OSU Lichen Group.

Students of LSU School London

Speak to me, lichen

How clean is the air?

We are students at La Sainte Union Catholic School in north London. For our Silver CREST Project, we explored the relationship between levels of the pollutant nitrogen dioxide (NO_2) and the distribution of indicator lichens in the vicinity of our school.

Lichens are indicators of changes in air quality; tolerant species replace those sensitive to a given pollutant. This effect is observed across urban and rural Britain, especially in regions where oxidised and reduced forms of nitrogen are present. NO_2 is the dominant air pollutant in urban areas, due to pollution from road traffic. Therefore, measuring levels of NO_2 can indicate the quality of our town air.

Key words
air pollution
lichen
quadrat
identification

What lichens can tell us

Lichens are composed of two different organisms living symbiotically; fungus and alga. They absorb atmospheric moisture, rain water and minerals over their entire surface area. This makes them extremely sensitive to atmospheric pollution (such as NO_2) and therefore very good biological indicators of levels of atmospheric pollution. Lichens can be placed into three categories:

- Nitrogen-sensitive; found in clean, non-polluted conditions
- Intermediate; found in clean AND polluted conditions
- Nitrogen-loving; found in conditions where levels of nitrogen dioxide are particularly high.

Two lichen species: Parmelia sulcata *is nitrogen-sensitive, while* Xanthoria parietina *is nitrogen-tolerant.*

We monitored NO_2 pollution by placing NO_2-diffusion tubes at different sites (see below) and mapped the distribution of lichens on trees at different locations along and either side of Highgate Road.

For a guide to identifying lichens, see Identification on the OPAL website: www.OPALexplorenature.org.

Our hypotheses were:

- The concentration of pollutants would be highest along the main road (Highgate Road).
- There would be a correlation between data from the NO_2 diffusion tubes and lichen distribution.
- Information from the Camden Air Monitoring website showed us that air quality is poor in our borough, Camden: in 90% of locations, NO_2 levels exceed the Air Quality Standard.

Method

Learning to identify lichens: We started identifying lichens on twigs using keys. We then surveyed the trees on the Heath with the help of lichen experts Pat Wolseley and Holger Thüs of the Natural History Museum. We kept lichen samples that were authenticated by Holger as our 'reference herbarium'.

Making a ladder quadrat: We cut out a strip of five 10 cm by 10 cm squares from thick plastic of a bin-liner (see photograph).

Surveying lichens in Hampstead Heath – note the ladder quadrats

Then, for each tree:

- We recorded tree species and girth at 1.50 m above ground.
- We placed our plastic ladder quadrat on the north aspect of the trunk.
- We recorded the presence of species of foliose and/or fruticose lichens ('Macrolichens') in each square.
- We repeated on all compass points (N, E, S, W).

In this way, the presence of lichen species in 20 squares was recorded for each trunk. To check reliability we moved to a new tree every 15 minutes. Each group surveyed the same three trees and we then compared our results. When there was a discrepancy, we went back to the tree and rechecked.

Location of NO_2 tubes and trees surveyed

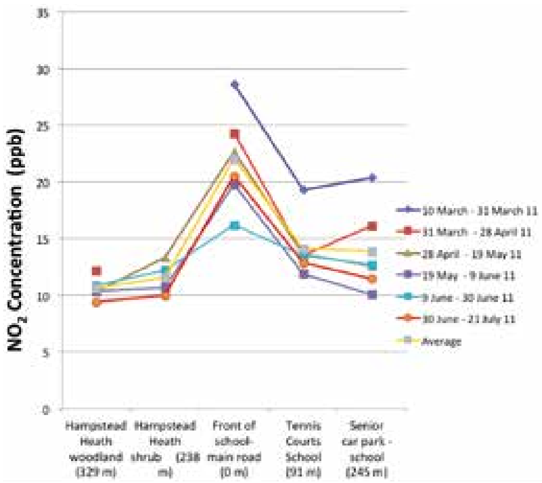
Monitoring NO_2: NO_2-diffusion tubes (Gradko International) were placed into position with the open end at the bottom to prevent rainwater collection. NO_2 in the air diffuses along the tube and is absorbed by a fluid on a grid in the lid. The tubes were replaced every three weeks and sent off to be analysed. The concentration of NO_2 was determined by spectrophotometry.

What we found

This graph shows the relationship of NO_2 concentrations and the locations. Perhaps we should have used a bar chart because our independent variable is categoric, but line graphs made it easier to see trends.

The values for the front of the school (the main road) were highest.

The first set of data (10 March – 31 March 11) showed higher values than the rest. More people may have driven to work due to the cold weather, and there is less movement of air so the local concentrations of the NO_2 would remain high.



This graph shows the nitrogen dioxide concentrations at different locations from 10 March – 21 July 2011 (corrected for blank readings); ppb = parts per billion

Macrolichen diversity

The table shows what we found when we looked for a correlation between the NO_2 and lichen diversity. Nitrogen-loving lichens were found on all the trees sampled, but a greater diversity of macrolichens including more 'intermediate' lichens, were found on the Heath. We might have expected a wider diversity of lichens on the fruit trees in the Orchard as they are set back from the road.

	NO_2 concentration (ppb)	**Average number of different lichens per tree**
Hampstead Heath	11.1	9.7
Orchard	14.1	4.0
Highgate Road	22.0	4.5

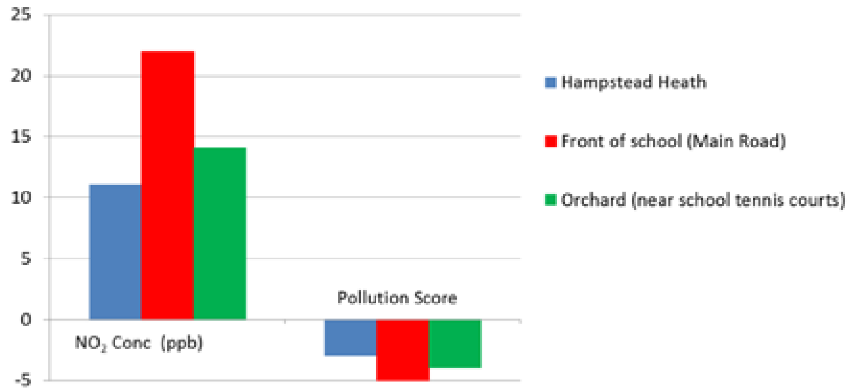
However several factors may have affected lichen results, e.g:

- bark pH (related to tree species)
- age of tree
- proximity to sources of nitrogen (e.g. fertiliser)
- immediate surroundings of tree (e.g. hedge)
- shading of the orchard by the surrounding buildings.

We then calculated a pollution score based on the frequency of nitrogen-loving and nitrogen-sensitive lichens. Nitrogen-sensitive species counted +1 as they will not tolerate polluted air. Nitrogen-loving species counted -1 each as they grow in polluted air.

The bar chart shows the correlation between the NO_2 concentration and the pollution score (derived from the lichen data). The pollution score was minus 5 at the front of the school (on Highgate Road) where the NO_2 levels were highest, while the pollution score was minus 3 on Hampstead Heath where the NO_2 levels were the lowest.

Given more time, we could have measured NO_2 levels and surveyed trees on the back roads and also deeper in Hampstead Heath away from the traffic. We could also have looked at lichens on twigs because this would have provided more recent history of lichen growth and air pollution.



Madeleine A., Mary D., Maureen L., Connie M., Isabel S., Linnet M., Hannah R., and Siobhan P. were Year 10-11 pupils at La Sainte Union Catholic School in Highgate, London, at the time of this research. Their project was exhibited at the Royal Society's annual Summer Science Exhibition.

	Indicator lichens								Total pollution score
	nitrogen-loving species					nitrogen-sensitive species			
Location	*Xanthoria ucrainica*	*Xanthoria parietina*	*Xanthoria polycarpa*	*Physcia adscendens*	*Physcia tenella*	*Evernia prunastri*	*Flavoparmelia caperata*	*Parmelia sulcata*	
Orchard	-1	-1	-1	-1	-1			-1	-4
Highgate Road	-1	-1	-1	-1	-1				-5
Hampstead Heath	-1	-1	-1	-1	-1		-1	-1	-3

What are lichens?

Lichens consist of at least two organisms - a fungus and a photosynthesizing alga (a cyanobacterium) living together. In this amazing association both the fungus and the alga benefit.

- The alga provides food for itself and the fungus, using its chlorophyll for photosynthesis in the same way as green plants do. The fungus does not have any chlorophyll.
- The fungus plays a vital role in providing a physical structure to shelter the alga from excess sunlight and in particular, water loss. Also, the fungus absorbs water, nutrients and gases from the environment to share with the alga.

How can we improve air quality?

Small changes in our everyday behaviour can make big differences to the quality of London's environment.

- Turn down the central heating when possible.
- Install home energy efficiency measures e.g. loft, cavity wall insulation.
- Use public transport rather than the car wherever possible.
- Walk or cycle for short journeys, instead of using the car.
- Use eco-driving techniques to reduce your fuel use.
- Ensure your car is not wasting fuel, by regularly checking oil and tyre levels.
- Avoid burning garden or domestic waste, especially in urban areas.