



epa

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Ambient Air Monitoring

In

Drogheda

19th Febuary 2002 – 3rd January 2003

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Summary

An assessment of air quality was carried out in Drogheda, Co. Louth from 19th February 2002 until 3rd January 2003. Concentrations of carbon monoxide, nitrogen dioxide, sulphur dioxide, benzene and lead were below their respective lower assessment thresholds. The limit value for PM₁₀ was not exceeded when the allowed margin of tolerance was taken into account. The limit value does not come into force until 2005. The directive allows the limit value for PM₁₀ to be exceeded by a margin of tolerance which is defined as a percentage of the limit value which reduces at twelve monthly intervals to reach 0% on 1 January 2005.

| | Below Lower Assessment Threshold | Below Upper Assessment Threshold | Above Upper Assessment Threshold | Above Limit |
|------------------------|---|---|---|--------------------|
| PM₁₀ | | | | |
| NO₂ | | | | |
| CO | | | | |
| SO₂ | | | | |
| Benzene | | | | |
| Pb | | | | |

Drogheda 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 PM₁₀ will need to be monitored continuously
- Levels of CO, SO₂, NO₂, 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 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 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 SO₂, 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:

- Dedicated monitoring instruments which continuously measure and record concentrations of the pollutants sulphur dioxide, nitrogen oxides and carbon monoxide.
- Particulate monitor 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

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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 4.7 μ m.

Sulphur Dioxide

Sulphur dioxide was monitored using an Advanced Pollution Instrumentation SO₂ Fluorescent Analyser - Model 100A. This is a continuous analyser which measures the fluorescence of SO₂ molecules after excitation by ultraviolet radiation.

Nitrogen Dioxide and Oxides of Nitrogen

NO_x species were monitored using an Advanced Pollution Instrumentation Chemiluminescent NO/NO₂/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 NO₂ present is then reduced to NO by a molybdenum converter giving a second value for total NO_x concentration. The amount of NO₂ present is found by subtraction.

Particulate Matter

A gravimetric method was used to monitor PM₁₀ 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 10 μ m. The particles were collected on preweighed glassfibre filters (Whatman GF/A, 47mm). The filters were equilibrated at constant temperature and humidity (T = 293 \pm 1 $^{\circ}$ K, R.H. = 50 \pm 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 control the airflow and 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, Northwich, 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, PM₁₀, PM_{2.5} and PM₁.

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 Metrical membrane filter (Gelman, 37mm, 0.8µm) situated in a calming chamber. The filters were changed every 3-4 weeks. They were digested in conc. HNO₃ and analysed for lead and other metals using ICP-MS (Inductively Coupled Plasma-Mass Spectrometry).

All results for CO, SO₂, 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

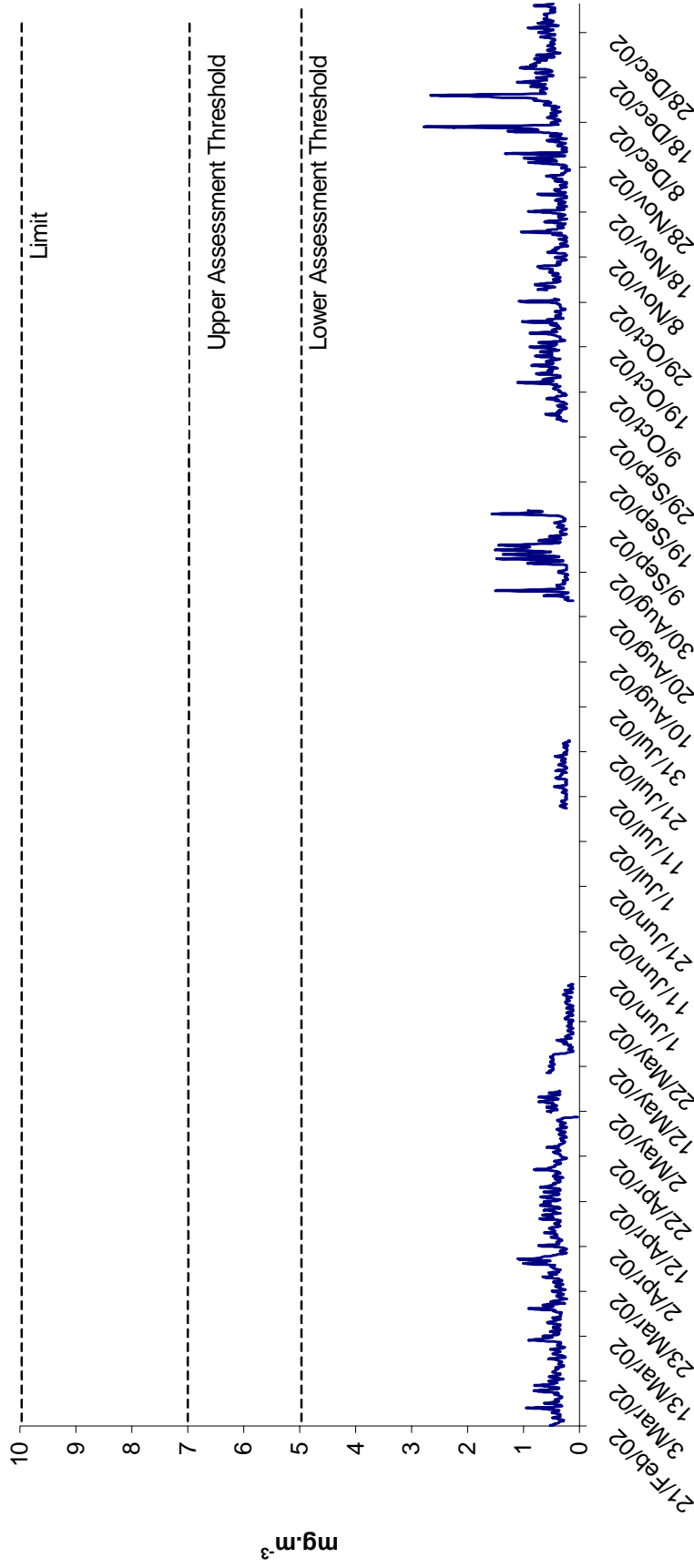
| | |
|---|------------------------|
| No. of hours | 7602 |
| Missing values (including routine maintenance) | 2328 46 |
| No. of measured values | 5274 |
| Percentage covered | 69.7 |
| Maximum hourly value | 5.4 mg.m ⁻³ |
| 98 percentile for hourly values | 1.3 mg.m ⁻³ |
| Mean hourly value | 0.4 mg.m ⁻³ |
| Maximum 8-hour mean | 2.8 mg.m ⁻³ |
| 98 percentile for 8-hour mean | 1.1 mg.m ⁻³ |

Proposed Directive Limits

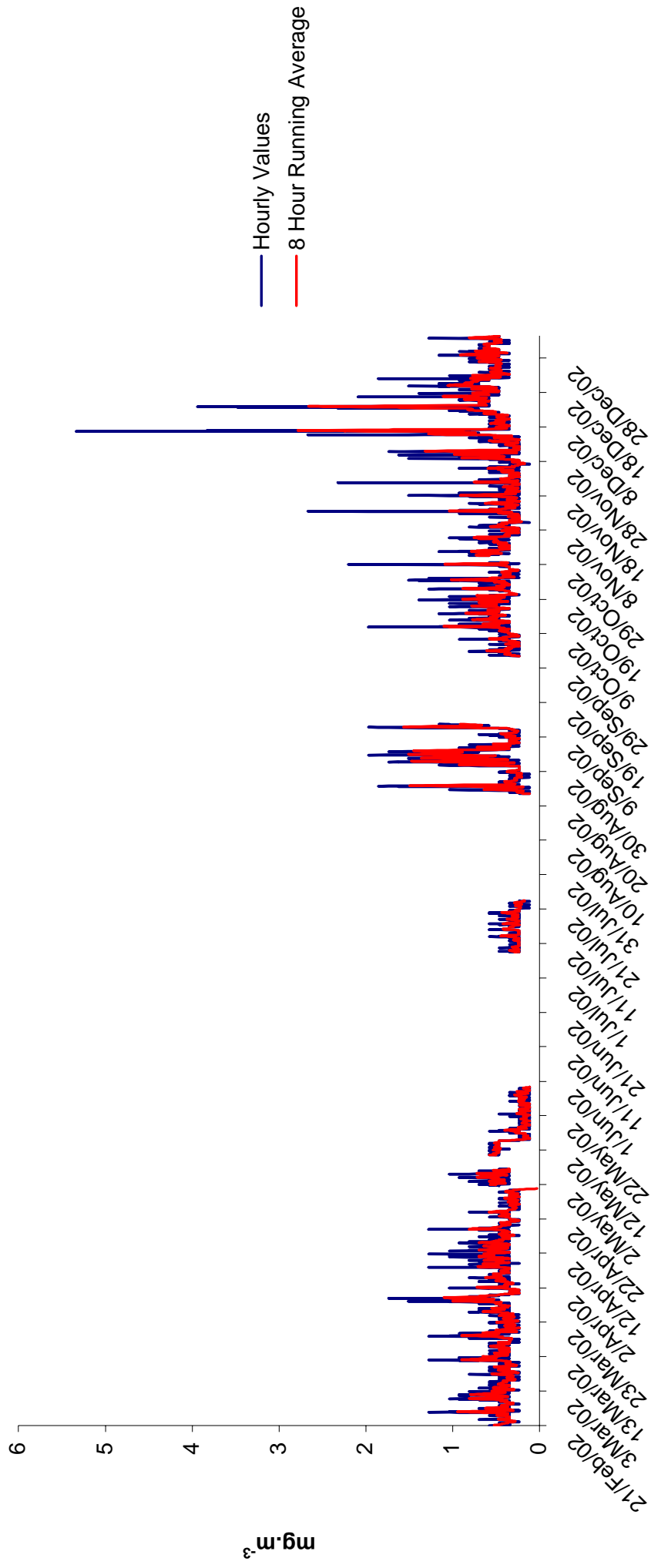
| | Averaging Period | Limit Value | Date by which limit value is to be met |
|--|------------------------|-----------------------|--|
| Limit Value for the protection of human health | 8-hour running average | 10 mg m ⁻³ | 1 January 2005 |
| Upper assessment threshold | 8-hour running average | 7 mg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

The lower assessment threshold was not exceeded during the monitoring period (Figure 2).

Fig. 2 Carbon Monoxide 8-hour Running Average
Trailer 1 in Drogheda 19/2/02 - 3/1/03



**Fig. 3 Carbon Monoxide
Trailer 1 in Drogheda 19/2/02 - 3/1/03**



Sulphur Dioxide

| | |
|---|----------------------------|
| No. of hours | 7602 |
| Missing values (including routine maintenance) | 2727 49 |
| No. of measured values | 4875 |
| Percentage covered | 64.1 |
| Maximum hourly value | 288.3 $\mu\text{g.m}^{-3}$ |
| 98 percentile for hourly values | 58.4 $\mu\text{g.m}^{-3}$ |
| Mean hourly value | 13.8 $\mu\text{g.m}^{-3}$ |
| Maximum 24-hour value | 56.8 $\mu\text{g.m}^{-3}$ |
| 98 percentile for 24-hour values | 33.6 $\mu\text{g.m}^{-3}$ |

Directive Limits (1999/30/EC)

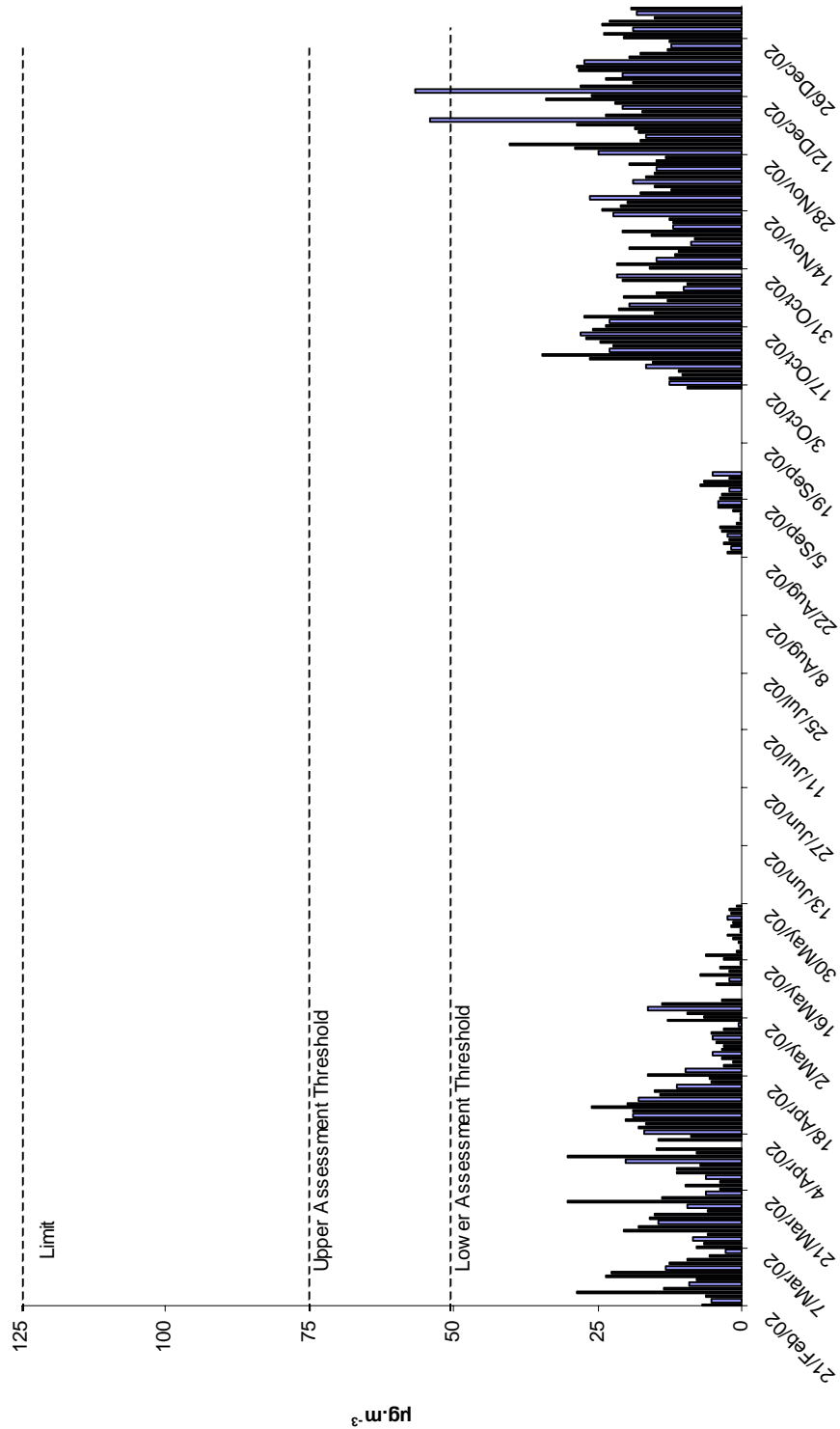
| | Averaging Period | Limit Value | Date by which limit value is to be met |
|---|--|--|--|
| Hourly limit value for the protection of human health | 1 hour | 350 $\mu\text{g m}^{-3}$ not to be exceeded more than 24 times a calendar year | 1 January 2005 |
| Daily limit value for the protection of human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

Directive Limits (1999/30/EC) continued

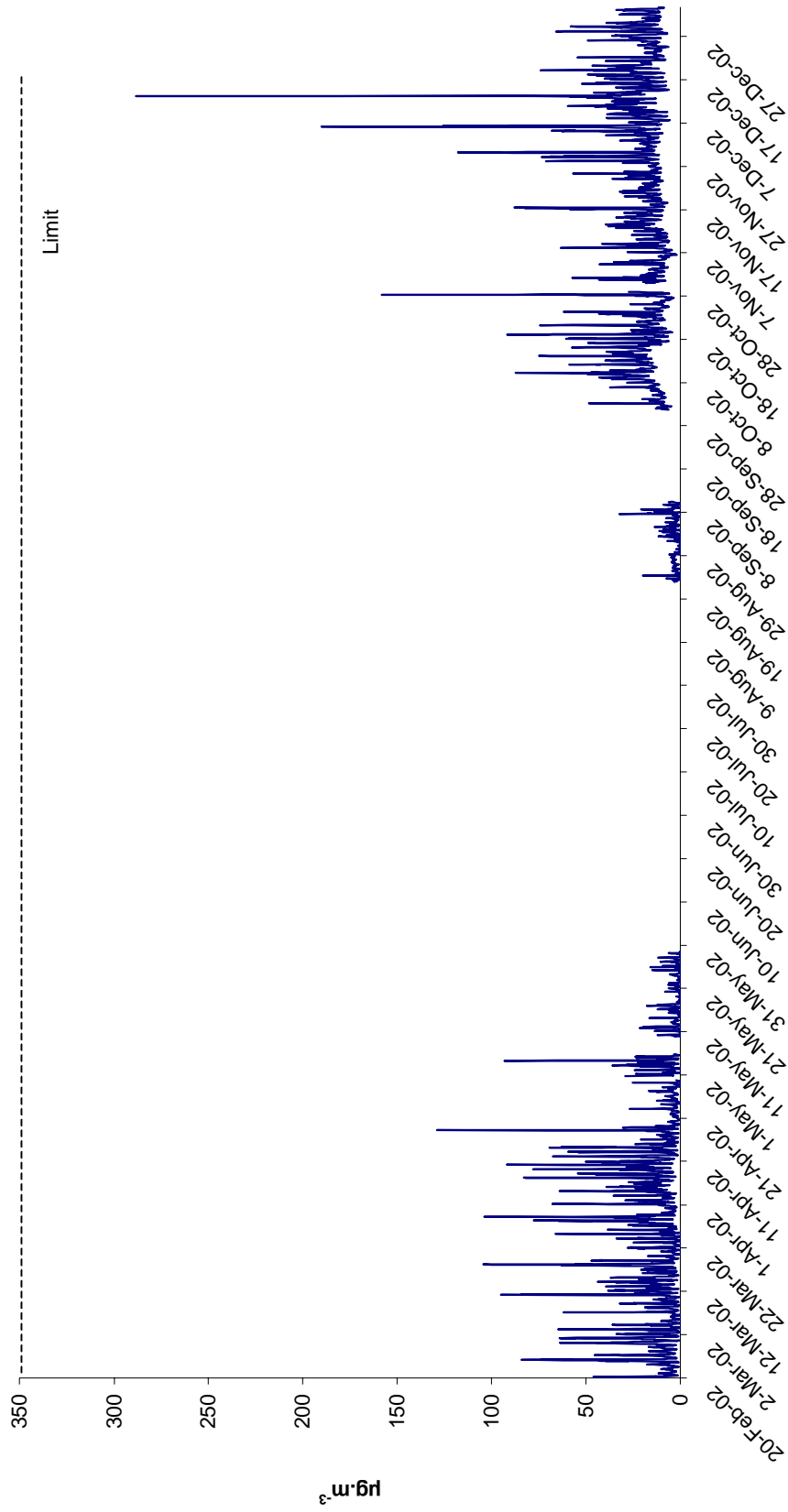
| | Averaging Period | Limit Value | Date by which limit value is to be met |
|---|--|--|--|
| Upper assessment threshold for the protection of human health | 24 hours | 75 $\mu\text{g m}^{-3}$ not to be exceeded more than 3 times a calendar year | |
| Lower assessment threshold for the protection of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

The hourly and daily limit values for the protection of human health were not exceeded during the measurement period. The lower assessment threshold for the protection of human health was exceeded on two occasions during the six month measurement period (Figure 4). A break in operations occurred during the summer months of the assessment when levels of emissions from domestic heating can be expected to be lower than at other times. Consequently, it is assumed that the two exceedences recorded during the winter months are unlikely to have been repeated during the summer months. The directive stipulates that the assessment thresholds should not be exceeded more than three times in a calendar year. The mean hourly value of 13.8 $\mu\text{g.m}^{-3}$ exceeds the upper assessment threshold for the protection of vegetation. However, this threshold may not be relevant to monitoring in an urban area.

Fig. 4 Sulphur Dioxide 24 Hour Averages
Trailer 1 in Drogheda 19/2/02 - 3/1/03



**Fig. 5 Sulphur Dioxide Hourly Averages
Trailer 1 in Drogheda 19/2/02-3/1/03**



Nitrogen Dioxide and Oxides of Nitrogen

| | |
|--|---|
| No. of hours | 7602 |
| Missing values (including routine maintenance) | 3170 53 |
| No. of measured values | 4432 |
| Percentage covered | 71.5 |
| Maximum hourly value (NO ₂) | 123.4 µg.m ⁻³ |
| 98 percentile for hourly values (NO ₂) | 64.2 µg.m ⁻³ |
| Mean hourly value (NO ₂) | 22.7 µg.m ⁻³ |
| Mean hourly value (NO _x) | 37.1 µg.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 µg 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 µg m ⁻³ NO ₂ | 1 January 2010 |
| Annual limit value for the protection of vegetation | Calendar year | 30 µg m ⁻³ NO _x | 19 July 2001 |
| Alert threshold | | 400 µg 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 $\mu\text{g m}^{-3}$ 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 $\mu\text{g m}^{-3}$ NO ₂ | |
| Lower assessment threshold for the protection of human health | 1 hour | 100 $\mu\text{g m}^{-3}$ 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 $\mu\text{g m}^{-3}$ NO ₂ | |
| Upper assessment threshold for the protection of vegetation | Calendar year | 24 $\mu\text{g m}^{-3}$ NO _x | |
| Lower assessment threshold for the protection of vegetation | Calendar year | 19.5 $\mu\text{g m}^{-3}$ NO _x | |

The hourly limit value for the protection of human health was not exceeded during the measurement period (Figure 6). The hourly lower assessment threshold was exceeded on four occasions during the six months of the assessment for which monitoring data is

available. The directive stipulates that the lower assessment threshold is deemed to be exceeded if there are more than 18 exceedences in a calendar year. Thus, there would have had to be over nine exceedences in the six month period to exceed the lower assessment threshold. The average NO₂ (22.7 µg.m⁻³) value for the period of the assessment did not exceed the lower assessment threshold based on an averaging period of a calendar year (26 µg.m⁻³).

NO, NO₂ 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 NO₂) is used. No formula is specified for NO_x, the directive requires it to be expressed as NO₂ (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 during the measurement period (37.0 µg.m⁻³) exceeds the annual limit value for the protection of vegetation.

**Fig. 6 NO₂ Hourly Values
Trailer 1 in Drogheda 19/2/02-3/1/03**

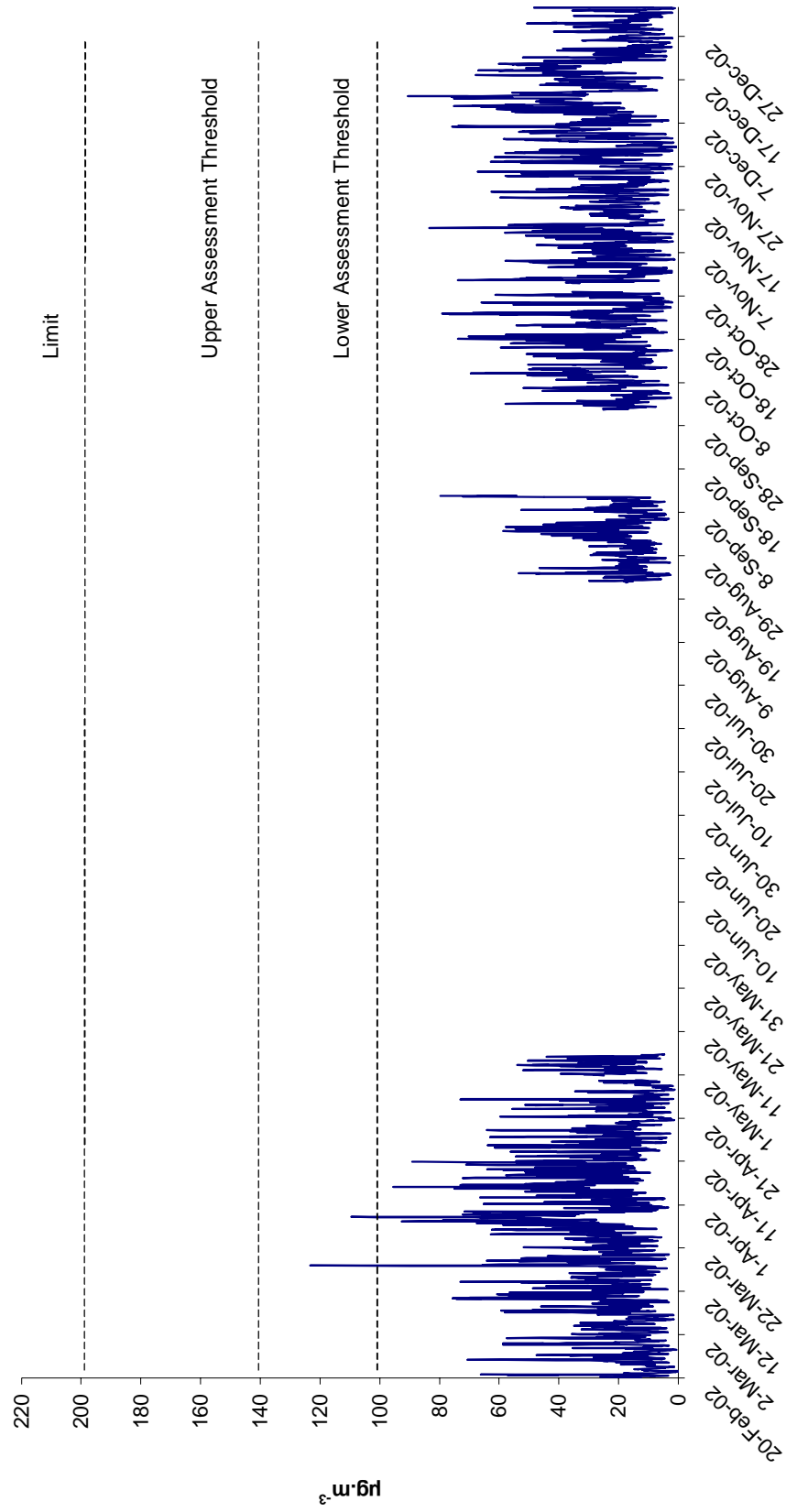
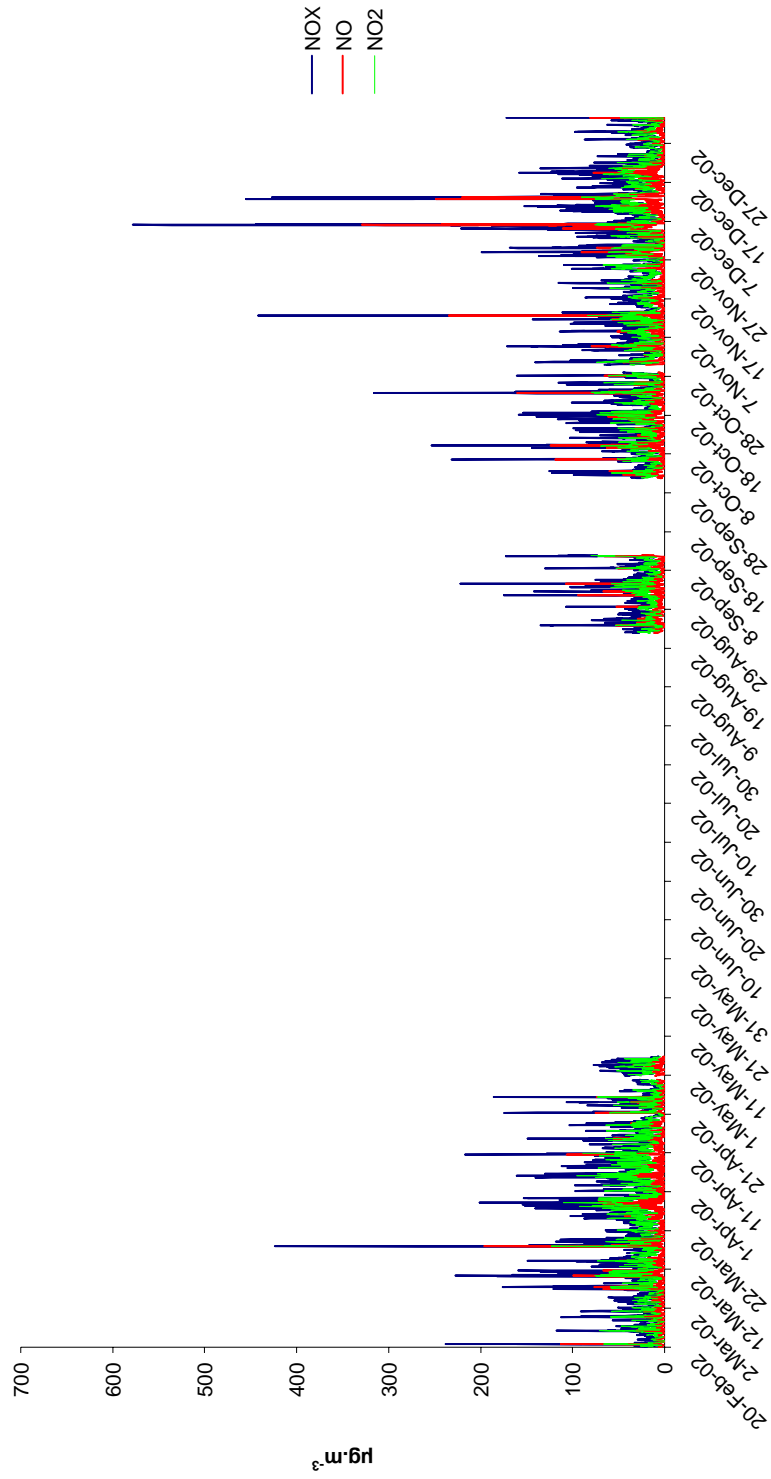


Fig. 7 NO_x Hourly Values
Trailer 1 in Drogheda 19/2/02-3/1/03



Particulate Matter

PM₁₀ : gravimetric method

| | |
|---|---------------------------------------|
| No. of days | 317 |
| Missing values (including routine maintenance) | 217 |
| No. of measured values | 100 |
| Percentage covered | 31.5 |
| Maximum daily value | 112.6 $\mu\text{g}\cdot\text{m}^{-3}$ |
| 98 percentile for daily values | 65.0 $\mu\text{g}\cdot\text{m}^{-3}$ |
| Mean daily value | 32.4 $\mu\text{g}\cdot\text{m}^{-3}$ |

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 $\mu\text{g m}^{-3}$ 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 $\mu\text{g m}^{-3}$ PM ₁₀ | 1 January 2005 |
| Upper assessment threshold for the protection of human health | 24 hour | 30 $\mu\text{g m}^{-3}$ PM ₁₀ not to be exceeded more than 7 times a calendar year | <i>based on the indicative limit values for 1 January 2010</i> |
| Upper assessment threshold for the protection of human health | Calendar year | 14 $\mu\text{g m}^{-3}$ PM ₁₀ | <i>based on the indicative limit values for 1 January 2010</i> |

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 $\mu\text{g m}^{-3}$ PM ₁₀ not to be exceeded more than 7 times a calendar year | <i>based on the indicative limit values for 1 January 2010</i> |
| Lower assessment threshold for the protection of human health | Calendar year | 10 $\mu\text{g m}^{-3}$ PM ₁₀ | <i>based on the indicative limit values for 1 January 2010</i> |

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 $\mu\text{g m}^{-3}$ 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 $\mu\text{g m}^{-3}$ PM ₁₀ | 1 January 2010 |

There were 11 exceedences of the 24 hour limit value for the protection of human health during the 100 days of the assessment period for which results are available (Figure 8). The directive stipulates that the limit value must not be exceeded more than 7 times in a calendar year. Thus, the limit (50 $\mu\text{g.m}^{-3}$) would have been exceeded if these results are extrapolated for the entire year. However, the limit value plus margin of tolerance (65 $\mu\text{g.m}^{-3}$) would not have been exceeded. During the assessment period, the upper assessment threshold was exceeded on 51 days (51% of measured values)

while the lower assessment threshold was exceeded on 82 days (82% of measured values). Both assessment thresholds were exceeded as the directive stipulates that each assessment threshold must not be exceeded more than 7 times in a calendar year. The mean of the daily values during the measurement period ($32.4 \mu\text{g}\cdot\text{m}^{-3}$) exceeds the upper assessment threshold based on an averaging period of one 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), PM₁₀ and PM₁. All measurements were hourly values.

The concentration of PM₁₀ measured by the OSIRIS and that measured using the gravimetric method were compared to give a daily correction factor. The correction factor was used to estimate the concentration of PM_{2.5} using the formula:

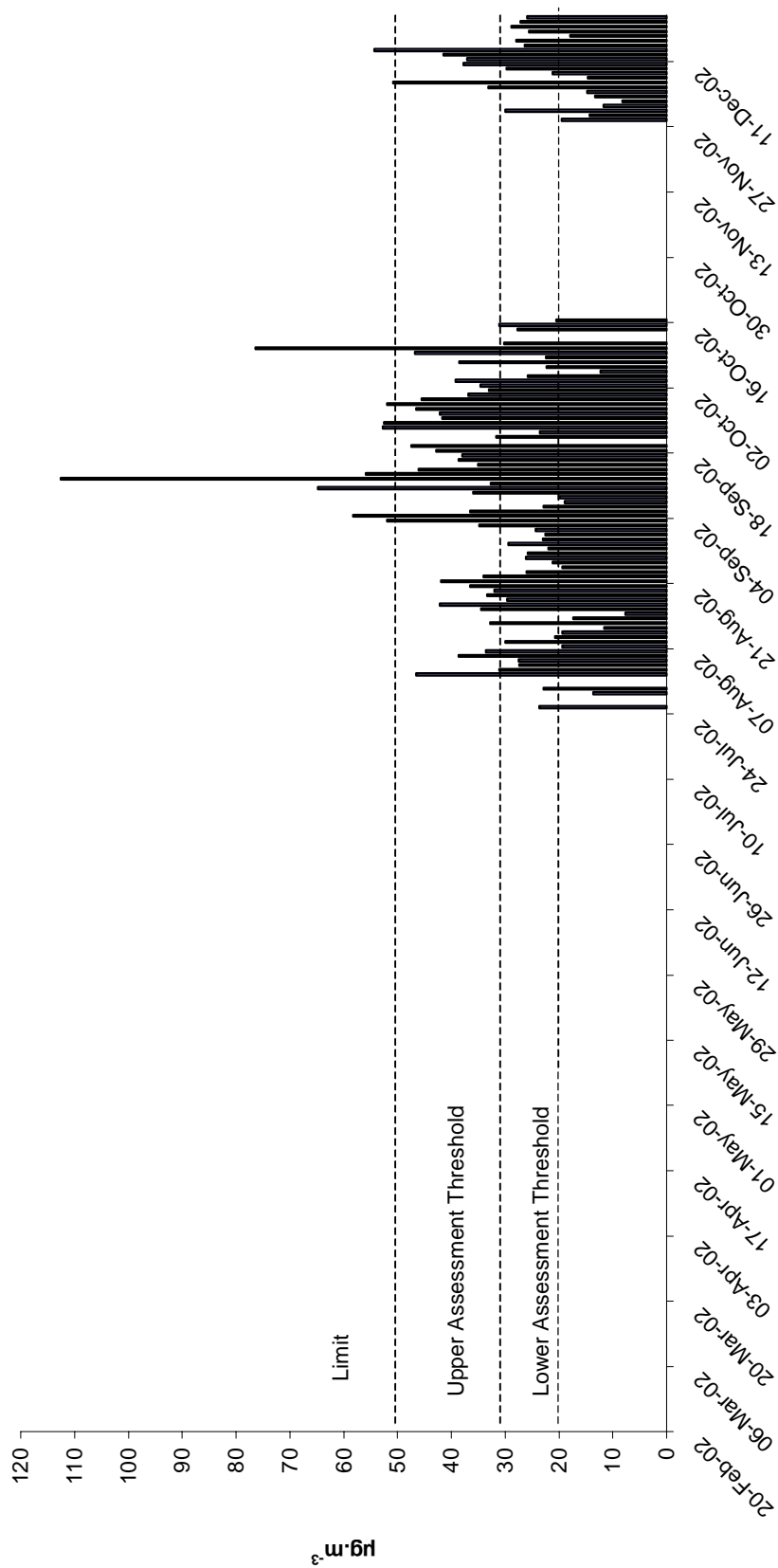
$$\begin{array}{l} \text{24-hour average} \\ \text{concentration} \\ \text{of PM}_{2.5} \end{array} = \begin{array}{l} \text{OSIRIS 24-hour} \\ \text{average concentration} \\ \text{of PM}_{2.5} \end{array} \times \frac{\text{gravimetric 24-hour average PM}_{10}}{\text{OSIRIS 24-hour average PM}_{10}}$$

Results:

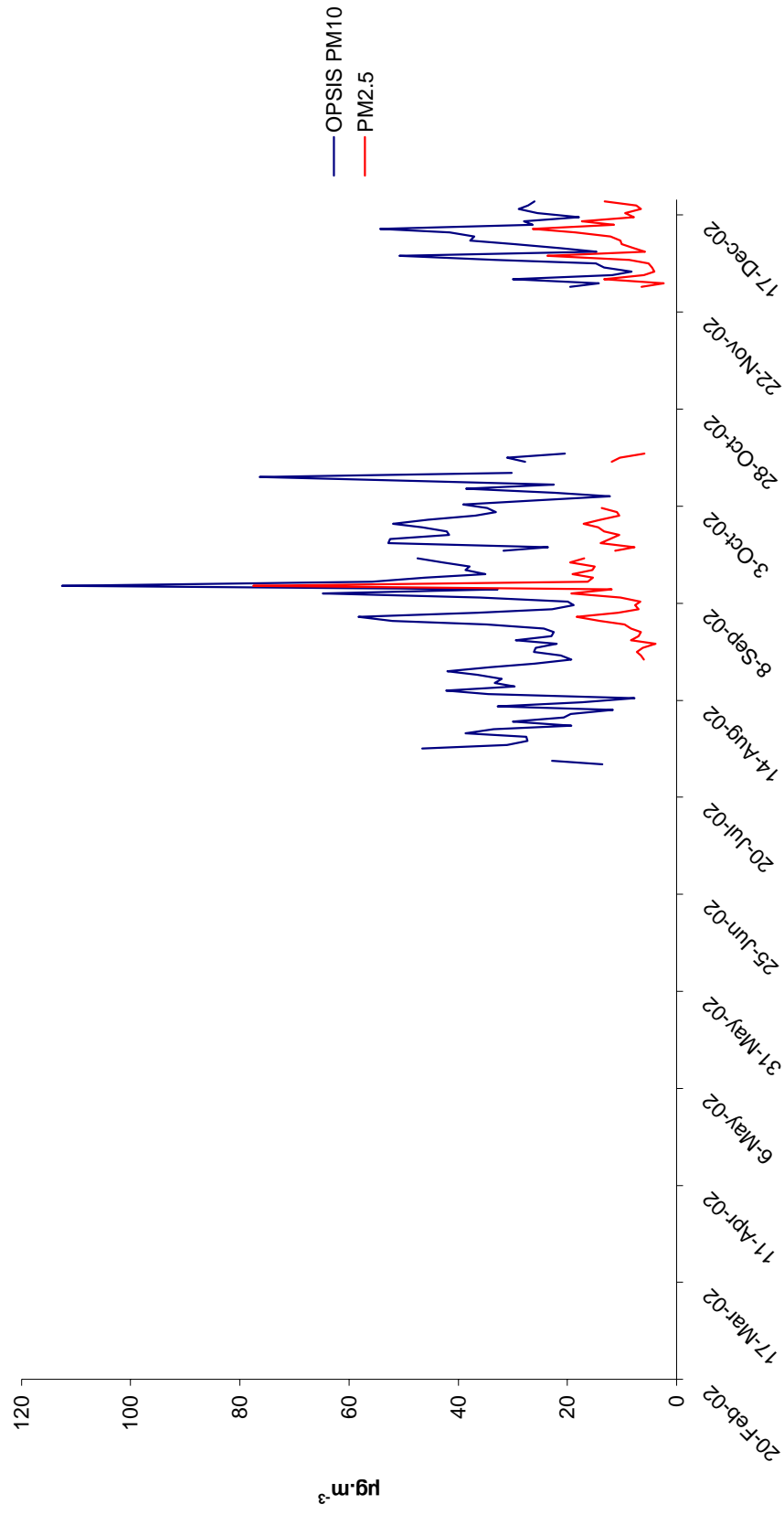
| | |
|---|---------------------------|
| No. of days | 317 |
| Missing values (including routine maintenance) | 252 |
| No. of measured values* | 65 |
| Percentage covered | 20.5 |
| Maximum daily value | 77.5 $\mu\text{g.m}^{-3}$ |
| 98 percentile for daily values | 25.6 $\mu\text{g.m}^{-3}$ |
| Mean daily value | 12.1 $\mu\text{g.m}^{-3}$ |
| Median daily value | 10.5 $\mu\text{g.m}^{-3}$ |

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

**Fig. 8 PM₁₀ Daily Values
Trailer 1 in Drogheda 19/2/02-3/1/03**



**Fig. 9 PM₁₀ and PM_{2.5} Daily Values
Trailer 1 in Drogheda 19/2/02-3/1/03**



Benzene

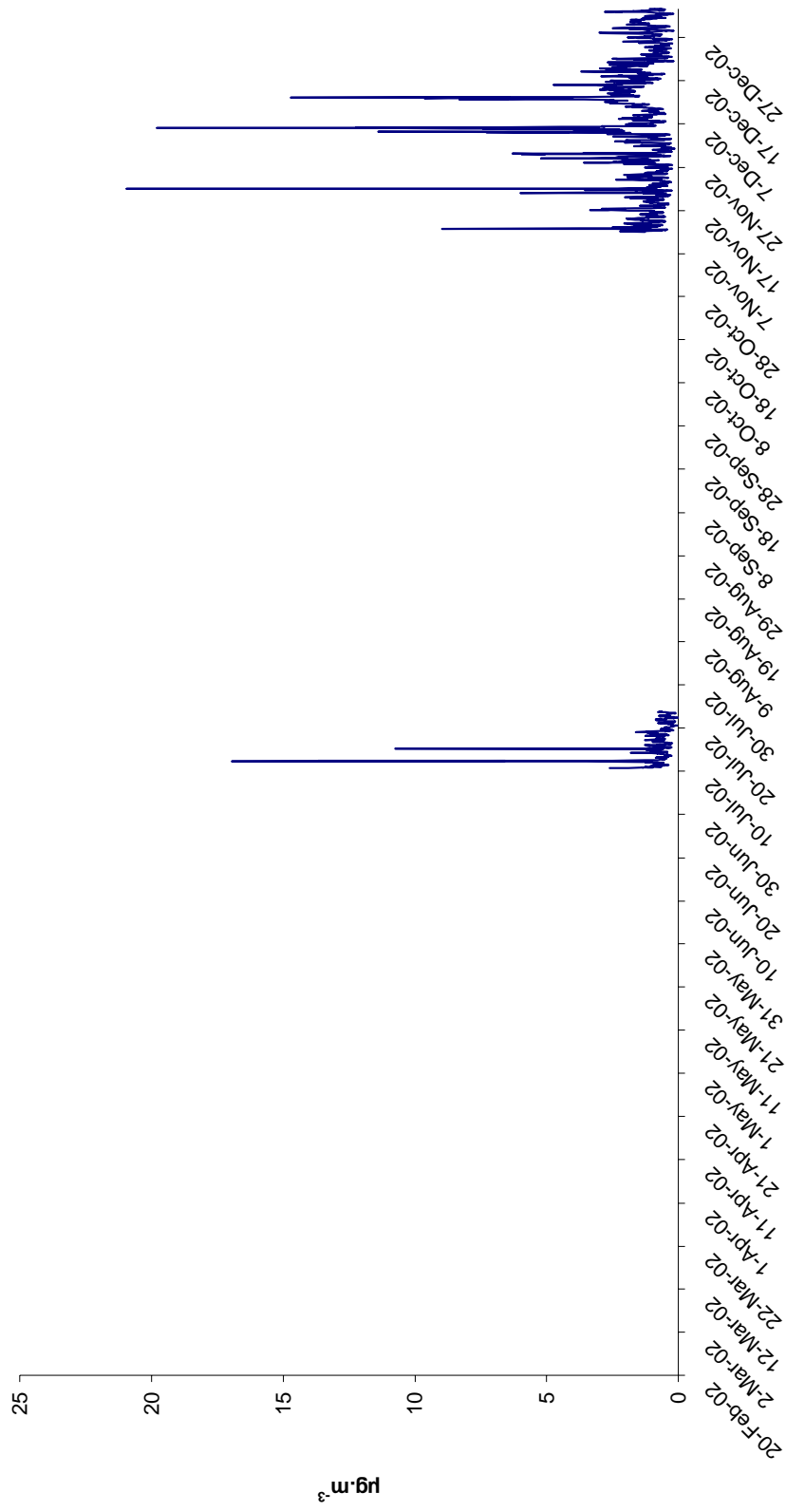
| | |
|---|--------------------------------------|
| No. of hours | 7602 |
| Missing values (including routine maintenance) | 6046 |
| No. of measured values | 1556 |
| Percentage covered | 20.5 |
| Maximum hourly value | 20.9 $\mu\text{g}\cdot\text{m}^{-3}$ |
| 98 percentile for hourly values | 6.0 $\mu\text{g}\cdot\text{m}^{-3}$ |
| Mean hourly value | 1.3 $\mu\text{g}\cdot\text{m}^{-3}$ |

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 $\mu\text{g m}^{-3}$ | 1 January 2010 |
| Upper assessment threshold for the protection of human health | Calendar year | 3.5 $\mu\text{g m}^{-3}$ | |
| Lower assessment threshold for the protection of human health | Calendar year | 2 $\mu\text{g m}^{-3}$ | |

The mean hourly value for the measurement period is below the lower assessment threshold for the protection of human health (Figure 10).

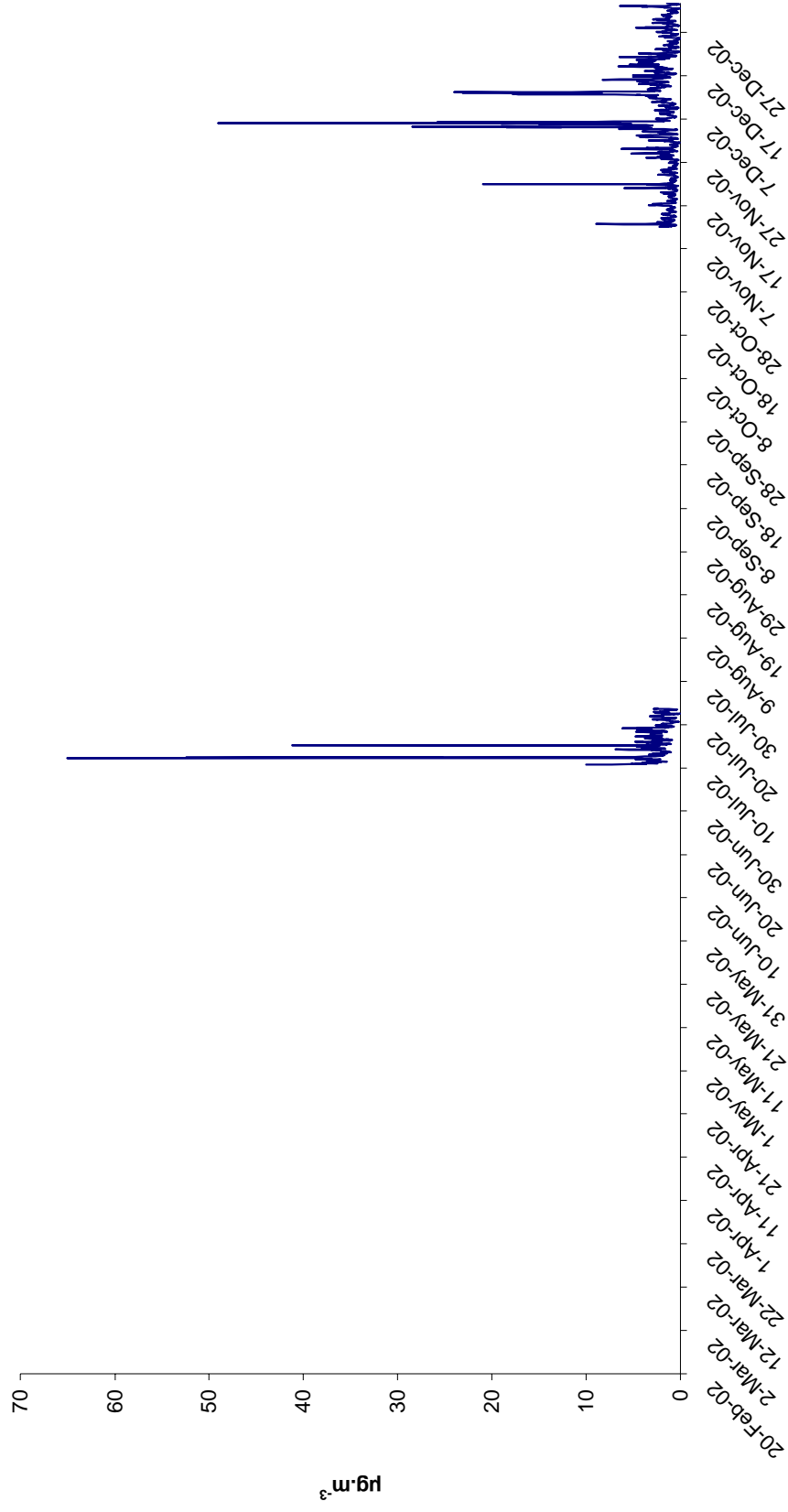
**Fig. 10 Benzene Hourly Values
Trailer 1 in Drogheda 19/2/02-3/1/03**



Toluene

| | |
|---|--------------------------------------|
| No. of hours | 7602 |
| Missing values (including routine maintenance) | 6046 |
| No. of measured values | 1556 |
| Percentage covered | 20.5 |
| Maximum hourly value | 65.0 $\mu\text{g}\cdot\text{m}^{-3}$ |
| 98 percentile for hourly values | 13.3 $\mu\text{g}\cdot\text{m}^{-3}$ |
| Mean hourly value | 2.3 $\mu\text{g}\cdot\text{m}^{-3}$ |

**Fig. 11 Toluene Hourly Values
Trailer 1 in Drogheda 19/2/02-3/1/03**



Lead

| | |
|---|--------------------------------------|
| No. of days | 318 |
| Missing days (including routine maintenance) | |
| No. of measured days | 318 |
| Percentage covered | 100 |
| Concentration of Pb | 0.02 $\mu\text{g}\cdot\text{m}^{-3}$ |

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 $\mu\text{g m}^{-3}$ | 1 January 2005 |
| Upper assessment threshold | Calendar year | 0.35 $\mu\text{g m}^{-3}$ | |
| Lower assessment threshold | Calendar year | 0.25 $\mu\text{g m}^{-3}$ | |

The concentration of lead during the measurement period was 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 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 2.7 ng.m^{-3}

The maximum concentration of nickel in air was found to be 5 ng.m^{-3}

The levels of arsenic in air were lower than trace levels of arsenic known to exist on the filters

