



Ambient Air Monitoring

at

Trinity College, Dublin

16 July 1999 - 15 December 1999

and

6 April 2000 – 13 July 2000

Contents

Introduction	3
Time Period	4
Location	4
Monitoring Methods	5
<i>Results</i>	
Carbon Monoxide	7
Sulphur Dioxide	10
Nitrogen Dioxide and Oxides of Nitrogen	14
Particulate Matter	19
Benzene	24
Lead	26
Cadmium	27
Arsenic	27
Nickel	28
Mercury	28

List of Figures

Fig. 1	Map of Site Location	4
Fig. 2	Carbon Monoxide 8-hour Running Averages	8
Fig. 3	Carbon Monoxide Hourly Averages and 8-hour Running Averages	9
Fig. 4	Sulphur Dioxide 24-hour Averages	12
Fig. 5	Sulphur Dioxide Hourly Averages	13
Fig. 6	Nitrogen Dioxide Hourly Averages	17
Fig. 7	Oxides of Nitrogen Hourly Averages	18
Fig. 8	PM ₁₀ Daily Values	22
Fig. 9	PM ₁₀ and PM _{2.5} Daily Values	23
Fig.10	Benzene Hourly Averages	25

Introduction

Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management states in Article 5 that

“ Member States which do not have representative measurements of the levels of pollutants for all zones and agglomerations shall undertake series of representative measurements, surveys or assessments in order to have the data available in time for implementation of the legislation referred to in Article 4.”

In accordance with this the E.P.A. monitored a range of pollutants over an eight month discontinuous period in Dublin city centre using a mobile laboratory. This contained the following instruments:

- Monitoring instruments for the continuous recording of the levels of the gases sulphur dioxide, nitrogen oxides and carbon monoxide.
- Instrument for the continuous recording of the levels of particulate matter.
- Gas chromatograph for on site measurement 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 and laboratory determination of the weight).
- Sampler for lead and other metals in air (collection on filter for determination in the laboratory).
- Recorder for temperature, relative humidity, wind speed and direction.

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

For further information please contact Barbara O’Leary, John Finnan or Ciaran O’Donnell.

Time Period

One mobile laboratory (Trailer1) was in place from 16 July 1999 to 15 December 1999. A different mobile laboratory (Trailer3) was in place from 6 April 2000 to 13 July 2000.

Location

The mobile laboratory was situated in the corner of a city-centre car park belonging to Trinity College Dublin (Fig.1). The site is at the junction of Pearse Street and Westland Row and the sample inlets were approximately 20 metres from the centre of a busy traffic junction and 10 metres from kerbside. Southwest of the site are the grounds of Trinity College with an area of approximately 2000m². The site is surrounded in all other directions by commercial districts with a high traffic volume. Approximately 40 metres from the sample inlets was an overhead railway line on which electric and diesel trains run. Pearse railway station is 50 metres from the site.

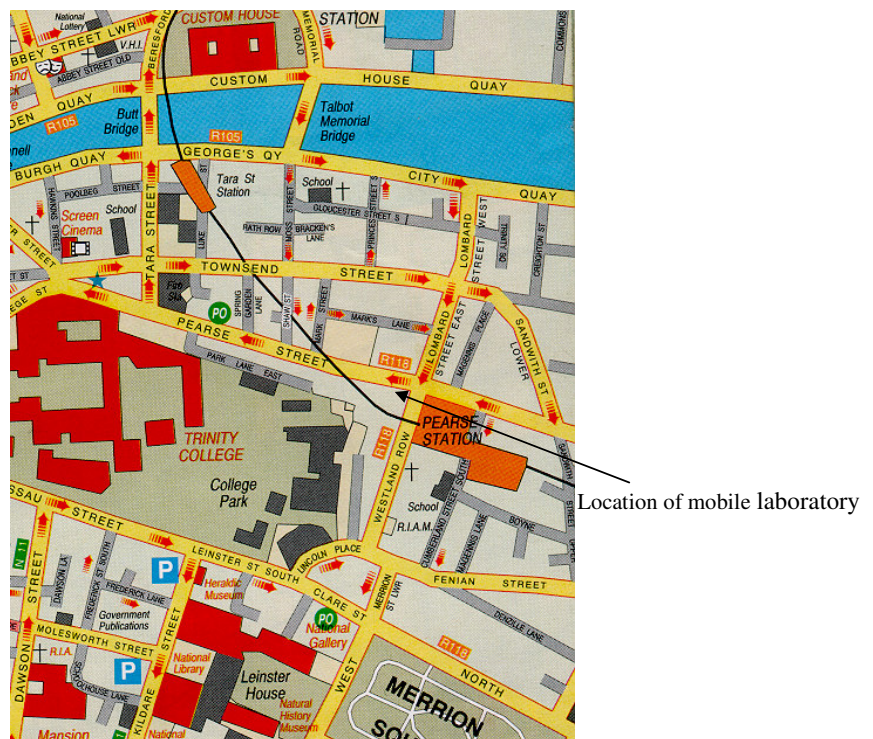


Fig. 1 Map of site location

Monitoring Methods

Carbon Monoxide

Carbon monoxide was monitored using a Gas Filter Correlation CO Analyser (Advanced Pollution Instrumentation, Model 300). This is a continuous analyser based on the absorption of infrared radiation by CO molecules at wavelengths near 4.7 μ m.

Sulphur Dioxide

Sulphur dioxide was monitored using a SO₂ Fluorescent Analyser (Advanced Pollution Instrumentation, Model 100A). This is a continuous analyser which measures the fluorescence of SO₂ due to absorption of ultraviolet radiation.

Nitrogen Dioxide and Oxides of Nitrogen

NO_x species were monitored using a Chemiluminescent NO/NO₂/NO_x Analyser (Advanced Pollution Instrumentation, Model 200A). This is a continuous analyser which utilises the chemiluminescent reaction of nitric oxide in the sample with ozone to measure the NO concentration. Any NO₂ present is then reduced to NO by a molybdenum converter giving a second value for the total NO_x concentration. The amount of NO₂ present is found by subtraction.

Particulate Matter

A gravimetric method was used to monitor the PM₁₀ fraction (as defined in the European Standard prEN 12341, July 1998) The air was sampled by an Ambient Dust Automatic Monitor (OP SIS, Model SM200) which changed the filters daily at midnight. 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 $^{\circ}$ C, R.H. = 50 \pm 3%) in a WTB Binder APT.Line KBF115 Climatic Chamber for at least 48 hours prior to weighing.

Particulate matter was also measured using an OSIRIS Environmental Dust Monitor (Turnkey Instruments). 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 (Syntech Spectras, BTX Analyser GC855) This GC samples automatically every 15 minutes and is equipped with a photoionisation detector.

Lead and other metals

Ambient air was pumped through a Metricel membrane filter (Gelman, 37mm, 0.8 μ m) situated in a calming chamber. The pump rate was $\sim 2.2 \text{ l min}^{-1}$. 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.

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 limit values in Council Directive 1999/30/EC.

Where applicable, the units given are standardised at a temperature of 293K and a pressure of 101.3 kPa.

Results

Carbon Monoxide

No. of hours	6021
Missing values (including routine maintenance)	1229 (9)
No. of measured values	4792
Percentage covered	80%
Maximum hourly value	5.8 mg m ⁻³
98 percentile for hourly values	2.6 mg m ⁻³
Mean hourly value	0.8 mg m ⁻³
Maximum 8-hour mean	3.7 mg m ⁻³
98 percentile for 8-hour mean	2.2 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 limit value was not breached at any time.

All the data is below the lower assessment threshold.

Sulphur Dioxide

No. of hours	6021
Missing values (including routine maintenance)	176 (11)
No. of measured values	5845
Percentage covered	97%
Maximum hourly value	149.6 $\mu\text{g m}^{-3}$
98 percentile for hourly values	33.3 $\mu\text{g m}^{-3}$
Mean hourly value	8.5 $\mu\text{g m}^{-3}$
Maximum 24-hour value	40.3 $\mu\text{g m}^{-3}$
98 percentile for 24-hour values	23.5 $\mu\text{g m}^{-3}$

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 $\mu\text{g m}^{-3}$	

None of the limit values were breached at any time.

All the data is below the lower assessment threshold for the protection of human health.

The observed mean is 8.5 $\mu\text{g m}^{-3}$ which is above the lower assessment threshold value of 8 $\mu\text{g m}^{-3}$ for the protection of ecosystems. However, this limit refers to the mean for the calendar year plus winter; the measured mean is for an eight month period in an urban area and therefore may not be relevant to the limits in the directive for ecosystem protection.

Nitrogen Dioxide and Oxides of Nitrogen

No. of hours	6021
Missing values (including routine maintenance)	230 (31)
No. of measured values	5791
Percentage covered	96%
Maximum hourly value (NO ₂)	310.2 µg m ⁻³ NO ₂
98 percentile for hourly values (NO ₂)	122.7 µg m ⁻³ NO ₂
Mean hourly value (NO ₂)	52.0 µg m ⁻³ NO ₂
Mean hourly value (NO _x)	122.6 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	

All the data is above the upper assessment thresholds.

The hourly NO₂ limit value for the protection of human health (200 µg m⁻³ NO₂; 18 breaches permitted) was breached 9 times during the 8 month monitoring period. All the breaches occurred during one pollution episode on the 28-29 July 1999.

There are 70 hourly NO₂ values above the upper assessment threshold for the protection of human health (140 µg m⁻³ NO₂; 18 breaches permitted). 93% of these occurred during the period 26 - 31 July 1999.

There are 228 hourly NO₂ values above the lower assessment threshold for the protection of human health (100 µg m⁻³ NO₂; 18 breaches permitted).

The mean NO₂ value of 52.0 µg m⁻³ NO₂ is above the annual limit value for the protection of human health (40 µg m⁻³ NO₂). It is within the margin of tolerance permitted by the directive until 1 January 2005 when the limit + margin of tolerance will be 50 µg m⁻³ NO₂.

The mean NO_x value of 122.6 µg m⁻³ NO₂ is well above the annual limit value for the protection of vegetation (30 µg m⁻³ NO₂) however the monitoring site was in an urban area and may therefore not be relevant to the limits in the directive for the protection of vegetation.

NO_x and NO₂ levels are usually highest in the winter months of November, December and January and lowest in the summer. The monitoring period covered summer and winter and therefore the mean values for NO_x and NO₂ measured in this study should be representative of the annual mean.

An isolated episode of high NO_x and NO₂ levels occurred during a six day period, 26-31 July 1999. The weather during this period was unusually hot and sunny. If the data from July 1999 were omitted, the results would be:

Maximum hourly value (NO ₂)	149.8	µg m ⁻³ NO ₂
98 percentile for hourly values (NO ₂)	110.0	µg m ⁻³ NO ₂
Mean hourly value (NO ₂)	50.7	µg m ⁻³ NO ₂
No. of hourly averages > 200 µg m ⁻³	0	
No. of hourly averages > 140 µg m ⁻³	5	
No. of hourly averages > 100 µg m ⁻³	228	
Mean hourly value (NO _x)	117.4	µg m ⁻³ NO ₂

Particulate Matter

PM₁₀ : gravimetric method

No. of days	250
Missing values (including routine maintenance)	63 (0)
No. of measured values	187
Percentage covered	75%
Maximum daily value	67.6 $\mu\text{g m}^{-3}$
98 percentile for daily values	60.3 $\mu\text{g m}^{-3}$
Mean daily value	29.7 $\mu\text{g m}^{-3}$

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 $\mu\text{g m}^{-3}$ 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	
Upper assessment threshold for the protection of human health	Calendar year	14 $\mu\text{g m}^{-3}$ PM ₁₀	

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	
Lower assessment threshold for the protection of human health	Calendar year	10 $\mu\text{g m}^{-3}$ PM ₁₀	

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

All the data is above the upper assessment thresholds.

The 24-hour limit value for the protection of human health (50 $\mu\text{g m}^{-3}$ PM₁₀; 35 breaches permitted) was breached 12 times during the 8 month monitoring period.

There are 81 PM₁₀ values above the upper assessment threshold for the protection of human health (30 $\mu\text{g m}^{-3}$ PM₁₀; 7 breaches permitted).

There are 142 PM₁₀ values above the lower assessment threshold for the protection of human health (20 µg m⁻³ PM₁₀; 7 breaches permitted).

The mean PM₁₀ value of 29.7 µg m⁻³ is below the Stage I annual limit value for the protection of human health (40 µg m⁻³ PM₁₀) but above the Stage II limit (20 µg m⁻³ PM₁₀).

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.”

In the mobile laboratory, concentration of PM_{2.5} was measured with an OSIRIS Environmental Dust Monitor. 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	203
Missing values (including routine maintenance)	84 (0)
No. of measured values*	119
Percentage covered	59%
Maximum daily value	27.0 µg m ⁻³
98 percentile for daily values	23.2 µg m ⁻³
Mean daily value	8.1 µg m ⁻³
Median daily value	6.9 µg m ⁻³

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

Benzene

No. of hours	6021
Missing values (including routine maintenance)	810 (53)
No. of measured values	5211
Percentage covered	87%
Maximum hourly value	20.7 $\mu\text{g m}^{-3}$
98 percentile for hourly values	6.3 $\mu\text{g m}^{-3}$
Mean hourly value	1.3 $\mu\text{g m}^{-3}$

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 $\mu\text{g m}^{-3}$	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 $\mu\text{g m}^{-3}$	

All the data is below the lower assessment threshold for the protection of human health.

Lead

No. of days	248
Missing days (including routine maintenance)	17 (0)
No. of days sampled	231
Percentage covered	93%
Concentration of Pb	0.021 $\mu\text{g m}^{-3}$

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

All the data is below the lower assessment threshold for the protection of human health.

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. The results for these metals follow.

Cadmium

No. of days	248
Missing days (including routine maintenance)	17 (0)
No. of measured days	231
Percentage covered	93%

For 79% of the measured days the concentration of cadmium was below the detection limit of approximately 0.1 ng m^{-3} .

For the remaining 21% of the measured days the average concentration of cadmium was 0.5 ng m^{-3} .

Arsenic

No. of days	248
Missing days (including routine maintenance)	17 (0)
No. of measured days	231
Percentage covered	93%

For all the measured days the concentration of arsenic was below the detection limit of approximately 1.3 ng m^{-3} .

Nickel

No. of days	248
Missing days (including routine maintenance)	17 (0)
No. of measured days	231
Percentage covered	93%

The average concentration of nickel was 3.8 ng m^{-3} .

Mercury

Mercury was only measured from 6 April 2000 to 13 July 2000.

No. of days	99
Missing days (including routine maintenance)	0 (0)
No. of measured days	99
Percentage covered	100%

For all the measured days the concentration of mercury was below the detection limit of approximately 0.13 ng m^{-3} .