A comparative study on air quality at St. Michael School

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Abstract

The project aims to analyse the air at St.Michael School over a period of around 400hrs (17 days) by measuring Nitrogen Oxide gas (NO2), VOC, Carbon Dioxide gas (CO2), PM1, PM2.5, PM4, PM10. This study was carried out to sensitise the social community such as the St.Venera local council and also the school community about the air breathed by a popolution of 400 persons for 35 hours and 36 weeks per year. This study was in collaboration with other schools in Malta and Gozo, and so it will be a comparative study based on geographic location too. This study will also compare results from a previous study on air quality carried out on 2021. Results indicated that St Michael School has among the highest concentration of NO2 levels and PM levels. This study provides evidence which supports the results obtained. It also proposes actions on how NO2 can be lower at both national and local level, especially around the school.

Key words: Air quality, Nitrogen Dioxide, Emissions, Clouds, Temperature, Traffic, Atmosphere, Carbon Dioxide, PM1, PM2.5, PM4, PM10, VOC, Airborne Particular matter (PM).

Research Questions

What is the effect of air pollution from traffic around the school?

A similar project was carried out 4 years ago. Comparing the results, was there any difference in Nitrogen levels?

The PM levels are within limits? Is there any relation between NO2 levels and PM levels?

Does temperature, humidity, and rain affect air quality? And what is the effect of pollution on such parameters?

Urbanization and high dependency on private cars are causing an increase in nitrogen levels. Supported by the knowledge obtained by the students during the sharing of ideas during meetings with their collaborating partners together with the research conducted on air quality, it was concluded that nitrogen dioxide levels and PM levels around the school are high.

Hypothesis: Our school is situated in a busy and urbanized area. A previous study of 4 years ago noted a high level of NO_2. Based on geographical location, the NO_2, TVOC and PM levels will be high.

Introduction

The aim of this study was to find the level of NO2 gases and VOC, CO2 and PM levels present in the air around the school and how this has changed since its reading was last recorded (4 years ago). The observation and monitoring period was between November 2024 and December 2024 and readings were taken from 1 site in the school facing a busy main road. Nitrogen dioxide (NO2) gas is an increasing problem for air quality all over the world. Gas can cause serious problems such as lung damage, acid smog or rain. As little as 50 ppb can cause airway inflammation in lungs. NO2 primarily gets in the air from the burning of fuel. NO2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment. Our school is situated in a busy and urbanized area. Previous studies noted a high level of NO2. Volatile organic compound (VOC) are organic chemical compounds that under normal conditions are gaseous or can vaporise and enter the atmosphere. VOCs include such compounds as methane, benzene, xylene, propane and butane. Exposure to very high levels of VOCs may cause damage to the liver, kidney, or central nervous system (brain and spinal cord). High levels may also cause vision and memory problems. VOCs are a class of chemicals, not a single chemical. Some are known to be highly toxic while others have no known health effects.

PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Exposure to such particles can affect both your lungs and your heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased respiratory

symptoms, such as irritation of the airways, coughing or difficulty breathing. People with heart or lung diseases, children, older adults, minority populations, and low socioeconomic status populations are the most likely to be affected by particle pollution exposure, either because they are more sensitive or may have higher exposures.

Indoor CO2 levels are generally higher than outdoor levels due to CO2 exhaled by occupants. It should be noted that there can be harmful impacts when concentrations are higher than about 1000 ppm such as health risks and reduced work efficiency.

This study was done to increase awareness of the large number of harmful gases which are found near the school's premises. It was also carried out to show that climate change is upon us, and action must be taken to reduce the presence of these gases. Additionally, readings for other factors, of which weather parameters, were also measured and reported. A barometer was used to measure the air pressure, a thermometer was used to measure the temperature, and a measuring cylinder was used to measure the amount of rainfall. The wind direction was also recorded as it could have had an impact on the results.

When the readings for the NO2 gases were taken, these were sent to a lab in Switzerland. The results indicated that NO2 levels are like those of 2021 which means pollution is still quite worrying.

Study site:

Our school is physically built in an urban environment, near two separate industrial areas and a main traffic artery which is laden with heavy traffic during most of the day.

The students identified 4 study sites around the school (Figure 1). The school has been supplied with a diffusion tube from Passam Laboratories in Switzerland, and this has been put up in front of the school gate (Roadside) (Red). The VOC, CO2, and PM were monitored by a monitor with different sensors in the computer lab near an open window facing the same street. (Purple)

Weather parameters: cloud cover and sky conditions, air temperature, wind, rainfall, and humidity were measured from the school roof using GLOBE Protocols. (Yellow). Car count was taken in front of gate every day. (Blue)

Figure 1 (School and observation sites)

Apparatus used:

- Data logger to measure air temperature, humidity and air pressure.
- Rain Gauge
- GLOBE Observer App to record cloud type and cover
- 1 Diffusion tube

- Air quality monitor
- Stopwatch
- Data sheets
- Clipboard and pen

Methodology:

Every day, from 11th November 2024 to 6th December 2024, the students took rainfall readings together with the air temperature, humidity, and air pressure. They also observed the cloud cover using the GLOBE Observer App and described the general outlook of the weather and surface conditions following the steps of the GLOBE Protocols (GLOBE, 2014). During the same observation period, the student carried a traffic count in front of the school using a stopwatch for 5 minutes. Everyday students also noted the results from the air quality monitor (Figures 3 and 4).

The diffusion tube, which measures NO2 gas, was put up on Monday 11th November at 08:00, in front of the school gate facing the main road (Figure 2). The site was the same as the one used in a similar analysis done 4 years ago. The tube was numbered and marked with a special code provided by the laboratory. This was sponsored by ERA (Environment and Resources Authority).

The project was carried out in collaboration with 9 other schools across Malta and Gozo, sister island to Malta. The readings of the car count were taken in the morning. On the 6th of December, the tube was sent to Passam Laboratory in Switzerland for analysis together with the other schools from across Malta and Gozo. Readings of humidity, rain, air pressure, and cloud observations were taken around noon during the midday break. Other air quality parameters were taken during the day using another monitor with different sensors (Figure 5).

Figure 1: Tube installed in the school premesis

Figure 3: Students carrying out a car count and making weather observations

Figure 4: Students doing weather observations

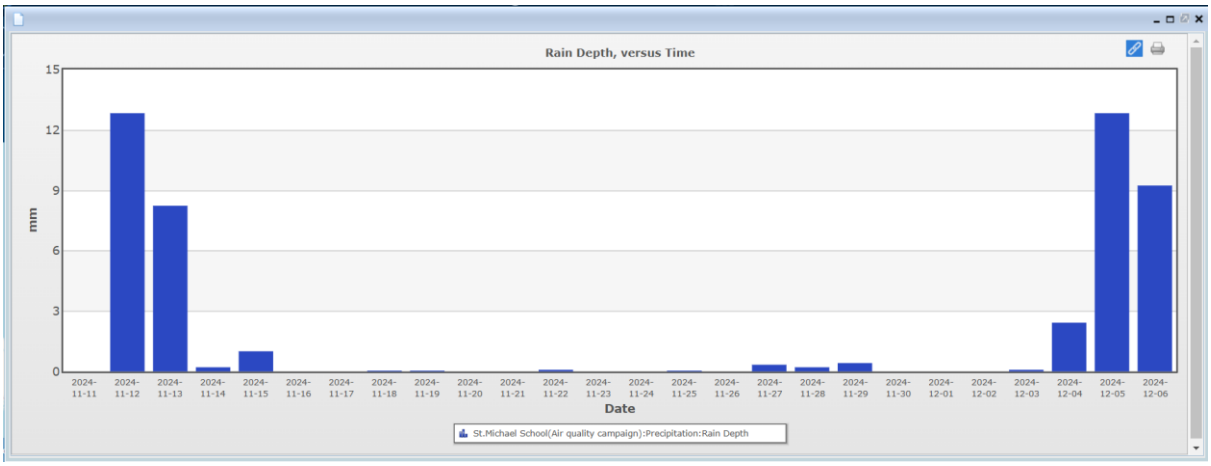
Figure 5: Air quality monitor

Data Analysis

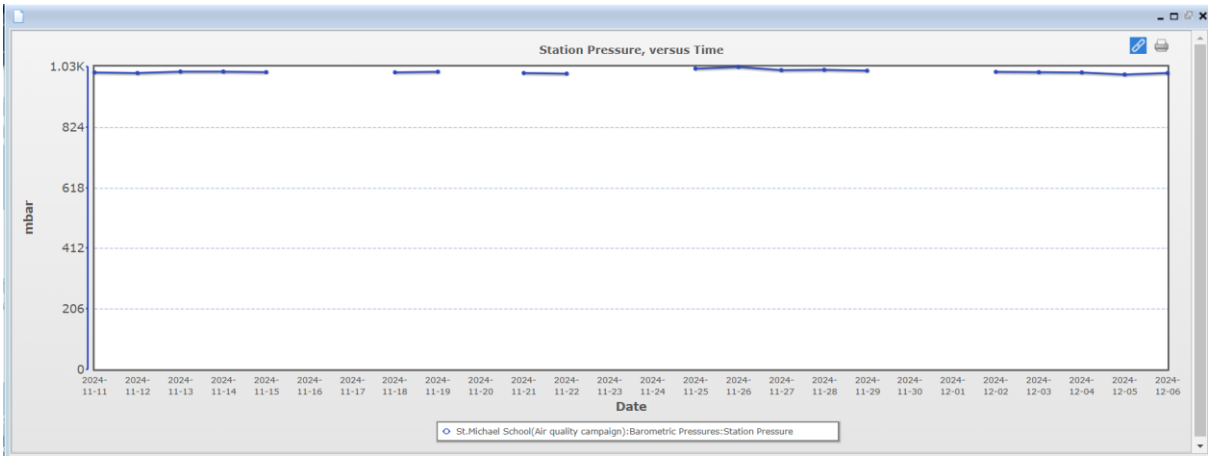
All data collected (Air Temperature, Barometric Pressure, Humidity, Rainfall, Wind, Visibility, Car count, VOC, CO2, PM) was recorded on a template and uploaded on GLOBE database through the Data Entry tool on the GLOBE Observer App. The diffusion tube was sent abroad for analysis and received by email after three weeks. Data collected was compared with a previous study which was carried out 4 years ago at our school which again focused on air quality, mainly NO_2 only.

Results

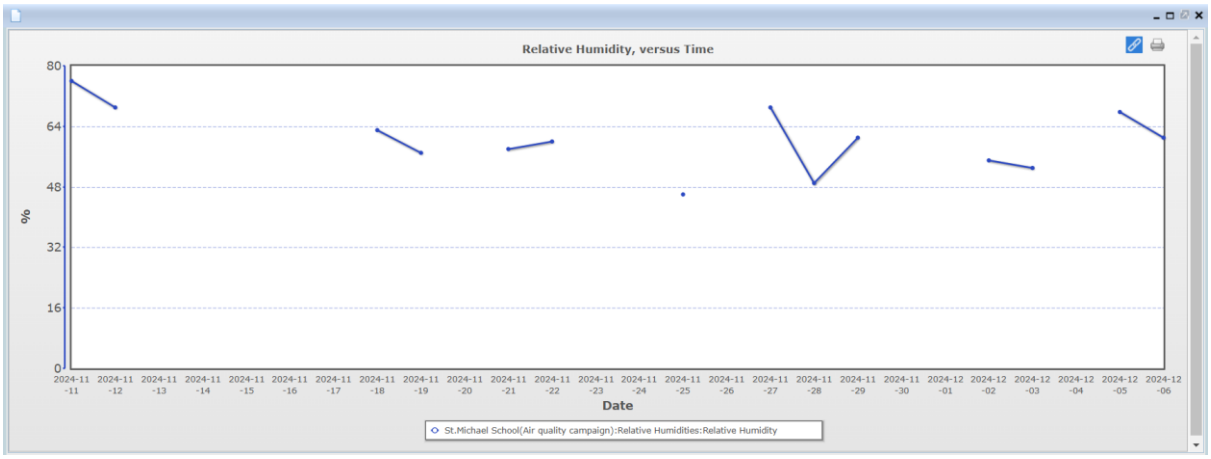
The screenshots below show data uploaded on GLOBE website during observation period between November 2024 and December 2024 (Figures 6, 7, 8, 9, 10, 11). Students collected daily readings of air temperature, barometric pressure, humidity, rainfall and cloud cover and type together with surface conditions following GLOBE Protocols guide. All readings are shown in Table 1, 2, 3, 4. Graphs from the air monitoring apparatus were plotted showing the air quality during the observation period (Figure 12)



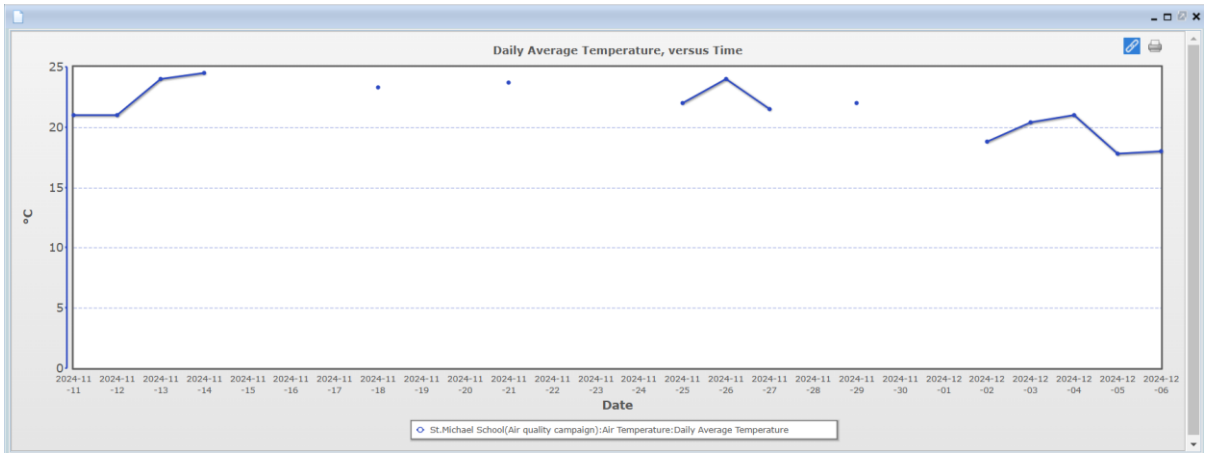
Figures 6: Rainfall plot of VIZ GLOBE



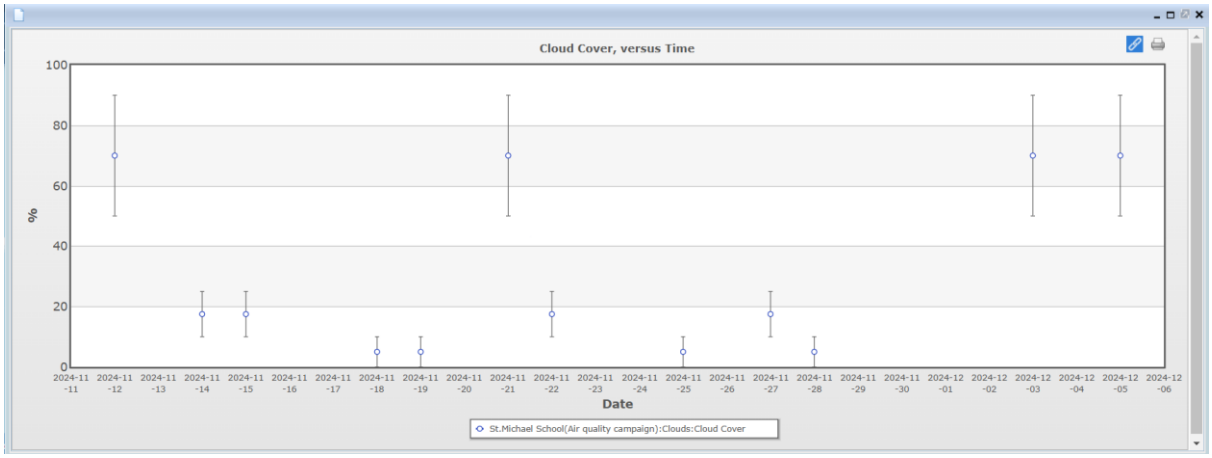
Figures 7: Barometer plot of VIZ GLOBE



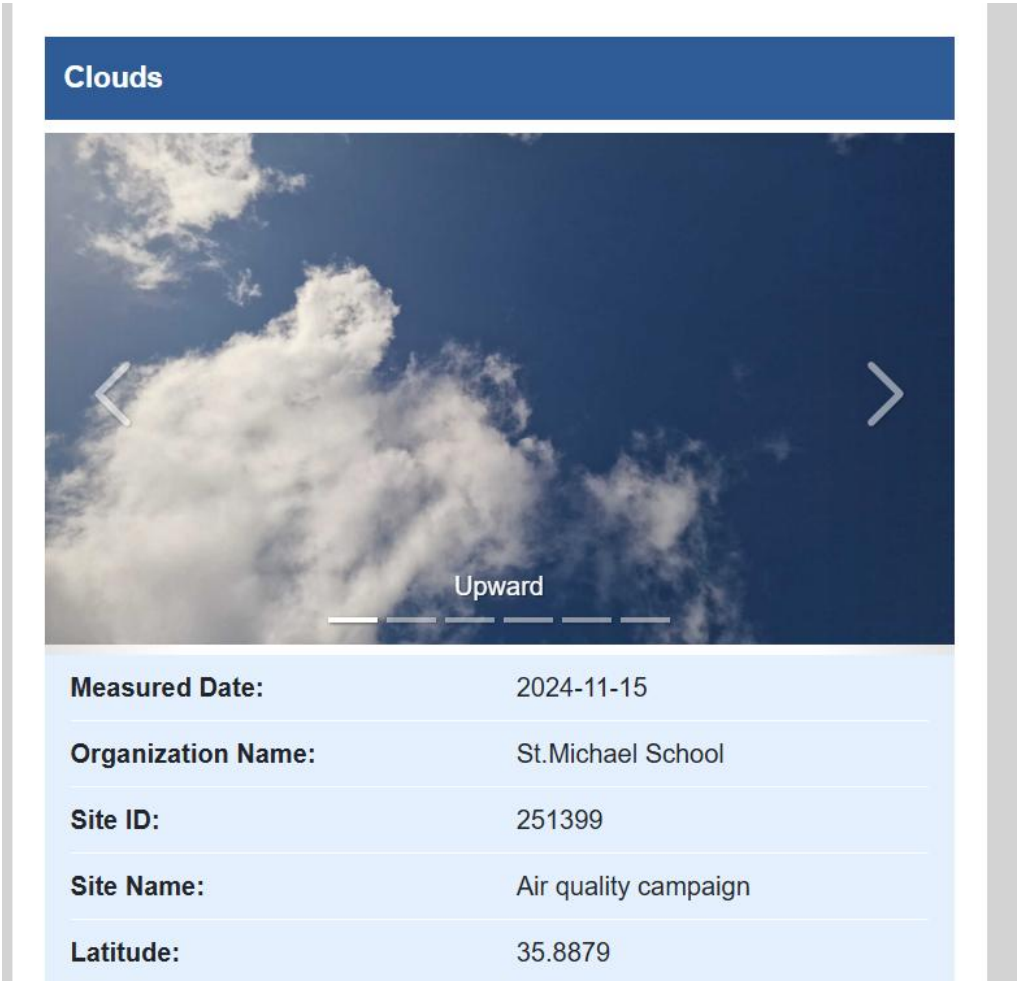
Figures 8: Humidity plot of VIZ GLOBE



Figures 9: Temperature plot of VIZ GLOBE



Figures 10: Cloud Coverage plot of VIZ GLOBE



Figures 11: Cloud Observation

Table 1: Data Sheet – Atmospheric conditions and Cloud Type

Date	Time	Rainfall		Wind			Visibility		
		Yes	No	Strong	Light	Calm	Good	Fair	Poor
11-Nov	12.30	✓				✓			✓
12-Nov	12.05		✓			✓	✓		
13-Nov	10.30		✓		✓		✓		
14-Nov	12.30		✓		✓		✓		
15-Nov	12.30		✓		✓			✓	
18-Nov	12.00		✓		✓				✓
19-Nov	12.00		✓		✓			✓	
20-Nov	09.30		✓			✓	✓		
21-Nov	12.30		✓	✓				✓	
22-Nov	12.30		✓		✓		✓		
25-Nov	12.00		✓			✓	✓		
26-Nov	12.15		✓			✓	✓		
27-Nov	12.00	✓				✓	✓		
28-Nov	12.30		✓		✓		✓		
29-Nov	12.00		✓		✓				✓
02-Dec	12.00		✓		✓		✓		
03-Dec	12.00		✓		✓			✓	
04-Dec	10.00		✓			✓		✓	
05-Dec	12.00	✓			✓			✓	
06-Dec	10.00		✓	✓			✓		

Date	Time	Cloud type			Air Temperature (°C)	Humidity (%)
		High	Mid	Low		
11-Nov	12.30		✓	✓	21	76
12-Nov	12.05	✓	✓	✓	21	69
13-Nov	10.30	✓	✓	✓	24	64
14-Nov	12.30			✓	24.5	54.7
15-Nov	12.30		✓	✓	23	58
18-Nov	12.00	✓		✓	23.2	64
19-Nov	12.00			✓	25	54
20-Nov	09.30	✓			25.2	53.4
21-Nov	12.30	✓	✓	✓	23.9	64.9
22-Nov	12.30	✓	✓	✓	23.7	54
25-Nov	12.00			✓	22	64
26-Nov	12.15		✓		24	41
27-Nov	12.00		✓	✓	21.5	69
28-Nov	12.30	✓		✓	23.5	49
29-Nov	12.00			✓	18.8	55
02-Dec	12.00		✓	✓	20.4	53
03-Dec	12.00	✓		✓	21	65
04-Dec	10.00			✓	21	65
05-Dec	12.00	✓	✓	✓	17.8	67.8
06-Dec	10.00	✓	✓	✓	18	61

Table 2: Data Sheet – Air quality parameters

Date	Time	VOC	CO2	PM			
				1.0	2.5	4.0	10
11-Nov	12.30						
12-Nov	12.05						
13-Nov	10.30						
14-Nov	12.30	54	505	1	1	1	1
15-Nov	12.30	109	763	2	3	3	3
18-Nov	12.00	56	413	1	1	1	1
19-Nov	12.00	222	702	1	1	1	1
20-Nov	09.30	492	856	3	3	3	3
21-Nov	12.30	439	884	1	2	2	2
22-Nov	12.30	90	540	1	1	1	1
25-Nov	12.00	42	593	4	4	4	4
26-Nov	12.15	76	577	3	4	4	4
27-Nov	12.00	76	626	1	1	1	1
28-Nov	08.00	160	596	3	3	4	3
29-Nov	08.30	201	647	4	4	4	4
02-Dec	13.00	61	807	1	2	2	2
03-Dec	12.45	159	642	1	1	1	1
04-Dec	10.15	277	737	1	2	2	2
05-Dec	12.00	43	557	1	1	1	1
06-Dec	10.00	70	441	0	1	1	1

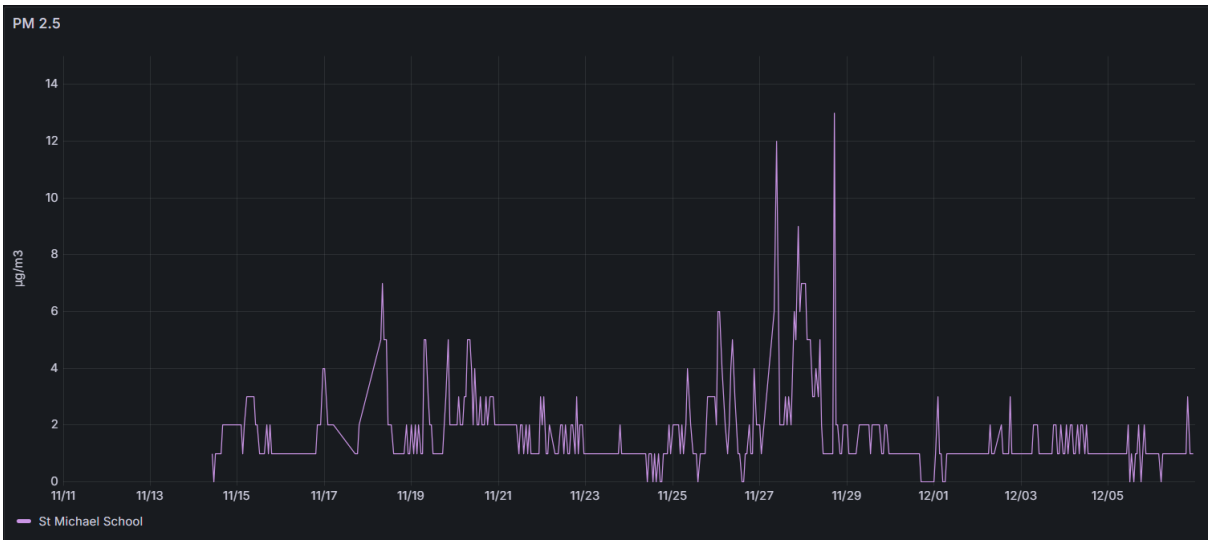
Table 3: Data Sheet – NO2 results from different schools

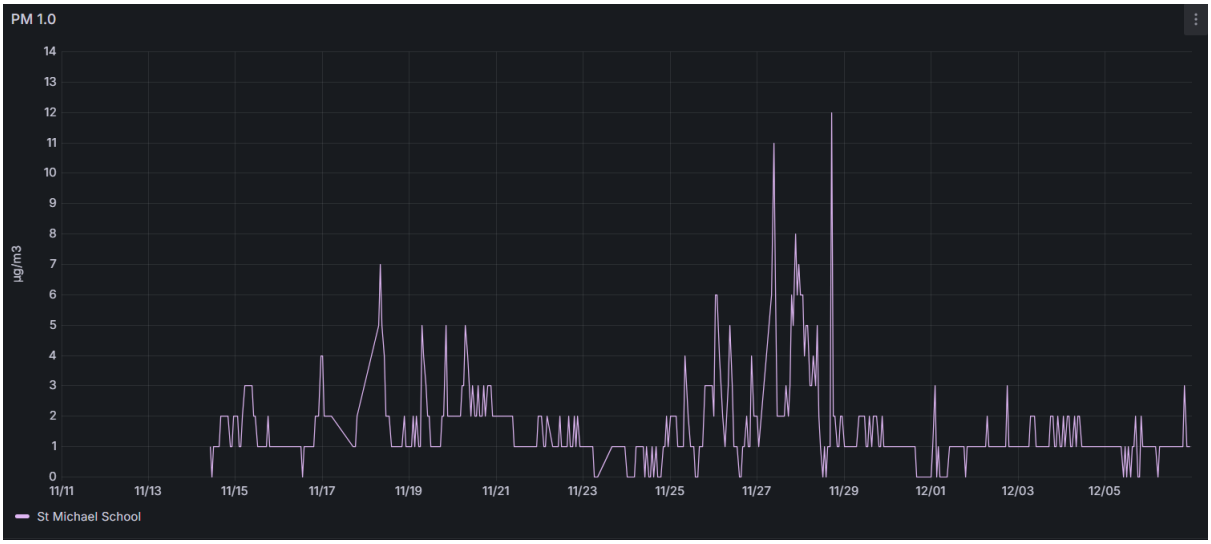
School name	Start date	Start time	End date	End time	NO_2 ($\mu g/m^3$)
Handaq Middle School	11/11/2024	8:10	06/12/2024	8:05	13.9
Maria Regina College - Mosta Secondary	11/11/2024	12:35	06/12/2024	8:58	14.1
St. Michael School, St. Venera	11/11/2024	8:00	06/12/2024	7:50	34.8
Sannat Primary & Special Unit (Gozo)	11/11/2024	12:35	06/12/2024	9:00	8.7
St. Margaret College - Erin Serracino Inglott, Middle School	11/11/2024	8:04	06/12/2024	8:05	30.1
Stella Maris College	11/11/2024	7:30	06/12/2024	7:30	36.2
Sir Arturo Mercieca Rabat Primary School (Gozo)	11/11/2024	13:36	06/12/2024	8:04	38.1
St. Paul's Bay Primary	11/11/2024	6:50	06/12/2024	7:00	7.9
St. Nicholas College Rabat Middle School	11/11/2024	10:00	06/12/2024	9:00	9.2

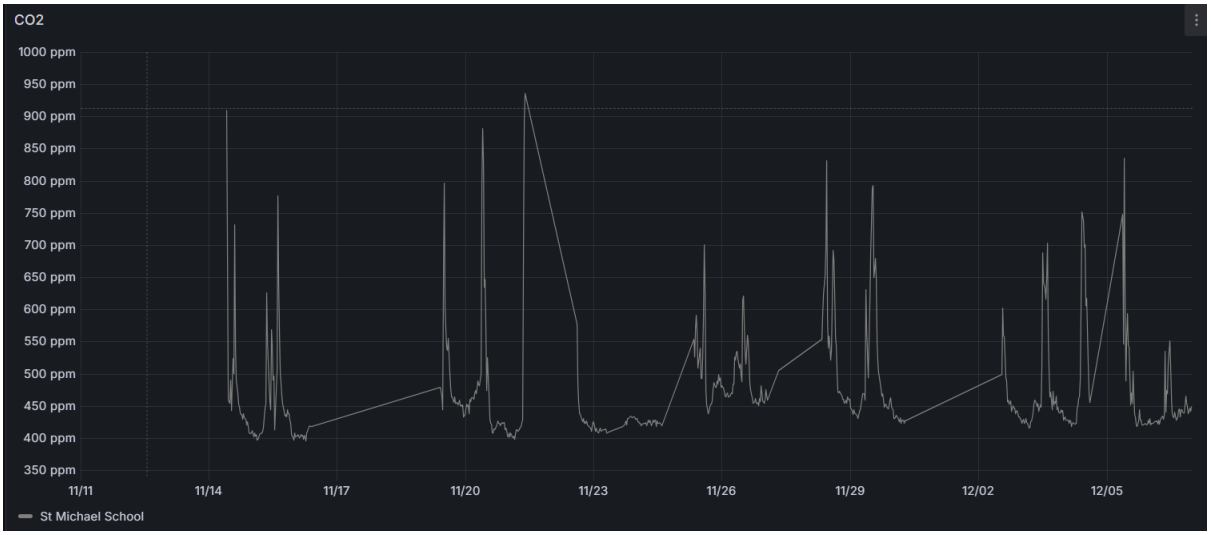
Table 4: Data Sheet – Car count

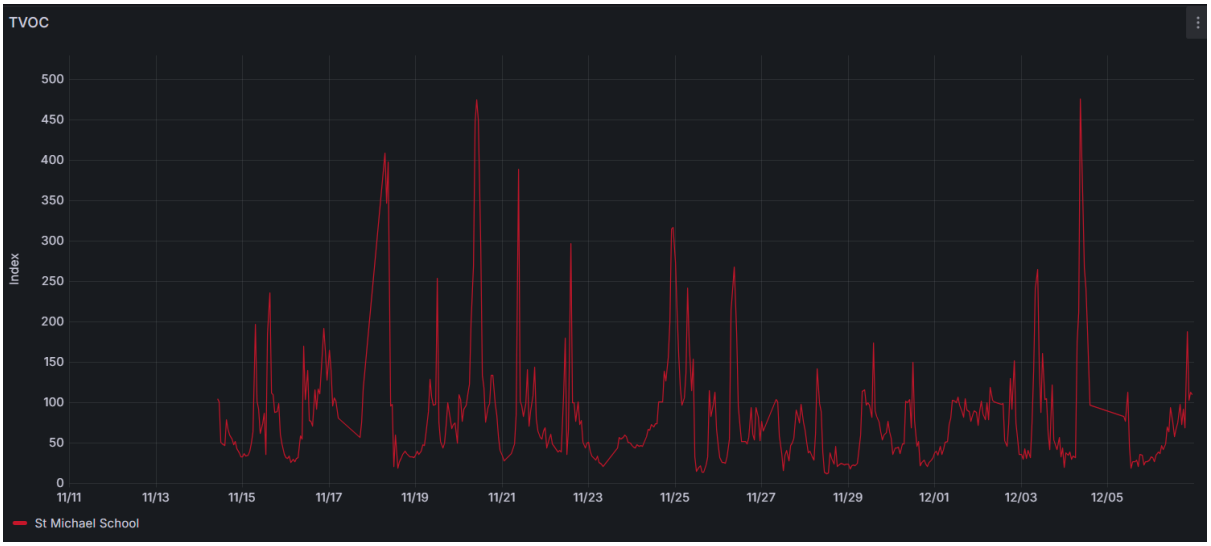
Date	Vehicles	Bicycles
11-Nov	118	0
12-Nov	175	0
13-Nov	246	0
14-Nov	257	1
15-Nov	244	1
18-Nov	206	1
19-Nov	176	0
20-Nov	228	3
21-Nov	199	1
22-Nov	145	1
25-Nov	189	0
26-Nov	175	2
27-Nov	234	0
28-Nov	183	2
29-Nov	103	0
02-Dec	225	3
03-Dec	42	1
04-Dec	183	2
05-Dec	154	0
06-Dec	150	2

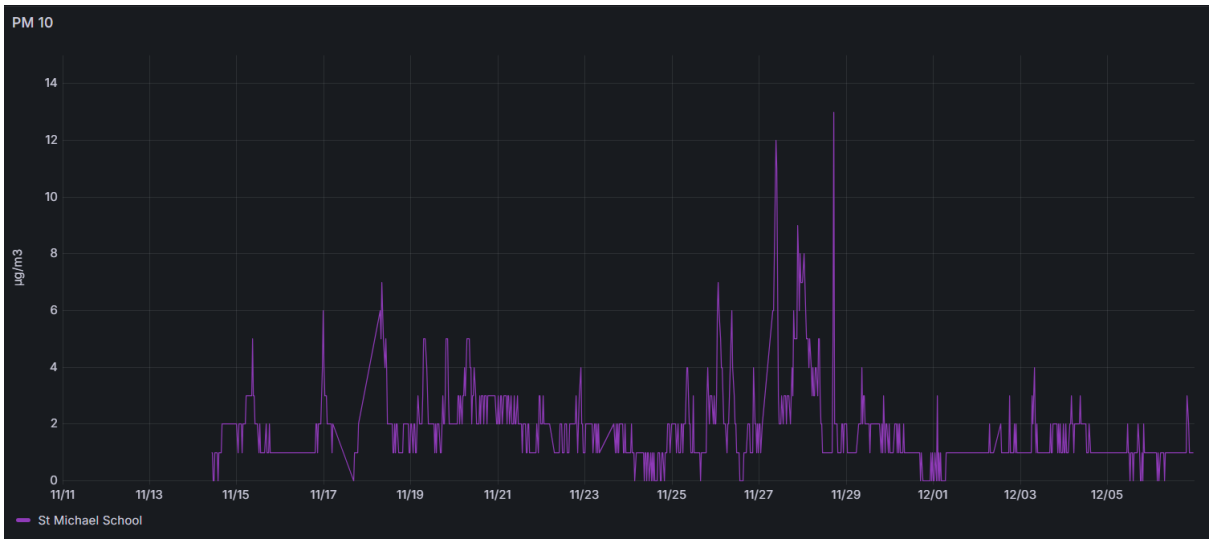
Figure 12 Screenshots showing Air Quality parameters throughout the study






CO2
1000 ppm
950 ppm
900 ppm
850 ppm
800 ppm
750 ppm
700 ppm
650 ppm
600 ppm
550 ppm
500 ppm
450 ppm
400 ppm
350 ppm
11/11
11/14
11/17
11/20
11/23
11/26
11/29
12/02
12/05
St Michael School


TVOC
Index
500
450
400
350
300
250
200
150
100
50
0
11/11
11/13
11/15
11/17
11/19
11/21
11/23
11/25
11/27
11/29
12/01
12/03
12/05
St Michael School


PM 10
µg/m3
14
12
10
8
6
4
2
0
11/11
11/13
11/15
11/17
11/19
11/21
11/23
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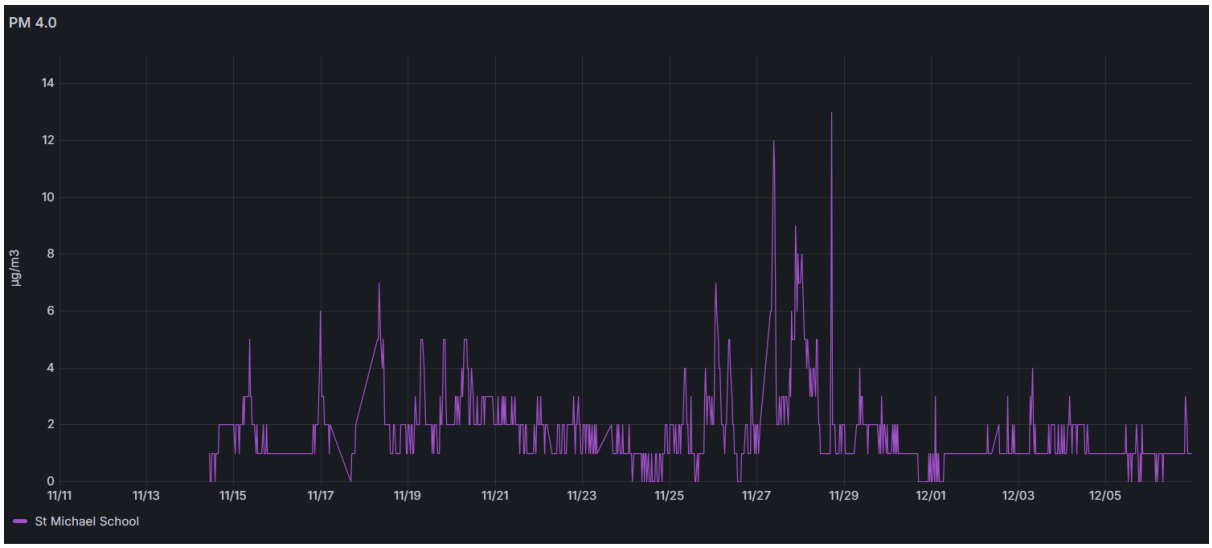
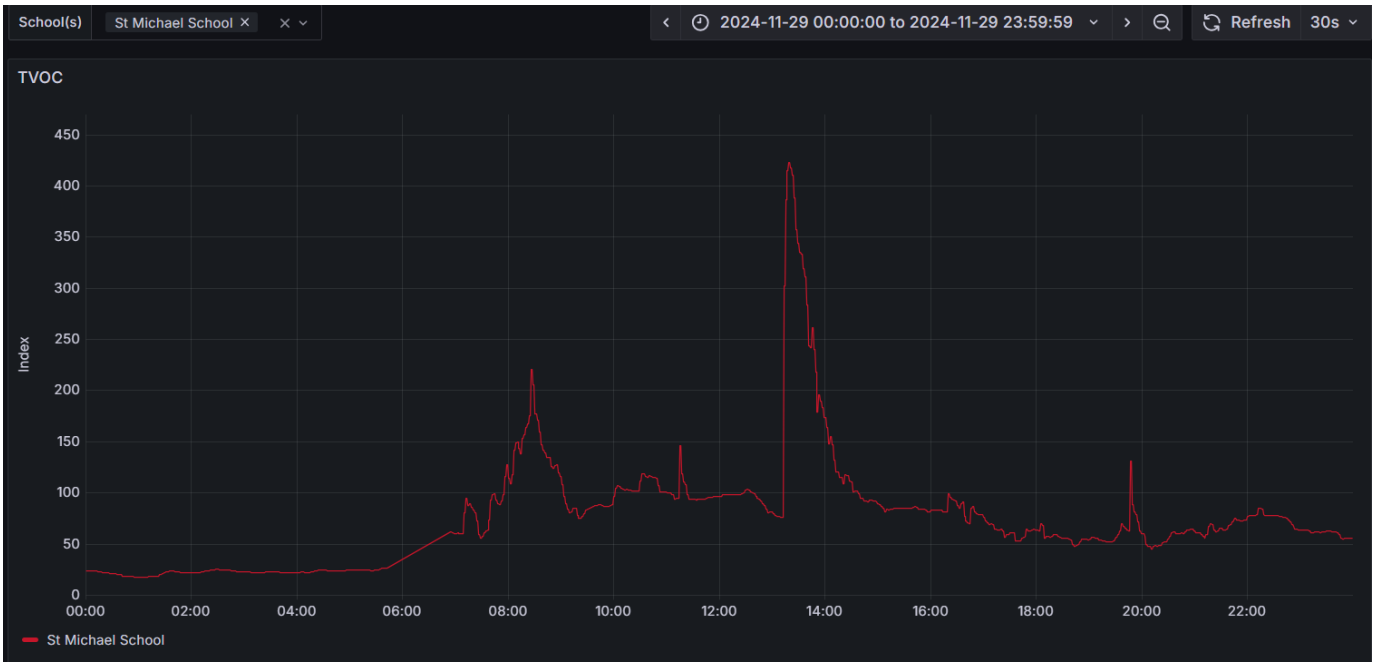
11/27
11/29
12/01
12/03
12/05
St Michael School


PM 4.0
µg/m3
14
12
10
8
6
4
2
0
11/11
11/13
11/15
11/17
11/19
11/21
11/23
11/25
11/27
11/29
12/01
12/03
12/05
St Michael School

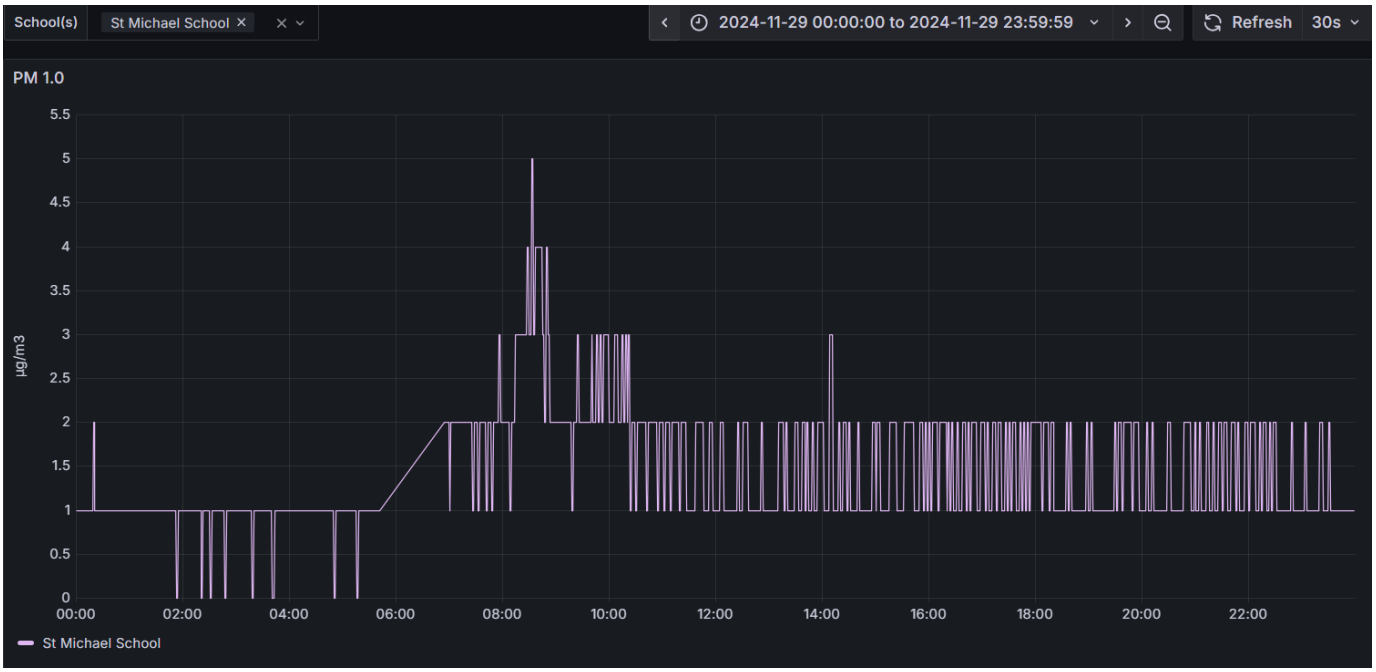
Discussion

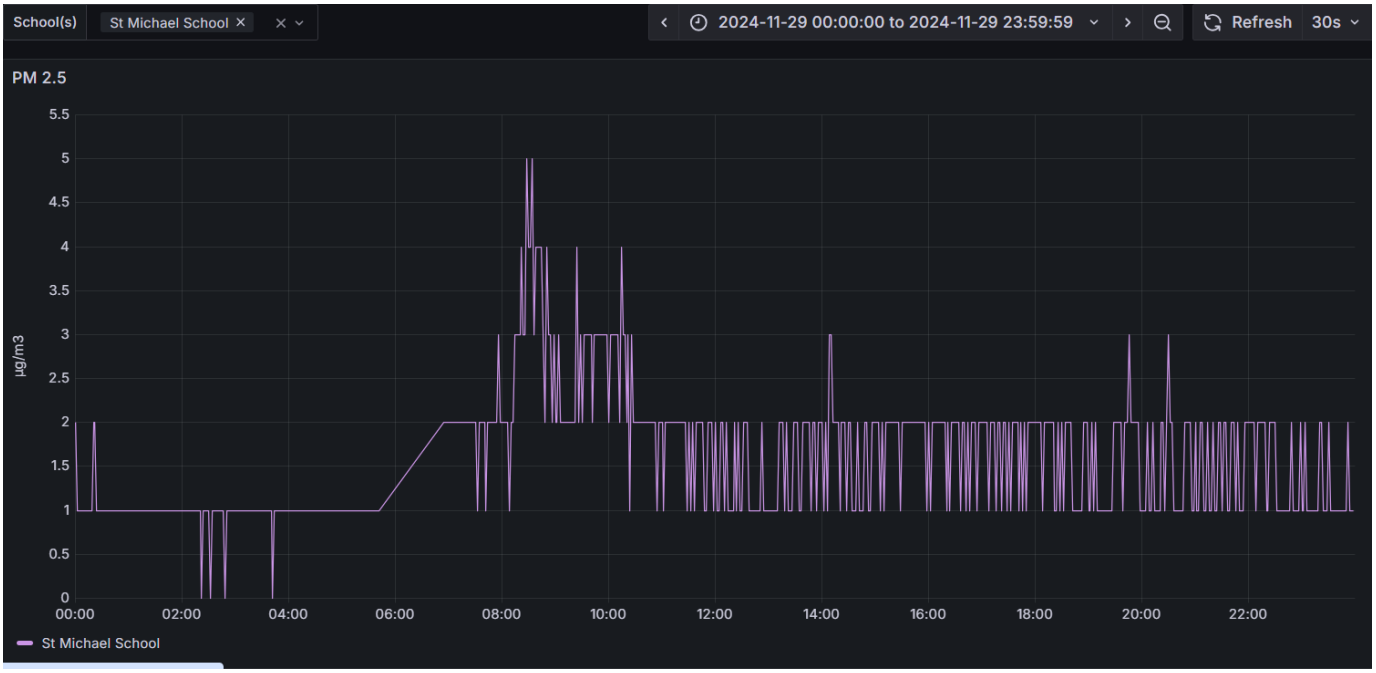
The results obtained were discussed between all schools involved via Skype. Unfortunately, our school recorded again almost the highest level of Nitrogen Dioxide among all schools. Having the data in our hands we did a comparative study between this study on air quality and a similar study of 4 years ago. Results were similar.

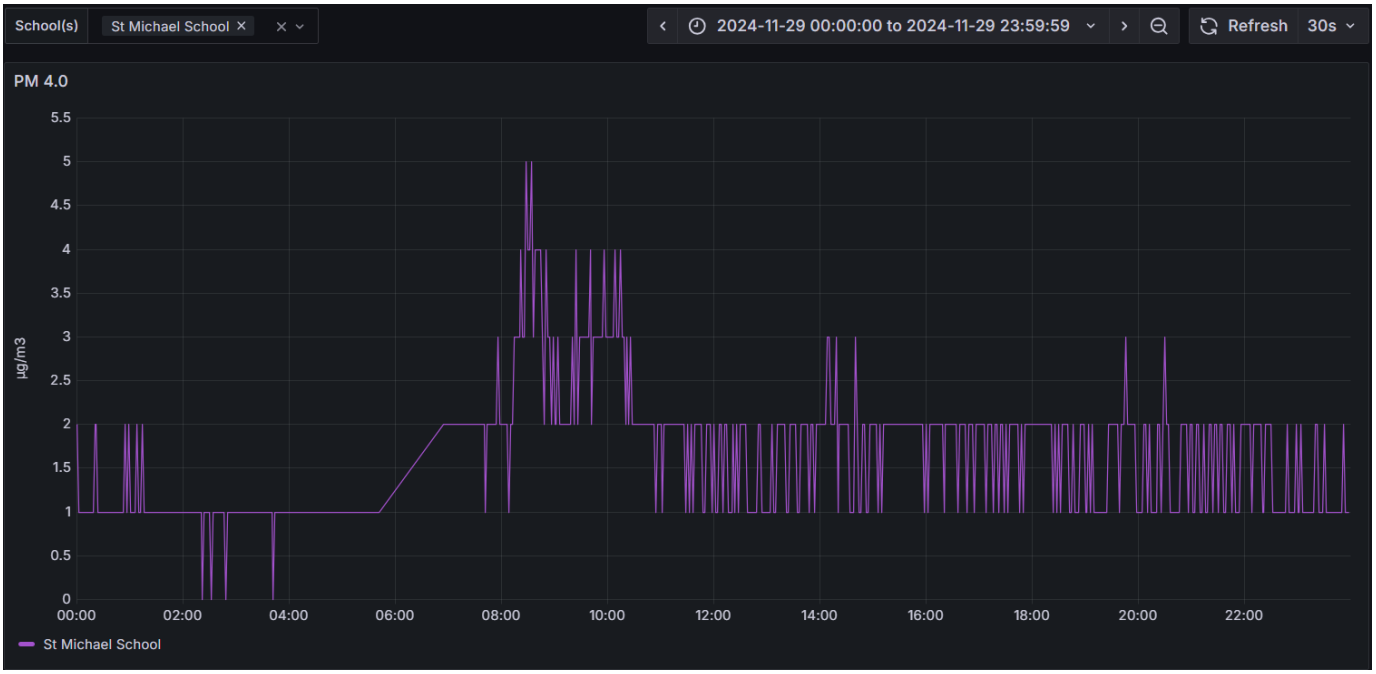
Starting with the car count. We can confirm that our school is situated on one of the busiest streets in Malta among two industrial estates. During the morning it is more busy than during mid-day. Then although not investigated, it again will be very busy during the late afternoon. In some intances, there was a complete standstill of traffic. With the help of the ongoing air quality monitor, we can confirm that in rush hours there was almost always an increase in VOC, CO2, and PM's. When compared with a weekend, these levels were different. It was noted that there is a relation to an increase in VOC, CO2, and PM's at the same time and hence they are related (Figure 13). Also noted that on weekends there were different readings of VOC, CO2, and PM's compared with the high numbers or sudden changes during the weekdays.



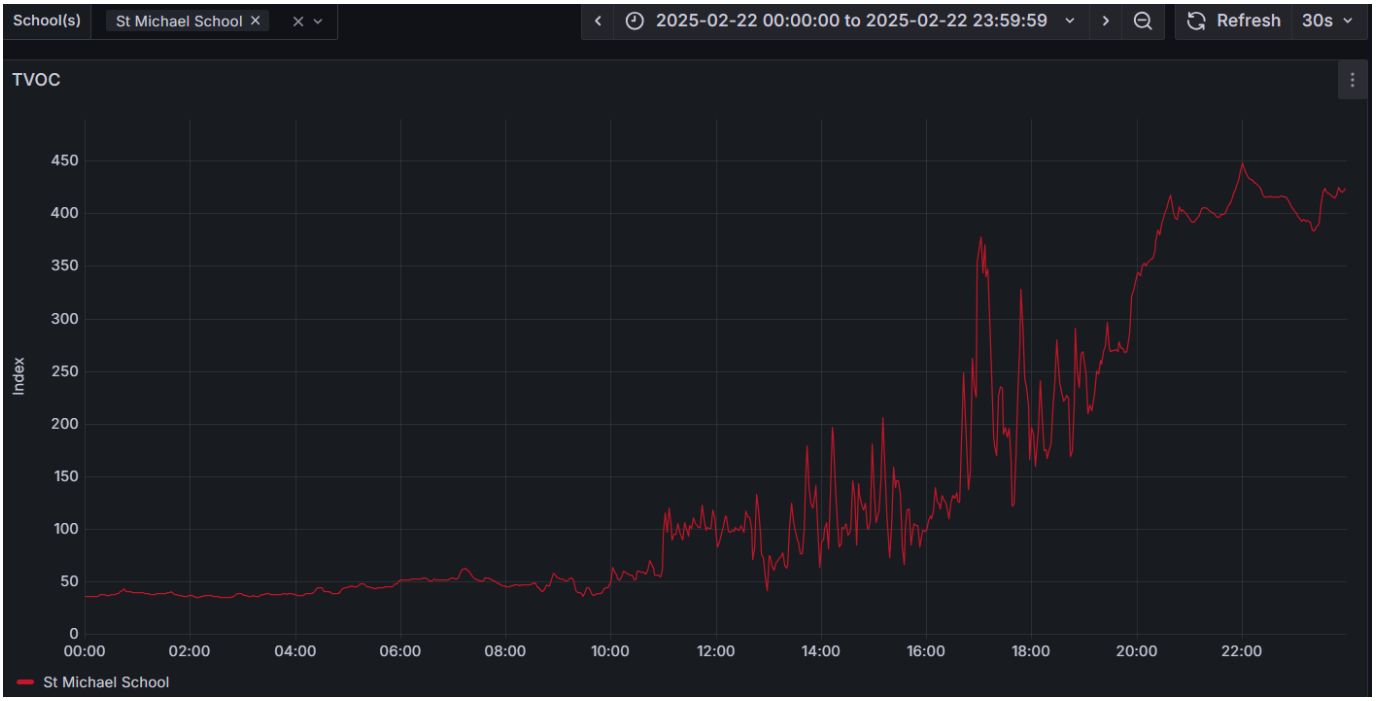

School(s)
St Michael School
2024-11-29 00:00:00 to 2024-11-29 23:59:59
Refresh
30s
CO2
850 ppm
800 ppm
750 ppm
700 ppm
650 ppm
600 ppm
550 ppm
500 ppm
450 ppm
400 ppm
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
St Michael School

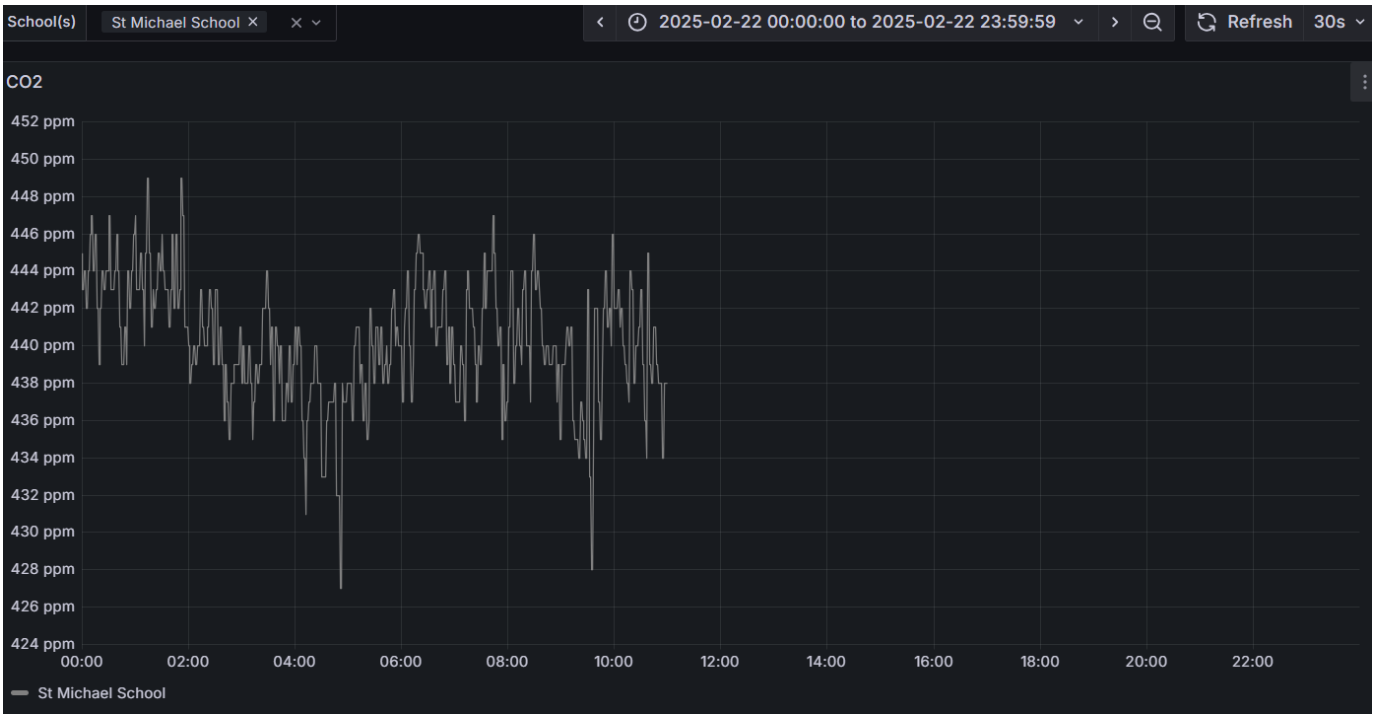

School(s)
St Michael School
2024-11-29 00:00:00 to 2024-11-29 23:59:59
Refresh
30s
PM 1.0
µg/m3
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
St Michael School





Figures 13: Graphs showing one particular day





Conclusion

Based on last study findings, most reasons remained the same. The level of NO_2 has remained almost like 4 years ago study. The air quality within the school during rush hours is above the WHO (World Health Organization), as the limit is 400 ppm. The same reference levels from the EU when compared to findings are quite worrying as we didn't test for all compounds mainly derived from fuel. Our study was also limited to a short period of time.

	Concentration (EU limits)	Averaging period
Fine particles ($PM_{2.5}$)	25 µg/m^3	1 year
Fine particles ($PM_{2.5}$)	20 µg/m^3	1 year
Sulphur dioxide (SO_2)	350 µg/m^3	1 hour
Sulphur dioxide (SO_2)	125 µg/m^3	24 hours
Nitrogen dioxide (NO_2)	200 µg/m^3	1 hour
Nitrogen dioxide (NO_2)	40 µg/m^3	1 year
Particulate matter (PM_{10})	50 µg/m^3	24 hours
Particulate matter (PM_{10})	40 µg/m^3	1 year
Lead (Pb)	0.5 µg/m^3	1 year

The reasons for this increase in Air Quality are :

An increase in population – The Maltese population has escalated in the last 20 years. As a result, more people go to work with their own private car and so, pollution increases. Many cars pass in front of our school every day, on average, 110 cars per 5 minutes during the rush hours which are between 6:45am – 8:30am and between 3:30pm – 6:30pm.

Cars and vans stopping in front of school – Students are taken to school either by van or by their parent's car. When they arrive at school, the vans and cars leave their engines on while the students are getting off. Even though this only takes a couple of seconds, this factor may still affect in the long run.

Fuel Station – The fact that there is a fuel station exactly in front of the school's main entrance may increase the levels of NO_2 and other chemicals associated with fuel.

Urban area – St. Michael School is found between two industrial estates which apart heavy machinery and traffic leading to them, some of them use fuel to operate which lead to more emissions. Another point to add is that there is a lack of trees in the surrounding areas.

Our NO_2 level infront of the school drop off (side of the main road) is 34.8 µg/m^3 , which is similar when compared to the 37.6 µg/m^3,of last study 4 years ago. Altough within the limits of 40 µg/m^3 of the EU per year. Still we believe that in certain days and time when also there is alot of slow moving traffic, the levels are much higher. This will also effect the VOC, PM's, CO_2 which are also a health hazard.

Our suggestions for reducing the levels of NO_2 and other Air quality parameters within the school area would can be:

- Car-pooling between students or workmates turning off car engines when dropping off students to school
- Better traffic managment
- Planting more trees which improve air quality in the area.

Recommendations:

The next study will be linked with this study where we will analyse and investigate the soil around the school for chemicals derived from traffic.

References

GLOBE teacher guide https://www.globe.gov/ (Accessed October 2024)

GLOBE Observer https://observer.globe.gov/ (Accessed March 2024)

https://www.sciencedaily.com/releases/2020/06/200626114750.htm

https://www.epa.gov/no2-pollution/basic-information-about-no2

Badges Description:

I am a Data Scientist

Students analysed their own data (from their measurements). They were able to analyse line graphs to interpret the data. They also became aware of the limitations of the data and could only draw conclusions from the samples studied. From the data analysis, the students answered their research questions and made suggestions for future research. Also they compared results with past findings.

I am a STEM storyteller

This research was shared on an ArgisStory, and study was disseminated on school website, facebook and newsletter. Also students participated in webinar to share their findings.

I make an Impact

Nitrogen Dioxide and other gases are causing a detrimental effect on our environment. The research helped students, and the community recognize the effect of emissions. In addition to taking measurements at school, students also disseminated their knowledge among family and friends and with other schools in project. Finally, students made recommendations for future research in other periods of time and in the same period to better understand the effect of Nitrogen Dioxide and air quality.