONMENTAL CHEMISTRY GROUP

LSx London Sustainability Exchange

Trust for London Tackling poverty and inequality

Action Planning toolkit

This toolkit provides you with resources to get you started with some monitoring experiments to measure the Particulate Matter levels where you live. We have provided advice on how the instruments work and how we would like you to carry out the first experiment and after that we hope you will be able to plan your own experiments. The science team will be behind you and are here to help you and get the most out of the project, for you and for the science and the data it can provide. Good luck!

Contents

The Hiri sensors

The hiri sensors use a low cost $PM_{2.5}$ sensor (http://aqicn.org/sensor/pms1003) accompanied with the appropriate electronics, communication system and battery that have been tested in the laboratory in Santiago de Chile.
The instrument has a 3D printed casing and is robust and portable, with a 2 hour battery life with easy usb charging.

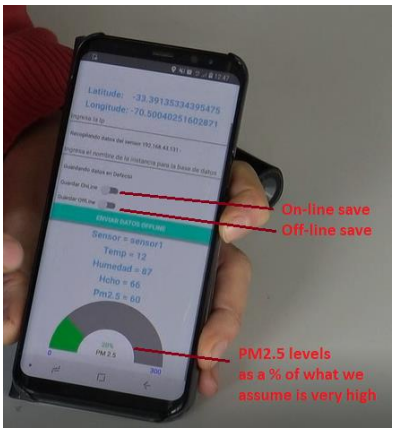
We have produced 2 videos that explain how to use the sensors:
Video 1 explains the general usage and how to plan the experiment
Video 2 explains how to download the app and how to set up the app

Particulate Matter ($PM_{2.5}$)

Particulate matter ($PM_{2.5}$ and PM_{10}) are solid or liquid particles suspended in the air released through a range of mediums including the burning of fuels and vehicular wear and tear (e.g. from tyres and brake pads). The 2.5 and 10 represent the size of the particles, with 2.5 µm being the size limit of the smallest particles that can pass into the lungs and even into the blood stream. The World Health Organisation (WHO) annual mean limit for $PM_{2.5}$ is 10 micrograms per metre cubed (µg/m^3) and the 24-hourly mean is µg/m^3. These are frequently breached and can lead to difficulties for people with asthma, increase the rate of children developing breathing issues and overall reduce life expectancy. It can be measured using a PM monitor that uses a laser to measure a specific frequency of light absorbed by the particles.

Data collection and visualisation

The instrument is designed to be linked to a smartphone (Android or Apple) using wifi via the Hiri app (which will be downloaded via the Apple store or Googleplay) and each sensor is linked to one smartphone. The person carrying the instrument should always have their smartphone within 2 metres of each instrument if they have internet on their phone. If they do not have internet on their phone they just set it to off-line save and the data will be recorded on their phone and then as soon as they have wifi, when they click on-line save it will all be uploaded.



The HIRI sensors and the smartphone app displaying preliminary PM2.5

The app is used to:

- Assign the IP address (or sensor number) of a sensor to the phone (it should then remember this sensor every time you have wifi).
- Assign each experiment (use the date and your name in the form)
- All the experiments will go in the "London" folder for the scientists in Chile to have all the data in one place
- Check your position is being measured (Latitude and longitude will be displayed). This just needs GPS so as long as your phone isn't in aeroplane mode it should find it even if it doesn't have internet
- Leave comments on important things you see or events on your walk (e.g. car belching pollution, building site in full swing with dust in the air)
- Two measurement modes (off-line save and on-line save). While you want to record, always have off-line save on (this records on your phone). If you have internet on your phone and want to save it as you go along, turn on-line save on and the data will continuously be saved on the database. If you don't have internet until you get back to the wifi zone, make sure the off-line save is kept on and turn the on-line save on to let the saved data be transmitted to the internet database.

How to download and use the HIRI app

- Go to Googleplay or Apple store (download HIRI app)
- When you have wifi, go to settings in your phone and look for wifi signals. Find one sensor. If all 5 are on, you might want to turn one on at a time and link to that one and note which one it is! You are now connected to that sensor and in the app it may appear as sensor1 or sensor2 or just an IP address. If it doesn't automatically fill this in in the HIRI app form, please add that.
- Once you have sent you data via on-line save while you have internet (remember to have it on off-line save during the experiment if you don't have wifi!), it will have sent the data instantaneously to the internet database and the scientists in Chile.
- The next time you use the app they will have calibrated the data and you may be able to see it on a map on your phone

Calibration

The sensors will have been tested in Santiago prior to shipping to London, however we strongly recommend running **all** the sensors in one location to test the values they measure when first turned on. They may need to be re-calibrated before being separated out into 4 sets of instruments.

A calibration involves locating 2 or more instruments in the same location for a time of a period of 10 minutes to a few hours (or even a few days). The sensors measure on a 1 second time scale so an hour provides 3600 data points. The science team will look at this data and make any appropriate adjustments to the data.

Experimental design

After an initial calibration we recommend that the first mobile experiment will start with a calibration of at least 10 minutes with all 5 sensors in the central hub, the starting position before the walk.

2km² area divided into 4 quadrants and with 4 walking routes

You will need to plan a walk around your local neighbourhood that lasts about 45 minutes. It will start from a point of interest like a school, a mosque or a community centre. The route should be about 2km long and take in as many different types of road (e.g. back streets, busy roads, congested cross roads or roundabouts, go through or on the outskirts of parks and green spaces and approach open squares with little greenery.

The team in Chile can help to design a route if you give them the starting location and places of interest you would like to pass. They have 3D mapping software that shows building height so they can make sure there is a mix of tall and low buildings in the route.

It is worth measuring the same route at different times of day. As such, this route should be logged clearly in case it is be walked by more than one person. When measuring the same route, try to keep the walking speed as close as possible to the original, so time the route each time

These experiments could be repeated several times to show temporal, day of the week, seasonal or random factors:

- Repeated on the same day at for example 8 a.m. and 12.00 and 17:00.
- Repeated on a Monday, a Wednesday, a Friday and a Sunday at the same time of day.
- Repeated on the first week of November and then again on the last week of November. Note the weather- has it got colder, was it raining more?

Over to you- your mobile experiments

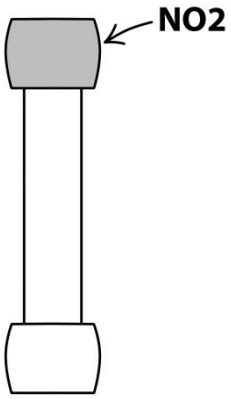
Now we have told you what to do for the first experiment, it is over to you to carry out some real citizen science. Here are some questions you may want to answer about air pollution in your area:

- Is the air pollution higher at ground level or on the second floor? (set up one monitor by a ground floor window of a school and another just outside a second floor window).
- Is there less PM2.5 in the middle of our local park than at the entrance? (set up to sensors for a few hours in both locations)
- Is the pollution worse on my commute to work if I cycle or take the Underground? (Attach a monitor to your bike or on your backpack and track your commute for a few days).
- There is a building site near my community centre. Is there a difference between the levels of pollution at the site compared with at my community centre? (Set up 2 instruments here on work days)
- There is a busy road flyover near my house. What is the difference in air pollution under the flyway and at flyway level? (Only do this if you can safely access the flyway)

Nitrogen dioxide (NO2) diffusion tubes

LSx have a number of NO_2 diffusion tubes. These will be placed at strategic locations at the community hub and at other locations that the public think may be polluted. You can find the official diffusion tube network results here for Tower Hamlets.

What is an NO_2 diffusion tube?



Diffusion tubes have been used since 2013 to complement official static monitoring networks (AURN) and measure the average concentration of NO_2 in the local atmosphere.

The diffusion tube has a steel mesh coated with a chemical – hidden under the grey cap. When air passes over this mesh NO_2 reacts with the chemical. The chemical change that occurs tells us the average concentration of NO_2 in the air over the study period.

Why we measure NO_2

NO_2 damages our health and is responsible for many respiratory diseases. The majority of this pollutant is produced by road transport, and the concentration of NO_2 is increasing in some areas. The WHO health guidelines put limits at 40 $\mu g/m^3$ as an annual mean or 200 $\mu g/m^3$ 1 hour mean (this is 20 ppb and 100 ppbv in the other unit of parts per billion).

The measurements are suitable for citizen science as they can indicate where pollution is highest, and where further study is needed. This is particularly relevant at moment, with the UK Government calling for Birmingham to designate an area of the city a Clean Air Zone by the end of 2019.

It's important to decide what it is you would like to find out. To give you some idea, you could carry measurements out to:

- Compare routes and recommend quiet/less polluted routes to people;
- Demonstrate where traffic calming or anti-idling measures are needed;
- Examine the potential need for structural interventions, such as moving the school entrance, or placing green barriers around the playground;
- Compare pollution levels between term-time and holiday time.

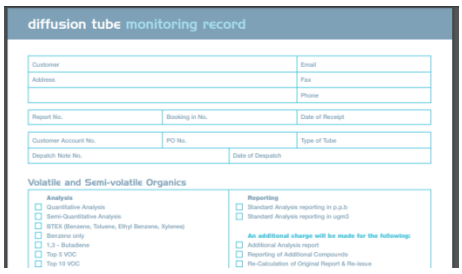
How to use the diffusion tubes

Choose a site

- When deciding where to place the tubes, you'll need to set **one** tube up next to an **official monitoring site**. This is so that we can work out the accuracy of the data. Here is the website to find their locations: https://www.birmingham.gov.uk/info/20076/pollution/1276/air_pollution/3
- Minimise the risk of losing tubes by using **locations that you know,** it is also recommended that tubes are placed at a minimum height of 2m
- Think about **what you want to find out from this experiment?** Do you want to look at the difference between a busy road and a quieter road? Or look at the impact a park could have on pollution levels?
- The tubes should be **located by roads** (so not in your back garden!). Think about areas you know with a lot of traffic or where this would impact those more vulnerable to air pollution (e.g. near schools, hospitals).
- The immediate area around **the location must be open,** allowing free circulation of air around the tube. Make sure the site is not covered by trees, bushes or other plants. Avoid setting them up in a doorway or hole in a wall because the air will not be flowing freely enough. A lamp post would be a perfect place to put a diffusion tube as the air can flow freely and it's easy to secure with zip ties, if necessary.

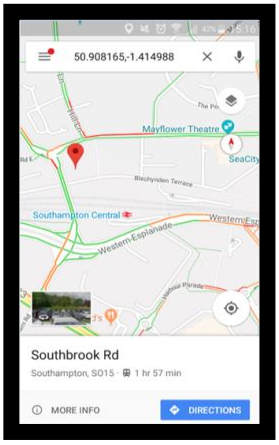
How to set up the diffusion tubes

- Have you got your **monitoring sheet** ready?


diffusion tube monitoring record

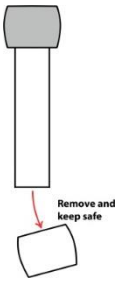
Customer | Email
Address | Fax
Phone
Report No. | Booking in No. | Date of Receipt
Customer Account No. | PO No. | Type of Tube
Depatch Note No. | Date of Despatch
Volatile and Semi-volatile Organics
Analysis | Reporting

- **Firstly**, stick one of the bar code labels onto the tube, and the corresponding one onto the monitoring sheet.
- Add information to the monitoring sheet about **location** of the tube's address and its **coordinates**, as well as filling in the **start date and time**
- To find the coordinates using an **Android** smart phone, **press and hold on your location in Google Maps**. The coordinates will be in the search bar (see image).



- To find the coordinates using an **IPhone** smart phone, Make sure that **Location Services and Compass is ON**. **Open the Compass app.** The coordinates will be displayed below (see image).

Next you will need to put your diffusion tube in place:



Step 1: Remove the white cap

- **Don't lose the white cap!** Keep it safe. You need to replace it at the end of the two weeks.

Step 2: Fix the tube to the wall

- Depending on the type of holder, either push the tube into the black plastic fixing clip, or push the tube into the fixing ring and place in holder
- Peel off the red patch on the back of the fixing clip and stick to the surface (lampposts work best!).
- Additional string or zip ties may be used.
- Safety should be an important consideration when placing tubes at height or near to roads.

Figure 3-2 Examples of right and wrong ways to expose diffusion tubes

Collecting the diffusion tubes

- **Collect** the tubes **after two weeks**.
- Make sure you have the **white caps** and **monitoring sheet with you**
- When you have found the tube, first **close** the tube with the **white cap** and then remove it from the plastic fixing
- On your monitoring sheet **record the date and time** that the cap is replaced
- Record details of **tube condition under** 'Other information' (Dirt? Insects? Dislodged?) Has anything changed in the area?
- As soon as you can (ideally on the same day), send the tubes along **with the completed monitoring form** in a **padded envelope to Gradko** with the **track and trace option**. If can't send the same day, please **place the tubes in a fridge** to send on when you can.

Address: Gradko International Limited
St. Martins House
77 Wales Street
Winchester
Hampshire SO23 0RH

- **Keep your receipt** and invoice LSx for the cost of postage.

Accessing DEFRA monitoring data

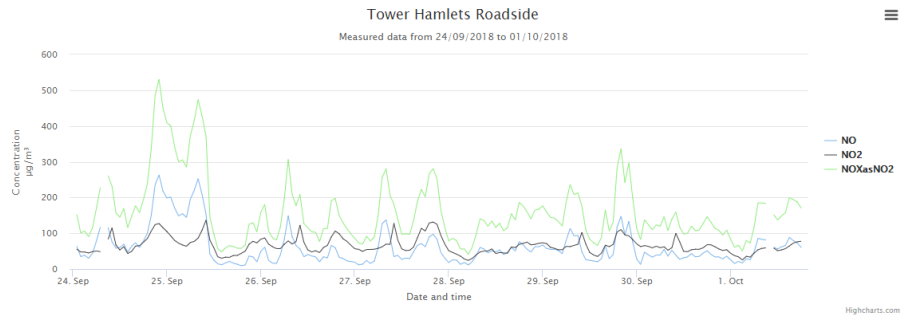
These experiments are with low cost sensors. Do you want to see the official data that is used to check whether we are compliant with UK and EU legislation?

You can access the official data from the DEFRA AURN station at Tower Hamlets

The data selector page allows you to select a time period for the measured pollutants (NO, NO2 and NOx) and you can download the data or show it as a graph. There does not seem to be any PM2.5 data. Try Marylebone road for an example of a central London station or North Kensington as a background urban station.

UK AIR
Air Information Resource

Search



Tower hamlets NO and NO2 data timeseries you can compare your data to

Marylebone road air quality station

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