

Air quality in school - measuring and analyzing CO₂ levels

ELEMENTARY SCHOOL ŠIME BUDINIĆ ZADAR
CROATIA, EUROPE

Students: Marinela Dlaka, Marija Cicvarić, Iva Kapljić
Mentor: Zrinka Klarin, geography teacher
2025



OUR TEAM



**MARINELA
DLAKA**
7th grade



**MARIJA
CICVARIĆ**
7th grade



**IVA
KAPLJIĆ**
6th grade

Mentor: Zrinka Klarin, geography teacher

Carbon dioxide

- Colorless and odorless gas
- Consists of one carbon atom and two oxygen atoms is produced as a result of respiration, decomposition of organic matter, combustion of fossil fuels...
- Participates in the process of photosynthesis in which oxygen and organic sugar are produced, which are the basis of aerobic life on Earth
- Its values in the atmosphere are shown in ppm (parts per million)



Carbon dioxide

- It is important to monitor CO₂ levels indoors
- Children are particularly sensitive to air pollution
- According to the WHO *“it is important to regularly measure the air quality in classrooms in order to react in time if levels are elevated”*
- The main causes of changes in carbon dioxide concentration indoors:

The presence of living beings and their activity, ventilation of rooms, presence of plants...



RESEARCH GOAL

The aim of this research is to find out how the concentration of carbon dioxide in different school areas (classroom, school hall, school kitchen and school gymnasium) changes during the school day and during the summer/winter season.

The research aimed to answer the following research questions:

- Is there a significant difference in the concentration of carbon dioxide in different school areas (classroom, school hall, school kitchen and school gymnasium) during the school day?
- Is there a difference in the concentration of carbon dioxide in school areas regarding the summer/winter season?
- How does the frequency of airing and ventilation affect the concentration of carbon dioxide in school areas?

STUDENT HYPOTHESES:

- The concentration of carbon dioxide in the air is the highest in the classroom during classes due to poor airing and in the kitchen during meal preparation. The school hall and school gymnasium have lower levels of carbon dioxide in the air due to larger space, better airing and ventilation.

- Carbon dioxide concentration in school areas is higher during winter than during summer due to often closed windows and less fresh air flow.

- Well-aired and ventilated spaces have significantly lower carbon dioxide levels compared to those where airing is irregular or inadequate.



RESEARCH CONDUCT

First location: school building (closed space) - geography classroom, school hall, school kitchen and school gymnasium

Second location: Vruljica park (open space) - GLOBE biometric station

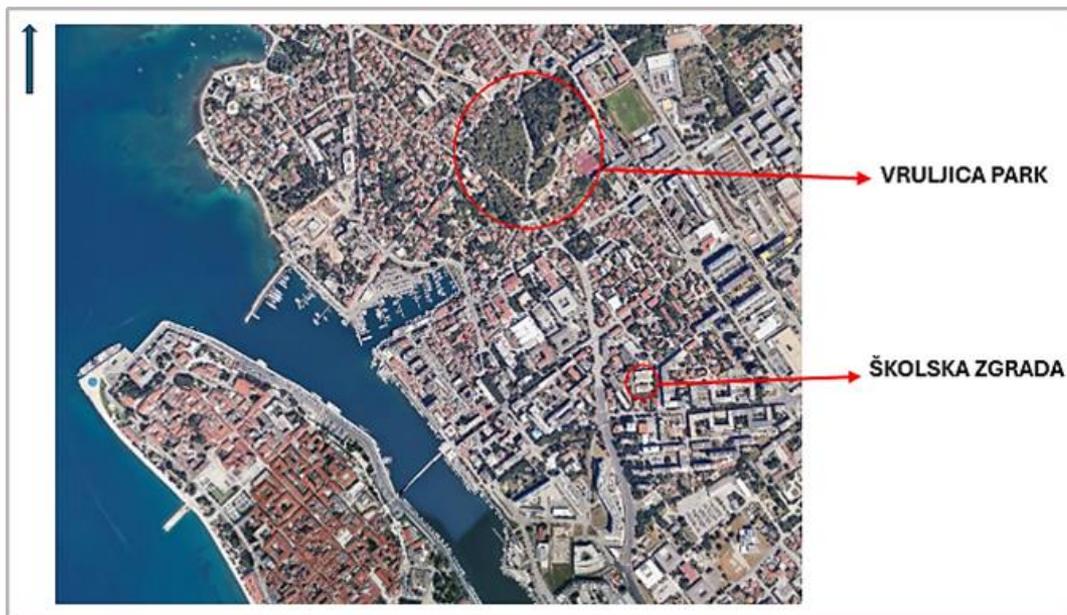


Figure 1 Location of the Šime Budinić school building in Zadar and the Vruljica park

RESEARCH IMPLEMENTATION TIME

SUMMER

10 days

8:00 - 14:00

svaki puni sat

Intensive Observation Period (IOP - Intensive Observation Period)

- geography classroom
- 2 days - 25 people
- from 8:00 to 14:00, every 30 minutes

Devices: Smart Sensees (indoor)
Go Direct CO₂ Sensor (outdoor)

WINTER

10 days

8:00 - 14:00

svaki puni sat

CARBON DIOXIDE CATEGORIES



Table 1 Categories of indoor carbon dioxide level

CO ₂ level (ppm)	Air quality category	Impact on health and well-being
350 - 450 ppm	Very good air quality	Natural level of carbon dioxide in the open air, optimal for breathing.
450 - 800 ppm	Good air quality	Comfortable level, well-ventilated spaces.
800 - 1000 ppm	Acceptable air quality	Feeling of stuffiness in the space, ventilation required.
1000 - 1500 ppm	Poor air quality	Possible drowsiness, decreased concentration, headache.
1500 - 2000 ppm	Very poor air quality	Discomfort, fatigue, headache, urgent ventilation is recommended.
>2000 ppm	Hazardous air quality	Risk of serious problems such as dizziness, nausea, breathing problems.

Table 2 Categories of carbon dioxide levels in outdoor areas

CO ₂ level (ppm)	Air quality category	
< 350 ppm	High quality air	Low pollution levels, naturally clean air.
350 ppm - 450 ppm	Moderate air quality	Moderate air pollution. Increased levels of dust, particles or gases.
>450 ppm	Poor air quality	Heavily polluted air, high pollution levels.



Geography classroom

- The volume of the classroom is 630 m³
- There are windows along the entire length of the east side
- There is no ventilation system or potted plants
- Ventilation depends on the students and the teacher
- Heating is via a central heating system
- Every 45 minutes, students rotate according to the school schedule



Geography classroom

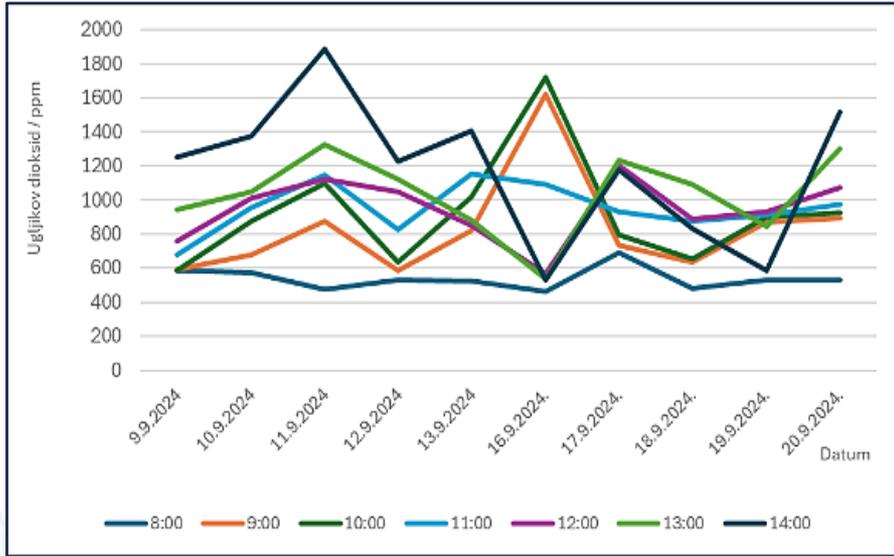


Figure 2 Graphical representation of carbon dioxide values in a geography classroom, September 2024

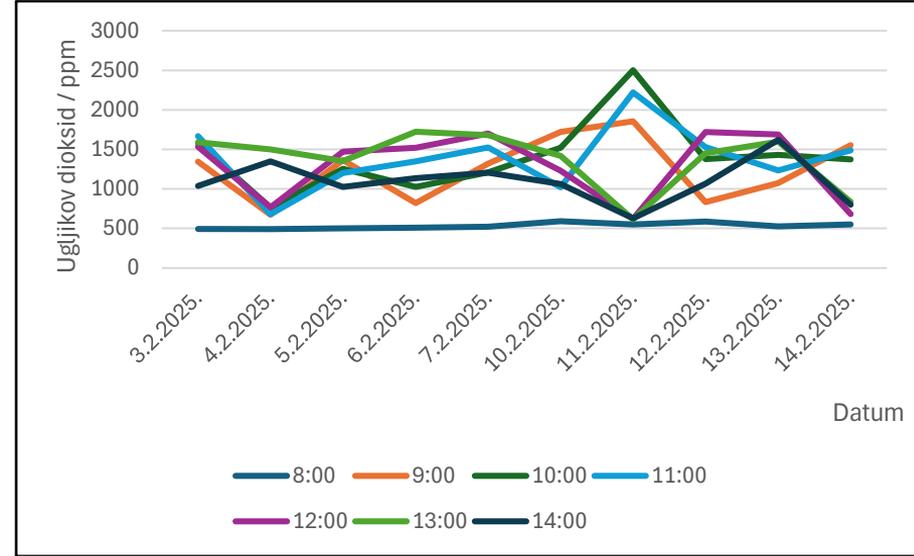


Figure 3 Graphical representation of carbon dioxide values in a geography classroom, February 2025

Geography classroom

Table 4 Comparison of summer/winter data and mean hourly carbon dioxide levels in the geography classroom.

Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima
8:00	8:00	9:00	9:00	¹ 10:00	10:00	11:00	11:00	12:00	12:00	13:00	13:00	14:00	14:00
587	493	590	1345	583	1582	678	1670	756	1532	945	1590	1250	1040
574	492	680	674	873	764	956	680	1010	770	1046	1500	1378	1350
476	501	875	1366	1100	1255	1145	1200	1122	1470	1328	1354	1890	1025
530	510	589	820	635	1025	826	1350	1046	1520	1123	1724	1225	1137
523	522	823	1320	1018	1210	1152	1524	850	1701	879	1682	1409	1205
463	592	1623	1720	1721	1520	1089	1023	567	1230	538	1420	528	1063
690	552	731	1856	798	2502	930	2221	1200	622	1231	615	1180	629
479	589	638	832	656	1378	874	1531	891	1720	1092	1452	830	1066
528	527	871	1076	902	1432	912	1235	931	1689	844	1599	583	1622
531	553	895	1552	928	1374	974	1489	1074	682	1299	836	1520	802
538	533	831	1256	921	1404	954	1392	945	1293	1032	1377	1179	1093

Color legend: 350 - 450 ppm, very good air quality - green color, 450 - 800 ppm, good air quality - yellow color, 800 - 1000 ppm, acceptable air quality - orange color, 1000 - 1500 ppm, poor air quality - red color, 1500 - 2000 ppm, very poor air quality - blue color, 2000+ ppm, hazardous quality - purple color.

School hall

- The volume of the school hall is 2204 m³
- Most of the space is open to the height of the second floor
- Large entrance door and corridors with windows
- Plants in pots
- Winter period of the year - central heating
- No built-in ventilation system
- Ventilation depends on the school's technical staff and teachers



School hall

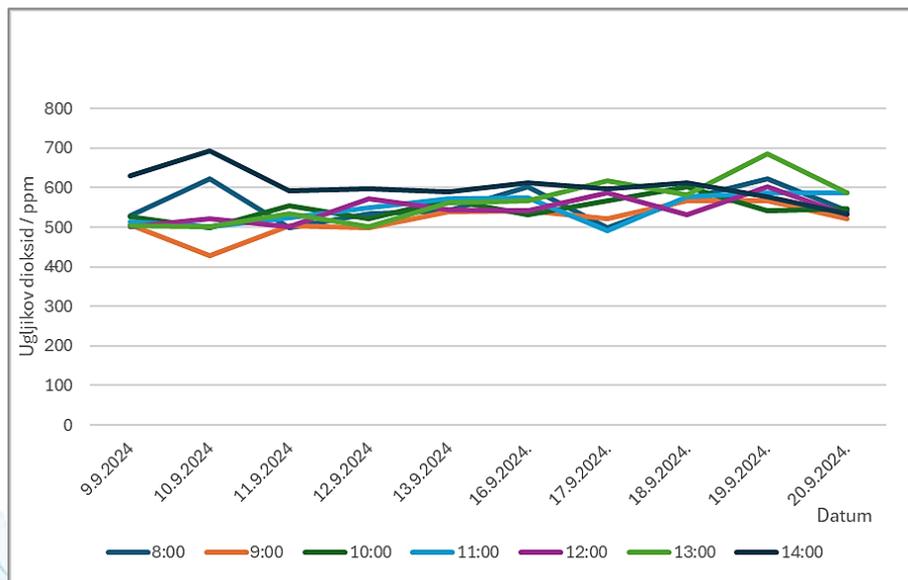


Figure 4 Graphical representation of carbon dioxide values in the school hall, September 2024

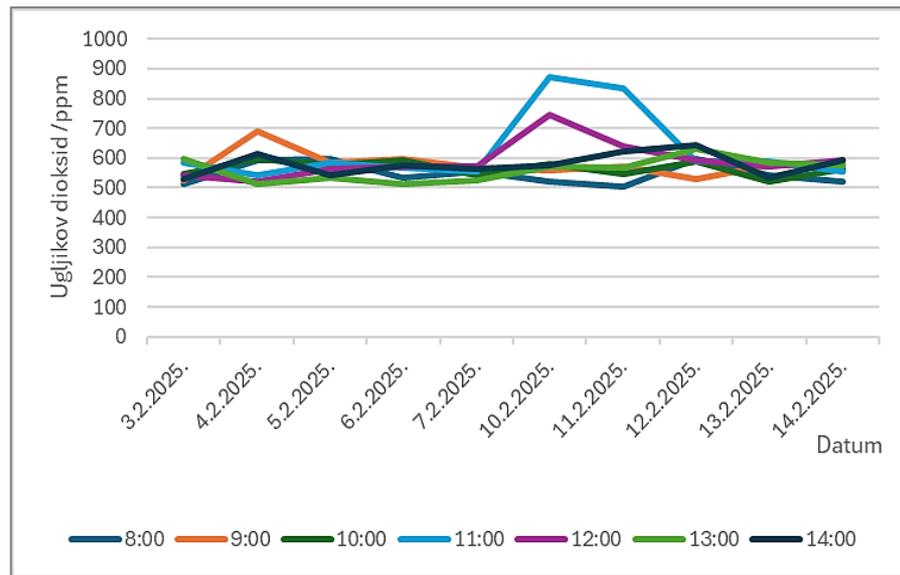


Figure 5 Graphical representation of carbon dioxide values in the school hall, February 2025

School hall

Table 5 Comparison of obtained summer/winter data and mean hourly carbon dioxide levels in the school hall.

Ljeto	Zima												
8:00	8:00	9:00	9:00	10:00	10:00	11:00	11:00	12:00	12:00	13:00	13:00	14:00	14:00
529	513	506	526	526	546	513	583	502	542	504	599	629	529
621	591	429	689	499	599	502	542	521	521	501	512	692	612
498	598	504	584	555	575	524	584	502	562	533	533	591	541
533	533	498	598	522	592	548	568	572	572	501	511	598	578
542	553	538	567	569	542	571	556	544	571	561	527	589	563
603	522	541	558	532	579	574	871	541	744	566	571	612	575
499	503	521	571	568	548	491	832	587	641	618	567	598	622
572	599	566	531	601	588	578	587	532	591	581	632	612	642
622	542	566	576	542	521	586	588	601	572	685	584	578	532
542	522	521	576	547	562	588	556	532	591	587	575	533	592
556	547	519	577	546	565	547	626	543	590	563	561	603	578

Color legend: 350 - 450 ppm, very good air quality - green color, 450 - 800 ppm, good air quality - yellow color, 800 - 1000 ppm, acceptable air quality - orange color, 1000 - 1500 ppm, poor air quality - red color, 1500 - 2000 ppm, very poor air quality - blue color, 2000+ ppm, hazardous quality - purple color.

School kitchen

- The volume of the school kitchen is 48 m³
- It was created by converting a former hallway
- It is equipped with a ventilation system
- Ventilation depends on the school's technical staff
- The kitchen uses a large gas stove and two ovens for preparing meals



School kitchen

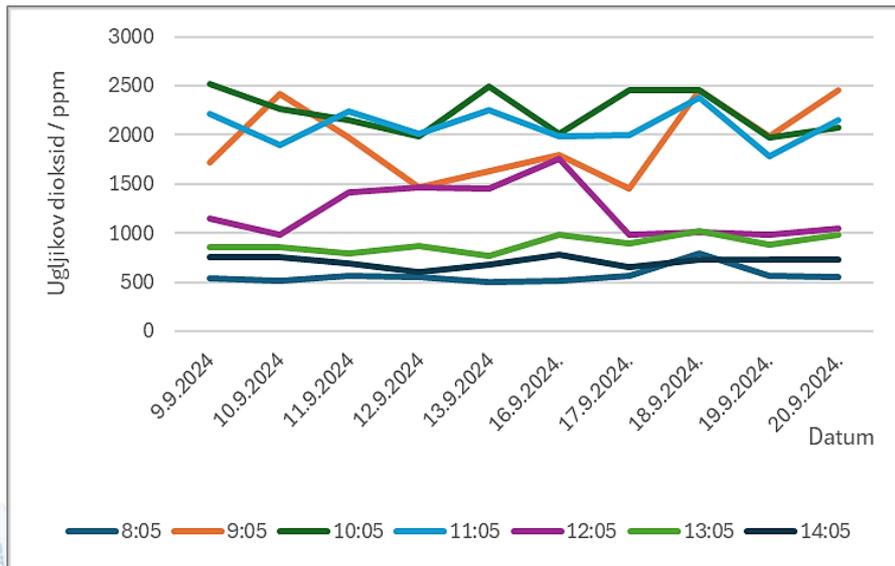


Figure 6 Graphical representation of carbon dioxide values in the school kitchen, September 2024

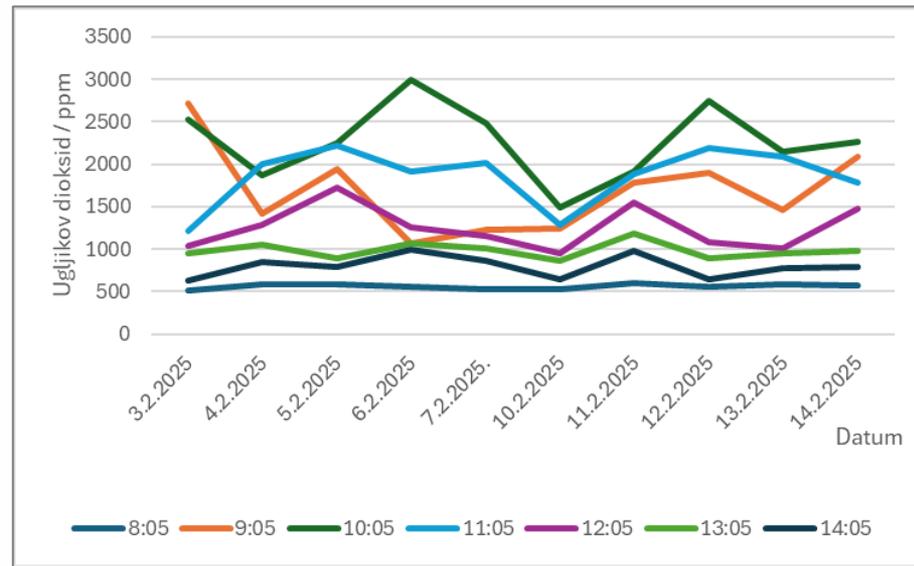


Figure 7 Graphical representation of carbon dioxide values in the school kitchen, February 2025

School kitchen

Table 6 Comparison of summer/winter data and mean hourly carbon dioxide levels in the school kitchen.

Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima
8:00	8:00	9:00	9:00	¹ 10:00	10:00	11:00	11:00	12:00	12:00	13:00	13:00	14:00	14:00
542	516	1721	2721	2521	2531	2210	1210	1142	1042	854	954	752	635
508	588	2413	1413	2265	1865	1899	1999	986	1286	856	1056	754	854
563	583	1978	1948	2147	2247	2245	2214	1420	1720	789	889	687	787
547	556	1465	1065	1985	2985	1998	1912	1462	1250	863	1063	598	998
499	523	1635	1223	2487	2480	2256	2020	1447	1147	765	1002	678	862
509	529	1789	1235	2008	1487	1985	1286	1752	947	978	865	785	648
568	599	1457	1788	2456	2009	2004	1885	987	1552	896	1178	654	985
788	558	1458	1897	1451	2745	1879	2184	1002	1087	1015	886	724	644
563	578	1985	1454	1968	2151	1785	2084	978	1002	875	955	732	774
548	563	2452	2085	2078	2258	2145	1785	1050	1478	987	975	724	789
563	569	1835	1682	2136	2265	2042	1857	1222	1251	887	982	708	797

Color legend: 350 - 450 ppm, very good air quality - green color, 450 - 800 ppm, good air quality - yellow color, 800 - 1000 ppm, acceptable air quality - orange color, 1000 - 1500 ppm, poor air quality - red color, 1500 - 2000 ppm, very poor air quality - blue color, 2000+ ppm, hazardous quality - purple color.

School gymnasium

- The volume of the school gymnasium is 3304 m³
- The windows are placed along the ceiling on the north and south sides along the entire length of the wall
- Ventilation is provided throughout the year
- The hall does not have a ventilation system installed



School gymnasium

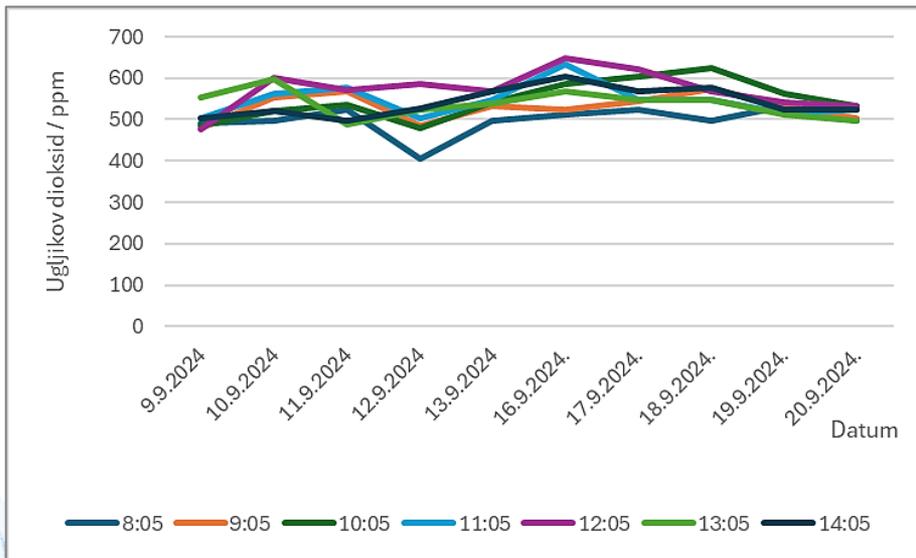


Figure 8 Graphical representation of carbon dioxide values in a school gymnasium, September 2024

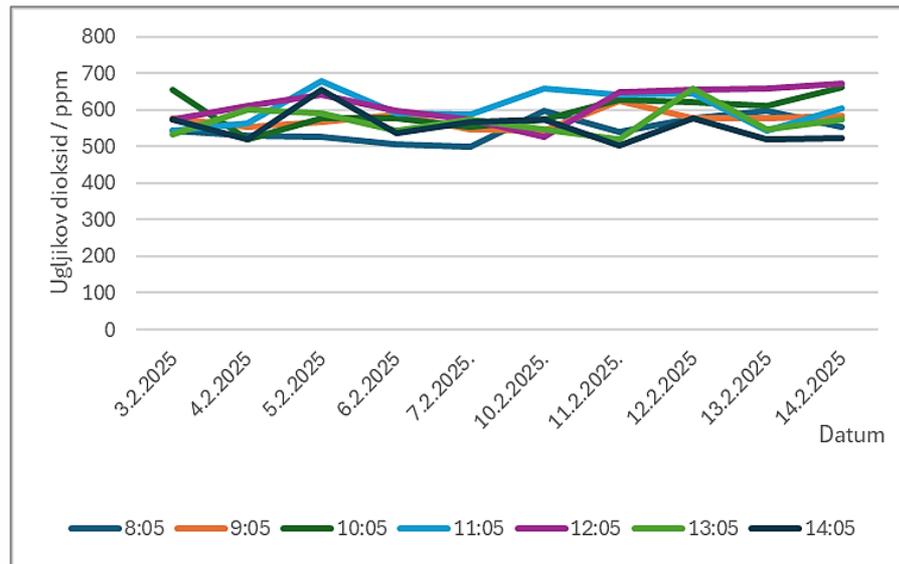


Figure 9 Graphical representation of carbon dioxide values in a school gymnasium, February 2025

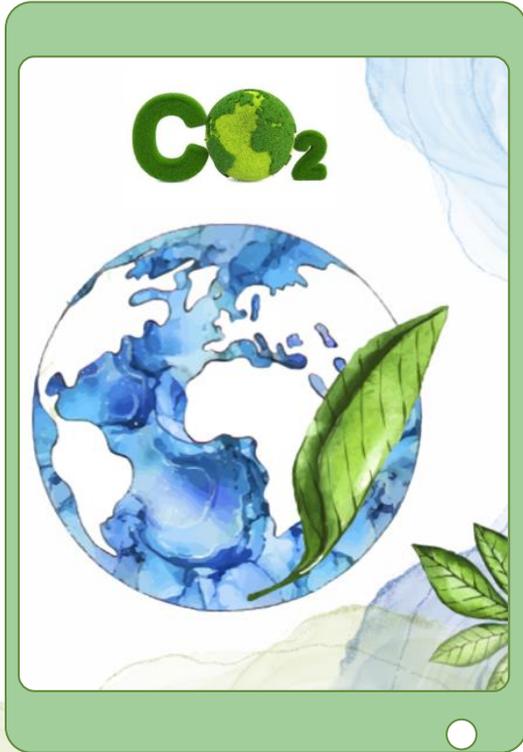
School gymnasium

Table 6 Comparison of summer/winter data and mean hourly carbon dioxide levels in the school gymnasium

Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima	Ljeto	Zima
8:00	8:00	9:00	9:00	¹ 10:00	10:00	11:00	11:00	12:00	12:00	13:00	13:00	14:00	14:00
492	542	478	578	485	655	502	542	475	575	552	532	503	573
498	528	552	552	521	521	563	563	602	612	599	599	521	521
525	525	567	567	536	576	578	678	572	642	489	589	496	656
406	506	486	586	478	578	502	592	587	597	523	543	526	536
498	498	532	548	542	553	547	587	567	572	538	574	568	568
511	598	523	542	586	572	632	657	648	527	568	548	603	575
523	541	544	623	604	626	548	642	622	648	548	518	568	503
498	578	574	578	625	622	547	645	568	654	547	658	578	578
532	598	532	578	562	612	514	542	542	658	512	547	523	518
496	552	504	582	532	662	524	604	533	672	496	572	524	523
497	546	529	573	547	597	545	605	571	615	537	568	541	555

Color legend: 350 - 450 ppm, very good air quality - green color, 450 - 800 ppm, good air quality - yellow color, 800 - 1000 ppm, acceptable air quality - orange color, 1000 - 1500 ppm, poor air quality - red color, 1500 - 2000 ppm, very poor air quality - blue color, 2000+ ppm, hazardous quality - purple color.

IOP - Intensive Observation Period



- Geography classroom
- September (summer), 2 days
- September 23 and 24, 2024, from 8:00 AM to 2:00 PM
- Measurement every half hour
- First day without ventilation and airing
- Second day with constant ventilation and airing

IOP - Intensive Observation Period

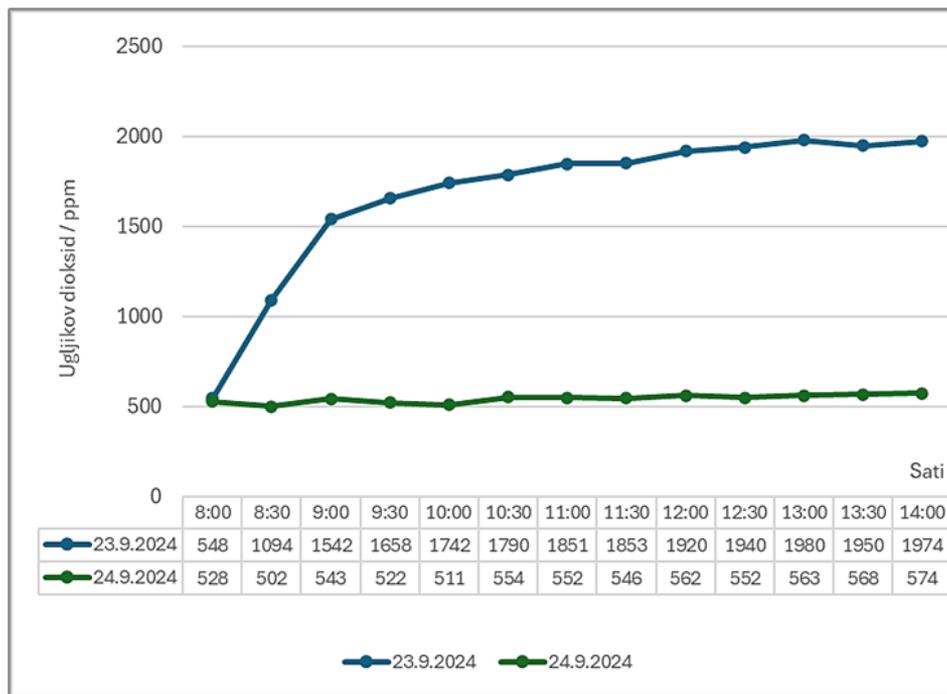


Figure 10 Period of intensive measurement of carbon dioxide concentration in the geography classroom, September 23 and 24, 2024

PARK VRULJICA

- Vruljica park - GLOBE biometric station Vruljica park
- February 17, 2025, from 8:00 to 14:00,
- Every 30 minutes
- Predominantly *Aleppo pine* forest
- Park is surrounded by a public road and built-up facilities





PARK VRULJICA

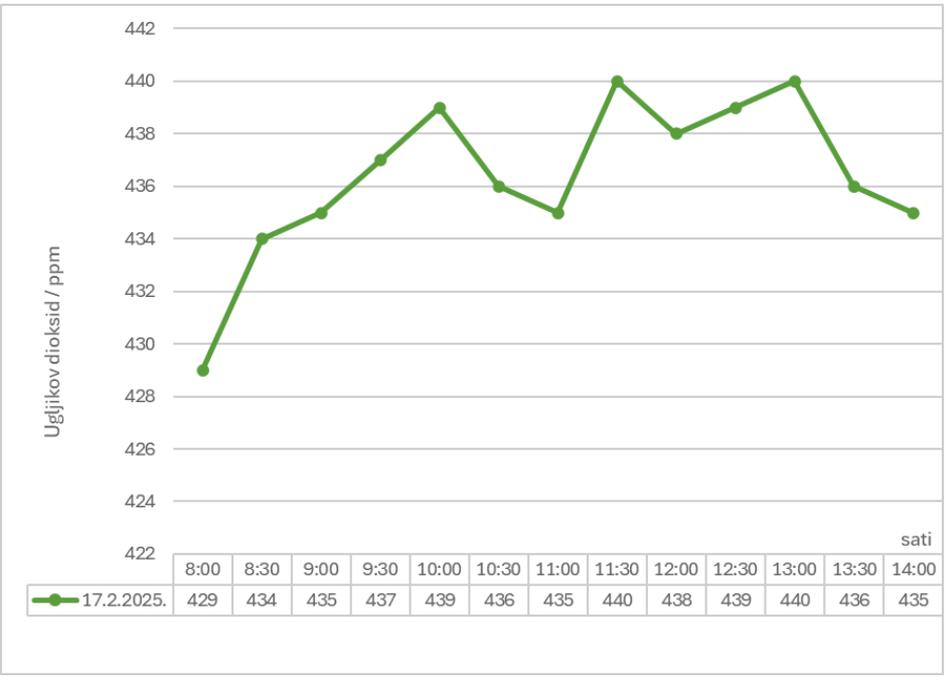
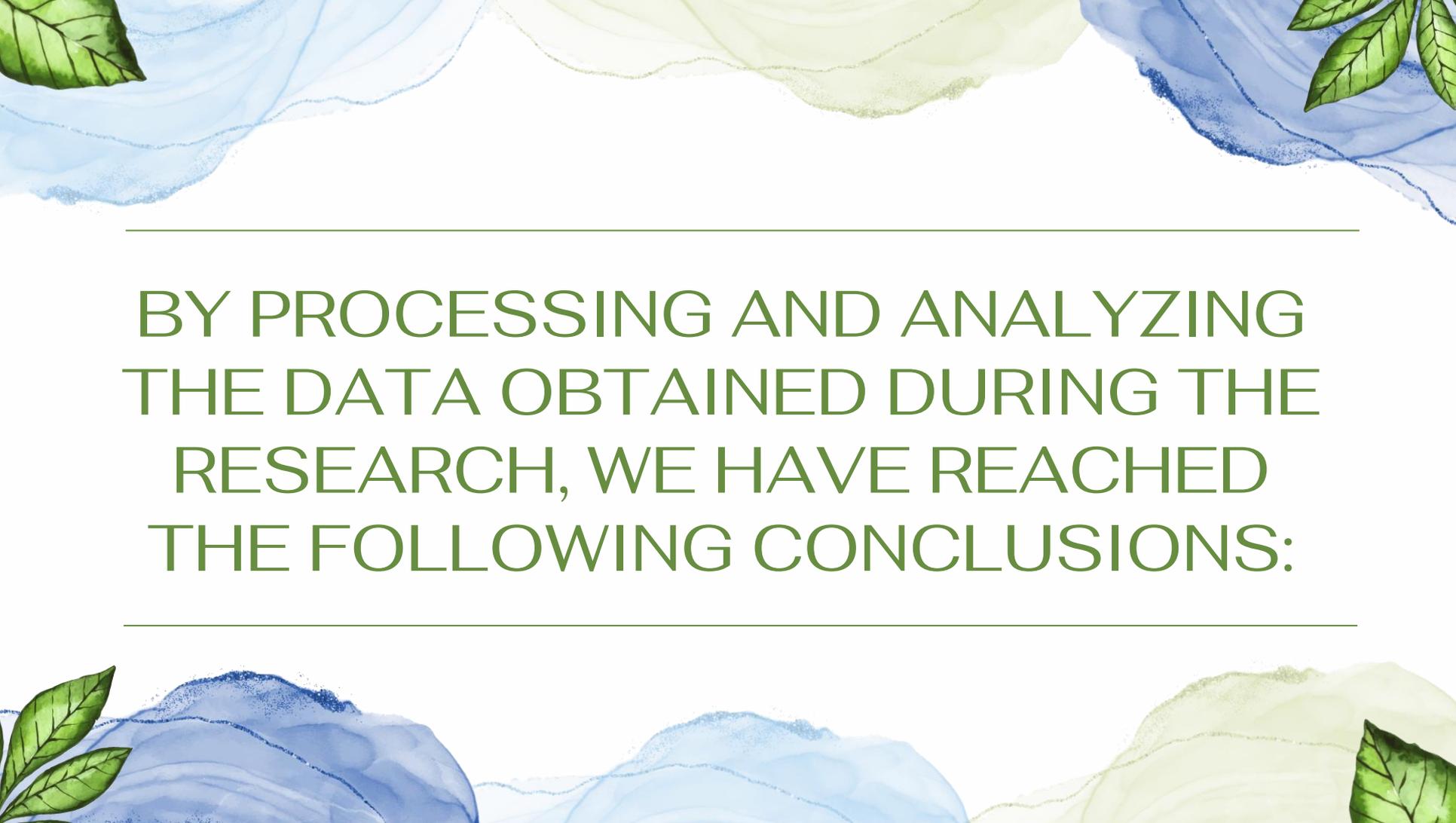


Figure 11 Measured carbon dioxide values in Vruljica Park, February 17, 2025





BY PROCESSING AND ANALYZING
THE DATA OBTAINED DURING THE
RESEARCH, WE HAVE REACHED
THE FOLLOWING CONCLUSIONS:

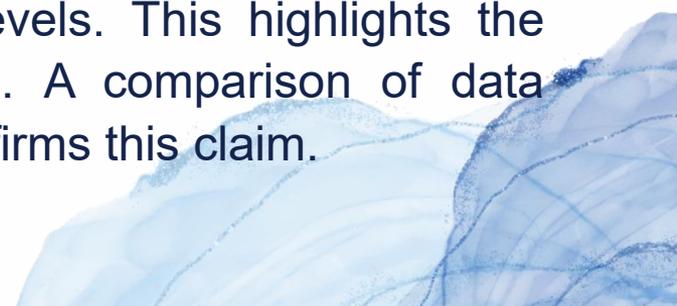


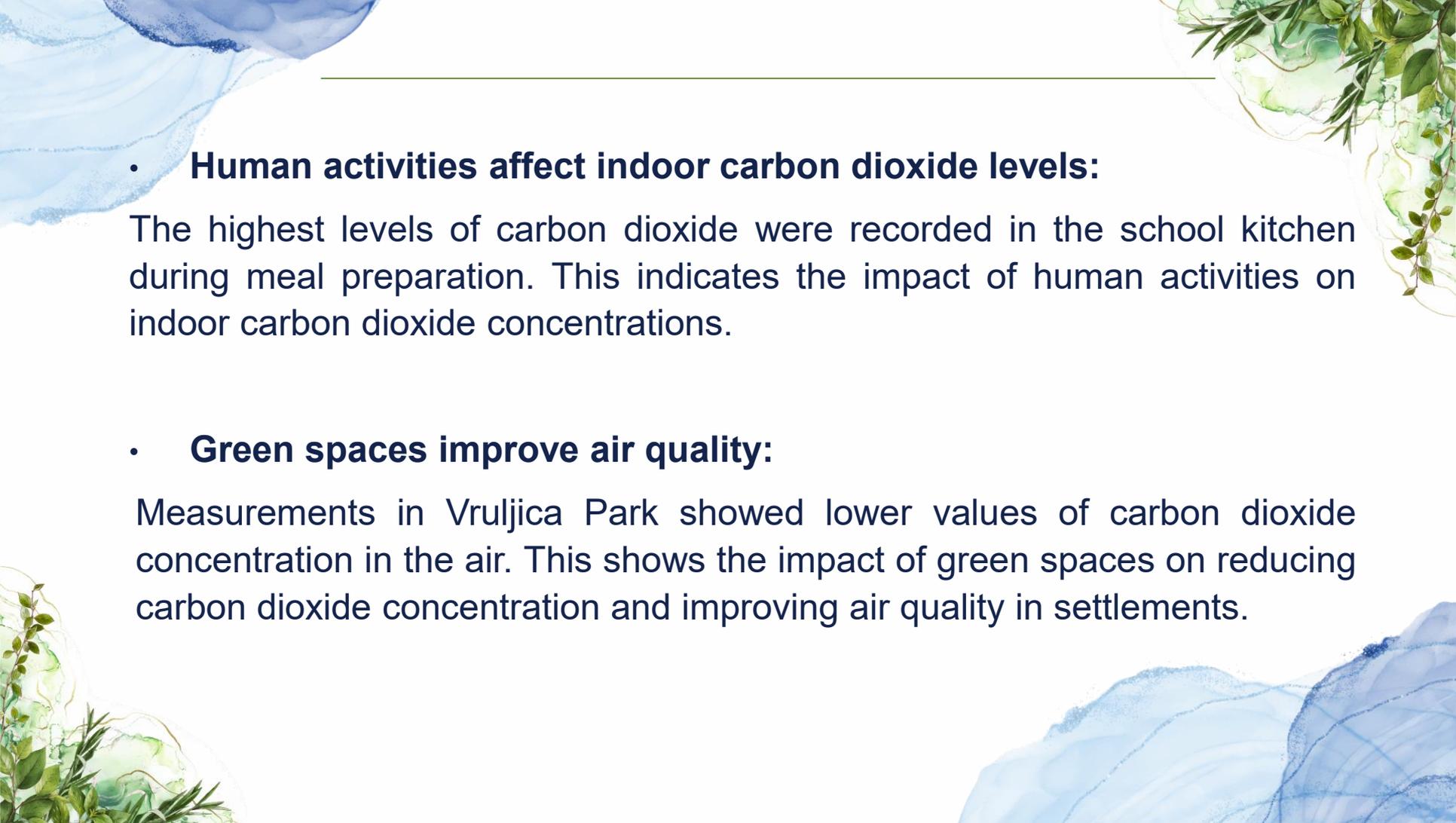
- **Indoor carbon dioxide concentration is variable:**

The study showed significant differences in carbon dioxide levels in different school areas, which are influenced by the presence of people, human activities, airing, ventilation and the presence of plants in the area.

- **Ventilation and air conditioning systems are important for reducing carbon dioxide concentrations:**

Intensive classroom measurements have confirmed that ventilation and air conditioning significantly reduce carbon dioxide levels. This highlights the importance of regularly ventilating indoor spaces. A comparison of data obtained during the winter and summer months confirms this claim.





- **Human activities affect indoor carbon dioxide levels:**

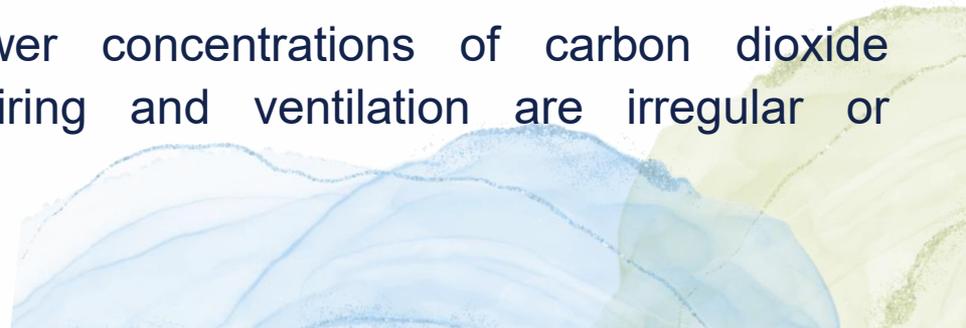
The highest levels of carbon dioxide were recorded in the school kitchen during meal preparation. This indicates the impact of human activities on indoor carbon dioxide concentrations.

- **Green spaces improve air quality:**

Measurements in Vruljica Park showed lower values of carbon dioxide concentration in the air. This shows the impact of green spaces on reducing carbon dioxide concentration and improving air quality in settlements.



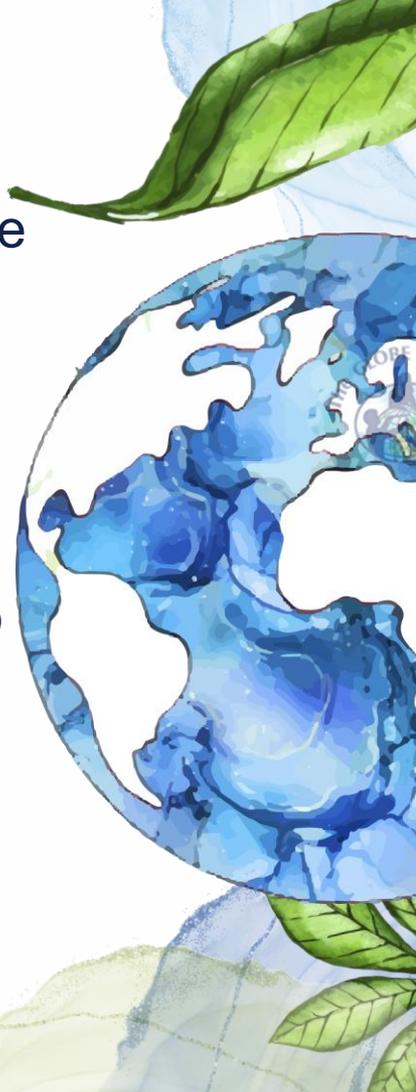
WE HAVE CONFIRMED THE HYPOTHESES

- The concentration of carbon dioxide in the air is highest in the classroom during classes due to poor ventilation and in the kitchen during meal preparation. The school hall and the school gymnasium have lower values of carbon dioxide concentration in the air due to larger space and better airing of the space.
 - The concentration of carbon dioxide on school premises is higher during the winter compared to the summer due to frequently closed windows and lower flow of fresh air.
 - Well-aired premises have lower concentrations of carbon dioxide compared to those where airing and ventilation are irregular or inadequate.
- 

STUDENT RECOMMENDATION

- Indoor spaces should be ventilated as often as possible
- Install air quality measurement devices in all school rooms and install ventilation systems or air purification devices
- Plant pots should be placed in school indoor spaces to reduce carbon dioxide concentrations and improve air quality

This will create a more comfortable and healthier environment for students and teachers to live in.





Thank you for your attention

Elementary School Šime Budinića
Zadar, Croatia

Students: Marinela Dlaka, Marija Cicvarić, Iva Kapljić
Mentor: Zrinka Klarin