L 02/69

Mapping of Air Pollution Levels in Tallinn

Measurement campaigns with diffusive samplers during 2000 - 2002

Göteborg 2002-12-21

IVL Swedish Environmental Research Institute

Karin Sjöberg

Summary

As a part of an Air Quality Management Project in Tallinn the air pollution levels of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and volatile organic compounds (VOC) were measured during 1996-1998. The measurements were carried out using Diffusive Samplers. In order to study the trends of the pollutants and possible changes in the pollution concentration pattern a second session of campaigns has been carried out during 2000-2002.

A total of 8 monthly campaigns were carried out during a period from July 2000 to April 2002. Monthly samples of SO_2 and NO_2 were collected during all campaigns, whilst VOCs were sampled during one week of each campaign.

The siting of measurement stations was mainly the same as during the previous campaigns; based on a classification into four types according to exposure to road vehicle emissions and street ventilation conditions. The measurements were made at urban as well as at background sites.

The measured monthly levels of SO_2 and NO_2 were, as expected, different at the different site categories, with a falling average concentration from the areas that were expected to show the highest load to the less polluted, i.e. the background areas. There were larger differences in concentration levels between the site categories for NO_2 than for SO_2, although the central parts of the town exhibited the highest monthly means. The highest pollution load was observed in February 2001. The highest weekly means of benzene were shown at the most heavily trafficked sites.

Although no regular annual measurements have been performed during these campaign measurements in Tallinn, the calculated average values from all campaigns would give a good indication of long-term average levels. In comparison to EU annual limit values it seems that for SO_2 the measured levels in Tallinn would be well below the limit value. For NO_2 the measured average concentrations at the most exposed sites were just below the upper assessment threshold. The benzene concentrations measured indicate a risk that the EU limit values are exceeded on an annual basis at several of the measurement sites in Tallinn.

A clear trend of decreasing levels of SO_2 between 1996 and 2002 can be found at almost all sites. Regarding the concentrations of NO_2 and benzene, no obvious trends are shown.

Contents

1 Introduction

During 1996-1998 the air pollution levels of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and volatile organic compounds (VOC) were measured in Tallinn. The measurements were carried out using Diffusive Samplers and were organised as a total of 12 monthly campaigns. The main purpose of the measurement campaigns was to generate data with high spatial resolution, to introduce a cost-effective air pollutant measurement technique in Estonia, and to validate dispersion modelling results.

In order to study the trends of the pollutants and possible changes in the pollution concentration pattern, a second period of campaigns has been carried out during 2000-2002.

The Swedish Environmental Research Institute (IVL) has carried out the measurements. This project is a part of an Air Quality Management Project in Tallinn, Estonia, financially supported by the Swedish International Development Co-operation Agency (Sida). The Estonian party is the Environment Department, Tallinn City Government, and the Swedish contractual party is Conexor Sensus AB.

A total of 8 monthly campaigns were carried out during the period from July 2000 to April 2002. Monthly samples of SO_2 and NO_2 were collected during all campaigns, whilst VOCs were sampled during one week of each campaign.

The siting of measurement stations was mainly the same as during the previous campaigns; based on a classification into four types according to exposure to road vehicle emissions and street ventilation conditions. The measurements were made at urban as well as at background sites. The Environment Department and IVL designed the station network in co-operation.

All practical matters related to the sampling have been accomplished by the Environment Department, Tallinn City Government. All chemical analyses of samples have been made at IVL.

2 Background

The Diffusive Samplers give average air concentrations with continuous time coverage from a few days up to a month. The technique is based on the concept of molecular diffusion, where the gas molecules diffuse into a sampler where they are quantitatively collected. The samplers are easy to handle, and the method does not require electricity or calibration in the field. The use of Diffusive Samplers, in combination with a careful selection of measurement sites, has proven to be a fruitful strategy in mapping geographical variations in levels of air pollutants in a region with a complex emission pattern.

Background information such as description of the Diffusive Sampling technique, EU limit values for air quality, and the emission structure in Tallinn can be found in the previous report (Sjöberg et al., (1999). Mapping of Air Pollution Levels in Tallinn", IVL Report L99/04).

The report is available on Conexor's homepage: www.conexor.com.

Since 1999 a new daughter directive concerning, among other compounds, benzene (C_6H_6) has been introduced. The EU limit values for benzene, as well as for SO_2 and NO_2, are presented in appendix 1.

2.1 Classification of sites

The locations of sites were initially chosen in order to achieve results representative for the conditions in various sub-areas of Tallinn. The measurement sites were classified into four types according to exposure to road vehicle emissions and street ventilation conditions, and the measurements were made at urban as well as at background sites. The classification of sites enables comparison of similar environments in a whole region, and of the variations in air pollution levels in different typical local environments.

The four classes of sites were:

A = busy street environment, poor ventilation
B = busy street environment, good ventilation
C = residential area
D = general pollution level, local background

Sampling was also performed in background areas, in order to be able to evaluate the difference between conditions within the city compared to the conditions in the very outskirts of the urban area. Sampling was also made at two background locations, south and north of the city.

The locations of the stations were selected by the Environmental Department in Tallinn in co-operation with IVL. During this second period of measurement campaigns a total of around 30 sites were used out of the 90 sites that were identified in the first part of the project. In Figure 1 the station network in Tallinn during 2000-2002 is presented.

2.2 Measurement programme

The measurements have been performed during 8 campaign periods, every third month from July 2000 to April 2002, with the exception of February 2001 instead of January. Monthly sampling of SO_2 and NO_2 were carried out at around 30 sites, whilst VOC was sampled during one week of each campaign at 10 of the sites.

Figure 1 Map of Tallinn with the sites marked as circles.

3 Results

3.1 Levels of NO_2

3.1.1 Measurement results

In Figure 2 below the results for NO_2 are presented as a mean value for all measurement campaigns at all sites in each of the site classes respectively. It is evident from the differences in the results that the selection of sites, mainly regarding the traffic situation, has been successful. As expected, there was a falling average concentration in the order A, B, C, D and background sites. The difference between the background measurements and the "local background", represented by the D sites, shows an influence also on D-sites from urban traffic.

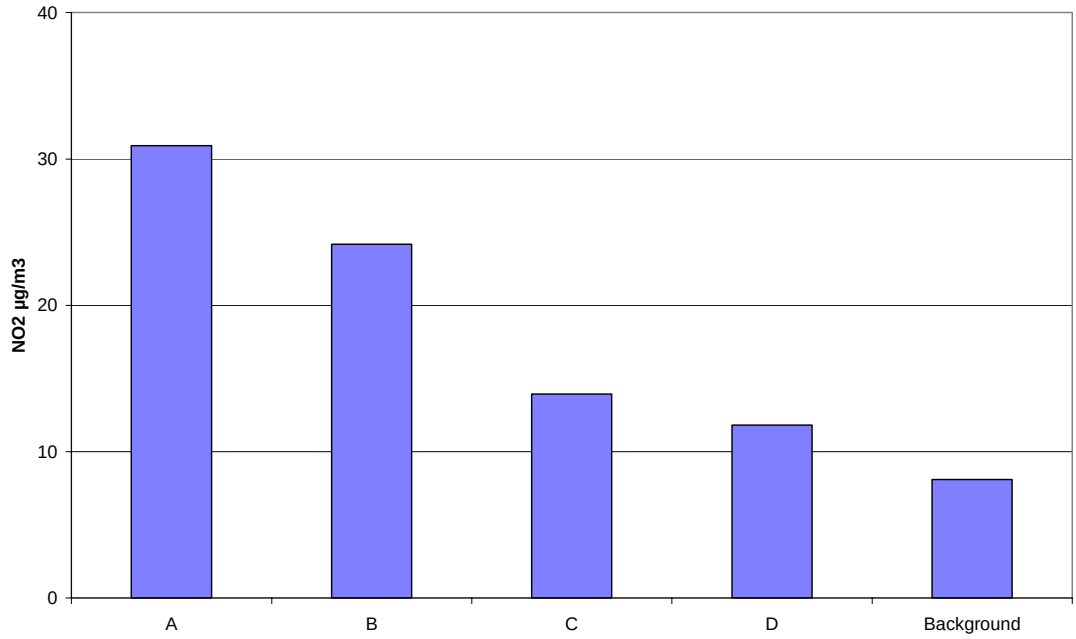
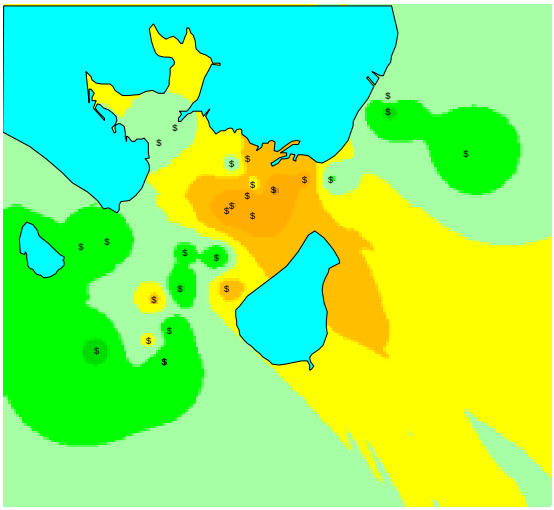
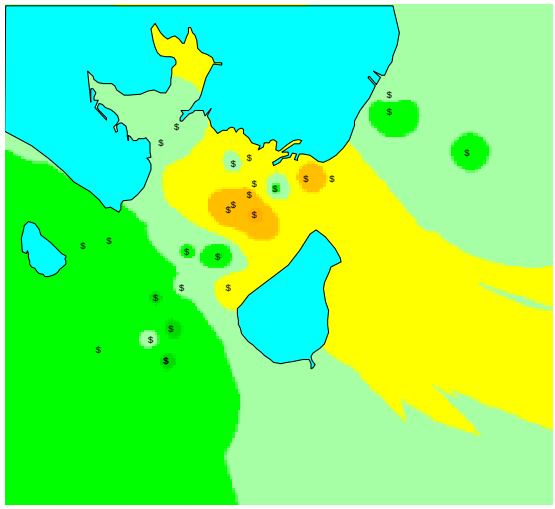


Figure 2 Mean values of NO_2 during 2000-2002 for all measurement campaigns at all sites in each of the site classes.

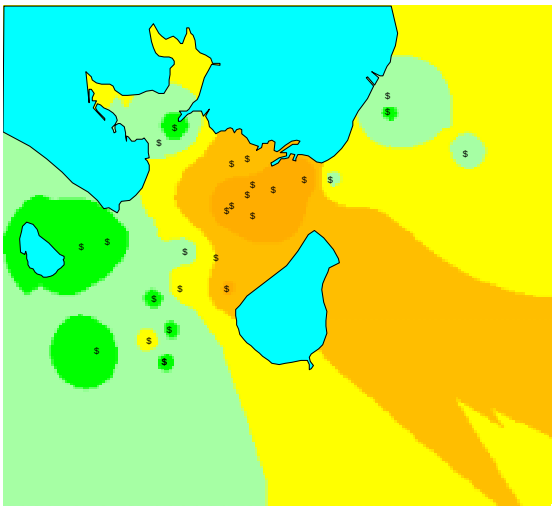
The geographical variations in concentration levels are illustrated in figure 3 below. A similar pattern is shown for all periods. The central parts of the town, where the traffic load can be expected to be high, exhibited the highest monthly means of NO_2. The highest pollution loads were observed in February 2001.



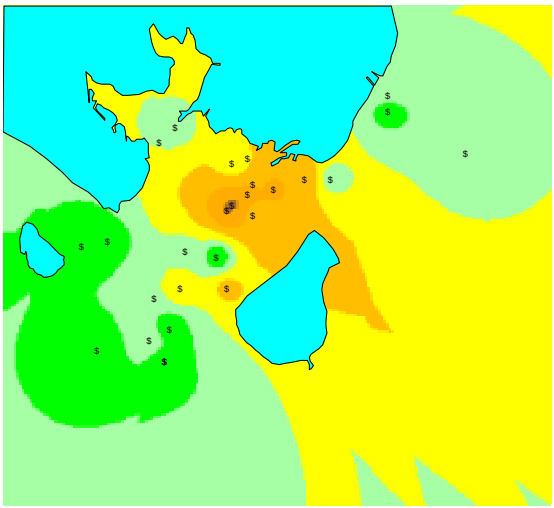
NO_2: July 2000



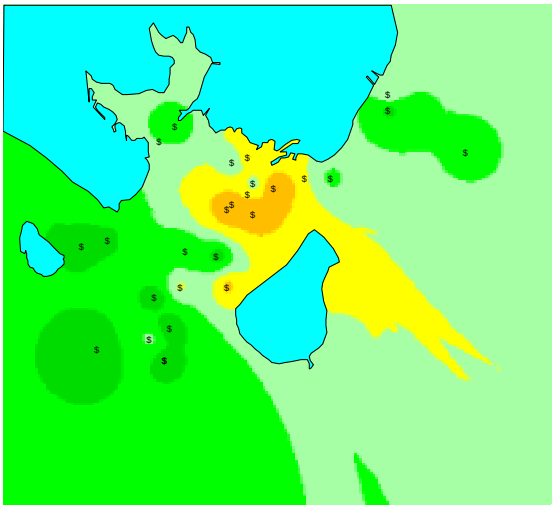
NO_2: October 2000



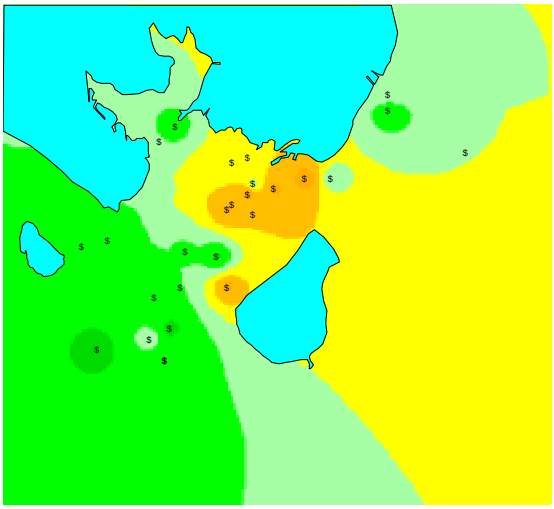
NO_2: February 2001



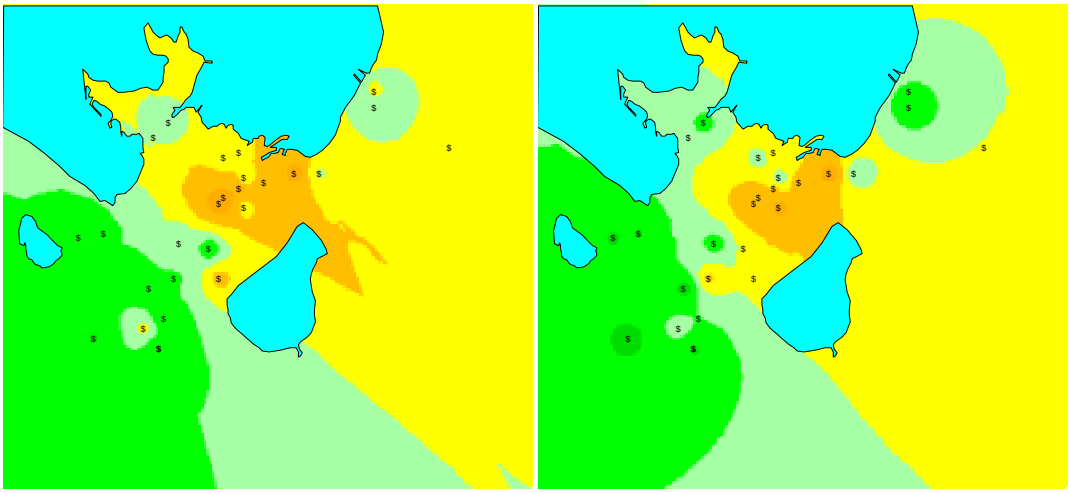
NO_2: April 2001



NO_2: July 2001



NO_2: October 2001



NO_2: January 2002 **NO_2: April 2002**

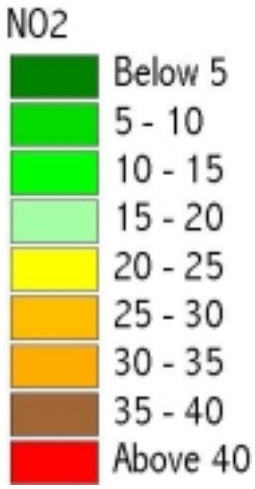


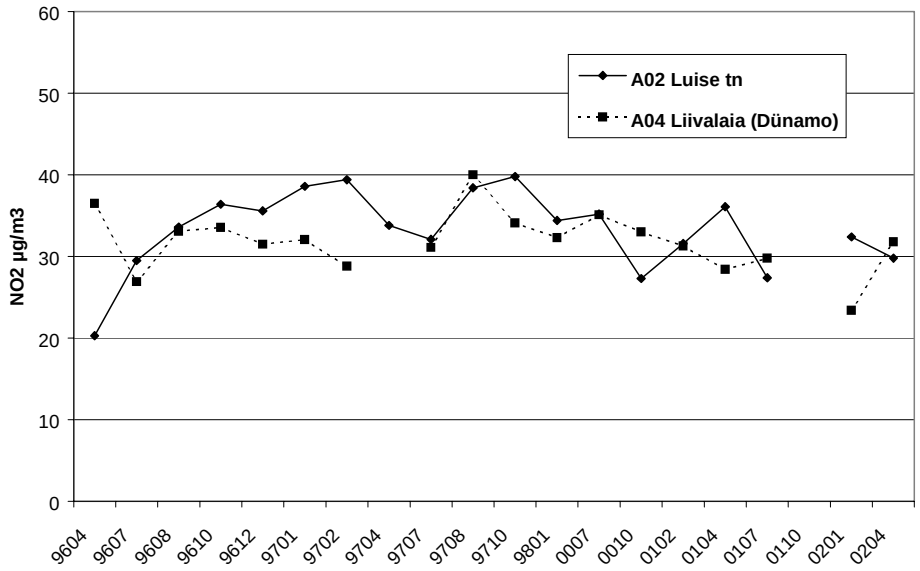
Figure 3 Levels of NO_2 (µg/m^3), all site categories included.

3.1.2 Comparison to EU limit values

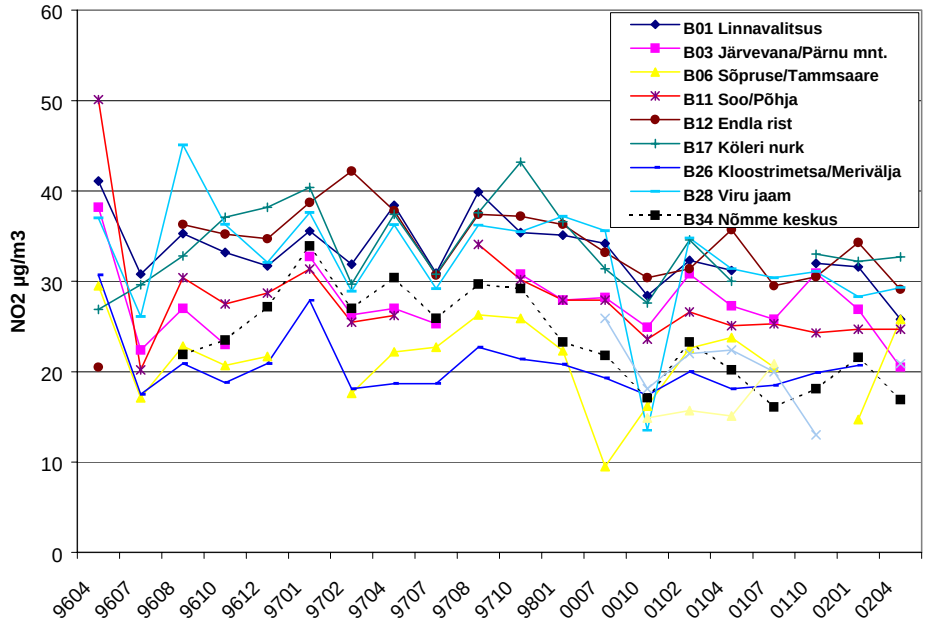
The EU limit values are not directly applicable to the measurements performed, but the average values calculated from all campaigns can be compared to the EU annual limit values (see Appendix 1). For NO_2 the annual limit value for protection of human health is 40 µg/m^3, and the upper and lower assessment thresholds are 32 and 26 µg/m^3 respectively. The limit value was not exceeded in Tallinn according to the measurements, but the lower assessment threshold was exceeded at the A sites (31 µg/m^3 as an average). The average NO_2-levels at the other measurement sites were all below the lower assessment threshold for protection of human health.

3.1.3 Trends

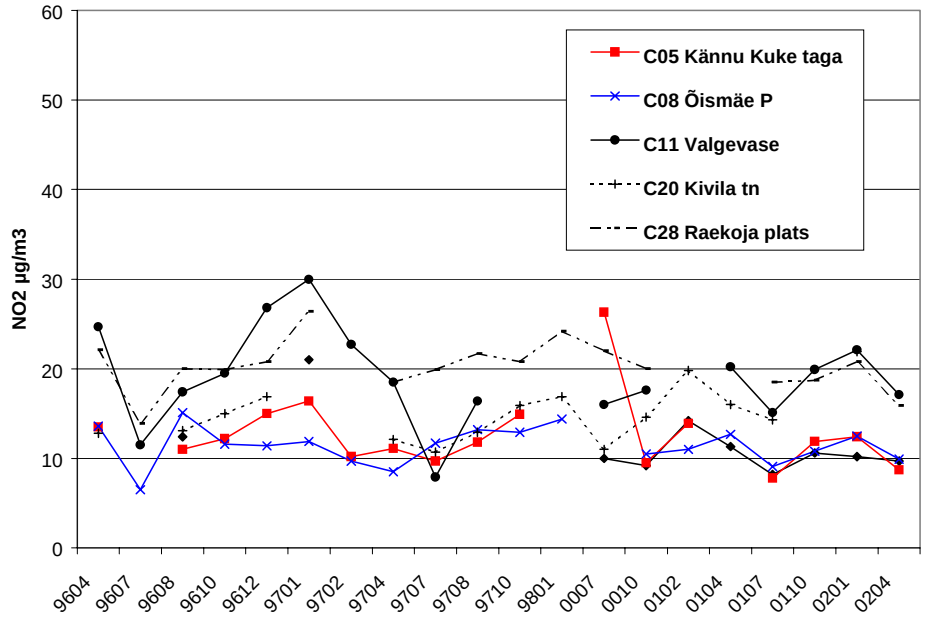
The NO_2 concentrations observed during 1996-2002 at the different sites are illustrated in Figure 4 below for each of the site classes. For the B sites there is a tendency of decreasing NO_2 levels, but for the rest no trends can be seen.



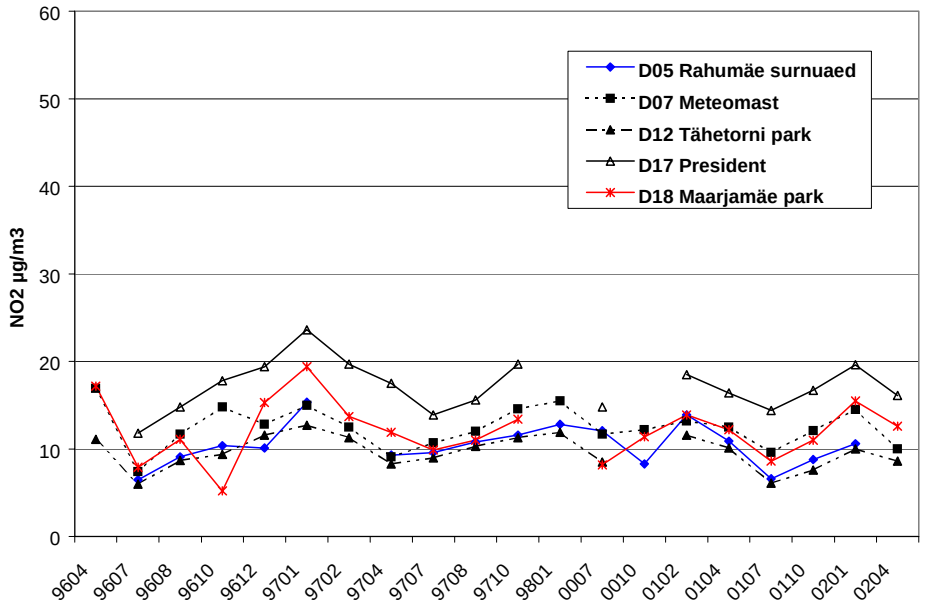
A sites



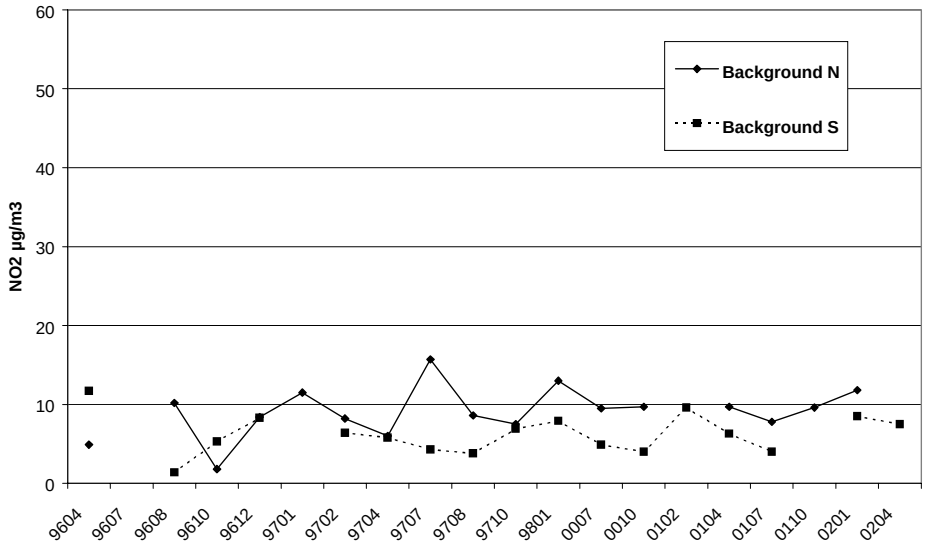
B sites



C sites



D sites



Background sites

Figure 4 NO_2 concentrations as monthly means during 1996-2002, divided into the different site categories.

3.2 Levels of SO_2

3.2.1 Measurement results

In Figure 5 below the SO_2 results are presented as a mean value for all measurement campaigns at all sites in each of the site classes respectively. There is a falling average concentration in the order from A to D and background sites, except a slightly higher mean value for B than for A sites. However, the differences are not as pronounced as for NO_2.

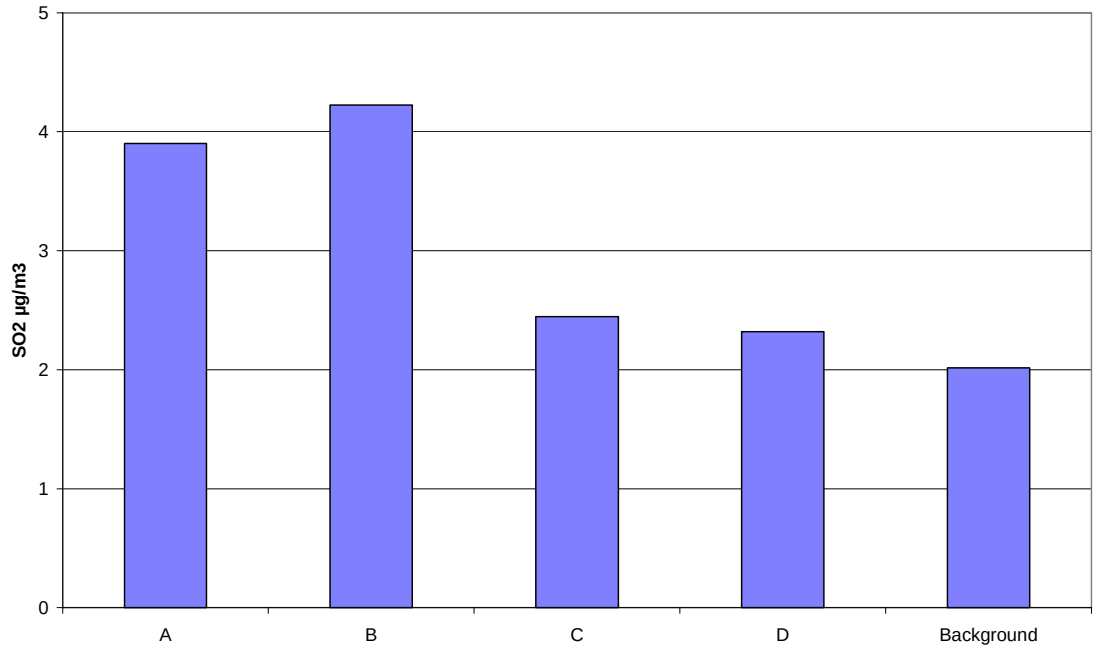
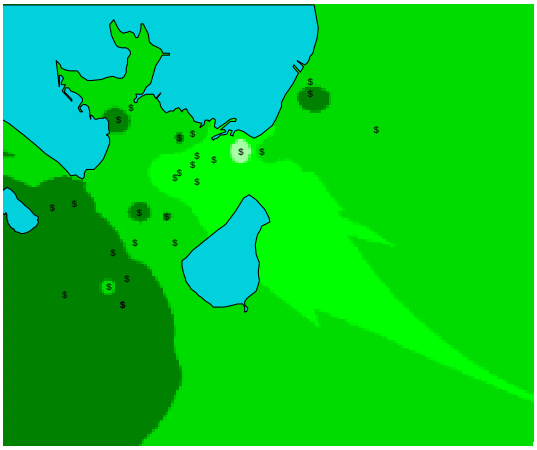
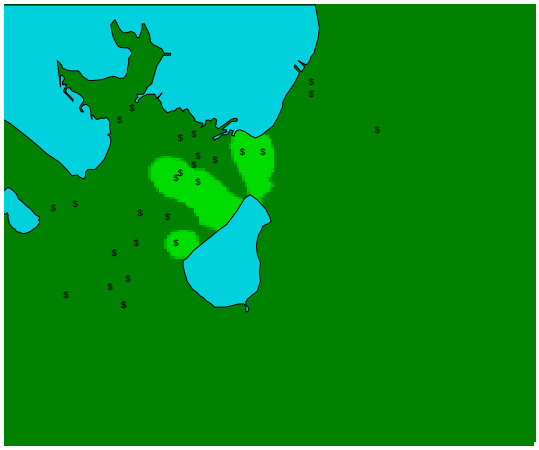


Figure 5 Mean values of SO2 during 2000-2002 for all measurement campaigns at all sites in each of the site classes.

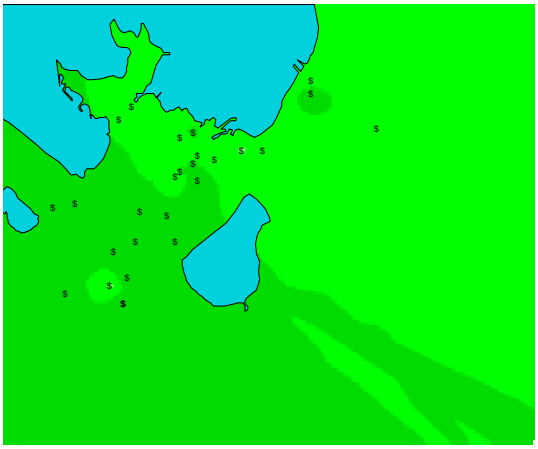
The geographical pattern of SO_2 levels including all sites for the different campaigns are shown in Figure 6. Also for SO_2 the highest concentrations were observed in the city centre, where the air was most polluted in February 2001. In general, the pollution load regarding SO_2 was quite low.



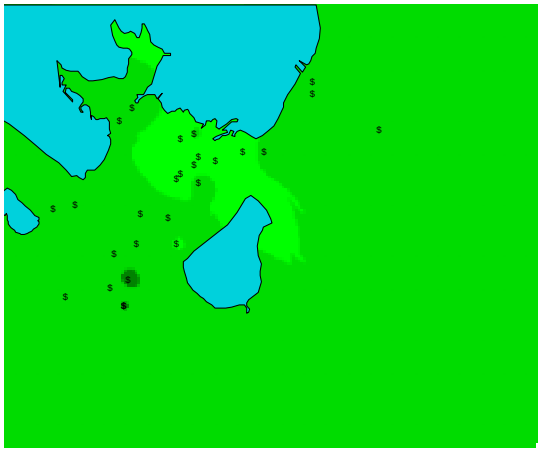
SO_2: July 2000



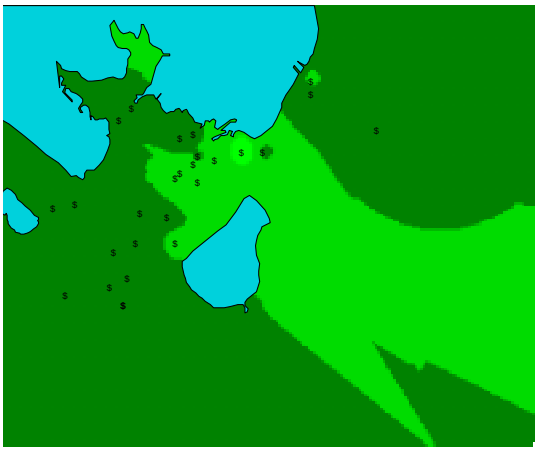
SO_2: October 2000



SO_2: February 2001

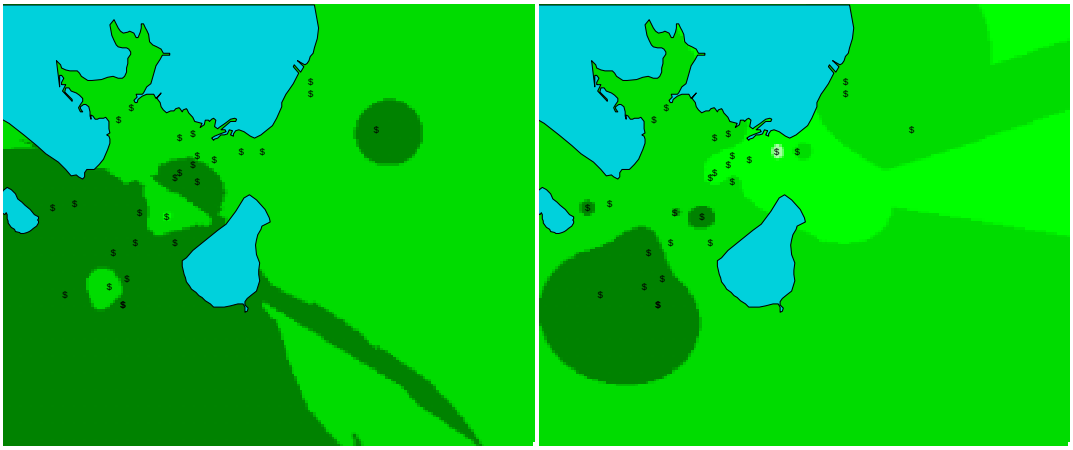


SO_2: April 2001



SO_2: July 2001

SO_2: October 2001



SO_2: January 2002 **SO_2: April 2002**

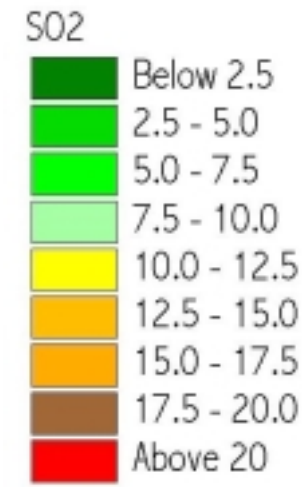


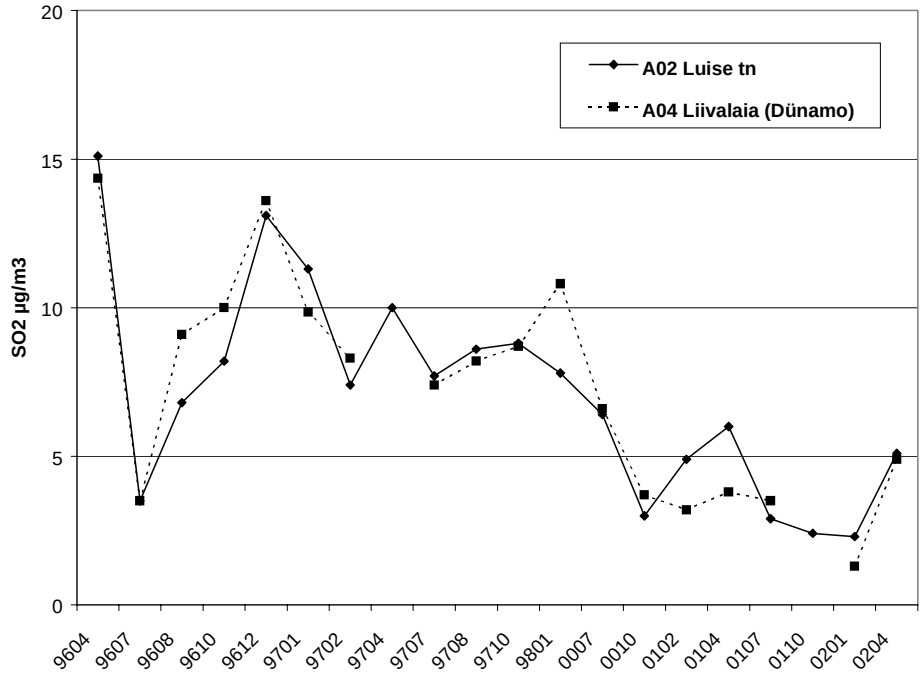
Figure 6 Levels of SO_2 (µg/m^3), all site categories included.

3.2.2 Comparison to EU limit values

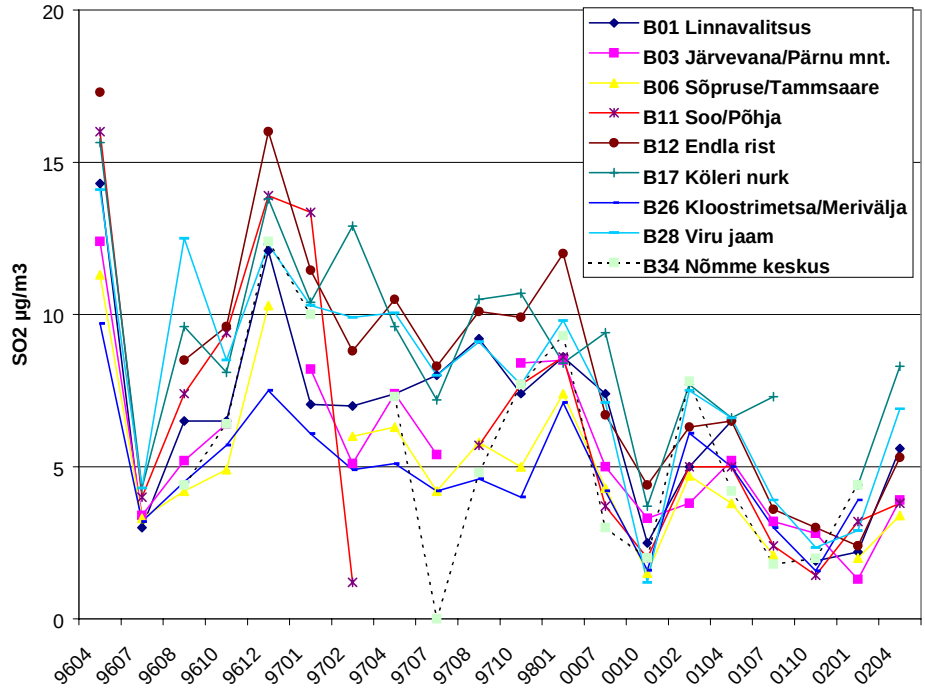
The measurement results, as an average for all campaigns, are well below the EU annual limit value of 20 µg/m^3 as well as the lower assessment threshold of 8 µg/m^3 (Appendix 1). The highest monthly mean concentration observed was 9.4 µg/m^3 at a B-site (Köleri nurk).

3.2.3 Trends

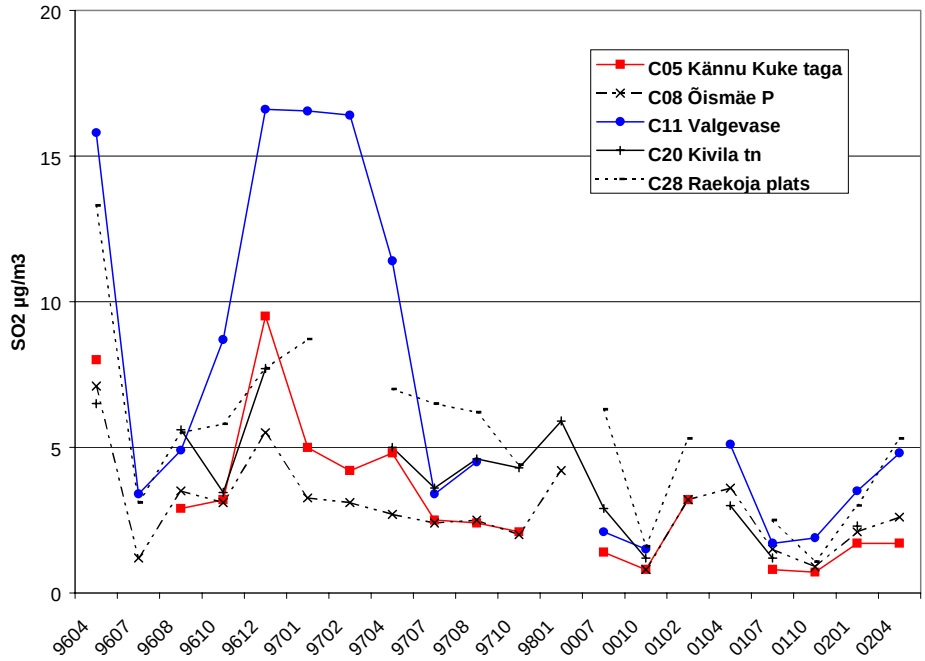
The SO_2 concentrations observed at the different sites are illustrated in Figure 7 below for each of the site classes. A clear trend of decreasing levels of SO_2 between 1996 and 2002 can be seen at almost all sites.



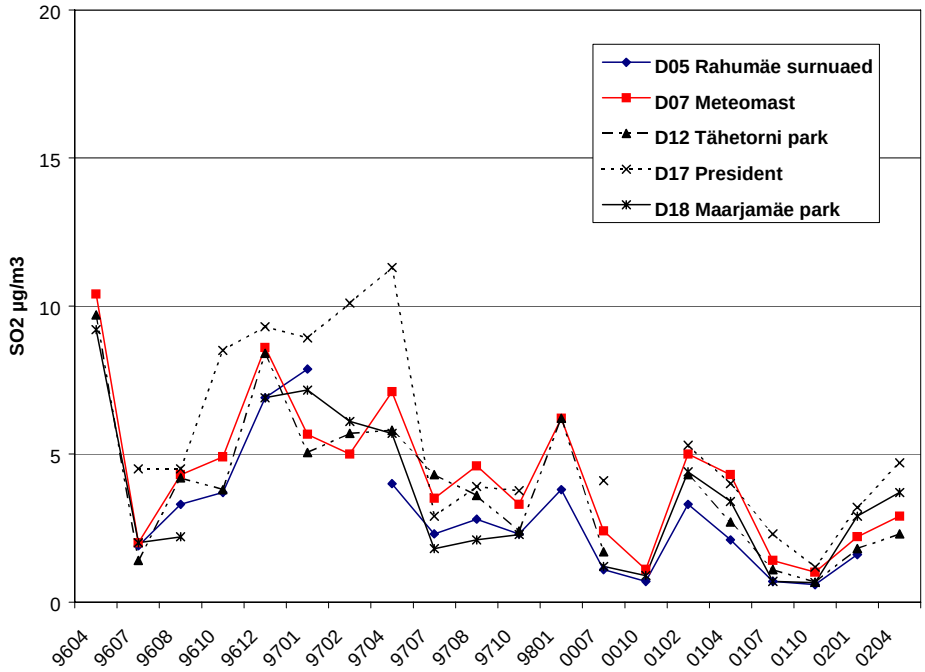
A sites



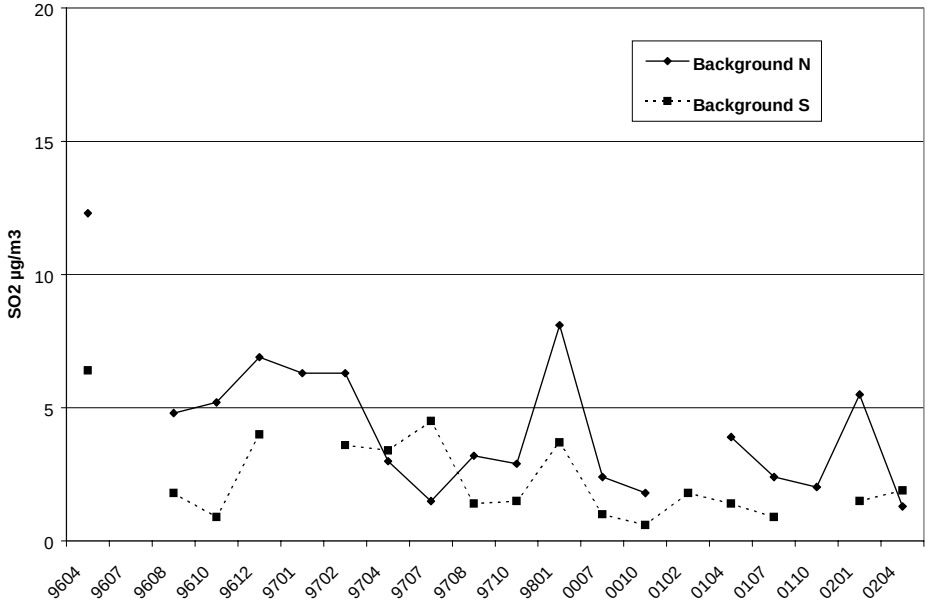
B sites



C sites



D sites



Background sites

Figure 7 SO_2 concentrations as monthly means during 1996-2002, divided into the different site categories.

3.3 Levels of benzene

3.3.1 Measurement results

Eight different components of VOCs were analysed; benzene, toluene, octane, butylacetate, ethylbenzene, m+p-xylene, o-xylene and nonane. Only the benzene concentrations are evaluated in this report.

The sites V4 - V9 were located in areas classified as B-sites. A brief description of the sites is found in table 1.

Station number	**Station name**	**Site type**	**Comments**
V1	Pirita	Living area	Mainly residential area with private houses
V2	Vaikne	Living area	Next to furniture factory. Private house area. Main sources are around 500 m to the west.
V3	Lasteaed, Saha tn.	Nursery school	
V4	Endla ristmik	High traffic crossroad	
V5	Kadaka ring	High traffic crossroad	Gasoline station located at the north side of the crossroad
V6	Järvevana/Pärnu mnt.	High traffic crossroad	Gasoline station located at the south side of the crossroad
V7	Peterburi mnt. Ringtee	High traffic crossroad	3 gasoline stations around the crossroad
V8	Laagna tee	8 lane highway	Relatively low traffic intensity
V9	Viru jaam	City centre	Station situated in a high traffic intensity area

Table 1 Description of sites

The results of benzene from the measurements in 2000-2002 are presented in figure 8 below as weekly means at the different sites. Generally there was a difference in pollution load regarding benzene, where sites defined as “High traffic crossroad” (see table 1) showed the highest levels. The lowest benzene concentrations were obtained at Pirita.

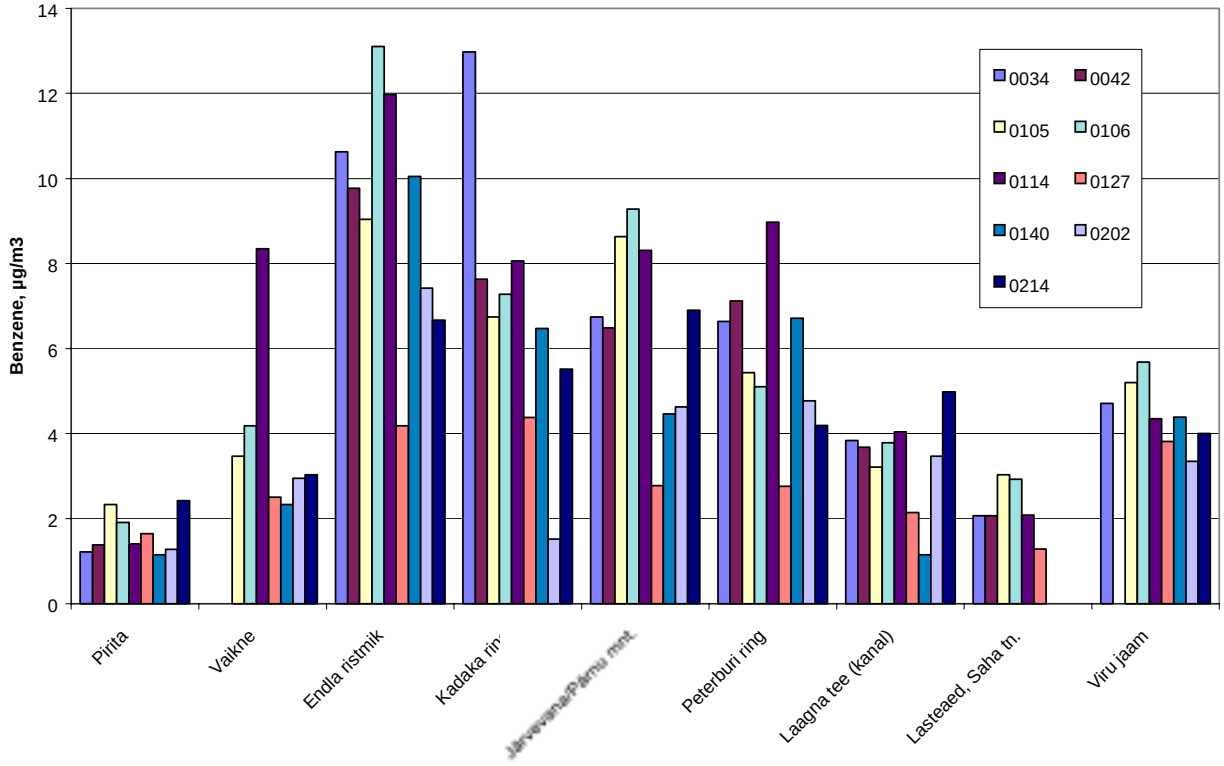


Figure 8 Weekly means of benzene, 2000-2002.

3.3.2 Comparison to EU limit values

The EU limit value for benzene is 5 µg/m^3 as an annual average to be met everywhere in 2010. It is not possible to compare the results achieved in this study directly with an annual mean value due to the low time coverage for the measurements. However, the benzene concentrations measured indicate a risk that the EU limit value is exceeded at all of the "High traffic crossroad" sites.

3.3.3 Trends

In Figure 9 below the levels of benzene at the sites, where measurements have been performed during both of the periods, 1996-1997 and 2000-2002 respectively, are presented as weekly means.

The measurements only cover some weeks each year, and are inhomogeneously spread over the different years. From the results no obvious trends can be seen, although the sites Endla ristmik (V4) and Viru jaam (V9) show slightly decreasing concentrations of benzene.

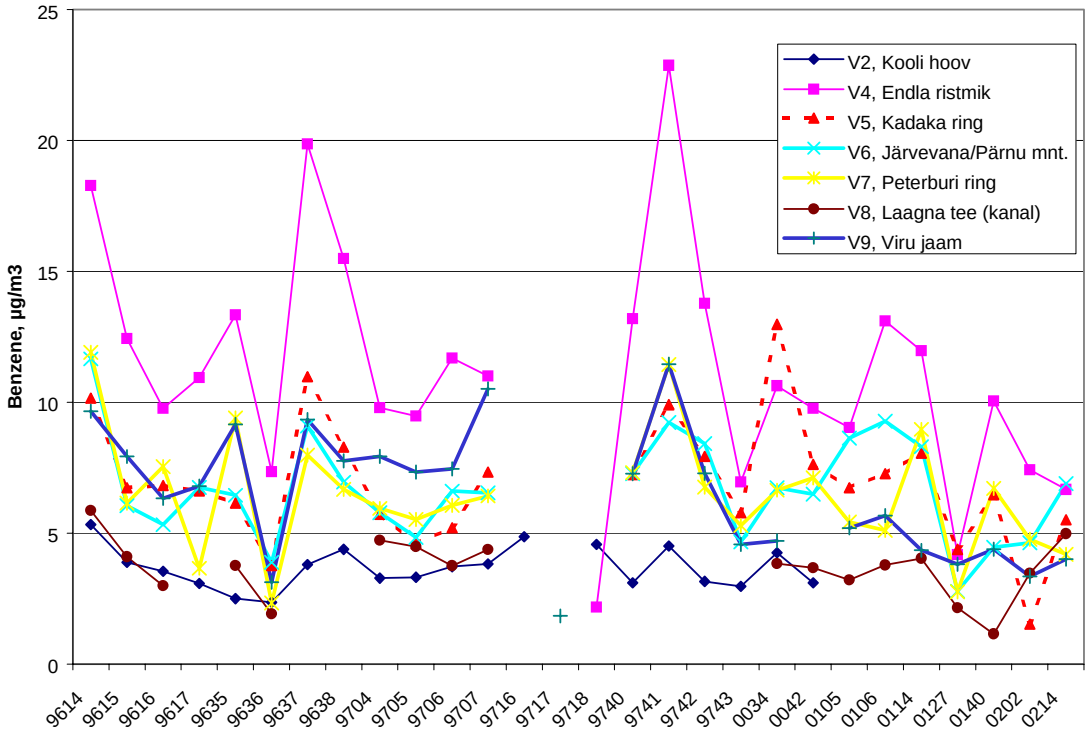


Figure 9 Weekly means of benzene, 1996-2002.

Appendix 1, EU limit values

EU limit values for **SO_2** not to be exceeded after 1 January 2005.

SO_2	**Time period**	**Limit value**	**Lower assessment threshold**	**Upper assessment threshold**
1. Hourly value for protection of human health	1 hour	350 µg/m^3 The value must not be exceeded more than 24 times/year	-	-
2. 24-hour value for protection of human health	24 hours	125 µg/m^3 The value must not be exceeded more than 3 times/year	50 µg/m^3 40% of 24 hour limit value	75 µg/m^3 60% of 24 hour limit value
3. Annual value for protection of ecosystems. Not to be applied close to sources.	1 year and during winter season (1 Oct-31 March)	20 µg/m^3	8 µg/m^3 40% of limit value for winter season	12 µg/m^3 60% of limit value for winter season

EU limit values for **NO_2** not to be exceeded after 1 January 2010.

NO_2	**Time period**	**Limit value**	**Lower assessment threshold**	**Upper assessment threshold**
1. Hourly value for protection of human health	1 hour	200 µg/m^3 The value must not be exceeded more than 18 times/year	100 µg/m^3 50% of hourly limit value	140 µg/m^3 70% of hourly limit value
2. Annual value for protection of human health	1 year	40 µg/m^3	26 µg/m^3 65% of limit value	32 µg/m^3 80% of limit value
3. Annual value for protection of vegetation. Not to be applied close to sources.	1 year	30 µg/m^3 As the sum of nitrogen oxides, NO_2+NO	19.5 µg/m^3 65% of limit value	24 µg/m^3 80% of limit value

EU limit values for **benzene** not to be exceeded after 1 January 2010**.**

Benzene	**Time period**	**Limit value µg/m^3**	**Lower assessment threshold**	**Upper assessment threshold**
Annual value for protection of human health	1 year	5 µg/m^3	2 µg/m^3	3.5 µg/m^3