

Environmental Research Centre

Report Series No. 10

New Transboundary Air Pollution Monitoring Capacity for Ireland

STRIVE

Environmental Protection
Agency Programme

2007-2013

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

The EPA is an independent public body established in July 1993 under the Environmental Protection Agency Act, 1992. Its sponsor in Government is the Department of the Environment, Heritage and Local Government.

OUR RESPONSIBILITIES

LICENSING

We license the following to ensure that their emissions do not endanger human health or harm the environment:

- waste facilities (e.g., landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g., pharmaceutical manufacturing, cement manufacturing, power plants);
- intensive agriculture;
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- large petrol storage facilities.

NATIONAL ENVIRONMENTAL ENFORCEMENT

- Conducting over 2,000 audits and inspections of EPA licensed facilities every year.
- Overseeing local authorities' environmental protection responsibilities in the areas of - air, noise, waste, waste-water and water quality.
- Working with local authorities and the Gardaí to stamp out illegal waste activity by co-ordinating a national enforcement network, targeting offenders, conducting investigations and overseeing remediation.
- Prosecuting those who flout environmental law and damage the environment as a result of their actions.

MONITORING, ANALYSING AND REPORTING ON THE ENVIRONMENT

- Monitoring air quality and the quality of rivers, lakes, tidal waters and ground waters; measuring water levels and river flows.
- Independent reporting to inform decision making by national and local government.

REGULATING IRELAND'S GREENHOUSE GAS EMISSIONS

- Quantifying Ireland's emissions of greenhouse gases in the context of our Kyoto commitments.
- Implementing the Emissions Trading Directive, involving over 100 companies who are major generators of carbon dioxide in Ireland.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT

- Co-ordinating research on environmental issues (including air and water quality, climate change, biodiversity, environmental technologies).

STRATEGIC ENVIRONMENTAL ASSESSMENT

- Assessing the impact of plans and programmes on the Irish environment (such as waste management and development plans).

ENVIRONMENTAL PLANNING, EDUCATION AND GUIDANCE

- Providing guidance to the public and to industry on various environmental topics (including licence applications, waste prevention and environmental regulations).
- Generating greater environmental awareness (through environmental television programmes and primary and secondary schools' resource packs).

PROACTIVE WASTE MANAGEMENT

- Promoting waste prevention and minimisation projects through the co-ordination of the National Waste Prevention Programme, including input into the implementation of Producer Responsibility Initiatives.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

MANAGEMENT AND STRUCTURE OF THE EPA

The organisation is managed by a full time Board, consisting of a Director General and four Directors.

The work of the EPA is carried out across four offices:

- Office of Climate, Licensing and Resource Use
- Office of Environmental Enforcement
- Office of Environmental Assessment
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet several times a year to discuss issues of concern and offer advice to the Board.

An Gníomhaireacht um Chaomhnú Comhshaoil

Is í an Gníomhaireacht um Chaomhnú Comhshaoil (EPA) comhlachta reachtúil a chosnaíonn an comhshaol do mhuintir na tíre go léir. Rialaímid agus déanaimid maoirsiú ar ghníomhaíochtaí a d'fhéadfadh truailliú a chruthú murach sin. Cinntímid go bhfuil eolas cruinn ann ar threochtaí comhshaoil ionas go nglactar aon chéim is gá. Is iad na príomh-nithe a bhfuilimid gníomhach leo ná comhshaol na hÉireann a chosaint agus cinntiú go bhfuil forbairt inbhuanaithe.

Is comhlacht poiblí neamhspleách í an Gníomhaireacht um Chaomhnú Comhshaoil (EPA) a bunaíodh i mí Iúil 1993 faoin Acht fán nGníomhaireacht um Chaomhnú Comhshaoil 1992. Ó thaobh an Rialtais, is í an Roinn Comhshaoil agus Rialtais Áitiúil a dhéanann urraíocht uirthi.

ÁR bhFREAGRACHTAÍ

CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaol i mbaol:

- áiseanna dramhaíola (m.sh., líonadh talún, loisceoirí, stáisiúin aistrithe dramhaíola);
- gníomhaíochtaí tionsclaíocha ar scála mór (m.sh., déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta);
- diantalmhaíocht;
- úsáid faoi shrian agus scaoileadh smachtaithe Orgánach Géinathraithe (GMO);
- mór-áiseanna stórais peitreal.

FEIDHMIÚ COMHSHAOIL NÁISIÚNTA

- Stiúradh os cionn 2,000 iniúchadh agus cigireacht de áiseanna a fuair ceadúnas ón nGníomhaireacht gach bliain.
- Maoirsiú freagrachtaí cosanta comhshaoil údarás áitiúla thar sé earnáil - aer, fuaim, dramhaíl, dramhuisce agus caighdeán uisce.
- Obair le húdaráis áitiúla agus leis na Gardaí chun stop a chur le gníomhaíocht mhídhleathach dramhaíola trí chomhordú a dhéanamh ar líonra forfheidhmithe náisiúnta, díriú isteach ar chiontóirí, stiúradh fiosrúcháin agus maoirsiú leigheas na bhfadhbanna.
- An dlí a chur orthu siúd a bhriseann dlí comhshaoil agus a dhéanann dochar don chomhshaol mar thoradh ar a ngníomhaíochtaí.

MONATÓIREACHT, ANAILÍS AGUS TUAIRISCÍÚ AR AN GCOMHSHAOIL

- Monatóireacht ar chaighdeán aer agus caighdeán aibhneacha, locha, uisce taoide agus uisce talaimh; leibhéil agus sruth aibhneacha a thomhas.
- Tuairiscíú neamhspleách chun cabhrú le rialtais náisiúnta agus áitiúla cinntiú a dhéanamh.

RIALÚ ASTUITHE GÁIS CEAPTHA TEASA NA hÉIREANN

- Cainníochtú astuithe gáis ceaptha teasa na hÉireann i gcomhthéacs ár dtiomantas Kyoto.
- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

TAIGHDE AGUS FORBAIRT COMHSHAOIL

- Taighde ar shaincheisteanna comhshaoil a chomhordú (cosúil le caighdeán aer agus uisce, athrú aeráide, bithéagsúlacht, teicneolaíochtaí comhshaoil).

MEASÚNÚ STRAITÉISEACH COMHSHAOIL

- Ag déanamh measúnú ar thionchar phleananna agus chláracha ar chomhshaol na hÉireann (cosúil le pleananna bainistíochta dramhaíola agus forbartha).

PLEANÁIL, OIDEACHAS AGUS TREOIR CHOMHSHAOIL

- Treoir a thabhairt don phobal agus do thionscal ar cheisteanna comhshaoil éagsúla (m.sh., iarratais ar cheadúnais, seachaint dramhaíola agus rialacháin chomhshaoil).
- Eolas níos fearr ar an gcomhshaol a scaipeadh (trí cláracha teilifíse comhshaoil agus pacáistí acmhainne do bhunscoileanna agus do mheánscoileanna).

BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Gníomhaireacht i 1993 chun comhshaol na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaímseartha, ar a bhfuil Príomhstíúrthóir agus ceithre Stíúrthóir.

Tá obair na Gníomhaireachta ar siúl trí ceithre Oifig:

- An Oifig Aeráide, Ceadúnaithe agus Úsáide Acmhainní
- An Oifig um Fhorfheidhmiúchán Comhshaoil
- An Oifig um Measúnacht Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáide

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

New Transboundary Air Pollution Monitoring Capacity for Ireland

Environmental Research Centre Report

Authors:

Stephan Leinert, Frank McGovern and S.G. Jennings

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699

E-mail: info@epa.ie Website: www.epa.ie

ACKNOWLEDGEMENTS

This report is published as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It is administered on behalf of the Department of the Environment, Heritage and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting environmental research.

Thanks to all the people contributing to the work in this project, either in the laboratory, in the field, or otherwise. In Wexford/Carnsore Point: John Delaney, Gavin Smith, Jennifer McKeon, Joe Tiernan and Barry Lynch. In Oak Park: John Hogan, Joe Tiernan and Barry Lynch. In Malin Head: the team at the meteorological station. In Glenveagh: Joe Gatins, Pat Vaughan, Robbie Miller, Seamus McGinty and Larry McDaid. In Met Éireann laboratories: Margaret Ryan, Aileen Byrne and Thomas Murphy. In EPA Richview: John Finnan, Barbara O'Leary, Wasim Bashir, Connor McDonagh, Phillip O'Brien, Peter Mooney, Alison Donnelly, Liam Burke and Frank McGovern.

DISCLAIMER

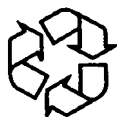
Although every effort has been made to ensure the accuracy of the material contained in this publication, complete accuracy cannot be guaranteed. Neither the Environmental Protection Agency nor the author(s) accept any responsibility whatsoever for loss or damage occasioned or claimed to have been occasioned, in part or in full, as a consequence of any person acting, or refraining from acting, as a result of a matter contained in this publication. All or part of this publication may be reproduced without further permission, provided the source is acknowledged.

Reports produced through the Environmental Research Centre are intended as contributions to inform policy makers and other stakeholders to the necessary debate on environmental protection.

ENVIRONMENTAL RESEARCH CENTRE PROGRAMME 2007–2013

Published by the Environmental Protection Agency, Ireland

PRINTED ON RECYCLED PAPER



ISBN: 1-84095-273-3

Price: Free

06/08/150

Details of Project Partners

Stephan Leinert

Environmental Protection Agency
McCumiskey House
Richview
Clonskeagh Road
Dublin 14
Ireland

Tel.: +353 1 2680184
Fax: +353 1 2680199
E-mail: s.leinert@epa.ie

Gerard Jennings

Atmospheric Research Group
Department of Experimental Physics
National University of Ireland, Galway
Galway
Ireland

Tel.: +353 91 492490
Fax: +353 91 494584
E-mail: gerard.jennings@nuigalway.ie

Frank McGovern

Environmental Protection Agency
McCumiskey House
Richview
Clonskeagh Road
Dublin 14
Ireland

Tel.: +353 1 2680160
Fax: +353 1 2680199
E-mail: f.mcgovern@epa.ie

Table of Contents

Acknowledgements	ii
Disclaimer	ii
Details of Project Partners	iii
1 Introduction	1
2 Background	2
2.1 The 1979 Geneva Convention on Long-Range Transboundary Air Pollution	2
2.2 Historic Monitoring in Ireland	2
2.3 EMEP Monitoring Strategy 2004–2009	4
2.3.1 Level 1	4
2.3.2 Level 2	4
2.3.3 Level 3	4
3 New Monitoring Sites	5
3.1 Malin Head/Glenveagh	5
3.2 Carnsore Point/Wexford	6
3.3 Oak Park	7
4 Instruments	8
4.1 High Volume Sampler	8
4.2 Precipitation Sampler	8
4.3 TEOM	9
4.4 Aethalometer	9
4.5 Condensation Particle Counter	9
4.6 Gas Monitors	9
4.7 Nephelometer	9
5 Data Acquisition and Data Transfer	12
5.1 Data Acquisition	12

5.2	Data Check/Visualisation	12
5.3	Data Transfer	13
6	Chemical Analysis	14
6.1	Analysis of Filter Samples (PM ₁₀)	14
6.2	Analysis of Precipitation Samples	14
7	Data	15
7.1	PM ₁₀ Ion Chemistry at Carnsore Point, Malin Head, Oak Park	15
7.2	PM ₁₀ Mass at Carnsore Point in 2006	16
7.3	Glenveagh, Wexford and Oak Park Precipitation Chemistry	16
8	Co-Operation	18
8.1	Persistent Organic Pollutant Global Atmospheric Passive Sampling	18
8.2	Persistent Organic Pollutants in Europe	18
8.3	Mace Head Mercury	19
8.4	Ozone Depleting Substances at Carnsore Point	19
9	Conclusions and Recommendations	20
10	Output	21
10.1	SOPs	21
10.2	Data Acquisition	21
10.3	Data Visualisation	21
	References	22

1 Introduction

Ireland is a party to a range of European and global initiatives in relation to air pollution issues, including the Convention on Long-Range Transboundary Air Pollution (CLRTAP), and its Gothenburg Protocol. As a member of the European Union (EU), Ireland is subject to the National Emissions Ceilings (NEC) Directive, and the Air Quality Framework Directive.

Regulatory monitoring of air pollutants covered under EU and National legislation is largely in relation to urban monitoring, and is implemented by the Environmental Protection Agency (EPA) and local authorities. The EPA monitoring network includes suburban and rural sites. However, the monitoring of PM₁₀ chemistry and precipitation chemistry required under the European Monitoring and Evaluation Programme (EMEP) is outside its scope.

The requirement for a non-urban national monitoring infrastructure was pointed to by McGettigan *et al.* (2000). Such monitoring provides ongoing analyses of the effectiveness of international agreements in relation to transboundary air pollutants. Such monitoring also is a requirement under the Convention (CLRTAP).

The work presented here aimed to address monitoring issues highlighted by McGovern (2002), including that on a national basis air quality monitoring has developed in a “*disparate and uncoordinated*” manner (McGettigan *et al.*, 2000) and that Aherne and Farrell (2000) point to significant limitations imposed on their study due to the absence of national data on atmospheric levels of acidic species.

The new monitoring capacity developed takes into account geographical coverage, access, operation and management of sites. In particular, establishing an east coast site provides data on levels of pollutants transported to Ireland. The new sites are also part of the Irish contribution to the EMEP monitoring network under the Convention (CLRTAP). This network complements the EPA air quality monitoring (Fig. 1.1).

This project was developed through the EPA/ERC (Environmental Research Centre) in co-operation with Met Éireann. The new sites are Malin Head, Oak Park, and Carnsore Point. They are run in co-operation with Met Éireann and Teagasc. Chemical analysis of filter samples and precipitation samples is carried out in the Met Éireann laboratory for all sites.

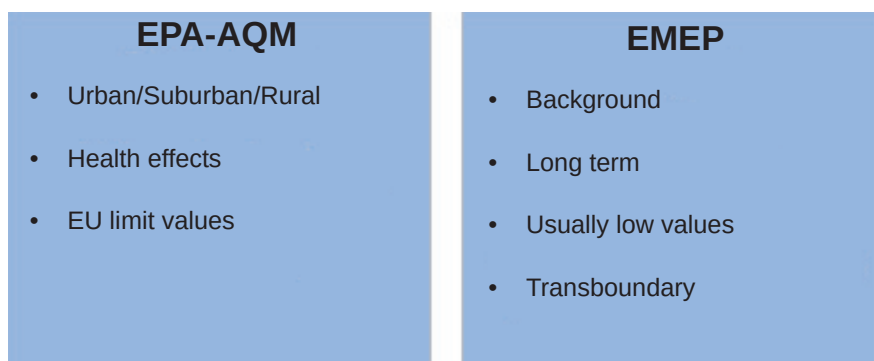


Figure 1.1. EPA air quality monitoring (AQM) and European Monitoring and Evaluation Programme (EMEP) monitoring.

2 Background

2.1 The 1979 Geneva Convention on Long-Range Transboundary Air Pollution

In the 1960s, scientists demonstrated the interrelationship between sulphur emissions in continental Europe and the acidification of Scandinavian lakes – a transboundary effect of air pollution. The United Nations Conference on the Human Environment, held in Stockholm in 1972, signalled the start of active international co-operation to combat acidification. Studies in the 1970s confirmed that pollutants can travel for thousands of miles before deposition and damage to the environment occurs. This led to the Convention (CLRTAP), in 1979 in Geneva, under the United Nations Economic Commission for Europe (UNECE). Subsequently, several protocols to the convention were agreed:

- 1984 EMEP on setting up a monitoring programme
- 1985 sulphur reduction
- 1988 on NO_x
- 1991 on volatile organic compounds (VOCs)
- 1994 on sulphur
- 1998 on heavy metals
- 1998 on persistent organic pollutants (POPs)
- 1999 on acidification, eutrophication, ground-level ozone.

The 1984 protocol agreed the European Monitoring and Evaluation Programme (EMEP) (Fig. 2.1).

The implementation of the protocol on sulphur reduction led to a substantial decrease of sulphur levels in ambient air over the last decades, as shown in Fig. 2.2 (data from Valentia Observatory).

The main objective of the EMEP is to “*regularly provide governments and subsidiary bodies ... with qualified scientific information...*”.

The three main elements are:

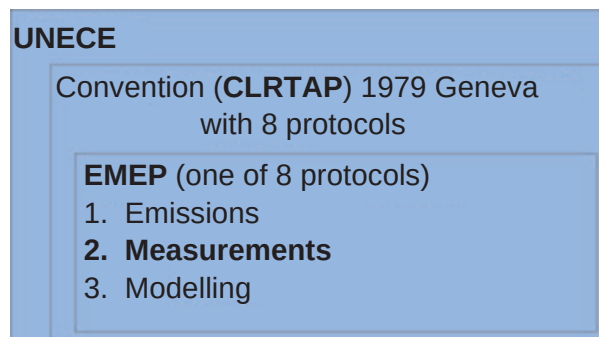


Figure 2.1. European Monitoring and Evaluation Programme (EMEP) in the context of the United Nations Economic Commission for Europe (UNECE) and the Convention on Long-Range Transboundary Air Pollution (CLRTAP).

1. Collection of emission data – data are compiled by the EPA and reported to the EMEP on an annual basis
2. Measurements of air and precipitation quality – this includes the EMEP monitoring network
3. Modelling of atmospheric transport and deposition of air pollution. The Meteorological Synthesizing Centre – West (MSC-West) models transboundary fluxes of acidifying air pollution and photochemical oxidants. The MSC-East mainly models long-range transport of POPs and heavy metals (HMs).

2.2 Historic Monitoring in Ireland

In Ireland, Met Éireann was given responsibility for monitoring air pollutants covered by CLRTAP. The longest running station for EMEP air quality monitoring is the Met Éireann Valentia Observatory, Caherciveen. It has been running since 1980. In Mace Head, ozone has been measured since 1988. Three other Irish sites – Turloch Hill, The Burren, Ridge of Capard – were established in 1991 (Turloch Hill) and 1997 (The Burren and Ridge of Capard), run by the ESB. These were discontinued by 2003.

The EMEP sites prior to 2003, and in 2006 are shown in Fig. 2.3.

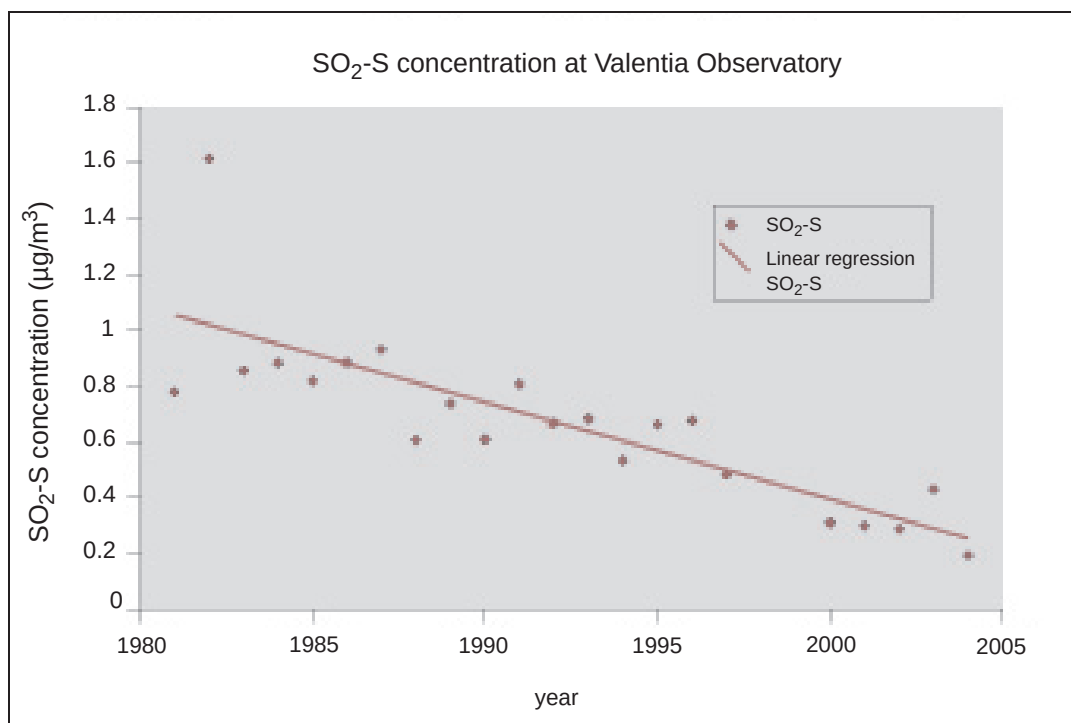


Figure 2.2. Annual averages for SO₂-S in ambient air at Valentia Observatory (from ERC Report Series No. 1).

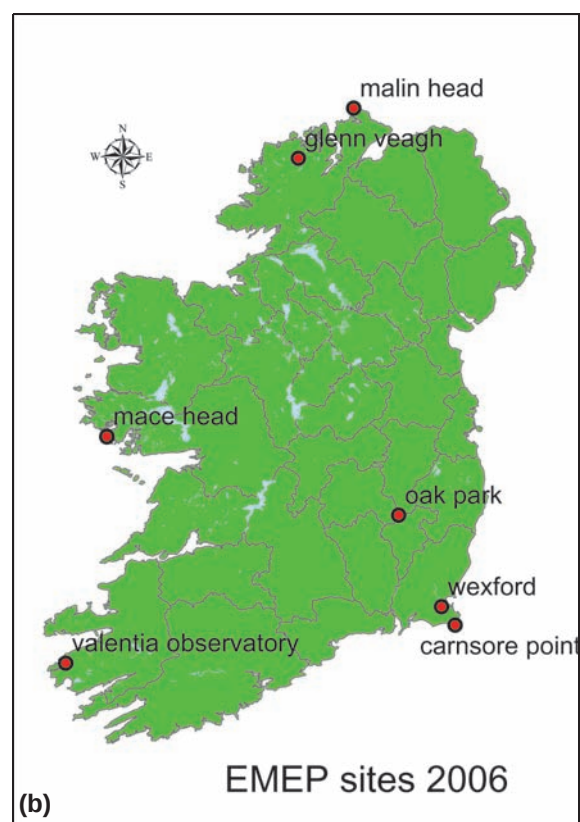
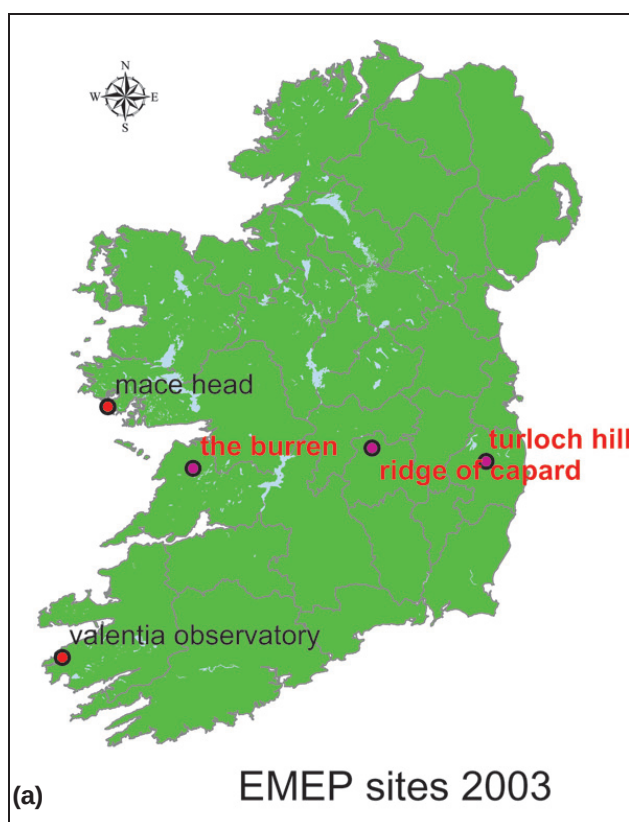


Figure 2.3. European Monitoring and Evaluation Programme (EMEP) sites prior to 2003 (a) and in 2006 (b).

2.3 EMEP Monitoring Strategy 2004–2009

The EMEP monitoring strategy (2004–2009) adopted a three-level approach for monitoring. It differentiates three different levels of sites, as outlined in Sections 2.3.1–2.3.3.

2.3.1 Level 1

- The main objective of Level-1 monitoring is to provide, in the long term, basic chemical and physical measurements of the traditional EMEP parameters
- The basic parameters in relation to particulate matter, acidification, eutrophication and heavy metals
- Also, meteorological data are requested (precipitation amount, temperature, wind direction, wind speed, relative humidity, atmospheric pressure)
- Low-cost methods are allowed for gas/particle partitioning.

Level-1 parameters are a priority when operating the network. By undertaking a more demanding

programme, the Level-1 sites should gradually be upgraded to Level-2 sites.

2.3.2 Level 2

- The main objective of Level-2 monitoring is to provide parameters essential for process understanding and further chemical speciation of relevant components
- Includes parameters required at Level-1 plus a series of additional ones
- These additional parameters include measurements at a higher temporal resolution, reliable gas/particle distribution, chemical speciation of aerosol mass, VOCs, HMs in air, mercury (Hg) and POPs in air and precipitation.

2.3.3 Level 3

- Research driven and may often be available at locations other than Level-1 and Level-2 sites; further data would typically be provided by institutions other than those responsible for implementing the national monitoring obligations
- A number of relevant parameters are identified as being of interest for the EMEP
- Level-3 sites may include campaign data.

3 New Monitoring Sites

The new EMEP monitoring strategy requires four Level-1 sites for Ireland. The sites were established under the ERC project, aiming for greater geographic coverage of the country. Ideally, sites would not be influenced by immediate local sources of air pollution. However, infrastructure and logistics had to be considered as well. Where possible, existing infrastructure was used, and co-operation with other agencies or bodies sought (Fig. 3.1). The sites chosen were therefore a compromise between location and availability of the necessary infrastructure.

The sites chosen were:

1. Malin Head/Glenveagh
2. Carnsore Point/Wexford
3. Oak Park.

The set-up of monitoring in Ireland is also aiming at:

1. Automated operation of instrumentation, i.e. avoiding the need of daily maintenance for filter or bottle changes
2. Automated data transmission where possible, through satellite connection.

The main sites are Malin Head and Carnsore Point, with a precipitation sampler associated with these two sites in Glenveagh and Wexford. Also, there is new monitoring capacity in Oak Park. A map of Ireland showing the location of the new sites is shown in Fig. 2.3.

The site at Carnsore Point is placed at the east coast, as proposed in the outline proposal by McGovern (2002), conveniently located for measuring pollution transported to Ireland from continental Europe. It has considerable potential for scientific studies of processes and transformation of air pollutants.

3.1 Malin Head/Glenveagh

The Malin Head monitoring site is placed with the Met Éireann Malin Head meteorological station. The presence of Met Éireann staff around the clock greatly benefits the smooth operation of the site. The site is placed at 55° 22' North and 7° 20' West, at 22 m elevation. The Malin Head site is shown in Fig. 3.2.

Prevailing winds are from the west, south-west, or south, as shown in the windrose in Fig. 3.3 (10 years hourly wind data, provided by Met Éireann).

Location of new EMEP sites

Site	Location	Level	Co-operation
Carnsore Point	52° 11' N 06° 22' W	9 m	EPA
Glenveagh	55° 03' N 07° 56' W	44 m	NPWS
Malin Head	55° 22' N 07° 20' W	22 m	Met Éireann
Oak Park	52° 52' N 06° 55' W	59 m	Teagasc
Wexford	52° 18' N 06° 30' W	62 m	EPA

Instrumentation at sites

Malin Head	O ₃ , CO, SO ₂ , NO _x , BC (aethalometer), PM ₁₀ chemistry (HVS), CPC
Oak Park	Precipitation (wet only) PM ₁₀ chemistry (HVS)
Glenveagh	Precipitation (wet only)
Wexford	Precipitation (wet only)
Carnsore Point	CO, SO ₂ , NO _x , BC (aethalometer), PM ₁₀ chemistry (HVS), CPC PM ₁₀ mass (TEOM) Particle scattering (nephelometer)

Figure 3.1. Location of the new European Monitoring and Evaluation Programme (EMEP) sites, and instrumentation at the sites (NPWS, National Parks & Wildlife Service; BC, black carbon; HVS, high volume sampler; CPC, concentration particle counter).

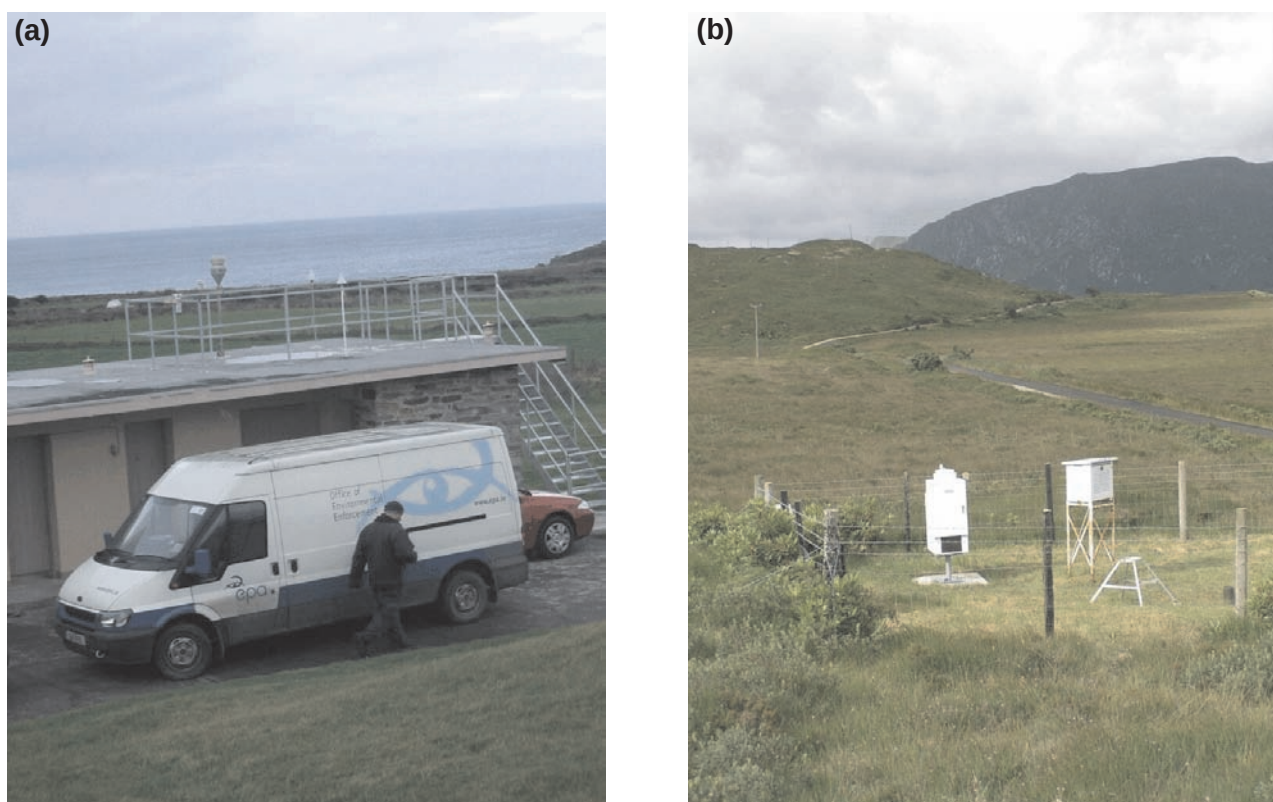


Figure 3.2. Malin Head site (a) and associated precipitation sampler in Glenveagh (b).

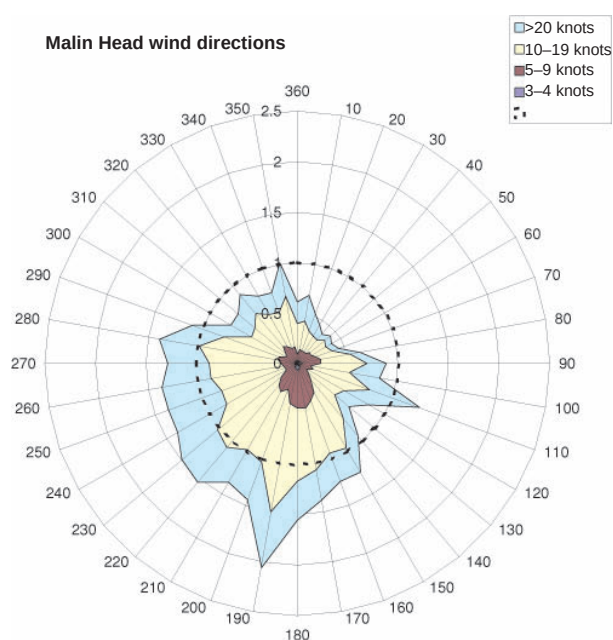


Figure 3.3. Windrose for Malin Head site.

The precipitation sampler linked to the Malin Head site is situated in Glenveagh National Park. It is operated in co-operation with the National Parks & Wildlife Service. The site was chosen for its more sheltered

location as opposed to Malin Head, and because there had been precipitation measurements in the past at this location. The site is placed at 55° 03' North, 7° 56' West, at an elevation of 44 m. The Glenveagh site is shown in Fig. 3.2.

3.2 Carnsore Point/Wexford

The Carnsore Point monitoring station is located within the Hibernian Power wind farm, close to the meteorological mast, near wind generator No. 2. The location is 52° 11' North, 6° 22' West, at an elevation of 9 m. Filter changes are performed by EPA personnel. The Carnsore Point site is shown in Fig. 3.4. Prevailing winds are clearly coming from the south-west, as shown in the wind rose in Fig. 3.5 (10 years hourly wind data for Rosslare station, provided by Met Éireann).

The precipitation sampler linked to Carnsore Point is placed in Johnstown Castle Estate, Wexford, in the meteorological field near the Teagasc building. It is operated by EPA personnel. The site is placed at



Figure 3.4. Carnsore Point site (a) and associated precipitation sampler in Wexford (b).

52° 18' North, 6° 30' West, at an elevation of 62 m. The Wexford site is shown in Figure 3.4.

3.3 Oak Park

This site is placed at the meteorological field at the Teagasc Research Facility, Oak Park, near Carlow. It

is operated in co-operation with Teagasc. The placement with the meteorological site run by Met Éireann allows for additional information on meteorological data. The Oak Park site is placed at 52° 52' North, 6° 55' West, at an elevation of 59 m. The Oak Park site is shown in Fig. 3.6.

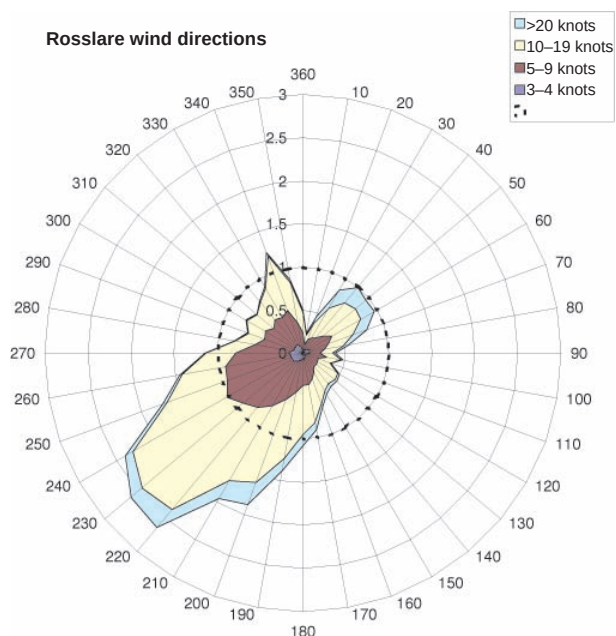


Figure 3.5. Windrose for Carnsore Point site (from Rosslare).



Figure 3.6. Oak Park site.

4 Instruments

The main instruments for EMEP monitoring are the high volume sampler (HVS), for measuring inorganic compounds in air (particles), and the precipitation sampler, for measuring inorganic compounds in precipitation. The instruments used at the sites are described below.

4.1 High Volume Sampler

A Digitel HVS is used for measuring the chemical composition (inorganic ions) of PM_{10} . The sampler is equipped with a PM_{10} inlet head. The PM_{10} inlet head only allows particles in that have an aerodynamic diameter of $10\ \mu m$ or less. The sampler sucks ambient air through the inlet head, and downstream through a filter. Particles in the airflow are deposited onto the filter.

The sampler automatically changes filters once a day. The flow rate is 500 l/min, which is equivalent to $720\ m^3$ per day. Filters have a diameter of 150 mm, with an area of 140 mm in diameter used for sampling.

Once a week, filters are sent back to Met Éireann laboratories for chemical analysis. The HVS is shown in Fig. 4.1.

4.2 Precipitation Sampler

For precipitation samples, the Eigenbrodt model NSA 181, wet-only precipitation sampler is used. 'Wet-only' means that the sampler is closed — the funnel is covered by a lid if it is not raining. Once there is precipitation, the lid opens, and the sampler collects rain in a bottle. This wet-only approach ensures that precipitation only is collected. In contrast, a bulk sampler would have a constantly open funnel, thus also collecting particles deposited in the funnel by dry deposition.

The sampler used collects precipitation in bottles, one bottle per day. Bottles are changed automatically, at midnight GMT. Samples are shipped back to Met Éireann laboratories for analysis once a week. The precipitation sampler is shown in Fig. 4.2.



Figure 4.1. High volume sampler (HVS).





Figure 4.2. Precipitation sampler, wet only.

4.3 TEOM

The TEOM is an instrument for measuring PM_{10} mass concentration at high time resolution. Air is passing a PM_{10} inlet head, and is then sucked through a filter. Particles contained in the airstream are deposited onto the filter. The filter mass is determined by measuring the resonance frequency of the filter, which changes with additional particle mass. From the airflow through the filter, and the filter mass, the PM_{10} mass concentration is calculated. The TEOM operates at a flow rate of 16.67 l/min through the PM_{10} inlet head; 3 l/min of this flow rate pass the filter and are used for the actual measurement. The TEOM is shown in Fig. 4.3. It consists of a control unit that does the data processing and the flow regulation, as well as the temperature control, and a sensor unit that contains the actual filter for depositing the particulate matter.

4.4 Aethalometer

The aethalometer is used for measuring black carbon (BC) concentrations in air. For this purpose, ambient air is sucked through a filter. Particles are deposited onto the filter. At the same time, a light is shone through the filter, and light intensity after passing the particle-laden filter is measured. This yields the absorption, and from that the BC content of the ambient air. The aethalometer is shown in Fig. 4.4.

4.5 Condensation Particle Counter

The condensation particle counter (CPC) measures the particle number concentration in air. The model used is a TSI-3760A. Air is supersaturated with butanol. The supersaturation forces the butanol to condense onto particles that are present, thus forming little butanol droplets around each particle. These butanol droplets are then detected and counted optically. The particles themselves, without the butanol droplet, would usually be too small for optical detection. The size range of the CPC is about 11 nm to 3 μ m. The CPC is shown in Fig. 4.4.

4.6 Gas Monitors

Several gases are monitored continuously for their concentration in the ambient air, e.g. ozone, SO_2 , NO_x , CO. The instruments used are API gas monitors. As an example, gas monitors running at Malin Head station are shown in Fig. 4.5.

4.7 Nephelometer

The nephelometer is used for measuring particle scattering of ambient particles. To this effect, ambient air is sucked through the instrument. The air is illuminated by a light source and the scattered light is measured using a photomultiplier tube. The nephelometer is shown in Fig. 4.5. The type used is a TSI model 3563, working at three different wavelengths.

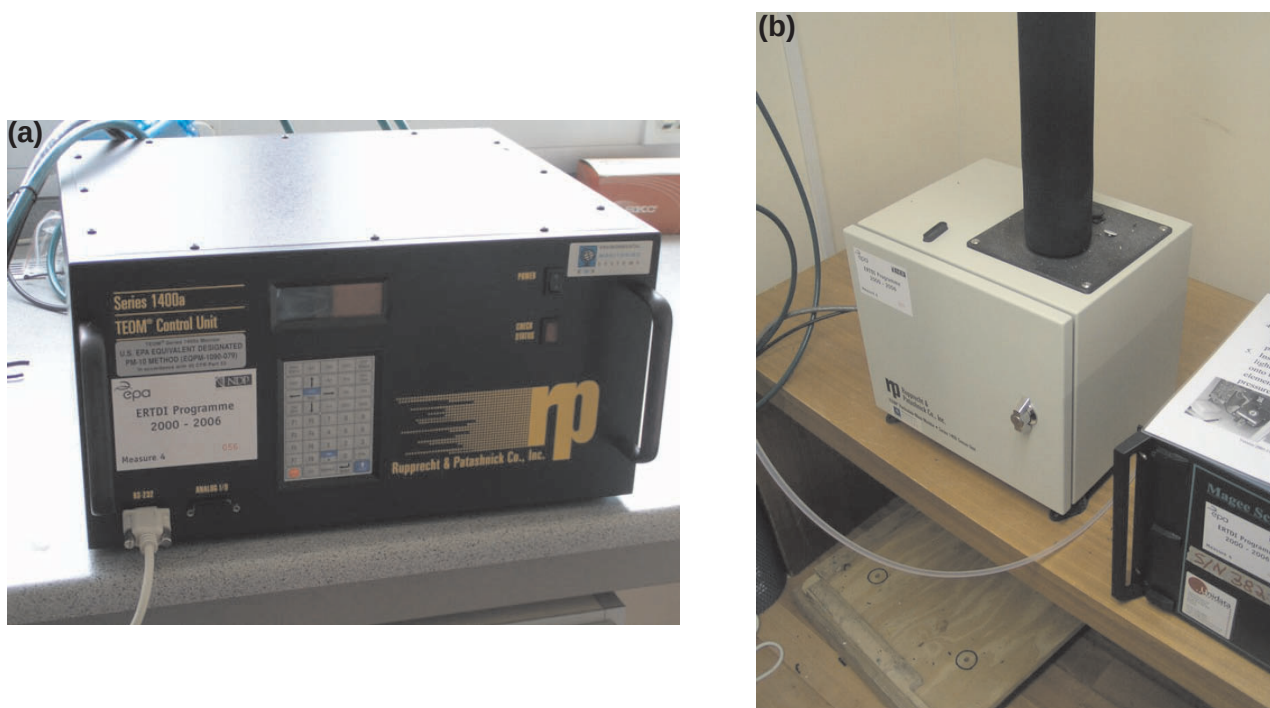


Figure 4.3. TEOM at Carnsore Point: control unit (a) and sensor unit (b).

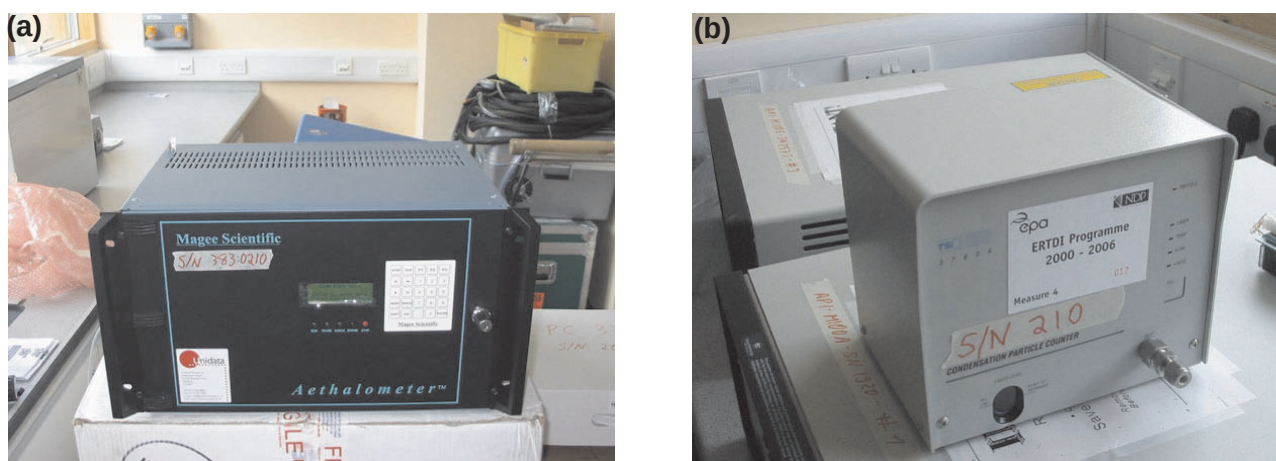


Figure 4.4. The aethalometer for black carbon (BC) measurements (a) and the concentration particle counter (CPC) (b).

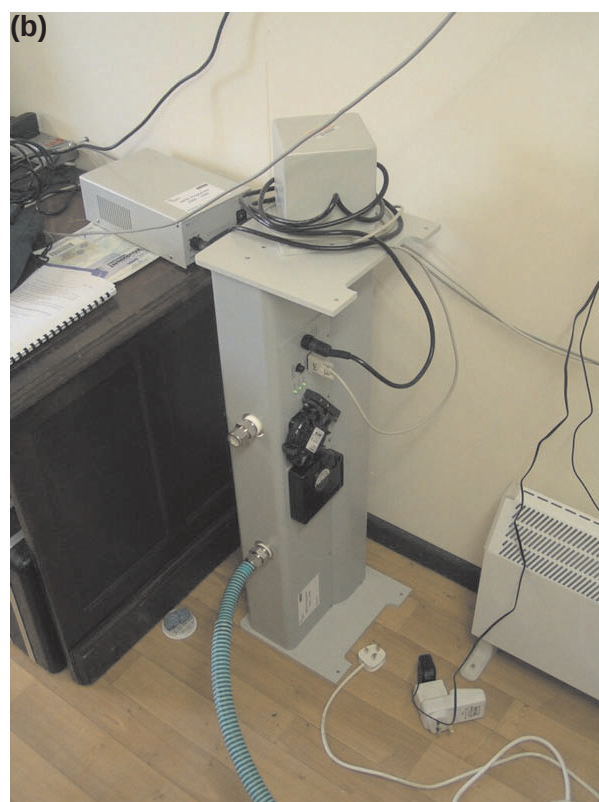


Figure 4.5. Gas monitors (a) and nephelometer (b).

5 Data Acquisition and Data Transfer

The need for an advanced data acquisition (DAQ) and communication system arises from the approach taken to set up the new sites – i.e. direct data transfer where possible. Some instruments used for air quality monitoring produce physical samples that need to be sent back to Met Éireann laboratories for analysis (e.g. bottles with precipitation samples, filters from the HVS).

Other instruments produce online readings of parameters describing the ambient air, e.g. particle number concentration, SO₂ content, BC content, etc. For these instruments, the following approach was used, including three separate tasks:

1. DAQ
2. Data check/visualisation
3. Data transfer.

To clearly structure the handling of data, these three tasks were kept separate (they might be running on the same machine, e.g. the on-site PC). This ensures easy maintenance, if parts of the data handling system need to be updated or modified. The programming of the DAQ or data visualisation LabView programs takes place centrally; from the programmed code, executables are created for running on the on-site PCs.

5.1 Data Acquisition

Data acquisition is performed by custom-written LabView programs. Certain guidelines were implemented for DAQ:

- One separate DAQ program for each instrument – this allows updating/improving the software for one instrument, without affecting the others
- DAQ through serial communication (RS 232)
- Polled operation if possible (the PC requests data from the instrument; this operation mode is not possible for the aethalometer, which produces

reports and sends them to the serial port without being polled)

- Data are written to the on-site PC as ASCII text files
- The DAQ program is always running in the background
- Data are usually stored in one file per day for each instrument
- DAQ programs are set up to start automatically after a power failure, once the on-site PC starts again
- A time stamp is added to each (polled) data report when it is written to the file; this time stamp is created by the LabView program, based on the computer time of the on-site PC, thus ensuring a common time base, even if internal clocks of instruments are off
- All times are based on GMT all year round, thus avoiding shifts when changing to daylight saving time.

The concept for DAQ and data visualisation is shown in Fig. 5.1.

5.2 Data Check/Visualisation

Data check/visualisation can be performed on site, using a separate set of custom-built LabView programs. These were programmed to meet the following criteria:

- One data visualisation program for each instrument/type of data
- The visualisation program never communicates to the instruments directly, but only displays the stored data from the on-site PC
- Usually, one day's worth of data is displayed, with an option to toggle through the recent days of data.

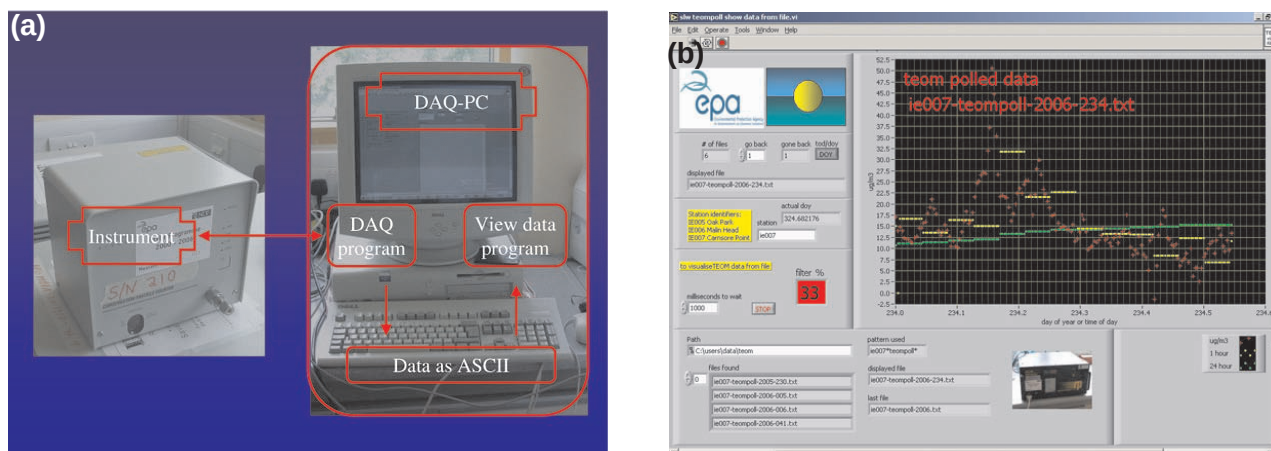


Figure 5.1. Schematic of data acquisition (a) and example of data visualisation (b).

These programs are placed on the on-site PC, or for data check on any PC that has access to the data.

5.3 Data Transfer

A satellite connection was set up for the Carnsore Point and Malin Head sites. Data are transferred from the field site to a directory on a server in Dublin, using

rsync. This program updates/synchronises the data folder in Dublin to match the data at the on-site PC. It only transfers the changes, e.g. the data acquired since the last data transfer. Data are updated every hour (see Fig. 5.2). The concept for data transfer is shown in Fig. 5.2.

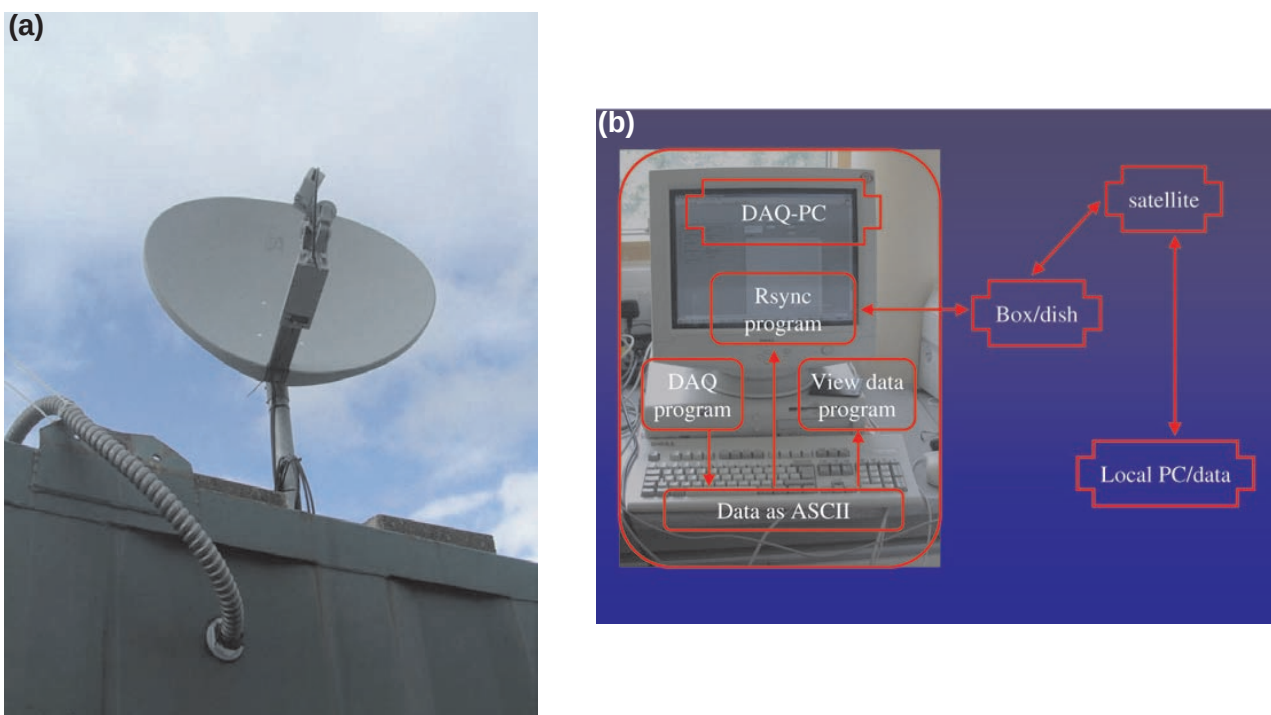


Figure 5.2. Satellite connection at Carnsore Point (a), and schematic of data transfer (b).

6 Chemical Analysis

All filter samples (PM₁₀, from HVSs) and precipitation samples are sent back to Met Éireann laboratories once a week for analysis of their chemical composition.

6.1 Analysis of Filter Samples (PM₁₀)

Filters from the HVS have a diameter of 150 mm. A circular fraction of 47 mm in diameter is cut out, using a punch. This fraction is then used for analysis.

The filter paper is placed in a beaker, to which 20 ml of extraction solvent (deionised H₂O) are added and left for 24 h. About 1.5 ml of the sample are then transferred into a vial, and analysed with an ICS-3000 dual-system Dionex Ion Chromatograph. Anions are analysed with an AS18 2-mm column, cations are analysed with a CS16 3-mm column. Along with the samples, a set of five anion and six cation standards,

and two controls, are analysed with the ion chromatograph, for quality assurance and calibration purposes. The results from the ion chromatography yield an amount of the ions analysed. This, in combination with the air volume sucked through the filters, results in the concentration of the species in air. The samples are analysed for SO₄-S, NO₃-N, NH₄-N, Na, Mg, K and Ca.

6.2 Analysis of Precipitation Samples

For precipitation samples, no extraction is required. The samples are analysed with the Dionex Ion Chromatograph, provided there was enough precipitation for the day in question (20 ml). Also, the pH and conductivity of the precipitation sample are measured. The sample is analysed for SO₄-S, NO₃-N, NH₄-N, Na, Mg, K, Ca and Cl.

7 Data

7.1 PM₁₀ Ion Chemistry at Carnsore Point, Malin Head, Oak Park

Particulate matter (PM₁₀) is collected on filters in Oak Park, Malin Head and Carnsore Point, one filter a day. These filters are then analysed in Met Éireann

laboratories for several chemical species. PM₁₀ filter sampling at Carnsore Point only started in May 2005. Annual averages of the main chemical compounds for 2005 and 2006 are shown in Fig. 7.1. Sea-salt contributions are especially high at coastal locations, with annual means around 6 µg/m³ at Malin Head and

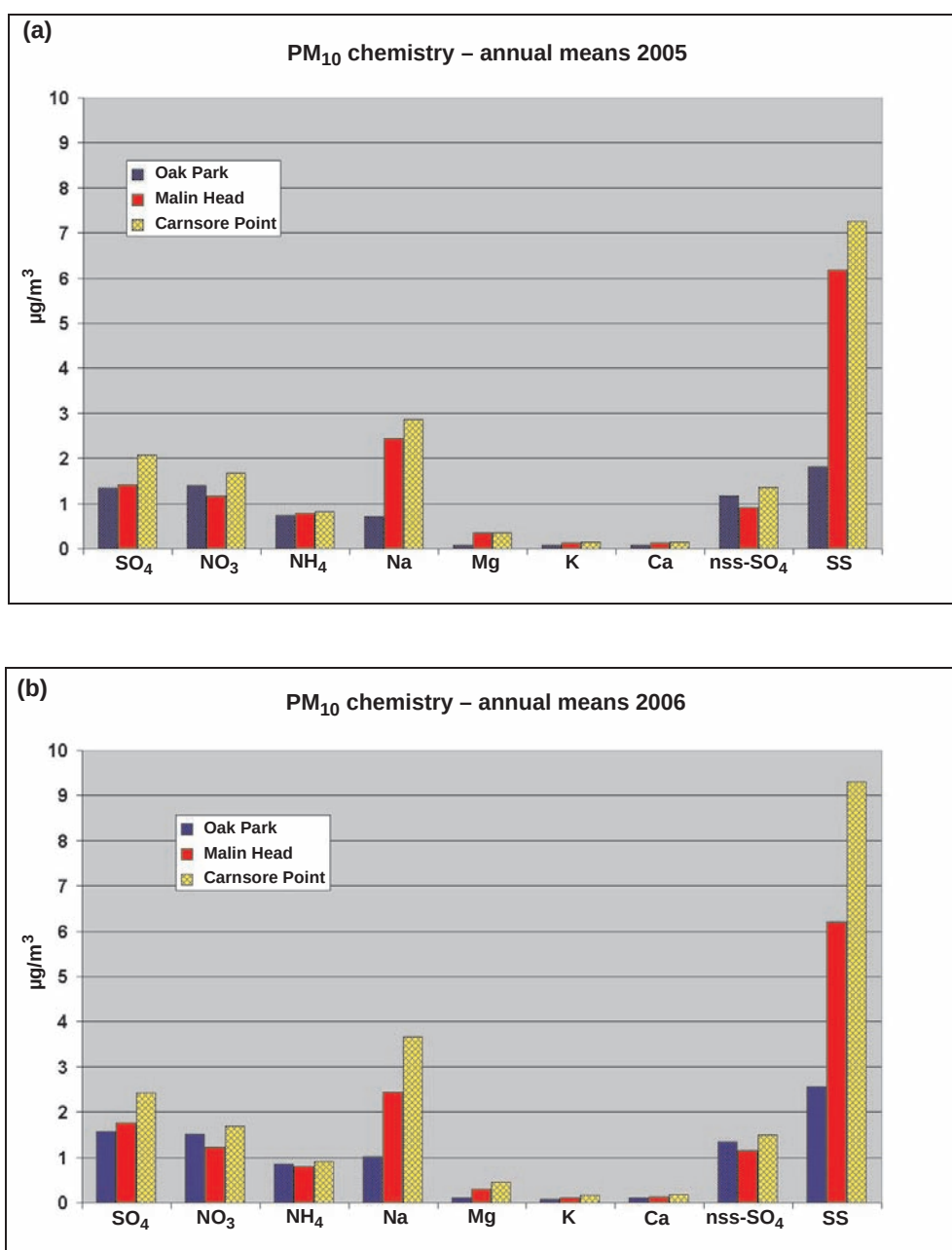


Figure 7.1. Contribution of different compounds to PM₁₀, annual mean for 2005 (a) and 2006 (b).

7–9 $\mu\text{g}/\text{m}^3$ at Carnsore Point. Even at the inland site at Oak Park, annual average sea-salt levels are around 2 $\mu\text{g}/\text{m}^3$. The maximum daily value reached 40 $\mu\text{g}/\text{m}^3$ at Carnsore Point in 2006. Even at the inland site at Oak Park, a maximum daily value of 12.6 $\mu\text{g}/\text{m}^3$ was observed.

7.2 PM_{10} Mass at Carnsore Point in 2006

PM_{10} levels were measured at Carnsore Point using a TEOM. These measurements started in 2006, and complement the PM_{10} chemistry measurements with the HVS at Carnsore Point. TEOM raw data are commonly multiplied by a factor of 1.3 to make data comparable to gravimetric methods (weighing of filters). The annual mean of daily PM_{10} values derived from the TEOM (including the 1.3 factor) is 27 ± 12 $\mu\text{g}/\text{m}^3$. This is comparable to PM_{10} values at urban traffic sites. Part of the high PM_{10} levels at Carnsore

Point can be attributed to sea salt, with an average of 8 ± 7 $\mu\text{g}/\text{m}^3$.

Sea-salt levels (daily averages) were as high as 40 $\mu\text{g}/\text{m}^3$, with high sea-salt levels usually coinciding with high PM_{10} levels. Figure 7.2 shows the PM_{10} values at Carnsore Point (raw data and including the 1.3 factor). Missing values are due to power failures or instrument malfunction.

7.3 Glenveagh, Wexford and Oak Park Precipitation Chemistry

Precipitation (wet only) is collected at Glenveagh, Wexford and Oak Park, a bottle a day. These precipitation samples are then analysed in Met Éireann laboratories for several chemical species. Precipitation measurement at the Oak Park site started in 2005, at Glenveagh in April 2005, and at Wexford in March 2006. Annual weighted means of the main chemical compounds for 2005 and 2006 are shown in Fig. 7.3.

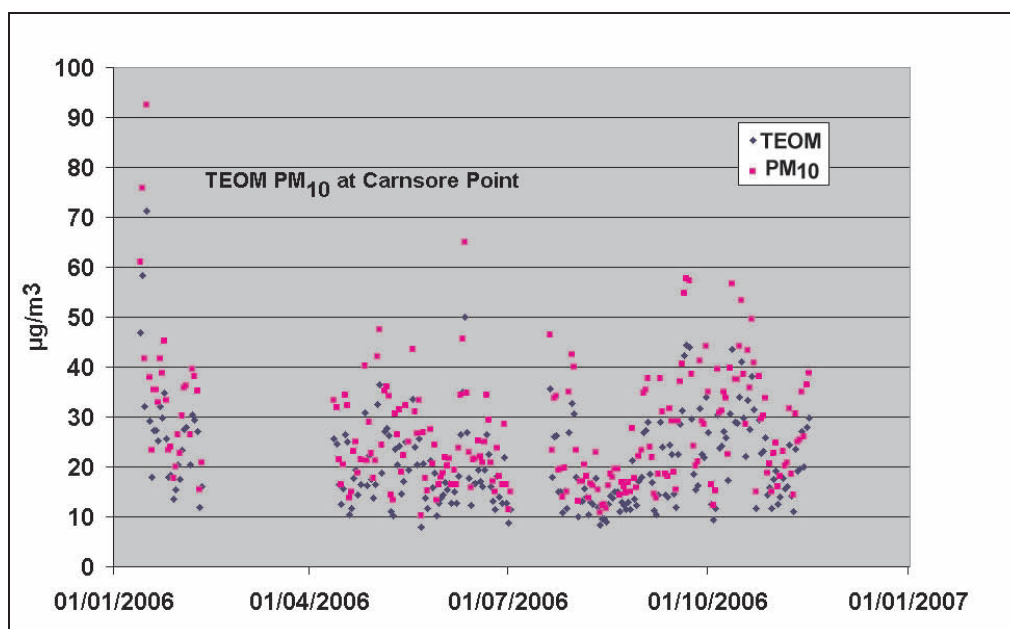


Figure 7.2. PM_{10} daily averages for 2006 at Carnsore Point, TEOM data.

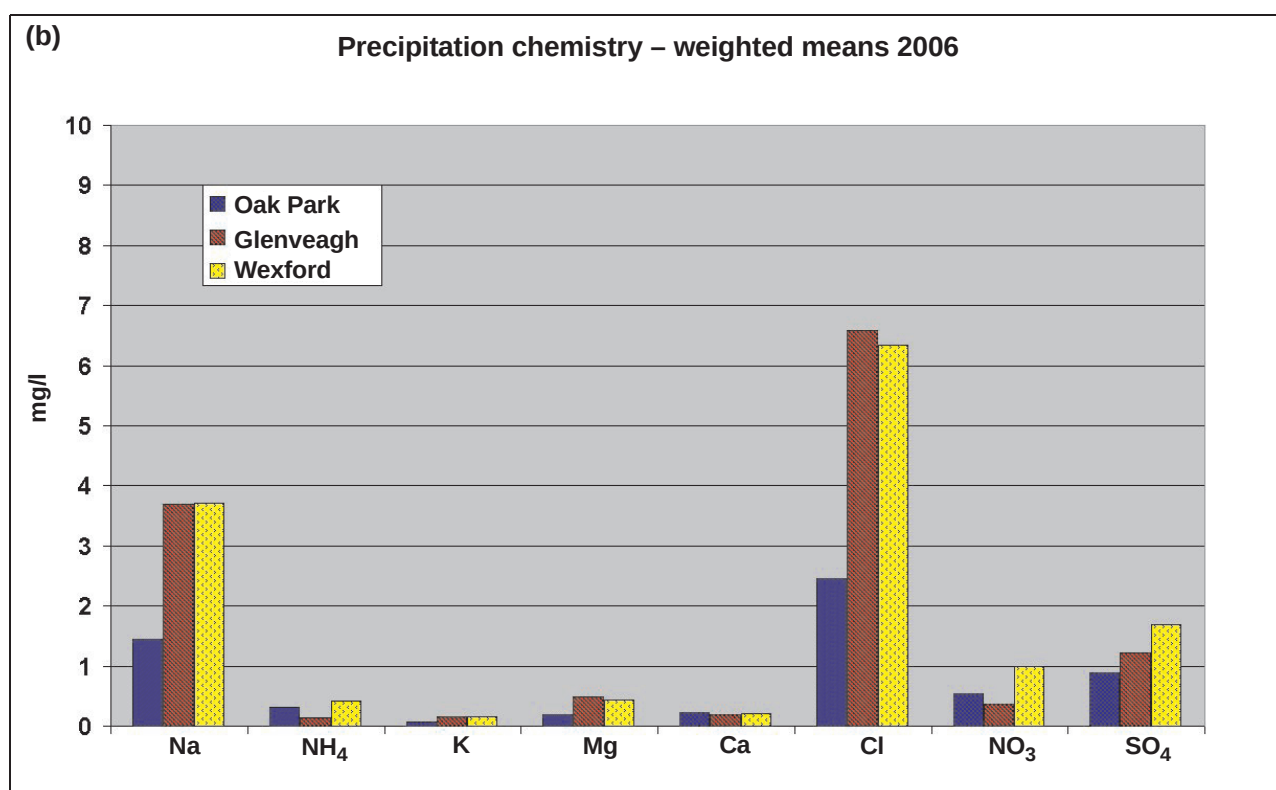
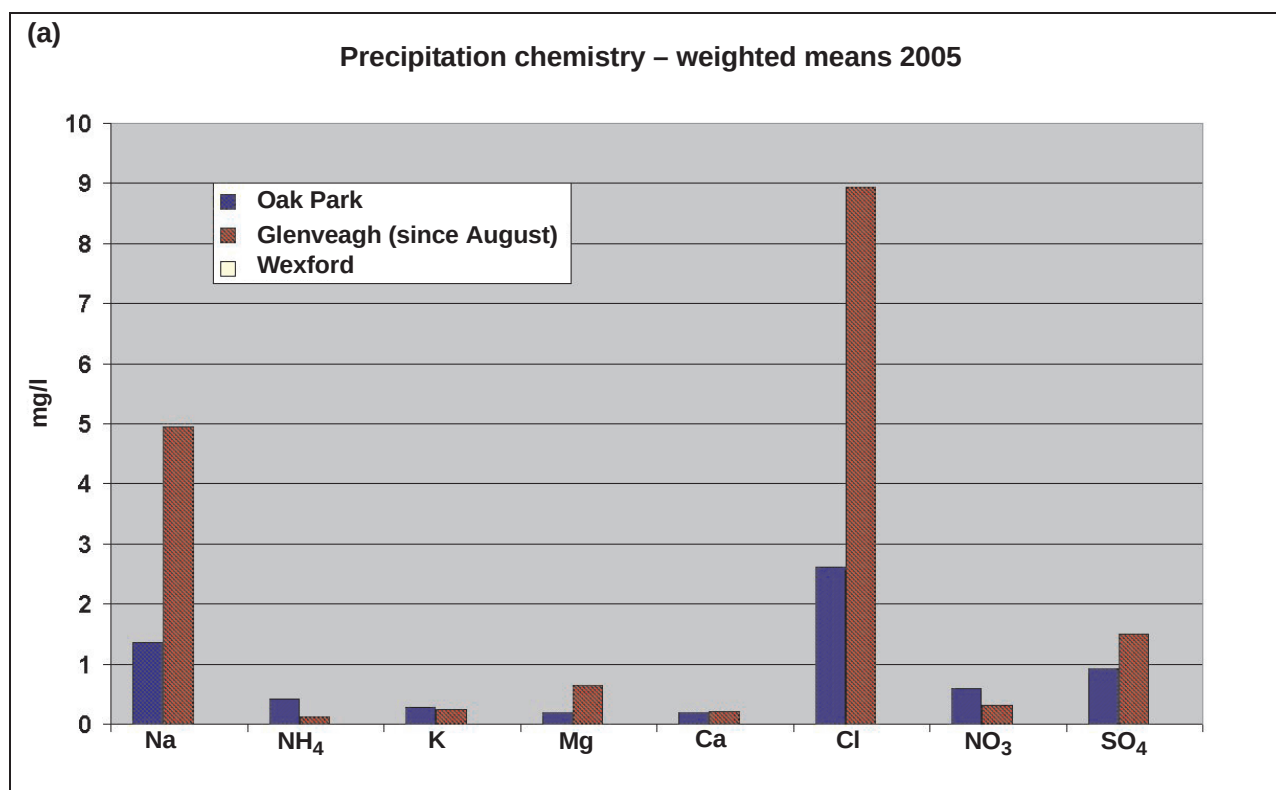


Figure 7.3. Contribution of different compounds in precipitation, weighted means for 2005 (a) and 2006 (b).

8 Co-Operation

Several projects that are not core EMEP monitoring were supported/facilitated as part of the TXB (Transboundary Air Pollution) fellowship. They contribute to air quality monitoring on an Irish, European or global level.

8.1 Persistent Organic Pollutant Global Atmospheric Passive Sampling

The Global Atmospheric Passive Sampling (GAPS) study aims to demonstrate the feasibility of using passive samplers to assess the spatial distribution of POPs worldwide. The GAPS network comprises more than 40 sites on seven continents. The sites are shown in Fig. 8.1. One passive POP sampler is deployed in Malin Head, Ireland. Information on the GAPS project can be found on the website: <http://www.msc-smc.ec.gc.ca/gaps/>

8.2 Persistent Organic Pollutants in Europe

The EMEP-Chemical Coordinating Centre (CCC)/Norwegian Institute for Air Research (NILU) network co-ordinated a large European-scale passive air sampling campaign during the summer of 2006 to

support the work on POPs carried out under the Convention (CLRTAP).

Passive air samplers were deployed across Europe at about 100 sites simultaneously. The aims of this project are:

- To gain new insight into the spatial patterns of POPs in background air using consistent sampling and analytical methodologies
- To evaluate possible limitations of the current EMEP measurement network with respect to spatial coverage of POPs measurements
- To evaluate the use of passive air samplers as a complementary and cost-efficient tool with respect to potential future monitoring strategies within the EMEP (and beyond)
- To improve models by supporting model validation exercises at MSC-East (and beyond).

Passive POP samplers were deployed during summer 2006 at Malin Head and Carnsore Point.



Figure 8.1. (a) Sites for passive samplers for the Global Atmospheric Passive Sampling (GAPS) study; (b) passive persistent organic pollutant (POP) sampler at Mace Head.

8.3 Mace Head Mercury

Mercury measurements were continued at Mace Head station, carried out by the GKSS Research Centre, Geesthacht, Germany.

Continuous measurements of total gaseous mercury (TGM) concentration with a 15-min time resolution have been carried out at Mace Head since 1995 (Fig. 8.2). Mace Head, together with a Canadian site in the high Arctic, was one of the first research stations generating continuous TGM measurements at high time resolution. Since October 2001 the measurements are carried out by GKSS on a contractual basis for the EPA. Mace Head is ideally situated for studying the atmospheric composition under Northern Hemispheric background conditions. The long-term average of TGM concentration at Mace

Head is 1.7 ng/m^3 , with a seasonal variation of about 20%.

8.4 Ozone Depleting Substances at Carnsore Point

Bristol University is carrying out a feasibility study of hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) at Carnsore Point to determine the quality of the site for such measurements, and the potential for such measurements to support and advance analytical modelling methods applied to similar data for the Mace Head site in analysis of emissions and trends. To this effect, the Bristol University mobile laboratory is located at Carnsore Point for a period of 12 months to measure selected ozone depleting substances (ODSs) and greenhouse gases. The mobile laboratory is equipped with similar instrumentation to that located at Mace Head.

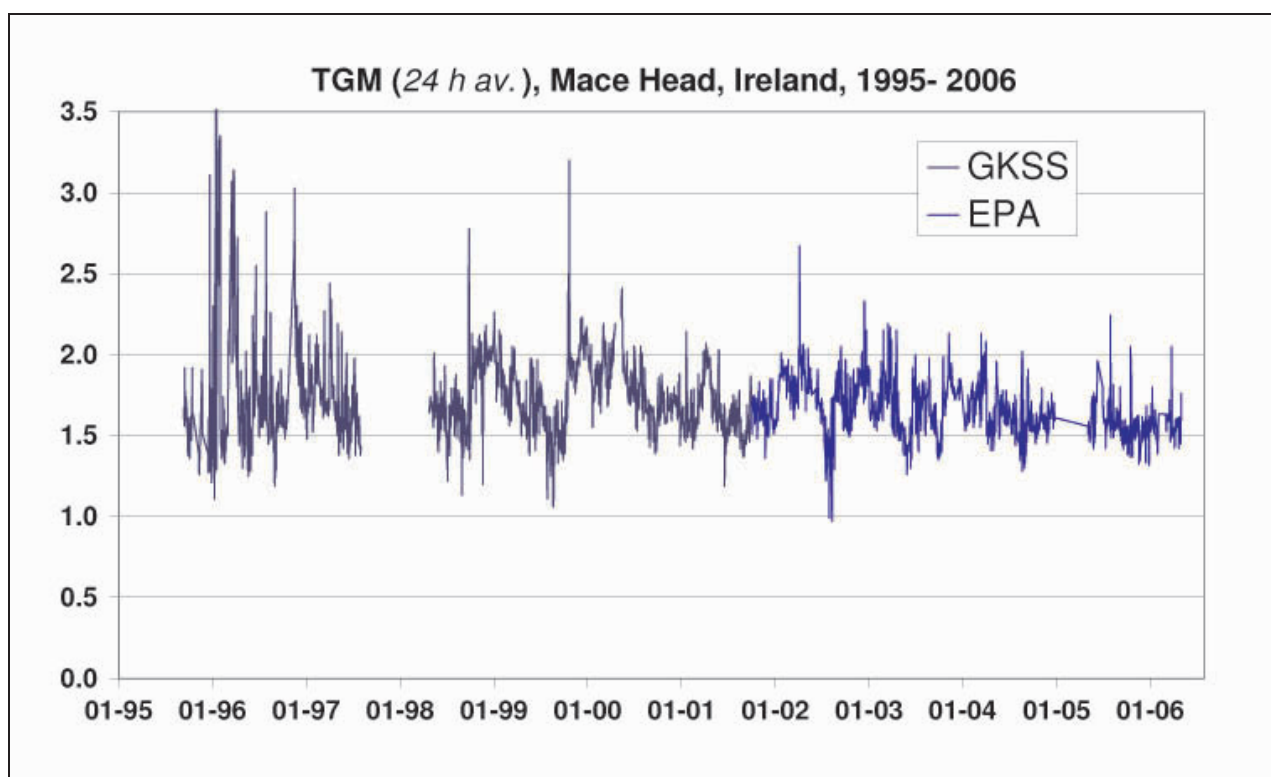


Figure 8.2. Total gaseous mercury (TGM) concentration at Mace Head, in ng/m^3 .

9 Conclusions and Recommendations

Within this ERC project new sites were established and are operational, yielding vital new data on background levels of air pollutants in Ireland and contributing to the EMEP network.

Important links have been established to the EPA Air Quality Monitoring Team, to external research groups (e.g. Ralf Ebinghaus/GKSS for mercury monitoring in Mace Head, Simon O'Doherty/Bristol University for ODS measurements in Carnsore Point), and to the EMEP/TFMM (Task Force on Measurements and Modelling) community.

Analysis of the historical data for atmospheric

pollutants from the Met Éireann Valentia Observatory was carried out (ERC Report Series No. 1).

The setting up of monitoring sites was well suited for being undertaken as a project, and a follow-up project for further consolidating the established sites, as well as interpretation of the acquired data sets, is advisable.

In the long term, however, the running, maintenance, and troubleshooting of the sites should be undertaken on a more continuous basis, e.g. by the EPA or Met Éireann, or a similar body.

10 Output

As part of this project, there are several products, apart from the physical stations being set up for monitoring. These are standard operating procedures (SOPs) for on-site personnel, as well as software for DAQ and data visualisation.

10.1 SOPs

- SOP for precipitation sampler, bottle change
- Sampling sheet for bottle change
- SOP for the HVS, filter change
- Sampling sheet for filter change
- SOP for the CPC, butanol refill
- SOP for the TEOM, filter change
- Station sheet for Carnsore Point

10.2 Data Acquisition

- DAQ program for the aethalometer
- DAQ program for the TEOM
- DAQ program for the nephelometer
- DAQ program for the CPC
- DAQ program for gas monitors.

10.3 Data Visualisation

- Data visualisation program for the aethalometer
- Data visualisation program for the TEOM
- Data visualisation program for the nephelometer
- Data visualisation program for the CPC
- Data visualisation program overview for the aethalometer, TEOM, nephelometer and CPC.

References

- Aherne, J. and Farrell, E.P., 2000. *Critical Loads and Levels*. Final Report. Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland.
- McGettigan, M., O'Donnell, C. and Toner, P., 2000. *National Air Quality Monitoring Programme, A Discussion Document*. Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland.
- McGovern, F., 2002. *National and Transboundary Air Pollution, Sources, Impacts and Policy Options, Outline Proposal*. p. 30. Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland.

The EPA's Environmental Research Centre (ERC) was established as a centre of excellence under the National Development Plan (NDP) to build capacity in environmental data handling, modelling, assessment and guidance. The objective of the ERC is to allow for a more structured approach to environmental research, through the development of advanced innovative techniques and systems to address priority environmental issues and thereby support environmentally sustainable development.