Content: "Measuring yourself" guidelines

Content

I. KNOWLEDGE

1. How do you proceed?

Before you start a scientific project, you need to know exactly what you are getting into. Start from a good **research question.** To do this, you need to immerse yourself in the subject matter. Search the internet (watch out for unreliable sources) or contact (experience) experts. Pay enough attention to this step, because it will make or break the rest of your project.

a. Pollutants

What aspect of air quality do you want to measure and why? There is no such thing as a single unit of measurement for 'air quality'. Different pollutants, so-called pollutants, each have a different effect on our health. Some substances also have an impact on the environment. For example, NO2 plays an important role in the acidification and eutrophication of soil and water. And in addition, it reduces biodiversity in natural areas.

In this project, we mainly work around **particulate matter** (PM) and **nitrogen dioxide** (NO_2). These pollutants have a major impact on our health and are quite easy to measure.

b. Sources

Traffic, agriculture, industry and the wood stove in winter: all these activities make the air you breathe every day contain pollutants.

It is important to decide beforehand which aspect of **air quality** you want to measure in your area,. For example, choose NO_2 measurements if you want to find out the contribution of traffic, or measure particulate matter if you want to know the impact of wood-burning stoves in your neighbourhood.

2. Check your local situation

Look at the situation in your neighbourhood before you start your research. What info is already available? Did one of your neighbours happen to take measurements during the Curious Noses project? You might find the answer to your question in detailed **computer models** or in the official measurements of Flanders or the Netherlands.

Does your neighbourhood have a high or just very low concentration of a pollutant? This will help determine which approach you choose. To draw up an interesting search question, it is best to know the **patterns** in air quality in your neighbourhood.

Do you want to compare two specific places? Or rather do you want to investigate the evolution of air quality in one specific place?

3. What factors influence air quality?

A lot of factors influence air quality. The concentrations of particulate matter and other polluting particles often vary widely in place and time. The type, distance from the pollution source and weather conditions also help determine how much particulate matter is in the air.

a. Surroundings

Where you measure has a big impact on **what** you measure. The closer you are to the pollution source, the more pollutants you find in the air. Besides the wind direction, the width of the street and the height of the buildings also play a role. In a ***street canyon***, a narrow street with tall buildings, the air is trapped making it worse diluted. Open space between buildings provides **ventilation**, reducing the accumulation of air pollution. Soundproof walls, hedges and large trees also influence ventilation.

Tip! *Ask yourself the question : "Are my measurements representative of the period and environment I want to make a statement about?". If you want to know the air quality for a larger area, take the measurement in a reasonably open place. Want to measure concentrations in a* street canyon*? Then don't hang your measuring instrument in a semi-enclosed cubicle or room.*

b. Types of pollution sources

Fine dust consists of two types of pollutants.

Driving a car or lighting the barbecue are examples of combustion processes that directly release pollutants. These are the so-called **primary pollutants.** Even the wear of car tyres and brakes produces polluting mineral dust. As does **resuspension**, by the way, the phenomenon in which dust particles are resuspended by traffic.

The story of **secondary pollutants** is a bit more complicated. These are created by chemical or physical reactions in the air. Organic compounds (e.g. alcohols or sugars) or gases such as ammonia (NH_3), sulphur dioxide (SO_2) and nitrogen oxides (NO_x) react with each other and form new pollutants. Existing dust particles can also clump together to form larger particles. The formation of secondary dust is highly dependent on weather conditions.

> Did you know that *particle transport is very complex? The* ***largest particles*** *(10 micrometres and larger) usually fall down close to the pollution source because they are quite heavy. Only in strong winds or at high altitudes do they sometimes end up thousands of kilometres away, think of the Sahara sand that occasionally colours our cars yellow. The smallest particles, the* ***ultrafine dust****, then quickly coalesce into larger particles, so they too are mainly found close to the source.* ***Particles about 1 micrometre in size*** *in particular float longest in the air: the wind transports them sometimes hundreds of kilometres away. After all, they do not clump together quickly like the smallest particles, nor are they as heavy as the largest particles.*

c. Weather conditions

Weather conditions have a lot of impact on the concentration of pollutants in the air. Therefore, keep good records of what the weather was like during your experiment. This will make it easier to see the difference between local air pollution and a general **smog episode** later on. If necessary, take a look at the website of the Flemish **RMI** or the Dutch **KNMI** for real-time or past measurements.

Note here:

- **Wind strength** - Is it windy? Much more likely to breathe cleaner air. High wind speeds dilute pollution. In low winds, pollutants accumulate and localised emissions linger longer.

  > Did you know that *the wind carries certain substances with it over considerable distances? So we sometimes gift pollution we produce in our country to our neighbours. And vice versa, of course.*

- **Wind direction** - Air reaching us over the Atlantic tends to be less polluted than air from central Europe.
- **Rain** - A brisk shower washes pollution out of the air. After a rainstorm, you usually find little fine dust in the air. Conversely, dirt actually accumulates during long droughts.
- **Sun** - The amount of sunlight and temperature also play a role. Under the influence of UV

light in sunny and warm weather, ozone is created by the air pollution present. This is bad for our lungs and airways, and even for plants.

- **Humidity** - High humidity speeds up a lot of chemical reactions. Thus, mist droplets act as chemical factories for secondary pollutants.

d. Time

Concentrations of pollutants sometimes depend heavily on when you measure.

This is the case during peak hours that create higher concentrations of polluted air. An inversion **layer** can also form in the atmosphere at night or during the day. Then a warm layer of air lies like a blanket over a cold layer of air. As a result, smoke plumes do not rise beyond the warm layer. The smoke then spreads horizontally, creating **smog** in the lower layer.

> Tip: *Want to measure the impact of certain sources? Then keep in mind* ***daily and weekly patterns.*** 4. How do you ensure good quality of your measurements?

Check whether your set-up is **feasible in practice**. Do you have the time, resources and any permits to implement everything correctly? For example, you cannot just hang your measurement infrastructure from a lamppost.

Conduct a **test experiment**. This way, you often discover small areas of improvement and predict potential problems.

Follow everything carefully, regularly check if your setup is still working and note any information that might impact your research, such as weather conditions or works on your street.

Process your data. Check all data for outliers and calculate daily or monthly averages. In certain cases, it is best to adjust your results based on official measurements. This is called **calibration**. Only then can you reliably compare your results with other measurements.

Bundle your results. Add any graphs or figures. And discuss everything with your fellow researchers. Have you answered your research question? Do the results match those of others or your expectations? No? Then ask yourself what caused it.

> Tip: *An unanswered question does not mean that your research made no sense. In science, you sometimes learn more from things that don't work than from things that do*

work.

4. Getting started with your results

Time to interpret your data. That is the last and sometimes most difficult step.

If you have followed our tips meticulously, you will have a logbook lying around in addition to your measurement results and know the measurements of official measurement sites.

a. Visualise your data

A **visualisation** expresses your measurement results in images and helps you interpret your data. It is often a good way to share your results with others. You can show your results using different types of figures.

- **Boxplot** - This is a figure that simplifies the distribution of your measurement values. The 'box' shows the middle 2 quartiles of your dataset and thus contains half of your measurement values. Usually it also shows the mean or middle value within the box. *This allows* you to check which concentrations occurred frequently and which were rather exceptional.
- **Time plot** - This **dot plot** displays concentrations as a function of time. You can immediately see when air quality was good or bad.
- **Scatter diagram** - This point diagram compares two measurement methods. It is a way of comparing two datasets Think of measurements from two sensors, or official measurements versus your own dataset.

b. Analyse your data

The Flemish Environment Agency (VMM) has developed a data portal where you can automatically compare your particulate matter data with official measurements. RIVM has a data portal for the pollutants PM, NO2 and NH3.

The free software package 'R' and the OpenAIR' module are also useful working tools. With OpenAIR, for instance, you can use 'pollution boxes' to discover where most air pollution comes from, automatically create daily, weekly and annual graphs , and much more.

It does take some time to learn to work well with this programme.

c. Interpret your results

Was your experimental design appropriate to answer your research question? Ask yourself the following questions:

- Did I measure in the right place?
- Have I measured long enough?
- Was the quality of my measurement method sufficient to answer my question? Is my measurement period representative of the period I want to make statements about?

Did you know that *in some cases it is okay to compare annual and monthly averages? That can be done by* ***scaling up or extrapolating****. That calculation is relatively simple. For example, we did this for the Curious Noses project. That ran in the month of May, but the researchers used the measurements to estimate values for a full year. This was possible because the VMM has an extensive monitoring network that has been measuring continuously for years. By looking at the average ratio of the average in May and the annual average, they were able to extrapolate the May values to an average of the past 12 months.*

Of course, this ratio was not identical everywhere, but all in all, the differences were at most a few micrograms per cubic metre. This still allowed the researchers to compare the 'indicative annual averages' with the World Health Organisation's advisory values.

Such an approach takes much less time and money than measuring for a year, but you do pay a price because your result is slightly less accurate.

Tip: *Do not simply compare an average value of one month of your choice with the values of another month or an entire year. After all, concentrations fluctuate throughout the year, depending on sources, weather and seasons.*
Therefore, be extra careful when comparing your measurements with the European Union and World Health Organisation limit and advisory values.

For your information: *How do you convert your result from a NO2 sampler to a 12-month period?*

You can do this using the official readings from the VMM or the Dutch RIVM.

1. First, calculate the average of several VMM measurement sites during your own measurement period.
   - *For example, your sampler gives an average of 30 µg/m³. Suppose: during your measurement period, the VMM devices gave an average of 25 µg/m³ .*
2. Compare that average with the average for the past 12 months for those same monitors.
   - *Over the past 12 months, for example, VMM devices recorded an average of 28 µg/m³.*
3. The ratio between those 2 figures is your 'extrapolation factor'.
   - *The extrapolation factor here is 25/28=0.89. This means that the concentration of nitrogen dioxide during the measurement period was 11% lower than the average for the previous 12 months.*
4. Apply this calculation to the averages of your samplers. This is your indicative annual average.
   - *Now dividing your average (30) by 0.89 you then obtain 33.6 µg/m³ as indicative annual average.*

This way, you can largely capture the influence of the weather during your measurement period. This is especially useful if the weather during your measurement period was a bit unusual.

Consider, for example, lots of rain or wind (very good for air quality) or, conversely, long periods of smog or windless weather (very bad for air quality).

II. FORMULATE YOUR RESEARCH QUESTION

1. What do you want to determine, and why really?

Ask yourself these two important questions; they will guide your research.

- **What do you want to determine**? A possible example is: "I want to know about the air quality in my street."
- **Why do you want to know**? "Because I am concerned about air pollution in my street"

2. How will you determine that?

Decide what **type of** research you want to conduct:

- **Comparison**: e.g. 'Is there a difference between the air quality at the front and back of my house?"

- **Description**: e.g. "What pollutants am I exposing myself to?"

- **Review**: For example. "Is a certain limit being exceeded?"

3. Where and when?

Put limits on yourself.

- **True**: For example, "I measure in my street."

- **When**: For example, "In the winter months, because that's when people use their wood-burning stoves more."

4. Your research question

Use the answers to the what, how and where questions to formulate your precise research design. For example:

- "I want to conduct a **comparative** (= type) study. What is the impact of traffic-free making my School Street (= where)?"

OR

- "I want to carry out a **review** (=type) study. What is the **current** (=when) air quality **in my street** (=where) compared to the average air quality in Flanders?"

III. YOUR EXPERIENCE

1. What do you want to measure?

Before you start measuring, you obviously need to know *what* you are going to measure. To do this, look again at your research question**.** Which **sources** are important for your experiment? What pollutant does the source emit? For example, the concentration of nitrogen dioxide (NO_2) is a good indicator of traffic pollution. Do not underestimate the influence of weather conditions. Therefore, check whether data from a weather station are available, such as precipitation, temperature, wind speed, wind direction or relative humidity. If not, it is best to keep an eye on the weather yourself. So keeping a **logbook** is a great idea.

2. Specifically, where do you want to measure?

Of course, you don't go measuring just anywhere. Depending on your research question, some locations are simply better than others. Are you measuring air quality at your home, for example? Even then, you have to decide whether to measure in your garden or at your front door.

We'll give you some tips in advance:

- **Measure downwind** to correctly estimate the maximum impact of a source. If you want to investigate the net effect of a particular source, it is best to also measure windward of the source. Then calculate the difference between the two measurements.

  Did you know that in Flanders, the most common wind direction is *southwest*? *Therefore, in open environments, it is best to measure northeast of the source. In* street canyons*, there are no general rules because wind patterns there are more complex. Sometimes measuring on different sides of a* street canyon *can even give differences.*
- **Avoid very local sources** if you want results that are representative of a larger area.
- Are you measuring your personal exposure? Then do so at a spot representative of the air you breathe. Best at your own **body height**, in other words.
- Ensure a **free flow of air** around the opening of your measuring device. It is best to measure at breathing height, but to avoid vandalism you can also place the device a few metres higher.

3. When do you want to measure?

Think carefully about *when* you want to measure. The season, the day of the week, the exact hour, everything has its influence. For instance, fewer cars drive on weekends during peak hours and people rarely light the wood stove in summer. Ask yourself the following questions to determine during which period you will measure, for how long and at what times:

- Do you expect higher values of the pollutant in a particular season?
- Do you expect fluctuations in concentrations according to the days of the week?
- Do you want to measure peaks, or rather averages over a longer period?

4. How do you want to measure?

There are several ways to measure air quality. Measuring devices vary in price, quality and ease of use. Which device you need again depends on your research question and the corresponding active or passive measurement method.

a. Active method: sensor

If you check the air quality at different times in one day, preferably use an **active measurement method**. For this, you need a **sensor**. Such a device gives new readings every second or minute. To read these data, you often need a computer. As this gives you a lot of data, you can usually interpret in more detail.

b. Passive method: measuring tube/sampler

If short-term differences are not important for your research, a **passive measurement method** will suffice. Here, you collect pollutants with a **measuring tube/sampler** during a certain period. At the end of that period, you get one value. Because you collect less data, the processing time is shorter and usually requires less computing power. Passive measurement methods work without power and are often cheaper for short measurement campaigns. A disadvantage, however, is that your results are not immediately available because specialised labs have to process the tubes.

5. Take care of your measurement

By now, you know what, where, when and with what instruments you want to measure. But how you measure - and especially how carefully - also influences the quality of your research. Therefore, always carry out a thorough **quality check**.

> Tip: ***Documenting*** *your experiment well helps guarantee the quality of the result. Write down your steps and observations. Take photos or make drawings of your experiment. Also make a note of the* ***weather conditions.*** *Add the report of your findings to your measurement results.*

What should you look out for in a quality check? We give a simple example based on a temperature measurement:

- Check that your thermometer measures with sufficient **precision**, for example to measure small temperature differences (0.1 °C).
- Check that your thermometer measures **correctly** (check **calibration**). For example, does it indicate the correct temperature of 100 °C in boiling water?
- Check that your **experimental design** is **correct** (***experimental design***). Is the thermometer hanging in a place with a relatively constant temperature, e.g. not directly in the sun? This obviously depends on your research question.

a. Precision of your measuring instruments

If you want to test how precise your measuring instruments are or check whether they work properly, measure simultaneously with two, three or more instruments of the same type. Do they all give the same result? Then your measurement is precise and reproducible. This means that your result is accurate and you get the same result for the same measurement. If so, you can move on to the next step. If not? Then see if you can use another instrument, or at least take it into account when interpreting your results. Either way, always state your margin of error.

> Caution! Some sensors exhibit **drift.** This means that their sensitivity varies according to time or conditions. In addition, they can also suffer from **interference**. For example, most cheap particulate sensors have difficulty distinguishing between fog and fine dust, so they will often seriously overestimate the concentration in humid weather.

b. Correctness of instruments

Want to know if your instruments are measuring correctly? Then you should first compare them with measurements that you are sure are correct, i.e. a standard or reference. For example, use an official measurement from the VMM to **calibrate** your instrument.

For example, a sensor or sampler can be very precise but systematically measure higher or lower than the *true* value of air pollution. In that case, you don't have to throw your measurements in the trash, provided you convert or rescale them to the correct values. In your project, you then note the deviations from the standard in a correction table. When processing your final measurements, you offset your values against these correction values.

Also keep in mind that the accuracy of your instrument may vary over time. We therefore recommend checking the accuracy regularly.

Check **variability**: by choosing the most appropriate **time interval** between measurements (every second, minute, 15 minutes) you make it easy on yourself. For instance, a short time interval may give you more information, but it often means more noise on your measurements and more data storage. So do a mini-test first: perform an increased number of measurements (i.e. at shorter time intervals) over a certain period of time. That way you can see how hard your data vary and whether you just need more or fewer measurements for your specific study.

c. Detect outliers

After your measurements are done, it's best to go through your data with a critical eye. Are there measurements that give strange results or deviate significantly from your entire measurement set? Sometimes it is necessary or desirable to remove non-representative measurements, so-called *outliers*, from your dataset. You can only do this if you also have a good reason to do so: a problem with your experimental design,
an electronic problem with your sensor, or even an exceptional phenomenon. An example of such a phenomenon is that demolition works happen to be taking place in your street when you just want to measure traffic-related pollution. Chances are that the dust development skews your figures. Or maybe foggy weather caused a disturbance. Necessary to investigate such things before drawing conclusions from your data.

If you take these tips to heart, your experiment is sure to yield useful results. Get started and do your bit for better air quality! Still have questions? Contact samenvoorzuiverelucht@vmm.be