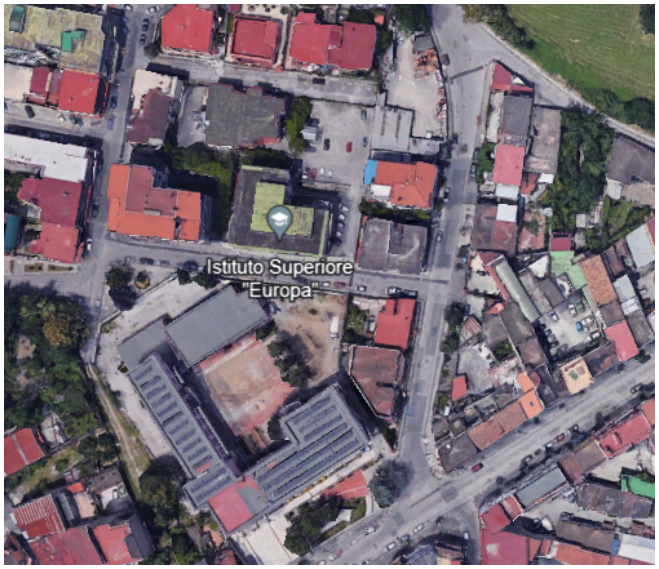
Carbon around us

- **Introduction**

We are students of class 2Cg at ISIS "Europa", a school a few km from Naples and located in the city of Pomigliano D'Arco, in Italy.



Coordinate geografiche	
Latitudine	40°54'40" N
Longitudine	14°23'00" E

This year we too as students, but above all as citizens, joined the Globe Program, the global environmental program, and carried out a study on understanding carbon in the Earth system. To better understand local-scale carbon, where it is found and how it is measured, we considered the environmental changes that are emerging in our local ecosystem, particularly on temperature, and collected biomass data using GLOBE protocols and carried out learning activities in and outside the classroom.
The climate of our dear planet is changing in worrying ways and human activities are *responsible* for these changes.

Among the main causes of global warming we find:

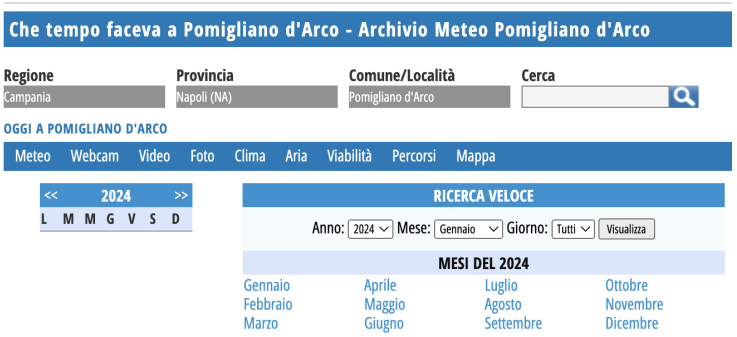
- The use of fossil fuels
- Intensive agricultural activities
- Deforestation

Some gasses present in the Earth's atmosphere act a bit like glass in a greenhouse: they capture the sun's heat, preventing it from returning to space, causing the so-called greenhouse effect and global warming. Many of these gasses are present in nature, but human activities increase the concentrations of some of them in the atmosphere, in particular: carbon dioxide (CO_2),methane, nitrogen oxide (N_2O), fluorinated gasses. Today's climate phenomena are increasingly extreme, frequent and devastating. Human-induced global warming is currently increasing at a rate of 0.2 °C per decade. Consequently, an increase of 2 °C compared to past temperatures is associated with serious negative impacts: on health and well-being, on the natural environment with a much higher risk of dangerous and catastrophic changes.

For this reason, the international community has recognized the need to keep warming well below 2°C and to continue efforts to limit it to 1.5°C.

- **Analysis of the average temperature trend 1980 - 2023 in Pomigliano d'Arco**

Starting from these considerations, our study begins with the search for data relating to the **average temperature** from the 1980s to the 2023s in Pomigliano d'Arco
via the site: www.ilmeteo.it

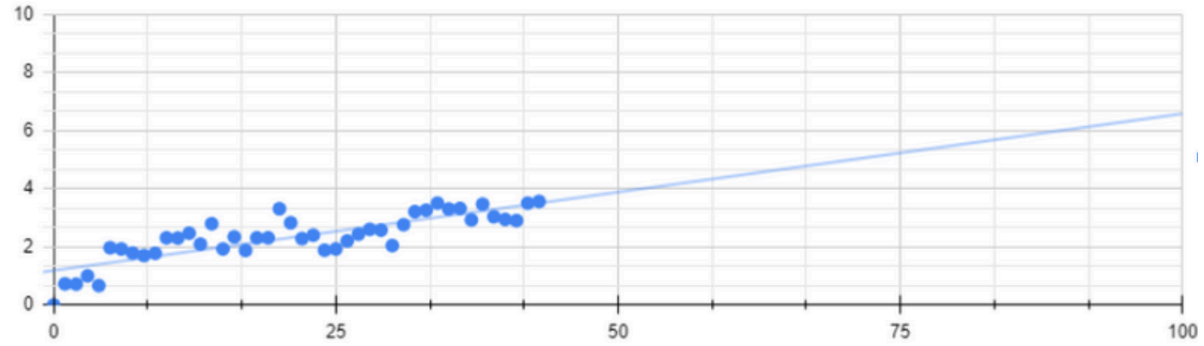


data that is collected in tables for analysis

[Temperatura a Pomigliano dal 1980 al 2023]

TEMPERATURE DI POMIGLIANO D'ARCO IN 43 ANNI				
Anno	anno	Temperatura media annua	Variazione percentuale media	incremento annuale
			%	°C
1980	0	14,42		0
1981	1	15,14	5,03	0,73
1982	2	15,13	4,97	0,72
1983	3	15,42	6,94	1,00
1984	4	15,08	4,62	0,67
1985	5	16,38	13,64	1,97
1986	6	16,34	13,35	1,93
1987	7	16,20	12,37	1,78
1988	8	16,12	11,79	1,70
1989	9	16,19	12,31	1,78
1990	10	16,73	16,01	2,31
1991	11	16,72	15,95	2,30
1992	12	16,88	17,11	2,47
1993	13	16,51	14,51	2,09
1994	14	17,21	19,36	2,79
1995	15	16,34	13,35	1,93
1996	16	16,76	16,24	2,34
1997	17	16,29	13,01	1,88
1998	18	16,73	16,01	2,31
1999	19	16,73	16,01	2,31
2000	20	17,73	22,95	3,31
2001	21	17,24	19,60	2,83
2002	22	16,70	15,84	2,28
2003	23	16,82	16,65	2,40
2004	24	16,30	13,06	1,88
2005	25	16,34	13,35	1,93
2006	26	16,62	15,26	2,20
2007	27	16,85	16,88	2,43
2008	28	17,02	18,03	2,60
2009	29	16,99	17,86	2,58
2010	30	16,46	14,16	2,04
2011	31	17,18	19,13	2,76
2012	32	17,63	22,25	3,21
2013	33	17,68	22,60	3,26
2014	34	17,92	24,28	3,50
2015	35	17,72	22,89	3,30
2016	36	17,73	23,01	3,32
2017	37	17,34	20,29	2,93
2018	38	17,88	24,05	3,47
2019	39	17,45	21,04	3,03
2020	40	17,36	20,40	2,94
2021	41	17,32	20,12	2,90
2022	42	17,92	24,28	3,50
2023	43	17,98	24,68	3,56

Subsequently, we reported these values in the Cartesian plane obtaining **the set of points** and, to build the mathematical model, we considered that the point cloud can be **approximated by a straight line**.



After that, we calculated the equation of the straight line using the centroid method, according to which we divide the set of all values into two subsets. In the first subset we insert the values ranging from the year 1980 to the year 2022. In the second subset we insert the values ranging from the year 2003 to the year 2023.

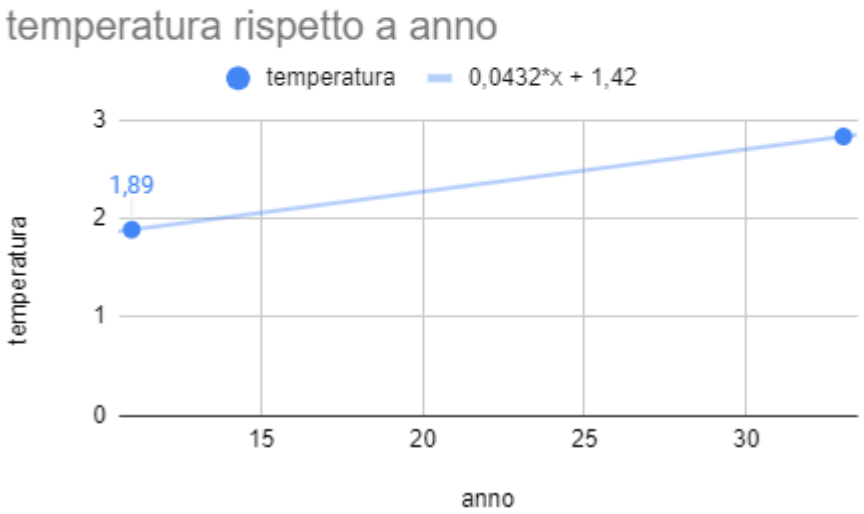
Sottoinsieme1				Sottoinsieme2		
Anno		incremento annuale		Anno		incremento annuale
1980	0	0		2003	23	2,40
1981	1	0,73		2004	24	1,88
1982	2	0,72		2005	25	1,93
1983	3	1,00		2006	26	2,20
1984	4	0,67		2007	27	2,43
1985	5	1,97		2008	28	2,60
1986	6	1,93		2009	29	2,58
1987	7	1,78		2010	30	2,04
1988	8	1,70		2011	31	2,76
1989	9	1,78		2012	32	3,21
1990	10	2,31		2013	33	3,26
1991	11	2,30		2014	34	3,50
1992	12	2,47		2015	35	3,30
1993	13	2,09		2016	36	3,32
1994	14	2,79		2017	37	2,93
1995	15	1,93		2018	38	3,47
1996	16	2,34		2019	39	3,03
1997	17	1,88		2020	40	2,94
1998	18	2,31		2021	41	2,90
1999	19	2,31		2022	42	3,50
2000	20	3,31		2023	43	3,56
2001	21	2,83			33	2,84
2002	22	2,28				
	11	1,89				

Subsequently, we calculated the **average of the values** of subset 1 and subset 2, obtaining the following points: A (11 ; 1.89); B (33 ; 2.84)

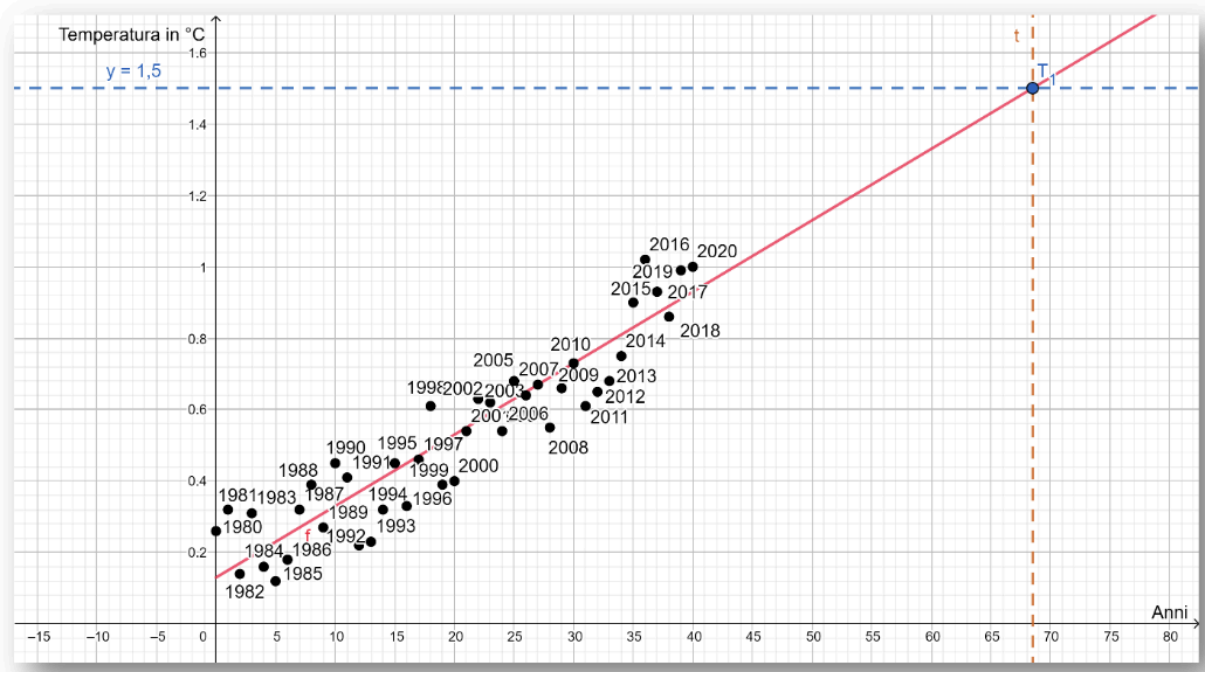
Using point A (11; 1.89) and point B (33; 2.84), we can obtain the equation of the line and construct the graph

y = 0.0432*x + 1.42

where x represents the years and y the increase in the average local temperature in Pomigliano D'Arco.



The slope of the approximation line is 0.04, which means that every



year the average temperature increases by 0.04 °C and, consequently, 0.4 °C per decade. **The international community** has recognized the need to keep warming well below 2°C and to continue efforts to limit it to 1.5°C.

The temperature rise limit (point of no return) corresponds to 1.5 °C, therefore, drawing a straight line of equation: y = 1.5, we obtain the intersection with the global warming line at point T1 (68.5;1.5). The year 68.5 corresponds to the middle of the year 2028, when the point of no return will be reached if the trend remains unchanged.

What will happen to Pomigliano in 2048?

In the previous equation we replace x=43+25, we have y=0.0432(67)+1.42 =4.3144~ 4

Therefore, in Pomigliano there will be an increase of 4°C compared to the temperature of 1980, compared to last year (2023) it was 3.56°C, from which we can deduce that the temperature will increase by almost 1 degree. (4.3144°C -3.56°C)=0.7544*C

Online

https://futuranetwork.eu/focus/533-2849/piantare-mille-miliardi-di-alberi-si-puo-fare-e-sarebbe-risolutivo,

We read that “The immediate solution to reduce global warming, as Stefano Mancuso, the plant neurobiologist, states, is to plant a trillion trees”. *Stefano Mancuso*, in fact, in an interview given to Avvenire, proposed his idea to reduce the concentration of CO2 in the atmosphere: intensive reforestation for carbon capture, which is one of the so-called Nature based solutions. ” to fight global warming. In particular, his analysis predicts reaching **1 trillion** new trees by 2050. This would reduce the carbon dioxide present in the atmosphere by **25%** and cancel approximately 20 years of anthropogenic emissions.

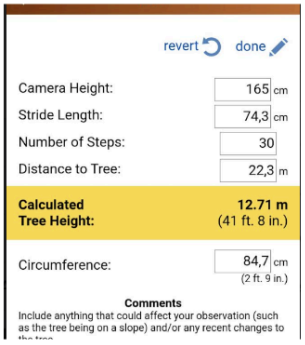
- **Globe's Tree protocol**

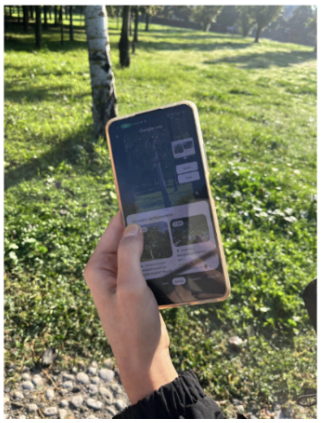
Our investigation continues and from the classroom we move to the Water Park, a park a few meters from the school for an outdoor activity.

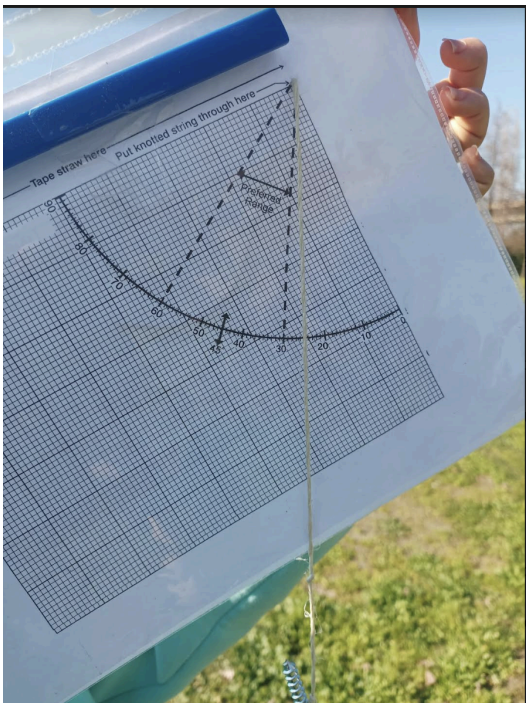
In small groups we experiment with Globe's "Tree" protocol to

determine the height (also with a clinometer) and circumference of some tree species present in the park in order to then obtain the carbon contained in them.

https://www.globe.gov/web/trees-around-the-globe/overview/start-taking-measurements
https://www.globe.gov/web/trees-around-the-globe/overview/getting-started-student-research/visualize-tree-campaign-protocol-data







In un file excel

	Specie	Tipo di legno	Densità (kg/m^3)	Forma	Raggio m	Volume m^3	Massa kg	Circonferenza m	Altezza m	Età (anni)	C02	C02(t)
Albero 1	Betulla	Duro	640	Cilindro	0,23	3,77E+00	2,41E+03	1,4444	22,67	57	3.449	3,4
Albero 2	Pioppo	Duro	445	Cono	0,14	2,02E-01	8,99E+01	0,8792	9,85	36	129	0,13

we reported the data collected with the observed app (species, circumference, height), the information searched online regarding the type of wood and density and finally we obtained the other variables (radius, volume, mass, age) to calculate the amount of CO_2 seized per tree through the empirical formula:

quantità di CO_2 sequestrata per albero (in kg) = massa dell'albero (kg di biomassa fresca) x 65% (massa secca) x 50% (% di carbonio) x 3,67 x 120%

A birch tree grows to adulthood on average in 30 years. Our birth is 57 years old, so for the subsequent calculation we believe we are referring to its 27 years of adult life. Therefore, the kg of CO_2 that our birch absorbs every year is equal to 3449/27 = 128 kg which is very close to the 155 kg/year reported in the literature for birch.

To conclude, returning to the trees to be planted, we analyze the number of trees per capita to dispose of the production of CO_2 in a year in Italy.
We know that every Italian produces on average 5.5 t of CO_2 per year, and that the amount of CO_2 absorbed on average by a mature tree during the year is, in the case of our birch (one of the best trees for absorption of CO_2): 128 kg/year.
Let's convert the amount of CO_2 produced by an Italian on average during the year from t to kg: 5.5 t/year = 5500 kg/year.
Therefore, the number of trees needed to absorb the production of CO_2 per capita in a year is:

5500 kg/year/ 128 kg/year~**43 mature trees**

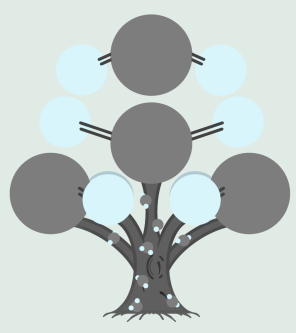
43 trees per year will be needed to absorb the production of CO_2 per capita.
The mathematical function that expresses the number of trees needed to absorb CO_2 as a function of the number of people is: **n =43x** with n,x>0 with x=number of people, n number of trees.

Finally, the equation y= 43 x, with x=number of trees, indicates the mathematical function that expresses the absorption of CO_2 as a function of the number of trees planted in a year.

Conclusions

The mathematical models created revealed that:

- global temperature has increased by 0.2°C every decade;
- +1.5 °C will be reached (point of no return) in mid-2048;
- In the city of Pomigliano, it will even reach +4 °C, according to our study.



- **Biomass combustion is carbon neutral!**

We have already underlined that every Italian produces on average 5 and a half tons of carbon dioxide (CO_2) every year: over a third from transport, another third from food and waste, the rest from heating (25%) and lighting and household appliances (5%). Carbon dioxide is essentially produced by two chemical reactions: combustion and respiration. Combustion and respiration have many aspects in common: they both consume oxygen, producing carbon dioxide and energy. They can be schematized like this:

combustion reaction

C	**+**	**O_2**	**=**	**CO_2**	**+**	**energia**

1 mole	reagisce con	1 mole	per formare	1 mole	ed	energia

breathing reaction

$C_6H_{12}O_6$	+	$6O_2$	=	$6CO_2$	+	$6H_2O$	+ energia
6 moli di C	reagiscono con	6 moli	per formare	6 moli	e	6 moli	+ energia

By studying the stoichiometric ratios between reactants and products we notice that between C and CO_2 the ratio is always 1 to 1 in both combustion and respiration. In fact, in the first one a molecule of carbon dioxide is formed from each C atom, in the second 6 carbon dioxide molecules are formed from a molecule of glucose containing 6 carbon atoms. With chlorophyll photosynthesis, trees absorb carbon dioxide and transform it into glucose and oxygen.

$$6CO_2 + 6H_2O + \text{energy of the sun} = C_6H_{12}O_6 + 6O_2$$

chlorophyll photosynthesis reaction

Glucose makes the tree grow and therefore increases its biomass while oxygen allows living beings to breathe. The stoichiometry of photosynthesis indicates that for every molecule of carbon dioxide absorbed there is a carbon atom that becomes part of the glucose molecule.

Let's consider the birch and poplar of the Acque park that we observed outdoors.

CALCOLO DELLE MOLI

	B	C	D	E	F	G	H	I
1	Specie	biomassa fresca kg	biomassa secca kg	Carbonio kg	Carbonio g	n*C nell'albero	nCO2 assorbite	nCO2 prodotte con la combustione
2	Betulla	2410	1566,5	783,25	783250	65271	65271	65271
3	Pioppo	899	584,35	292,175	292175	24348	24348	24348
4								
5				*numero di moli				

The moles of carbon stored by trees come from the carbon dioxide they have absorbed through chlorophyll photosynthesis.

If the carbon stored in the trees, in the trunk, in the branches, in the leaves was burned:

$$C+O_2 = CO_2 + \text{ energy}$$

it would produce energy and put into circulation the same quantity of carbon dioxide absorbed.

Conclusions

This means that if we use biomass as fuel we do not contribute to the increase in carbon dioxide in the atmosphere. Using biomass as fuel is a carbon neutral process. It involves using the energy that trees have taken from the sun through photosynthesis to:

- home heating
- Transports
- power plants

it would therefore reduce the carbon footprint of each of us by 60%. Planting trees, using vertical green walls, using agricultural processing residues to produce biofuels are all solutions to combat global warming

- **Effects of CO_2 in indoor**

Human beings produce carbon dioxide, which is why CO_2 concentrations in occupied indoor spaces are higher than those in outdoor spaces. The less ventilation the greater the difference between internal and external carbon dioxide levels. When you monitor indoor

air quality you measure:

- the CO_2 present
- the temperature
- humidity
- the presence of VOCs, volatile organic compounds

Outdoors, the CO_2 concentration should be between 300 and 400 parts per million (ppm). Indoor breathing can cause levels to exceed 3000 ppm, especially in unventilated rooms or kitchens. In indoor environments, the temperature should not exceed 1500 ppm, therefore regular ventilation of the rooms is very important.

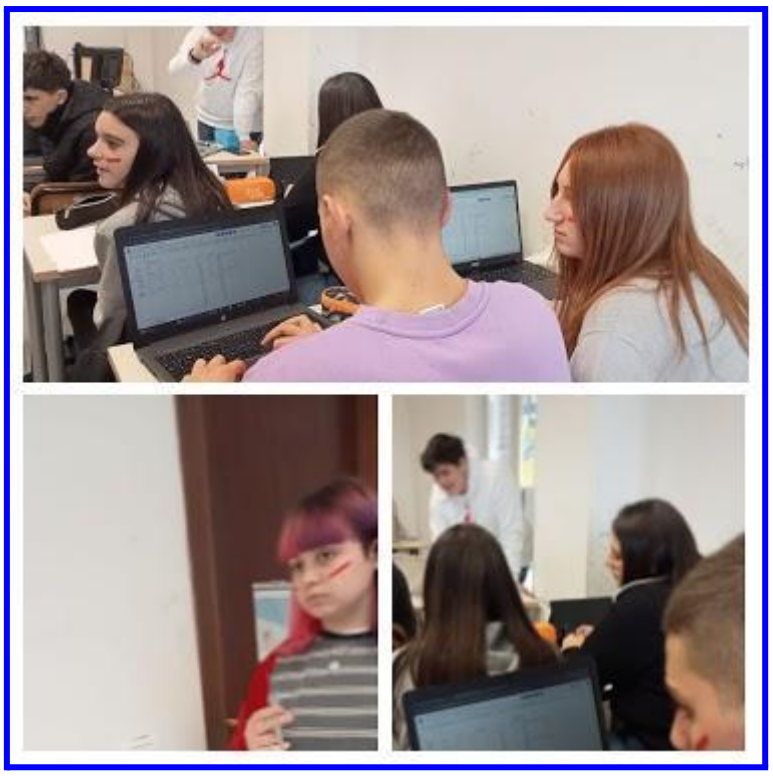
Increased levels of CO_2 in the air make the blood acidic, which increases the frequency and depth of breathing. After many days of exposure to high levels of CO_2 there may be renal mechanisms that influence calcium metabolism in the bones. When CO_2 levels increase people report headaches, mucosal irritation and are more often absent from work or school!

The 2013 experiment conducted by a group of scientists from the Lawrence Berkeley Laboratory in California demonstrated that high concentrations of CO_2 inside buildings, without changes in the ventilation speed of the outside air, have negative effects on the decision-making process of the occupants! Although CO_2 does not represent an important risk for health, it does influence decision-making ability: it represents a risk for the cognitive abilities of people! Indoor monitoring of this gas with appropriate equipment is therefore recommended because the CO_2 level can indicate when to change the air. Poor ventilation makes the home, school and office uncomfortable,

reducing productivity, increases internal humidity which causes mold and dust mites to grow which trigger asthma, increases VOCs released from furniture, construction products, and chemical detergents, which are carcinogenic.

We spend a lot of our time at school. It would be very important to keep carbon dioxide levels in classrooms under control. We only have one CO_2 meter for the entire school and we are looking for a way to ensure good air quality throughout the school. We therefore decided to address this problem by monitoring the CO_2 concentration in our classroom.

The trend of carbon dioxide concentration values in parts per million is obtained by points. The data is collected at a regular interval of thirty seconds.

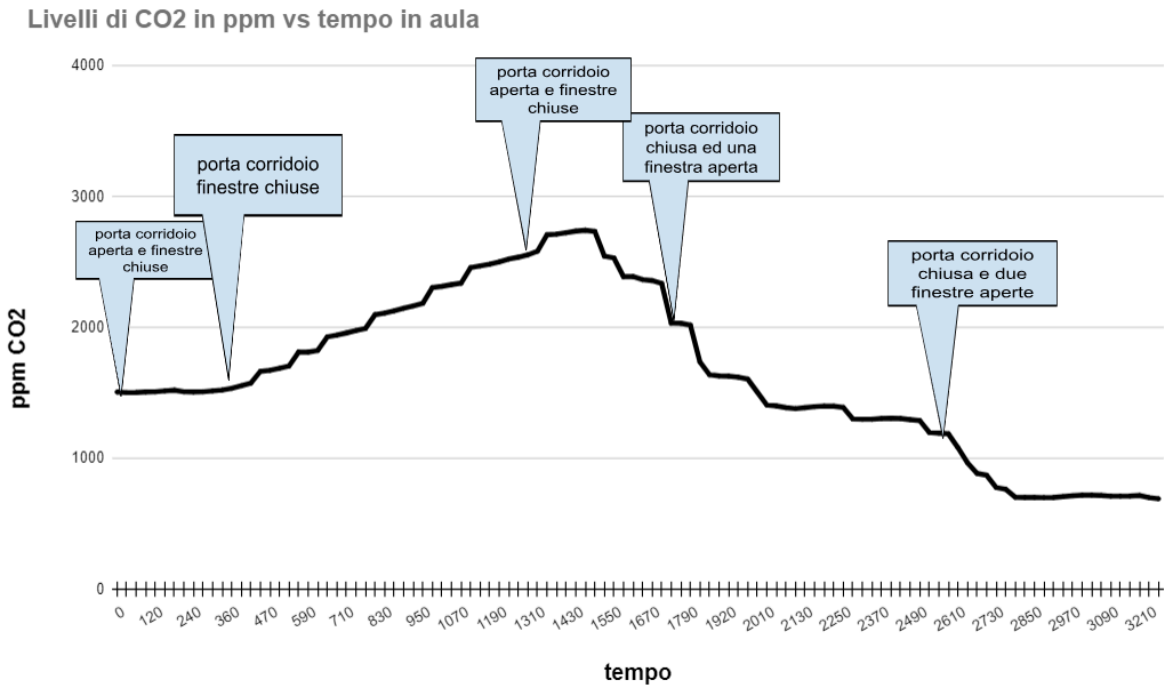


The data is reported in an Excel folder organized into sheets depending on the measurement conditions. The measurement conditions refer to the opening or closing of doors and windows in different combinations. It is necessary to measure the three dimensions of the classroom: length, width and height. The indirect measurement of the volume of the classroom is then carried out by approximating its shape to that of a parallelepiped:

Volume = Base Area * Height; Classroom volume = 68.4m3

The monitoring of carbon dioxide levels is carried out with the PCE-AQD 10 CO_2 Datalogger. All measurements are reported in the attached excel sheet.

- MONITORAGGIO CONCENTRAZIONE DI CO2 NELL'AULA DI SCUOLA S15

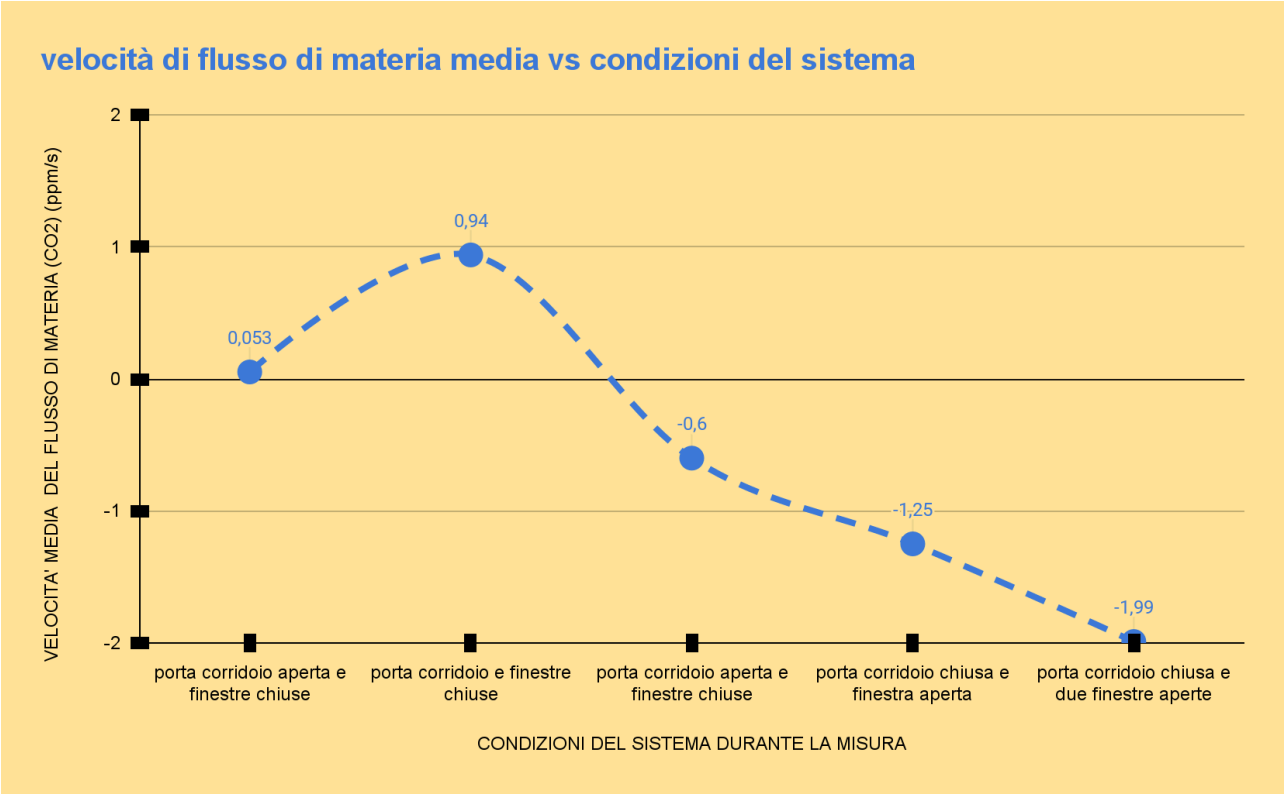


In the morning as soon as you entered:

- CO_2 levels found in the classroom with the windows closed are 1500 ppm and the flow rate is very small 0.056 ppm/s
- closing the door causes CO_2 levels to increase at a rate of 0.94 ppm/s
- when the corridor door is opened, the levels drop at a rate of 0.6

ppm/s

- by closing the corridor door and opening a window the reduction speed becomes 1.25 ppm/s
- by also opening the second window the speed becomes 1.99 ppm/s



Measurement conditions	**CO2 flow rate measured in room S15 of 68.4 m3 with 16 people present**	**CO2 flow rate per 1 m3 and per 1 person (The speed per m3 and per person is obtained by dividing the speed value by the (volume of room S15 equal to 68.4 m3 and by the number of people present equal to 16)**
Entrance to school with closed windows and open corridor door	**0.056 ppm/s**	**0.000051**

Hallway door and windows closed	**0.94 ppm/s**	**0.00087**
Corridor door open and windows closed	**0.6 ppm/s**	**0.00055**
Corridor door closed and window open	**1.25 ppm/s**	**0.0011**
Hallway door closed and two windows open	**1.99 ppm/s**	**0.0018**

We wondered: *How can this data be useful?*

Can they help us keep carbon dioxide levels in classrooms under control in the absence of a CO_2 level meter like the one we used for our monitoring?

We considered a classroom different from ours in terms of volume and number of occupants and we tried to project the results obtained so far.

Measurement conditions	**CO2 flow rate per 1 m^3 and per 1 person**	**CO2 flow rate measured in the 70 m^3 classroom with 20 people present**
Entrance to school with closed windows and open corridor door	**0.000051**	**0.000051*70*20 = 0.071 ppm/s**
Corridor door and windows closed	**0.00087**	**0.00087*70*20 = 1.22 ppm/s**
Corridor door open and windows closed	**0.00055**	**0.00055*70*20 = 0.77 ppm/s**
Corridor door closed and one windows open	**0.0011**	**0.0011*70*20 = 1.54 ppm/s**

Corridor door closed and two windows open	**0.0018**	**0.0018*70*20 = 2.52 ppm/s**

Condizioni di misura Valore iniziale al mattino 1500 ppm Valore outdoor 700 ppm	**Velocità di flusso della CO_2 misurata nell'aula di m^3 70 con 20 unità**	**Tempo**
Porta del corridoio e finestre chiuse	**1.22 ppm/s**	Per passare da 700 a 3000 ppm 2300/122=1885s = 31 minuti Per passare da 1500 a 3000 ppm 1500/1.22= 1230s = 21 minuti
Porta del corridoio aperta e finestre chiuse	**0.77 ppm/s**	Per passare da 3000 ppm a 700 ppm 2300/0.77=2987s = 50 minuti
Porta del corridoio chiusa ed una finestra aperta	**1.54 ppm/s**	Per passare da 1500 ppm a 700 ppm 800/1.54=519s = 9 minuti Per passare da 3000 ppm a 700 ppm 2300/1.54=1494=25 minuti
Porta del corridoio chiusa e due finestre aperte	**2.52 ppm/s**	Per passare da 1500 ppm a 700 ppm 800/2.52=317s=5 minuti Per passare da 3000 ppm a 700 ppm 2300/2.52=913s = 15 minuti

For the situation considered, the control of CO2 levels can be carried out in the absence of a data logger in this way:

- if the classroom is found closed, it must be ventilated with both windows open for 5 minutes in order to bring it into balance with the outside
- door and windows can be kept closed for about 30 minutes
- the replacement must be done by opening the two windows for 15 minutes

The process is repeated for the entire school day.

Conclusions

We can conclude that:

it is possible to create a protocol, to be applied in our school, to keep carbon dioxide levels under control, when we do not have a measuring instrument available that signals when the limit has been exceeded;

- even at home or at school, plants, especially broad-leaved ones, are very useful for reducing CO_2;
- The outdoor level of carbon dioxide of 700 ppm that we measured, very different from those between 300 and 400 ppm reported in the literature, is clearly an alarming figure as it signals the pollution of traffic and industries present in our territory.

Conclusions of the study carried out

Based on the analysis of the data collected in each part of this work, we can only launch an invitation:

LET'S PLANT MORE TREES AND LESS DRUGS!

Messa a dimora di bulbi e fioritura

Piante aromatiche

www.ilmeteo.it
Temperatura a Pomigliano dal 1980 al 2023
piantare mille miliardi di alberi
calcolo delle Moli
https://www.globe.gov/web/trees-around-the-globe/overview/getting-started-student-research/visualize-tree-campaign-protocol-data
monitoraggio CO_2 nell'aula

Messa a dimora di bulbi e fioritura

Piante aromatiche

pareti verdi verticali

PM 10 Pomigliano d'Arco

LA TOP TEN DELLE PIANTE ANTI SMOG