GLOBE Investigation

Title: An international comparative study of nitrogen dioxide levels recorded at schools in Malta and Ireland

Organization: GLOBE Ireland & GLOBE Malta

Student(s): GLOBE students at Gozo College Secondary School, Victoria, Gozo and St. Michael School, St. Venera in Malta, Kishoge Community College, Dublin and Ramsgrange Community School, Wexford in Ireland

Grade Level: 9th - 16th Grades (High School, ages 14-18)

GLOBE Teacher: Aileen Bright, Ramona Mercieca, Joseph Savona, Pauline Vella, Jane Shovlin, Matthew Butler

Report Type(s): International Virtual Science Symposium Report

Protocols: Atmosphere

Presentation Type: Poster

Optional Badges: I am a Data Scientist, I am a Collaborator, I make an Impact

Abstract

This is a GLOBE international comparative air quality investigation between four schools from the countries of Malta and Ireland that began in October 2021. Air pollution is a growing concern across the globe, in fact according to the World Health Organisation, air pollution is one of the greatest risks to health. This project is focused on measuring nitrogen dioxide, a gaseous traffic-related pollutant that is emitted from vehicle exhausts in combination with gathering GLOBE protocol atmosphere data and traffic count data from around schools. Four schools from a mix of urban, suburban, and rural areas received 3 nitrogen dioxide (NO_2) diffusion tubes each to place outside at their school for a period of 4 weeks. The tubes were placed: near a main road; at a car park/drop off location; and one in a relatively sheltered area away from traffic. The purpose of this project is to investigate local variations in nitrogen dioxide levels around schools, to demonstrate the link between traffic volume and recorded nitrogen dioxide concentrations, and to understand what other parameters influence nitrogen dioxide concentration in the atmosphere. The students observed that the NO_2 levels recorded are variable between schools and between different locations at each school. Students identified a strong correlation between the number of vehicles counted and the measured NO_2 concentrations where the most heavily trafficked area corresponds to the highest recorded NO_2 concentration. A correlation between air temperature and

sky visibility/cloud cover and measured NO_2 could not be identified. However, it was noted that more data is needed to explore this topic further. Having discovered the effects of traffic on air quality around schools, the students wanted to bring change, be agents of change and think like an engineer. They suggested ways on how to reduce NO_2 levels both at local and national level.

Key words: Nitrogen Dioxide, Traffic, Air Quality, Rural Areas, Urban Areas

Research Questions

How do nitrogen dioxide (NO_2) levels vary between four different schools?

Can we demonstrate a clear link between observed traffic volumes at our schools and measured nitrogen dioxide levels?

What other parameters influence recorded nitrogen dioxide levels?

Introduction

GLOBE Ireland and GLOBE Malta are presenting a collaborative project from 4 schools on the topic of air quality outside at schools that began in October 2021. The schools involved were following the non-GLOBE nitrogen dioxide protocol as designed by the Irish Environmental Protection Agency Air Quality Team in conjunction with the Environmental Education Unit of An Taisce, GLOBE Ireland program. The campaign is coordinated by GLOBE Ireland since 2019, over 400 schools around Ireland have participated in this project to date.

Air pollution is a growing concern across the globe, in fact according to the World Health Organisation, air pollution is one of the greatest risks to health. The topic of air pollution has received recent attention with the occurrence of the covid-19 pandemic and the increased focus on the air we breathe. The most polluted areas tend to be heavily populated cities and other urbanised areas.

The schools that took part in this project measured nitrogen dioxide (NO_2), a traffic-related gaseous pollutant that originates from vehicle exhaust emissions. The European Environmental Agency estimates that, in 2019, NO_2 alone was linked to 40,400 premature deaths (Source EEA Website). The highest levels of NO_2 are typically found closest to busy roads. There are often wide variations in local air quality going undetected that can have significant impacts on the health and wellbeing of local communities. The collection of local measurements on nitrogen dioxide can highlight NO_2 ‘hotspots’ that could be harmful to the community. By measuring NO_2, the students are collecting meaningful data that can ultimately benefit the environment.

The schools that took part in this collaborative project linked their NO_2 results to other physical parameters (e.g., air temperature, cloud observations) and traffic counts to better understand the factors that influence air pollution.

Research Methods

There are 4 school study sites, two sites in Ireland and two sites in Malta.

Study Sites - Ireland

The island of Ireland is situated in north-western Europe. Ireland's climate is generally mild with mean temperatures in winter of 4-7 degrees Celsius and mean temperatures in summer of 12-15 degrees Celsius. The strong Atlantic maritime influence brings frequent rain and wind, particularly in the west of the country. While Ireland's overall air quality is generally good by international standards it is now apparent that local air quality may not be as consistently good (EPA Air Quality report 2020).

Figure 1: Google Map of Ireland showing red dots marking Kishoge Community College, Dublin (East Ireland) and Ramsgrange Community School, Wexford (South-East)

Kishoge Community College, Dublin, Ireland

Latitude - 53.3364N, Longitude - 6.4257E, Elevation - 60.8534m

Kishoge Community College is located in a suburban area west of Dublin city. The school is surrounded by housing estates and moderately busy roads to the north and green fields and trees to the south.

Ramsgrange Community School, Wexford, Ireland

Latitude - 52.245608N, Longitude - 6.917108E, Elevation - 68.2m

Ramsgrange Community School is located in a rural area of southeast Ireland. The school is surrounded by small local roads and agricultural land.

Study Sites - Malta

The Maltese Islands are situated in the Mediterranean Sea, to the south of Europe. The Maltese archipelago has a typical Mediterranean climate with hot, dry summers and mild, wet winters. The transition between the two is sudden, but no definite time for when this occurs exists. The annual mean temperature of the Maltese Islands stands at 18.2°C with mean monthly temperatures ranging from 12.7°C in January to 27.1°C in August. Rainfall patterns show that the yearly average rainfall is considerably low at 585.6 mm. This is also unreliable, as one year can be much wetter and the next can be much drier. Like Ireland, Malta's overall air quality is generally good by international standards however, local air quality especially in densely built-up areas with heavy traffic may not be as good.

Figure 2: Google Map showing location of Gozo College Secondary School in the centre of the island of Gozo and St Michael School in centre of Malta.

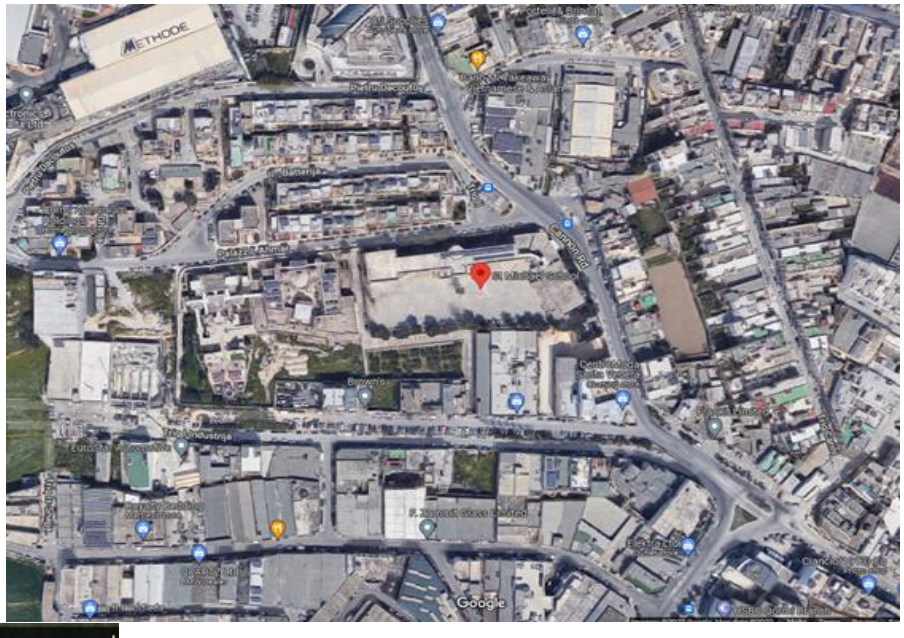
Gozo College Secondary School, Victoria, Gozo

Latitude - 36.0241N, Longitude - 14.1441, Elevation - 71m

Gozo College Secondary School is located in the north-east side of Victoria, the capital city of Gozo, sister island to Malta. The school is parallel to the main road and overlooks a secondary road which is quite busy especially during rush hours.

St Michael School, St. Venera, Malta

Latitude - 35.5315N, Longitude - 14.2825, Elevation - 40m



St Michael School is located in a highly urbanised area in the centre of Malta. It is situated along a busy road with a petrol station nearby and sandwiched between two industrial estates.

Diffusion Tube Method to Measure Air Quality

Each school received 3 diffusion tubes to place at 3 different locations around their school grounds. The tubes are mounted by teachers and students at three locations at their school: one near a main road; one at a car park/drop off location; and one in a relatively sheltered area away from traffic. The tubes are left in place for 4 weeks from October 11th until November 8th 2021. At the end of the period, the tubes are taken down and sent to a laboratory (Gradko UK) for analysis. The laboratory analyses the tubes and provides an average NO_2 (µg/m3) value for each tube for the period of measurement.

Figure 3: Setting up of one of the diffusion tubes at the main entrance point of Gozo College Secondary School

How do the Diffusion Tubes work?

Diffusion tubes are small plastic tubes with a cap at each end one of which is coloured. Under the coloured cap is a steel mesh disc which is coated with triethanolamine (TEA) a chemical that absorbs nitrogen dioxide. When gases pass over this mesh the chemical changes. This chemical change tells us how much nitrogen dioxide was in the air during the monitoring period. (Figure 4). The tubes were left in place for a period of 4 weeks at each school.

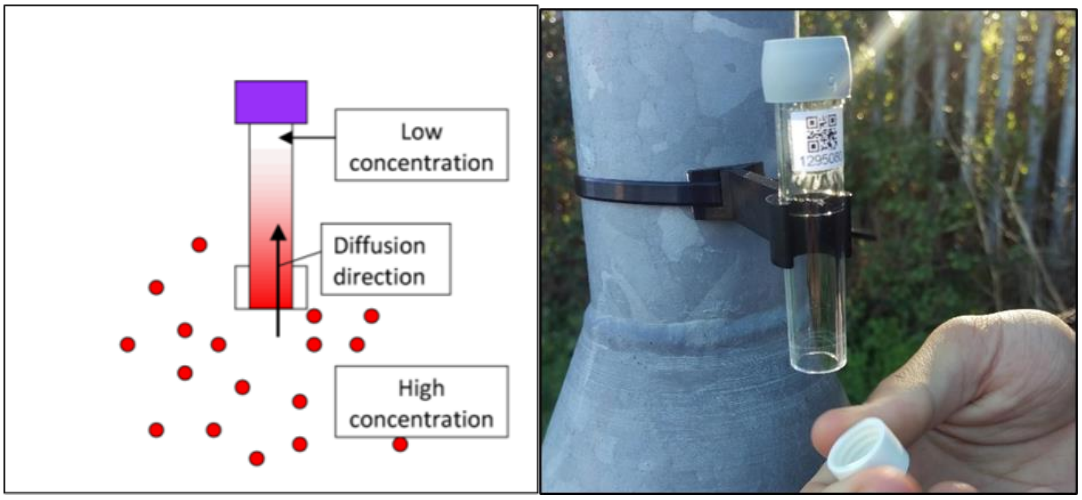


Figure 4: Diffusion tube drawing showing process of diffusion (left) and installed photo of diffusion tube (right). https://www.gradko.com/environmental/

- GLOBE Cloud Observation Method
- GLOBE Air Temperature Method

During the 4-week observation period the students measured the air temperature, observed cloud cover using the GLOBE Observer App and described the general outlook of the weather following the steps of the GLOBE Protocols (GLOBE, 2014).

- Traffic Count Method

Each school conducted travel count surveys using a tally method on road(s) near their schools for short periods. Students counted every vehicle that passed for a given time period and then calculated the number of vehicles per 5-minute intervals.

Figure 5: Student from Ramsgrange Community School, making cloud cover observations.

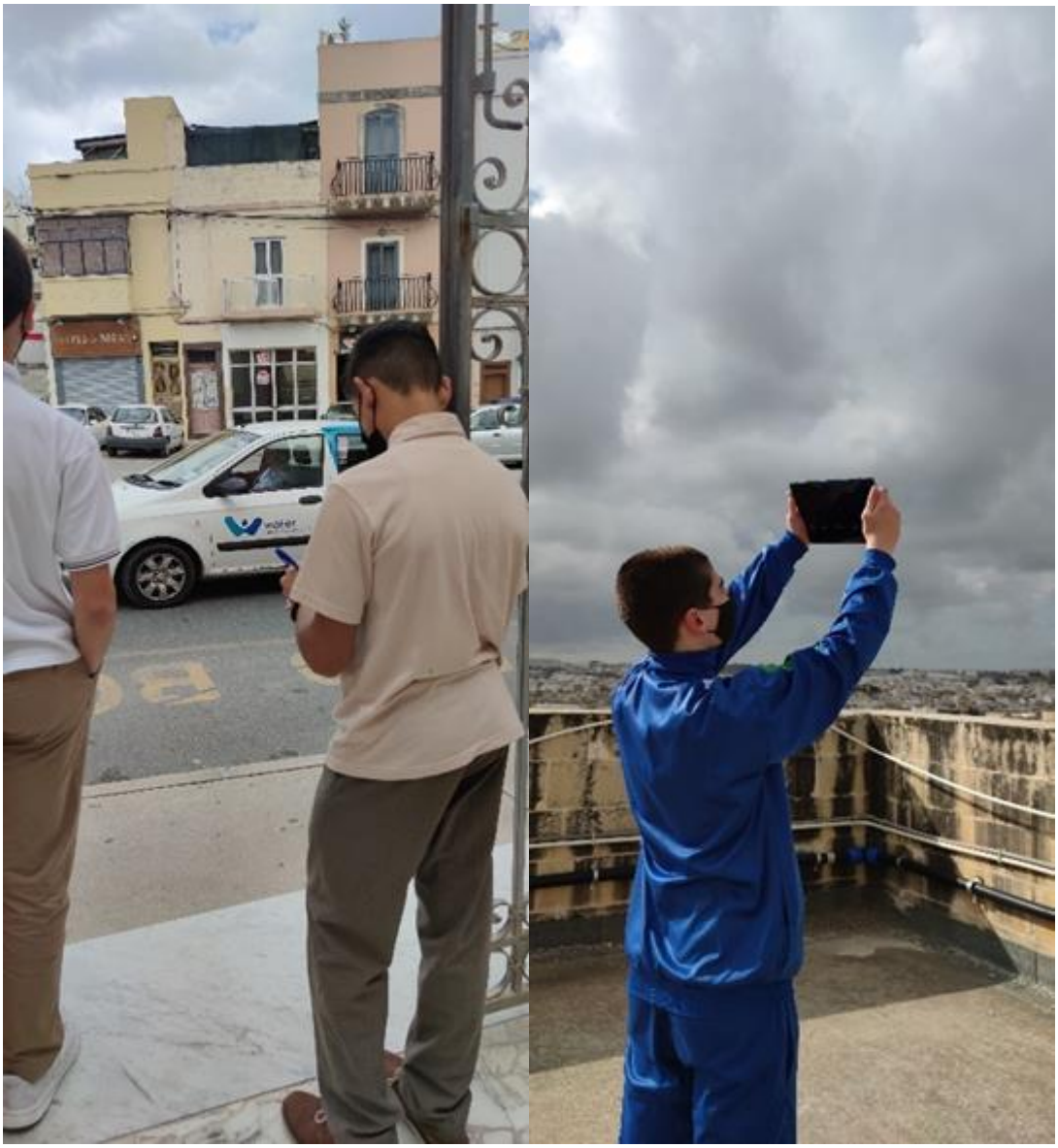
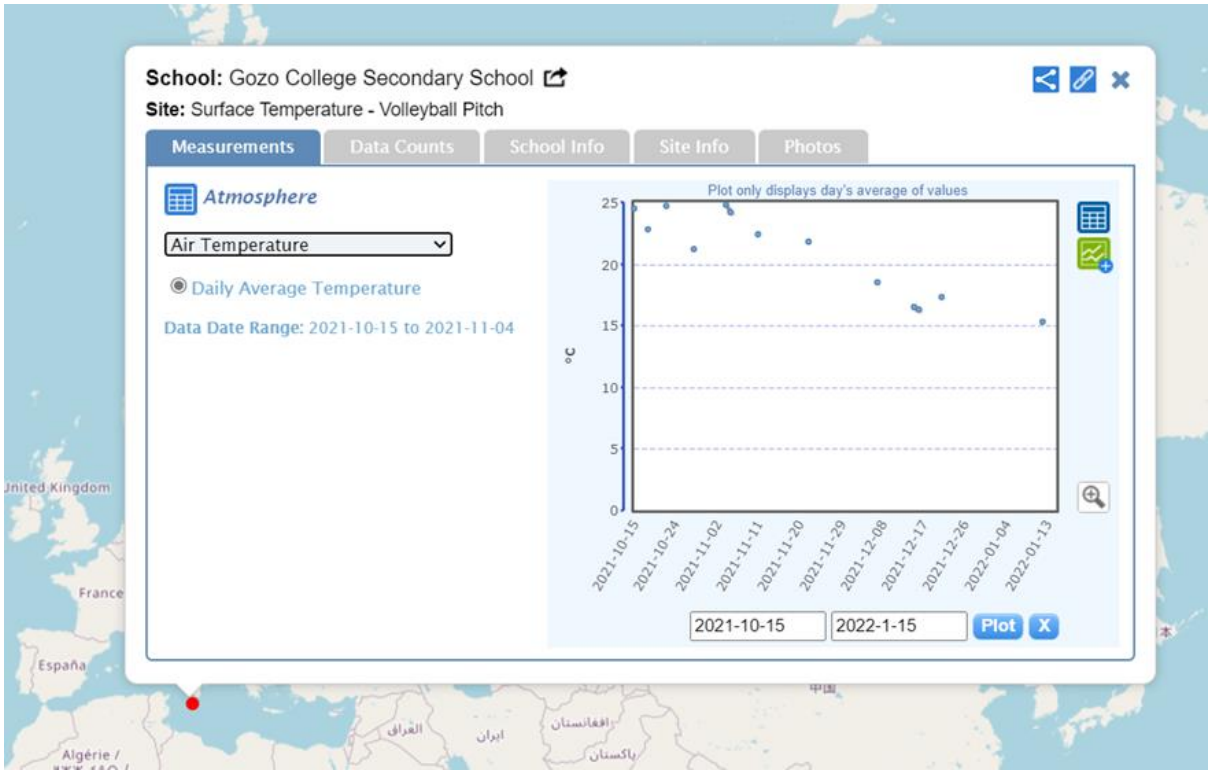


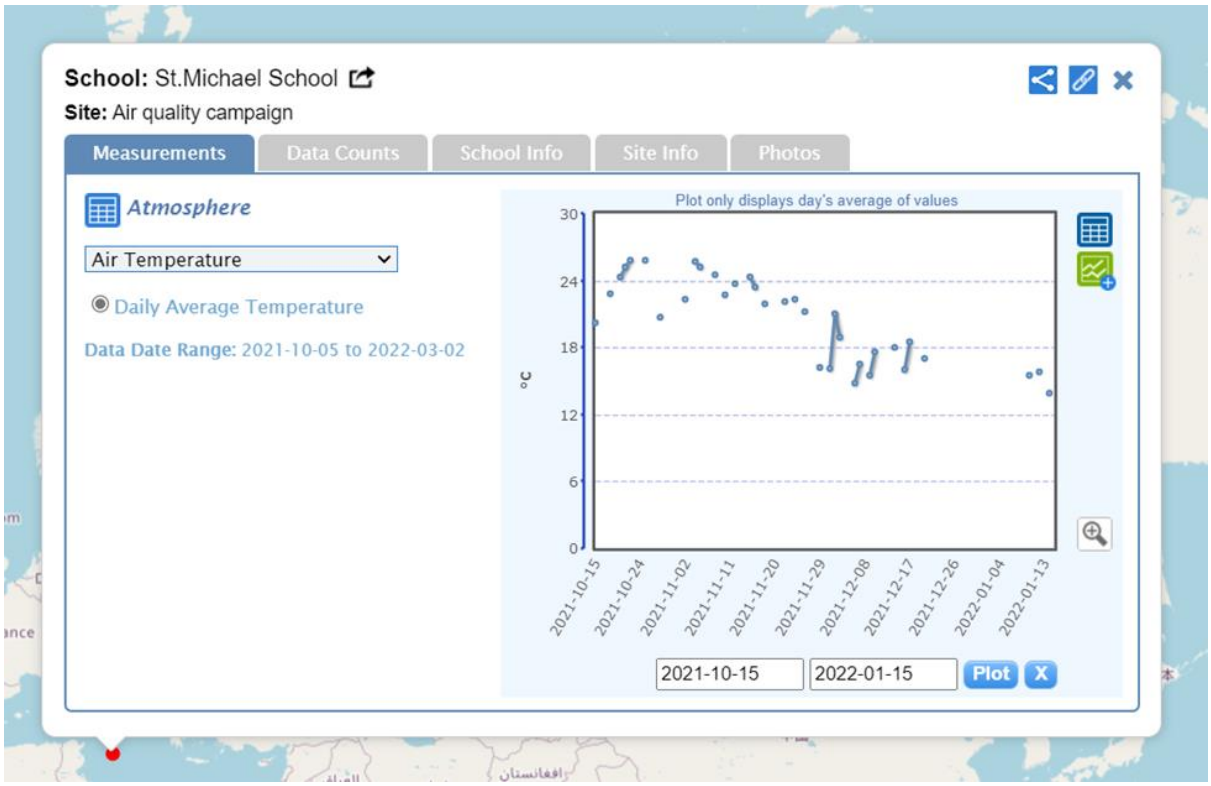
Figure 6: Students from St Michael School, St. Venera conducting traffic count and making cloud cover observations

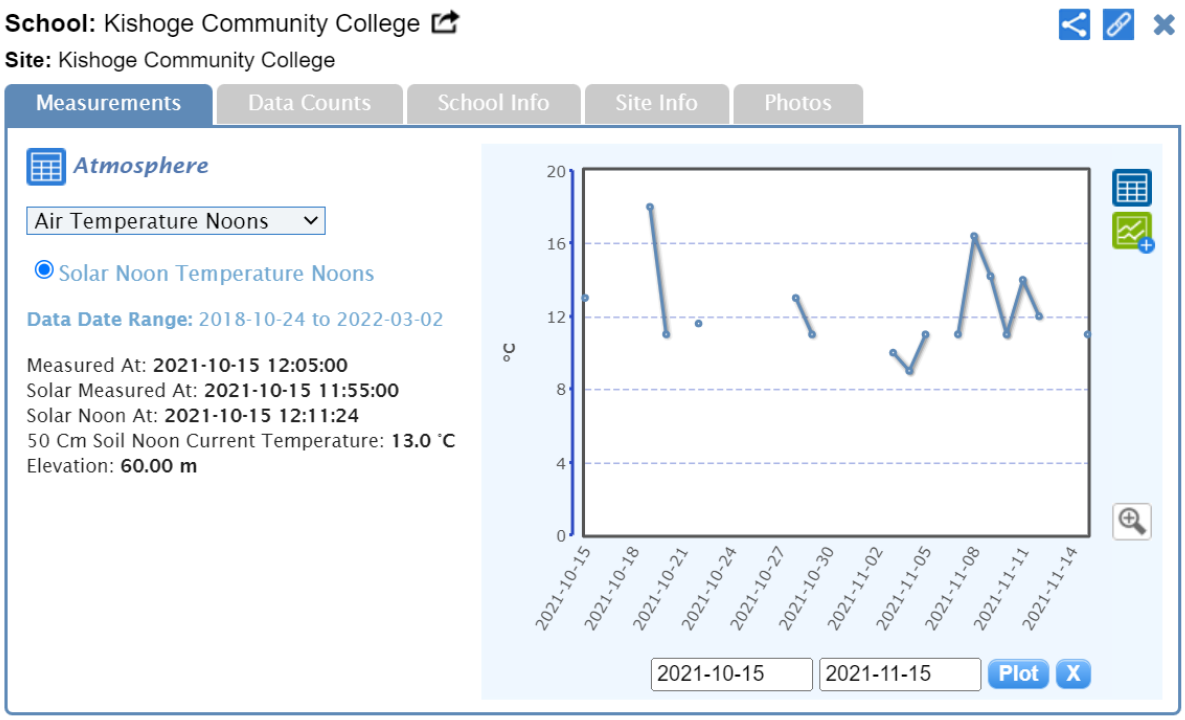
Results

The screenshots below show data uploaded on GLOBE website during the observation period between October 2021 and November 2022. Students collected daily readings of air temperature, cloud cover and type together with surface conditions following GLOBE Protocols guide.

Air Temperature






School: Kishoge Community College
Site: Kishoge Community College
Measurements
Data Counts
School Info
Site Info
Photos
Atmosphere
Air Temperature Noons
Solar Noon Temperature Noons
Data Date Range: 2018-10-24 to 2022-03-02
Measured At: 2021-10-15 12:05:00
Solar Measured At: 2021-10-15 11:55:00
Solar Noon At: 2021-10-15 12:11:24
50 Cm Soil Noon Current Temperature: 13.0 °C
Elevation: 60.00 m
°C
20
16
12
8
4
0
2021-10-15
2021-10-18
2021-10-21
2021-10-24
2021-10-27
2021-10-30
2021-11-02
2021-11-05
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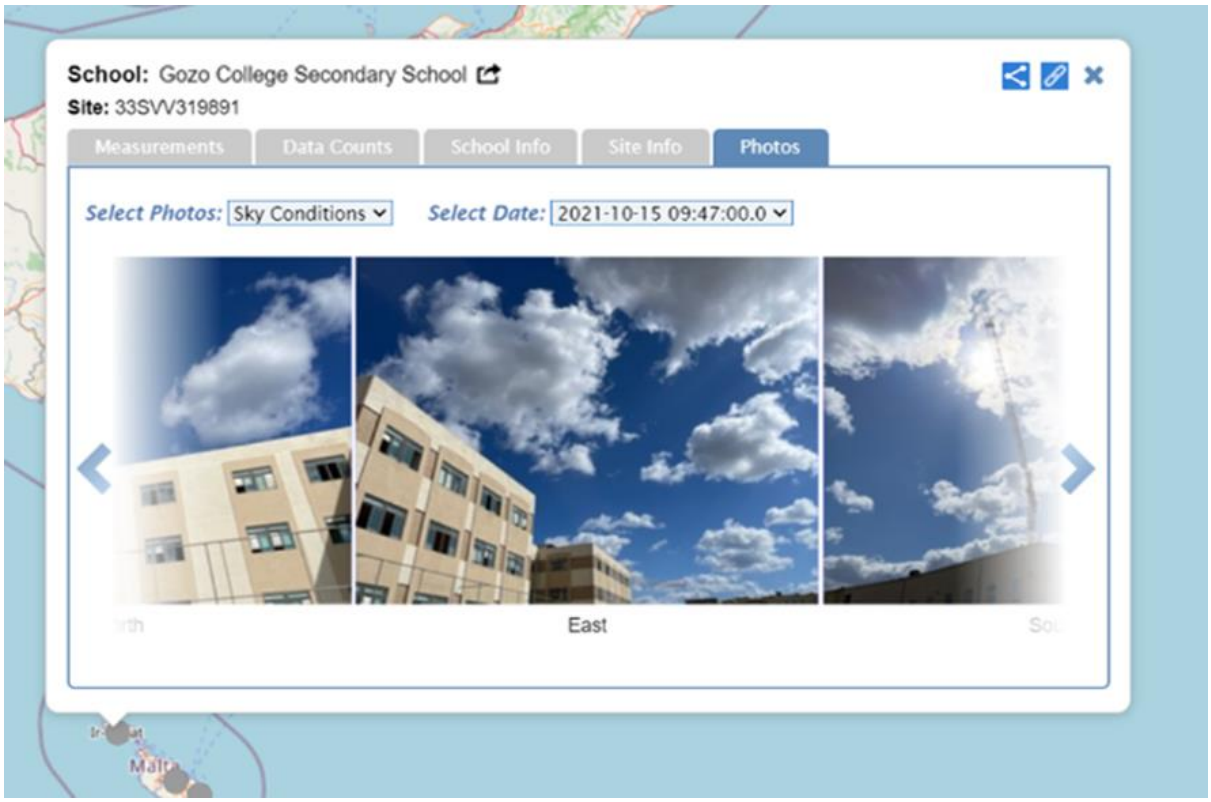
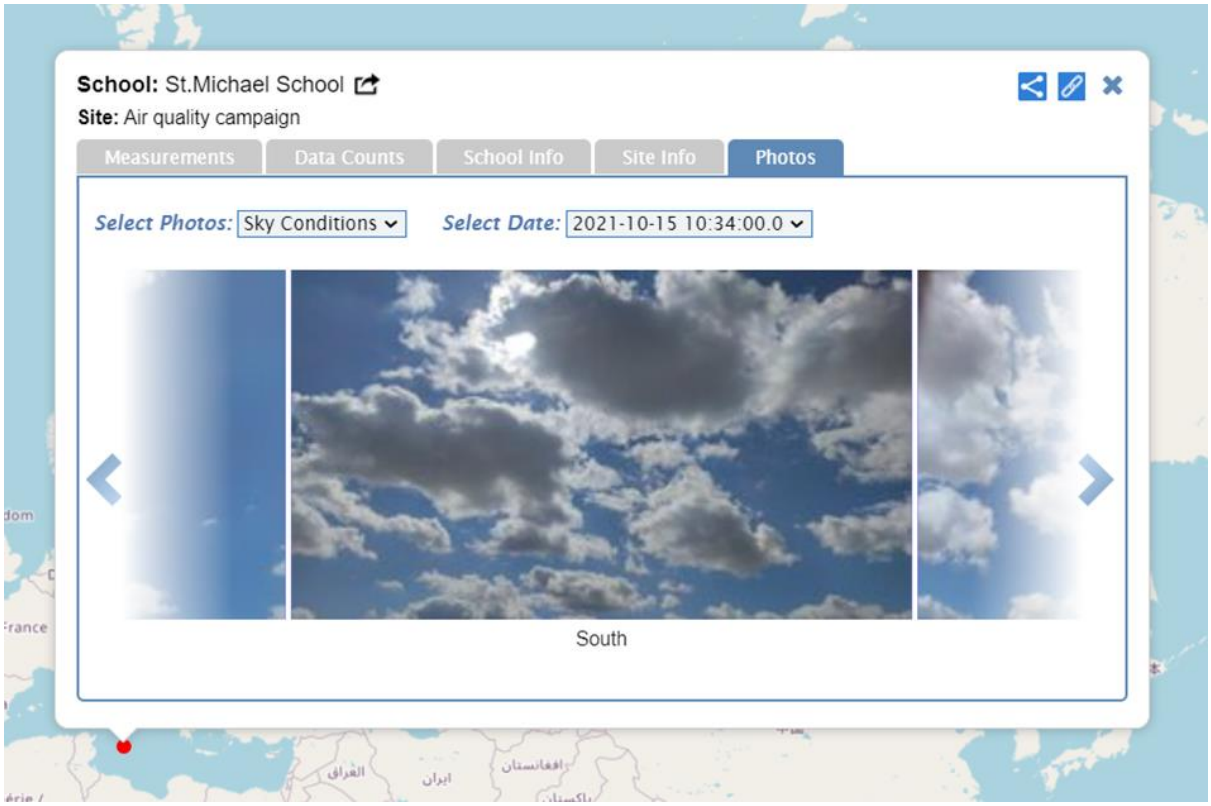
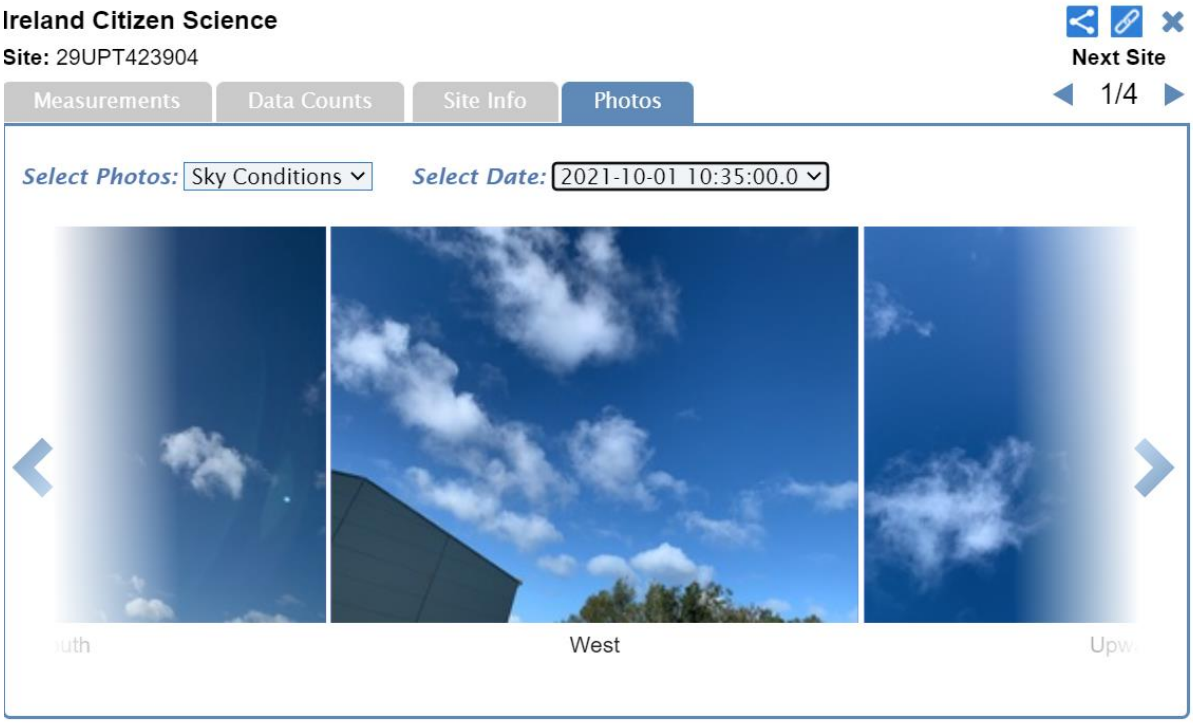
Plot
X

Cloud Cover


School: Gozo College Secondary School
Site: 33SVV319891
Measurements
Data Counts
School Info
Site Info
Photos
Select Photos: Sky Conditions
Select Date: 2021-10-15 09:47:00.0
East



Ramsgrange Community School



Traffic count at Gozo College Secondary School, Victoria, Gozo

Date	Time	Cars	Lorries	Buses	Vans	Bicycle	Scooter/ Skateboard	Idling Vehicles
11/02/22	12:00-12:20	30	23	7	16	3	1	15
15/02/22	11:25 - 11:45	90	22	12	12	6	3	0
24/02/22	13:00 - 13:20	85	15	2	12	5	0	0
25/02/22	08:40 - 09:00	98	14	1	5	0	6	1
25/02/22	11:20 - 11:40	123	15	2	12	5	9	3

Traffic count at St Michael School, St. Venera, Malta

Date	Morning (7.00-7.05)	Afternoon (12.00-12.05)
12-Oct	169 to standstill	160
13-Oct	/	/
14-Oct	150	85
15-Oct	60 to slow moving	Very slow moving
18-Oct	93	70
19-Oct	75	112
20-Oct	90	46
21-Oct	140	96
22-Oct	80	90
25-Oct	102	52
26-Oct	Very slow moving	105
28-Oct	102	62
29-Oct	113	74
02-Nov	/	/
04-Nov	145	80
05-Nov	135	75
08-Nov	142	67

Traffic Count - Kishoge Community College

Date	Time	Student-related Vehicles	Staff-related Vehicles	Total Vehicles	Vehicles/5 minutes
01/03/2022	8:40 - 9:10	146	76	222	37

This traffic count was conducted on the school grounds, where vehicles enter the school at morning drop off

Traffic Count - Ramsgrange Community School

Date	Time	Vehicles	Vehicles/5 minutes
February	11:00-11:20	84	21

Nitrogen Dioxide Results

The results reflect the average NO_2 level at that measuring location for a short 4 week period of time, simply a snapshot of ambient NO_2 pollution levels in the air. The results do not capture hourly or daily lows and highs, but they do indicate a general level of NO_2 pollution for the period.

Nitrogen Dioxide results for Malta Schools

Location of Diffusion Tube	µg/m^3
Main Entrance School, Europe Street, Victoria Gozo	19.02
Entrance to Parking @ Europe Street, Victoria Gozo	20.56
Ground Turf Area at Gozo College Secondary School	12.78
Road side of St. Michael School St. Venera	37.06
Parking Entrance at St. Michael School St. Venera	22.61
Balcony overlooking school ground at St. Michael School	22.44

Nitrogen Dioxide results for Irish Schools

Location of Diffusion Tube	NO_2 µg/m^3
Ramsgrange CS – School Car Park	3.89
Ramsgrange CS – Sheltered are at back of school	9.85
Kishoge CC – Near road entering school	20.46
Kishoge CC – Student drop-off point	23.74
Kishoge CC – Sheltered area	17.71

Discussion

All 4 schools met virtually both before the observation period and after the diffusion tubes were taken down when results from Gradko Laboratory were returned. During their first online meeting, which was held on zoom platform, the students introduced themselves and gave a brief description of the school. They also shared facts about the climate and the physical and human factors surrounding their schools. Together they discussed the best sites where to put up their diffusion tubes.

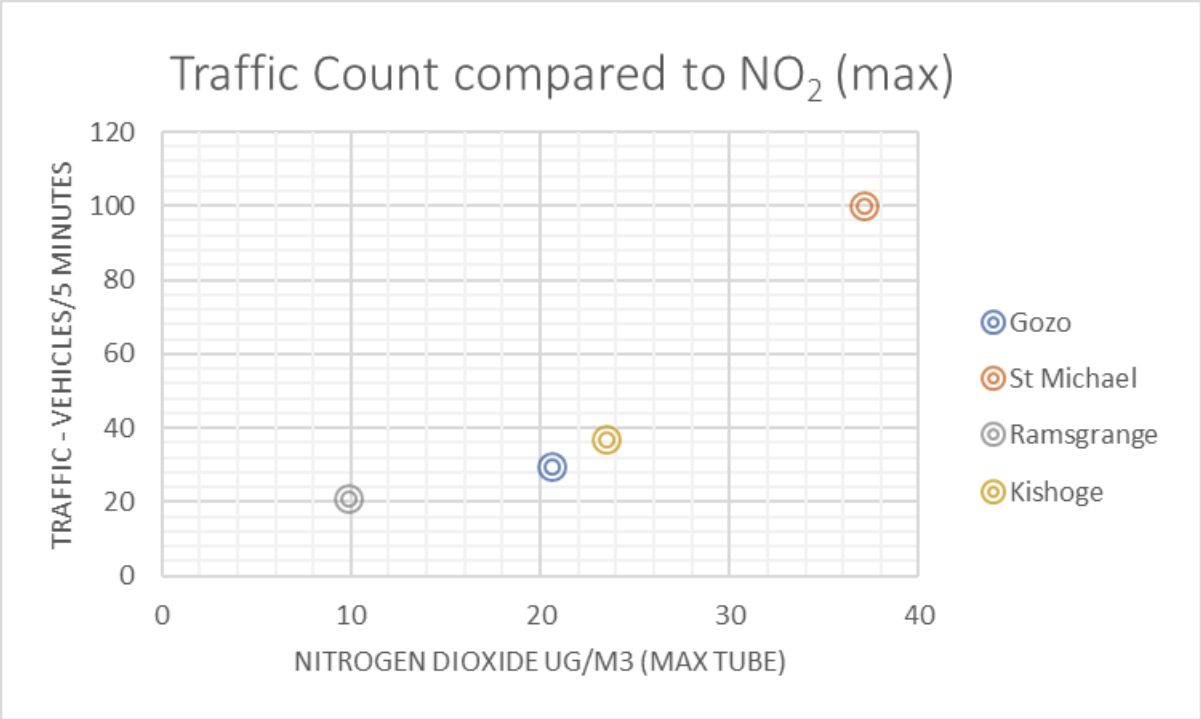
After the 4-week observation period students and teachers for all 4 collaborating schools met virtually, this time to share results, compare data and discuss their findings.

Discussion on the first research question - *How do nitrogen dioxide levels vary between four different schools?*

The students recognised that the NO_2 levels recorded are variable between schools and between different locations at each school. The lowest recorded NO_2 value was measured at Ramsgrange Community School in Ireland and the highest NO_2 value was measured at St Michael's school in Malta. The students noticed that the maximum values recorded were in proximity to roads and drop-off points near the schools. The lowest values recorded were in sheltered areas.

Discussion on the second research question - *Can we demonstrate a clear link between observed traffic volumes at our schools and measured nitrogen dioxide levels?*

The students compared their NO_2 results to the traffic count data they collected. They identified a strong correlation between the number of vehicles counted and the measured NO_2 concentrations where the most heavily trafficked area correlates to the highest recorded NO_2 concentration.



Graph showing average traffic count (per 5 min intervals) plotted against maximum recorded nitrogen dioxide concentration level for each school.

Discussion on the third research question - *What other parameters influence recorded nitrogen dioxide levels?*

The students compared their NO_2 results to their cloud observation data and recorded air temperatures. The students noticed the variability in recorded air temperature during the measurement period. In Ireland, the temperature varied between 9 and 18 degrees Celsius and in Malta temperature varied between 13 and 28 degrees Celsius. A correlation between air temperature and measured NO_2 could not be identified. Likewise, students did not identify a relationship between cloud cover and sky visibility and recorded nitrogen dioxide levels, however it is noted that more data is needed to explore this topic further.

The students also discussed how NO_2 pollution impacts human health and the environment. An NO_2 concentration scale (Figure 7) was shared by GLOBE Ireland, the scale (based on EPA Ireland Clean Air Together scale) is useful for examining the link between NO_2 concentration and health. Students learnt about the current European Union and World Health Organisation (WHO) guideline values for NO_2 concentration. The current WHO guideline was revised in 2021 and is now 10 µg/m^3 (annual mean) and the EU guideline is 40 µg/m^3 (annual mean). The students noticed that 3 of the 4 schools recorded measurements above the WHO value of 10 µg/m^3 (annual mean), however it was noted that measurements at schools were recorded for only 1 month and therefore cannot be directly compared to the 12-month WHO and EU guideline values.

It is important to remember that NO_2 is just one part of determining overall air quality. There are other air pollutants that can seriously affect our health, such as, particulate matter (pm), ozone (O_3) and sulphur dioxide (SO_2).

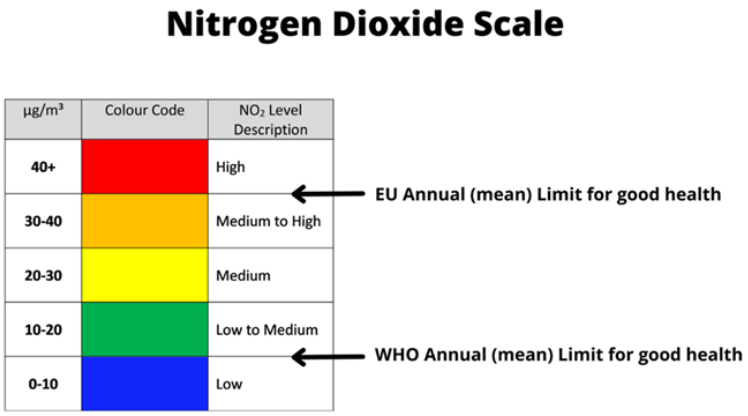


Figure 7: GLOBE Ireland/EPA Nitrogen Dioxide Scale annotated with arrows showing EU and WHO guideline values.

Conclusion

This collaborative air quality project between GLOBE Ireland and GLOBE Malta schools set-out to measure and compare NO_2 concentration levels collected during the same 4-week period in 2021. The students really enjoyed the opportunity to share their air quality investigation with students from another country. The opportunity to collaborate with each other improved student communication skills, increased curiosity, and increased learning on the topic of air pollution.

The students identified a strong correlation between traffic volumes and recorded NO_2 concentration levels. The students did not stop here. Having discovered the effects of traffic on air quality around the school, they wanted to bring change, be agents of change and think like engineers.

The students suggested ways on how to reduce NO_2 levels both at local and national level in Malta and Ireland.

The recommendations from this project are:

- Raise awareness amongst the local school community and local area as regards use of alternative modes of travel like use of public transport and active travel (walking, cycling).
- Raise awareness of the importance of turning off vehicle engines ‘anti idling’ when not driving, this is particularly important at school drop-off and pick-up times.

- Continue to monitor nitrogen dioxide around schools and gather more detailed weather observations to identity parameters that affect the results.
- Gather more detailed traffic data to understand traffic flow and identify potential traffic-solutions around schools, for example, limiting the number of cars that can enter the school grounds.
- Inform environmental bodies and authorities of air quality results to raise awareness and inform decision making at a local and national scale.

Bibliography

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Ireland's Environmental Protection Air Quality Report (2020): https://www.epa.ie/publications/monitoring--assessment/air/air-quality-in-ireland-2020.php (accessed March 2022)

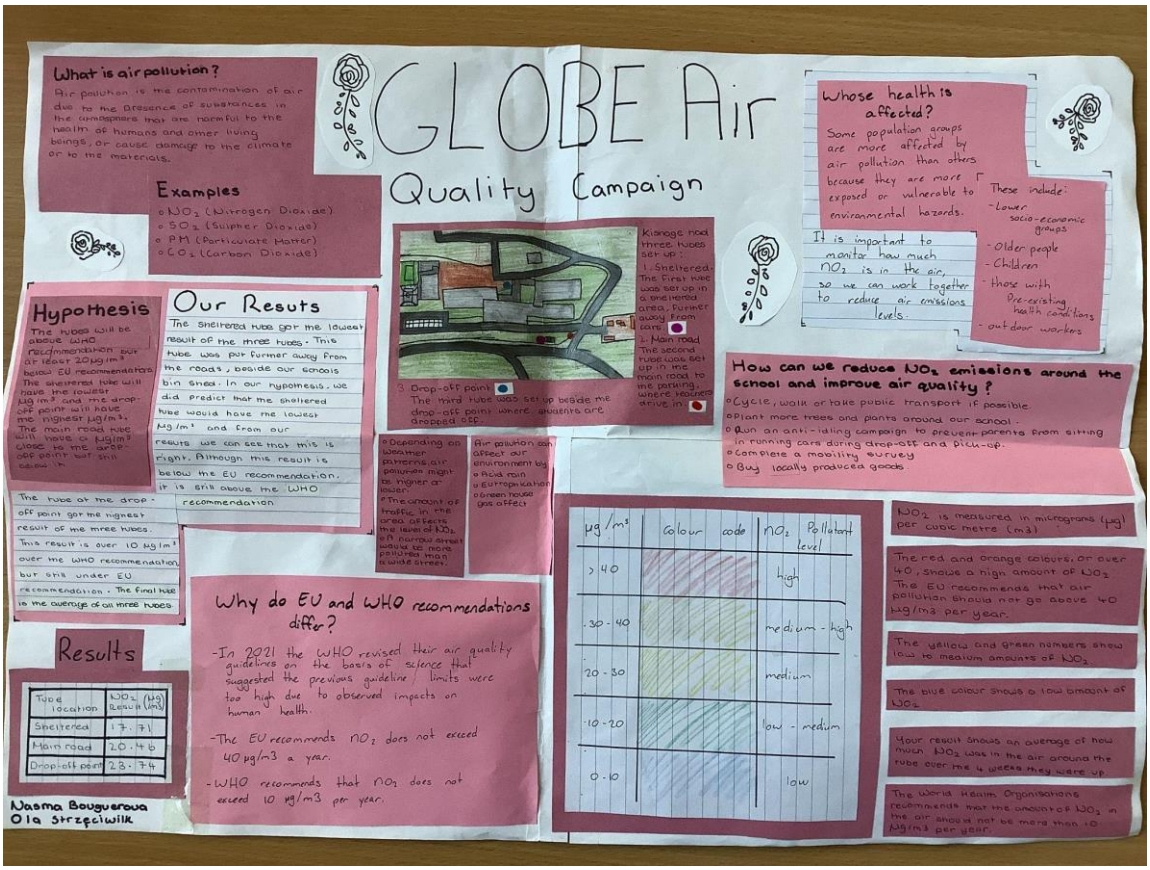
Badge Descriptions/Justifications:

I am a Data Scientist

Students collected and analysed their own data. From the data analysis, the students answered their research questions and made suggestions for future research.

I make an Impact

The research helped students and the school community of all participating schools to recognize the effect of nitrogen dioxide. In addition to taking measurements at school, students also discussed results and made recommendations to the school leadership team and Local Councils. Students made posters to share with their school community to raise awareness on the topic of air pollution - example from Kishoge Community College.



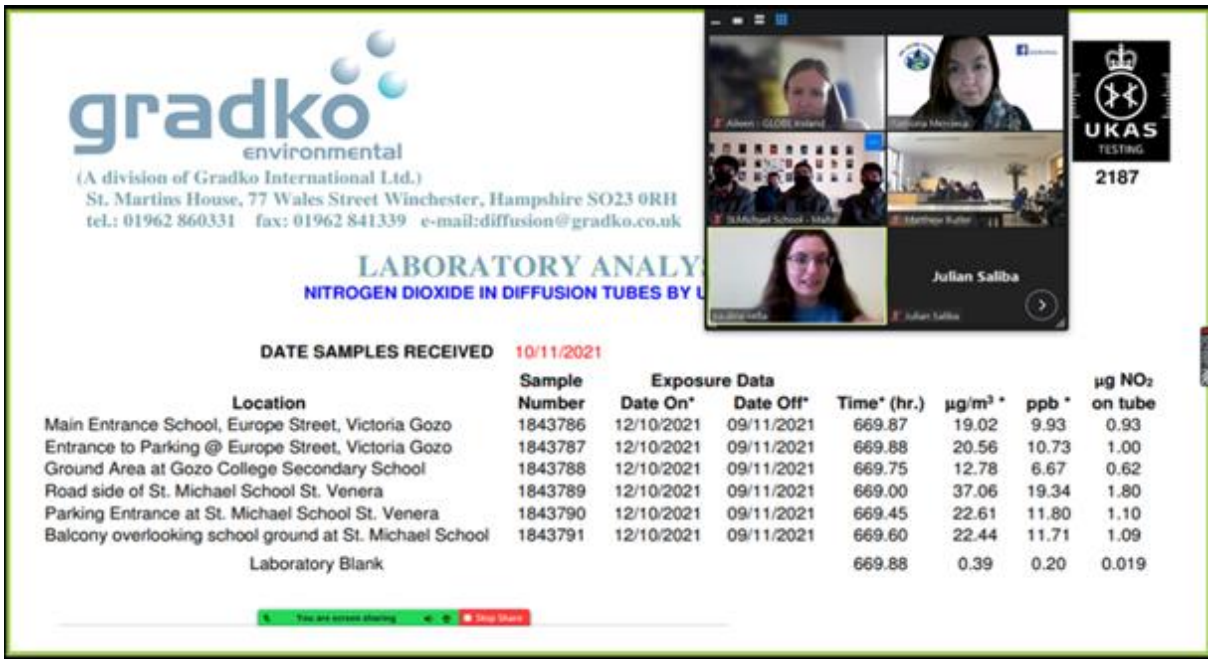
I am a Collaborator

All four schools collaborated through Zoom sessions during which they introduced themselves and the location of their school. Schools shared videos showing the whereabouts of their schools and of the diffusion tubes.

Link to video made by Ramsgrange Community School Students https://youtu.be/Jj85NAE-sZU

Link to video made by Gozo College Secondary School Students https://youtu.be/kv8HKT-fZZc

After the 4-week observation period the students, teachers and GLOBE coordinators discussed results and findings, as seen in the screenshot below.



Location	Sample Number	Exposure Data Date On*	Date Off*	Time* (hr.)	µg/m³ *	ppb *	µg NO_2 on tube
Main Entrance School, Europe Street, Victoria Gozo	1843786	12/10/2021	09/11/2021	669.87	19.02	9.93	0.93
Entrance to Parking @ Europe Street, Victoria Gozo	1843787	12/10/2021	09/11/2021	669.88	20.56	10.73	1.00
Ground Area at Gozo College Secondary School	1843788	12/10/2021	09/11/2021	669.75	12.78	6.67	0.62
Road side of St. Michael School St. Venera	1843789	12/10/2021	09/11/2021	669.00	37.06	19.34	1.80
Parking Entrance at St. Michael School St. Venera	1843790	12/10/2021	09/11/2021	669.45	22.61	11.80	1.10
Balcony overlooking school ground at St. Michael School	1843791	12/10/2021	09/11/2021	669.60	22.44	11.71	1.09
Laboratory Blank				669.88	0.39	0.20	0.019