Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Ambient Air Monitoring

In

Clonmel

10th June 2004 – 13th January 2005

Contents

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Summary

An assessment of air quality was carried out in Clonmel, Co. Tipperary from 10th June 2004 until 13th January 2005.

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 for this parameter.

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

Clonmel is in Zone C of the country. The implications of this assessment are that within Zone C (specified urban centres with populations in excess of 15,000)

- Levels of PM_{10} will need to be monitored 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.

The national ozone monitoring network has already been established. Ozone concentrations were measured in Clonmel from August to November 2004. During this period

- The population information and alert thresholds were not exceeded
- The target value for the protection of human health was not exceeded
- The long term objective for the protection of human health was not exceeded

Introduction

The European Union introduced a new approach to the monitoring, assessment and management of air quality in 1996 when it introduced 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 in the determination of 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). The third daughter directive on ozone was adopted in March 2002 (2002/3/EC) and was transposed into Irish law as the Ozone in Ambient Air Regulations 2004 (S.I No 53 of 2004). The third daughter directive differs from the preceeding two in that no assessment thresholds or limit values are set for ozone. Instead, long term objectives and target values have been set for ozone in addition to thresholds for health protection, public information and public alert.

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. The trailer sited in Clonmel contained the following instruments:

- Monitoring instruments which continuously measure and record concentrations of the pollutants sulphur dioxide, nitrogen oxides, ozone, carbon monoxide and PM_{10}
- Instrument which continuously measures and records the levels of particulate matter.
- Gas chromatograph which measures levels of benzene and toluene
- Sampler for lead and other metals in air (collection on filter for determination in the laboratory).

The sample inlets are at a height of ~3m.

For further information please contact

John Finnan, Barbara O' Leary or Ciaran O' Donnell.

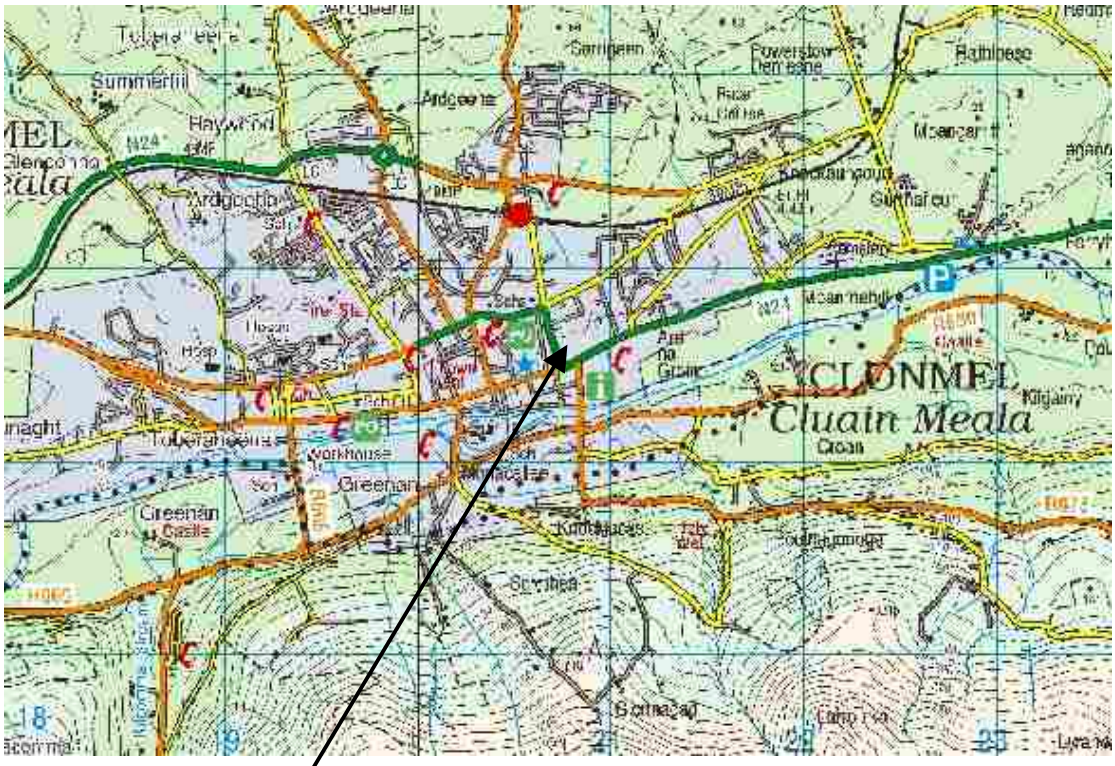
Time Period

The trailer was brought to Clonmel on 10th of June 2004. Monitoring continued until 13th January 2005 when the trailer was removed from site.

Siting

The trailer was located in Kickham army barracks in a mixed commercial/residential area. In this site the trailer was within 200m of the town centre.

Fig. 1 Map of site location (with kind permission from Ordnance Survey Ireland)



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 whose measurement technique is 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 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.

Ozone

Ozone (O_3) was measured using an Advanced Pollution Instrumentation UV absorption O_3 analyser – Model 400E. This is a continuous analyser which measures the absorption of UV radiation by molecules of ozone.

Particulate Matter

Concentrations of PM_{10} were measured using an instrument which employed tapered element oscillating microbalance technology (TEOM, Rupprecht & Patashnick Co. Inc., 25 Corporate Circle, Albany, New York). This is a continuous method in which the air from the sampling head is passed through a filter placed on a tapered element. A mass transducer relates changes in the frequency of the tapered element to changes in particulate matter on the filter, the difference between the filter's current weight and it's initial weight gives the total mass of collected particulate matter. An inertial impactor sampling head restricted the sampled particles to those with a diameter less than 10μm. PM_{10} concentrations measured by the TEOM were multiplied by a correction factor of 1.3 to compensate for the loss of volatile matter as recommended by the EC working group on particulate matter.

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 3-4 weeks. They were digested in concentrated 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	5196	
Missing values	12	
(including routine maintenance)	3	
No. of measured values	5184	
Percentage covered	99.7	
Maximum hourly value	3.2	mg m^{-3}
98 percentile for hourly values	1.0	mg m^{-3}
Mean hourly value	0.3	mg m^{-3}
Maximum 8-hour mean	1.8	mg m^{-3}
98 percentile for 8-hour mean	0.9	mg m^{-3}

Directive Limits (2000/69/EC)

	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}	

The lower assessment threshold was not exceeded (Figure 2).

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Fig. 2 Carbon Monoxide 8-hour Running Average
Trailer 1 in Clonmel 10/6/04-13/1/05

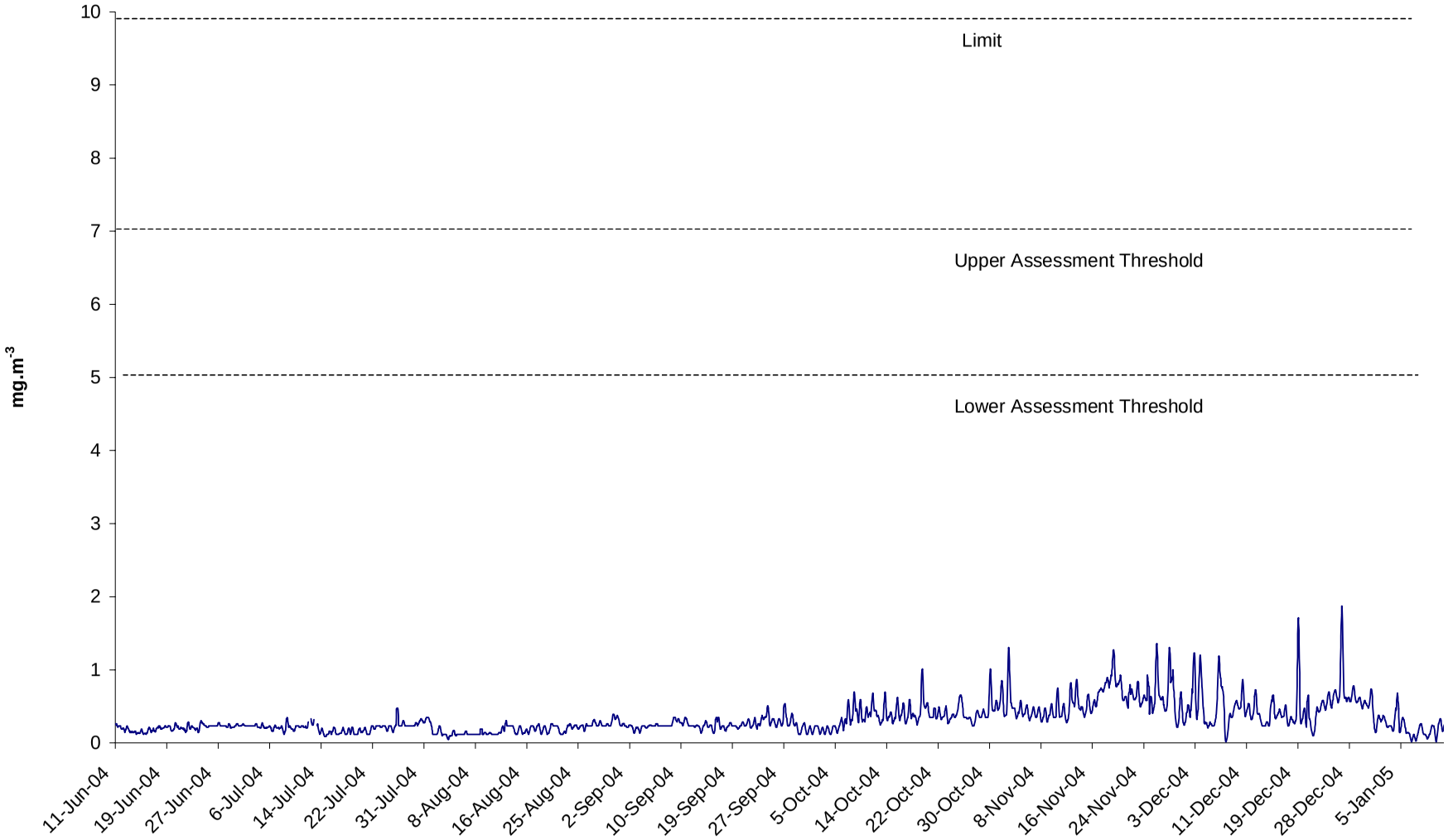
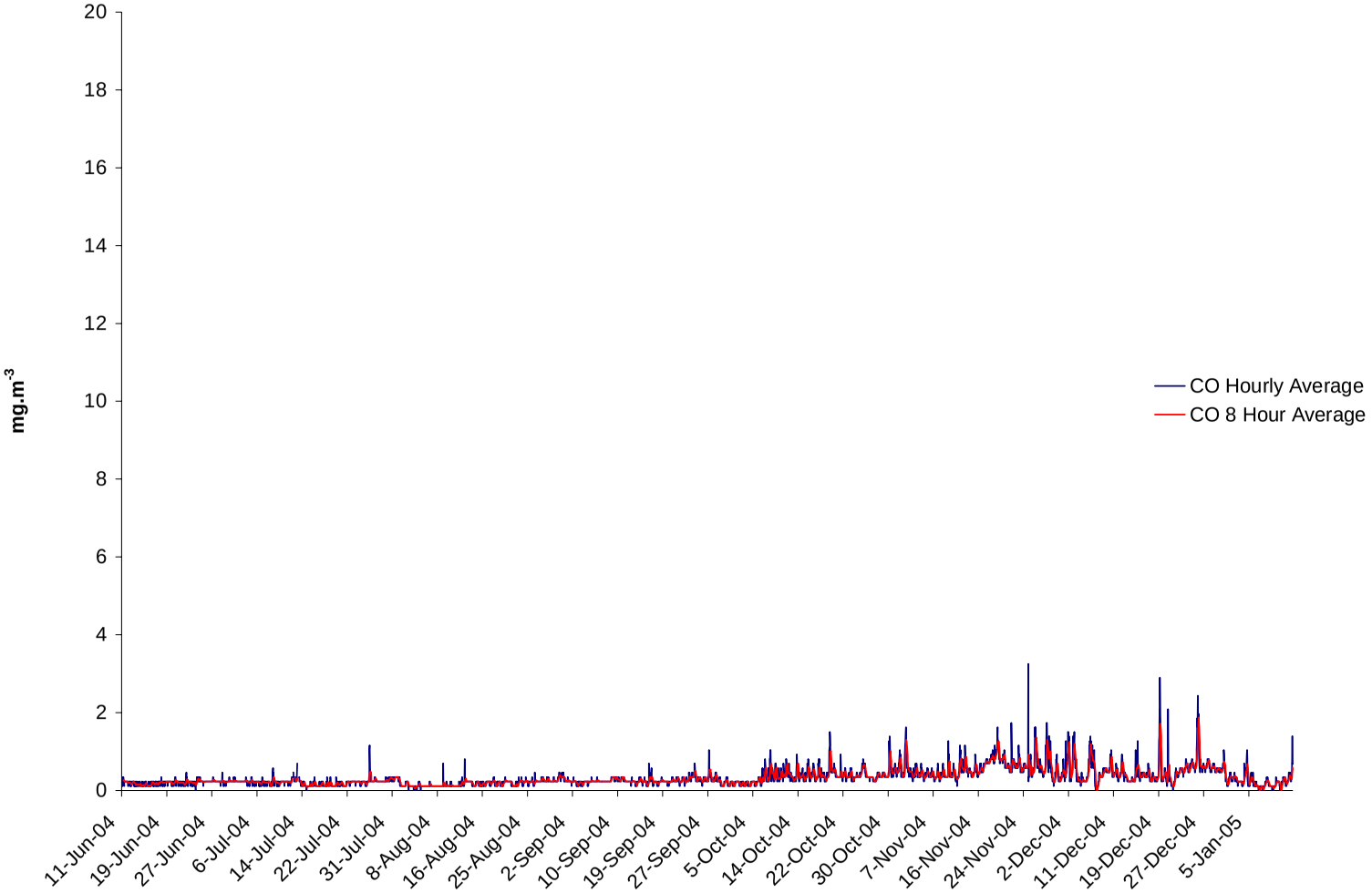


Fig. 3 Carbon Monoxide
Trailer 1 in Clonmel 10/6/04-13/1/05



Sulphur Dioxide

No. of hours	5196	
Missing values	3	
(including routine maintenance)	2	
No. of measured values	5193	
Percentage covered	99.9	
Maximum hourly value	33.2	$\mu g.m^{-3}$
98 percentile for hourly values	11.1	$\mu g.m^{-3}$
Mean hourly value	3.0	$\mu g.m^{-3}$
Maximum 24-hour value	9.6	$\mu g.m^{-3}$
98 percentile for 24-hour values	7.3	$\mu g.m^{-3}$

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 μg 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 μg 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 μg m^{-3}	
Lower assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	8 μg m^{-3}	

The lower assessment thresholds for the protection of human health and for the protection of ecosystems were not exceeded (Figure 4).

Fig. 4 Sulphur Dioxide 24 Hour Averages
Trailer 1 in Clonmel 10/6/04 - 13/1/05

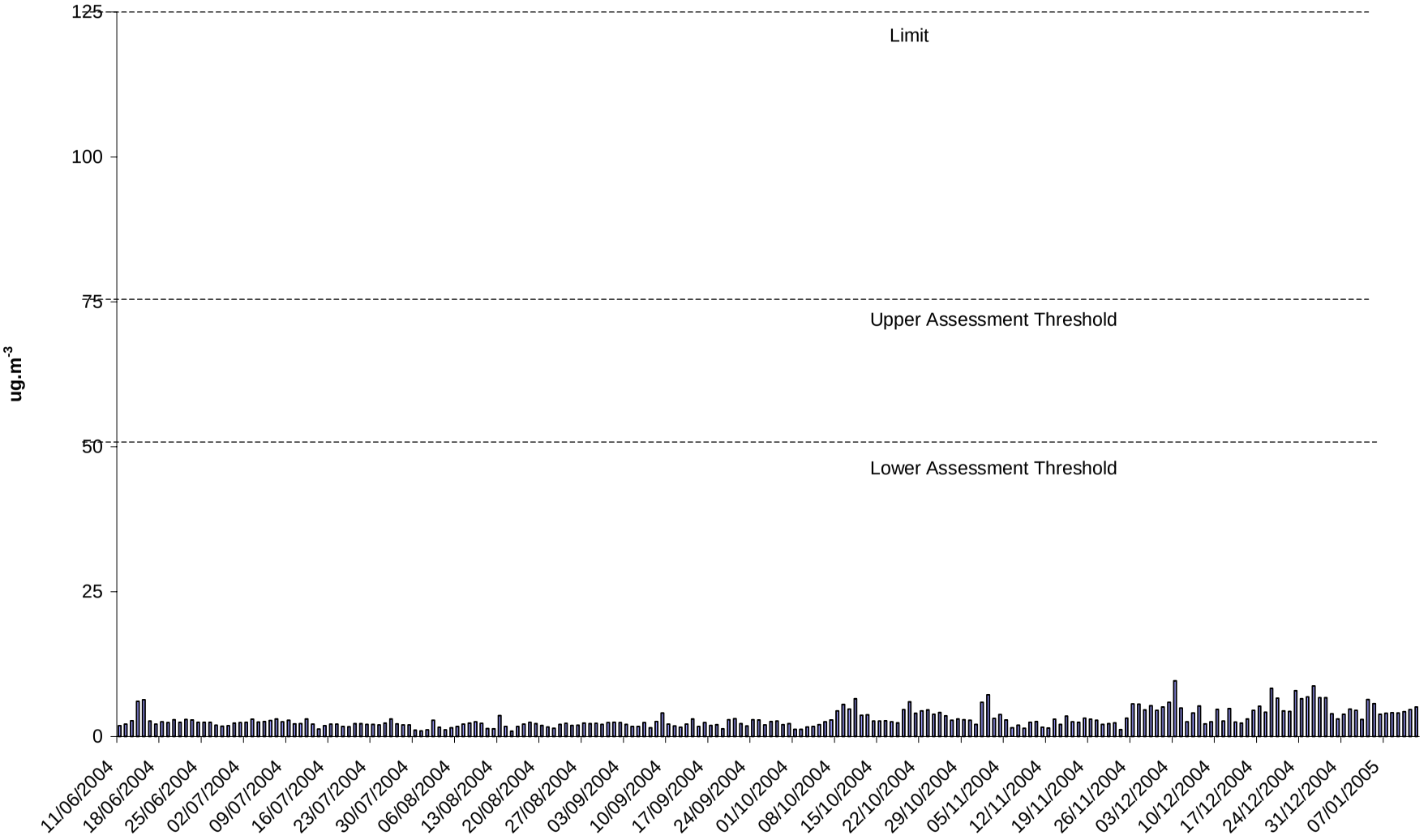
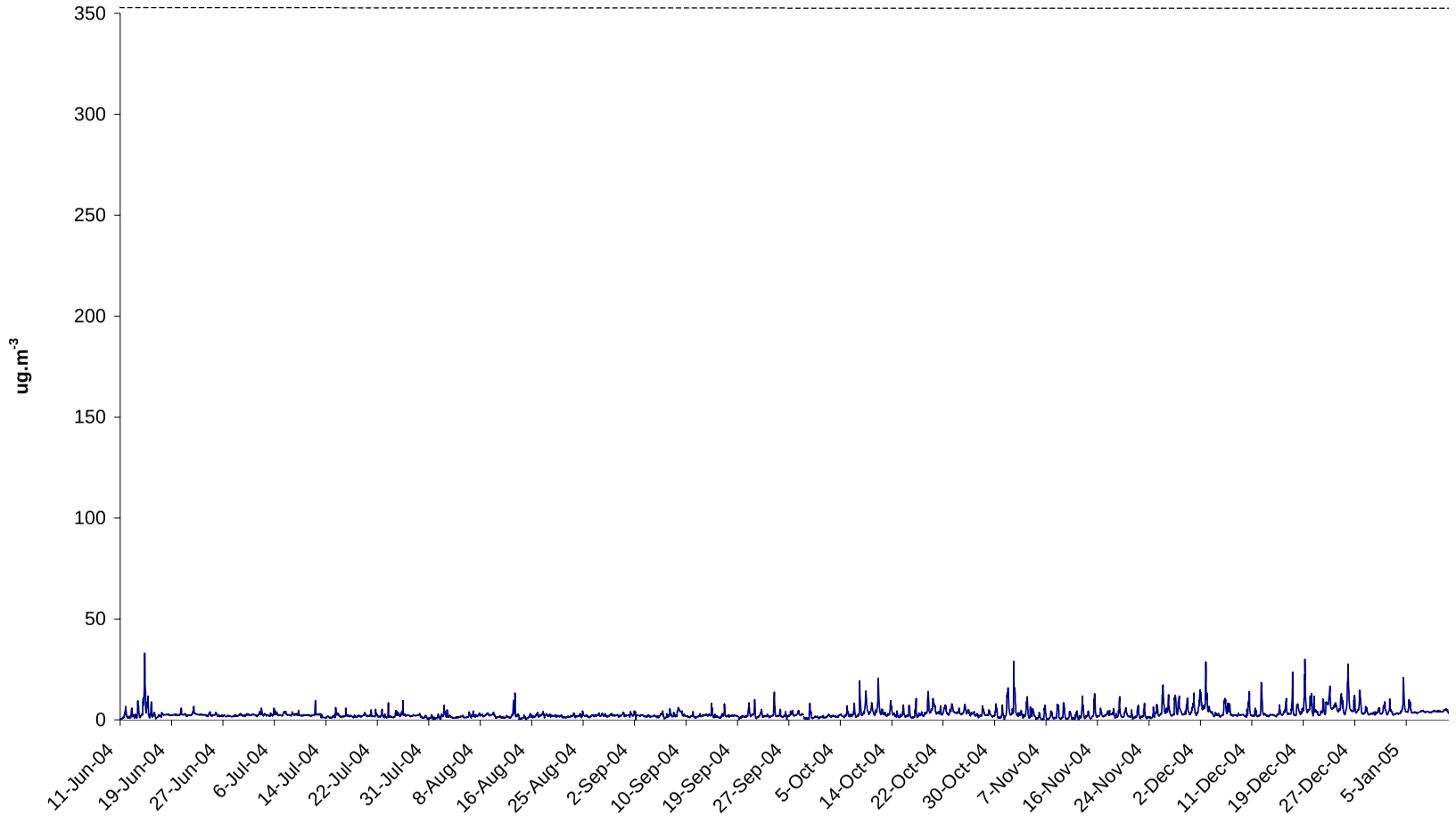


Fig. 5 Sulphur Dioxide Hourly Averages
Trailer 1 in Clonmel 10/6/04 - 13/1/05



Ozone

No. of hours	5196
Missing values	2927
(including routine maintenance)	0
No. of measured values	2239
Percentage covered	43.1
Maximum hourly value	121 $\mu g.m^{-3}$
98 percentile for hourly values	83.4 $\mu g.m^{-3}$
Mean hourly value	49.6 $\mu g.m^{-3}$
Maximum 8-hour mean	108.1 $\mu g.m^{-3}$
98 percentile for 8-hour mean	81.2 $\mu g.m^{-3}$

Directive (2002/3/EC) Target Values, Long Term Objectives, Information and Alert Thresholds

	Averaging Period	Limit Value	
Information Threshold for the protection of human health	1 hour	180 $\mu g.m^{-3}$	
Alert Threshold for the protection of human health	1 hour	240 $\mu g.m^{-3}$	
Target value for the protection of human health	Maximum daily 8hr mean	120 $\mu g.m^{-3}$ not to be exceeded more than 25 days per calendar year averaged over three years	2010
Target value for the protection of vegetation	AOT40 calculated from 1hr values from May to July	18,000 averaged over 5 years	2010
Long term objective for the protection of human health	Maximum daily 8hr mean within a calendar year	120 $\mu g.m^{-3}$	2020
Long term objective for the protection of vegetation	AOT40 calculated from 1hr values from May to July	6000 $\mu g.m^{-3}$	2020

The long term objective and the target value for the protection of human health were not exceeded during the measurement period (Figure 7). Similarly, the information and alert thresholds were not exceeded (Figure 6). No attempt was made to assess the effect of the measured ozone levels on vegetation as monitoring commenced in August and the index used to measure ozone effects on vegetation (AOT40) is calculated between the months of May and July for vegetation and between April and September for forests.

Fig. 6 Ozone Hourly Averages
Trailer 1 in Clonmel 10/6/04 - 13/1/05

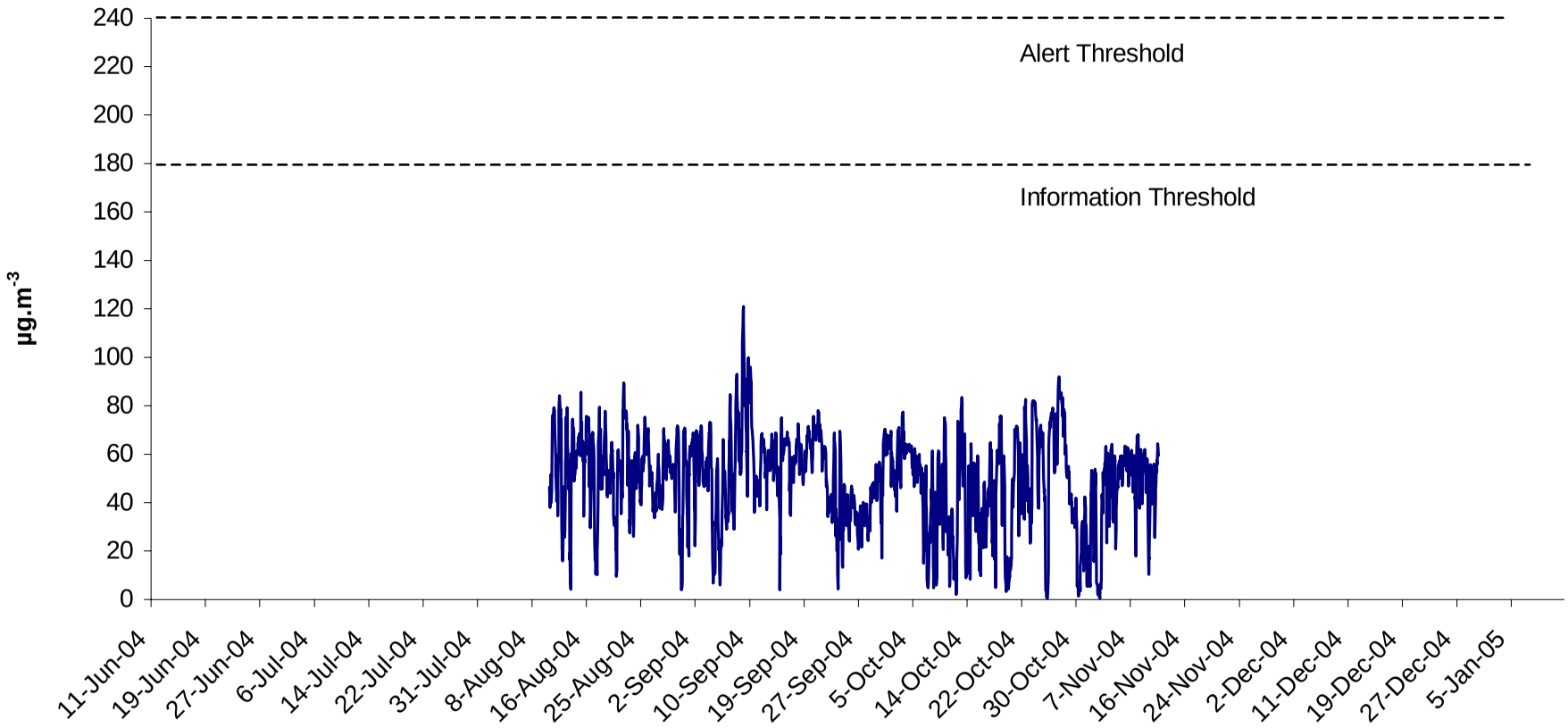
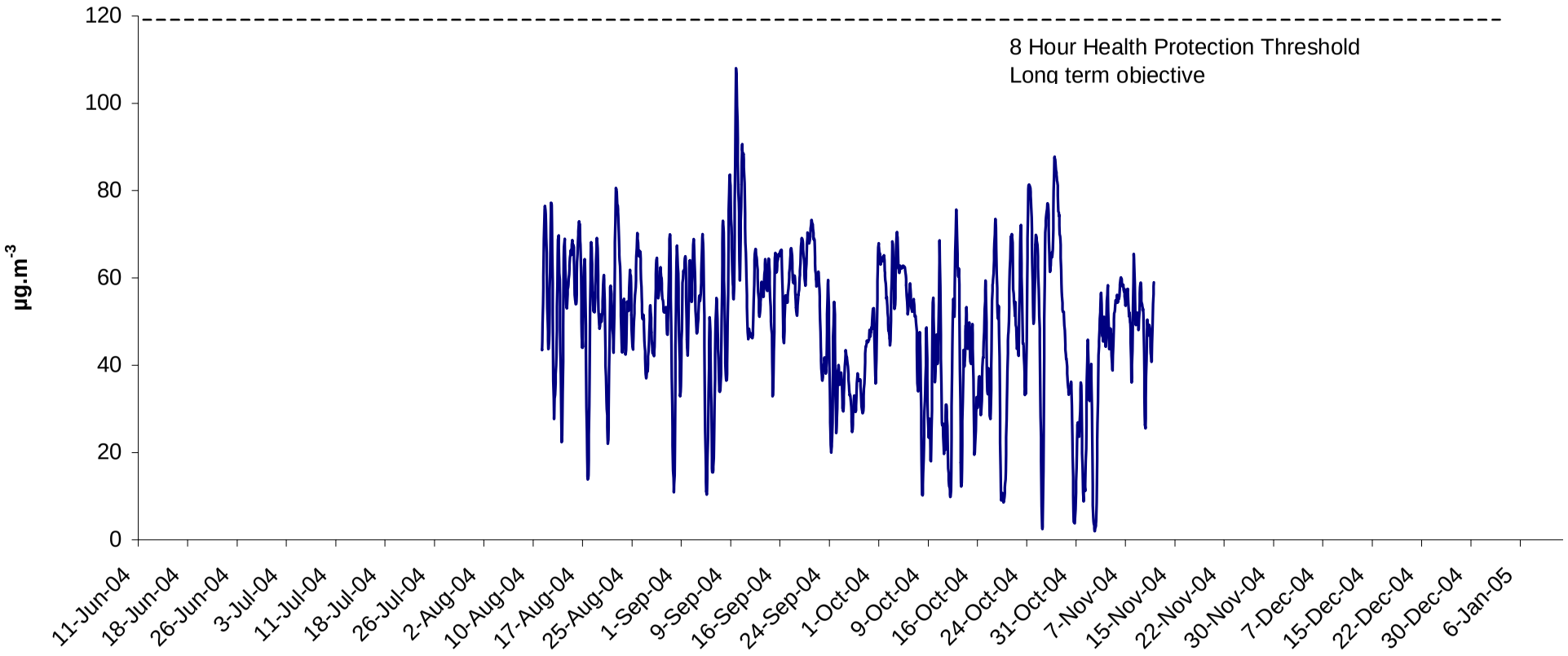


Fig. 7 Ozone 8 Hour Averages
Trailer 1 in Clonmel 10/6/04 - 13/1/05



Nitrogen Dioxide and Oxides of Nitrogen

No. of hours	5196	
Missing values	1	
(including routine maintenance)	1	
No. of measured values	5195	
Percentage covered	99.9	
Maximum hourly value (NO_2)	112.7	$\mu g.m^{-3}$
98 percentile for hourly values (NO_2)	38.6	$\mu g.m^{-3}$
Mean hourly value (NO_2)	10.1	$\mu g.m^{-3}$
Mean hourly value (NO_x)	14.2	$\mu g.m^{-3}$ 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	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	
Lower assessment threshold for the protection of vegetation	Calendar year	19.5 μg m^{-3} NO_x	

The hourly and annual limit values for the protection of human health were not exceeded during the assessment period. Similarly, the lower assessment threshold for the protection of vegetation was not exceeded. There was one exceedence of the lower assessment threshold for the protection of human health during the assessment period. However, Clonmel is still classified as being below the lower assessment threshold for the protection of human health as 18 exceedences are permitted in a calendar year.

NO, NO_2 and NO_X are measured as ppb (parts per billion) by volume. To convert to $\mu g.m^{-3}$, 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.

Fig. 8 NO_2 Hourly Values
Trailer 1 in Clonmel 10/6/04 - 13/1/05

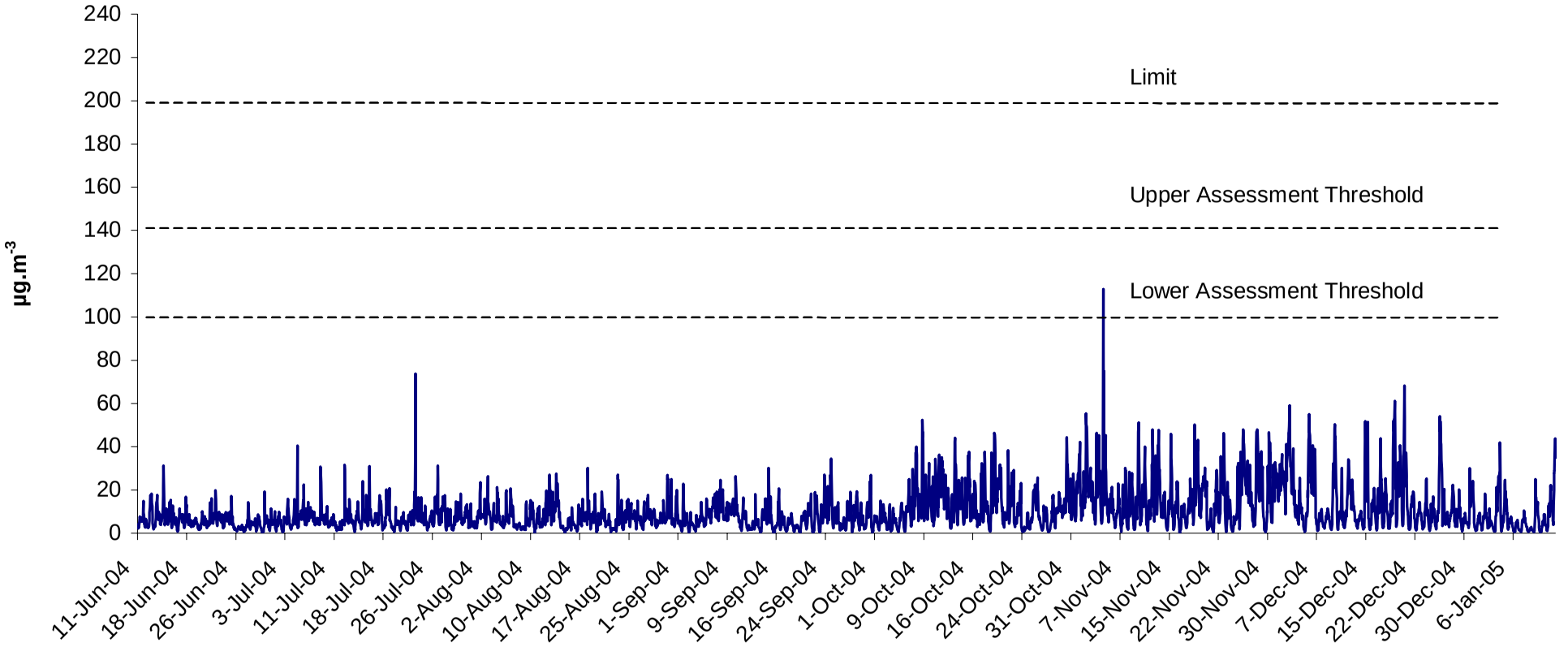
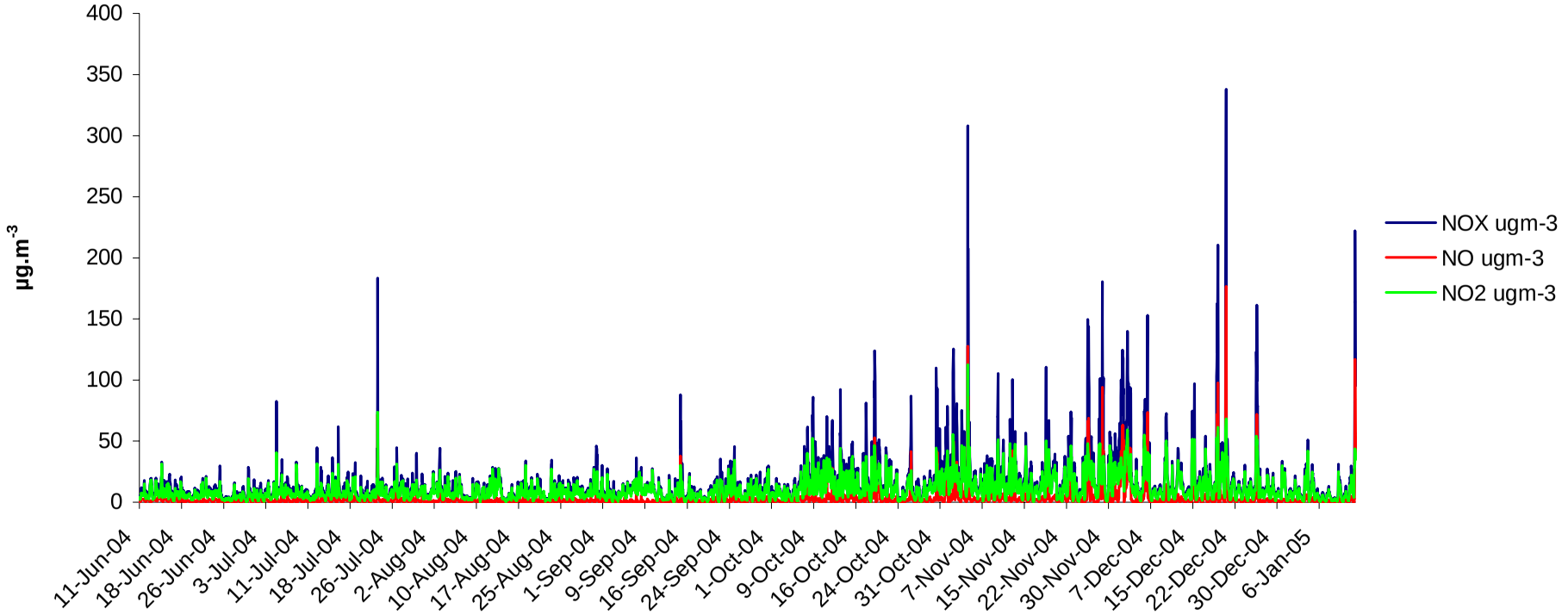


Fig. 9 NO_X Hourly Values
Trailer 1 in Clonmel 10/6/04 - 13/1/05



Particulate Matter

PM_{10} : gravimetric method

No. of days	216	
Missing values	0	
(including routine maintenance)	0	
No. of measured values	216	
Percentage covered	100	
Maximum daily value	55.8	$\mu g.m^{-3}$
98 percentile for daily values	47.5	$\mu g.m^{-3}$
Mean daily value	20.1	$\mu g.m^{-3}$

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 limit value plus margin of tolerance for 2004 (55 µg.m^{-3}) was exceeded on one day while the 2005 limit value (50 µg.m^{-3}) was exceeded on two days. However, the limit was not exceeded as 35 exceedences are permitted in a calendar year. Both the lower and upper assessment thresholds were exceeded, the lower assessment threshold was exceeded on 89 days while the upper assessment threshold was exceeded on 21 days. The directive only permits 7 exceedences of the assessment thresholds in a calendar year.

Particulate Matter : $PM_{2.5}$

Article 5 of Council Directive 1999/30/EC of 22 April 1999 states that

"Member States shall ensure that measuring stations to supply data on concentration of $PM_{2.5}$ are installed."

The concentration of $PM_{2.5}$ was measured with an OSIRIS Environmental Dust Monitor in the mobile laboratory. This also measured total suspended particles (TSP), PM_{10} and PM_1. All measurements were hourly values.

The concentration of PM_{10} measured by the OSIRIS and that measured using the TEOM were compared to give a daily correction factor. The correction factor was used to estimate the concentration of $PM_{2.5}$ using the formula:

$$\text{24-hour average concentration of } PM_{2.5} = \text{OSIRIS 24-hour average concentration of } PM_{2.5} \times \frac{\text{gravimetric 24-hour average } PM_{10}}{\text{OSIRIS 24-hour average } PM_{10}}$$

Results:

No. of days	216	
Missing values	83	
(including routine maintenance)	0	
No. of measured values*	133	
Percentage covered	61.6	
Maximum daily value	29.0	$\mu g.m^{-3}$
98 percentile for daily values	23.7	$\mu g.m^{-3}$
Mean daily value	10.1	$\mu g.m^{-3}$
Median daily value	9.5	$\mu g.m^{-3}$

* no. of days with measurements from both the OSIRIS monitor and the gravimetric method.

Fig. 10 PM_{10} Daily Values
Trailer 1 in Clonmel 10/6/04 - 13/1/05

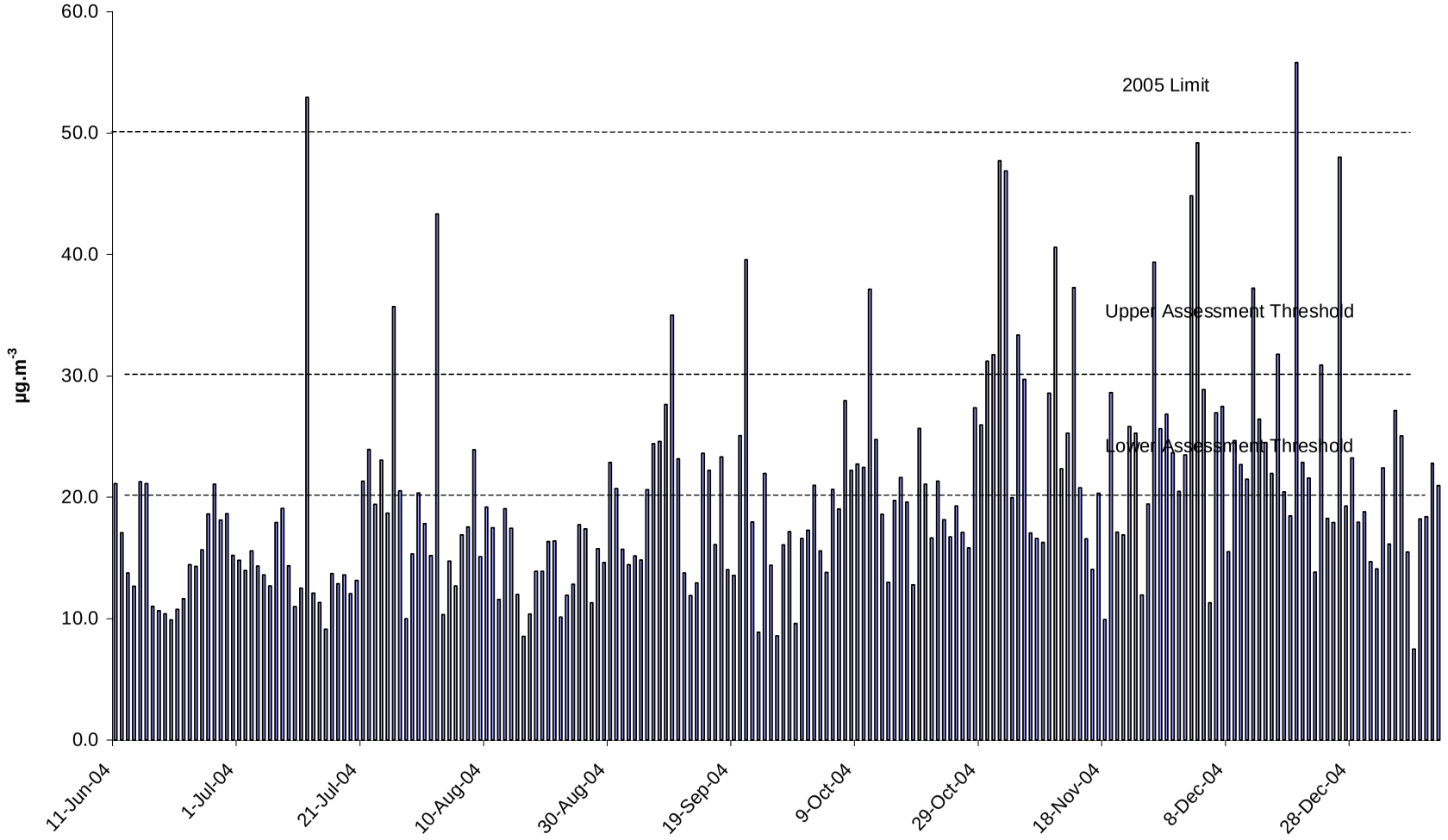
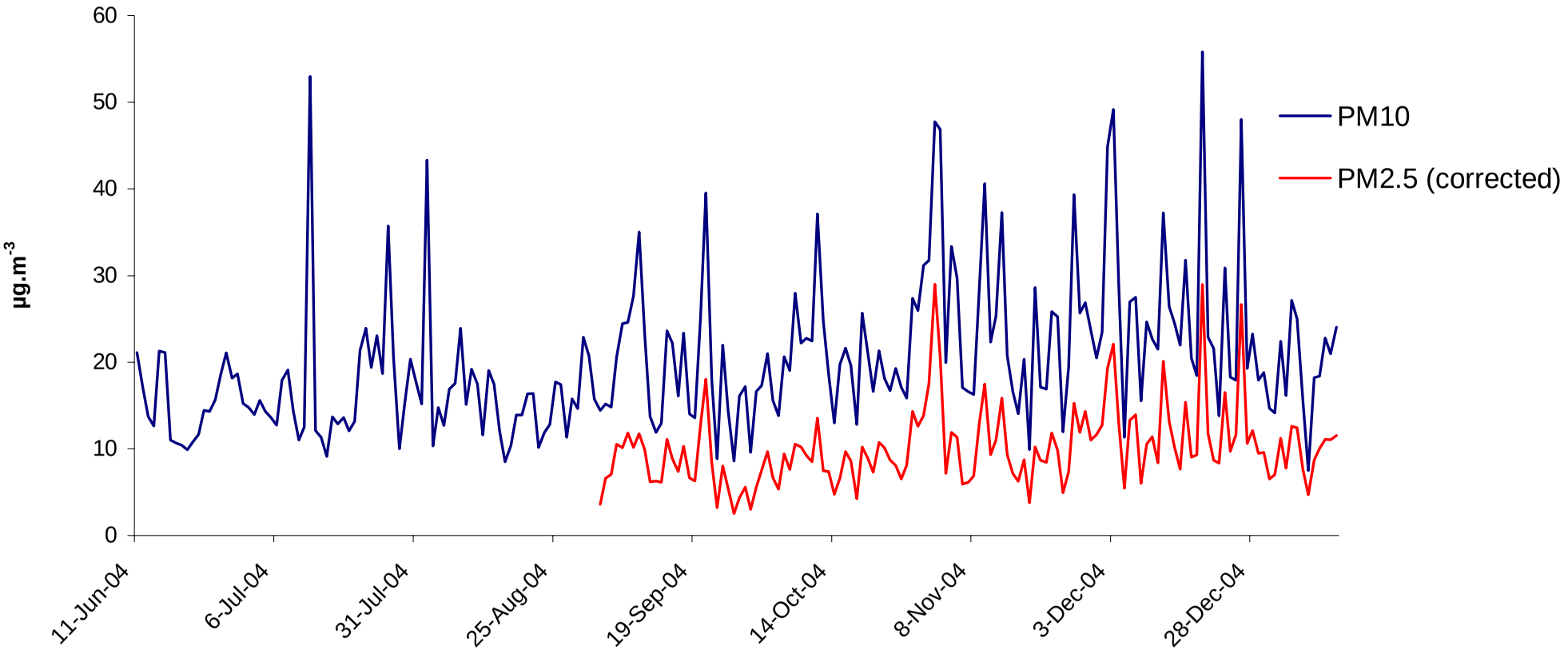


Fig. 11 PM_{10} and $PM_{2.5}$ Daily Values
Trailer 1 in Clonmel 10/6/04 - 13/1/05



Benzene

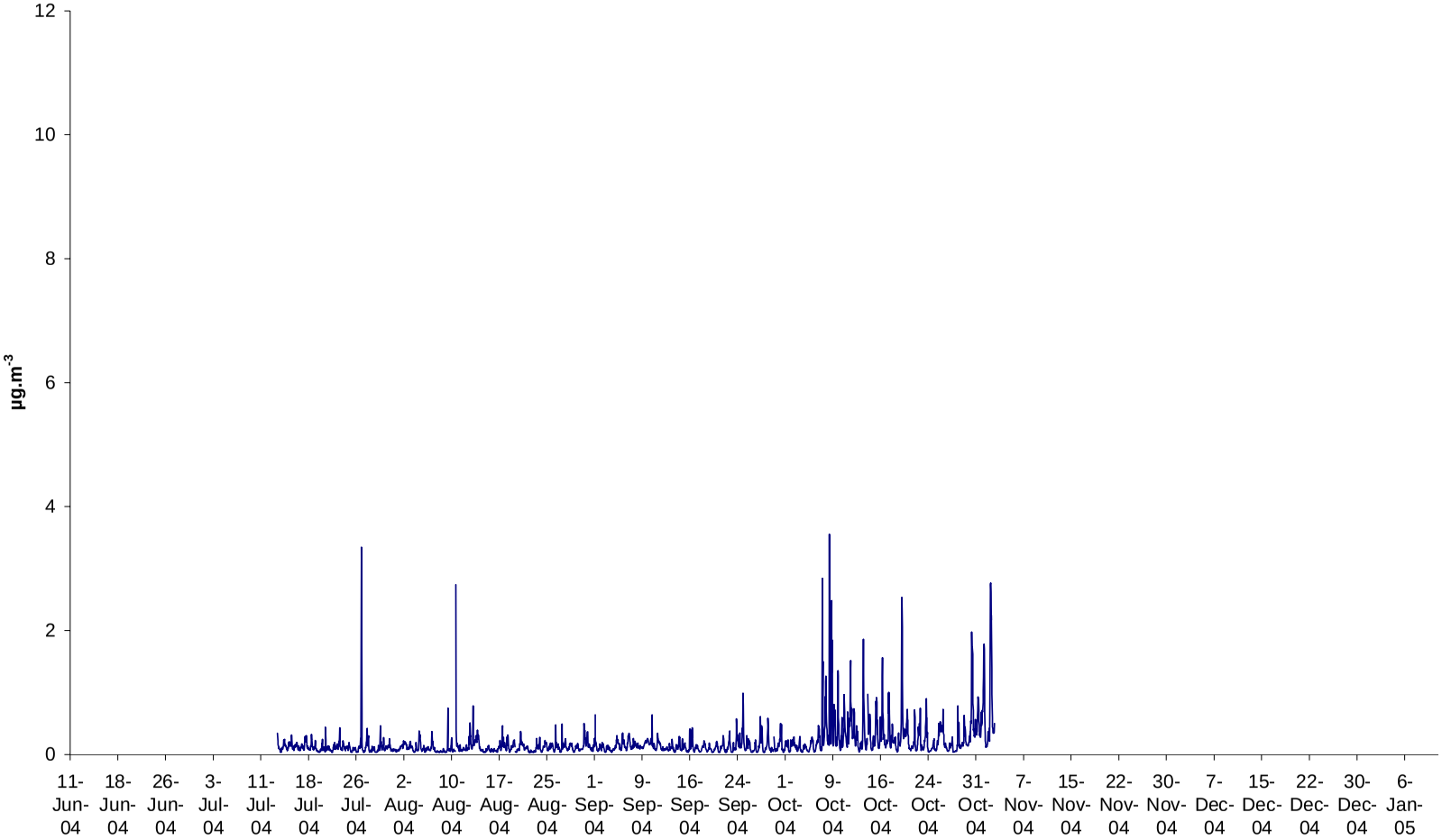
No. of hours	5196	
Missing values	2493	
(including routine maintenance)	4	
No. of measured values	2703	
Percentage covered	52.0	
Maximum hourly value	3.5	$\mu g.m^{-3}$
98 percentile for hourly values	0.9	$\mu g.m^{-3}$
Mean hourly value	0.2	$\mu g.m^{-3}$

Directive Limits (2000/69/EC)

	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 lower assessment threshold was not exceeded during the assessment (Figure 12).

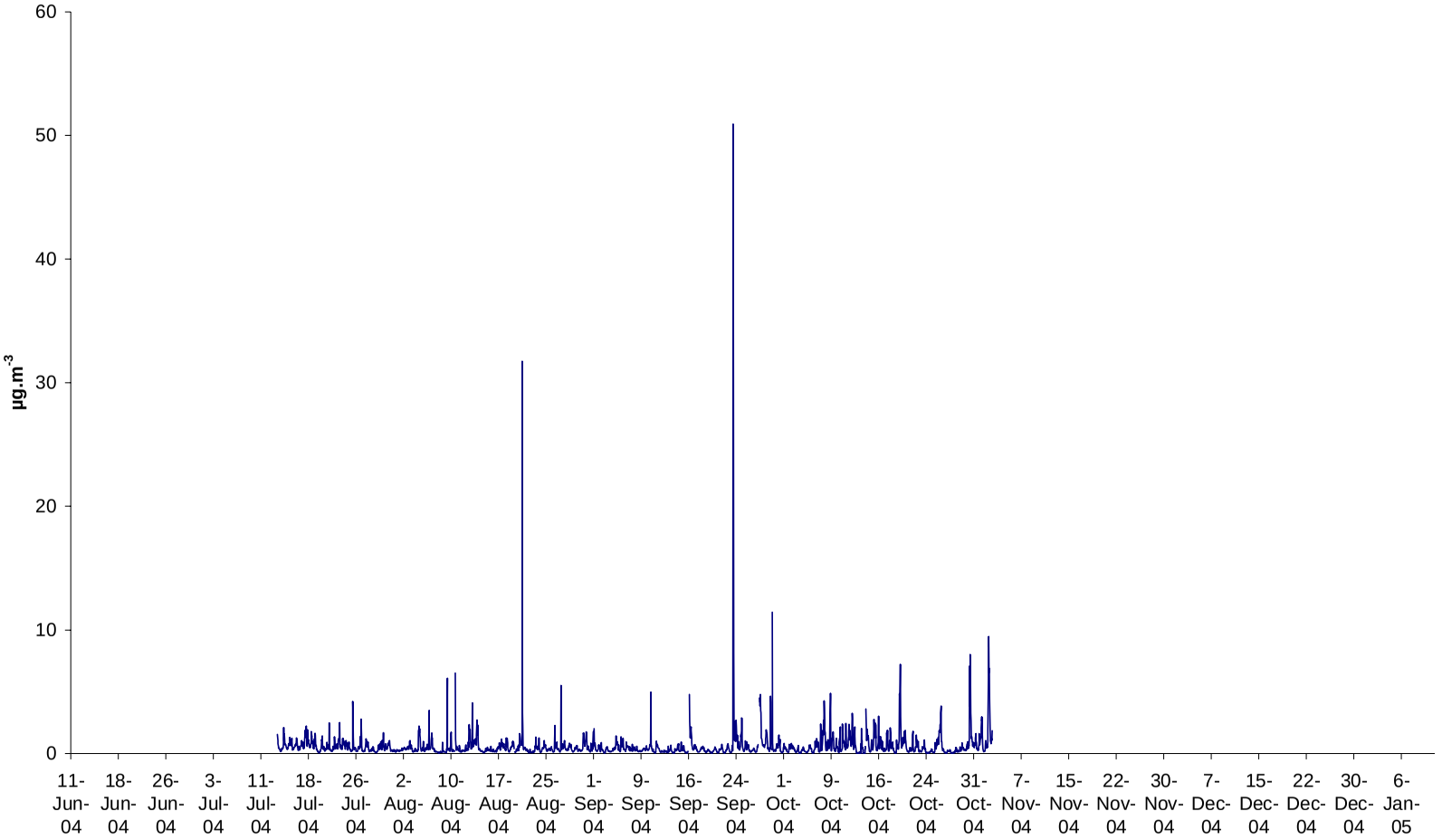
Fig. 12 Benzene Hourly Values
Trailer 1 in Clonmel 10/6/04 - 13/1/05



Toluene

No. of hours	5196	
Missing values	2493	
(including routine maintenance)	4	
No. of measured values	2703	
Percentage covered	52	
Maximum hourly value	50.9	$\mu g.m^{-3}$
98 percentile for hourly values	2.9	$\mu g.m^{-3}$
Mean hourly value	0.6	$\mu g.m^{-3}$

Fig. 13 Toluene Hourly Values
Trailer 1 in Clonmel 10/6/04 - 13/1/05



Lead

No. of days	218	
Missing days	0	
(including routine maintenance)	0	
No. of measured days	218	
Percentage covered	100	
Concentration of Pb	0.01	$\mu g.m^{-3}$

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 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 have subsequently been set out in the fourth daughter directive (2004/107/EC). The fourth daughter directive requires metals to be determined in the PM_{10} fraction.

The method used in this assessment to measure lead and other metals involved pumping air through a filter for several weeks before digesting the filter and analysing the digest for lead and other metals using ICP-MS. This method only provides an indication of metal concentrations in air and is not the proper method as specified in the fourth daughter directive

The results, although indicative, do provide some indication of metal concentrations in air.

During this assessment

The maximum concentration of Cadmium in air was found to be 1.5 $ng.m^{-3}$
The maximum concentration of Nickel in air was found to be 66.9 $ng.m^{-3}$
The levels of arsenic in air were lower than trace levels of arsenic known to exist on the filter papers

Sampling Date	**As**	**Cd**	**Ni**
10/6/04-10/8/04	BDL	BDL	0.3
10/8/04-29/9/04	BDL	0.9 $ng.m^{-3}$	BDL
29/9/04-3/11/04	BDL	1.5 $ng.m^{-3}$	BDL
3/11/04-10/12/04	BDL	BDL	66.9 $ng.m^{-3}$
10/12/04-13/1/05	BDL	BDL	15.2 $ng.m^{-3}$

BDL : Below detection limit