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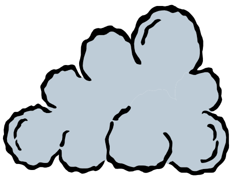
ANALYSIS OF AIR POLLUTION



Chemistry project of students of the 7.c,
B®G Carnerigasse,
with Mag.Pia Jaritz

September 2000– July 2001

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1.Introduction:

Since January 2000 students of *B®G Carnerigasse* and I have been working on the analysis of the air quality around our school building (Graz, Geidorf) during the chemistry classes. The reason why we started the project was that at that time a large road was being built next to our school grounds and we wanted to find out about the consequences for the air quality. We decided to determine ozone, nitrous oxides and dust quantitatively. Since autumn 2000 our works have been part of the Comenius project "Examining pollution in our neighbourhood". Also students and teachers from *Mikolaj Kopernik High School* in Lublin/Poland and from *I.E.S Alexander Graham Bell* in Madrid/Spain take part in this project.
On September 28, 2000 we put up 10 measuring stations on the school grounds and on an area within a radius of one kilometre from our school. We supplied each of these stations with two protective hoods (see illustration) in a height of 1.5 metres. Inside the hoods we placed our measuring papers (passive collectors) so that they were protected from rain and snow. Each station was also equipped with a beaker for the collection of dust.

Protective
hood

Our first measuring period during the Comenius project started on October 12, 2000. Until May 23, 2001 we conducted eight measuring periods, each lasting for 28 days. At the moment, we are only monitoring the concentration of ozone. This is done by a single student, who is working on a paper for her school leaving exams. During the school year 2001/02 I am is not able to conduct measurements with a whole form because I am not teaching chemistry lab classes this year.

In September 2000 the students of 7c formed groups of two who were asked to provide new equipment (paper strips and beakers) for the measuring stations after every 28 days. In addition to that, they had to conduct the photometric measurements of the reaction products of ozone (=isatine) and of the nitrous oxides (=diphenylenitroseamine) and to determine the amount of dust gravimetrically.

These data were used to assess the concentration of air pollutants during the whole respective measuring period. This type of measurement (integral measurement) is not as precise as a continuous measurement. Nevertheless, it is quite common, especially when many measurements are to be made on a small area.

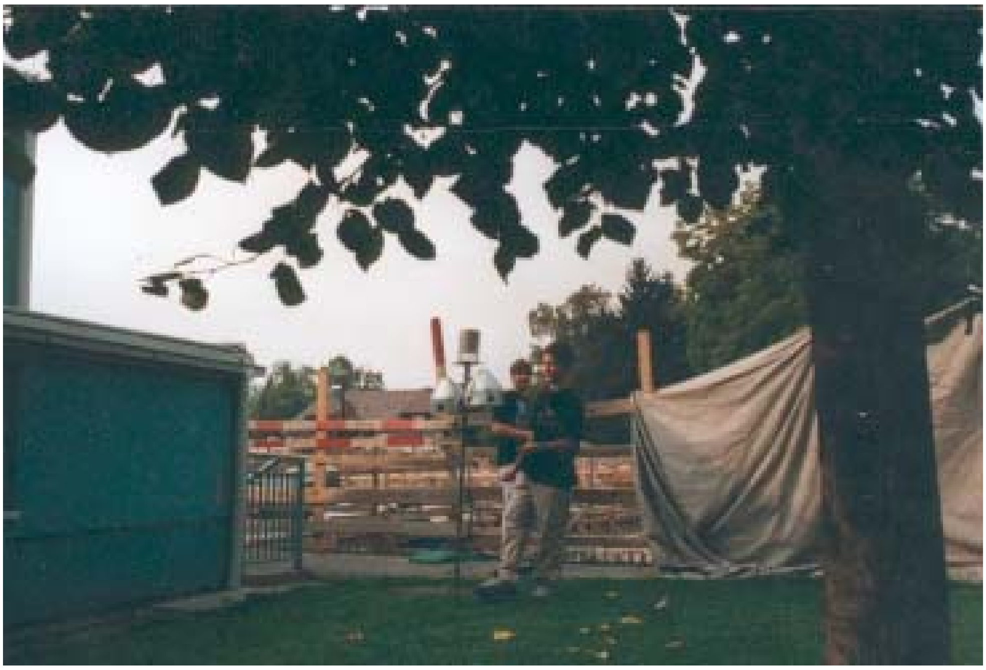
The aim of this study is to give the students the possibility of conducting different methods of quantitative analysis as well as getting some practice in evaluating and interpreting measuring data. Apart from that, we are looking forward to comparing our results with those of the other participating schools and to finding out about the air quality in other European countries.

2. Our fields of work and responsibilities

	New supply	Measurement	Responsible for
Dominic Erjautz	31.1.	1.2.	Poster about measuring stations, information folder
Heike Foditsch	6.12. and 31.1.	7.12. and 1.2.	Measuring methods
Florian Friedrich	28.3.	29.3.	Map
Georg Gobetz	28.3.	29.3.	Cover
Andreas Haidmayer	8.11. and 24.5.	9.11.	Evaluation of data with *Excel*
Julia Kellner	8.11. and 31.1.	9.11. and 1.2.	Ozone
Rene Kollmann	25.4. and 24.5.	26.4.	Nitrous oxides
Stefan Pirker	25.4. and 24.5.	26.4.	Measuring stations, pictures
Cornelia Pölzl	6.12. and 24.5.	7.12.	Dust
Johannes Ritter	28.1. and 24.5.	1.3.	Introduction
Michael Schalk	28.2. and 24.5.	1.3.	Passive accumulators, mobile measuring stations
Mag. Josefine Jaritz	3.1.	4.1.	Coordination und final editing

3. Geographic situation of stations

Station 4, Vogelweider-Road



4. Description of measuring stations

We chose the positions of our measuring stations so that air pollution on many different spots on and around the school grounds could be monitored. We also tried to place our stations in areas with much traffic as well as in traffic-calmed zones.

Nr. 1 House of the caretaker:
On a small meadow in front of the house of the caretaker of our school; next to the intersection of Carneri-Lane und Theodor-Körner-Road.

Nr. 2 Atrium:
In the atrium next to a small pond. During the breaks the atrium is a meeting place for smokers.

Nr. 3 Sports field:
On an embankment at the far end of the sports field, next to a hedge bordering on Theodor-Körner-Road. Extensive roadworks are going on in the immediate neighbourhood. Badge collectors were used at this station temporarily.

Nr. 4 Rear entrance, gym:
On a meadow behind the school near the entrance of the gym. A large construction site is very close, but the measuring station is separated from this area by a protective fence. Temporarily a badge collector was applied to this station. In February and March 2001 the mobile measuring station 2 of the Styrian government was situated next to our measuring station.

Nr. 5 Kalvarienberg-Bridge:
On a traffic island after a busy junction, which is controlled by traffic lights.

Nr. 6 Dr. Putz:
On the balcony of the flat of Dr. Putz and his family; on the seventh floor. We did not conduct dust measurements here.

Nr. 7 Graben-Road:
On a traffic island at a busy junction. Badge collectors were temporarily used here.

Nr. 8 Old people's home
On a grass verge in front of the old people's home in Theodor-Körner-Road.

Nr. 9 Theodor-Körners-Road/ Robert Stolz -Lane:
Next to the tram stop "Robert Stolz –Lane" adjoining Theodor Körner-Road. This measuring station disappeared in January.

Nr. 10 Andritz Maut:
At the junction of three roads (Graben-Road, Theodor Körner-Road and Körösi-Road) and next to a petrol station.

5. Description of measuring methods

5.1 The measuring methods we used

During our project me monitored the concentration of the following air pollutants: **ozone**, **nitrous oxides** and **dust**.

5.1.1 Photometrical Measurements

The basic principle of photometric measurement is to send light of a certain wavelength trough a sample in a cuvette. The original intensity I_o of the light is weakened when the light leaves the sample because part of it was absorbed. According to the rule of Lambert Beer, the following equation can be found:

$$\boxed{A = \varepsilon . c . d = I_0 / I}$$

A = absorption (in former times also called „extinction“)
ε = molar absorption coefficient, characteristic value for each substance; can be determined by calibration as the gradient of the calibration line.
D= layer thickness of the cuvette.

For the determination of ozone we used the indigo method. Indigo (blue) is oxidised to isatine (yellow) by ozone and other oxidants. The amount of isatine is determined with the help of a photometer, by reading the absorption values at a wavelength of 408 nm.

In order to determine nitrous oxides, we used diphenylamine which reacts to form diphenylnitrosamine. We calculated the amount of diphenylnitrosamine from absorption measurements at a wavelength of 390 nm.

We did not use the absorption values to calculate the actual concentrations of isatine or diphenylnitrosamine because our aim was the determination of ozone and nitrous oxides. So we made a correlation between our absorption data and the data for the concentration of ozone and nitrous oxides from the Styrian government (station Graz North), which were obtained by continuous measurements. We did so by summing up the daily averages of station Graz North for each measuring period and found a linear correlation between these data and our results.

Heike Foditsch working at the photometer

5.1.2 Gravimetrical Measurements:

The basic principle of gravimetrical measurements is simple. The amount of a certain substance is determined by weighing it precisely on scales. We used the "Bergerhoff method" to determine the amount of dust.

The content of the Bergerhoff beaker (usually rainwater, dust, and the like) is put into a dry beaker of which the exact weight has been determined earlier. Unwanted substances (e.g. beetles) are removed with a pair of tweezers. Then the beaker is put into the cabinet drier and left there for several hours at 100°C. After all the water has vaporized, the remaining dust can be weighed. Finally the result is converted into g/m^2.

5.2 Additional Methods of Measurement:

5.2.1 Badge Collectors:

The Badge Collectors were produced by the Institute of Analytical Chemistry of the University of Technology, Vienna (Department for Environmental Analytics). We used them to determine the concentrations of nitrous dioxide and sulfur dioxide. The collectors are boxes made of polypropene, with a height of 9 mm, a diameter of 29 mm and an active collector surface of 6,6 cm^2. A steel net which was impregnated with triethanolamine (basic) is used as the absorbing layer. This layer can bind acid air pollutants. To protect the collectors from soiling, they are covered by a teflon membrane which is permeable for gas. The principle of this method is diffusion of pollutants to an active layer.

After exposure the carriers are eluted and the collected substances are determined with the help of ionchromatography. From the amount of the adsorbed gases the average concentration of the components in the surroundings of the measuring station can be calculated according to Fick's First Law of Diffusion.

5.2.2 The Mobile Measuring Station:

Mobile measuring stations monitor the concentrations of sulfur dioxide (SO_2), dust, nitrous monoxide (NO), nitrous dioxide (NO_2), and carbon monoxide (CO) in the air. The stations are equipped with gauges that record the concentrations continuously and operate according to the following principles:

Pollutant	**Measuring method**	**Type of instrument**
Sulfur dioxide	UV-fluorescence	Horiba APSA 350E
Dust	β-ray absorption	Horiba ABDA 350E (Mobile 2)
Nitrous oxides	chemolumeniscence	Horiba APNA 350E
Carbon monoxide	gasfilter correlation	Horiba APMA 350E
Ozone	UV-photometry	Horiba APOA 305E

Apart from the concentrations of air pollutants, the mobile stations also record meteorological data like temperature, humidity, wind direction and wind speed. Computers facilitate the complete recording and monitoring of the measuring process. The plausibility of the results is checked automatically. The data obtained are transmitted to the *Luftgütezentrale* (office for the monitoring of air quality) in Graz, where they are again checked for their plausibility and finally confirmed. The calibration of the readings is carried out according to ÖNORM M5889. The standards used are regularly checked and adjusted to international standards.

Mag. Schopper from the Styrian government in front of the mobile measuring station

The interior of the mobile measuring station

6. Legal limits for pollutants

6.1 LUIS (*Landes-Umwelt-Information Steiermark*)

LUIS (system for environmental information in Styria) was founded in 1988. Its purpose is the collection and distribution of environmental data from various fields of interest. So LUIS does not only display data on air pollution, but also on climate, protection of threatened species, noise pollution, tourism and the like. More information about Luis can be obtained under http://www.stmk.gv.at/LUIS.

6.2 Legal situation in Styria and Austria

6.2.1 Explanation of terms used

Various federal and regional laws concerning air pollutants apply to our situation in Graz. In all these regulations the following abbreviations are found. The measuring stations of the Styrian government record readings every few seconds and then transmit them to the *Luftgütezentrale Graz* (office for monitoring air pollution). Then these data are used to calculate average values for different periods of time.

	German expression	Translation and explanation
HMW	*Halbstundenmittelwert*	Average of readings over half an hour of measuring
HMWmax	*Maximaler Halbstundenmittelwert*	Highest HMW during the whole measuring period
MW3	*3-Stundenmittelwert*	Average of readings over three hours, calculated from the respective HMWs
MW8	*8-Stundenmittelwert*	Average of readings over 8 hours, calculated from the respective HMWs
MW8max	*Maximaler 8-Stundenmittelwert*	Highest MW8 within the whole measuring period
TMW	*Tagesmittelwert*	Average of readings over 24 hours, calculated from the respective HMWs
TMWmax	*Maximaler Tagesmittelwert*	Highest TMW during the whole measuring period
Mtmax	*Mittleres tägliches Maximum*	Average of the highest HMWs for each day of the measuring period
PMW	*Messperiodenmittelwert*	Average of readings over the whole measuring period, calculated from the respective TMWs

The two most important laws concerning air pollution in Austria are the *Immissionsschutzgesetz –Luft*, IG-L (law for the protection from air pollution; BGBl. I Nr. 115) from 1997 and the *Ozongesetz* (ozone law; BGBl. Nr. 210) from 1992. In Styria also the *Immissionsgrenzwerteverordnung der Steiermärkischen Landesregierung* (act about limits for air pollutants by the Styrian government; LGBl. Nr. 5) from 1987 has to be observed.

6.2.2 Legal limits for different air pollutants

Ozone (according to BGBl. 210, 1992):

	MW3 [mg/m³]
Early warning level	0.200
Warning level 1	0.300
Warning level 2	0.400

Nitrous oxides (according to LGBl. 5, 1987)

	HMW [mg/m³]	**TMW [mg/m³]**
NO	0.60	0.20
NO_2	0.20	0.10

Dust (according to LGBl. 5, 1987)

	TMW [mg/m³]
April - October	0.12
November - March	0.20

The legal limits mentioned above only apply to the concentration of dust in the air. We, however, measured dust deposition, and for this type of measurement there is no legal regulation. We can only cite the usual amount of dust deposition in cities with 5-6 g/m^2*28 days.

Sulfur dioxide (according to LGBl. 5, 1987)

	HMW [mg/m³]	**TMW [mg/m³]**
April - October	0.10	0.05
November - March	0.20	0.10

Carbon monoxide (according to LGBl. 5, 1987)

HMW [mg/m³]	**TMW [mg/m³]**
20	7

7. Ozone

7.1 Preparation of passive collectors

Method: Indigo – summation method

7.1.1 Impregnating the paper strips:

2 g indigo (Fluka standard) are dissolved in 1000 ml dimethylformamide p.a. at 60°C while stirring constantly.

The chromatographic paper strips, 10 cm by 8 cm, (Macherey & Nagel no. 827) are placed in this solution for approximately 10 seconds (see illustration). Then the solution is allowed to drip off, and the paper strips are dried in a vacuum drier over night. This procedure is repeated the next day. For storing, the paper strips are sealed in airtight plastic bags.

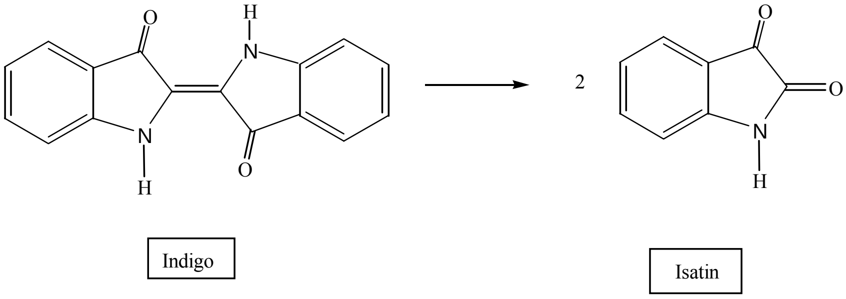
Impregnation of the chromatographic paper strips with indigo

7.1.2 Installing the indigo-paper strips:

The impregnated paper strips are placed inside the measuring stations under the protective hood and remain there for 28 days.

7.2 Measuring:

Then the paper is removed and put into 50 ml of ethanol for about 30 minutes while shaken frequently. Parts of the blue indigo will have oxidized to yellow isatine during the time of exposure (compare reaction equation). The solution is filled into 1cm cuvettes and measured in a photometer at 408 nm against ethanol (UV–1202 UV–VIS spectrophotometer, Shimadzu).



Reaction of indigo to isatine

Dr. Kosmus,
Department of
Analytical
Chemistry at
Karl-Franzens
University
Graz

7.3 Results:

Table 1:

Readings for isatine

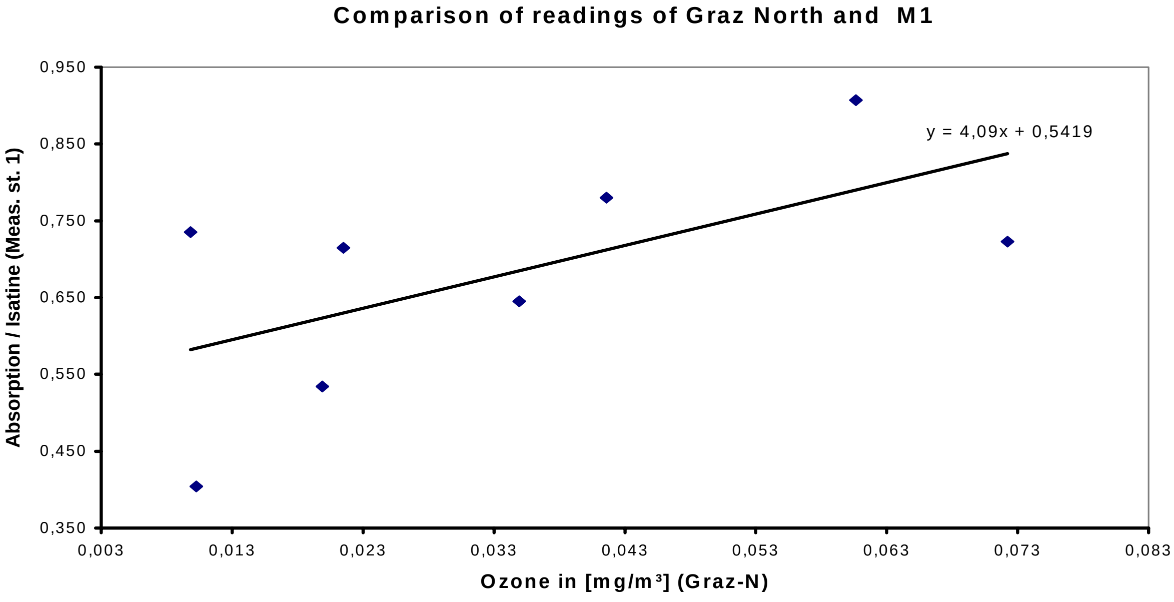
Measuring period	exposure		days	station	reading [ABS] at 408 nm
	from	to			
I	12.10.00	08.11.00	28	1	0,715
I	12.10.00	08.11.00	28	2	1,022
I	12.10.00	08.11.00	28	3	0,899
I	12.10.00	08.11.00	28	4	0,776
I	12.10.00	08.11.00	28	5	0,328
I	12.10.00	08.11.00	28	6	1,073
I	12.10.00	08.11.00	28	7	No reading
I	12.10.00	08.11.00	28	8	1,037
I	12.10.00	08.11.00	28	9	0,757
I	12.10.00	08.11.00	28	10	No reading
II	9.011.00	06.12.00	28	1	0,735
II	9.11.00	06.12.00	28	2	1,313
II	9.11.00	06.12.00	28	3	0,777
II	9.11.00	06.12.00	28	4	0,553
II	9.11.00	06.12.00	28	5	No reading
II	9.11.00	06.12.00	28	6	0,797
II	9.11.00	06.12.00	28	7	0,490
II	9.11.00	06.12.00	28	8	0,343
II	9.11.00	06.12.00	28	9	0,715
II	9.11.00	06.12.00	28	10	0,228
III	07.12.00	03.01.01	28	1	0,404

III	07.12.00	03.01.01	28	2	0,502
III	07.12.00	03.01.01	28	3	0,394
III	07.12.00	03.01.01	28	4	0,608
III	07.12.00	03.01.01	28	5	0,180
III	07.12.00	03.01.01	28	6	0,339
III	07.12.00	03.01.01	28	7	0,292
III	07.12.00	03.01.01	28	8	0,385
III	07.12.00	03.01.01	28	9	0,462
III	07.12.00	03.01.01	28	10	0,409
IV	04.01.01	31.01.01	28	1	0,534
IV	04.01.01	31.01.01	28	2	0,571
IV	04.01.01	31.01.01	28	3	0,345
IV	04.01.01	31.01.01	28	4	0,355
IV	04.01.01	31.01.01	28	5	0,299
IV	04.01.01	31.01.01	28	6	0,002
IV	04.01.01	31.01.01	28	7	0,041
IV	04.01.01	31.01.01	28	8	0,163
IV	04.01.01	31.01.01	28	9	0,449
IV	04.01.01	31.01.01	28	10	No reading
V	01.02.01	28.02.01	28	1	O,473
V	01.02.01	28.02.01	28	2	0,512
V	01.02.01	28.02.01	28	3	0,340
V	01.02.01	28.02.01	28	4	0,602
V	01.02.01	28.02.01	28	5	0,122
V	01.02.01	28.02.01	28	6	0,159
V	01.02.01	28.02.01	28	7	0,922
V	01.02.01	28.02.01	28	8	0,877
V	01.02.01	28.02.01	28	9	No reading
V	01.02.01	28.02.01	28	10	0,829
VI	01.03.01	28.03.01	28	1	0,780
VI	01.03.01	28.03.01	28	2	0,774
VI	01.03.01	28.03.01	28	3	0,965
VI	01.03.01	28.03.01	28	4	1,089
VI	01.03.01	28.03.01	28	5	1,055
VI	01.03.01	28.03.01	28	6	0,760
VI	01.03.01	28.03.01	28	7	0,826
VI	01.03.01	28.03.01	28	8	1,053
VI	01.03.01	28.03.01	28	9	No reading
VI	01.03.01	28.03.01	28	10	0,600
VII	29.03.01	25.04.01	28	1	0,907
VII	29.03.01	25.04.01	28	2	0,789
VII	29.03.01	25.04.01	28	3	1,016
VII	29.03.01	25.04.01	28	4	0,942
VII	29.03.01	25.04.01	28	5	0,860
VII	29.03.01	25.04.01	28	6	0,821
VII	29.03.01	25.04.01	28	7	1,148
VII	29.03.01	25.04.01	28	8	0,523

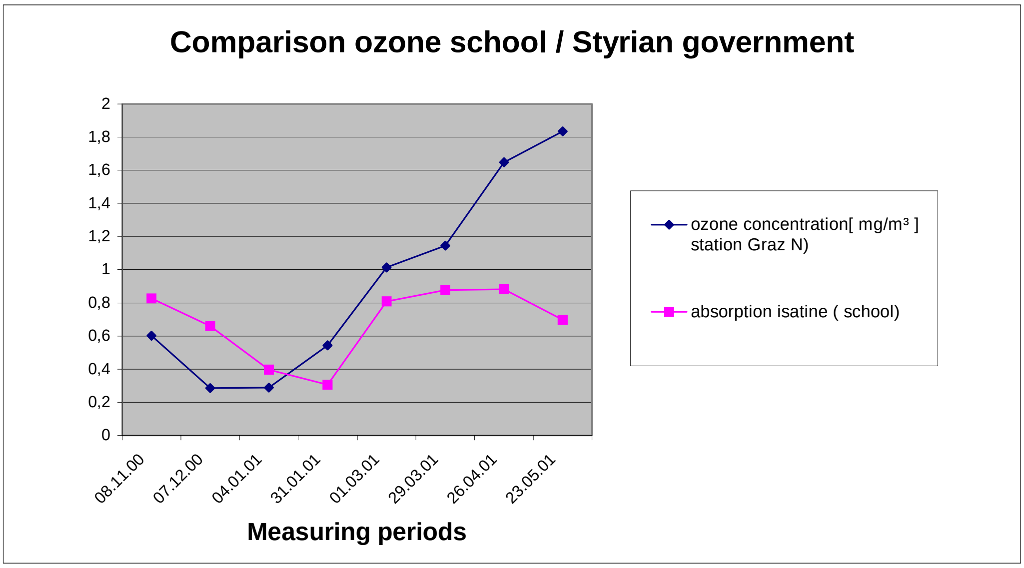
VII	29.03.01	25.04.01	28	9	No reading
VII	29.03.01	25.04.01	28	10	0,931
VIII	26.04.01	23.05.01	28	1	0,723
VIII	26.04.01	23.05.01	28	2	0,487
VIII	26.04.01	23.05.01	28	3	0,695
VIII	26.04.01	23.05.01	28	4	0,613
VIII	26.04.01	23.05.01	28	5	0,807
VIII	26.04.01	23.05.01	28	6	0,507
VIII	26.04.01	23.05.01	28	7	0,844
VIII	26.04.01	23.05.01	28	8	0,910
VIII	26.04.01	23.05.01	28	9	No reading
VIII	26.04.01	23.05.01	28	10	0,691

7.4 Interpretation of results

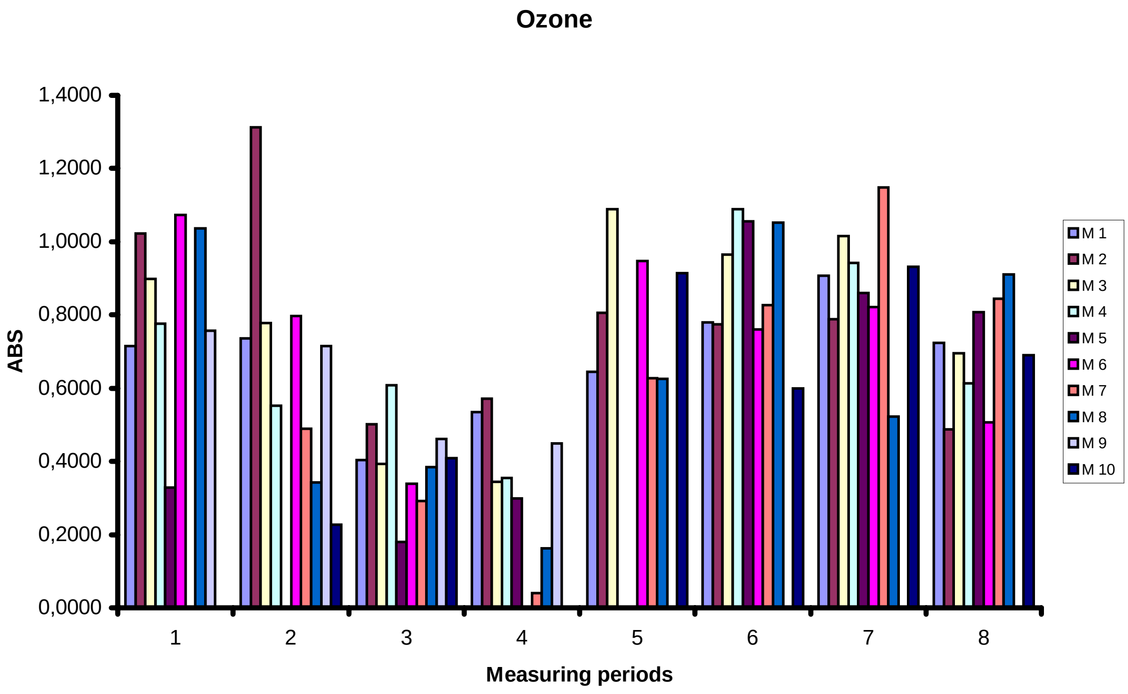
Integral measurement only allows statements about the whole measuring period (28 days), whereas results for single days or even changes within one day cannot be observed. We measured the absorption of isatine and can assess the actual amount of isatine with the appropriate calibration. However, we are more interested in the concentration of ozone. Thus we made a correlation between our readings for isatine and the ozone concentrations of the continuous station Graz North. For each measuring period we calculated the average of the daily averages of the ozone concentration and drew them in a graph against our absorption values of isatine. We are quite happy about the good correlation between these two types of results and that we obtained similar results as Dr. Kosmus and Dr. Schmidt from the Institute for Analytical Chemistry of Graz University. (see chart).



The good correlation between the two methods can also be seen in the following chart:



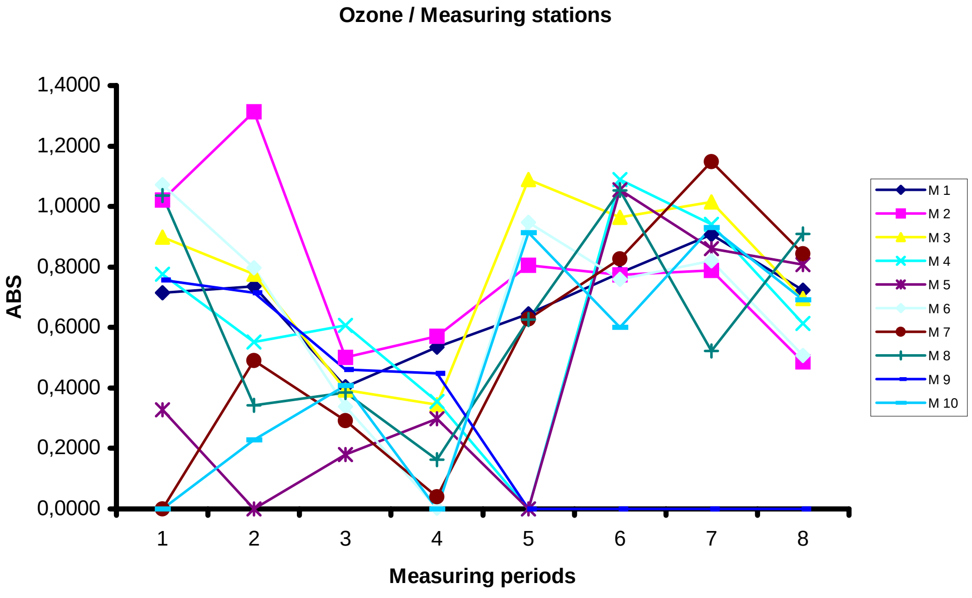
The minimum of absorption values was found in periods three and four, which correspond to the months January and February. This fits in with the fact that there is not so much sunshine in winter, so that ozone is built to a lesser extent. In spring the concentration of ozone rapidly increases. We expected that this tendency would keep on during spring and summer, and so we were quite astonished at the decrease of ozone in the eighth measuring period. However, we are going to monitor the trend in further measurements, so that we will be able to judge whether this decrease might be due to some faulty measurement or not.



We took over the following categorization from Johann Leitner and Stefan Schmidt (Summation methods for monitoring O_3 and NO_x in the ambient air. p. 10):

Summation method absorption	continous method mg/m^3	category
0,00-0,45	0,000-0,040	1
0,46-0,90	0,041-0,080	2
0,91-1,36	0,081-0,120	3
>1,36	>0,120	4

At the beginning of our measurements in autumn we obtained results that fall into category 3. During the winter months the concentration of ozone decreased and finally turned to values as low as category 2 and 1. Then, however, the results soon reached category 3 again so that we expect results in category 4 for the summer. These results confirm the measurements we did last year.



8. **Nitrous oxides**

8.1 Preparation of the passive collectors:

8.1.1 Impregnation of paper strips:

We got special ceramic cylinders from the *Forstliche Bundesversuchsanstalt Schönbrunn* in Vienna and most of the other necessary chemicals and tools from Dr. Walter Kosmus of Karl-Franzens University, Graz.

First we place the cylinders in water for a few hours to clean them. Then we tie a piece of chomatographic paper, 10cm by 8cm (Macherey&Nagel No. 888827), to the exterior surface of each cylinder and dip the cylinders with the paper into diphenylamine solution (0.22g diphenylamine to one litre ethanol). Finally we fill the cylinders with a KSCN-solution (potassium thiocyanate – solution) (0.23g KSCN in one litre propanetriol).

8.1.2 Setting up the passive collectors:

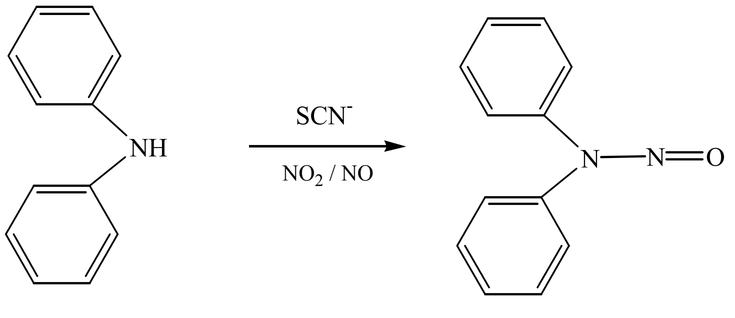
We seal the cylinders with a rubber plug and hang them on the measuring stations under a protective hood. The cylinders are collected for analysis after 28 days.

8.2 Measuring process:

The paper strips have to be transported in a sealed container to avoid further reactions.

In the chemistry lab each paper strip is soaked with 50ml ethanol (96%) and then shaken carefully for 30 minutes. We use a small pipette to remove a bit of the solution and fill it into square cuvettes for single use. According to our measurement instructions we should use 5 cm cuvettes for this purpose, but they do not fit into our photometer.

We use a spectral photometer (Shimadzu, UV-1202) for the measuring. The yellow colouring of diphenylnitrosamine, stemming from the reaction on the cylinder (see diagram), can be measured at 390nm.



Diphenylamine Diphenylnitrosamine

Reaction of diphenylamine to diphenylnitrosamine

We put six cuvettes into the photometer at the same time (Attention! Only touch the cuvettes at the grooved surfaces!). The first cuvette is the control sample, which is filled with 96% ethanol.

8.3 Results:

Table 2

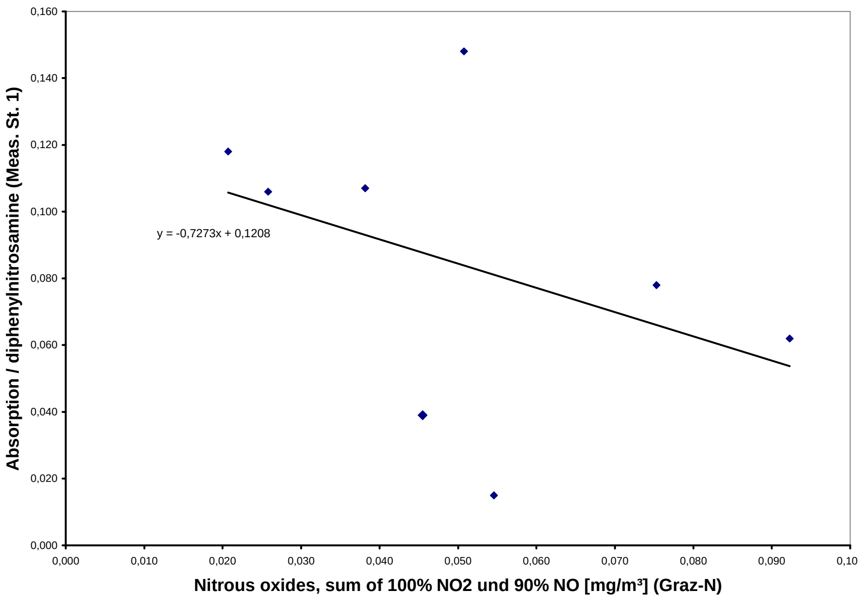
Measuring period	Exposure		days	station	readings [ABS] at 390nm
	from	to			
I	12.10.00	08.11.00	28	1	0,008
I	12.10.00	08.11.00	28	2	0,004
I	12.10.00	08.11.00	28	3	0,014
I	12.10.00	08.11.00	28	4	0,007
I	12.10.00	08.11.00	28	5	0,044
I	12.10.00	08.11.00	28	6	0,010
I	12.10.00	08.11.00	28	7	0,009
I	12.10.00	08.11.00	28	8	0,006
I	12.10.00	08.11.00	28	9	0,040
I	12.10.00	08.11.00	28	10	0,039
II	9.011.00	06.12.00	28	1	0,017
II	9.11.00	06.12.00	28	2	0,040
II	9.11.00	06.12.00	28	3	0,116
II	9.11.00	06.12.00	28	4	0,063
II	9.11.00	06.12.00	28	5	0,032
II	9.11.00	06.12.00	28	6	0,210
II	9.11.00	06.12.00	28	7	0,077
II	9.11.00	06.12.00	28	8	0,051
II	9.11.00	06.12.00	28	9	0,030
II	9.11.00	06.12.00	28	10	0,078
III	07.12.00	03.01.01	28	1	0,025
III	07.12.00	03.01.01	28	2	0,010
III	07.12.00	03.01.01	28	3	0,031
III	07.12.00	03.01.01	28	4	0,032
III	07.12.00	03.01.01	28	5	0,059
III	07.12.00	03.01.01	28	6	0,060
III	07.12.00	03.01.01	28	7	0,475
III	07.12.00	03.01.01	28	8	0,067
III	07.12.00	03.01.01	28	9	0,056
III	07.12.00	03.01.01	28	10	0,074
IV	04.01.01	31.01.01	28	1	0,007
IV	04.01.01	31.01.01	28	2	0,002
IV	04.01.01	31.01.01	28	3	0,009
IV	04.01.01	31.01.01	28	4	0,035
IV	04.01.01	31.01.01	28	5	0,024
IV	04.01.01	31.01.01	28	6	0,029
IV	04.01.01	31.01.01	28	7	0,004
IV	04.01.01	31.01.01	28	8	0,027

IV	04.01.01	31.01.01	28	9	0,008
IV	04.01.01	31.01.01	28	10	0,015
V	01.02.01	28.02.01	28	1	0,047
V	01.02.01	28.02.01	28	2	0,028
V	01.02.01	28.02.01	28	3	0,038
V	01.02.01	28.02.01	28	4	0,035
V	01.02.01	28.02.01	28	5	0,123
V	01.02.01	28.02.01	28	6	0,412
V	01.02.01	28.02.01	28	7	0,089
V	01.02.01	28.02.01	28	8	0,079
V	01.02.01	28.02.01	28	9	No reading
V	01.02.01	28.02.01	28	10	0,127
VI	01.03.01	28.03.01	28	1	0,024
VI	01.03.01	28.03.01	28	2	0,052
VI	01.03.01	28.03.01	28	3	0,031
VI	01.03.01	28.03.01	28	4	0,029
VI	01.03.01	28.03.01	28	5	0,063
VI	01.03.01	28.03.01	28	6	0,070
VI	01.03.01	28.03.01	28	7	0,078
VI	01.03.01	28.03.01	28	8	0,089
VI	01.03.01	28.03.01	28	9	No reading
VI	01.03.01	28.03.01	28	10	0,107
VII	29.03.01	25.04.01	28	1	0,023
VII	29.03.01	25.04.01	28	2	0,020
VII	29.03.01	25.04.01	28	3	0,046
VII	29.03.01	25.04.01	28	4	0,031
VII	29.03.01	25.04.01	28	5	0,083
VII	29.03.01	25.04.01	28	6	0,102
VII	29.03.01	25.04.01	28	7	0,059
VII	29.03.01	25.04.01	28	8	0,074
VII	29.03.01	25.04.01	28	9	No reading
VII	29.03.01	25.04.01	28	10	0,107
VIII	26.04.01	23.05.01	28	1	0,139
VIII	26.04.01	23.05.01	28	2	0,074
VIII	26.04.01	23.05.01	28	3	0,074
VIII	26.04.01	23.05.01	28	4	0,064
VIII	26.04.01	23.05.01	28	5	0,107
VIII	26.04.01	23.05.01	28	6	0,101
VIII	26.04.01	23.05.01	28	7	0,118
VIII	26.04.01	23.05.01	28	8	0,070
VIII	26.04.01	23.05.01	28	9	No reading
VIII	26.04.01	23.05.01	28	10	0,118

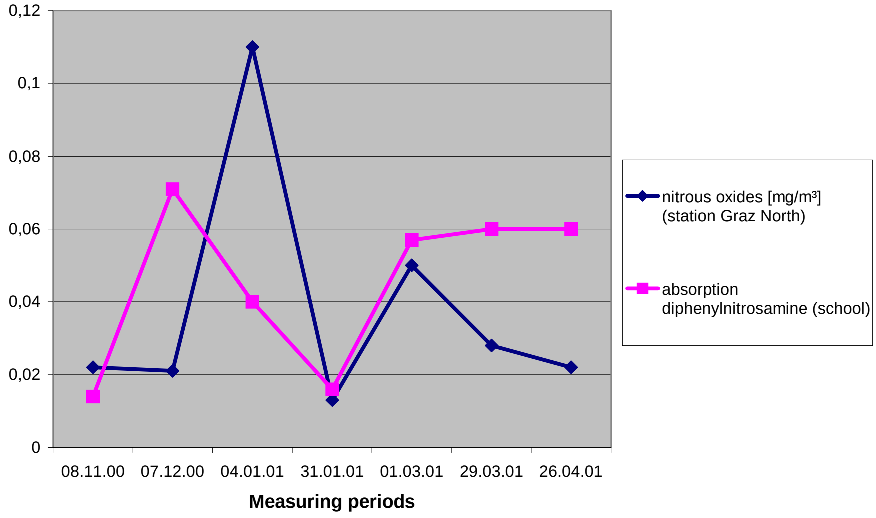
8.4 Interpretation of results

We measure the absorption of diphenylnitrosamine per measuring period (28 days) with the help of a spectral photometer and compare these values with the average values of station Graz North for the respective measuring period. Following the advice of Dr. Kosmus and Dr. Schmidt we include NO_2 to 100% and NO to 90%.

As can be seen in the following chart from measuring station 1, the correlation between our results and those of the government could be better.

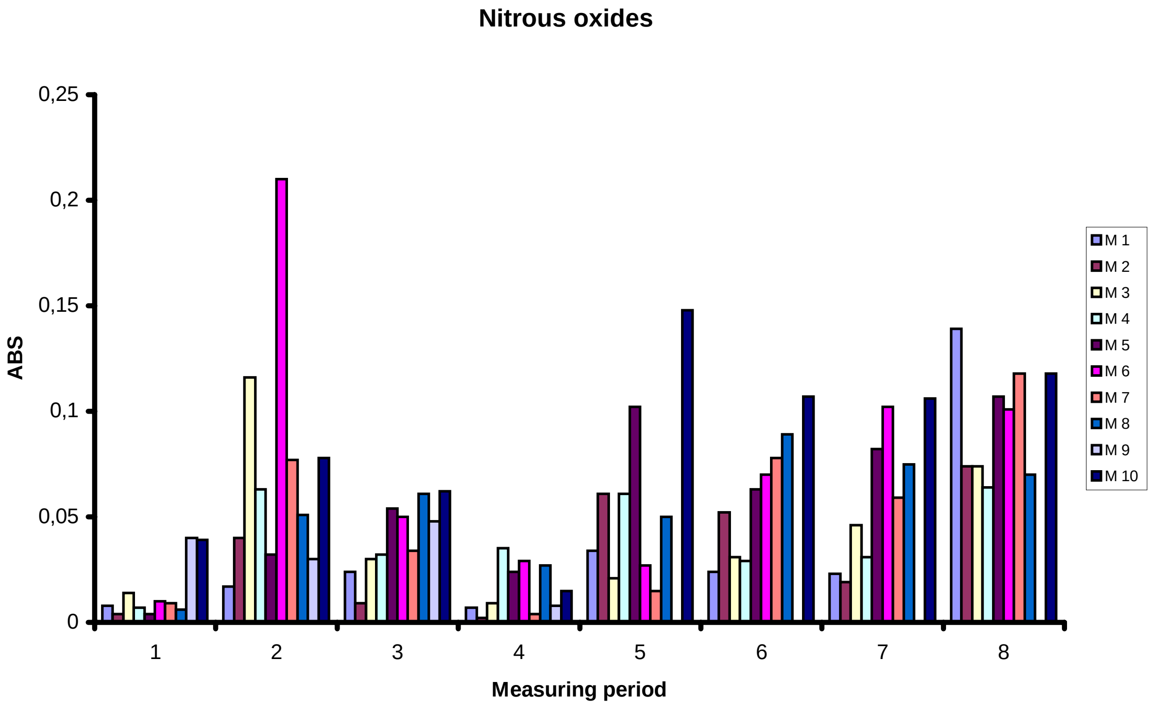

Comparison of readings of Graz North and M1

There are similar trends in our results and those of the Styrian government (Station Graz North), as the following graph shows. The differences towards the end of the measuring series might be due to a certain lack of enthusiasm on the part of the students.


No$_x$-Comparison: Styrian government - school

Our absorption readings (ABS) are very low: the highest result is 0,475, measured on January 4, 2001 at station 7 (junction Graben-Road). Our lowest result is 0,002 and was taken on February 2, 2001 at station 2 (atrium of the school). In general station 2 (atrium) shows lower readings than all the other stations. This is a very positive development compared to last year's results. Last year we observed enormous variations in the absorption readings at this station and suspected that students, who spent their breaks there, blew cigarette fumes at the station on purpose. This year the students seem to have realized the aim of our project and the importance of the station.

Naturally the highest readings are to be found in the surroundings of busy junctions (e.g. station 10, Andritzer Maut; station 7, Graben-Road and station 5, Kalvarienberg-Bridge). Quite unexpectedly we twice also observed maximum values for the station on Dr. Putz's balcony (on December 7, 2000 and on March 1, 2001). Checking with the calendar made us suspect that these high values might have resulted from smokers celebrating „Krampus" and carnival on the balcony. However, the more probable explanation is that students simply mixed up the samples of station 5 (Kalvarienberg-Bridge) and station 6 (Dr. Putz).

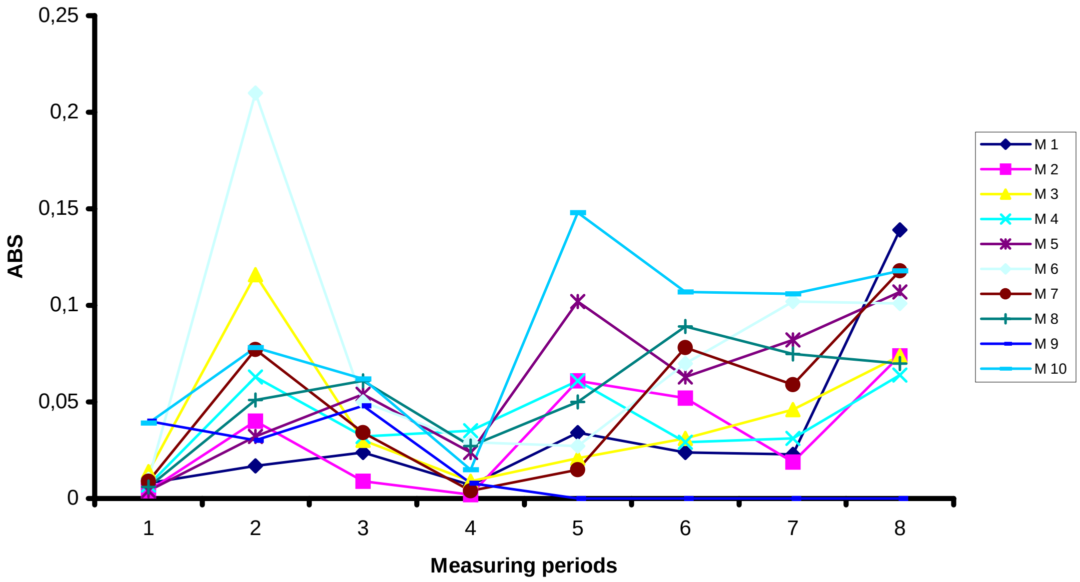


We took over the categorization of absorption values into 4 groups from Dr. Leitner and Dr. Schmidt. Apart from a few exceptions, all our readings belong to the first category (ABS = 0.0 to 0.35), which means that at the most 0.05 mg nitrous oxides / m³ were found

Like last year our readings in general are too low for precise measurement, although we used fresh, well-dipped cylinders for each run. By using fresh cylinders we managed to avoid a decrease in the readings from one period to the next, which we had observed last year. However, we could not prevent the papers from getting soaked with water during heavy snow and rain in winter.

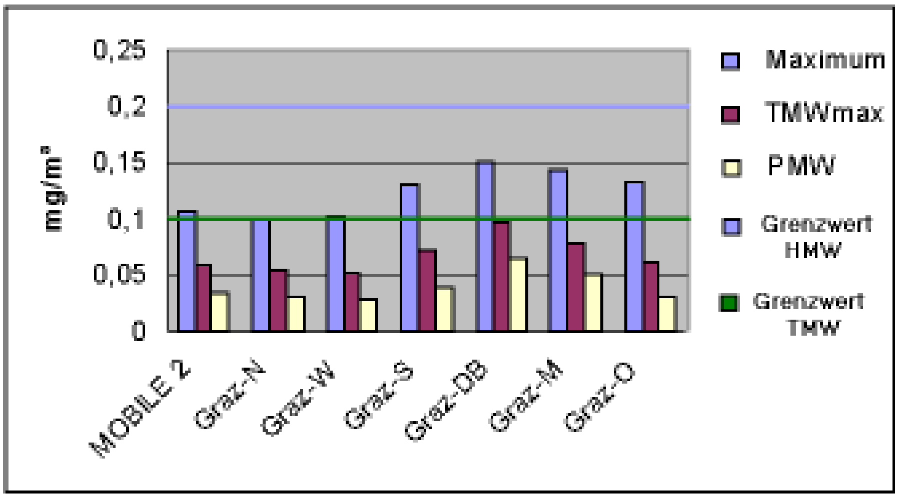
Like last year we were not able to conduct our measurements with the required 5 cm cuvettes. However, as we received a new spectral photometer from the parents’ association, we will be able to use these cuvettes for further measurements. Even in literature frequent variations in the readings are reported, so that we can be quite content with our results, as they were obtained with rather simple equipment.

Nitrous oxides / Measuring stations

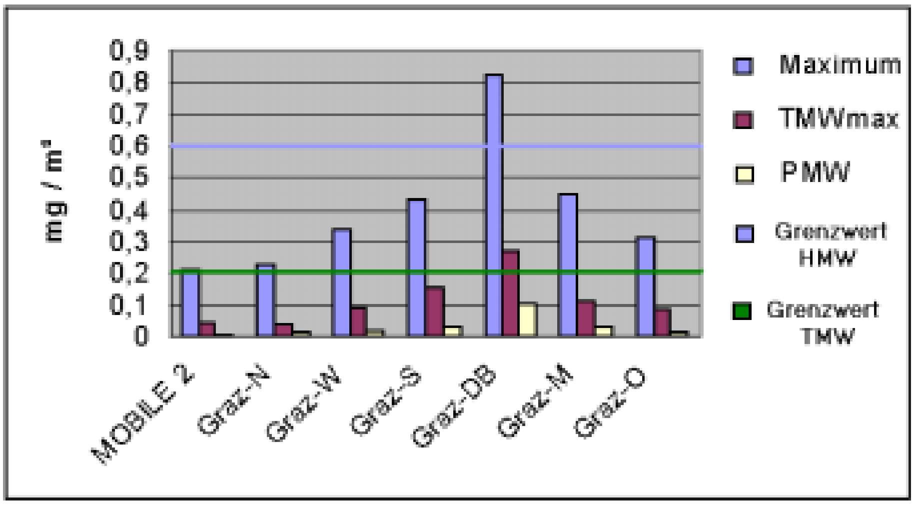


As the following diagrams for the concentrations of NO and NO_2 show, the results of the mobile measuring station and of the station Graz North are quite similar. So our assumption that the air quality in Gösting (station Graz North) and Geidorf/Andritz (Mobile 2) are similar seems to be have been justified.

Concentration of NO_2 (Styrian government)



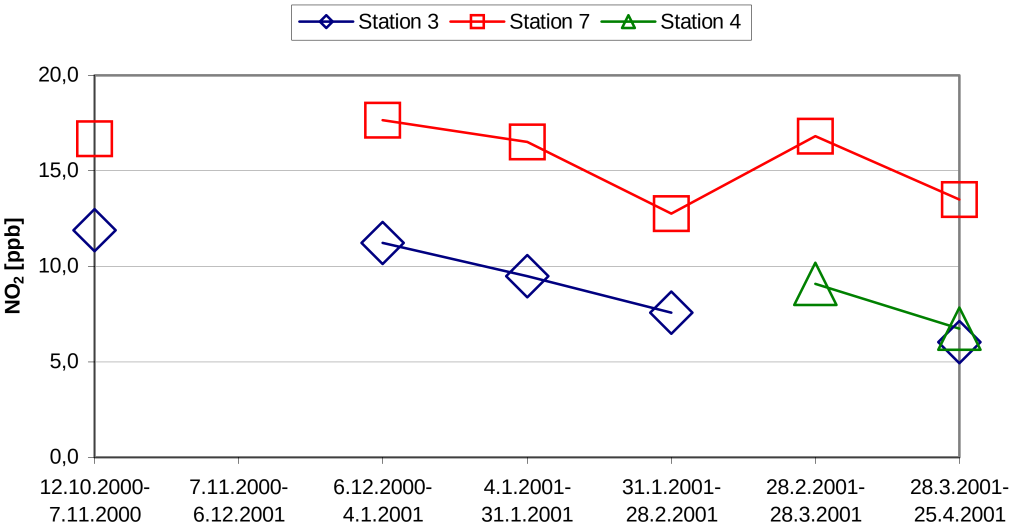
Concentration of NO (Styrian government)



The diagram above shows that the air quality in Carnerigasse is quite good – at least as far as the concentration of NO is concerned. In comparison to Graz West, South, Middle and East, the concentration of pollutants is far lower. Graz Don Bosco (Kärntner-Road) even shows a concentration of NO four times as high as that around our school. We must not forget, however, that even at our school the results are close to the limit of the daily average values (Grenzwert TMW = 0,2 mg/m³ for NO and 0,1 mg/m³ for NO_2).

Some of our measuring stations were equipped with passive collectors for NO_2 from the University of Technology, Vienna. The university staff analyzed the readings. As the following diagram shows, the results for station 3 (sports fields) and station 4 (rear entrance of school) are lower than those of station 7 at a busy junction (Graben-Road).

NO_2 - Carnerigasse (Winter 2000/2001)



9. **Dust**

9.1 Determination of dust according to the Bergerhoff-method

9.1.1 The Bergerhoff-beaker

One technical way to measure dust deposition is to collect deposits in a container with a defined area of opening (in our case a circular opening with the diameter of 10cm; see illustration). A beaker is put on a pole at about 1.5m above the ground for approximately 30 days (± 2 days) (Bergerhoff-apparatus). This apparatus is also called a "bulk-collector" as all the different components of dust are collected together. The amount of dust deposition is measured in mg/m² per day.

Bergerhoff
beaker

9.2 Measurements

An empty glass beaker is weighed and numbered. The dust in the Bergerhoff-beaker is washed out into the glass beaker with 20 ml (or less) distilled water and with the help of a glass bar with a rubber wiper. If there is enough rainwater in the beaker, no distilled water has to be added. Large pollutants (e.g. beetles, leaves) can be taken out with a pair of tweezers. The glass beaker is put into the cabinet drier for about 9 hours at 105°C and then it is weighed again.

9.2.1 Calculations

$$X = \frac{G}{F \cdot T} \left[g/m^2 \cdot d \right]$$

G ………………difference in grams
F………………..opening area = $r^2.\pi = 78{,}53$ cm² (r=5)
T ……………….days

9.3 Results:

Table 3

Measuring period	Exposure		Days [d]	Station	Difference dust [g]	Result [g/m^2.d]	Result [g/m^2.28d]
	form	to					
I	12.10.00	08.11.00	28	1	0,0196	0,0909	2,5468
I	12.10.00	08.11.00	28	2	0,015	0,0559	1,5663
I	12.10.00	08.11.00	28	3	0,0192	0,0477	1,3371
I	12.10.00	08.11.00	28	4	0,0262	0,0468	1,3116
I	12.10.00	08.11.00	28	5	0,0568	0,2015	5,6411
I	12.10.00	08.11.00	28	6	No reading	No reading	No reading
I	12.10.00	08.11.00	28	7	0,1075	0,2588	7,2456
I	12.10.00	08.11.00	28	8	0,0952	0,1451	4,0621
I	12.10.00	08.11.00	28	9	0,0895	0,3720	10,4164
I	12.10.00	08.11.00	28	10	0,0471	0,2210	6,1887
II	09.11.00	06.12.00	28	1	0,0196	0,0891	2,4959
II	09.11.00	06.12.00	28	2	0,015	0,0682	1,9101
II	09.11.00	06.12.00	28	3	0,0192	0,0873	2,4449
II	09.11.00	06.12.00	28	4	0,0262	0,1191	3,3363
II	09.11.00	06.12.00	28	5	0,0568	0,2583	7,2329
II	09.11.00	06.12.00	28	6	No reading	No reading	No reading
II	09.11.00	06.12.00	28	7	0,1075	0,4889	13,6890
II	09.11.00	06.12.00	28	8	0,0952	0,4329	12,1227
II	09.11.00	06.12.00	28	9	0,0895	0,4070	11,3969
II	09.11.00	06.12.00	28	10	0,0471	0,2142	5,9977
III	07.12.00	03.01.01	28	1	0,1036	0,4711	13,1924
III	07.12.00	03.01.01	28	2	0,0105	0,0477	1,3371
III	07.12.00	03.01.01	28	3	0,0157	0,0714	1,9992
III	07.12.00	03.01.01	28	4	0,0750	0,3411	9,5505
III	07.12.00	03.01.01	28	5	0,0638	0,2901	8,1243
III	07.12.00	03.01.01	28	6	No reading	No reading	No reading
III	07.12.00	03.01.01	28	7	0,0777	0,3534	9,8943
III	07.12.00	03.01.01	28	8	0,0536	0,2438	6,8250
III	07.12.00	03.01.01	28	9	0,0915	0,4161	11,6516
III	07.12.00	03.01.01	28	10	0,0745	0,3388	9,4868
IV	04.01.01	31.01.01	28	1	0,0353	0,1605	4,4951
IV	04.01.01	31.01.01	28	2	0,0069	0,0314	0,8786
IV	04.01.01	31.01.01	28	3	0,0089	0,0405	1,1333
IV	04.01.01	31.01.01	28	4	0,0070	0,0318	0,8914
IV	04.01.01	31.01.01	28	5	0,0602	0,2738	7,6659
IV	04.01.01	31.01.01	28	6	No reading	No reading	No reading
IV	04.01.01	31.01.01	28	7	0,0745	0,3388	9,4868
IV	04.01.01	31.01.01	28	8	0,0482	0,2192	6,1378
IV	04.01.01	31.01.01	28	9	0,0172	0,0782	2,1902
IV	04.01.01	31.01.01	28	10	0,0629	0,2833	7,9333

V	01.02.01	28.02.01	28	1	0,0421	0,1915	5,3610
V	01.02.01	28.02.01	28	2	No reading	No reading	No reading
V	01.02.01	28.02.01	28	3	0,0234	0,1064	2,9735
V	01.02.01	28.02.01	28	4	0,0527	0,2397	6,7108
V	01.02.01	28.02.01	28	5	0,0593	0,2697	7,5512
V	01.02.01	28.02.01	28	6	No reading	No reading	No reading
V	01.02.01	28.02.01	28	7	0,0715	0,3252	9,1048
V	01.02.01	28.02.01	28	8	0,1594	0,7249	20,2980
V	01.02.01	28.02.01	28	9	No reading	No reading	No reading
V	01.02.01	28.02.01	28	10	0,0505	0,2297	6,4307
VI	01.03.01	28.03.01	28	1	0,0360	0,1637	4,5842
VI	01.03.01	28.03.01	28	2	0,0105	0,0477	1,3371
VI	01.03.01	28.03.01	28	3	0,0403	0,1833	5,1318
VI	01.03.01	28.03.01	28	4	0,0138	0,0628	1,7573
VI	01.03.01	28.03.01	28	5	0,0811	0,3688	10,3273
VI	01.03.01	28.03.01	28	6	No reading	No reading	No reading
VI	01.03.01	28.03.01	28	7	0,1196	0,5439	15,2298
VI	01.03.01	28.03.01	28	8	0,0423	0,1924	5,3865
VI	01.03.01	28.03.01	28	9	No reading	No reading	No reading
VI	01.03.01	28.03.01	28	10	0,1053	0,4789	13,4089
VII	29.03.01	25.04.01	28	1	0,0642	0,2920	8,1752
VII	29.03.01	25.04.01	28	2	0,2620	1,1915	33,3630
VII	29.03.01	25.04.01	28	3	0,0505	0,2297	6,4307
VII	29.03.01	25.04.01	28	4	0,0264	0,1201	3,3618
VII	29.03.01	25.04.01	28	5	0,1472	0,6694	18,7444
VII	29.03.01	25.04.01	28	6	No reading	No reading	No reading
VII	29.03.01	25.04.01	28	7	0,1023	0,4652	13,0269
VII	29.03.01	25.04.01	28	8	0,0614	0,2792	7,8187
VII	29.03.01	25.04.01	28	9	No reading	No reading	No reading
VII	29.03.01	25.04.01	28	10	0,0797	0,3624	10,1490
VIII	26.04.01	23.05.01	28	1	0,0328	0,1492	4,1767
VIII	26.04.01	23.05.01	28	2	0,0646	0,2940	8,2260
VIII	26.04.01	23.05.01	28	3	0,0587	0,2669	7,4750
VIII	26.04.01	23.05.01	28	4	0,0285	0,1296	3,6292
VIII	26.04.01	23.05.01	28	5	0,0927	0,4216	11,8044
VIII	26.04.01	23.05.01	28	6	No reading	No reading	No reading
VIII	26.04.01	23.05.01	28	7	0,1703	0,7745	21,6860
VIII	26.04.01	23.05.01	28	8	0,1441	0,6553	18,3497
VIII	26.04.01	23.05.01	28	9	No reading	No reading	No reading
VIII	26.04.01	23.05.01	28	10	0,0970	0,4411	12,3520

category I: 0,00 – 1,14 g/m^2 . 28d
1,15 – 2,29 g/ m^2 . 28d

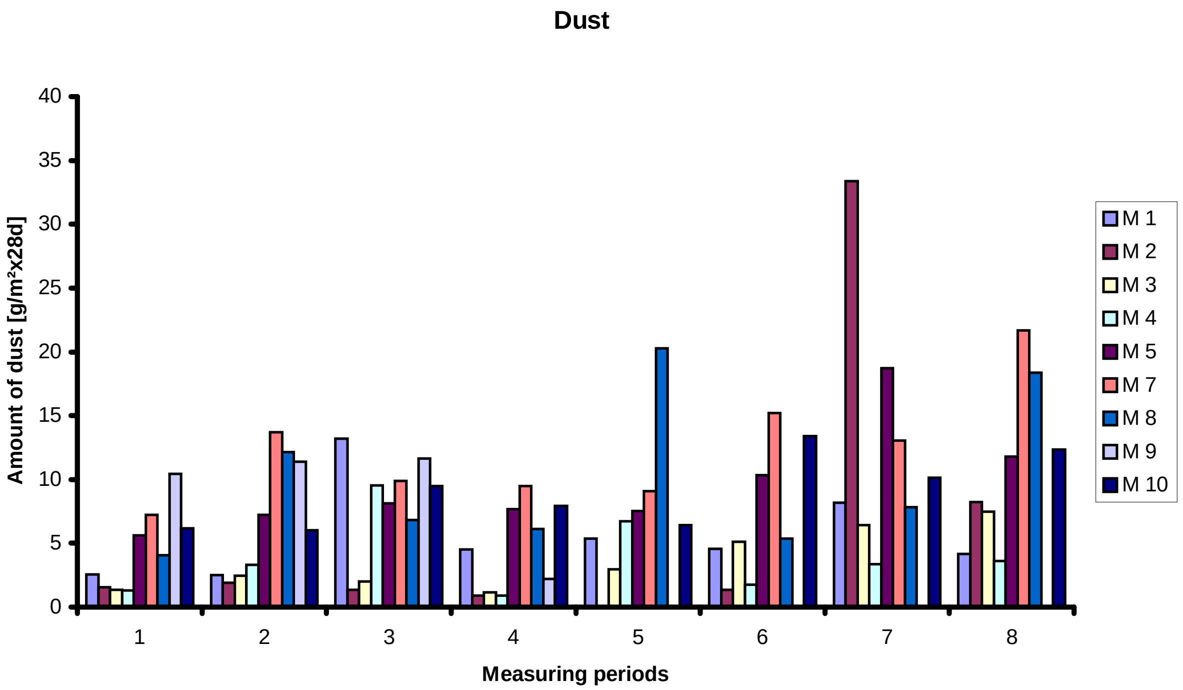
category II: 2,30 – 3,44 g/ m^2 . 28d
3,45 – 4,59 g/ m^2 . 28d

category III: 4,60 - 9,40 g/ m^2 . 28d

9.4 Interpretation of results

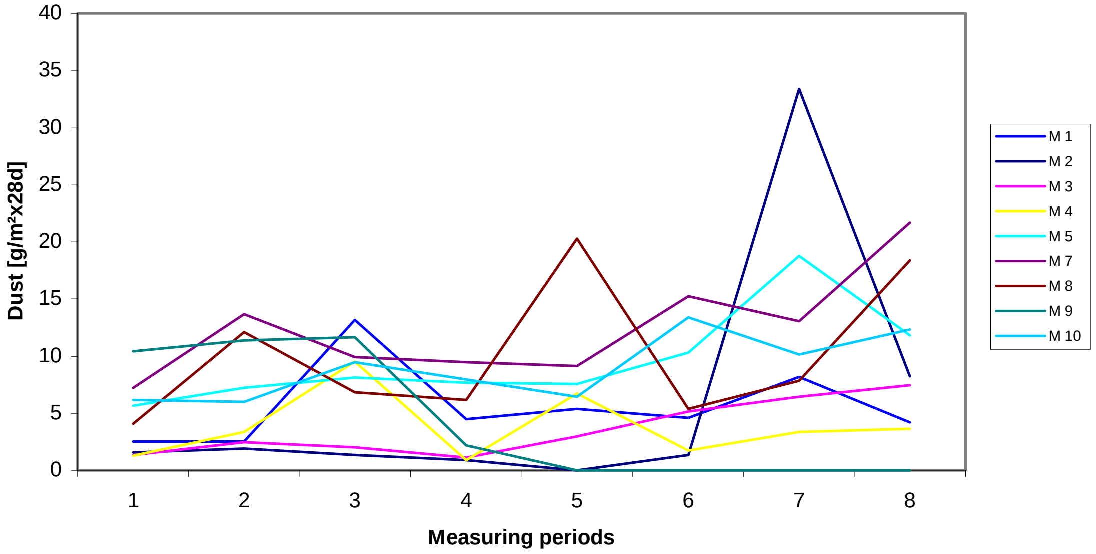
Our measurements confirmed the results of last year because we again collected a high amount of dust at our stations. The lowest readings always came from station 2 (atrium) with the minimum amount of 0,87g/m²*28d, measured on February 1, 2001. The results of station 2 mostly fall into category 1 (1,15 – 2,29 g/m².28d). As we expected, the highest readings came from stations in areas with much traffic; e.g. station 5 (Kalvarienberg-Bridge), station 7 (Graben-Road) und station 10 (Andritzer Maut). These stations showed results as high as 20g/m².28d (maximum reading: 21g/m².28d at station 7, last measuring period). These results are above the highest category for dust deposition. Also station 8 (old people's home) and station 9 (Theodor Körner-Road; station disappeared in January) often showed results above 10g/m².28d.

We could observe that dust deposition decreases in winter. The relatively low results for station 1 (house of the caretaker) and station 3 (sports field) show the positive influence of a hedge for filtering dust from the air. At station 6 (balcony of Dr. Putz) we did not conduct dust measurements. The very high last result of station 1 can be explained by the fact that the Bergerhoff-beaker was thrown off the station so that earth got into it.



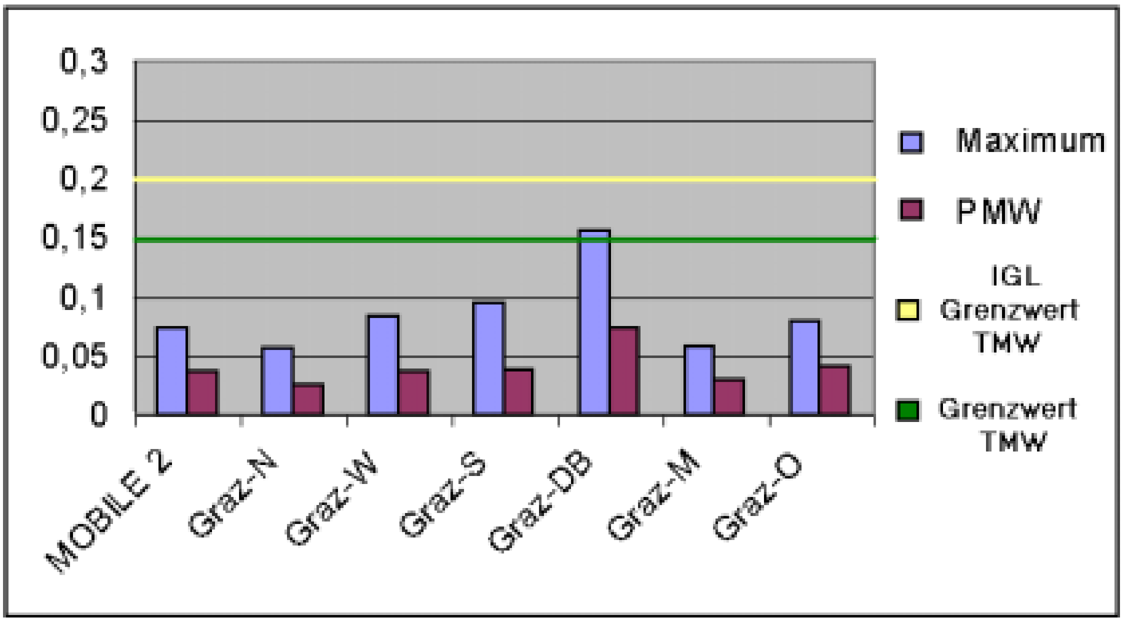
The yearly average for dust according to the Bergerhoff-method amounts to 210 mg/m²*d. Table 3 shows that out of 67 measurements this limit was exceeded 39 times. We have to emphasize that the readings of station 10 (Andritzer Maut) and station 7 (Graben-Road) were above this limit in all the 8 measurements, followed by station 5 (Kalvarienberg-Bridge) showing readings higher than the limit in 7 measurements. Station 1 (house of the caretaker), 2 (atrium), 3 (sports field) and 4 (rear entrance) only seldom showed results above the limit.

Dust / Measuring stations



The following diagram shows that the amount of dust monitored by mobile measuring station 2 (Styrian government), which was situated next to our measuring station 4 (rear entrance), showed similar results as station Graz North, which we used to compare our data with during the whole measuring phase. With these measurements however, we have to take into considerations that they refer to the concentration of dust in the air, while we determine the dust deposition. The chart also shows that the amount of dust around our school (Mobile 2) is lower than the results for many other measuring stations in Graz (Graz-West, -South, - Don Bosco and –East).

Dust (Styrian government)



10. Sulfur dioxide

10.1 General information

We measured SO_2 in January 2000 by using the so called “lead-cylinder method”. In this method PbO_2 on the cylinders reacts with SO_2 in the air to form $PbSO_4$, which can be determined gravimetrically. Our results were very low, indicating that SO_2 does not belong to the most important pollutants in our area. Moreover, the lead-cylinder-method is extremely time-consuming. So we decided not to measure sulfur dioxide again but only take over the results from the mobile measuring station of the Styrian government, which was temporarily situated on our school grounds.

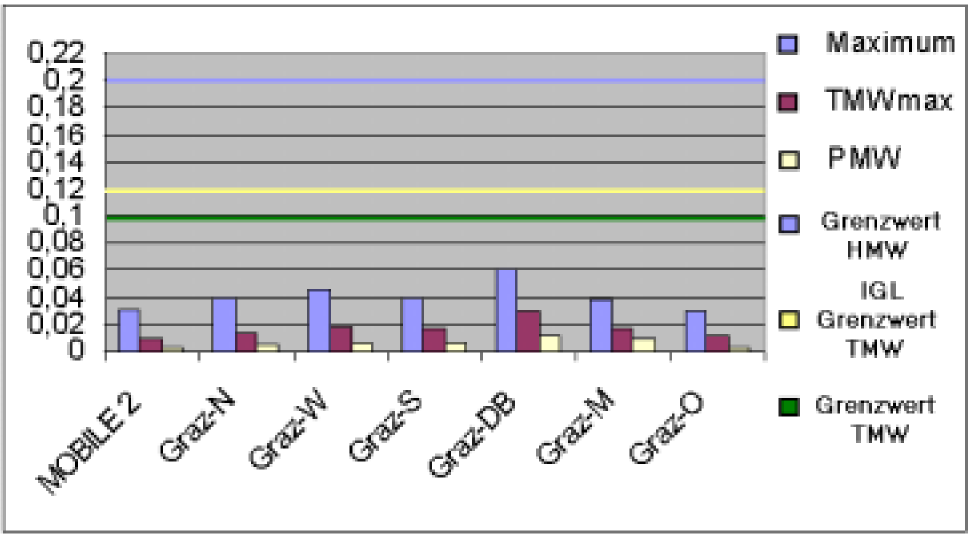
10.2 Results

08.02.2001- 17.04.2001	**Concentrations SO_2 [mg/m³]**	**Legal limits SO_2 [mg/m³]**	**Laws and regulations**	**% of legal limits**
HMW max	0.031	0.20 0.20	LGBl. Nr.5 /1987 BGBl. I Nr.115/1997	15% 15%
Mtmax	0.011			
TMWmax	0.01	0.10 0.12	LGBl. Nr.5 /1987 BGBl. I Nr.115/1997	10% 8.3%
PMW	0.004			

10.3 Interpretation of results

SO_2 is mainly produced by burning S-containing fuels in households and factories. So the emission of sulfur dioxide is much higher in the cold season. Except for areas with an extremely high volume of traffic, exhaust fumes only play a minor part in the production of SO_2 because the fuels used today are usually desulfurized.

Sulfur dioxide (Styrian government)



As the chart above shows, the sulfur dioxide concentration recorded by the mobile measuring station on our school grounds (Mobile 2) were always far below the legal limits. Moreover, the results were even lower than those of all the other measuring stations in Graz (Graz – North, -West, -South, -Don Bosco, -Middle and –East). This means that the air quality around our school is very good – at least regarding SO_2. This is mainly due to the fact that most households in this area are heated by district heating powered by natural gas.

11. Carbon monoxide

11.1 General information

We did not measure the concentration of carbon monoxide because it is not possible to do this with simple methods. So we decided to cite again the results of the mobile measuring station (Mobile 2) on our school grounds.

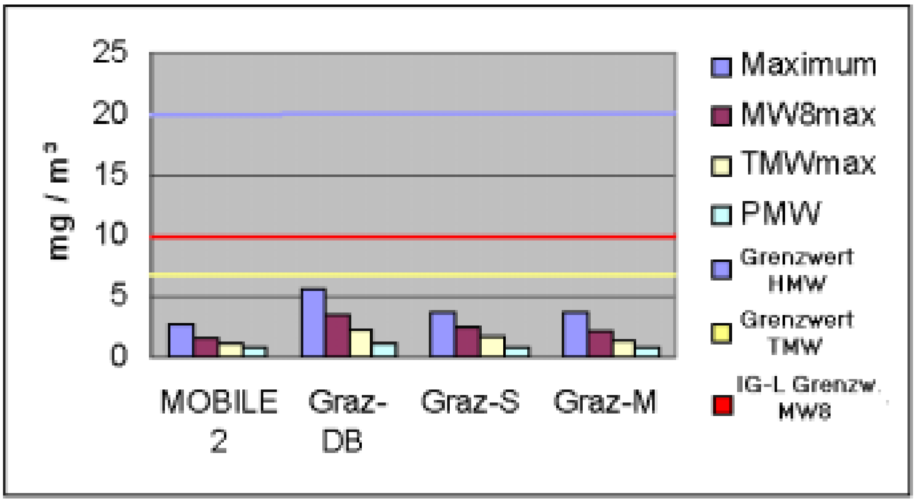
11.2 Results

08.02.2001-17.04.2001	**Results CO [mg/m³]**	**Legal limits CO [mg/m³]**	**Laws and regulations**	**% of legal limit**
HMWmax	2.782	20	LGBl. Nr.5/1987	14%
Mtmax	1.342			
MW8max	1.584	10	BGBl. I Nr. 115/1997	16%
TMWmax	1.223	7	LGBl. Nr. 5/1987	17%
PMW	0.833			

11.3 Interpretation of results

For carbon monoxide as well as for the nitrous oxides traffic is considered the main source of emissions. Unlike nitrous oxides, however, the concentration of carbon monoxide decreases fast when the distance to a busy road becomes larger. The concentrations of nitrous oxides for BG Carneri were very low, so we expected to find low readings for carbon monoxide as well. The following diagram shows that the air quality around our school is indeed very good – at least in terms of CO – and that results above the legal limits are not to be expected.

Carbon monoxide (Styrian government)



12.Conclusion

Since January 2000 students of B®G Carnerigasse and I have been working on the analysis of the air quality around our school building (Graz, Geidorf). The reason why we started this project was that at that time a large road was being built next to our school grounds and we wanted to find out about the consequences for the air quality. Since autumn 2000 our works have been part of the Comenius project “Examining pollution in our neighbourhood”. Also students and teachers from *Mikolaj Kopernik High School* in Lublin/Poland and from *I.E.S Alexander Graham Bell* in Madrid/Spain take part in this project. In September 2000 we put up 10 measuring stations and from September 2000 to June 2001 we conducted 8 series of measurements. The following pollutants were determined quantitatively in measuring periods of 28 days: **ozone, nitrous dioxide, nitrous monoxide and dust .**

The analyses were all done in the school lab, which was equipped with some loans from the Styrian government and Karl-Franzens University, Graz (e.g. photometer, scales, etc). We determined ozone and the nitrous oxides photometrically, while dust was measured gravimetrically. Our readings were compared to continuous measurements of station Graz North. The classification of the results into categories was taken over from literature.

For the determination of **ozone** we used the indigo method. Indigo (blue) is oxidized to isatine (yellow) by ozone and other oxidants. The amount of isatine was determined photometrically at 408 nm. We observed a clear minimum of ozone in winter. We compared our values for the absorption of isatine with the results for the ozone concentration of station Graz North and found a clear correlation. At the moment we are already observing readings as high as category 3, so that we expect even higher results in summer.

In order to determine **nitrous oxides**, we used diphenylamine, which reacts to form diphenylnitrosamine. The amount of diphenylnitrosamine was determined photometrically at 390 nm. Also in this case we tried to establish a relation between our results and the daily average concentrations for NO_2 and NO from station Graz North. Although we have improved our measuring methods since last year and although we have tried to avoid possible errors, our results are again very low. The measurements of the mobile station also showed quite low results for nitrous oxides compared to results from other parts of Graz. To verify our results, we borrowed passive collectors from the University of Technology, Vienna. Also the results thus obtained were rather low. There were, however, clear differences in the concentration of nitrous oxides between areas with much and little traffic.

Dust was determined according to the “Bergerhoff-method”. Like last year we observed a very high amount of dust. The usual result for dust in cities is 5-6 g/m^2*28 days. This limit was always exceeded by stations in areas with much traffic; we even observed results that were 4 to 5 times as high. We measured dust as total deposition because it is not possible to determine single components of dust with simple available methods. However, only the composition of dust could give valuable information about possible health risks.

As **sulfur dioxide** and **carbon monoxide** do not belong to the most important pollutants in Graz, we decided not to measure them ourselves. We know, however, that these substances cause problems in the other participating countries. So we asked the Styrian government to provide us with measuring data so that we will be able to compare results with the schools from Spain and Poland also concerning SO_2 and CO.

We want to add that this project helped us develop a feeling for numbers, readings and data. Above all, we realized what is happening to the air around us as one of our most precious goods.