Ambient Air Monitoring

In

Galway City

March 13th 2001 – 23rd October 2001

Contents

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Summary

An assessment of air quality was carried out in Galway city centre from March 13th 2001 until October 23rd 2001. No limit values were exceeded during the measurement period.

Concentrations of carbon monoxide, sulphur dioxide, nitrogen dioxide, benzene and lead were below their respective lower assessment thresholds. Levels of PM_{10} exceeded the upper assessment threshold.

	Below Lower Assessment Threshold	**Below Upper Assessment Threshold**	**Above Upper Assessment Threshold**	**Above Limit**
PM_{10}				
NO_2				
CO				
SO_2				
Benzene				
Pb				

Galway city is in Zone C of the country. The implications of this assessment are that within Zone C (specified population centres >15,000)

- Levels of PM_{10} will need to be measured continuously
- Levels of CO, SO_2, NO_2, benzene and lead can be assessed using modelling or objective estimation techniques

The directive states that modelling or objective estimation techniques may be used to assess ambient air quality if levels of the pollutant in question in that zone are below the lower assessment threshold. Continuous monitoring is required if levels exceed the upper assessment threshold.

Introduction

The European Union introduced a new approach to the monitoring, assessment and management of air quality in 1996 when it published a framework directive on air quality (96/62/EC, 2nd September 1996). The basic principle of the framework directive is that each country should be divided into zones and that the monitoring, assessment, management and reporting of air quality will be undertaken in relation to these zones. For the purposes of the directive, Ireland has been divided into four zones; Dublin (Zone A), Cork Urban Area (Zone B), specified population centres > 15,000 inhabitants (Zone C) and non-urban areas (Zone D).

Limit values are set for each individual pollutant which need to be met by a specific attainment date. Upper and lower assessment thresholds are also set for each pollutant, assessment thresholds are levels below the limit value, used solely to determine the level of monitoring needed for that pollutant in a particular zone. The extent of monitoring in any zone is determined by population size and air quality status. Measurement is mandatory in agglomerations (population >250,000) and where concentrations are above the lower assessment threshold. The greatest monitoring effort applies if concentrations are above the upper assessment threshold. Less intensive monitoring is required when concentrations are between the two assessment thresholds.

Limit values, assessment thresholds, measurement techniques and other specifics for each pollutant are defined in a series of daughter directives. The first daughter directive was adopted in April 1999 (1999/30/EC) and covered SO_2, NO_X, particulate matter and lead. The second daughter directive was adopted in November 2000 (2000/69/EC) and covers CO and Benzene. The directives were transposed into Irish law as the Air Quality Standard Regulations 2002 (S.I No. 271 of 2002).
To comply with the directive the Environmental Protection Agency uses mobile laboratories to carry out assessments in areas with no history of air pollution measurements. These trailers contained the following instruments:

- Monitoring instruments which continuously measure and record concentrations of the pollutants sulphur dioxide, nitrogen oxides and carbon monoxide.
- Instrument which continuously measures and records the levels of particulate matter.
- Gas chromatograph which measures levels of benzene, toluene and xylene
- Sampler for particulate matter (the official method specified for this parameter by the EU commission involves collection of the particulate matter on a filter on site followed by laboratory determination of the filter's increase in weight).
- Sampler for lead and other metals in air (collection on filter for determination in the laboratory).
- Mini meteorological station for measuring and recording temperature, relative humidity, wind speed and direction.

The sample inlets are at a height of ~3m.
For further information please contact
John Finnan, Barbara O' Leary or Ciaran O' Donnell.

Time Period

The mobile laboratory was in place from 13th March 2001 until 23rd October 2001.

Siting

The mobile laboratory was situated in a car park located adjacent to County Buildings on Bothar na mBan. In this location the trailer was sited approximately 500 m from the centre of Galway City. Bothar na Mban links the Headfort Road with Prospect Hill, it is a busy road with commuter and shopping traffic. The trailer was located at the entrance to the carpark and traffic entering and leaving the carpark passed immediately beside the trailer during business hours. The area is a mixed residential/commercial district of Galway City. In its carpark location the trailer was situated beside the gable end of one of the local houses.

Fig. 1 Map of site location

Location of Mobile Laboratory

Monitoring Methods

Carbon Monoxide

Carbon monoxide was monitored using a Gas Filter Correlation CO Analyser (Model 300, Advanced Pollution Instrumentation, 6565 Nancy Ridge Drive, San Diego, California). This is a continuous analyser based on the absorption of infrared radiation by CO molecules at wavelengths near 4.7μm.

Sulphur Dioxide

Sulphur dioxide was monitored using an Advanced Pollution Instrumentation SO_2 Fluorescent Analyser - Model 100A. This is a continuous analyser which measures the fluorescence of SO_2 molecules after excitation by ultraviolet radiation.

Nitrogen Dioxide and Oxides of Nitrogen

NO_x species were monitored using an Advanced Pollution Instrumentation Chemiluminescent $NO/NO_2/NO_x$ Analyser - Model 200A. This is a continuous analyser which utilises the chemiluminescent reaction between nitric oxide in the sample and ozone to measure the NO concentrations. Any NO_2 present is then reduced to NO by a molybdenum converter giving a second value for total NO_x concentration. The amount of NO_2 present is found by subtraction.

Particulate Matter

A gravimetric method was used to monitor PM_{10} particles (as defined in European Standard, prEN12341, July 1998, Central Secretariat, rue de Stassart, 36, B-1050 Brussels). An inertial impactor sampling head restricted the sampled particles to those with a diameter less than 10μm. The particles were collected on preweighed glassfibre filters (Whatman GF/A, 47mm). The filters were equilibrated at constant temperature and humidity (T = 293±1°K, R.H. = 50±3%) for at least 48 hours in a WTB Binder APT.Line KBF115 Climatic Chamber prior to weighing. An Ambient Dust Automatic Monitor (Model SM200CD with β source removed, OPSIS, S-24402, Furulund, Sweden) was used to change the filters daily at midnight.

Particulate matter was also measured using an OSIRIS Environmental Dust Monitor (Turnkey Instruments, 1&2 Dalby Court, Gadbrook Business Centre, Northwitch, Cheshire CW9 7TN). This instrument uses a light scattering technique to determine the concentration of airborne particles and dust; it is not an approved method. Results are given for total suspended particulates, PM_{10}, $PM_{2.5}$ and PM_1.

Benzene

Benzene was measured using a gas chromatograph (BTX Analyser GC855 supplied by Syntech Spectras, G. Meirstraat 11, 9728 TB Groningen, Nederland). This gas chromatograph samples automatically over a fifteen minute cycle and is equipped with a photoionisation detector.

Lead and Other Metals

Ambient air was pumped through a Metricel membrane filter (Gelman, 37mm, 0.8µm) situated in a calming chamber. The filters were changed every 1-2 weeks. They were digested in conc. HNO_3 and analysed for lead and other metals using ICP-MS (Inductively Coupled Plasma-Mass Spectrometry).

All results for CO, SO_2, NO_X and the continuous particulate monitor were integrated to give 1-hour average values as required for comparison with the Directive limit values.

Results

Carbon Monoxide

No. of hours	5356	
Missing values	823	
(including routine maintenance)	2	
No. of measured values	4533	
Percentage covered	84.6%	
Maximum hourly value	2.8	$mg.m^{-3}$
98 percentile for hourly values	1.3	$mg.m^{-3}$
Mean hourly value	0.5	$mg.m^{-3}$
Maximum 8-hour mean	1.6	$mg.m^{-3}$
98 percentile for 8-hour mean	1.1	$mg.m^{-3}$

Proposed Directive Limits

	Averaging Period	Limit Value	Date by which limit value is to be met
Limit Value for the protection of human health	8-hour running average	10 mg m^{-3}	1 January 2005
Upper assessment threshold	8-hour running average	7 mg m^{-3}	
Lower assessment threshold	8-hour running average	5 mg m^{-3}	

There were no exceedences of the lower assessment threshold during the measurement period (Figure 2).

Fig. 2 Carbon Monoxide 8-hour Running Average
Trailer 1 in Galway 13/3/01-23/10/01

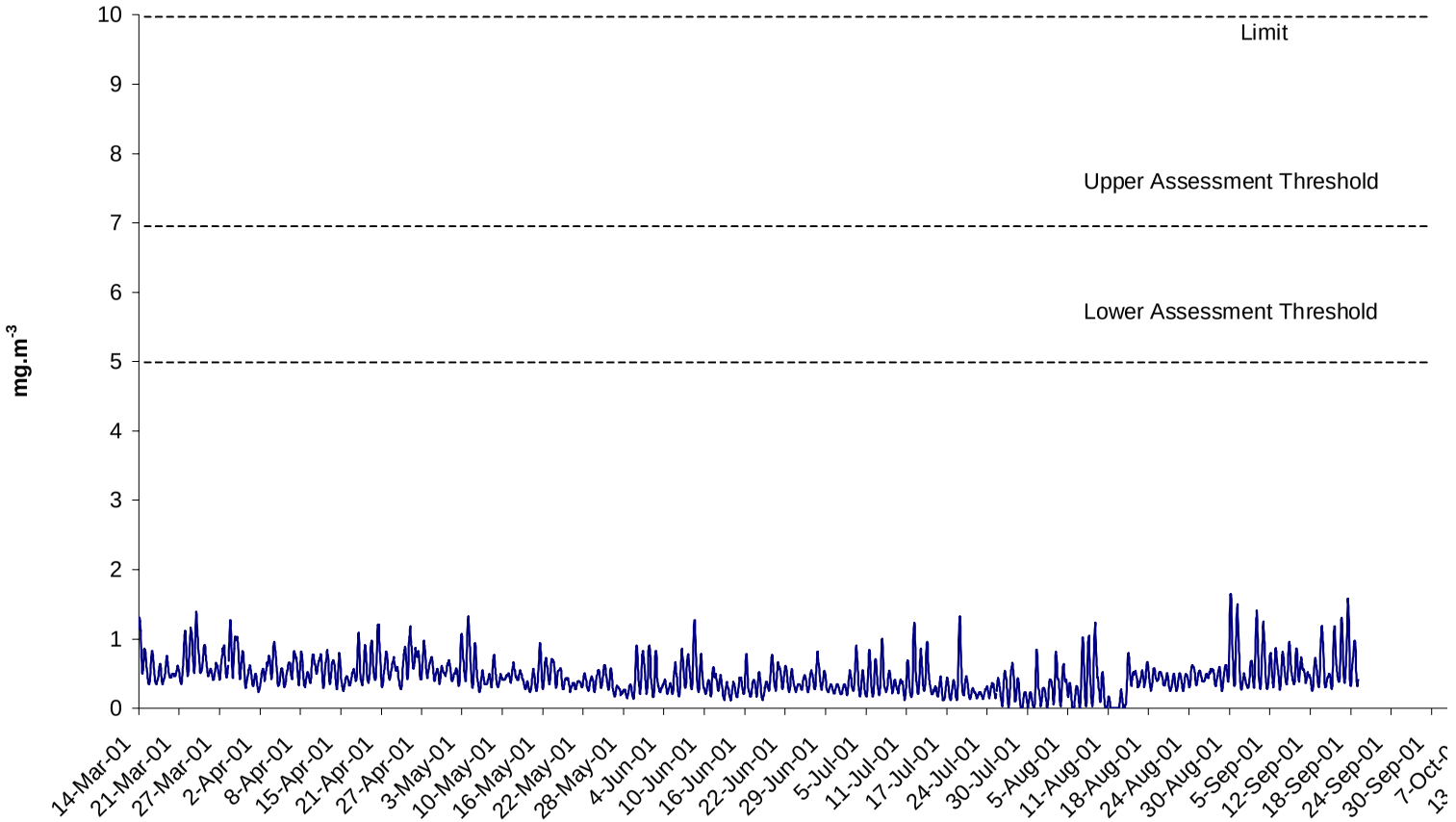
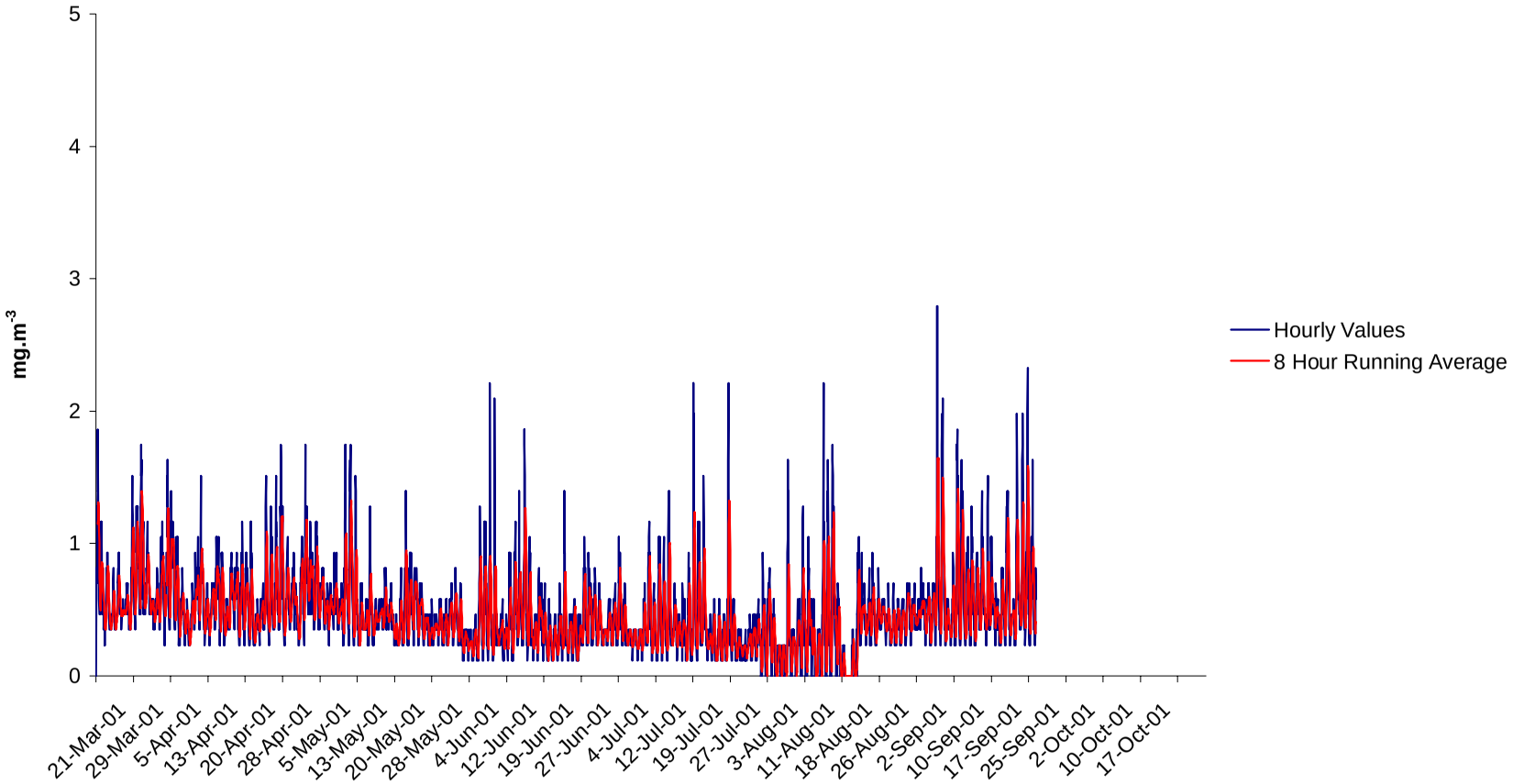


Fig. 3 Carbon Monoxide
Trailer 1 in Galway 13/3/01-23/10/01



Sulphur Dioxide

No. of hours	5356	
Missing values	1684	
(including routine maintenance)	21	
No. of measured values	3672	
Percentage covered	68.6%	
Maximum hourly value	87.8	$\mu g.m^{-3}$
98 percentile for hourly values	42.3	$\mu g.m^{-3}$
Mean hourly value	10.0	$\mu g.m^{-3}$
Maximum 24-hour value	31.1	$\mu g.m^{-3}$
98 percentile for 24-hour values	27.7	$\mu g.m^{-3}$

Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Hourly limit value for the protection of human health	1 hour	350 $\mu g\ m^{-3}$ not to be exceeded more than 24 times a calendar year	1 January 2005
Daily limit value for the protection of human health	24 hours	125 $\mu g\ m^{-3}$ not to be exceeded more than 3 times a calendar year	1 January 2005
Limit value for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	20 $\mu g\ m^{-3}$	19 July 2001
Alert threshold		500 $\mu g\ m^{-3}$ over three consecutive hours	

Directive Limits (1999/30/EC) continued

	Averaging Period	Limit Value	Date by which limit value is to be met
Upper assessment threshold for the protection of human health	24 hours	75 $\mu g\ m^{-3}$ not to be exceeded more than 3 times a calendar year	
Lower assessment threshold for the protection of human health	24 hours	50 $\mu g\ m^{-3}$ not to be exceeded more than 3 times a calendar year	
Upper assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	12 $\mu g\ m^{-3}$	
Lower assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	8 $\mu g\ m^{-3}$	

The hourly limit value was not exceeded during the measurement period (Figure 5). The lower assessment threshold was not exceeded during the measurement period (Figure 4). The mean hourly value of 10 $\mu g.m^{-3}$ exceeds the lower assessment threshold for the protection of ecosystems but not the upper assessment threshold. However, this threshold may not be relevant to monitoring in an urban environment.

Fig. 4 Sulphur Dioxide 24 hour Averages
Trailer 1 in Galway 13/3/01-23/10/01

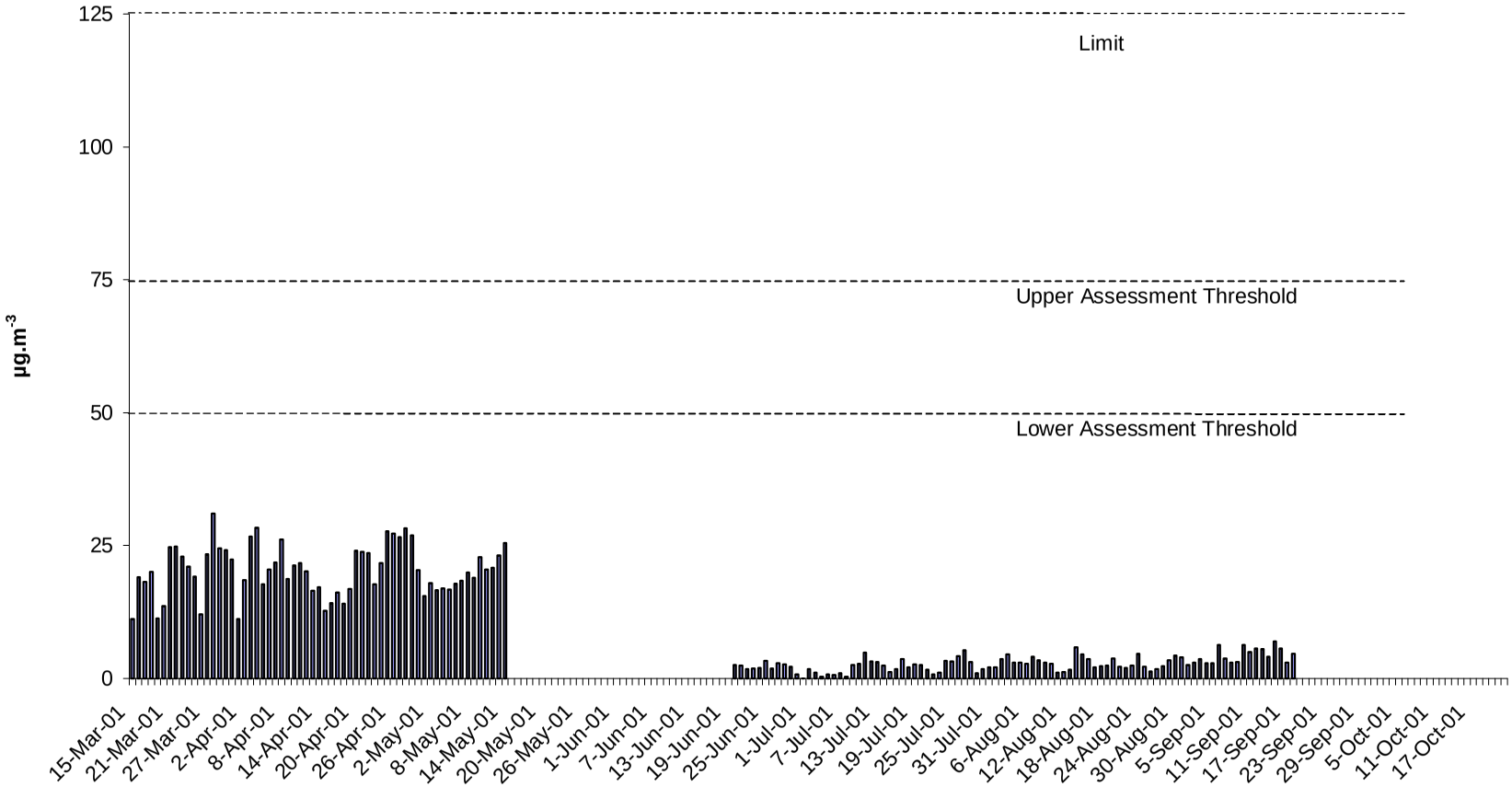
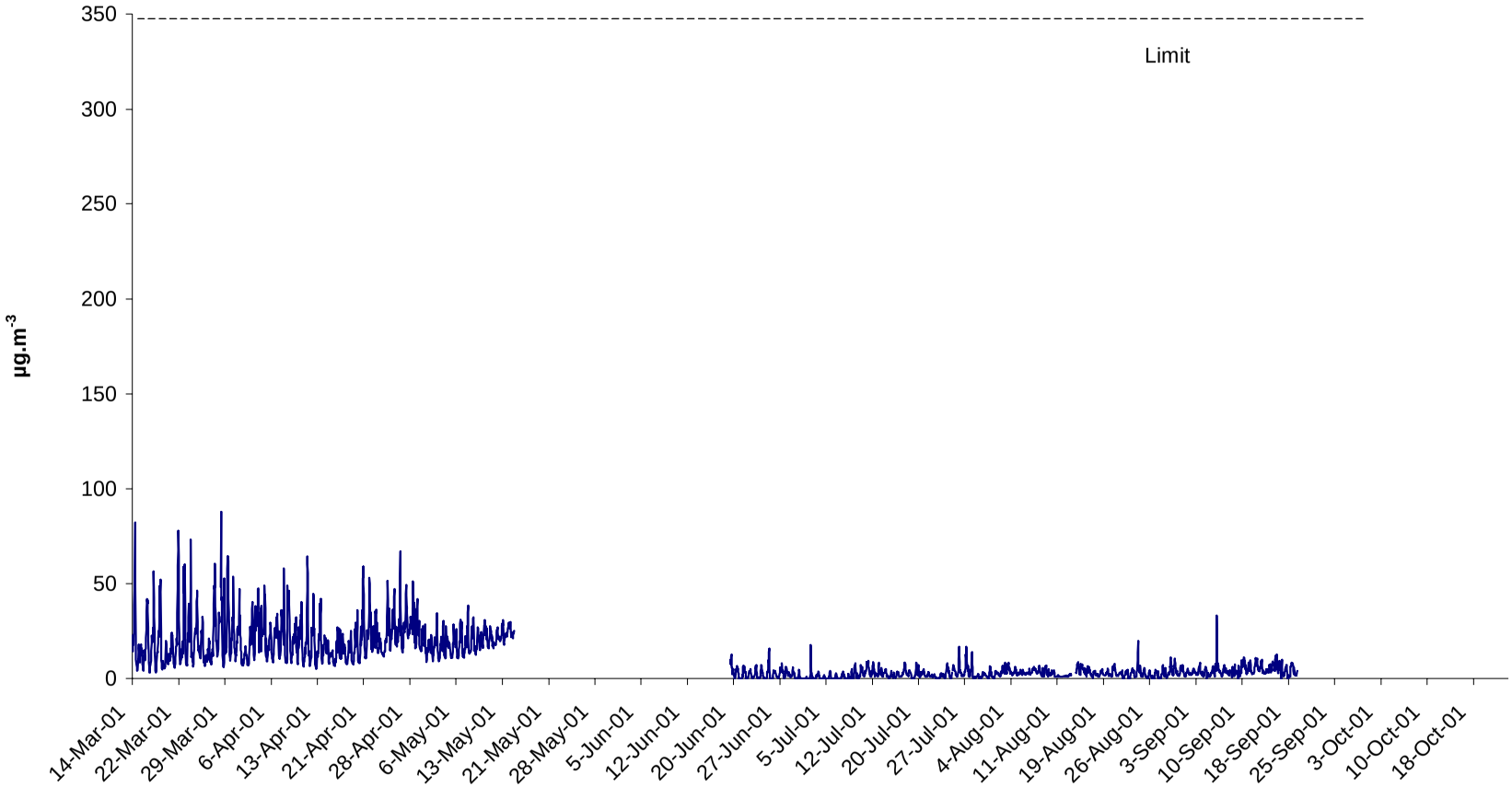


Fig. 5 Sulphur Dioxide Hourly Averages
Trailer 1 in Galway 13/3/01-23/10/01



Nitrogen Dioxide and Oxides of Nitrogen

No. of hours	5356	
Missing values (including routine maintenance)	825	
No. of measured values	4531	
Percentage covered	84.6%	
Maximum hourly value (NO_2)	120.7	$\mu g.m^{-3}$
98 percentile for hourly values (NO_2)	50.5	$\mu g.m^{-3}$
Mean hourly value (NO_2)	19.9	$\mu g.m^{-3}$
Mean hourly value (NO_x)	34.8	$\mu g.m^{-3}$ NO_2

Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Hourly limit value for the protection of human health	1 hour	200 $\mu g\ m^{-3}$ NO_2 not to be exceeded more than 18 times a calendar year	1 January 2010
Annual limit value for the protection of human health	Calendar year	40 $\mu g\ m^{-3}$ NO_2	1 January 2010
Annual limit value for the protection of vegetation	Calendar year	30 $\mu g\ m^{-3}$ NO_x (expressed as NO_2)	19 July 2001
Alert threshold		400 $\mu g\ m^{-3}$ NO_2 over three consecutive hours	

Directive Limits (1999/30/EC) continued

	Averaging Period	Limit Value	Date by which limit value is to be met
Upper assessment threshold for the protection of human health	1 hour	140 μg m^{-3} NO_2 not to be exceeded more than 18 times a calendar year	
Upper assessment threshold for the protection of human health	Calendar year	32 μg m^{-3} NO_2	
Lower assessment threshold for the protection of human health	1 hour	100 μg m^{-3} NO_2 not to be exceeded more than 18 times a calendar year	
Lower assessment threshold for the protection of human health	Calendar year	26 μg m^{-3} NO_2	
Upper assessment threshold for the protection of vegetation	Calendar year	24 μg m^{-3} NO_x (Expressed as NO_2)	
Lower assessment threshold for the protection of vegetation	Calendar year	19.5 μg m^{-3} NO_x (Expressed as NO_2)	

The hourly limit value was not exceeded during the measurement period (Figure 6). One hourly mean NO_2 value was above the lower assessment threshold, the directive stipulates that the lower assessment threshold should not be exceeded more than 18

times in a calendar year. With the exception of this value, all other hourly mean NO_2 values were below the lower assessment threshold.

The mean hourly NO_2 value (19.9µg.m^{-3}) during the measurement period was below the annual lower assessment threshold for the protection of human health (26 µg.m^{-3}).

NO, NO_2 and NO_X are measured as ppb (parts per billion) by volume. To convert to µg.m^{-3}, a factor (1.25 for NO, 1.91 for NO_2) is used. No formula is specified for NO_X, the directive requires it to be expressed as NO_2 (i.e. ppb*1.91). This applies even when most of the NO_X is present as NO.

The mean hourly value of NO_X (34.8 µg.m^{-3} NO_2) during the measurement period exceeded the annual limit value for the protection of vegetation (30 µg.m^{-3} NO_2). However, the applicability of this limit to urban air pollution monitoring is questionable.

Fig.6 NO_2 Hourly Values
Trailer 1 in Galway 13/3/01-23/10/01

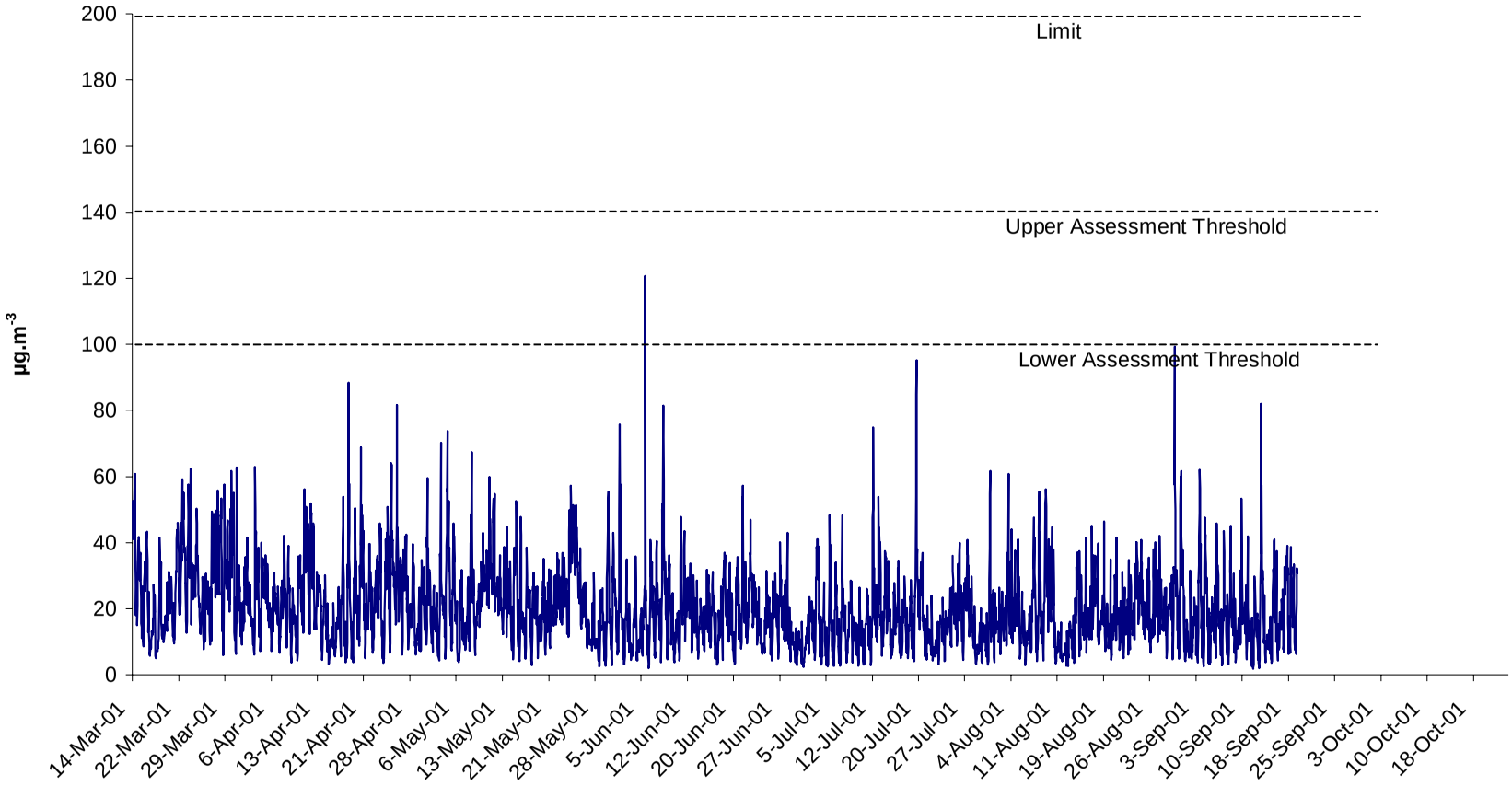
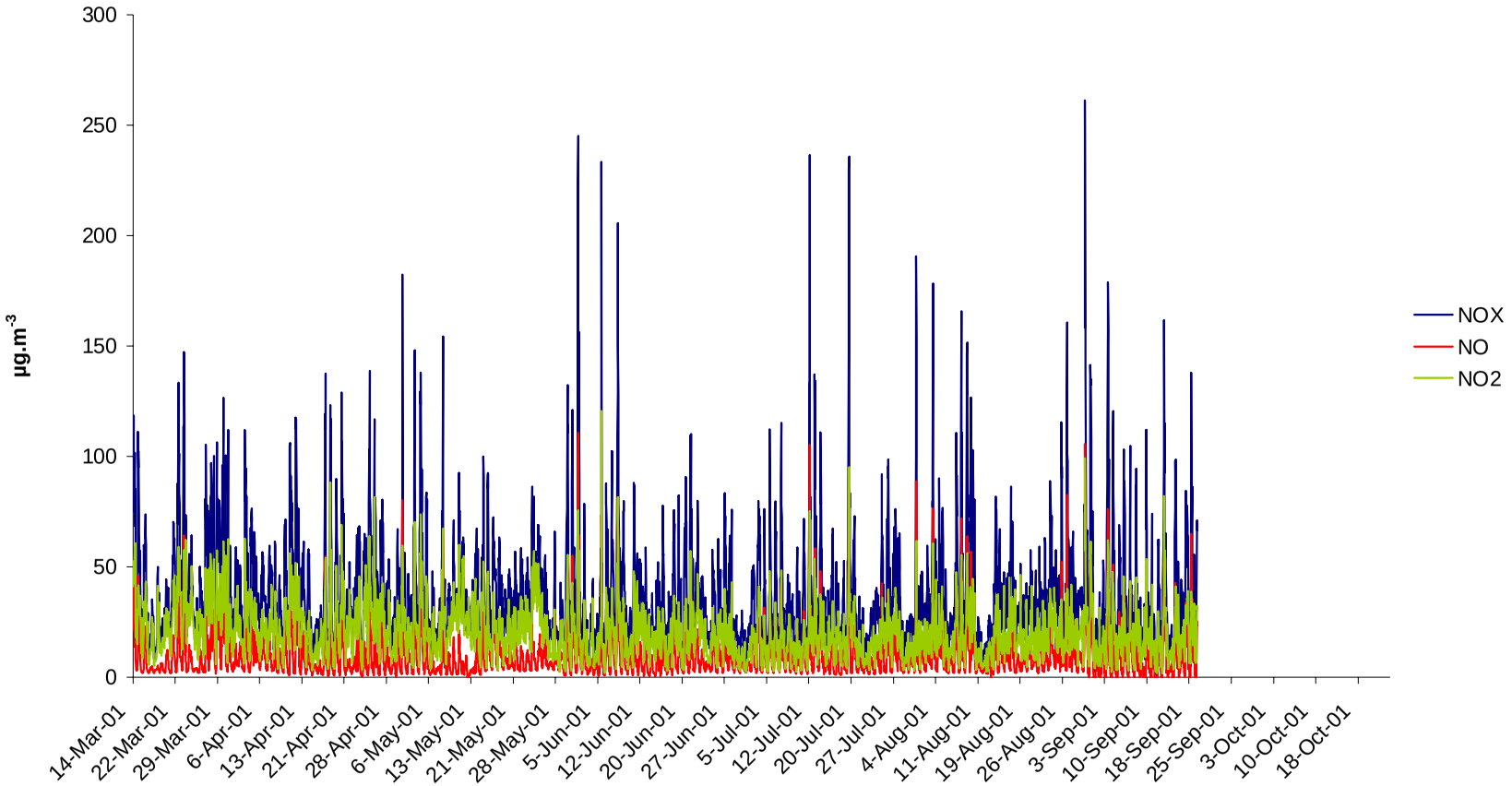


Fig.7 NO_X Hourly Values
Trailer 1 in Galway 13/3/01-23/10/01



Particulate Matter

PM_{10} : gravimetric method

No. of days	223	
Missing values	36	
(including routine maintenance)	1	
No. of measured values	187	
Percentage covered	83.8%	
Maximum daily value	49.9	$\mu g.m^{-3}$
98 percentile for daily values	45.8	$\mu g.m^{-3}$
Mean daily value	22.1	$\mu g.m^{-3}$

Directive Limits (1999/30/EC)

STAGE I

	Averaging Period	Limit Value	Date by which limit value is to be met
24-hour limit value for the protection of human health	24 hour	50 $\mu g\ m^{-3}$ PM_{10} not to be exceeded more than 35 times a calendar year	1 January 2005
Annual limit value for the protection of human health	Calendar year	40 $\mu g\ m^{-3}$ PM_{10}	1 January 2005
Upper assessment threshold for the protection of human health	24 hour	30 $\mu g\ m^{-3}$ PM_{10} not to be exceeded more than 7 times a calendar year	*based on the indicative limit values for 1 January 2010*
Upper assessment threshold for the protection of human health	Calendar year	14 $\mu g\ m^{-3}$ PM_{10}	*based on the indicative limit values for 1 January 2010*

Directive Limits (1999/30/EC) Stage I continued

	Averaging Period	Limit Value	Date by which limit value is to be met
Lower assessment threshold for the protection of human health	24 hour	20 μg m^{-3} PM_{10} not to be exceeded more than 7 times a calendar year	*based on the indicative limit values for 1 January 2010*
Lower assessment threshold for the protection of human health	Calendar year	10 μg m^{-3} PM_{10}	*based on the indicative limit values for 1 January 2010*

STAGE II

	Averaging Period	Limit Value	Date by which limit value is to be met
24-hour limit value for the protection of human health	24 hour	50 μg m^{-3} PM_{10} not to be exceeded more than 7 times a calendar year	1 January 2010
Annual limit value for the protection of human health	Calendar year	20 μg m^{-3} PM_{10}	1 January 2010

The twenty four hour limit value for the protection of human health (50μg.m^{-3}) was not exceeded during the measurement period (Figure 8). The upper assessment threshold was exceeded on 32 days (17.1% of measured values), the lower assessment threshold was exceeded on 96 days (51.3% of measured values). The directive stipulates that each of the assessment thresholds should not be exceeded more than 7 times in a calendar year.

The mean of the daily values during the measurement period (22.2 µg.m^{-3}) is below the annual limit value for the protection of human health (40 µg.m^{-3}).

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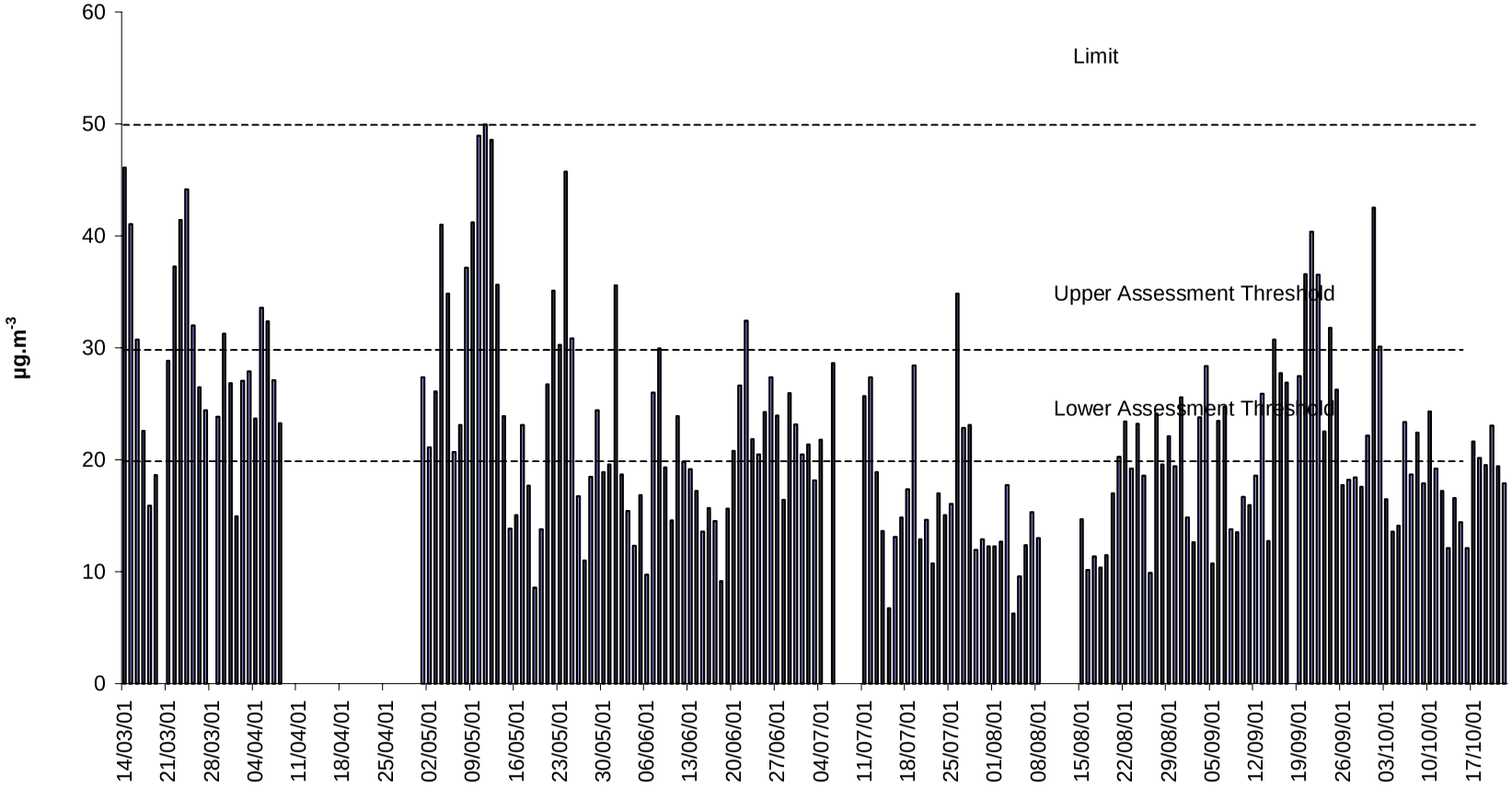
Fig. 8 PM_{10} Daily Values
Trailer 1 in Galway 13/3/01-23/10/01



Benzene

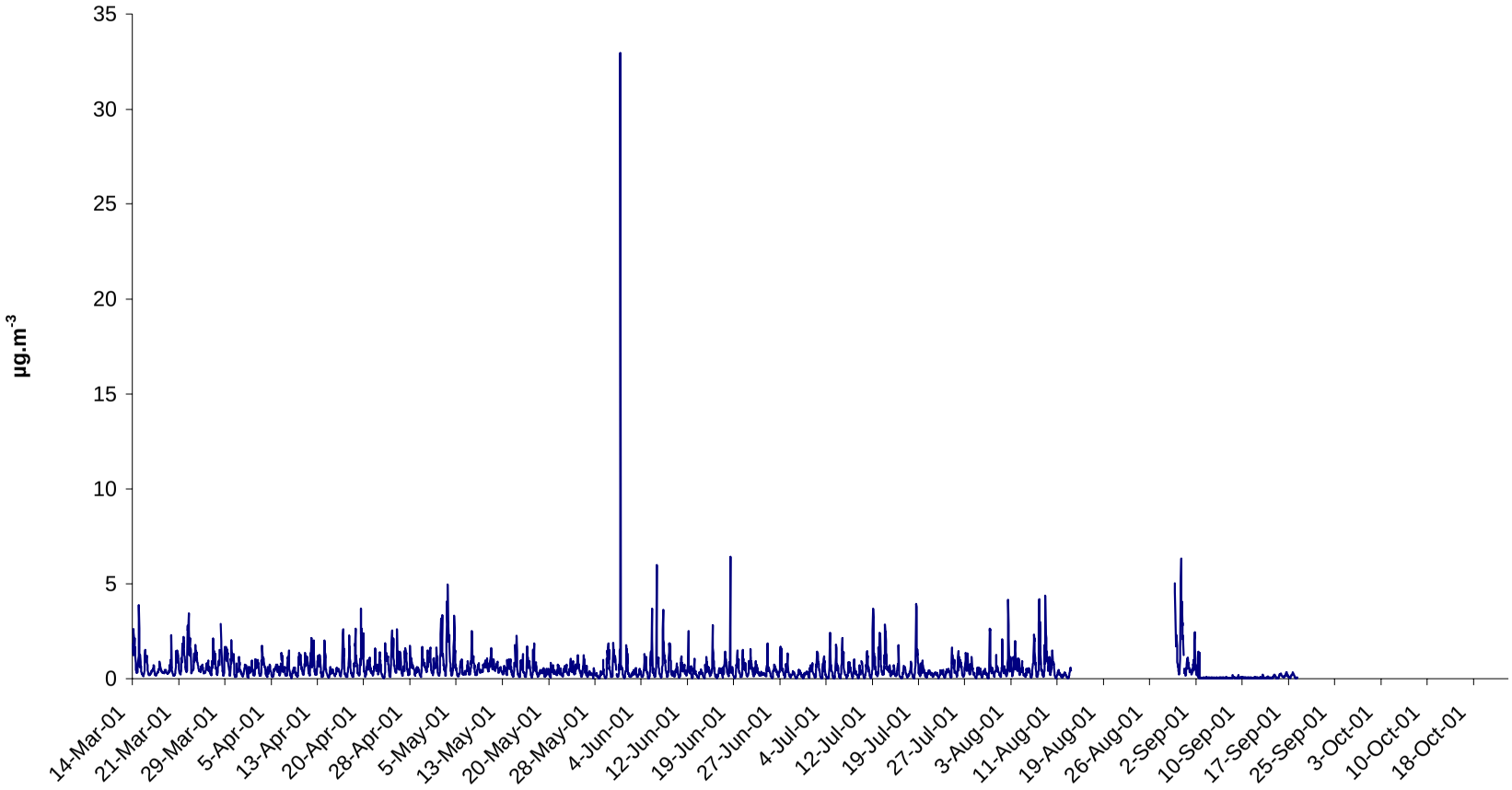
No. of hours	5356	
Missing values	1248	
(including routine maintenance)	22	
No. of measured values	4108	
Percentage covered	76.7%	
Maximum hourly value	32.9	$\mu g.m^{-3}$
98 percentile for hourly values	2.3	$\mu g.m^{-3}$
Mean hourly value	0.5	$\mu g.m^{-3}$

Proposed Directive Limits

	Averaging Period	Limit Value	Date by which limit value is to be met
Limit value for the protection of human health	Calendar year	5 $\mu g\ m^{-3}$	1 January 2010
Upper assessment threshold for the protection of human health	Calendar year	3.5 $\mu g\ m^{-3}$	
Lower assessment threshold for the protection of human health	Calendar year	2 $\mu g\ m^{-3}$	

The mean hourly value for the measurement period (0.5 $\mu g.m^{-3}$) is below the lower assessment threshold for the protection of human health (Figure 9).

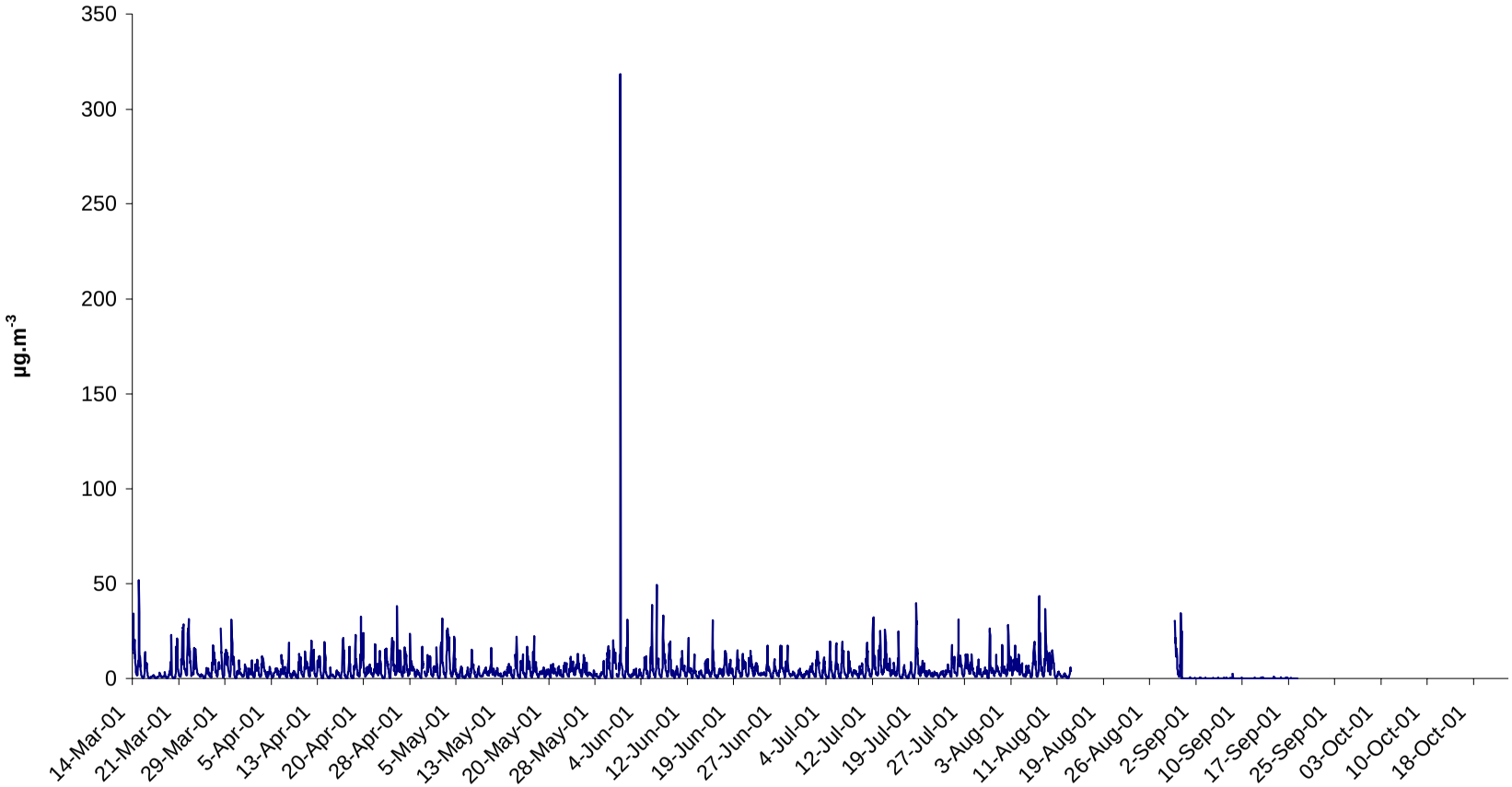
Fig. 9 Benzene Hourly Values
Trailer 1 in Galway 13/3/01-23/10/01



Toluene

No. of hours	5356	
Missing values	1248	
(including routine maintenance)	22	
No. of measured values	4108	
Percentage covered	76.6%	
Maximum hourly value	318.5	$\mu g.m^{-3}$
98 percentile for hourly values	20.7	$\mu g.m^{-3}$
Mean hourly value	4.3	$\mu g.m^{-3}$

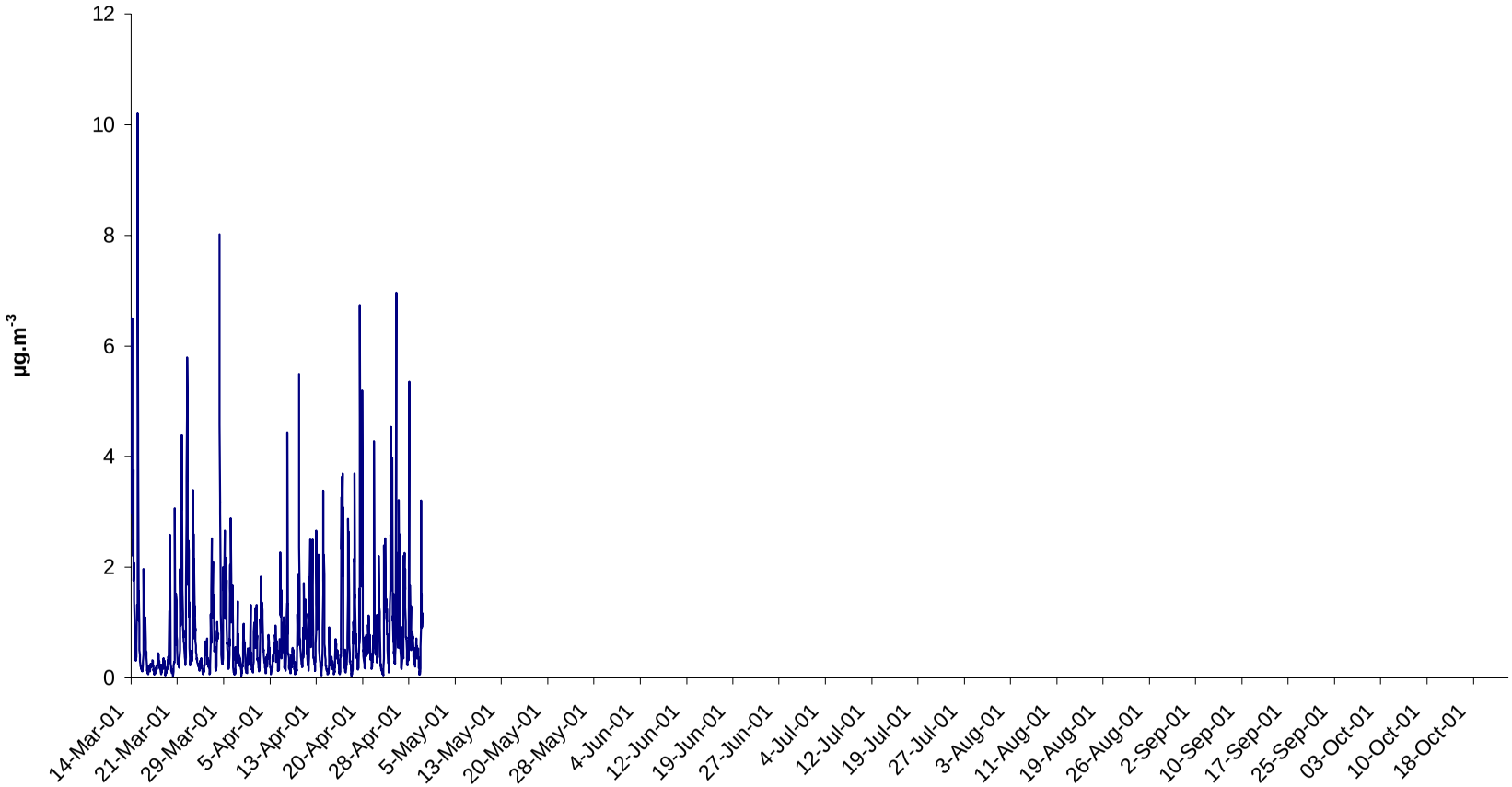
Fig.10 Toluene Hourly Values
Trailer 1 in Galway 13/3/01-23/10/01



o-Xylene

No. of hours	5356	
Missing values	4230	
(including routine maintenance)	22	
No. of measured values	1126	
Percentage covered	21.0%	
Maximum hourly value	10.2	$\mu g.m^{-3}$
98 percentile for hourly values	3.8	$\mu g.m^{-3}$
Mean hourly value	0.8	$\mu g.m^{-3}$

Fig. 11 o-Xylene Hourly Values
Trailer 1 in Galway 13/3/01-23/10/01



Lead

No. of days	224	
Missing days	35	
(including routine maintenance)	0	
No. of measured days	189	
Percentage covered	84.4%	
Concentration of Pb	0.002	$\mu g.m^{-3}$

Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Annual limit value for the protection of human health	Calendar year	0.5 $\mu g\ m^{-3}$	1 January 2005
Upper assessment threshold	Calendar year	0.35 $\mu g\ m^{-3}$	
Lower assessment threshold	Calendar year	0.25 $\mu g\ m^{-3}$	

The concentration of lead during the measurement period was well below the lower assessment threshold.

Other Metals:

Annex I of council directive 96/62/EC (Air Framework Directive) lists four metals other than lead to be taken into consideration in the assessment and management of ambient air quality. These are cadmium, arsenic, nickel and mercury. Limit values and measurement methods for these metals as well as certain polycyclic aromatic hydrocarbons will be set out in the fourth daughter directive.

An indicative method was used during this assessment to measure prevailing concentrations of cadmium, nickel and arsenic in air. This method is detailed above and essentially involves pumping air through a filter for several weeks before digesting the filter and analysing the digest for lead and other metals using ICP-MS. The problem with this method is that the detection limit is influenced both by any traces of metal in the filter paper as well as by the volume of air passed through the filter.
The results, although indicative, do provide some indication of the concentrations of these metals in air.

During this assessment

The maximum concentration of cadmium in air was found to be 0.7 $ng.m^{-3}$

The maximum concentration of arsenic in air was lower than trace levels of arsenic known to exist on the filter papers.

The maximum concentration of nickel in air was found to be 0.7 $ng.m^{-3}$