

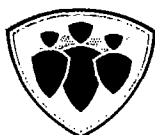


Department of Agriculture, Food
and Rural Development



Investigations of Animal Health Problems at Askeaton, County Limerick

ENVIRONMENTAL QUALITY



BÓRD SLÁINTÉ
AN MHEÁN-IARTHAIR



Agriculture and Food Development Authority

Environmental Protection Agency

Establishment

The Environmental Protection Agency Act, 1992, was enacted on 23 April, 1992, and under this legislation the Agency was formally established on 26 July, 1993.

Responsibilities

The Agency has a wide range of statutory duties and powers under the Act. The main responsibilities of the Agency include the following:

- the licensing and regulation of large/complex industrial and other processes with significant polluting potential, on the basis of integrated pollution control (IPC) and the application of best available technologies for this purpose;
- the monitoring of environmental quality, including the establishment of databases to which the public will have access, and the publication of periodic reports on the state of the environment;
- advising public authorities in respect of environmental functions and assisting local authorities in the performance of their environmental protection functions;
- the promotion of environmentally sound practices through, for example, the encouragement of the use of environmental audits, the setting of environmental quality objectives and the issuing of codes of practice on matters affecting the environment;
- the promotion and co-ordination of environmental research;
- the licensing and regulation of all significant waste disposal and recovery activities, including landfills and the preparation and periodic updating of a national hazardous waste management plan for implementation by other bodies;
- implementing a system of permitting for the control of VOC emissions resulting from the storage of significant quantities of petrol at terminals;
- implementing and enforcing the GMO Regulations for the contained use and deliberate release of GMOs into the environment;

- preparation and implementation of a national hydrometric programme for the collection, analysis and publication of information on the levels, volumes and flows of water in rivers, lakes and groundwaters; and
- generally overseeing the performance by local authorities of their statutory environmental protection functions.

Status

The Agency is an independent public body. Its sponsor in Government is the Department of the Environment and Local Government. Independence is assured through the selection procedures for the Director General and Directors and the freedom, as provided in the legislation, to act on its own initiative. The assignment, under the legislation, of direct responsibility for a wide range of functions underpins this independence. Under the legislation, it is a specific offence to attempt to influence the Agency, or anyone acting on its behalf, in an improper manner.

Organisation

The Agency's headquarters is located in Wexford and it operates five regional inspectorates, located in Dublin, Cork, Kilkenny, Castlebar and Monaghan.

Management

The Agency is managed by a full-time Executive Board consisting of a Director General and four Directors. The Executive Board is appointed by the Government following detailed procedures laid down in the Act.

Advisory Committee

The Agency is assisted by an Advisory Committee of twelve members. The members are appointed by the Minister for the Environment and Local Government and are selected mainly from those nominated by organisations with an interest in environmental and developmental matters. The Committee has been given a wide range of advisory functions under the Act, both in relation to the Agency and to the Minister.



Investigations of Animal Health Problems
at Askeaton, Co. Limerick

ENVIRONMENTAL QUALITY

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Environmental Quality

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NOTE

This document is one of a five-volume report on the investigations of animal health problems in the Askeaton area of Co. Limerick, carried out in the period 1995 – 1998. The five volumes are as follows:

- Main Report
- Animal Health
- Soil, Herbage, Feed and Water
- Human Health
- Environmental Quality

The investigations were prompted by reports of severe animal health problems on two farms in the Askeaton area, which first came to notice in the early 1990s. In February 1995, following preliminary investigations by Limerick County Council, the Environmental Protection Agency was requested by the Minister of State at the Department of Agriculture, Food and Rural Development to co-ordinate a wider study of the situation. This was considered necessary, as there were local concerns that human health was also being affected in the area and that environmental pollution was involved.

Arrangements for the undertaking of the investigative work were put in place in late February 1995, this being assigned to the Veterinary Research Laboratory of the Department of Agriculture, Food and Rural Development (animal health), Teagasc (soils, herbage and related aspects), the Mid Western Health Board (human health) and the Environmental Protection Agency (environmental quality aspects). Subsidiary studies were carried out by Coillte and the Mid Western Health Board, respectively, on tree health and the levels of metals and other substances in vegetable produce.

Field measurements and observations took place between March 1995 and December 1998. Interim reports were published in December 1995, June 1997 and August 1998.

Acknowledgements

The authors thank all of their present and past colleagues in the EPA for their assistance in the field and laboratory aspects of the environmental investigations at Askeaton and in particular Mr Jim Penny who undertook the daily collection of the precipitation samples between 1995 and 1998. Thanks are also expressed to the farmers in the Askeaton area who facilitated the placing on their lands of measuring and sampling equipment.

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Chapter One

INTRODUCTION

This report gives a detailed description of the results of the environmental and related measurements and observations made by the Environmental Protection Agency (EPA) between 1995 and 1998 during the course of the investigations of animal health problems in the Askeaton area of County Limerick. The background to and the organisation of these investigations are described in the Main Report and will not be repeated here.

It was clear at the start of the investigations that there were strong suspicions on the part of the farmers directly concerned and of many others in the farming and non-farming communities in the Askeaton area, that the animal health problems and possible human health problems were caused by environmental pollutants. Emissions from the alumina production plant at Aughinish Island, located some 8 km west of the affected farms, were a particular focus of these suspicions. Among the substances suggested to be involved were aluminium and fluoride. Other possibilities put forward were organic compounds such as dioxins and PCBs. These suggestions were not based on any record of contamination in the area although material from the scientific literature was put forward by independent advisers to the farmers as underpinning such possibilities. In view of the strong feeling on the matter locally, it was considered necessary that, whether or not the suspicions were justified, a full assessment of the pollution risks and the environmental quality position in the area be undertaken.

Prior to the investigations, Limerick County Council, as the statutory pollution control authority in the area, commenced measurements of air and precipitation quality on one of the two affected farms (Somers) in 1993. In addition, air quality monitoring networks had been operating around both the Aughinish Alumina Ltd. (AAL) and the Electricity Supply Board (ESB) plants since the commencement of their operations in the mid 1980s and some of these, particularly those operated by Forbairt (now Enterprise Ireland) for AAL, are near to the locations of the affected farms. These monitoring operations constituted the only relevant measurements of environmental quality available in the area for the period when the animal health problems were at their most severe (late 1980s to mid 1990s).

Following assessment of the pollution potential of the local industrial activity and the data from the existing monitoring programmes, the EPA commenced a preliminary measurement programme for environmental parameters in March 1995 and continued this up to September 1995. Besides examination of precipitation and air quality, this included measurements of organic compounds, including dioxins, in soil and milk. In November 1995, a more intensive regime of air quality monitoring and precipitation sampling was instituted and this continued up to the end of November 1998 in order, *inter alia*, to have contemporaneous environmental data during the course of the animal health studies. It should be noted that these environmental measurements were complemented by the investigations undertaken by Teagasc, in particular those on soil which, in addition to assessing agronomic aspects, were intended to assess the level of contamination with potential pollutants (*see* Soil, Herbage, Feed and Water volume).

The protocol for the environmental investigations is set out in the following Chapter Two. An account of the potential pollutants emitted in the Askeaton area and their possible effects is given in Chapter Three and estimates of the quantities of the main gases emitted are set out in Chapter Four. The levels of sulphur dioxide measured in the air on the Somers and Ryan farms and at other locations in the Askeaton area are described in detail in Chapter Five together with an assessment of their significance in relation to standards. Chapter Six deals with the composition of the precipitation on the farms and the levels of deposition of key substances. Levels of particulate matter in air and deposition are given in Chapter Seven and the results of the other measurements made, including organic compounds, are set out in Chapter Eight. The results of the measurements are discussed in Chapter Nine.

Chapter Two

PROTOCOL FOR THE ENVIRONMENTAL INVESTIGATIONS

GENERAL APPROACH

The investigation was designed to assess the possibility that environmental pollution was occurring in the area at a level which might cause or contribute to the animal health problems and which might also be responsible for reported human ailments. In addition, the overall approach adopted was based on a consideration that, if environmental pollution was a factor, this was most likely to be of an atmospheric nature, resulting in poor air quality and/or harmful levels of pollutant deposition on farm land.

In order to achieve this objective, it was considered necessary to undertake the following tasks.

- a) Determine the potential for emissions of atmospheric pollutants from all important industrial sources and power stations likely to affect the area under investigation and the risks associated with such pollutants
- b) Estimate the quantities of relevant air pollutants emitted from all such sources.
- c) Assess the areas of greatest impact of these emissions and whether these include the problem farms.
- d) Determine the short-term variations of the potential gaseous pollutant concentrations on the affected farms and compare with a control farm.
- e) Estimate the deposition of the other potential pollutants on the farms and compare with a control site
- f) Investigate the level and potential impact of organic compounds including dioxins

It was also decided to concentrate the bulk of the environmental measurements on the farms originally reporting problems (Somers and Ryan). The problems on these two farms were generally acknowledged to be severe so that if environmental pollution was involved, it was reasonable to expect that measurements at those locations alone should be able to confirm this hypothesis. This approach paralleled that adopted for the veterinary and the soils and herbage investigations which were also concentrated on the Somers and Ryan farms.

EMISSION POTENTIAL OF LOCAL INDUSTRY

Information was obtained at the start of the investigation on the nature of the industrial processes in the area, particularly on waste emissions, and this is set out in Appendix A. Some of this information was obtained from the local authorities and directly from the industries but a considerable amount of data was already available in 1995 from the EPA's own records. Until 1993, the pollution potential of the industries in the area was controlled solely by the local authorities (Cos Limerick and Clare) under the Water Pollution, Air Pollution and Planning Acts but in the following years several have been required to apply for Integrated Pollution Control (IPC) licences in accordance with the EPA Act, 1992. This followed an assessment of the industrial activity in the area to determine which activities fell into the categories specified in the Act as requiring an IPC licence. Among these activities was the extraction of alumina from bauxite at the AAL facility and this plant received an IPC licence in May 1998. Although the ESB electricity generating plants at Moneypoint and Tarbert are scheduled activities under the Act, the deadline for IPC licensing of these plants post-dated the investigation.

EMISSION ESTIMATION

Estimates of the nature and magnitude of the emissions from the main sources were based mainly on calculations based on fuel usage and combustion conditions. Direct measurements on emission were used where available as a check on these estimates but the availability of such data was limited.

IDENTIFICATION OF AREAS OF POTENTIAL IMPACT

The results of modelling of emission dispersal were available for several of the industries in the area including the larger waste sources (AAL and the ESB plants). In each case the predictions were based on a commonly used US EPA emission dispersion model. The modelling exercise in the case of AAL replaced an earlier model, which did not account for the same detail in relation to emission characteristics and local topography, in particular elevation. This later model gives a different prediction to the earlier version, of the locations with the potentially highest impact from the emissions.

MONITORING OF SHORT-TERM VARIATIONS OF GASEOUS POLLUTANTS

It was mentioned above that ESB, AAL and Limerick County Council had carried out air quality monitoring for some time prior to the start of the investigations. In each case, this consisted of measurements of the average daily concentrations of sulphur dioxide (SO₂) and black smoke. In view of the possibility that these measurements might mask relatively high concentrations of the gas occurring only over short periods, it was considered necessary to complement them by installing continuously recording monitors on the two affected farms which could produce average hourly concentrations. An additional monitor was placed at Ballylongford, Co. Kerry, as a control; this was later moved to the Department of Agriculture and Food farm at Abbotstown, Co. Dublin where part of the animal health trials were being conducted (see Veterinary volume).

ESTIMATION OF POLLUTANT DEPOSITION

Measurement of the atmospheric deposition of pollutants on the Somers farm had also been undertaken since 1993 by the local authority. It was decided that this monitoring needed to be expanded to obtain more accurate and detailed information. Thus, total deposition collectors were placed on the two affected farms (Somers and Ryan) in April 1995. These were changed at weekly intervals up to November 1995 and daily from then until the termination of the investigations. The samples were used to determine the levels of sulphate, fluoride and other anions and cations in precipitation. A separate series of samples was collected at monthly intervals on the two farms for metals analyses, including aluminium. This frequency of sampling was chosen in order to allow direct comparison of the results with data for Valentia Island Co. Kerry and Turlough Hill, County Wicklow where the EPA was measuring metal concentrations in monthly samples of precipitation for other purposes.

Between November 1997 and the end of the investigations in November, 1998, an additional daily collection of deposition was carried out at a location near Aughinish Island where voles trapped as part of a UCG study were shown to have hepatic enzyme anomalies (see Veterinary volume). Weekly deposition samples were collected on two other farms, and on the Somers farm for comparison, between November, 1996 and November, 1998.

ORGANIC COMPOUNDS

The nature of the industrial activities in the area does not suggest that these are likely to be significant sources of environmental contamination by complex organic compounds of low volatility such as dioxins. This is borne out by measurements on the emissions from AAL and the ESB plants (see Appendix A). However, in view of suggestions that such substances were involved in the animal health problems it was decided to undertake measurements of their levels in the local environment. These measurements were carried out mainly on samples of soil from the two affected farms but some analyses of milk were also undertaken. In addition, some sampling programme for volatile organic compounds was carried out in 1995 in order to give a complete picture of the level of contamination in the area.

OTHER MEASUREMENTS

Arising from specific concerns in the area, additional measurements were made of environmental contamination on an *ad hoc* basis during the course of the investigations. Among these were measurements of the levels of aluminium and fluoride in milk and the monitoring for the presence of dust from the “red mud” waste lagoons at AAL. In addition, a special survey of the concentrations of particulate matter in air (PM₁₀) was commissioned. In the context of a “call out” facility to address suspected pollution incidents, examinations of vegetation and other samples were arranged.

Chapter Three

POLLUTANTS EMITTED AND POTENTIAL IMPACTS

INTRODUCTION

A detailed account of the nature of the industries in the Askeaton and surrounding area is set out in Appendix A. This indicates that the main activity in these industries giving rise to atmospheric emission of pollutants is the burning of oil and coal to generate power. The bulk of this activity takes place in the two ESB electricity generating stations at Moneypoint, Co. Clare and Tarbert, Co. Kerry and in the AAL alumina processing plant at Aughinish, Co. Limerick (see Fig. 3.1). The other main sources of atmospheric emissions in the area are the production processes, particularly calcining, at AAL. The pollutants arising from these and other activities in the area are discussed below.

SULPHUR DIOXIDE AND NITROGEN OXIDES

Sulphur dioxide (SO_2), arising from the oxidation of sulphur in the coal and oil, and nitrogen oxides (NO_x), (sum of nitric oxide (NO) and nitrogen dioxide (NO_2)), formed by the oxidation of atmospheric nitrogen in the high temperatures generated, are the main gaseous pollutants emitted by the combustion of oil and coal in the area. Both SO_2 and NO_2 are irritants of the respiratory system in man, asthmatics being particularly vulnerable, and they may also cause aggravation of cardiovascular disease.

There is little information in the literature on the direct effects of the pollutants on farm livestock (Brennan and Dowding, 1995) although experimental work with a variety of laboratory test animals have shown similar effects to those observed in man. In addition, high concentrations of SO_2 and NO_x in air can directly damage vegetation especially in combination with other stresses such as cold. It is noted that the recently issued EU directive dealing *inter alia* with air pollution by SO_2 and NO_x (CEC, 1999) has set limits on the concentrations of these gases relevant to the protection of ecosystems.

Both SO_2 and NO_x contribute to the "acid rain" phenomenon due to their conversion in the upper atmosphere to sulphur and nitric acids; this process is relatively slow and the main impacts are likely to occur well away from the emission sources. However, some deposition of sulphur may occur locally due to absorption on particulate matter and washout in rain. A substantial increase of soil sulphur levels resulting from such deposition could interfere with the uptake of minerals into herbage thereby creating a risk of ill health in livestock.

PARTICULATE MATTER

Combustion of fuel, such as coal at the Moneypoint plant and oil at the Tarbert and AAL plants, gives rise to the emission of particulate matter (PM) of mainly carbonaceous origin. PM may also be formed by reactions between other pollutants, such as SO_2 , NO_2 , volatile organic compounds and ammonia. Epidemiological studies have shown a relationship between the concentrations of such matter in the air and the incidence of various respiratory ailments, especially in the case of the smaller size fractions of less than 10 micrometres (PM_{10}).

Particulate matter is also emitted from the calciner and other process vents at AAL and, in addition, may be swept into the air from the surface of the waste ("red mud") lagoons. Besides their mechanical properties, the latter material contains metals (see next section). Particulate matter in general may have organic compounds adsorbed and thus introduce such substances to the respiratory system when inhaled.

METALS

There are releases to the local environment of metals and metallic compounds, such as vanadium from the fuel oil used at Tarbert and AAL, and alumina (aluminium oxide) from the calcining operations at AAL. There is also a potential for dust, containing metallic compounds, to be blown on to adjoining land from the waste lagoons at AAL, these compounds mainly consisting of oxides of iron and titanium. Metals and their compounds are

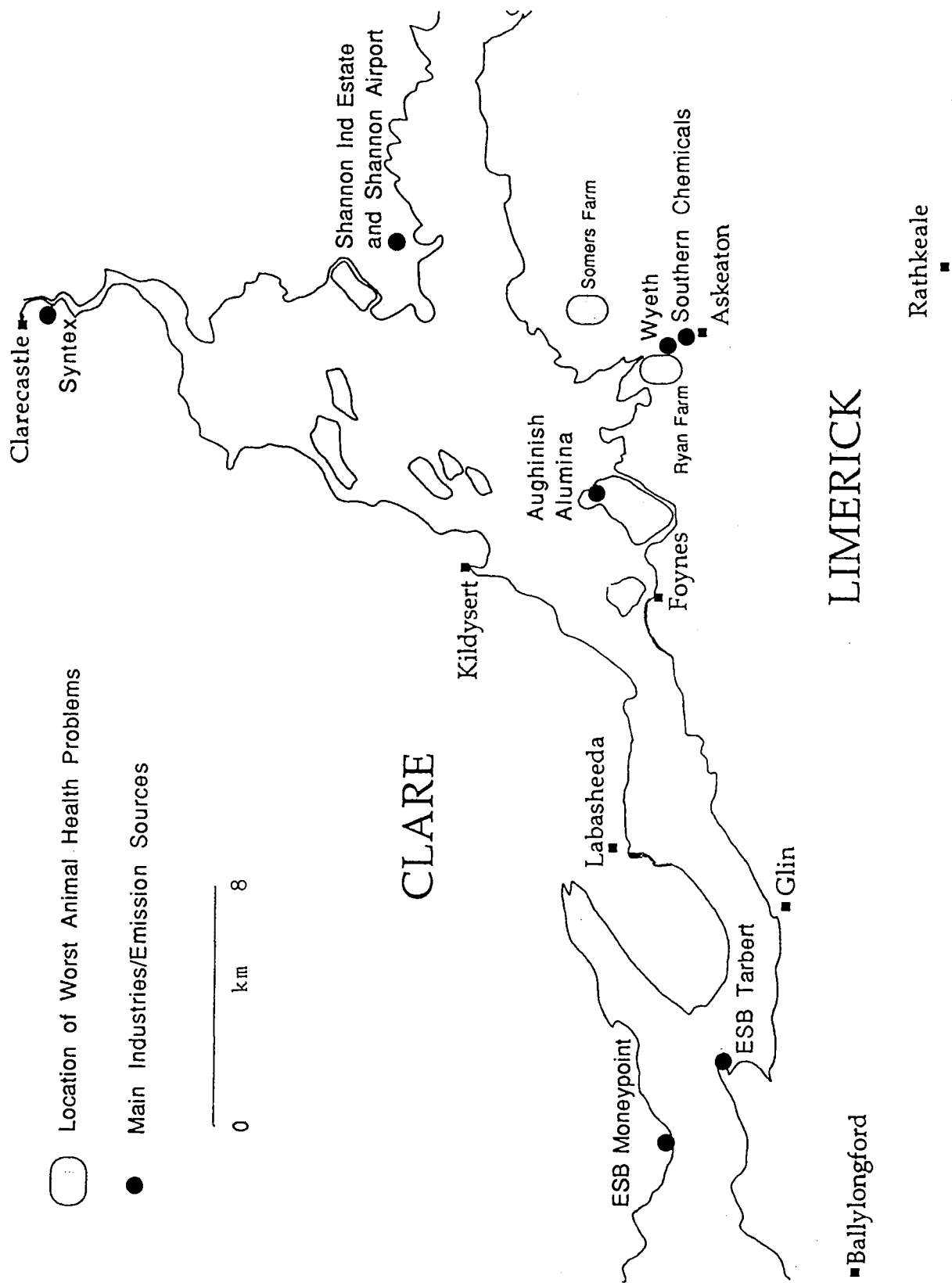


Fig. 3.1 Locations of the main industrial activities in the Shannon Estuary region

potentially toxic to plants and livestock but it should be noted that those aforementioned are of relatively low toxicity and are present naturally in soils at substantial concentrations (see Soils, Herbage, Feed and Water volume). There are no significant releases of the more toxic metals, such as cadmium, to the local environment.

At the start of the investigations, suggestions were made locally that aluminium contamination could be involved in the animal health problems in view of the proximity of the AAL plant. Aluminium salts are known to affect livestock through interference with phosphorus uptake from the gut leading to a variety of physiological dysfunctions. The risk of this effect in the Askeaton area is lessened by the fact that the form of aluminium released from AAL is the oxide which is relatively non-reactive and, thus, of low toxicity. As mentioned above, however, aluminium was measured in precipitation in order to determine if above normal levels were being deposited in the area. In addition, livestock have been checked for symptoms of aluminium poisoning (see Animal Health volume).

ORGANIC COMPOUNDS

There are no major sources of synthetic organic compounds in the Askeaton area but small amounts of such substances are emitted from a number of plants (see Appendix A). Methyl ethyl ketone, a solvent emitted from the Wyeth milk processing plant, where it originates in laquers, is the most notable organic compound emitted. Styrene (vinylbenzene) is released in the cutting of polystyrene blocks in the Southern Chemicals plant but there is no specific venting of this to the atmosphere. Concentrations in the plant resulting from fugitive emissions have been measured at less than 10 ppm, which can be compared to an occupational hygiene exposure limit of 50 ppm.

Further afield, several organic solvents such as acetone and toluene are released from the Roche (formerly Syntex) pharmaceutical plant near Clarecastle in Co. Clare. However, there has been a large reduction in these emissions recently due to the introduction of an incineration facility for the disposal of waste solvent. In addition, various organic compounds are emitted by smaller industries in the Shannon Industrial Estate.

Exposure to high concentrations of these substances is likely to have adverse effects such as dizziness, drowsiness, headache and nausea. However, the amounts emitted indicate that ambient concentrations in the Askeaton area would be insignificant and would not constitute a risk to human health. Measurement of volatile organic compounds was undertaken to confirm this assessment and the results are given later in the report.

At the start of the investigation there were suggestions that dioxins and related compounds might be involved in the animal health problems. A consideration of the industrial activity in the Askeaton area did not suggest that the area was exposed to any particular risk in this respect, other than the emissions from ubiquitous sources such as motor vehicles and the local burning of rubbish. Measurements undertaken on the emissions from the ESB plants and AAL confirmed that the dioxin levels in these waste streams were within the guideline limits for dioxin content (See Appendix A). In 1996, the EPA issued an IPC licence to Roche Ireland Ltd (formerly Syntex) in Clarecastle to operate an incinerator for the disposal of waste solvent. While this is a potential source of dioxins and other chlorinated organics, strict controls on the emissions of such compounds are contained in the licence and there is a specific monitoring scheme in place to ensure their enforcement.

In view, however, of the public concern expressed at the start of the investigations, it was considered advisable to conduct measurements to establish the levels of these substances in the local environment. The results of these measurements are set out in Chapter Eight.

NOTE ON FLUORINE

Fluorine was also mentioned as a possible pollutant in the area. This substance is known to have specific effects on livestock, including mottling of teeth. However, the main potential for fluorine pollution in aluminium production is associated with the smelting industry in which a fluorine-containing compound is used as a catalyst. The AAL facility is concerned solely with the extraction of alumina from bauxite, the product being shipped to smelters in the UK and further afield. It is known that due to local geological characteristics, soils in some parts of the Askeaton area have relatively high levels of fluorides (see Soil, Herbage, Feed and Water volume). Again, however, it was considered necessary to try and allay local concerns by establishing the factual position in regard to environmental levels of the substance in the local environment. These are given in Chapter Six in respect of precipitation and in Chapter Eight for milk.

Chapter Four

ESTIMATION OF EMISSION LEVELS OF SO₂ AND NO_x FROM MAIN SOURCES

INTRODUCTION

Detailed estimates were made of the quantities of SO₂ and NO_x emitted in the general area of Askeaton as these were clearly the pollutants with by far the greatest potential to cause environmental problems in the area. The main purposes of making these estimates were to determine the potential for air pollution in the area and to assess any trends in the quantities of the gases emitted in the period of interest (late 1980s to date).

EMISSIONS OF SO₂

Quantification Methodology

The estimations of the quantities of SO₂ emitted from the ESB plants at Moneypoint and Tarbert and from the AAL plant were based on fuel usage and sulphur content, together with information on the rates of SO₂ emission for different operating conditions at the plants. Measurements on stack gas composition were not comprehensive enough to allow direct calculations of emission rates. However, calculation based on sulphur content of fuel used is considered a sufficiently accurate method for the present purposes. Information on fuel usage and sulphur contents was made available by the operators of the plants together with records of independent assessment of sulphur contents (see Appendix A).

Emission Quantities and Trend

The estimated annual emissions of SO₂ from the ESB plants at Moneypoint and Tarbert and the AAL plant, together with the combined emissions from the other, smaller sources in the area, are set out in Table 4.1 for the years 1988 to 1999, inclusive.

Table 4.1

Estimated annual emissions (tonnes) of SO₂ from the ESB plants at Moneypoint and Tarbert, AAL and minor sources in the Askeaton area, 1988–1999

Year	ESB Moneypoint	ESB Tarbert	AAL	Others	Total
1988	47200	9220	11310	1000	68730
1989	67430	7300	11540	1000	87270
1990	74350	12540	15070	1000	102960
1991	65360	19070	14040	1000	99470
1992	56990	16430	15500	1000	89920
1993	47860	23370	15720	1000	87950
1994	52010	20000	19475	1000	92485
1995	51130	20460	14947	1000	87537
1996	41470	25370	13827	1000	81667
1997	42350	33186	15512	1000	92048
1998	46112	35837	16086	1000	99035
1999	40354	34361	16438	1000	92153

ESB Plants

The combined SO₂ emissions from the two ESB plants were not much different in the more recent years of the period for which data are shown in Table 4.1. However, there has been a marked increase in the level of emission from the Tarbert oil-fired plant over the whole period, the current emission rate being nearly four times that for 1988. This reflects an increasing uptake of the capacity of this plant, part of which had been stood down in the 1980s, in order to meet national demands for electricity. In

contrast, the emissions from Moneypoint show a reduction in recent years, reflecting the use of coal with lower sulphur content. In 1999 emissions of SO₂ from this plant were just over half of those estimated for 1990. Variations in the emissions of both plants are accounted for in part at least by the time they are out of service for repair or overhaul in any year.

AAL Plant

In the case of the alumina plant at Aughinish, which modelling indicates is likely to be the main influence on SO₂ levels in air in the Askeaton area, annual emissions of SO₂ varied from a minimum of 11310 tonnes in 1988 to a maximum of 19475 tonnes in 1994. In several months in 1994, SO₂ emissions exceeded the limits set in the planning permission; they arose from deliveries of oil to the plant, which were above specification (3%) for sulphur content. Apart from those in 1994, the annual emissions of SO₂ from the plant showed relatively little variation between 1990 and 1999.

The IPC licence granted to AAL in 1998 sets a limit of just over 23000 tonnes per annum for the total annual emission of SO₂ from the plant. This includes an individual limit of some 700 tonnes per annum on the emission from a proposed salt cake calciner which is not yet operational. The figure of 23000 tonnes is an increase on the limit of some 17000 tonnes set under the local authority planning permission which prevailed before the introduction of the IPC licence. However, it is clear from the data in Table 4.1 that the actual emissions were within both limits in the years after 1995. Currently, the EPA is considering an application for a revision of the IPC licence to provide for the installation of a Combined Heat and Power (CHP) system using natural gas. This approach would obviously lead to a near elimination of SO₂ emissions from the plant.

Other Sources

Compared to the foregoing, the other sources of SO₂ emissions in the Askeaton area are small and are estimated to amount to no more than 1000 tonnes *in toto* per annum. The larger of such sources are the boilers at the Wyeth milk processing plant and Southern Chemicals.

Total Emissions

Over the period of record shown in Table 4.1, the total emissions of SO₂ from industry in the area varied from approximately 69000 tonnes in 1988 to 103000 tonnes in 1990. However, subsequent to the latter year, annual emissions of the gas have shown a much smaller degree of variation. The combined emissions from the ESB two plants account for the bulk of the total, the proportion over the period varying from 77 to 85 per cent.

EMISSIONS OF NITROGEN OXIDES (NO_x)

Quantification Methodology

The emissions of NO_x were estimated using emission factors applicable to the combustion conditions in the different plants, as determined from direct measurements. These estimates are subject to considerably more uncertainty than in the case of SO₂.

Emission Quantities and Trend

The emissions of NO_x from the ESB plants and from AAL in the 1988-1999 period are given in Table 4.2.

ESB Plants

For the ESB plants, the variation over the period was similar to that for SO₂. The emissions from the Moneypoint plant showed a decrease through the 1990s due to the application of low-NO_x burners while those from Tarbert show a marked increase in line with the much greater use of the plant. The estimated emissions of NO_x from the latter plant in 1999 were almost exactly five times those for 1988.

AAL Plant

NO_x emissions from AAL, in contrast to the position for SO₂ at this plant, showed an upward trend over the period. However, the 50 per cent increase over the period was much less than the increase of NO_x emissions at Tarbert.

Other Sources

The smaller sources in the Askeaton area were estimated to account for some 150 tonnes of NO_x per annum. This is insignificant compared to the foregoing sources.

Table 4.2

Estimated annual emissions (tonnes) of NO_x from the ESB plants at Moneypoint and Tarbert, AAL and minor sources in the Askeaton area, 1988 – 1999

Year	ESB Moneypoint	ESB Tarbert	AAL	Others	Total
1988	22890	1172	1725	150	25937
1989	29366	1120	1844	150	32480
1990	29197	1658	1911	150	32916
1991	28894	2624	1973	150	33641
1992	35769	2247	2095	150	40261
1993	29629	2936	1971	150	34686
1994	27757	3323	2190	150	33420
1995	25196	3040	2230	150	30616
1996	23920	3780	2200	150	30050
1997	21970	4396	2516	150	29032
1998	21827	5199	2600	150	29776
1999	19399	5569	2663	150	27781

Total Emissions

During the review period, the total annual emission of NO_x from the industrial sources in the area varied from around 26000 tonnes in 1988 to 40000 tonnes in 1992. However, after the latter year, a gradual decrease in emission of NO_x occurred, due to reductions at Moneypoint. Thus the estimated total emission for 1999 was only 7 per cent greater than that for 1988. As with SO₂, the bulk of the NO_x emissions in the area come from the ESB plants, these together accounting for over 90 per cent of the total emission in most years in the period.

CONCLUDING COMMENTS

The industrial emissions of SO₂ and NO_x in the Askeaton area are relatively large in the Irish context and account for a considerable proportion of the national emissions of these gases. The 99000 tonnes of SO₂ estimated for the Askeaton area sources (Table 4.1) in 1998 represent 56 per cent of the national emission of 175000 tonnes of the gas estimated by McGettigan and Duffy (2000) for that year. The equivalent figure of 28000 tonnes for NO_x (Table 4.2) accounted for approximately 23 per cent of the national emission in 1998. These national emissions include the contribution from transport.

The emissions from AAL are more relevant in the present context than those from the ESB plants due to their proximity of their release point to the area with reported livestock health problems. Modelling of the dispersal of SO₂ from the plants (see Chapter Five) confirms this. While there was an increase in the emissions of SO₂ from AAL in the early 1990s and of NO_x throughout the period, these changes were not very large. The maximum annual emissions of SO₂ and NO_x from the plant in the period were, respectively, 172 and 156 per cent of the minima. It may be noted also, that the emissions of SO₂ from the plant in the period when the livestock rearing trials were being conducted on the Somers and Ryan farms were similar if not greater than those when livestock health problems were at their most severe.

However, it is the fate of these emissions in the environment which is the more pertinent consideration for the investigation and this is taken up in the next chapter.

Chapter Five

SULPHUR DIOXIDE CONCENTRATIONS IN AIR

BACKGROUND

It has been pointed out above that the main pollutant emitted to the atmosphere in the Askeaton area is sulphur dioxide (SO₂). The emissions of the gas in the area are relatively large in the Irish context and *a priori* create a potential for air pollution. It was considered, therefore, that detailed measurements of the ambient levels of the gas on the affected farms should be a key element of the environmental investigations. While there is little evidence in the scientific literature that the direct effect of SO₂ on the health of livestock has received much attention (Brennan and Dowding, 1995), indicating, perhaps, that the gas is not usually regarded as causing a problem in that respect, it was considered that the allegations of human respiratory ailments in the area, if substantiated, could be attributable to raised levels of SO₂. In addition, measurements of the gas could be useful as a means of tagging the impacts of the emissions of other harmful substances, such as nitrogen oxides, from the same sources.

The initial investigation set out to explain the illness and death of cattle on an unprecedented scale, as reported by some local farmers. It was expected that if stack emissions from nearby industrial sources were involved, there would have been regular occurrences of high levels of SO₂ due to events such as the grounding of the emission plumes for short periods. Using SO₂ as a marker would make the impact of the stack gases easy to detect, even if any damage caused was due to other materials in the emission. Conversely, low levels of SO₂ would indicate low levels of co-emitted stack gases.

LIMITS FOR SULPHUR DIOXIDE IN AIR

National limits for SO₂ in ambient air were implemented by Regulations in 1988 (DoE, 1988) giving effect *inter alia* to the provisions of the corresponding EU Directive (CEC, 1980). These limits (Table 5.1) are based on the daily mean concentrations of the gas and, in addition, are linked with limits for particulates as black smoke. The limits set are primarily intended to protect human health, in particular the respiratory system. Monitoring carried out by the local authorities at some 60 locations throughout the State, mainly in the urban areas, show a high degree of compliance with the standards in recent years (McGettigan, 2000; McGettigan and McGovern, 2001).

Revised limits for SO₂ (Table 5.2) have been set by the first daughter directive (CEC, 1999) to issue under the framework directive on air quality (CEC, 1996) and those pertaining to the protection of human health must be adhered to by 2005. It may be noted in particular here that the new directive introduces a limit of 350 µg/m³ for the average hourly concentration of the gas and permits only 24 exceedances of this concentration among the 8760 individual measurements recorded in a 365 day year (99.7 percentile). The daughter directive also sets a 24 hour limit of 125 µg/m³ which is much lower than that set by the earlier directive and may be exceeded on only three days in the year; this is effectively a 99 percentile compliance rate compared to 98 percentile for the existing standards of 250-350 µg/m³. In addition, the new directive sets an annual average limit of 20 µg/m³ for the protection of ecosystems; however, there is no limit in the Directive specifically associated with livestock health.

POTENTIAL FOR AIR POLLUTION IN THE ASKEATON AREA

The amelioration of the pollution potential of atmospheric emissions depends on the efficiency of the dispersal processes. Mathematical modelling of such processes can provide useful insights into the likely effects of emissions and this has been carried out for all of the major sources in the area.

Aughinish Alumina (AAL) Plant

A dispersion modelling study in relation to SO₂ emissions from the AAL plant was undertaken in July 1995 as part of the submission to the EPA for an Integrated Pollution Licence (ENVIROCON, 1995). The study was

Table 5.1Air Quality Standards for SO₂ and smoke set by National Regulations (µg/m³)

Statistic	Limit value for SO ₂	Associated Smoke Concentration	Limit value for Smoke
Annual median of daily mean values	80 120	>40 = or <40	80
Winter median of daily mean values	130 180	>60 = or < 60	130
98-percentile of daily mean values	250 350	>150 = or < 150	250
Not more than three consecutive days	250 350	>150 = or < 150	250

Table 5.2Limit values for SO₂ to be attained by January 2005 under EU Directive 1999/30/EC

Purpose	Averaging Period	Limit Value (µg/m ³)
Protection of Human Health	1 hour	350 not to be exceeded more than 24 times in a calendar year
Protection of Human Health	24 hours	125 not to be exceeded more than three times in a calendar year
Protection of Ecosystems	Calendar Year and winter (1 October to 31 March)	20*

*To be attained by July 2001

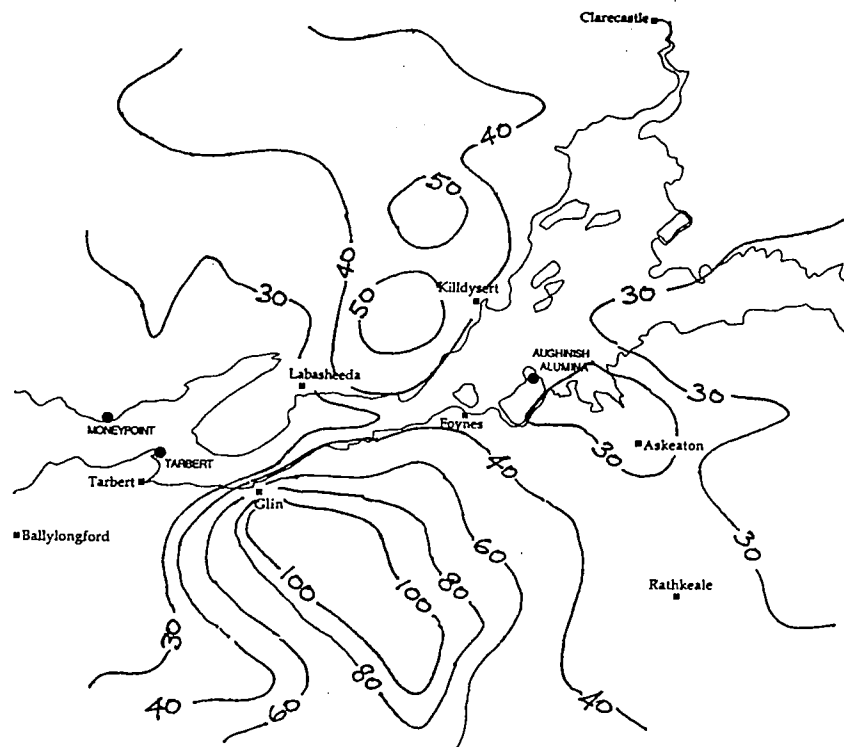
based on a standard US EPA dispersion model, widely used in this type of assessment. This superseded a previous modelling study carried out by Ove Arup, Consulting Engineers, for the plant owners, and incorporated an improved representation of physical characteristics of the emission from the plant as well as taking account of topographical effects on resultant ground level concentrations.

A selection of the ENVIROCON model results is summarised on Fig. 5.1. The predictions relate to maximum emission load conditions and are based on five-year meteorological data for the period 1990 through 1994. The model predicts much higher hourly concentrations of SO₂ for areas of high ground to the south of Foynes than it does for the Askeaton area, a marked difference with the earlier model which predicted that maximum concentrations would occur in the vicinity of Askeaton. The difference may be explained by the fact that the earlier model did not treat high ground with the same emphasis as the ENVIROCON model, i.e. it was not so terrain-sensitive.

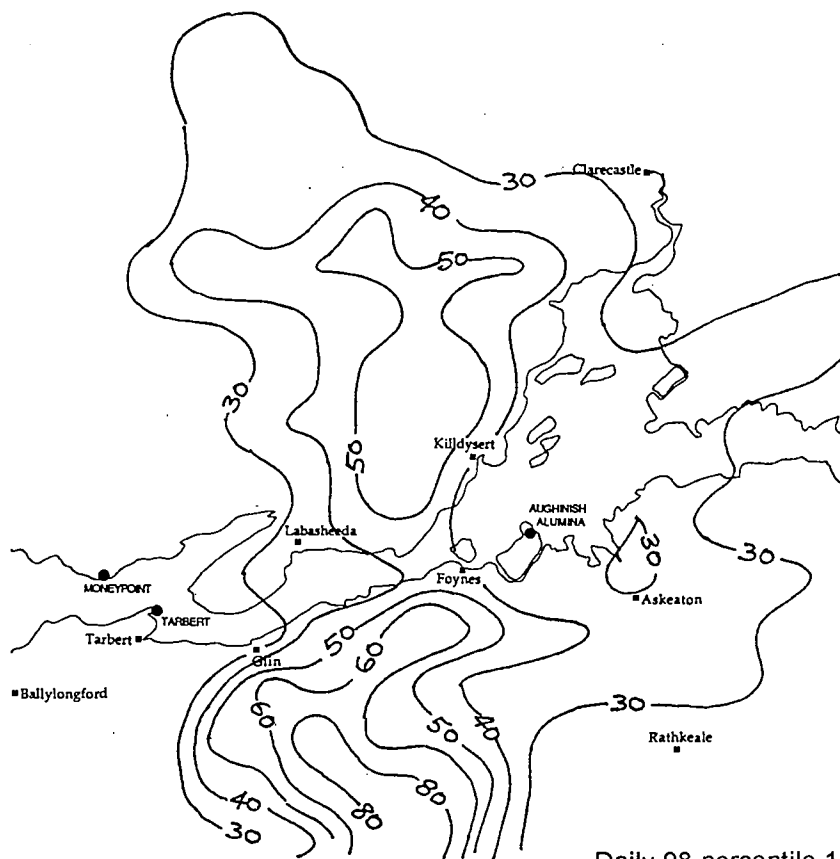
For the area in which the two problem farms are situated, the model predicts increases in ground-level concentrations of SO₂, due to the emissions from the alumina plant, of approximately 4 µg/m³ in respect of the annual average, 50 µg/m³ for the maximum daily average and 75 µg/m³ in the case of the maximum hourly value. The model predicts a 98-percentile value of 25 µg/m³ for the daily average concentrations in the area due to SO₂ emissions from AAL (Fig. 5.1). On this basis, and allowing for background concentrations, it is clear that the predicted ambient concentrations resulting from the emissions from the plant would not approach the



Fig. 5.1 Model predictions of SO₂ concentrations (µg/m³) – Aghinish Alumina emissions



Daily 98-percentile 1990 ($\mu\text{g}/\text{m}^3$)



Daily 98-percentile 1994 ($\mu\text{g}/\text{m}^3$)

Fig. 5.2 Model predictions of SO₂ concentrations ($\mu\text{g}/\text{m}^3$) – ESB Moneypoint and Tarbert emissions

currently applicable limit (Table 5.1). The predicted maximum hourly concentration for the area indicates that the corresponding limit of $350 \mu\text{g}/\text{m}^3$ in the 1999 directive would also be adhered to by a considerable margin.

ESB Plants at Moneypoint and Tarbert

Dispersion modelling of SO_2 emissions from the ESB power plants at Moneypoint and Tarbert has been carried out by the ESB using the same US EPA model as for AAL. Actual conditions were simulated for 1990 - the year of largest SO_2 emissions - and for 1994 for the two plants combined. Again, the purpose of the exercise was to produce a realistic output for SO_2 which would indicate the general impact of these plants on ambient concentrations and which could be compared with measured values and some relevant reference or standard. The concentration contours over the area of interest in respect of the 98-percentile of daily values are given on Fig. 5.2 for both 1990 and 1994. The model predicts a daily 98-percentile concentration of $30 \mu\text{g}/\text{m}^3$ for the Askeaton area for both years due to the combined emissions from the two ESB plants.

Dispersion of Emissions from Smaller Sources

Dispersion modelling in the mid 1990s by Forbairt in relation to the Southern Chemicals and Wyeth sources, again using US EPA approved models, indicate negligible impact on ambient SO_2 levels in the area of interest. This is to be expected, given their relatively small SO_2 emissions (950 tonnes and 70 tonnes, annually, for Wyeth and Southern Chemicals, respectively, based on 3.5 per cent sulphur in oil). In each case, the greatest impact would be within 500 m of the plants under stable (poor dispersion) conditions where maximum hourly concentrations of about 160 and $100 \mu\text{g}/\text{m}^3$, respectively, are predicted. Parts of the Ryan farm lie within this distance from the Wyeth plant but the Somers farm is considerably further away.

Dispersion modelling in relation to solvent emissions from the Syntex plant at Clarecastle was undertaken, at the request of the EPA, as part of the submissions for an IPC licence (Fehily, Timony, Weston, 1995). Model predictions for a range of volatile organic compounds emitted from the plant were compared with arbitrary public exposure limits, set as one hundredth of the relevant occupational short-term exposure limits, or other suitable standards, where appropriate. Predicted maximum ground level concentrations in all cases were below the chosen ambient standards, even for the worst-case scenario of simultaneous maximum emissions from all stacks. This information, together with EPA emission measurement data for existing discharges for the plant formed the basis for the IPC licence which was issued to Syntex on 10 October 1995.

Combined Impact of Emissions

It is clear from the foregoing that, apart from very local effects, the main sources likely to impact the air quality in the area are the AAL plant and the two ESB stations. The modelling indicates that the SO_2 concentrations in the Askeaton area resulting from the combined emissions of these plants should not have exceeded the existing or new standards in the period of interest. Since nitrogen oxides are emitted in smaller amounts than SO_2 and are likely to be dispersed in a similar manner, the modelling would indicate an even lower risk of pollution by those gases.

SULPHUR DIOXIDE CONCENTRATIONS IN THE ASKEATON AREA

Daily Measurements

Due to the possible involvement of environmental pollution, Limerick County Council, as the statutory pollution control authority, commenced measurements of average daily SO_2 concentrations on the Somers farm in 1993. In addition, similar measurements of SO_2 by the ESB at a network of stations in the area around the power plants at Tarbert and Moneypoint and by Forbairt, on behalf of AAL, at locations in the Askeaton area had commenced some eight years before the investigations. In all these cases, the standard 8-day samplers were used as specified in British Standard 1747; the concentrations of the gas are calculated from the change in acidity of the dilute peroxide solution through which air is drawn, assuming the change to be caused by SO_2 trapped in the solution. The locations of the stations are shown in Fig. 5.3.

Summaries of the data arising from a representative selection of the stations in the AAL and ESB networks between 1987 and 1998 are given in Figs 5.4 and 5.5. These show that the annual 98 percentile values of the daily average concentrations are well within both of the current limits of 250 and $350 \mu\text{g}/\text{m}^3$. The more stringent daily limit of $125 \mu\text{g}/\text{m}^3$, to be achieved nationally by 2005 and of which three exceedances are allowed in a year, was also respected at each monitoring station in the network. It is notable that the levels measured at the AAL locations in the Askeaton area are generally lower than those at the ESB locations further west towards

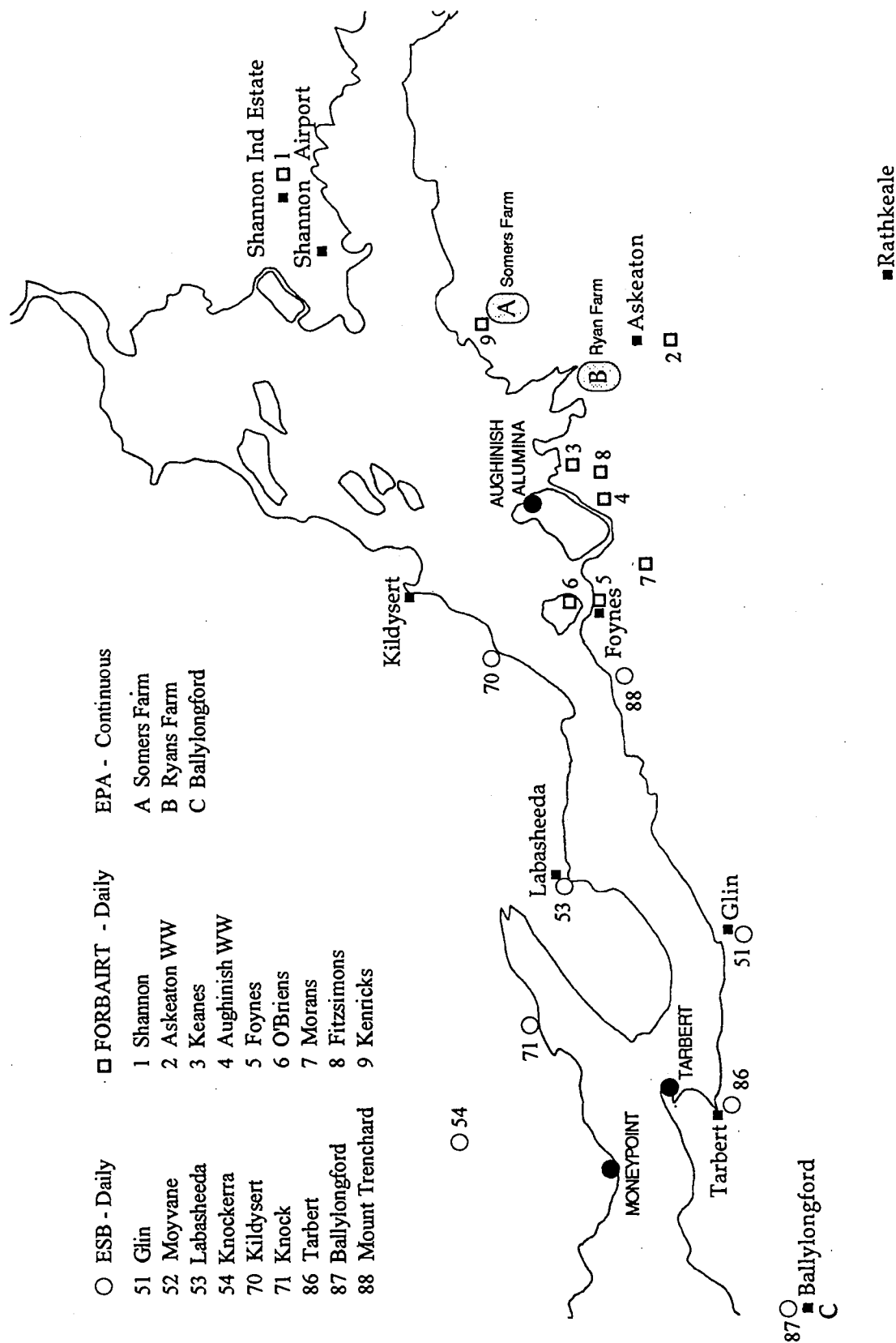


Fig. 5.3 Locations of air quality monitoring stations in the Askeaton and surrounding area

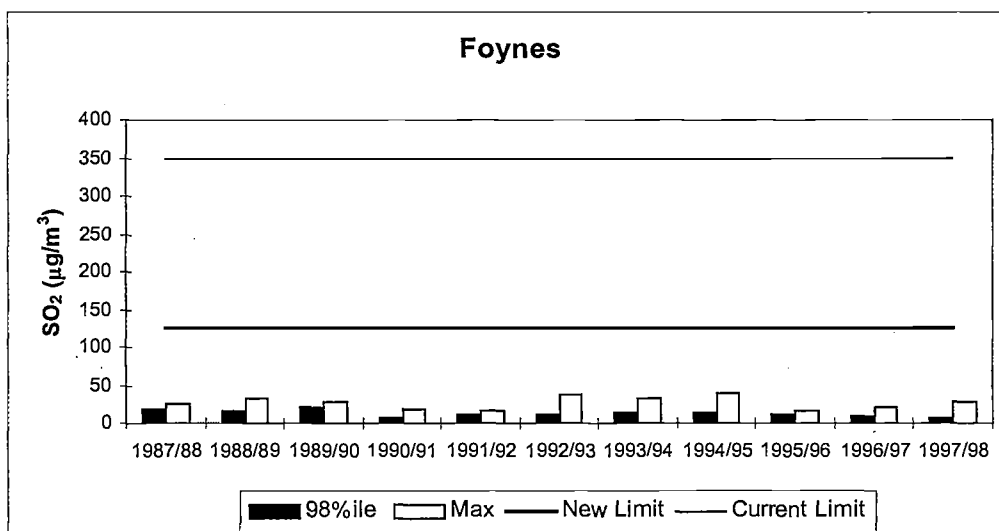
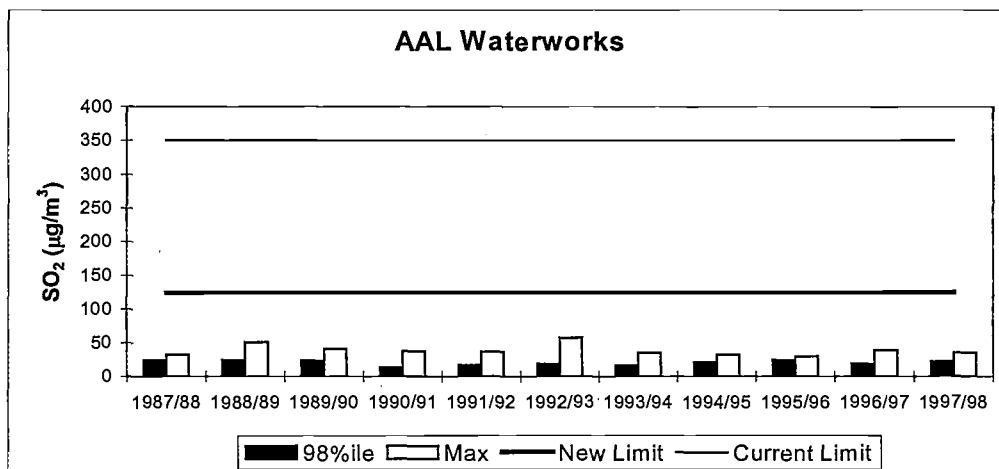
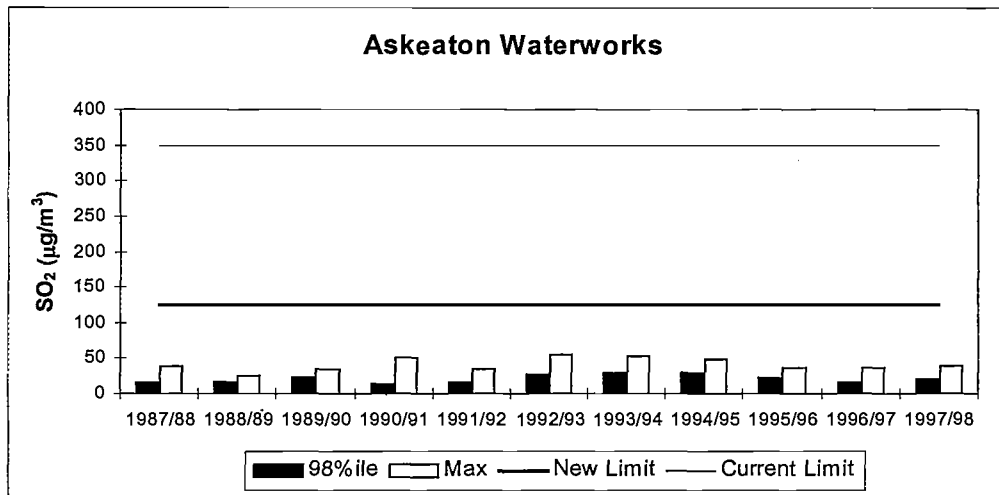


Fig. 5.4 Annual 98 percentile and maximum values of the daily average concentrations of SO₂ at selected stations in the AAL air quality monitoring network compared to current (98 percentile) and new (99 percentile) EU limits.

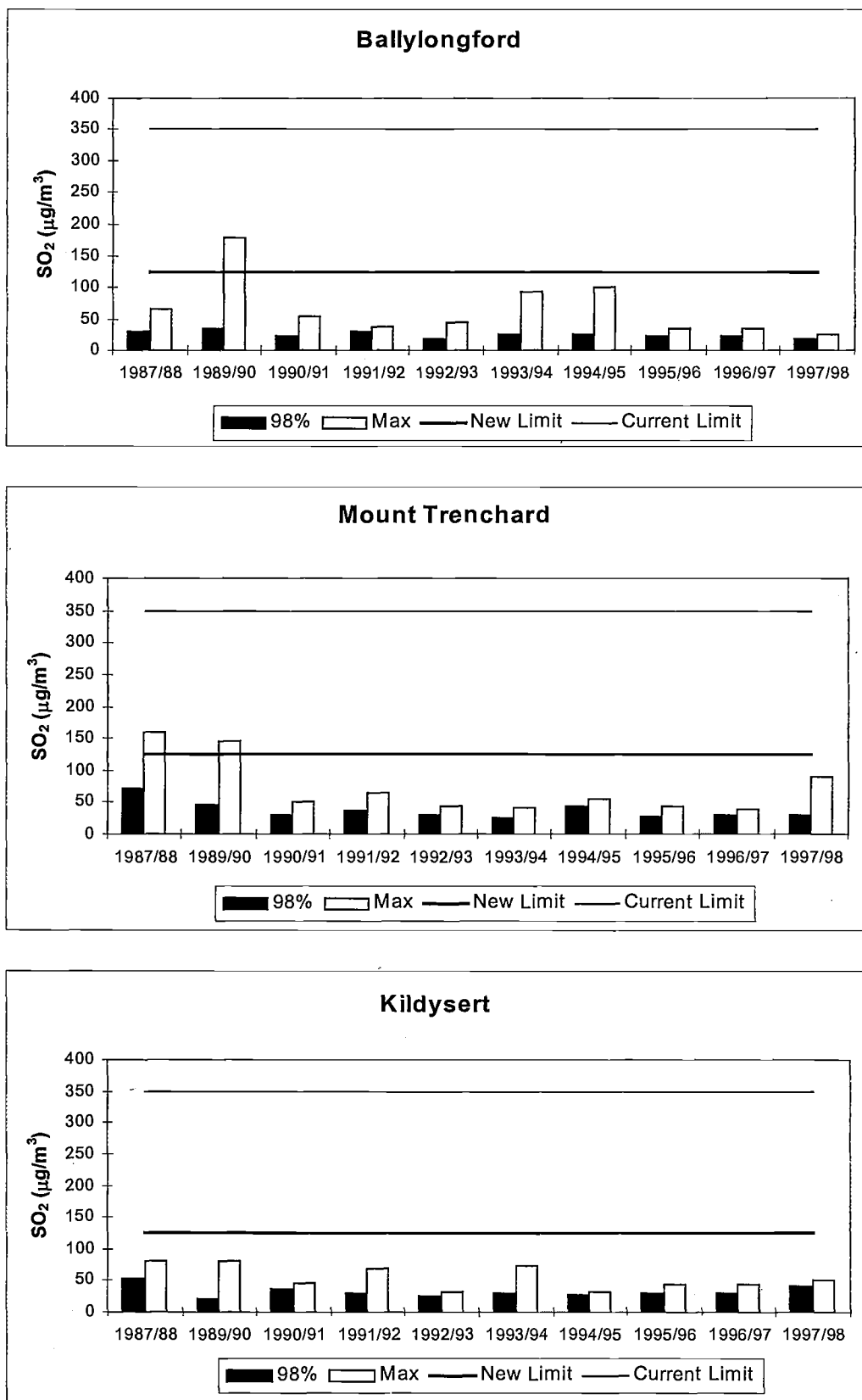


Fig. 5.5 Annual 98 percentile and maximum values of the daily average concentrations of SO₂ at selected stations in the ESB air quality monitoring network compared to current (98 percentile) and new (99 percentile) EU limits.

Moneypoint and Tarbert. Daily samples taken by Limerick County Council at Somers farm had shown that 24-hour average values were generally less than 20 µg/m³.

While the earlier Directive includes a limit of 120 µg/m³ for the annual median of the daily values, a more stringent limit of 20 µg/m³ for the annual mean concentration is set specifically for the protection of ecosystems in the new Directive. This limit, which must be achieved by July 2001, is particularly relevant in the current context. The annual mean values for the representative stations in the two networks are shown in Table 5.3. All of these stations show compliance with the annual limit in the 1987-1996 period which encompasses the years when problems on the Somers and Ryan farms were at their most severe. Examination of the data for all of the stations in the two networks indicates that this annual limit is respected across the whole area covered. However, it is notable that the values for the ESB stations are generally higher than those recorded at the AAL sites. However, it is probably not justified to read too much significance into this difference as the measurement method is at the limit of its detection capability below 20 µg/m³.

Table 5.3

Annual mean concentrations of SO₂ (µg/m³) measured at representative stations in the AAL and ESB monitoring networks between 1987 and 1996. Averaging period is 1st April to 31st March for the ESB sites and 1st November to 31st October for the AAL sites.

Year	AAL Sites			ESB Sites		
	Askeaton Water Works	AAL Water Works	Foynes	Ballylongford	Mount Trenchard	Kildysert
1987/1988	6	9	6	7	15	18
1988/1989	6	9	6	9	12	16
1989/1990	4	6	5	8	12	16
1990/1991	1	2	1	10	14	12
1991/1992	2	3	1	6	9	12
1992/1993	5	5	1	9	11	12
1993/1994	5	3	1	7	10	13
1994/1995	4	3	2	9	8	13
1995/1996	9	8	6	8	11	14

Hourly Measurements

Background

The results of the measurements available at the start of the investigations indicated, as shown above, that concentrations of SO₂ in the Askeaton area were relatively low. However, since the individual measurements were daily averages, the possibility remained that these masked short episodes of much higher concentrations which might explain the reports of respiratory irritation experienced by some local persons. It was decided, therefore, that it would be useful to set up continuous monitors capable of detecting any such episodes by measuring and recording short-term levels. While these monitoring instruments operate by continuously sampling and analysing the air, average values of one-hour duration were stored for comparison with internationally accepted air quality standards. It was decided further that this recording of short term variations of SO₂ concentrations should be carried out on the two affected farms.

Monitoring for extreme environmental conditions, which could have accounted directly for the reported animal health problems, was carried out during 1995. While no evidence for regular, short-term high levels of SO₂ was found in this initial phase of the investigation, it was decided that the monitoring should continue for the duration of the veterinary studies on the farms. Thus monitoring on both farms was continued up to 1998. It should be noted that calculation of annual average levels from hourly measurements only became possible using the data collected for 1997 and 1998, after the installation of new and more stable SO₂ monitors.

Measurement Method

The monitors used for this investigation were dedicated SO₂ monitors manufactured by Monitor Labs and Advanced Pollution Instruments in the USA. These instruments are widely used for ambient SO₂ monitoring and operate on the principle of continuous UV fluorescence measurement. This is the official method of analysis for SO₂ as specified in EU air quality Directives.

Calibration was performed using zero and span (full-scale) settings. Span gas was taken from certified cylinders containing SO₂ in air at concentrations in the region of 500 ppb. The zero setting was obtained by drawing air into the monitor through an activated carbon cartridge. The continuous signals from the SO₂ monitors were stored on data loggers and retained as 1-hour averages. These data were collected initially by direct connection to a laptop computer during service calls. The original data loggers had limited memory and had to be downloaded every two weeks. They were subsequently replaced, therefore, by Odessa loggers connected by modem and cellphone to data collection software in the EPA laboratory in Dun Laoghaire.

As the monitors were operating continuously and at some distance from the laboratory, the baseline signal was allowed to drift between service calls. Service intervals were initially every two weeks but after the establishment of data collection by telephone this was considerably extended. The baseline signal drift was of a longer-term nature than the observed concentration peaks and so did not mask the presence of transient events when the results were examined in graphical form. In 1997, the monitors were replaced with new instruments and the degree of baseline drift was much diminished.

Organisation of Measurement Campaign

Initially, SO₂ monitors were placed on the Somers and Ryan farms with a control station at Ballylongford, approximately 8 km west of the ESB generating station at Tarbert. The Somers farm site was established in April 1995, followed by the Ryan farm and Ballylongford in May 1995. After initial set-up and adjustments for local site conditions, data recovery improved at the Somers and Ryan farms. However, Ballylongford proved unsatisfactory due to the proximity of Tarbert ESB station and the fact that the initial results from there and Somers farm showed that it was too distant to be a useful upwind reference site. Thus, it was decided to abandon the site and to move the monitor to the Department of Agriculture farm in Abbotstown, Co. Dublin, where part of the herd from Somers farm had been transferred in connection with the veterinary investigations. This change was made in February 1996.

A considerable body of data was collected from 1995 to the end of 1998 when the measurement programme was completed. However, for local assurance, the monitoring of SO₂ at Somers farm has been continued through the period of preparation of this report and the site may be permanently incorporated into the measurement network of the EPA's national air quality monitoring programme.

SO₂ Concentrations measured on the Somers and Ryan Farms

The dates for which results are available are listed below:

Somers:	April 1995 to December 1998 (ongoing)
Ryan:	July 1995 to November 1998

The individual hourly concentrations recorded have been plotted for visual assessment on monthly graphs and these are given in Appendix B.

As in the case with the daily sampling networks, the hourly monitoring showed that SO₂ levels were generally low on the two farms, the vast majority of the values recorded being less than 25 µg/m³. However, occasional increases of concentrations well over this value occurred on both farms. In Table 5.4 the numbers of instances are given when hourly concentrations exceeded 80 µg/m³ on either farm in each year of the investigation. Although less than 25 per cent of the EU hourly limit of 350 µg/m³, this concentration would indicate a considerable anthropogenic enhancement of the background levels of the gas which would normally be expected to be around 5 µg/m³. Of the approximately 53500 hourly concentrations recorded on the two farms over the period of the investigation, 617 (1.1 per cent) were in excess of 80 µg/m³. The bulk (419) of these occurred on the Somers farm and there was a relatively small number of coincident peaks. A similar difference is noted in respect of hourly concentrations over 200 µg/m³, 30 of the 34 such recordings occurring on the Somers farm. This unequal distribution of the peak concentrations suggests either that the farms are not being affected by the same source or that a common source of the excess SO₂ has different impacts at the two locations.

The maximum hourly and annual mean concentrations recorded in each year of the investigations are given in Table 5.5. There were no exceedances of the new hourly limit of 350 µg/m³ on the Somers farm and just one on the Ryan farm, in 1995. Thus, both locations are in compliance with the hourly standard as given in Table 5.2 as this allows 24 exceedances of the limit in a calendar year. As explained above, it was not possible to calculate annual average concentrations for the two earlier years. However, the annual values for both farms in 1997 and

Table 5.4

Numbers of occurrences of hourly concentrations of SO₂ greater than 80 µg/m³ on the Somers and Ryan farms

	1995	1996	1997	1998
Somers				
Total hrs of record	4925	5296	7692	7691
Hours > 80 µg/m ³	65	73	105	176
Ryan				
Total hrs of record	3833	8307	8113	7701
Hours > 80 µg/m ³	33	52	16	97
Common Peaks	2	7	3	26

Table 5.5

Maximum hourly and annual mean concentrations of SO₂ recorded on the Somers and Ryan farms 1995-1998

Year	Somers			Ryan		
	Max. Hourly µg/m ³	Hrs >350	Ann Mean µg/m ³	Max. Hourly µg/m ³	Hrs >350	Ann. Mean µg/m ³
1995	250	Nil	NA	385	1	NA
1996	270	Nil	NA	350	Nil	NA
1997	298	Nil	8	198	Nil	5
1998	348	Nil	11	207	Nil	11

1998 were well within the limit of 20 µg/m³ set in the 1999 Directive. This is agreement with the annual concentrations based on the daily averages recorded in the ESB and AAL networks as discussed above.

The wind directions associated with the occurrences of hourly SO₂ concentrations over 80 µg/m³ on the two farms are shown in Figs 5.6 and 5.7. There is a clear clustering of these occurrences in the 250° - 260° sector on the Somers farm, suggesting that air coming from the AAL plant direction is responsible. There is also some clustering of the hourly occurrences over 80 µg/m³ in the equivalent sector (280° - 290°) on the Ryan farm although the spread is greater than at Somers and a considerable number correspond with winds from the opposite direction (120° - 170°).

A detailed analysis of the wind directions associated with the SO₂ concentrations above 80 µg/m³ is given in Table 5.6. This shows that on the Somers farm, 38 per cent of all such events were associated with winds from the AAL direction in 1995 and in much larger proportions – 63 to 75 per cent – in the 1996 to 1998 period. However, the hourly occurrences of raised concentrations with winds from the AAL sector are only a small proportion (7 to 11 per cent) of all of the hours when wind was recorded as blowing from that direction in the period. Thus, for most of the time on the Somers farm when wind trajectory was from the AAL direction, SO₂ concentrations were less than 80 µg/m³.

Although the Ryan farm is located nearer to the alumina plant, the picture here is somewhat different. The proportions (12 – 34 per cent) of all of the hourly events of raised SO₂ levels that were associated with winds from the AAL direction is much less than on the Somers farm; in addition, there was an appreciable number of such events associated with winds from the south-east (130° - 140°) which is in the direction of the nearby Wyeth factory and the town of Askeaton. As a consequence, of the total numbers of hours with winds recorded as coming from the AAL direction on the Ryan farm, only a minor fraction (1.1 – 4.7 per cent) were associated with measured concentrations over 80 µg/m³.

As pointed out above, there were relatively few instances of coincident peaks of SO₂ concentrations on the farms. Where both farms were affected simultaneously, this could have been caused by a nearby source in line with them. This would require a wind from a NNE (20°) or SSW (200°) direction. There were no events of SO₂ greater than 80 µg/m³ associated with these two wind directions; therefore, it seems likely that the source (or sources) was some distance away which allowed the plume to spread enough to cause raised concentrations simultaneously on the farms. The highest reading of 385 µg/m³ was recorded at Ryan's farm at 5pm on

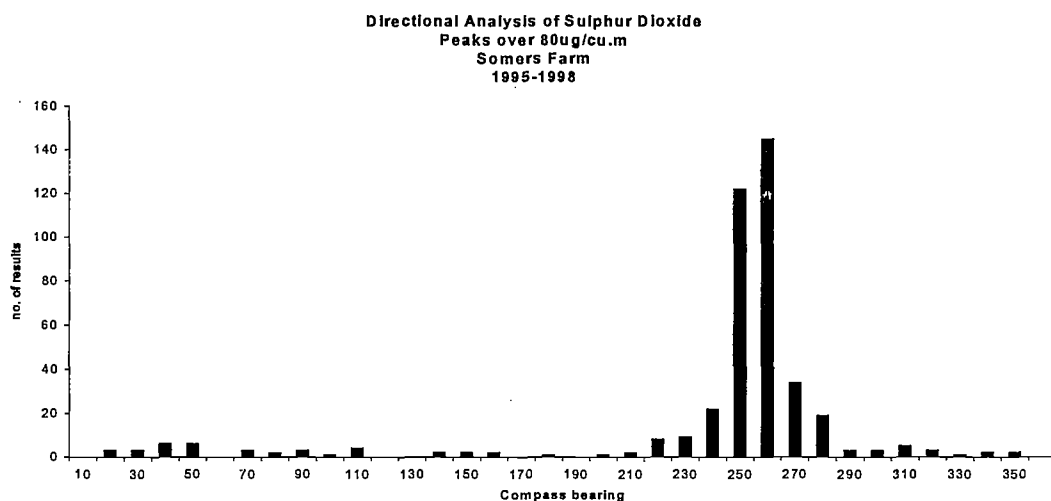


Fig 5.6 Wind direction associated with peaks over 80 $\mu\text{g}/\text{m}^3$ at Somers farm 1995-98

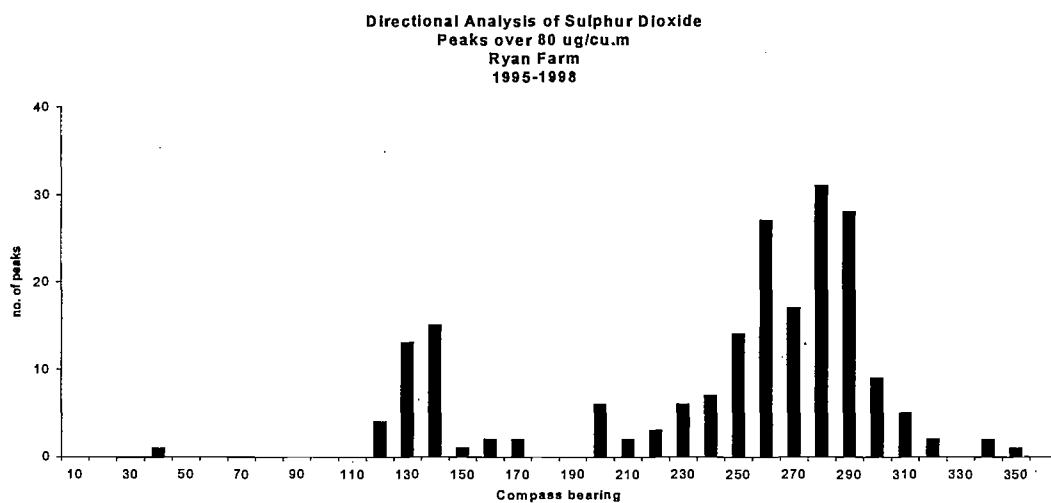


Fig 5.7 Wind direction associated with peaks over 80 $\mu\text{g}/\text{m}^3$ at Ryan farm 1995-98

Table 5.6

Association of hourly concentrations of $\text{SO}_2 > 80 \mu\text{g}/\text{m}^3$ with winds from the direction of the AAL plant on the Somers and Ryan farms in 1995 – 1998.

Period/Statistics	Somers Farm	Ryan Farm
1995		
Hrs with conc. $> 80 \mu\text{g}/\text{m}^3$	65	33
No. (%) of above associated with wind from AAL	25 (38.4)	4 (12.1)
Total hrs with winds from AAL	383	212
1996		
Hrs with conc. $> 80 \mu\text{g}/\text{m}^3$	73	52
No. (%) of above associated with wind from AAL	53 (72.6)	17 (32.6)
Total hrs with winds from AAL	513	560
1997		
Hrs with conc. $> 80 \mu\text{g}/\text{m}^3$	105	16 (0.2)
No. (%) of above associated with wind from AAL	79 (75.2)	5 (31.2)
Total hrs with winds from AAL	775	431
1998		
Hrs with conc. $> 80 \mu\text{g}/\text{m}^3$	176	97
No. (%) of above associated with wind from AAL	110 (62.5)	33 (34.0)
Total hrs with winds from AAL	982	703

September 11th 1995 and corresponds to a north-westerly wind direction (310 degrees). There is no obvious major source in that direction.

On both farms, there was a clear diurnal pattern in the occurrence of hourly concentrations above $80 \mu\text{g}/\text{m}^3 \text{SO}_2$, the majority of these hourly peaks being recorded between 1000 and 2000 (Figs 5.8 and 5.9). The clustering of the higher hourly concentrations in this period was more marked on the Somers farm. The reason for this pattern is not clear but does not seem to suggest the influence of a relatively steady emission source of SO_2 such as the continuous Bayer bauxite extraction process taking place at AAL.

It has been stated earlier that the measurements of SO_2 also act as a marker for other pollutants released to the atmosphere in the area. In this connection, it is of interest to consider the theoretical dilution of the SO_2 emissions from the alumina plant inferred from the measurements in air on the farms. The highest SO_2 peak measured at Somers farm was $348 \mu\text{g}/\text{m}^3$. If this is compared to measured stack concentrations of $4000 \text{ mg}/\text{m}^3$ at the alumina plant, it is equivalent to a reduction by a factor of about 11,500. A similar reduction in concentration could be expected to apply to any other gaseous contaminants. As this dilution of emissions is calculated for the highest recorded SO_2 level recorded, the reduction would have been even greater, by an order of magnitude or more, in the cases of the other concentrations measured.

SO_2 Concentrations measured at Ballylongford and Abbotstown

Data for these locations cover the following periods:

Ballylongford: May 1995 and June 1995
 Abbotstown: February 1996 to July 1997

The results of the monitoring at these sites are shown in Appendix C. In comparison to the results from the two farms, the Ballylongford monitoring showed only six peaks greater than $80 \mu\text{g}/\text{m}^3$, or less than 1 per cent of the recorded values. It was hoped that the Abbotstown sampler would provide some useful data on the levels of SO_2 on the Department of Agriculture's experimental farm, which had not experienced any of the animal health effects reported in Askeaton. As the site is located on the outskirts of Dublin City, it was expected that some high levels would be recorded. In fact, over the 16 months for which data were collected, the highest hourly value recorded was $107 \mu\text{g}/\text{m}^3$ and there were only two values over $80 \mu\text{g}/\text{m}^3$.

These data are interesting in demonstrating a lower level of SO_2 at a semi-rural site close to the Dublin urban area compared to the Shannon estuary region. This is perhaps only to be expected as up to 55 per cent of the emissions of SO_2 in the State occur in the Shannon area; however, it might be expected also that the location of

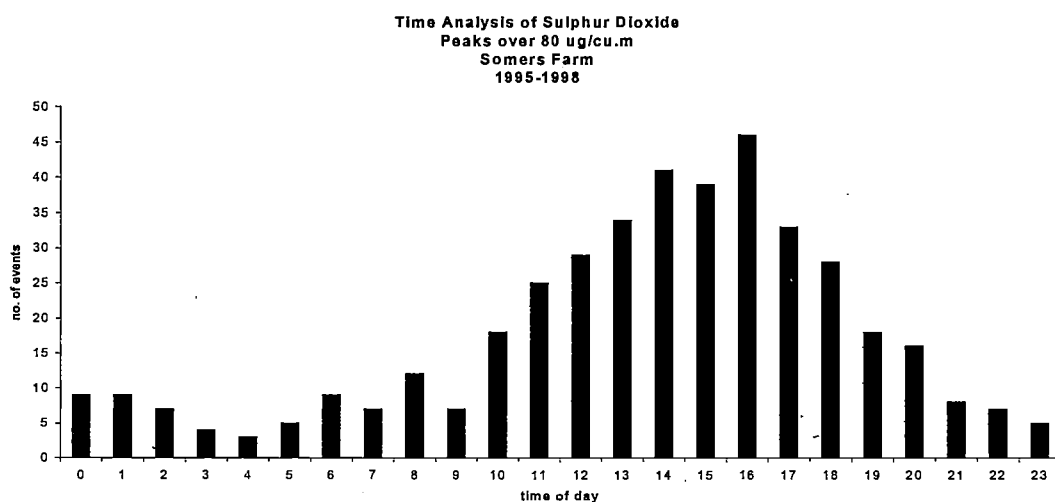


Fig 5.8 Time of day associated with peaks over 80 $\mu\text{g}/\text{m}^3$ at Somers farm 1995-98

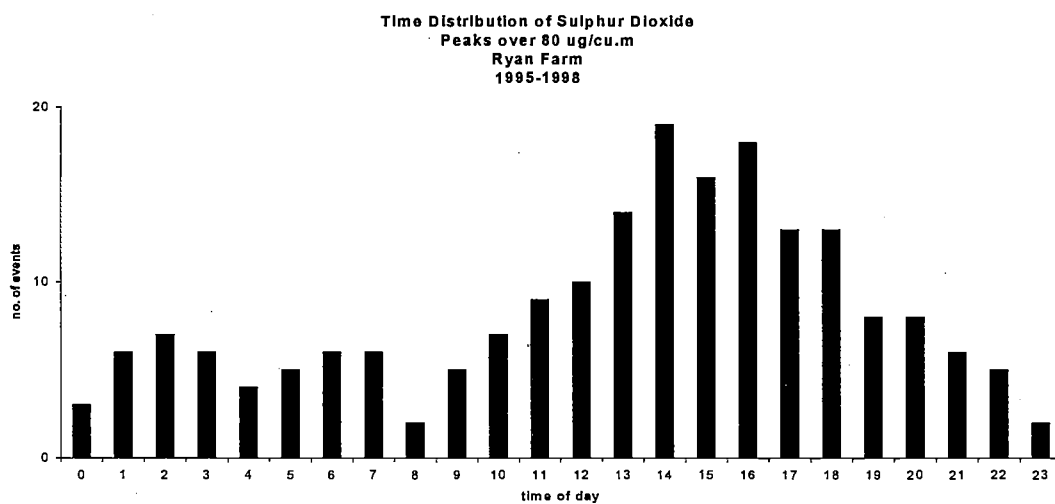


Fig 5.9 Time of day associated with peaks over 80 $\mu\text{g}/\text{m}^3$ at Ryan farm 1995-98

Abbotstown to the north-west of Dublin would reduce the impact of the city there. It had been intended to compare SO₂ data on this unaffected farm with the levels found on the Somers and Ryan farms, which had reported animal health problems up to 1995; however, the improvements on the latter farms after that year suggested that air quality conditions in the Askeaton area itself could be used to assess any risk to livestock health. No major health problems were reported during the period 1996-1998 when the two farms were managed by the Department of Agriculture and Food, thus indicating that cattle could remain healthy while experiencing the levels of SO₂ reported above for the farms.

CONCLUDING COMMENTS

The detailed measurements described above confirm that the levels of SO₂ in air on the two farms during the period of the investigation were well within the existing and revised EU limits set for the protection of human health. Results from the ESB and AAL monitoring networks suggest that this was also the position in the years preceding the investigation. There are no SO₂ standards for the protection of livestock but the annual limit (20 µg/m³) set for the protection of ecosystems in the recent EU directive is of some relevance in the situation. As shown above, the annual concentrations of SO₂ derived from the continuous monitors on the farms and from the ESB and AAL networks are all within this limit.

The occurrence of short-term peaks of SO₂ levels on the farms and the indication that some of these were associated with wind movements from the Aughinish direction appears to be consistent with the predictions of the dispersion modelling exercises undertaken for the emissions from the ESB and AAL plants.

Overall the results of the SO₂ monitoring undertaken for the investigations confirm that exposure on the Somers and Ryan farms was limited during the 1995-1998 period and reflect the position shown by the results from the ESB and AAL networks in the wider Askeaton and adjacent areas prior to 1995. However, the hourly monitoring showed that there were occasional increases of concentrations to levels significantly above background and greater than those recorded on the Abbotstown farm in Co. Dublin. Furthermore, the directional analysis indicated that the majority of these episodes were associated with winds from the direction of the AAL plant and, further west, the ESB plants.

Chapter Six

PRECIPITATION QUALITY AND POLLUTANT DEPOSITION

INTRODUCTION

It had been suggested *inter alia* that an increase in sulphur content of herbage, arising from atmospheric deposition, contributed to the animal health problems in the Askeaton area. Several investigators recommended more detailed investigation of the deposition of sulphate, in particular, but also of fluoride and aluminium. In addition, the potential for the wind-blowing of metalliferous dust from the production and wastes lagoon areas of the alumina plant was raised. Thus, a detailed examination of the characteristics of precipitation in the area and of the levels of deposition of potentially harmful substances was instituted as part of the environmental investigations.

POTENTIAL FOR SULPHUR DEPOSITION

Before examining the data arising from this and previous investigations, it is worth considering the potential impact of the main emission sources on precipitation quality and deposition in the area. The formation of acid rain (acid precipitation) associated with large point source emissions of SO₂ is a well known long-range phenomenon but usually does not cause severe adverse effects close to such sources. While the Moneypoint, Tarbert and AAL plants may be considered large sources of emissions in Ireland, they are relatively small in comparison to similar sources implicated in the acid deposition problem in some parts of Europe. In the period 1988 through 1999 average annual SO₂ emissions from Moneypoint were approximately 53,000 tonnes while the corresponding values for Tarbert and AAL, respectively, were 21,000 and 15,000 tonnes (see Chapter Four). This would place Moneypoint last in a list of the hundred largest emitters in Europe in the early 1990s (Anon., 1994). There were ten power stations in operation in England at this time with average SO₂ emissions more than three times those of the Moneypoint station.

The potential for the generation of acidifying compounds from the Moneypoint plant is therefore relatively moderate and clearly much less in the case of Tarbert and AAL. More importantly, the physical and chemical processes involved in the conversion of emissions to highly acidic compounds are so slow that deposition of these compounds via the dominant pathways occurs hundreds of kilometres from the sources (Irwin and Williams, 1988). It is generally accepted that deposition of sulphur within 50 km of large sources, such as power stations, occurs largely by washout during precipitation events and dry deposition of SO₂. Studies in relation to oil and coal-fired power stations (Granat and Rodhe, 1973 and Hales *et al.*, 1970) have shown that less than 10 per cent of sulphur emitted is deposited within 15 km by washout during periods of precipitation. This reduces to a fraction of one per cent when taken over the full period of emission.

Dry deposition of gases is normally estimated as the product of mean concentration near ground level and an appropriate deposition velocity. The data given in the previous section indicate that annual mean SO₂ concentrations in the area of interest are generally not much more than 5 µg/m³ above background. Combining this with an appropriate deposition velocity of 0.5 cm/s for SO₂ on agricultural land (Fowler, 1984) suggests dry deposition of the order of 0.4 g S/m², assuming all the excess above background is deposited. Dry deposition is therefore limited, at least on a long-term basis, simply by the low concentrations of SO₂. It is clear from the measurements made that there is the potential for relatively high SO₂ concentrations on occasion in the Askeaton area through the grounding of individual plumes from the emission sources, typically under windless conditions with a stable air column. These conditions occur approximately 1 per cent of the time in the Shannon Estuary region (Wann, 1973) and usually at night when the efficiency of the dry deposition process is much reduced, so that plume grounding would have little impact in terms of deposition.

These considerations suggest *a priori* that a major increase in sulphur deposition is unlikely in the area under investigations due to emissions from the Moneypoint, Tarbert and AAL plants. It should be noted also that the soils in the Askeaton area are mainly derived from limestones (see Soil, Herbage, Feed and Water Volume) and, therefore, would have a considerable capacity to buffer the effects of acidification, even if some increase in sulphur deposition were taking place.

PREVIOUS MEASUREMENTS OF DEPOSITION IN THE AREA.

The level of sulphate and nitrate deposition in the Shannon Estuary region was well quantified during the 1987 to 1989 period through intensive monitoring of precipitation at Gortglass and Doo Lough in County Clare (Bowman, 1991). The results showed that:

- a) annual mean deposition rates of non-marine sulphate and nitrate at the two locations (0.25 g S/m^2 and 0.12 g N/m^2) were low and similar to those for other locations in the west of Ireland. These deposition rates result from the combination of relatively large precipitation amounts and what can only be regarded as background levels of the two pollutants in bulk precipitation samples (volume-weighted annual mean of $15 \text{ } \mu\text{eq/l}$ for SO_4 and $10 \text{ } \mu\text{eq/l}$ for nitrate).
- b) It was estimated that approximately two-thirds of total sulphate in the precipitation was of marine origin. A very large proportion of marine sulphate deposition may occur during a very small number of storm events. No clear seasonal deposition patterns are evident and large year-to-year variability is common in the annual mean concentrations of non-marine sulphate.
- c) The highest concentrations of non-marine sulphate and nitrate in precipitation were found to be associated with winds of an easterly direction, indicating import from the UK and Europe.

However, the sites where these measurements were undertaken lie upwind of the alumina plant with the possibility that they were not representative of the area in which the two problem farms are situated.

PRELIMINARY MEASUREMENTS OF PRECIPITATION QUALITY

Background

Between March and August 1995, samples of bulk precipitation were collected on the Somers farm at approximately weekly intervals in order to obtain a general indication of the quality of precipitation in the area and to determine if the current deposition rate of pollutants was significantly above normal. Sampling of precipitation had been carried out on a monthly basis by Limerick County Council from a permanently open collector on the Somers farm for the period September 1993 to February 1995. However, these samples were considered unsuitable for an assessment of deposition, particularly for sulphate, because of the length of the sampling period and the delay in performing the necessary analyses.

Sulphate and Nitrate

The results of the analyses for sulphate and nitrate in the weekly samples from the Somers farm bulk collector are given in Table 6.1. Non-marine sulphate was estimated in the standard manner by reference to the sodium concentrations. While nitrate is not a factor likely to be connected with the animal health problems, concentrations of the ion were included as an additional indicator of the quality of precipitation which could also be affected by large emission sources and which could be compared with measurement data for other locations.

Total sulphate deposition for the 21-weeks of sampling amounted to 0.35 g S/m^2 and the non-marine fraction was 0.23 g S/m^2 . The latter approximates the mean annual value measured for the same fraction at the Gortglass and Doo Lough sites in the 1987/1989 period, as already discussed, and suggested that non-marine sulphate deposition on the Somers farm for 1995 was of the order of 0.5 g S/m^2 . However, this rate is still relatively low and significantly less than the rates recorded in areas subject to acidification problems. Furthermore, in view of the year to year variations of the deposition rates at Gortglass and Doo Lough (Bowman, 1991) and the uncertainties inherent in the measurement method, it was considered that the extrapolated rate for the Somers farm samples did not necessarily mean that the Ballysteen area was subject to higher annual deposition than the area represented by the Gortglass and Doo Lough sites.

In the case of nitrate, deposition for the period covered by Table 6.1 was 0.05 g N/m^2 , suggesting an annual value of the order of 0.1 g N/m^2 in 1995; this is the same as the rate recorded at the Gortglass and Doo Lough sites and generally indicative of background levels in Ireland.

Table 6.1.

Sulphate and nitrate levels in total precipitation on Somers farm in the period March to August, 1995, based on analysis of weekly samples.

Sampling Period	Precipitation mm	SO ₄ mg/l	SO ₄ [#] mg/l	NO ₃ mg/l	SO ₄ mg/m ²	SO ₄ [#] mg/m ²	NO ₃ mg/m ²
1/3/95-7/3/95	38.6	4.467	1.020	0.028	172.5	39.4	1.08
8/3/95-14/3/95	24.2	2.600	1.086	0.035	62.9	26.3	0.85
15/3/95-21/3/95	17.0	8.098	2.522	0.066	137.5	42.8	1.12
22/3/95-4/4/95	18.8	4.932	3.706	0.163	92.6	69.6	3.06
4/4/95-11/4/95	1.2	21.297	19.846	0.449	25.6	23.9	0.54
11/4/95-25/4/95	20.4	4.613	3.772	0.361	93.9	76.8	7.35
25/4/95-2/5/95	6.4	4.332	3.946	0.685	27.6	25.1	4.36
2/5/95-9/5/95	0.0*	3.837	3.837	0.148	10.8	10.8	0.42
6/6/95-13/6/95	0.0*	21.237	21.237	0.047	60.1	60.1	0.13
13/6/95-20/6/95	0.0*	15.188	15.188	0.148	42.9	42.9	0.42
20/6/95-27/6/95	19.6	3.086	2.764	0.505	60.5	54.1	9.88
27/6/95-4/7/95	13.6	2.915	2.295	0.667	39.6	31.2	9.06
4/7/95-11/7/95	18.9	1.906	1.803	0.195	36.0	34.0	3.69
11/7/95-18/7/95	38.6	1.125	0.936	0.079	43.4	36.1	3.07
18/7/95-25/7/95	8.4	1.511	1.235	0.072	12.7	10.4	0.61
25/7/95-8/8/95	25.8	3.269	3.203	0.350	84.3	82.6	9.02
16/8/95-22/8/95	3.5	2.721	2.450	0.050	9.5	8.5	0.17
22/8/95-29/8/95	6.7	7.190	5.993	0.017	48.4	40.3	0.11

non-marine sulphate

*For the periods when no precipitation occurred, i.e. when deposition was in the dry form only, the concentrations shown are those measured in the volume of washwater used to remove deposited material from the sides of the collecting funnel. It is assumed that all of the sulphate in these cases is non-marine; this is borne out by the relatively low sodium concentrations in the washwater

While the number of bulk samples for the Somers farm was quite limited, the results served to indicate the highly variable nature of the ion concentrations, which result from a combination of wet and dry deposition. In addition, the level of dry deposition suggested by the samples representing dry weeks seemed relatively high and it was considered that this particular aspect required further investigation. It was also noted that the highest nitrate concentrations did not correspond to the highest non-marine sulphate concentrations.

Fluoride and Metals

The precipitation samples collected by the local authority on a monthly basis from September 1993 to March 1995 and all weekly samples for the period February to September 1995 were analysed for fluoride ion. Fluoride content of the precipitation samples was generally very low. Concentrations in only four out of 36 samples analysed were above the detection limit of 0.1 mg/l. The highest level found was 0.4 mg/l during April 1995; levels of twice this amount are allowable in drinking water. None of the industries in the area have been identified as a significant source of fluorine emissions so that the most likely source of fluoride detected is soil particles in the area which have a natural fluoride content of several hundred parts per million.

Metal levels in precipitation were determined on a small number of weekly samples collected from the Somers and Ryan farms between February and September 1995. The results were compared with the levels found in samples collected at remote sites in Ireland (Table 6.2). These sites, at Valentia in Co. Kerry and at Turlough Hill near the Wicklow Gap, are part of a European network of stations used to study long-range transport of air pollutants. They are not affected by local emissions and can be regarded as background sites for comparison with the Shannon Estuary region. The results for the metals listed, although limited, indicated no significant differences between the background concentrations and those obtained on the two farms.

Table 6.2.

Metal concentrations in precipitation at Somers and Ryan Farms ($\mu\text{g/l}$) based on analysis of weekly samples taken in the period March to August, 1995.

Metal	Valentia	Turlough Hill	Somers Farm	Ryan Farm
Aluminium	9 – 84	32 - 98	21 - 72	24 – 53
Cadmium	0.2 – 2	0.6 - 2	0.05 – 0.4	<0.05 – 0.06
Chromium	<0.5	<0.5	0.8 – 0.9	<0.5
Copper	3 – 16	5 - 26	3 - 14	2 – 3
Lead	<0.5 – 2	1 - 2	0.8 - 1	1 – 2
Manganese	2 – 22	5 – 60	3 - 16	9 – 10
Nickel	<1 – 4	<1 – 8	1.4 – 1.8	<1 – 2
Vanadium	<10 – 11	<10	<10	<10 – 12

Conclusions from Preliminary Measurements

These preliminary measurements, which were of an exploratory nature, indicated that deposition of metals and fluorides were not significantly above background levels in the area. While there were indications, based on extrapolation of the measurements in the period, that the annual sulphur deposition rate in the area was above levels previously measured at locations west of Askeaton, the estimated rate did not invalidate the earlier assessments regarding the level of deposition to be expected in the Askeaton area and it was still appreciably lower than that recorded in areas affected by pollution. However, it was considered that more detailed information was desirable in order to assess more fully the situation.

DETAILED INVESTIGATIONS OF PRECIPITATION QUALITY AND DEPOSITION

Background

It was decided in autumn 1995, therefore, to increase the bulk sampling to a daily basis and to carry this out on both the Somers and Ryan farms in order to investigate in detail the range of concentrations which occur in the Askeaton area and to overcome some of the limitations of weekly samples. Sampling was planned to continue for at least one year so that more accurate estimates for annual deposition rates could be made and thus allow direct comparison with measurements made elsewhere in Ireland and other parts of Europe. In the event, sampling continued for three years up to the end of the investigation in 1998. In addition, daily sampling was extended at the end of 1997 to a third location (Askeaton Water Works (AWW)) near where trapping of specimens for a study on voles had been carried out (see Animal Health volume).

In order to increase further the amount of information on precipitation, the collection of weekly bulk samples commenced at two additional farms in November 1996. This was complemented by the collection of weekly samples on the Somers farm to provide a comparison between weekly samples and daily samples on the same site. Sampling ceased at all locations on 29 November 1998.

Sampling Details

The collector for the daily samples consisted of a 2 l polyethylene bottle attached to a 24.8 cm funnel secured in a bracket at the top of a 2 m wooden pole. A similar arrangement held for the collection of weekly samples but a 11cm funnel was used in this case. At the end of each sampling period, both daily and weekly, the collecting funnels at each location were washed into the sample bottle using 200 ml of de-ionised water, prior to the bottle being removed for analysis. This ensured that all matter deposited on the funnel was included in the sample and the results of the analysis were adjusted to take account of the dilution water. For technical reasons only daily samples taken on days when precipitation was greater than 0.5 mm and weekly samples in weeks when it was greater than 2.0 mm were considered in calculating the means, medians and ranges given in this report.

Monthly cumulative samples of precipitation were collected on the Somers and Ryan farms for metals analysis. A monthly period was used in this case as the results were being compared with data from Turlough Hill, Co. Wicklow and Valentia Co. Kerry, where similar sampling was being carried out for other purposes.

Daily samples taken from Monday to Sunday were retained in the EPA office in Limerick for dispatch with the corresponding weekly samples on the following Monday to the laboratory in the EPA Regional Inspectorate in Dun Laoghaire, Co. Dublin. Analyses were carried out on the following day.

Analytical Details

Anions (sulphate, chloride, fluoride) were measured by ion chromatography (Dionex system); cations (sodium, potassium, magnesium, calcium) were originally measured by flame photometry and later by ion chromatography. Nitrate, ammonium and phosphate were measured on an automated analysis system (Lachat Quick Chem system). Metals (Al, Cd, Cr, Cu, Mn, Ni, Pb, Va) were measured by atomic absorption spectrophotometry. A standard laboratory meter was used to measure pH, from which the hydrogen ion concentration was calculated.

Precipitation Quantities

The levels of precipitation measured in 1996 and 1997 on the Somers and Ryan farms were less than the long-term averages of 927 mm and 936 mm, respectively, for Shannon Airport and Askeaton; however, precipitation at both farm locations in 1998 was in excess of these average values (Table 6.3). It is calculated that over 98.5 per cent of the precipitation occurred on those days when the precipitation was greater than 0.5 mm. In the period, the seasonal pattern of precipitation was similar on the two farms but the annual amount measured on the Ryan farm was slightly greater than that on the Somers farm, the difference being approximately 5 per cent in each year.

Precipitation was collected at AWW for 1998 only and showed a similar pattern to but a higher volume than that observed on the two farms.

Table 6.3

Details of the precipitation at the Ryan, Somers and AWW sampling sites for each year (November to November years) examined.

	Ryan			Somers			AWW		
	95/96	96/97	97/98	95/96	96/97	97/98	95/96	96/97	97/98
Total Precipitation mm	858	907	1039	809	864	999	nm	nm	1130
Days with precipitation >0.5 mm	172	156	206	176	157	202	nm	nm	207
Days with precipitation <0.5 mm	72	92	75	66	87	78	nm	nm	80
Days with no recorded precipitation	122	117	84	124	121	85	nm	nm	78
Total no of days	366	365	365	366	365	365	nm	nm	365

Quality Of Precipitation

Analyses were carried out on each daily and weekly sample for pH, ammonium, molybdate reactive phosphate, chloride, nitrate, total sulphate, fluoride, sodium, potassium, magnesium and calcium. The results of these analyses for the daily samples are summarised in Table 6.4; the corresponding data for the weekly samples are given in Table 6.5. The volume weighted mean values for the principal parameters in the daily samples are given in Table 6.6; for comparative purposes, the Table also shows data for other west coast locations monitored in the period 1987 to 1989 and for a number of locations in the UK and Norway affected and unaffected by acidification.

Table 6.4

The minimum, median and maximum values for each parameter in the precipitation samples greater than 5mm at the daily sampling locations for the years 1996, 1997 and 1998.

Parameter	Year	Somers			Ryan			AWW		
		Min	Med.	Max	Min	Med.	Max	Min	Med.	Max
pH	1996	4.30	5.45	6.90	4.08	5.64	6.77			
	1997	4.12	5.35	8.26	4.11	5.43	7.32			
	1998	4.36	5.47	7.00	4.48	5.52	6.97	4.37	5.77	7.11
H ⁺	1996	0.1	3.6	50.5	0.2	2.3	84.0			
mg/l	1997	0.1	4.5	76.0	0.1	3.7	78.0			
	1998	0.1	3.4	44.0	0.1	3.0	33.4	0.1	1.7	43.0
Ammonium	1996	0.03	0.46	8.05	0.02	0.43	6.02			
mg N/l	1997	0.01	0.30	6.20	0.02	0.33	5.60			
	1998	0.01	0.25	5.28	0.03	0.33	5.76	0.02	0.27	3.13
Nitrate	1996	0.01	0.11	3.60	0.01	0.09	6.02			
mg N/l	1997	0.01	0.06	8.18	0.01	0.09	6.51			
	1998	0.01	0.05	3.60	0.01	0.06	1.70	0.01	0.06	1.71
MRP	1996	3	15.0	350	1	15.0	330			
µg P/l	1997	3	11.7	645	3	11.8	107			
	1998	3	11.4	205	3	11.2	79	3	11.3	434
Fluoride	1996	<0.05	<0.01	0.63	<0.05	<0.1	0.88			
mg F/l	1997	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10			
	1998	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride	1996	0.13	3.95	164	0.14	5.06	842			
mg Cl/l	1997	0.09	3.59	149	0.13	5.18	321			
	1998	0.12	4.41	105	0.11	4.86	225	0.12	4.17	137
Total Sulphate	1996	0.16	2.32	37.1	0.23	2.72	139			
mg SO ₄ /l	1997	0.11	2.22	23.2	0.09	2.71	46.5			
	1998	0.12	2.15	26.8	0.27	2.71	30.8	0.11	2.16	20.6
Non-Marine Sulphate	1996	0.01	1.38	25.6	0.16	1.57	21.9			
mg SO ₄ /l	1997	0.07	1.33	16.9	0.00	1.41	15.6			
	1998	0.00	1.00	23.9	0.00	1.28	16.2	0.00	0.76	13.2
Sodium	1996	0.10	2.44	86.0	0.1	2.92	465			
mg Na/l	1997	0.09	2.09	82.3	0.06	2.64	183.7			
	1998	0.10	3.14	62.9	0.07	3.38	116.5	0.09	2.97	75.9
Potassium	1996	0.01	0.16	6.21	0.01	0.19	9.54			
mg K/l	1997	0.01	0.15	2.81	0.00	0.13	6.39			
	1998	0.01	0.12	2.31	0.01	0.14	3.79	0.01	0.16	2.58
Magnesium	1996	0.01	0.29	5.93	0.01	0.36	4.74			
mg Mg/l	1997	0.01	0.24	9.79	0.01	0.31	21.37			
	1998	0.01	0.38	6.92	0.01	0.43	13.94	0.01	0.38	9.51
Calcium	1996	0.01	0.36	4.84	0.05	0.41	9.71			
mg Ca/l	1997	0.01	0.45	9.57	0.01	0.52	21.15			
	1998	0.08	0.42	3.67	0.01	0.48	7.10	0.07	0.58	5.63

Table 6.5

The minimum median and maximum values for each parameter in the precipitation samples greater than 5mm at the weekly sampling locations for the years 1996, 1997 and 1998.

Parameter	Year	Somers			White			Hannon		
		Min	Med.	Max	Min	Med.	Max	Min	Med.	Max
pH	1997	4.46	5.42	6.58	4.62	5.49	6.96	4.94	5.87	6.77
	1998	4.58	5.22	6.40	4.55	5.56	7.20	4.82	5.91	6.77
H ⁺	1997	0.26	3.80	34.9	0.11	3.20	37.2	0.17	1.34	11.6
	1998	0.40	6.10	26.5	0.10	2.80	28.5	0.17	1.30	15.20
Ammonium mg N/l	1997	0.08	0.58	5.60	0.10	0.60	2.96	0.10	0.86	6.46
	1998	0.01	0.25	3.76	0.06	0.35	4.03	0.21	0.75	5.20
Nitrate mg N/l	1997	0.04	0.29	5.87	0.04	0.17	2.24	0.05	0.22	4.56
	1998	0.00	0.07	1.83	0.00	0.07	0.90	0.04	0.13	1.92
MRP µg P/l	1997	2.7	13.4	183	0.7	11.4	237	5.3	19.1	534
	1998	1.3	7.5	71	2.0	8.5	388	3.0	13.2	204
Fluoride mg F/l	1997	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
	1998	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride mg Cl/l	1997	0.44	5.91	143	0.30	5.28	79	0.15	6.92	68
	1998	0.03	6.90	138	0.10	6.35	104	0.54	12.19	73.5
Total Sulphate mg SO ₄ /l	1997	0.46	3.58	23.9	0.31	2.53	19.7	0.40	3.10	22.2
	1998	0.01	2.67	20.3	0.01	2.37	16.21	1.04	3.24	15.45
Non-Marine Sulphate mg SO ₄ /l	1997	0.00	2.11	20.5	0.00	1.57	11.2	0.00	1.76	15.3
	1998	0.00	1.28	11.7	0.00	1.08	4.3	0.05	1.40	11.1
Sodium mg Na/l	1997	0.32	3.15	45.2	0.08	2.61	46.8	0.10	3.43	35.8
	1998	0.11	4.19	82.2	0.20	3.66	61.4	0.37	7.34	43.4
Potassium mg K/l	1997	0.03	0.21	1.70	0.01	0.20	2.78	0.01	0.36	1.81
	1998	0.01	0.15	3.00	0.01	0.18	2.30	0.04	0.38	1.60
Magnesium mg Mg/l	1997	0.05	0.42	5.70	0.05	0.34	5.59	0.03	0.47	4.97
	1998	0.02	0.50	9.85	0.05	0.49	6.34	0.08	0.94	5.27
Calcium mg Ca/l	1997	0.01	0.87	11.33	0.04	0.57	6.59	0.13	0.78	6.16
	1998	0.08	0.44	3.82	0.10	0.43	6.12	0.18	0.70	5.28

pH/Hydrogen Ion Concentration

The minimum pH values recorded at both the daily (Table 6.4 and Figs 6.1 and 6.2) and weekly sampling locations (Table 6.5) indicate episodes of markedly acidic precipitation each year at all five locations. These episodes were more pronounced in the values recorded at the daily sites; the minimum pH values were marginally

higher in the weekly samples. The higher pH minima in the weekly samples can be attributed to the diluting effect of less acidic precipitation at other times during the weekly sample collection period. An examination of

Table 6.6

The annual minimum and volume weighted mean pH and the annual volume weighted mean concentrations ($\mu\text{eq/l}$) for hydrogen ion, nitrate, ammonium, chloride, non-marine sulphate and sodium in the precipitation samples greater than 5mm at Ryan and Somers Farms for the years 1996, 1997 and 1998. Corresponding values for Gortglass and Doo Lough in Clare and Maam Valley in Co. Galway for the years 1987, 1988 and 1989 are also given. Mean concentrations for hydrogen ion, nitrate, ammonium and non-marine sulphate are given for unpolluted and artificially acidified locations in Western Europe

Location	Year	pH Min	pH Mean	H ⁺ Ion $\mu\text{eq/l}$	Nitrate $\mu\text{eq/l}$	NH ₄ $\mu\text{eq/l}$	N.M. SO ₄ $\mu\text{eq/l}$	Cl $\mu\text{eq/l}$	Na $\mu\text{eq/l}$
Ryan Farm	1996	4.08	4.83	15	10	24.1	28.7	268	224
	1997	4.11	4.89	13	10	18.3	24.2	225	179
	1998	4.49	4.99	10	7	21.6	24.4	286	266
Somers Farm	1996	4.30	4.89	13	11	27.4	23.1	181	151
	1997	4.12	4.83	15	9	15.5	21.0	167	138
	1998	4.47	4.95	11	6	16.1	19.7	183	179
AWW	1998	4.37	5.18	6	7	19.5	18.6	245	228
Gortglass Co Clare	1987	3.25	4.80	16	11	22	26	269	147
	1988	3.87	4.77	17	8	12	11	367	231
	1989	3.85	4.72	19	5	13	17	269	197
Doo Lough Co Clare	1987	4.02	4.86	14	8	10	15	273	178
	1988	4.06	4.84	15	8	10	9	316	300
	1989	3.48	4.56	27	5	11	11	276	210
Maam Valley Co Galway	1987	3.78	4.81	15	9	12	13	248	148
	1988	3.90	4.86	14	9	9	8	307	313
	1989	3.67	4.70	20	7	8	9	335	238
Artificially Acidified									
Birkeness (Norway) ¹				69	41	42	71		
E Scotland (Glen Dye) ²				35-46	28-42	22-33	39-49		
E Midlands England (High Muffles) ²				41-72	36-47	40-64	51-82		
S E England (Barcombe Mills) ²				12-24	19-31	16-50	33-52		
Unpolluted									
Kårvatn (Norway) ¹				17	5	6	12		
W Scotland (Polloch) ²				12-15	9-11	5-8	14-17		
W Wales (Llyn Brianne) ²				12-24	12-18	12-20	22-30		

¹Overrein *et al.*, 1981

²Vincent *et al.*, 1996

the dates on which the greatest acidity (pH values <4.5) occurred at the daily sites indicates that such events were of short duration rarely lasting more than one day. These values, while suggesting strongly acidic precipitation on those days, do not approach the lower levels recorded at both east and west coast locations in Ireland in the late 1980s or those for mainland European sites recognised as being subjected to artificially acidified precipitation.

The annual median pH values and hydrogen ion concentrations at both daily and weekly sampling sites were close to the values that are considered characteristic of unimpacted precipitation. The somewhat higher median

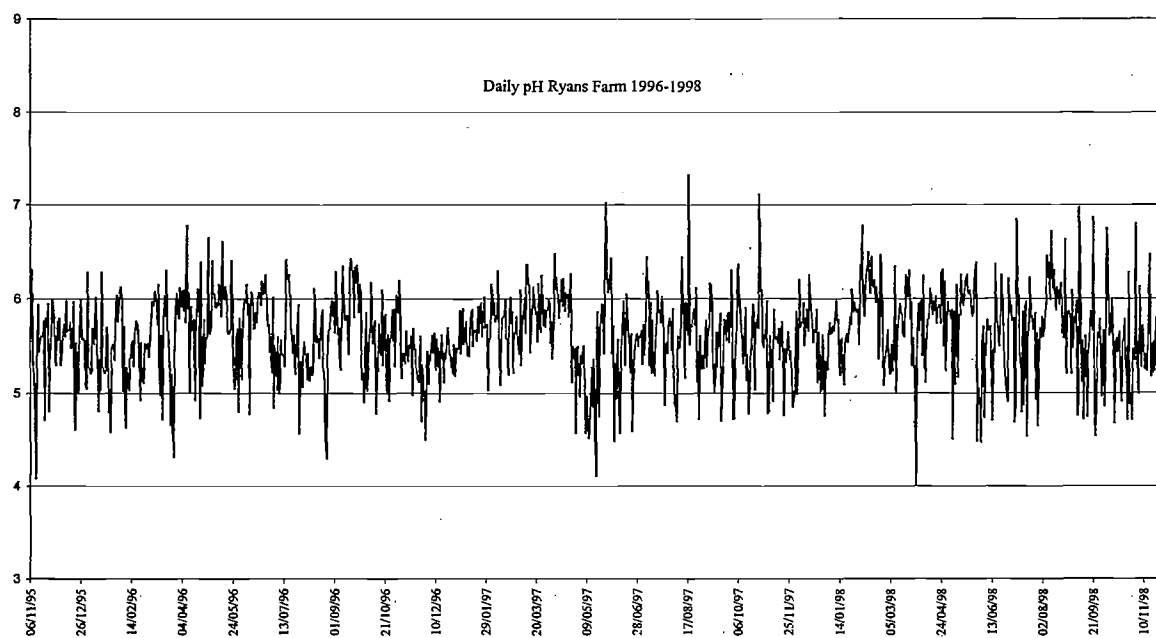
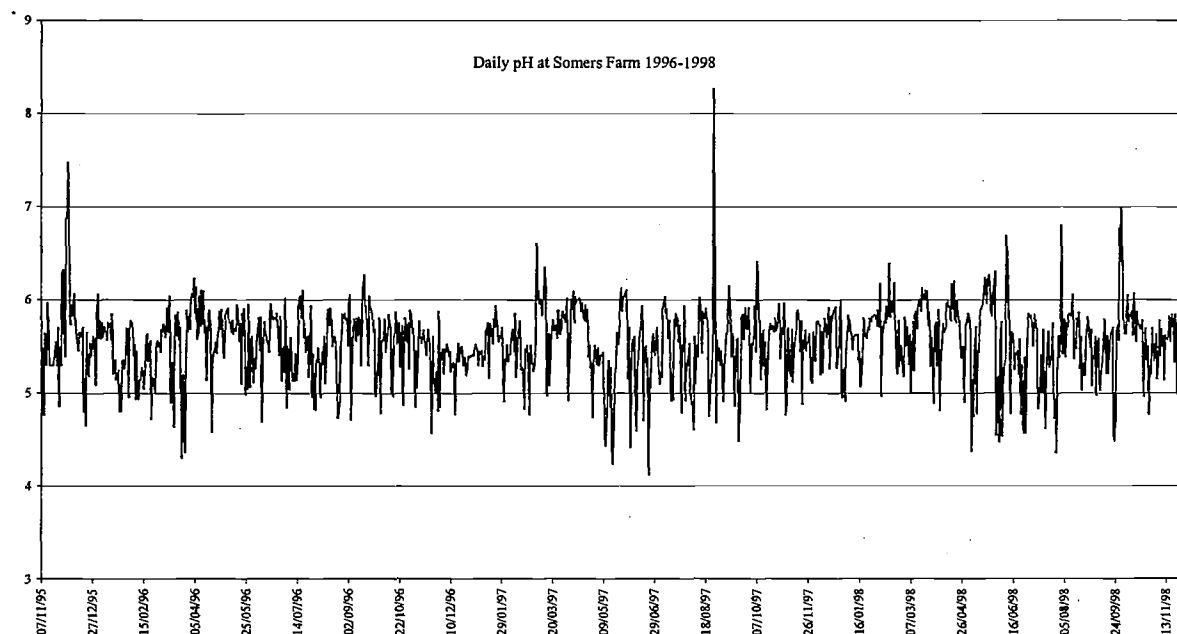


Fig 6.1 pH in daily rainfall samples on the Somers and Ryan farms, 1996-1998

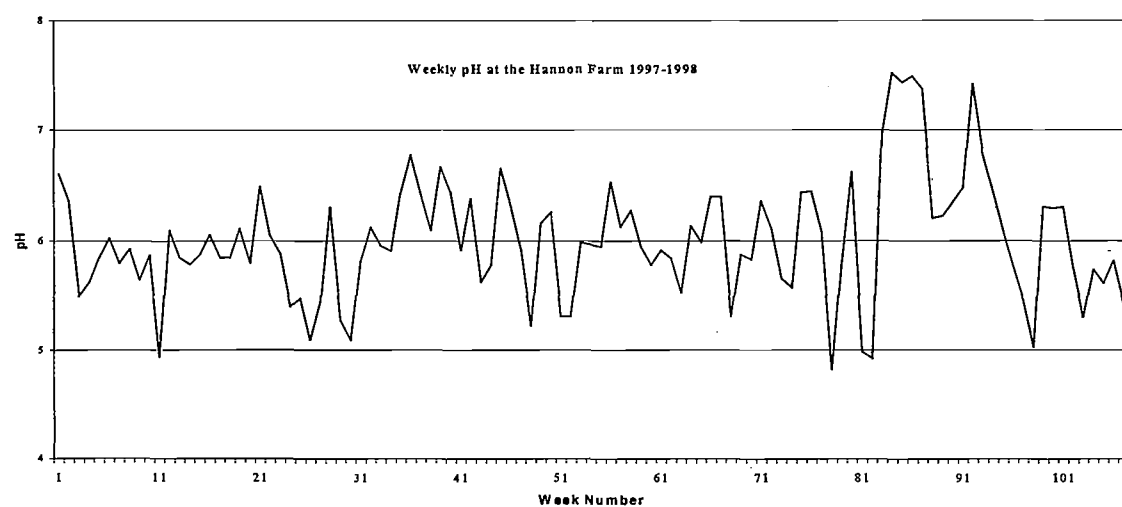
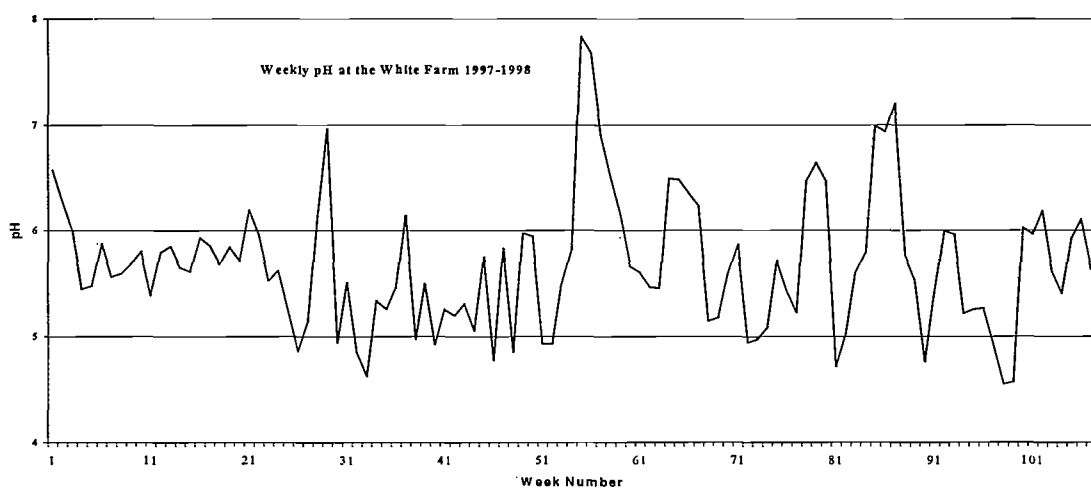
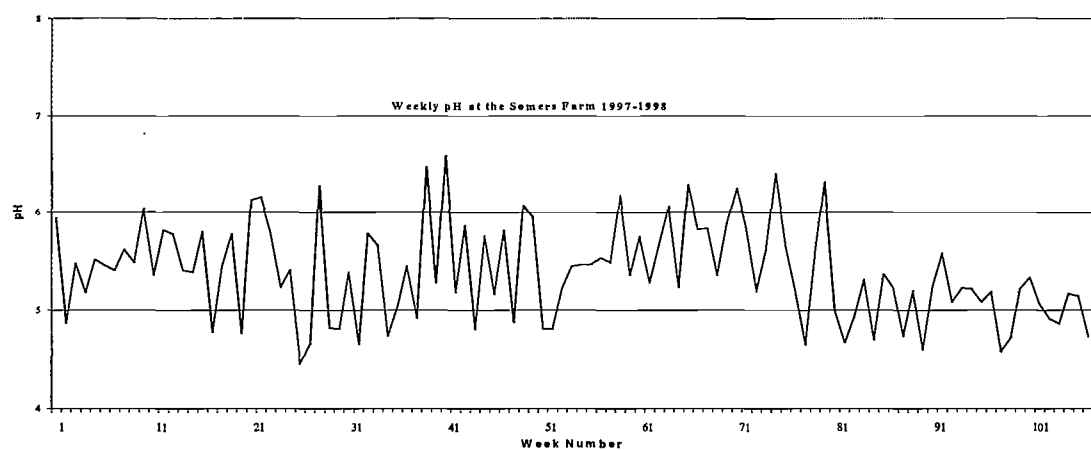


Fig 6.2 pH in weekly samples on the Somers, White and Hannon farms

pH values recorded in the weekly samples at Hannons sampling site may be due to the higher ammonium concentrations recorded at this location. Overall these pH values are one pH unit or more higher than the corresponding values (UNECE, 1989) measured at acid-impacted areas in Europe. The volume-weighted values for pH and hydrogen ion concentrations (Table 6.6) confirm the relatively low levels of acidity in the samples of precipitation from the Askeaton area.

The maximum values were, with the exception of that for the Somers Farm in 1997 (pH 8.26), neutral or slightly acidic indicating the absence of strongly alkaline pollutants. The high pH value in a sample from the Somers farm coincided with high ammonium and nitrate concentrations suggesting some form of contamination of the sample and is therefore not considered to be an accurate representation of the true pH of the precipitation at this time. The next highest pH value at this location in 1997 was 6.60. The higher values for maximum pH were recorded in the daily samples; the corresponding values for the weekly samples were lower possibly due again to the composition of precipitation falling at other times during the collection period.

The corresponding data for pH on those days when the precipitation was less than 0.5 mm is set out in Table 6.7. This group of samples was influenced to a greater extent or exclusively by dry deposition. With the exception of the maximum value at Somers in 1996 and the minimum value at Ryan in 1998 the values were within the ranges described for those samples of daily precipitation greater than 0.5 mm (Table 6.4). The two exceptional values do not suggest extreme levels of pH and were only marginally different to the corresponding values recorded at other stations during this investigation. The median values in these samples were higher than those for the other daily samples indicating generally lower levels of acidity in the precipitation on days with low or no precipitation.

Overall the levels of acidity recorded in the precipitation at the five sampling points in the Askeaton area during the period 1996-98 were consistent with those of an area relatively unaffected by artificial acidity and are close to those values recorded in areas of Europe recognised as unimpacted. With the exception of the pH of 8.26 recorded in one sample from Somers farm in 1997, markedly alkaline conditions in precipitation were not encountered during the investigation.

Table 6.7

The minimum median and maximum values for pH and hydrogen ions in the samples with precipitation less than 5mm at the daily sampling locations for the years 1996, 1997 and 1998.

Parameter	Year	Somers			Ryan			AWW		
		Min	Med.	Max	Min	Med.	Max	Min	Med.	Max
pH	1996	4.71	5.65	7.47	4.58	5.78	6.77			
	1997	4.77	5.62	6.60	4.59	5.71	7.02			
	1998	4.48	5.76	6.76	4.01	5.85	6.84	4.42	6.12	7.01
H ⁺	1996	0.1	2.2	19.7	0.2	1.7	26.5			
	1997	0.3	2.4	17.1	0.1	2.0	25.9			
	1998	0.2	1.8	33.4	0.1	1.4	98.0	0.1	0.8	38.4

Total Sulphate

The minimum and annual median concentrations of total sulphate in the precipitation at the sampling locations (Tables 6.4 and 6.5) were low and consistent with those of an area not subject to excessive anthropogenic contamination. A slight decrease in the annual median concentrations was noted over the measuring period on the Somers farm while those for the Ryan farm were almost identical. The maximum concentrations in the daily samples were much higher than the median values; however, the 12 highest values were, for the most part, associated with air masses borne on westerly (between 220 and 280 degrees) winds and with high concentrations of sodium and chloride, suggesting that a large portion of the sulphate was of marine origin. This is confirmed by the low concentrations of non-marine sulphate calculated for most of these days.

The median concentrations of total sulphate in the weekly samples at Somers (Table 6.5) were over 60 per cent higher in 1997 and 24 per cent higher in 1998 than the corresponding value for the daily samples at that site. The

maximum values in the weekly samples were lower than in the daily samples; this can be attributed to the dilution of the higher sulphate concentrations by precipitation of lower concentration at other times during the collection period.

Non-Marine Sulphate

This is the fraction of the total sulphate considered to be derived mainly from anthropogenic sources, in particular industrial processes involving the combustion of fossil fuel; it has been estimated here in the standard manner by reference to the sodium concentrations. The minimum and annual median concentrations of non-marine sulphate were low at the three daily sampling sites (Table 6.4). The latter values were less than 1.5 mg SO₄/l in all but one case, that for the Ryan farm in 1996, and showed a slightly declining trend over the period of examination on both farms. The median value recorded at the AWW site, where data were collected for 1998 only, was the lowest recorded in the area. The medians for the three weekly sampling sites (Table 6.5) were not much different to those for the daily sites.

For the days on which the 12 maximum non-marine sulphate concentrations occurred at the three daily sampling locations there is no clear pattern in respect of wind direction. While the majority of these values were associated with air masses borne on winds between 220 and 280 degrees, i.e. westerly winds, a substantial number were also associated with air masses borne on winds from other directions. However, it would be reasonable to conclude that a large proportion of the maximum non-marine sulphate concentrations associated with air masses borne on westerly winds were attributable to emissions from local industry.

The annual volume weighted mean concentrations of non-marine sulphate were calculated for each of the daily sampling locations (Table 6.6). The higher values were recorded at Ryan's farm and again an overall declining trend was indicated during the three-year period. The lowest value was recorded at the AWW sampling location in 1998. These values, while slightly elevated compared to those calculated in the period 1987-89 for other west coast locations, are low. When considered in the context of data for other European sites it is seen that the non-marine sulphate concentrations at Askeaton, in the range 19 - 29 µeq/l, are of the same order as those calculated for precipitation in the remoter parts of the continent where artificial impacts on acidity are minimal.

Ammonia

Ammonia gas in the atmosphere originates mainly from biological activity and is principally associated with animal rearing operations that produce large quantities of decomposing animal manure slurries. It is rapidly absorbed in cloud moisture and is deposited as ammonium ions in the immediate area.

The highest median and maximum ammonium values recorded at the Ryan and Somers farms during the period of the investigation were measured in 1996 (Table 6.4). The values recorded at the AWW sampling site in 1998 were of the same order as those measured that year at Ryan and Somers. The annual median ammonium values at the daily sites during the period of the investigation were in the range 0.25 - 0.46 mg N/l. The corresponding values for impacted areas in north central Europe, with a high level of intensive agricultural activity, are in excess of 2.0 mg N/l (UNECE, 1989).

The volume weighted mean values for ammonium at the daily sites (Table 6.6) were also at the lower end of the European scale. A comparison of these values with those calculated at other west coast locations in the period 1987-89 indicates a strong similarity between both periods. This is particularly so when the comparison is made with the values calculated in 1987-89 for the Gortglass sampling site, which is located across the River Shannon Estuary from the location of the current investigation.

The minimum and median ammonium concentrations in the weekly samples at Somers, White and Hannon sampling sites (Table 6.5) were generally higher than the corresponding values in the daily samples (Table 6.4). The opposite pattern was apparent for the maximum values. The median ammonium concentrations in the precipitation at the Hannon sampling location were higher than at the other locations.

Nitrate (Oxidised Nitrogen)

Oxidised nitrogen compounds, which contribute to the acidity of precipitation, are emitted from all combustion processes. In Ireland, car traffic, power generation and domestic heating are important sources. The median nitrate concentrations in the precipitation for each year were low at the daily sampling sites (Table 6.4) and those for the weekly sites (Table 6.5) in 1998 were of the same order. The corresponding data for the latter locations in 1997 were slightly elevated in comparison. An examination of the annual volume weighted mean nitrate values

(Table 6.6) for the daily sampling sites show them to be of the order recorded at other west of Ireland locations in the period 1987-89 and consistent with values recorded in unpolluted precipitation in remote parts of Europe.

Phosphate

The median concentrations of phosphate (MRP) (Tables 6.4 and 6.5) in the precipitation were moderate; however, some high maximum values were recorded associated with low volumes of precipitation. It is likely that these latter values reflect particles blown on to the sampler and resulting from some activity on the surrounding farmland.

Fluoride

Fluoride concentrations (Tables 6.4 and 6.5) were low and in nearly all instances less than 0.1 mg F/l, the level of detection.

Sodium and Chloride

Sodium and chloride, which are almost exclusively of marine origin, are the major ions in precipitation in Ireland, particularly along the western seaboard. The median and maximum concentrations of these ions for both daily and weekly sampling points (Tables 6.4 and 6.5) and the volume weighted mean concentrations at the former locations (Table 6.6) reflect the strong marine influences on precipitation in the Askeaton area. The influence of these and other salts of marine origin is highest in the area closest to the sea and declines rapidly with distance inland, a fact that probably accounts for the variation in the concentrations of sodium and chloride at these sites. The median and maximum concentrations were much higher at the Ryan sampling station compared to Somers, reflecting its greater proximity to the estuary. However, the lower maxima at the White and Hannon weekly sites and in the weekly samples from the Somers site are likely to be due as much to the diluting effect of a longer collection period on short-term peaks in concentrations, as to the more inland location of the sites. There is no immediate explanation for the significantly higher median concentrations of both sodium and chloride at the Hannon site in 1998.

Potassium, Magnesium and Calcium

Potassium and magnesium in precipitation are also of marine origin in large measure. Thus, like sodium and chloride, their maximum concentrations in the Askeaton area coincide with precipitation associated with air masses borne on westerly winds, containing relatively large amounts of salts of marine origin. There was a striking correspondence of the occurrences of the 12 highest daily concentrations of these four parameters at the different sampling points. This was particularly noticeable in 1998; however, in the case of potassium in 1996 the coincidence was less striking. A coincidence of the days of maximum concentrations of these four ions with the corresponding days for calcium in the precipitation is also apparent.

Of note during the investigation was an event recorded during the 24 hours from 0900 on 28/5/97 to 0900 on 29/5/97 represented by the sample dated 28/5/97 from the Ryan Farm. The collecting funnel was reported as coated in a "soot like" deposit. There was no precipitation measured during these hours so the deposited material on the funnel was washed into the bottle at 0900 on 29/5/97. On examination by microscope the deposited material appeared to consist of crystalline particles, dark in colour and transparent. It was not possible to determine the source of this material.

Comparison between Daily and Weekly Samples on the Somers Farm

The weekly samples give a reasonably reliable picture of the precipitation quality on the Somers farm when compared with the results of daily sampling. The apparent differences between the daily and weekly samples may be due largely to the generally low values recorded at the site. In such circumstances small variations in concentration may appear more significant than they actually are. It is concluded, therefore, that the results of the weekly sampling on the White and Hannon farms are also representative of precipitation quality at those locations and show that this too is not significantly polluted.

Annual Deposition Rates

The annual deposition rates for non-marine sulphate, nitrate and ammonium at Ryan and Somers farms for 1996, 1997 and 1998 and for the sampling point at AWW for 1998 are given in Table 6.8. These rates are calculated as the sum of the products of the daily precipitation amounts and the corresponding concentrations. Calculations were made excluding and including estimates for deposition on days when precipitation was less than 0.5 mm and both are given in Table 6.8.

Table 6.8

The annual deposition of non-marine sulphate ($\text{g S/m}^2/\text{y}$), nitrate and ammonium ($\text{g N/m}^2/\text{y}$) in the precipitation at the Askeaton sites in 1996-1998 for days with precipitation samples greater than 5 mm (values for all days given in parentheses). Corresponding values of non-marine sulphate and nitrate for Gortglass and Doo Lough in Co. Clare and Glencree in Co. Wicklow for the years 1987, 1988 and 1989 (Bowman, 1991) are also given.

Sampling Location	Year	NM-SO ₄ g S/m ² /y	NO ₃ g N/m ² /y	NH ₄ g N/m ² /y
Ryan Farm	1996	0.39 (0.48)	0.12 (0.17)	0.29 (0.37)
	1997	0.35 (0.44)	0.13 (0.17)	0.23 (0.32)
	1998	0.39 (0.49)	0.10 (0.12)	0.30 (0.39)
Somers Farm	1996	0.29 (0.37)	0.12 (0.17)	0.31 (0.43)
	1997	0.28 (0.28)	0.10 (0.10)	0.17 (0.18)
	1998	0.28 (0.35)	0.08 (0.10)	0.23 (0.29)
AWW	1998	0.35 (0.42)	0.11 (0.27)	0.32 (0.78)
West Coast				
Maam Valley	1987-89	0.35	0.26	-
Gortglass	1987-89	0.28	0.12	-
Doo Lough	1987-89	0.22	0.12	-
East Coast				
Glencree	1987-88	0.51	0.36	-

Non-Marine Sulphate

The annual deposition rates for non-marine sulphate at the daily sampling locations were similar over the period of examination at each of the farm sites although the rates for Somers were somewhat smaller than those for Ryan and for that at AWW in 1998. These calculated annual values are low and comparable to the corresponding values for other west coast locations in the period 1987-89. They also similar to the rates calculated for the less polluted regions of Europe, including Valentia in Co. Kerry, (Table 6.9) and indicate that the rate of deposition of sulphate of industrial origin at the Ryan and Somers farms and at AWW was not substantial in the three year period.

Of the 20 days with the highest rates of deposition of non-marine sulphate at each daily sampling location, the concentration was the principal factor in determining the rate in 1998, whereas in the earlier years the volume of precipitation was the more important factor. An examination of the wind direction, as measured at Shannon Airport, on each of the days when the high deposition rates were associated with high concentrations of non-marine sulphate does not show a clear association with air masses from any one sector. Similarly, the wind direction on the days when high deposition coincided with high volumes of precipitation showed considerable variation. Overall there was no apparent tendency for high deposition to be associated with air masses from any particular direction.

There was a noticeable similarity between the variations of the daily deposition rates at each site (Figs 6.3-6.5). However, higher values were calculated for the days of maximum deposition on the Ryan Farm. This is to be expected in view of the higher volumes of precipitation (Table 6.3) and non-marine sulphate concentration (Table 6.4) measured at this site. The pattern of deposition at AWW in 1998 is similar to that at the other two sites particularly to that for Somers. No clear seasonal pattern in non-marine sulphate deposition is apparent in the daily rates (Figs 6.3-6.5).

Nitrate

The annual deposition rates for nitrate at the daily sampling locations were consistently low over the period of examination (Table 6.8) and of the same order as those calculated for other west coast locations in the period

1987-89. These values indicate near background rates when compared with values calculated at other European locations with low and high deposition of nitrate (Table 6.9).

Table 6.9

Deposition rates for non-marine sulphate (g S/m²/y), nitrate and ammonium (g N/m²/y) at European locations with low and high deposition in 1989 and 1992 (Schaug *et al.*, 1991, 1992) contrasted with data from the Askeaton sites in 1996-1998 for days with precipitation samples greater than 5mm (values for all days given in parentheses).

Location	Non-marine Sulphate (g S/m ² /y)		Nitrate (g N/m ² /y)		Ammonium (g N/m ² /y)	
Rates at Low Deposition Sites						
	1989	1992	1989	1992	1989	1992
Valentia Ireland	0.28	0.35	0.10	0.15	0.11	0.14
Irafoss Iceland	0.35	0.55	-	-	-	-
Strath Vaich Scotland	0.18	0.23	0.09	0.12	0.08	0.08
Jergul N. Norway	0.16	0.10	0.06	0.06	0.06	0.02
Bredkalen Sweden	0.31	0.17	0.12	0.09	0.14	0.06
Jungfrau Switzerland	0.26	0.23	0.14	0.12	0.18	0.17
Mean	0.26	0.27	0.10	0.11	0.12	0.09
Rates at Artificially Acidified Deposition Sites						
Birkenes S. Norway	1.11	0.99	0.93	0.70	0.78	0.59
Kosetice CSFR	0.86	0.58	0.42	0.36	0.46	0.49
Ispira Italy	1.79	1.49	1.20	1.18	1.34	1.36
Jarczew Poland	0.77	0.83	0.30	0.33	0.46	0.46
Neuglobsow Germany	1.05	0.26	0.35	0.16	0.41	0.19
Illmitz Austria	0.93	0.60	0.30	0.26	0.32	0.34
Mean	1.08	0.79	0.58	0.50	0.63	0.57
Ryan Farm	1996	0.39 (0.48)	0.12 (0.17)	0.29 (0.37)		
	1997	0.35 (0.44)	0.13 (0.17)	0.23 (0.32)		
	1998	0.39 (0.49)	0.10 (0.12)	0.30 (0.39)		
Somers Farm	1996	0.29 (0.37)	0.12 (0.17)	0.31 (0.43)		
	1997	0.28 (0.28)	0.10 (0.10)	0.17 (0.18)		
	1998	0.28 (0.35)	0.08 (0.10)	0.23 (0.29)		
AWW	1998	0.35 (0.42)	0.11 (0.27)	0.32 (0.78)		

Concentration was the principal factor determining the 20 highest daily deposition rates for nitrate during the period of examination. However, in 1998, the 24-hour period with maximum precipitation (25/9/98) coincided with maximum nitrate deposition at all three sampling sites.

As with sulphate there was a strong coincidence of the days with maximum nitrate deposition at the two farm sampling sites each year. Of the 20 days with the highest nitrate deposition during 1996, 12 were common; the corresponding figure for 1997 and 1998, respectively, were 17 and 16. These days were not associated with air masses from any particular direction; however, a large number occurred on days when the wind was from various points in the north-eastern and south-eastern quadrants.

Ammonium

The annual deposition rates for ammonium, over the period of examination, were moderate when compared with values calculated at other European locations with low and high deposition (Table 6.9). Lying between those

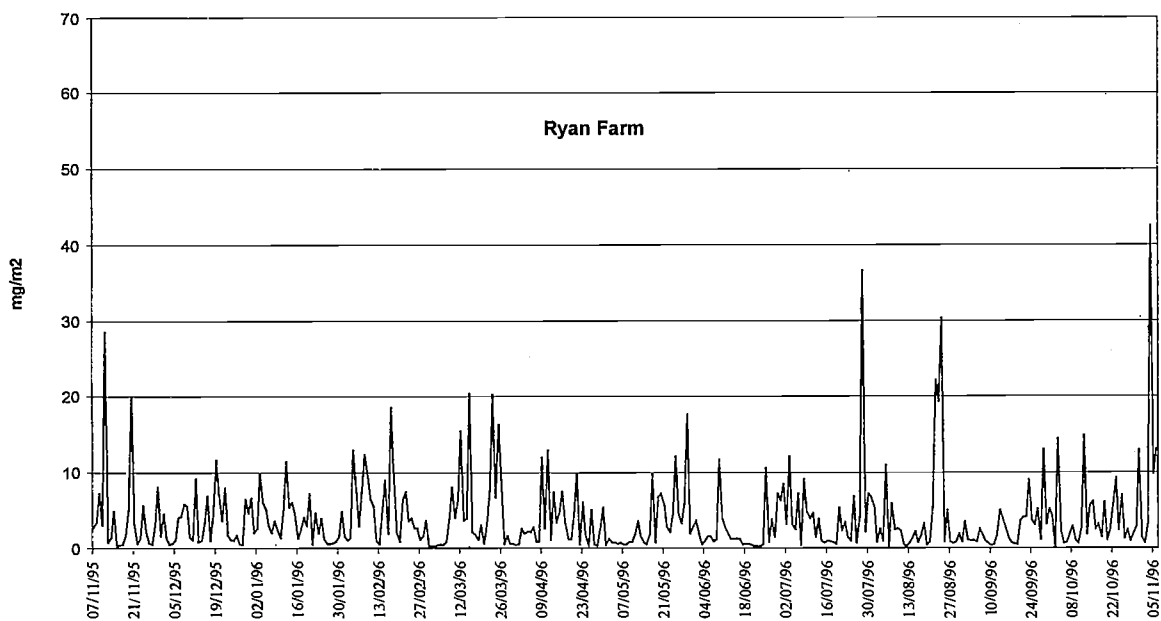
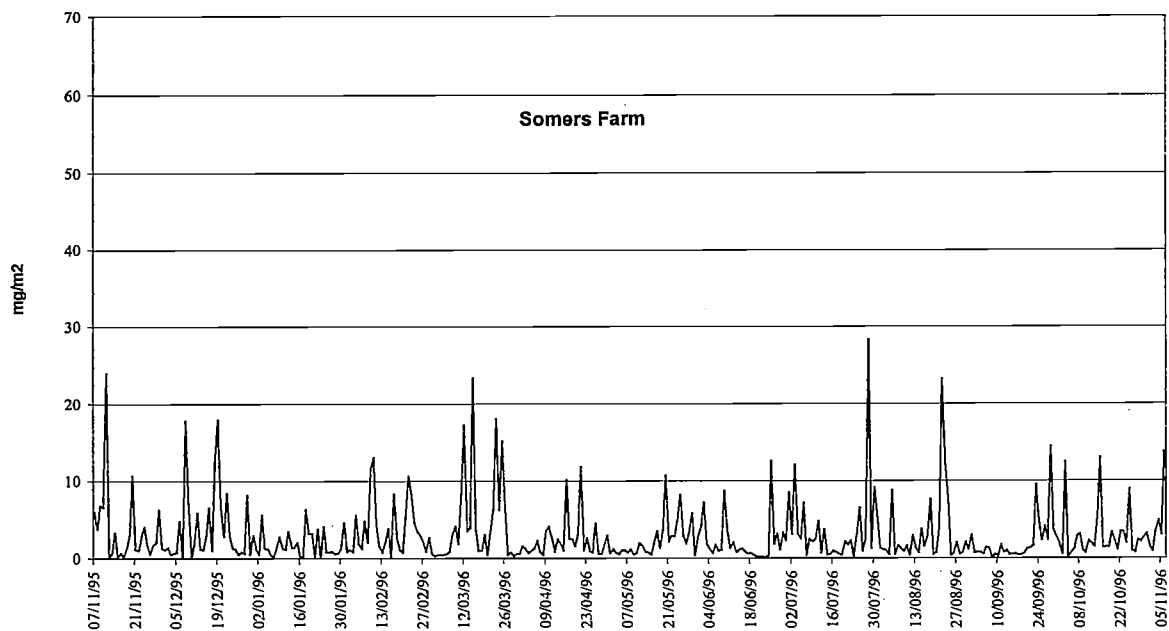


Fig. 6.3 Daily deposition rates of non-marine sulphate on the Somers and Ryan farms November 1995-November 1996

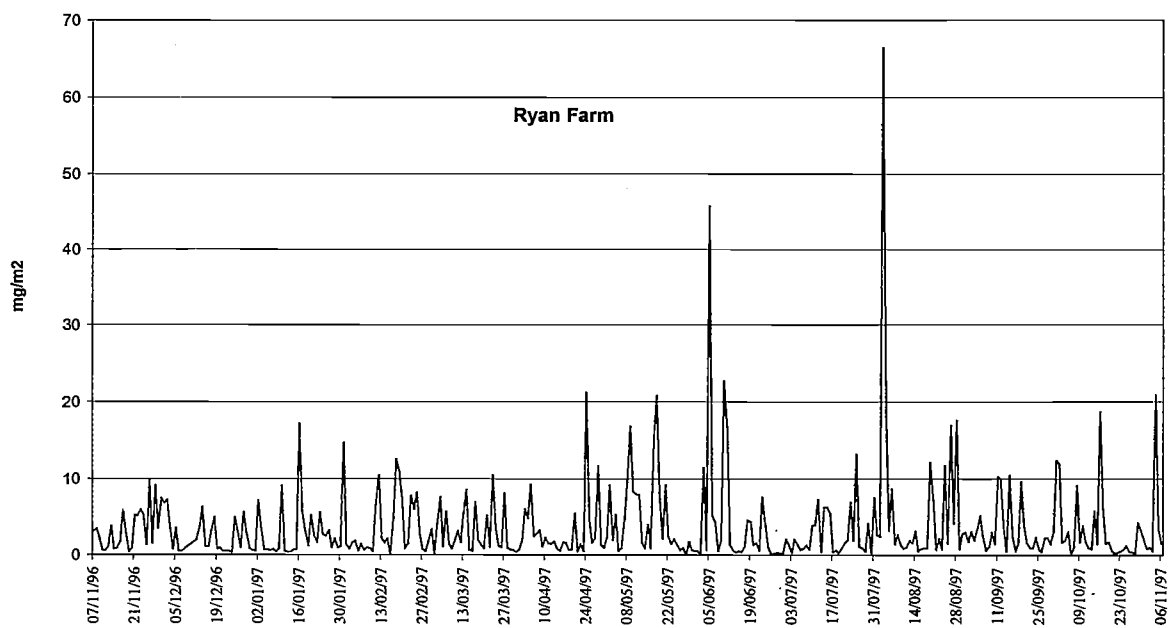
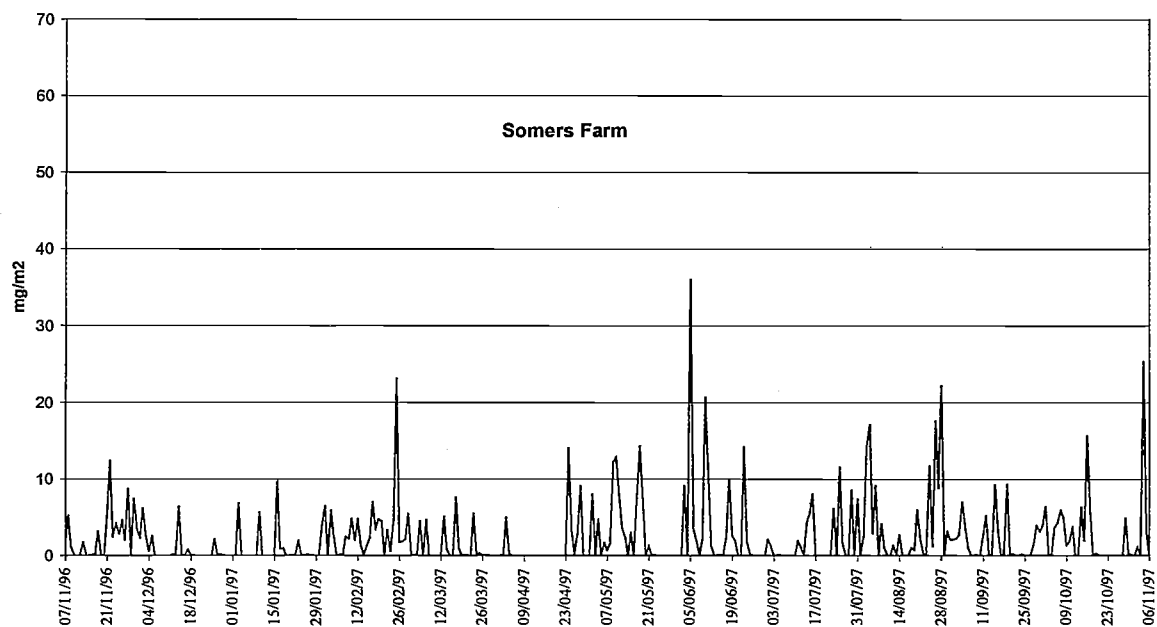


Fig. 6.4 Daily deposition rates of non-marine sulphate on the Somers and Ryan farms November 1996- November 1997.

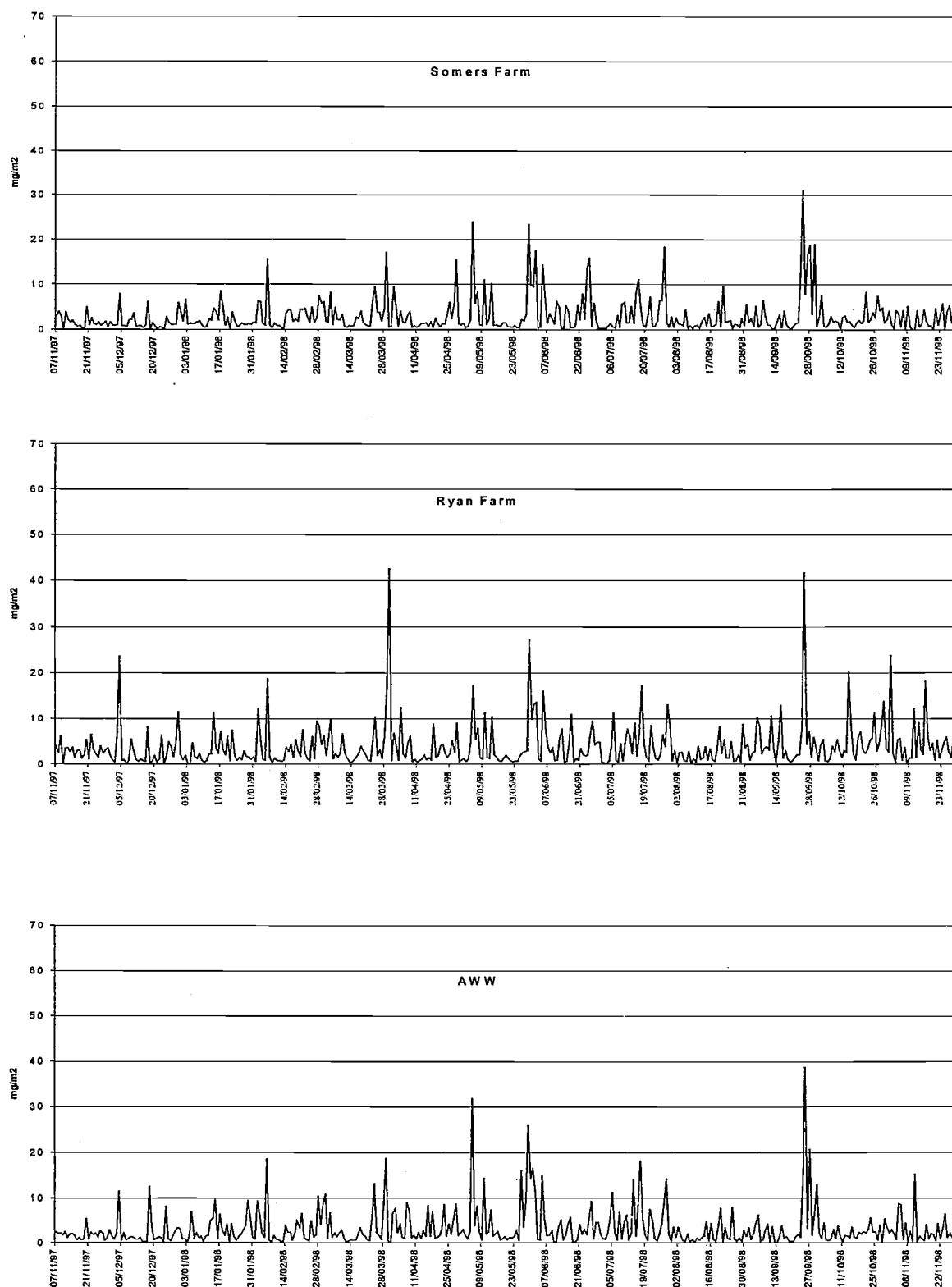


Fig. 6.5 Daily deposition rates of non-marine sulphate on the Somers and Ryan farms and at Askeaton Water Works (AWW) November 1997-November 1998.

recorded in naturally and artificially acidified regions, these rates for Askeaton probably reflect above background production of ammonium in the area due to agricultural activities; they are unlikely to represent any threat to the environment. However, in view of the relatively low concentrations of ammonium recorded in the precipitation, they are greater than expected and may result from the relatively high precipitation in the Askeaton area. A strong correspondence was noted in each year between the days with maximum ammonium deposition at the two farm sites. Of the 20 days with the highest ammonium deposition at each daily sampling location the concentration of ammonium was the principal factor in determining the deposition rate in 1998, whereas in the earlier years the volume of precipitation was the more important factor.

Deposition and pH

The days with the lowest pH values frequently coincided with the highest non-marine sulphate and to a lesser extent nitrate loading rates emphasising the importance of these anions, particularly sulphate, as the principal acidifying agents. On the lesser number of days when low pH values coincided with high ammonium deposition rates, high non-marine sulphate and/or nitrate loadings were also recorded. On these occasions it is reasonable to attribute the greater acidity to the overriding influence of the latter parameters. On the days when maximum ammonium deposition rates coincided with relatively low non-marine sulphate and nitrate loadings, the pH values in general tended towards the maximum.

METALS IN PRECIPITATION

Metal levels in rainwater were determined on samples collected weekly from the Somers farm and later at the Ryan farm. These are compared in Table 6.10 with the levels found in the background sites at Turlough Hill and Valentia, which are operated by the EPA for other purposes.

The results, although limited in number, indicate that there are no significant differences from background at these farms for most of the metals listed. Some raised levels of aluminium were found at the Somers farm in the April and July 1996 samples. These were both above the drinking water standard of 200 µg/l but levels fell back to the background site level in subsequent samples. The highest figure in 1997 was from the Ryan farm although this was at a lower level of 149 µg/l and the highest level for 1998 was from the background site in Valentia. It is possible that these higher levels could be due to particles of soil blowing into the samplers.

CONCLUDING COMMENTS

The levels of acidity measured at both the daily and weekly sampling sites in the Askeaton area in the period 1996-1998, while indicating infrequent episodes of markedly acidic precipitation of short duration at each location, were consistent with those recorded in unimpacted areas of Europe. The annual median pH values were one pH unit or more higher than values measured at impacted areas of Europe.

The principal ions contributing to the artificial acidity of precipitation in Ireland are non-marine sulphate and nitrate. The concentrations of both these ions in the precipitation over the three year period were similar to those measured at other locations in the west of Ireland in 1987-1989 and of the same order as values recorded in naturally acidified precipitation in remote parts of Europe. The annual loading rates for non-marine sulphate were similar to those calculated for areas not impacted by artificial acidity and indicate that the deposition of sulphate of industrial origin is not significant in the Askeaton area. Similarly, the deposition rates of nitrate were near background levels. There was no clear association between maximum deposition of non-marine sulphate and wind direction at any of the sampling points; however, the precipitation on the majority of days with high deposition of nitrate was associated air masses borne on winds from various points in the east.

Overall the quality of precipitation in the Askeaton area in the period 1996-1998 did not show signs of being adversely impacted by emissions from local or distant sources. The dominant ions in the precipitation were sodium and chloride which are of marine origin while the concentrations and deposition rates of the principal anthropogenic ions, non-marine sulphate and nitrate, were low or approaching background levels.

Table 6.10

Metal concentrations ($\mu\text{g/l}$) in precipitation at Valentia Island, Co. Kerry and Turlough Hill, Co. Wicklow, contrasted with data for the Somers and Ryan farms

Metal	Valentia Island		Turlough Hill		Somers Farm		Ryan Farm	
	Min	Max	Min	Max	Min	Max	Min	Max
Vanadium								
Oct 1995-Dec 1996	<10	11	<10	<10	<10	10	NM	NM
1997	<10	<10	<10	<10	<10	<10	<10	<10
1998	<10	<10	<10	<10	<10	<10	<10	<10
Farms at or below background sites								
Copper								
Oct 1995-Dec 1996	<0.5	29	<0.5	26	<0.5	3.6	NM	NM
1997	1.1	13.6	<0.5	8.8	2	16.8	<0.5	4
1998	<0.5	11.8	<0.5	1.6	<0.5	2.8	<0.5	5.8
Farms at or near background sites								
Lead								
Oct 1995-Dec 1996	<0.5	3.6	<0.5	5.1	<0.5	1.2	NM	NM
1997	<0.5	22	<0.5	9.5	<0.5	1	<0.5	1.2
1998	<0.5	5	<0.5	1.6	<0.5	1	<0.5	1
Farms below background sites								
Cadmium								
Oct 1995-Dec 1996	<0.05	2	<0.05	2	<0.05	0.2	NM	NM
1997	<0.05	0.59	<0.05	0.27	<0.05	0.13	<0.05	0.16
1998	<0.05	0.64	<0.05	0.15	<0.05	0.05	<0.05	0.09
Farms below background sites								
Chromium								
Oct 1995-Dec 1996	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	NM	NM
1997	<0.5	<0.5	<0.5	<0.5	0.6	3.3	<0.5	3.4
1998	<0.5	<0.5	<0.5	<0.5	<0.5	1.3	<0.5	2.2
Farms higher than background sites								
Nickel								
Oct 1995-Dec 1996	<1	4	<1	8	<1	<1	NM	NM
1997	<1	1.5	<1	1.4	<1	5.2	<1	2
1998	<1	<1	<1	1	<1	1.9	<1	2.3
Farms at or near background sites								
Aluminium								
Oct 1995-Dec 1996	3.3	84	9.4	98	19	346	NM	NM
1997	6.7	94.8	6.5	88.6	30.3	127	53.1	149
1998	6.9	333	8	33	13	151	17.1	123
Farms slightly above background sites								
Manganese								
Oct 1995-Dec 1996	<0.5	26	0.7	60	0.7	13	NM	NM
1997	0.5	7.2	<0.5	13.3	0.9	13.4	1.6	5.6
1998	<0.5	17.9	<0.5	6	<0.5	7.3	<0.5	24.7
Farms at or near background sites								
Zinc								
Oct 1995-Dec 1996	NM	NM	NM	NM	NM	NM	NM	NM
1997	4	60.9	1	195	2.9	34.5	4.3	27.6
1998	<0.5	411	0.9	4.7	<0.5	11.8	1.9	52.3
Farms below background sites								

Chapter Seven

PARTICULATE MATTER IN AIR

INTRODUCTION

The potential for increases over background of concentrations of particulates in air in the Askeaton area has been indicated in Chapter Three. This potential mainly arises from the combustion activities at the ESB and AAL plants and the calcining process at the latter site. In addition, particulates may be lost to the air from the areas of product storage and from the waste storage lagoons at the AAL plant. The IPC licence issued to AAL incorporates limits on the discharge of particulates from the various vents to the atmosphere (*see* Appendix A).

Of particular concern in relation to this material are the finer or “breathable” particles, which are likely to reach the bronchioles and alveoli of the lungs, leading to respiratory damage. The importance of these particles in air pollution is highlighted by the setting of limits for PM₁₀ in the first daughter directive (CEC, 1999) issued under the 1996 framework directive on air quality (CEC, 1996). It is only in recent years that such measurements have been made in Ireland. The main measurement of particulates in air has been undertaken in the local authority networks by means of the black smoke technique in which the stain produced on a filter paper through which air is passed may be related to the concentration of smoke particles in air. This procedure is used in connection with the monitoring carried out for the 1980 EU Directive on SO₂ and smoke (CEC, 1980).

BLACK SMOKE MEASUREMENTS

The air quality monitoring networks operated since the 1980s by Forbairt/Enterprise Ireland on behalf of AAL and by the ESB for its Moneypoint and Tarbert stations include the measurement of black smoke. A summary of the results from these measurements in the period 1986-1998 is given in Tables 7.1 and 7.2. It is clear from these data that the levels of black smoke in the area are generally very low and well within the limits set by the National Regulations made under the 1980 Directive (*see* Table 5.1).

Table 7.1

Medians and 98 percentiles of daily average black smoke concentrations ($\mu\text{g}/\text{m}^3$) at selected stations in the AAL monitoring network. Averaging period is 1st November to 31st October.

Period	Askeaton WW		AAL		Foynes	
	Median	98 %ile	Median	98 %ile	Median	98 %ile
1987/88	3	15	2	15	4	20
1988/89	3	16	2	14	4	18
1989/90	1	7	1	12	4	16
1990/91	1	15	2	16	5	39
1991/92	1	17	1	19	3	36
1992/93	1	10	2	12	4	26
1993/94	1	14	2	17	4	36
1994/95	2	8	2	10	4	28
1995/96	2	5	2	9	7	19
1996/97	2	16	2	14	6	23
1997/98	1	10	1	9	4	21

PM₁₀ MEASUREMENTS

An investigation of PM₁₀ in the Askeaton area was carried out between February and April 1998. The measurements were carried out on behalf of the EPA by Professor S. G. Jennings of UCG. The monitoring instrument used was a Tapered Element Oscillating Microbalance (TEOM) and this was located at the SO₂ recording site on the Ryan farm. For comparison, measurements were also made in early May 1998 at Mace

Table 7.2

Medians and 98 percentiles of daily average black smoke concentrations ($\mu\text{g}/\text{m}^3$) at selected stations in the ESB monitoring network. Averaging period is 1st April to 31st March

Period	Ballylongford		Mt. Trenchard		Kildysert	
	Median	98 %ile	Median	98 %ile	Median	98 %ile
1987/88	1	11	<1	10	1	10
1988/89						
1989/90						
1990/91	1	5	2	7	1	14
1991/92	1	4	1	5	1	10
1992/93	1	4	1	4	1	6
1993/94	1	3	1	3	1	6
1994/95	1	4	1	3	1	7
1995/96	1	8	1	9	1	9
1996/97	1	12	1	10	1	8
1997/98	1	9	1	11	1	8

Head, Co. Galway, a site remote from industry and urban areas. The full report on the measurements is given in Appendix D.

The limits set for PM_{10} in the recent EU directive (CEC, 1999) are an average daily concentration of $50 \mu\text{g}/\text{m}^3$ and an annual average of $40 \mu\text{g}/\text{m}^3$, these to be achieved by January 2005. In the case of the daily limit, 35 exceedances are permitted within the calendar year. The daily mean concentrations of PM_{10} recorded at Askeaton ranged from 4.0 to $36.7 \mu\text{g}/\text{m}^3$ and had an overall average of $11.4 \mu\text{g}/\text{m}^3$. While the period of record was only 73 days, the data indicate that the PM_{10} levels in the Askeaton area would be well inside the EU limits, corresponding to the position on black smoke limits.

A summary of the results of hourly measurements is given in Table 7.3. This shows that for more than 50 per cent of the hours of measurement, the PM_{10} concentration was less than $10 \mu\text{g}/\text{m}^3$ while there were no hours with concentrations greater than $70 \mu\text{g}/\text{m}^3$.

Table 7.3

Summary of results of hourly mean PM_{10} measurements on the Ryan farm, February – April 1998. Figures show the numbers of hours and the percentage of all recorded hours when concentrations exceeded the indicated levels.

	Total	$\mu\text{g}/\text{m}^3$						
		>10	>20	>30	>40	>50	>60	>70
No. hrs	1731	850	235	66	12	3	2	0
% hrs	100	49.1	13.6	3.8	0.7	0.2	0.1	0

Comparison of the hourly PM_{10} concentrations with wind data did not indicate any significant differences between the directional sectors, as shown by the figures below:

	Wind Direction (Degrees)				
	0-80	90-170	180-260	270-360	270-290
Average PM_{10} conc. $\mu\text{g}/\text{m}^3$	12.2	12.8	11.9	11.1	11.2

In particular, it may be noted that winds from the direction of the AAL plant (270° - 290°) were associated with concentrations of PM_{10} which are very similar to those in winds from the main directional sectors.

Following the measurements at Askeaton, the TEOM instrument was operated for two days at the UCG atmospheric research site at Mace Head, Carna, Co. Galway. The PM₁₀ levels measured here, which may be regarded as background, were similar to those measured at Askeaton.

OTHER INDICATORS OF PARTICULATE MATTER IN AIR

As pointed out above, there is a potential for the loss to air of dust from the waste storage lagoons at AAL. Possible impacts of this nature on the Somers and Ryan farms during the investigation were assessed by examining the filter papers through which precipitation samples were passed and those used in the SO₂ monitors. Suspended dust is included in the filtered samples when it settles on the sampler funnel or is washed out of the air by rainfall. This should include all of the heavy particles. Lighter material, which might remain in suspension in the air, would be drawn into the SO₂ monitors. These take in air at the rate of about 500 ml/minute and contain a Teflon filter with a 5 µm pore size to remove dust and protect the instrument. Filters are changed as part of the normal servicing of the analysers

The weekly rainfall samples were filtered through white filter paper and these papers were visually examined for evidence of easily detected material such as the red dust residue from bauxite refining. This monitoring was continued from January 1995 to November 1998 for the Somers farm and from July 1995 to November 1998 for the Ryan farm. The same procedure was applied to three weekly precipitation samplers installed in June 1996 on the Somers and two other farms. These samples were all filtered and the papers examined and stored. No red colour was observed on any of these filters. In all, a total of 760 filters were stored from the farms and can be examined for any further such materials if a concern arises.

A total of 25 of the protective dust filters fitted in the SO₂ monitors were also examined for evidence of red dust. The dust collected on these filters was similar in appearance to that on 14 filters from the monitor operated at Abbotstown in Co. Dublin and showed no evidence of red dust.

DUST DEPOSITION

Forbairt (now Enterprise Ireland) measures dust deposition rates in the Askeaton area as part of environmental monitoring related to AAL. The Forbairt classification of dust fallout rates are given in Table 7.4 for reference and deposition results for the period 1987 to 1994??? are summarised in Table 7.5. Mean deposition rates generally lie in the hardly noticeable category typical of rural areas and small towns with depositions of 30 to 100 mg/m² per day, and often less. The highest measured values were normally due to interference from algal growth in the precipitation associated with the samples.

Table 7.4

Classification of dust deposition rates

Fall-out (mg/m ² /day)	Typical Situation	Public Response
<30	Rural areas away from human activities	No problem
30 – 100	Other rural areas, small towns and suburbs	Hardly noticeable
100 – 150	Town centres and light industrial areas	Noticeable with occasional complaints
150 – 300	Larger urban areas and dusty industrial activities	Very noticeable with regular complaints
>300	Dusty industrial activities	Regular complaints

CONCLUDING REMARKS

The data presented above indicate that particulate matter in air was not a significant environmental problem in the Askeaton area during the period of the investigation and for the years prior to 1995.

Table 7.5

Dust deposition rates 1987/1988 to 1997/1998 (mg/m²/day). Figures are the annual means/maxima.
 NM: Not measured (station discontinued)

Year/Site ¹	Shannon	Askeaton WW	Keanes	AAL WW	Foynes	Moran's
1987/88	48/78	33/120	62/89	53/65	150/300	69/127
1988/89	72/83	41/63	91/188	61/91	150/289	113/200
1989/90	36/83	50/233	55/72	38/78	65/115	119/433
1990/91	60/139	31/90	75/139	53/104	93/138	73/136
1991/92	76/152	46/90	66/178	35/87	75/142	135/218
1992/93	41/87	45/79	67/129	30/72	62/121	103/199
1993/94	-/63	79/298	123/307	53/91	95/259	207/456
1994/95	NM	50/88	79/92	45/85	64/121	107/82
1995/96	NM	55/56	75/84	49/76	61/98	103/141
1996/97	NM	86/154	87/171	81/108	63/98	68/121
1997/98	NM	22/100	87/124	34/73	56/142	94/130

¹ See Fig. 5.3

Chapter Eight

OTHER MEASUREMENTS

INTRODUCTION

In addition to the concentrations of sulphur dioxide in air and sulphur in deposition, a number of other measurements of potential pollutants were made during the course of the investigations. Some of these measurements were prompted by particular concerns expressed locally which, while not appearing to be justified by any apparent risk, were, nonetheless, considered to warrant systematic assessment if only to allay such concerns.

ORGANIC SUBSTANCES IN SOIL, AIR, WATER AND COWS' MILK

Background

The nature of industrial development in the Askeaton area suggested that the likelihood of significant pollution from organic substances was small. There are, however, some man-made organic substances, which are ubiquitous in the general environment, and which have been implicated in incidents of animal health problems in other countries. The classes of compounds possibly involved include polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polychlorinated phenols (PCPs), pesticides and dioxins. In the light of this, it was felt prudent to confirm at the start of the investigations that these substances could be eliminated as possible causes of the animal health problems by carrying out a series of screening tests for their presence.

In addition, it was decided to extend the range of the survey of organic substances in the environment to include the measurements of volatile organic compounds such as industrial solvents. While it was considered that such substances were unlikely to be involved in the animal health problem, they could act as a tracer to identify the presence of emissions from specific sources.

All of these measurements were made in 1995.

Sampling Strategy

It was decided to concentrate the main sampling and analytical effort for the PCBs, PAH, dioxins and PCPs on soils since these act as a reservoir for such persistent substances and are thus most likely to reflect the presence of chronic environmental pollution. Volatile organics were measured in ambient air and in local water supplies. In addition to the foregoing, samples of milk from the affected farms were analysed for dioxins. Due to the association of these compounds with fatty substances, levels in cows' milk are also a good indicator of environmental contamination. Finally, a small number of milk samples taken in the area were tested for the presence of pesticides.

Organic Compounds In Soils

Sampling Details

Samples from the Ryan, Somers and the control farm were taken by Teagasc staff in March 1995 according to a standardised protocol for soils sampling (see Soils and Herbage Report). The samples were analysed for a number of different families of organic compounds, as follows:

- Samples were analysed for dioxins and polychlorinated phenols (PCPs) at the GfA Laboratory, Münster-Roxel, Germany.
- A second set was analysed for PCBs at the Teagasc, Johnstown Castle Research and Development Centre, Wexford.
- A third set was extracted at the Teagasc laboratory at Johnstown Castle and the extracts analysed for PAHs at the EPA laboratory, Pottery Rd, Dún Laoghaire.

Dioxins (PCDF and PCDD)

There are 17 separate dioxin compounds that are known to be toxic. In order to assess the overall toxicity relating to PCDD/F, the generally accepted international toxic equivalent (TEF) values were used (Table 8.1).

Table 8.1
International Toxic Equivalent Factors (TEF) (NATO/CCMS)

PCDDs	TEF	PCDFs	TEQ
2,3,7,8-TCDD	1	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	0.5	2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDD0	0.1	1,2,3,7,8-PeCDF	0.05
1,2,3,6,7,8-HxCDD0	0.1	1,2,3,4,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDD0	0.1	1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,6,7,8-HxCDF	0.1
OCDD	0.001	2,3,4,6,7,8-HxCDF	0.1
		1,2,3,4,6,7,8-HpCDF	0.01
		1,2,3,4,7,8,9-HpCDF	0.01
		OCDF	0.001

The TEFs are toxicity weighting factors which are multiplied by the concentrations of these dioxin compounds to give a total dioxins content expressed as Toxic Equivalents (TEQ).

The results are given in Table 8.2 and show that the sums of the TEQ values for those compounds which were detected were in the range 0.6 to 1.5 ng/kg for the six soil samples. A "worst case" TEQ scenario was also considered where the values of the detection limits for the compounds which were below such limits were also included in the TEQ calculation. For this estimation, the summed TEQ values were in the range 1.1 to 2.0 ng/kg. This means that the maximum TEQ value which could be assigned to any of the samples, even allowing for limitations imposed by analytical detection limits, was 2.0 ng/kg. There was little difference between the results from the three farms while the patterns of individual PCDD/F compounds were very similar for each of the six samples. They are typical of soil samples and are non-specific, i.e. they are not assignable to any particular type of source.

Previous data on dioxin levels in Irish grassland are very limited ; hence the above values were compared with concentrations in grassland samples from different UK and German areas. The German comparison showed that the TEQ values for the Askeaton farms values were in a range typical for grassland in rural Germany. The reference values for PCDD/Fs in soils according to the German "Bund-/Länder-Arbeitsgruppe DIOXINE" are given in Table 8.3. These show a target value of less than 5 ng/kg for uncontaminated soils.

A UK study of 77 soil samples in a 50 km grid across England, Wales and part of Scotland was carried out in 1988. The mean PCDD/F concentrations recorded in the study are considered to provide a reasonable estimate of the typical background environmental levels in soils from England, Wales and lowland Scotland. While not all of the individual PCDD/Fs relevant to TEQ calculations were individually listed, a minimum TEQ mean value of 13.44 ng/kg can be calculated from the data. A further study on soils from urban parklands in London and Birmingham shows significantly higher levels than this in such soils and indicated typical concentrations three or four times the rural equivalent. Finally, a preliminary UK DOE survey of 11 sewage sludges from locations across England gives an estimate for a mean TEQ of 150-200 ng/kg dry solids. These studies are summarised in a review undertaken by the UK Department of the Environment (1989).

It will be seen, therefore, that the maximum TEQ estimate of 2.0 ng/kg for the Askeaton soil samples compares very favourably with the values reported in the German and UK studies and indicates that dioxins in the Askeaton environment are at background levels. This is in line with the results of more recent national investigations of the occurrence of dioxins in the Irish environment (Concannon, 1996, 2001). Using levels in cows' milk as a key indicator, these investigations indicate that levels of contamination here are among the lowest in Europe.

Polychlorinated Phenols

The analytical data for PCPs are shown in Table 8.4. Of these compounds, only 2,4,6 trichlorophenol was detected, occurring in five out of the six samples at concentrations in the range 0.005 to 0.023 mg/kg. The significance of these concentrations can be judged by comparison with PCP values in Dutch soil protection law.

Table 8.2

Concentrations of individual PCDF/D compounds and sums of their TEQs in dry mass of soil samples from the Somers and Ryan farms and from a control farm, taken in 1995. TEQ concentrations are presented as minima (with zero assumed for compounds at less than the detection limits) and maxima (with the detection limit being assumed for compounds at less than that value). Analyses performed by Gesellschaft für Arbeitsplatz und Umweltanalytik mbH, Münster, Germany.

Compound	Somers A ng/kg	Somers B ng/kg	Ryan A ng/kg	Ryan B ng/kg	Control A ng/kg	Control B ng/kg
PCDF						
Total TetraCDF	11	8	7	10	8	6
Total PentaCDF	8	9	7	8	7	5
Total HexaCDF	5	14	10	11	7	5
Total HeptaCDF	3	14	10	10	12	7
OctaCDF	<10 ²	<50 ²	17	13	22	6
TOTAL TETRA- OCTACDF	27	45	51	52	56	29
2,3,7,8,-TetraCDF	1.2	0.5	0.5	0.7	0.6	0.5
1,2,3,7,8,-/1,2,3,4,8,-PentaCDF ¹	0.5	0.9	0.7	0.7	0.6	0.4
2,3,4,7,8-PentaCDF	1.7	1.0	0.7	0.9	0.8	0.5
1,2,3,4,7,8-/1,2,3,4,7,9-HexaCDF ¹	0.8	2.7	1.6	1.6	1.2	0.8
1,2,3,6,7,8-HexaCDF	0.5	1.2	0.9	0.8	<0.9	0.4
1,2,3,7,8,9-HexaCDF	<0.2	<0.3	<0.3	<0.3	<0.5	<0.2
2,3,4,6,7,8-HexaCDF	0.7	1.9	1.4	1.2	1.3	0.7
1,2,3,4,6,7,8-HeptaCDF	2.0	8.4	5.8	6.0	6.5	3.3
1,2,3,4,7,8,9-HeptaCDF	<0.4	2.9	2.1	1.7	3.3	1.9
PCDD						
Total TetraCDD	1	1	2	3	2	2
Total PentaCDD	2	4	3	4	2	2
Total HexaCDD	5	12	7	6	6	5
Total Hepta CDD	5	9	9	12	9	7
OctaCDD	17	19	16	26	20	16
TOTAL TETRA- OCTACDD	30	45	37	51	39	32
2,3,7,8-TetraCDD	<0.2	<0.2	<0.1	<0.3	<0.2	<0.2
1,2,3,7,8-PentaCDD	<0.2	<0.4	<0.2	0.2	<0.3	<0.2
1,2,3,4,7,8-HexaCDD	<0.3	<0.5	<0.4	<0.9	<0.6	<0.6
1,2,3,6,7,8-HexaCDD	<0.3	0.8	<0.5	<0.8	<0.5	<0.5
1,2,3,7,8,9-HexaCDD	<0.3	0.9	<0.8	<0.8	0.8	<0.8
1,2,3,4,6,7,8HeptaCDD	2.7	4.8	4.5	6.2	4.6	3.8
TOTAL TETRA- OCTACDF/D	57	90	88	103	95	61
ΣTEQ EXC DETECTION LIMIT	1.2	1.5	1.0	1.2	1.0	0.6
ΣTEQ INCL DETECTION LIMIT	1.6	2.0	1.4	1.8	1.6	1.1
Dry Mass (%)	53.9	55.6	53.1	51.4	56.2	55.9

¹ Maximum value; co-elution with other isomers cannot be excluded

² Relatively high detection limits due to interfering components

Table 8.3

Reference values for PCDF/D in soils and recommended action for land use and remediation of contaminated soil. (German "Bund/Länder-Arbeitsgruppe DIOXINE")

PCDF/D Contamination Level ng/kg TEQ	Recommended Action
<5	Target value
5-40	Unrestricted cultivation of foodstuffs but avoidance of critical land uses (e.g. grazing management) if increased dioxin levels are analysed in foodstuffs
>40	Limitation to defined agricultural and horticultural land uses; unlimited cultivation only of plants with minimum dioxin transfer (e.g. corn)
>100	Remediation contaminated soil in playgrounds
>1000	Remediation of contaminated soil in urban areas
>10000	Remediation of contaminated soil also in industrial areas

Table 8.4

Polychlorinated phenol concentrations in soil samples from the Somers, Ryan and control farms taken in 1995. Concentrations are related to the dry mass of the samples. Analyses performed by Gesellschaft für Arbeitsplatz und Umweltanalytik mbH, Münster, FRG.

Compound	Somers A mg/kg	Somers B Mg/kg	Ryan A mg/kg	Ryan B mg/kg	Control A mg/kg	Control B mg/kg
2,4,6 trichlorophenol	0.011	0.006	0.006	0.023	0.005	<0.005
2,3,6 trichlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,4,5 trichlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,3,5 trichlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
3,4,5 trichlorophenol ¹	<0.160	<0.026	<0.088	<0.072	<0.034	<0.047
2,3,4 trichlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,3,5,6, tetrachlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,3,4,6, tetrachlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,3,4,5, tetrachlorophenol	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
2,3,4,5,6 pentachlorophenol	<0.005	<0.005	<0.005	<0.005	<0.007	<0.005

¹ Relatively high detection limits due to interfering components

While they are greater than the reference concentrations given there for non-contaminated soils, the maximum concentration recorded in the Askeaton soil samples is only 0.23% of the Dutch intervention level of 10 mg/kg.

Polychlorinated Biphenyls (PCBs)

Concentrations of total PCB in the samples ranged from 0.66 to 1.54 µg/kg with a mean of 0.98 µg/kg. Levels in the soils from the control farm were slightly higher than in those from the affected farms. The levels of PCBs recorded on all three farms are typical of those found in agricultural soil with little input from industrial contamination (D. McGrath, pers comm.).

Polynuclear Aromatic Hydrocarbons (PAH)

Soil samples from the three farms were analysed for the six PAH reference compounds listed in the EU Drinking Water Directive (fluoranthene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene). These compounds are commonly accepted as indicators of the presence of PAH. The sum of these compounds for the samples tested was in the range 11.8 to 33.8 µg/kg (Table 8.5). Fluoranthene was the main component of the PAH in each case, with concentrations ranging from 5.6-14.8 µg/kg. All other compounds were present at concentrations less than 7 µg/kg.

Table 8.5

PAH in soil samples from the Somers, Ryan and the control farm taken in 1995.

Compound	Somers A µg/kg	Somers B µg/kg	Somers C µg/kg	Ryan A µg/kg	Ryan B µg/kg	Control A µg/kg	Control B µg/kg
Fluoranthene	9.3	5.6	4.6	7.0	14.8	8.9	7.5
Benzo(b)fluoranthene	4.7	2.0	2.4	3.3	6.1	3.3	2.1
Benzo(k)fluoranthene	2.3	0.7	0.7	1.5	3.0	1.4	1.3
Benzo(a)pyrene	2.0	1.8	1.7	1.6	5.5	1.7	2.2
Benzo(ghi)perylene	2.2	0.3	1.2	1.2	1.4	0.6	1.4
Indeno(1,2,3-cd)pyrene	4.0	1.4	1.5	2.6	3.0	2.3	1.4
Total PAH	24.5	11.8	12.1	17.2	33.8	18.2	15.9

Good data for comparison purposes are difficult to find in the literature. In studies carried out in the UK (Wild *et al.*, 1991) on the effect of adding sewage sludges on land, analysis of control (uncontaminated) soil samples taken between 1968 and 1988 gave much higher background concentrations (between 6 and 100 times higher for the individual compounds) for PAH than the Askeaton samples. A second study (Jones *et al.*, 1989) carried out on increases in PAH content of an agricultural soil over the last century at an experimental station in SE England again showed much higher background concentrations for PAH. The most recent sample for which complete data were available gave a concentration of 960 µg/kg for the sum of the same compounds.

On the basis of the foregoing, it is clear that the levels for PAH found in this present investigation are very low and, therefore, do not give any cause for concern.

Volatile Organic Compounds (VOCs) In Air

Sampling Details

Two separate surveys were undertaken to assess the level of contamination of the local environment with VOCs. In each case samples were taken by pumping air through absorbent-packed tubes. The VOCs trapped on the tubes were analysed by GC/MS at the EPA Regional Laboratory, Castlebar. The first survey involved the collection of eight daily samples at the Somers farm and Ballylongford (control) from 24/5/1995 to 31/5/1995; the second survey was based on a longer term exposures of tubes in the period 7/6/1995 to 26/7/1995, at these locations and at the Ryan farm.

First Survey

The following specific compounds were analysed for in this case: 2-methylpentane, benzene, isooctane, heptane, toluene, ethylbenzene, m-xylene, o-xylene, 1,2,3-trimethylbenzene. These were considered to be a representative range of commonly found volatile organic substances. For the Somers farm it is clear from Table 8.6 that, with the exception of m-xylene, none of the above compounds were detected above the concentrations found in the blank. In the case of m-xylene, amounts of between 0.060 and 0.09 µg for each of the eight days were detected. Since the tubes detect total amounts of VOC absorbed over a fixed period, there is no guarantee that a given pollutant was not collected in a very short timeframe instead of being more evenly dispersed through the 24 hour period. However, the relative similarity in concentrations between different tubes over the eight day period would suggest that the m-xylene was well dispersed in time.

Using the measurements of air volumes pumped through the sampling apparatus it was possible to calculate mean air concentration for the eight day period of 0.32 µg/m³ for m-xylene. This is a very low concentration and may be accounted for by ambient petroleum vapour. To put this figure into perspective the Irish occupational limit for 8 hr exposure for m-xylene (National Authority for Occupational Safety and Health, 1995) is 435 mg/m³ which is over one million times the figure detected.

Analysis of the sampling tubes from the control station at Ballylongford showed a very similar pattern to those from the Somers farm with the exception of toluene. This compound was detected at levels slightly above blank concentrations and may again be accounted for by ambient petroleum vapour.

Second Survey

It was decided to carry out a follow-up exercise over a seven week period - 7/6/1995 to 26/7/1995 - exposing each tube for a total of seven consecutive days instead of one 24 hour period, because of the extremely low

Table 8.6

Quantities (μg) of VOCs adsorbed on tubes exposed at sites on the Somers farm and Ballylongford between 24/5/95 and 31/5/95.

Sample No.	2-Methyl pentane	Benzene	Iso-octane	Heptane	Toluene	Ethyl-benzene	m-Xylene	o-Xylene	1,2,3-tri Methyl Benzene
Somers									
Blank	<0.05	<0.05	<0.05	0.096	1.24	<0.05	<0.05	<0.05	0.14
1.1	<0.05	<0.05	<0.05	<0.05	0.722	<0.05	0.063	<0.05	<1.0
1.2	<0.05	<0.05	<0.05	<0.05	0.572	<0.05	0.072	<0.05	<1.0
1.3	<0.05	<0.05	<0.05	<0.05	0.415	<0.05	0.06	<0.05	<1.0
1.4	<0.05	<0.05	<0.05	0.081	0.572	<0.05	0.071	<0.05	<1.0
1.5	<0.05	<0.05	<0.05	0.086	0.778	<0.05	0.089	<0.05	<1.0
1.6	<0.05	<0.05	<0.05	0.066	0.75	<0.05	0.067	<0.05	<1.0
1.7	<0.05	<0.05	<0.05	0.091	0.826	<0.05	0.073	<0.05	<1.0
1.8	<0.05	<0.05	<0.05	0.069	0.776	<0.05	0.069	<0.05	<1.0
Ballylongford									
Blank	<0.05	<0.05	<0.05	<0.05	0.15	<0.05	<0.05	<0.05	0.07
2.1	<0.05	<0.05	<0.05	<0.05	0.555	<0.05	0.075	<0.05	0.965
2.2	<0.05	<0.05	<0.05	<0.05	0.925	<0.05	0.122	<0.05	<1.0
2.3	<0.05	<0.05	<0.05	<0.05	0.51	<0.05	0.069	<0.05	<1.0
2.4	<0.05	<0.05	<0.05	<0.05	0.437	<0.05	0.069	<0.05	<1.0
2.5	<0.05	<0.05	<0.05	<0.05	0.381	<0.05	<0.05	<0.05	<1.0
2.6	<0.05	<0.05	<0.05	<0.05	0.332	<0.05	<0.05	<0.05	0.809
2.7	<0.05	<0.05	<0.05	<0.05	0.295	<0.05	<0.05	<0.05	0.949
2.8	<0.05	<0.05	<0.05	<0.05	0.303	<0.05	<0.05	<0.05	0.583

concentrations measured on the first occasion. In this exercise, an additional sampler was installed at the Ryan farm. In addition to the compounds analysed in the previous exercise, methyl ethyl ketone was also analysed for in the Ryan sample because of its use in an adjacent factory.

The longer sampling time in this exercise (Table 8.7) showed the presence of trace amounts of toluene, ethylbenzene, o- and m-xylene and 1,2,3-trimethylbenzene. These were too low to allow any estimate of mean concentrations other than to say that they were certainly below $10 \mu\text{g}/\text{m}^3$. A concentration of this order of magnitude would be insignificant for these compounds as regards potential harmful effects. As was the case in the first exercise, 2-methyl pentane, benzene, isooctane and heptane were not detected in the 7-day sample. Methyl ethyl ketone was not detected above its approximate detection limit of $0.2 \mu\text{g}/\text{m}^3$.

The most important finding in this study was that none of the sampling tubes showed any more than very small amounts of the substances tested for and neither did any tube show a concentration of any compound which was substantially out of line with any of the other tubes. This continuous sampling showed that no high levels of these volatile organic compounds occurred over the sampling period.

Volatile Organic Compounds In Water Samples

Samples were taken in February 1995 from sources on the Somers farm used to water livestock and screened for a range of common organic compounds using purge and trap analysis. The results are given in Table 8.8 where it will be seen that none of the substances analysed for were found above the detection limits. These detection limits are well below relevant EU limits ($10\text{--}12 \mu\text{g}/\text{l}$) for some of these compounds.

Organic Compounds In Cows Milk

Dioxins

Milk samples taken in 1995 from both the Ryan and Somers farms were analysed for dioxins at the CSL Food Laboratory, Norwich. The results (Table 8.9) showed concentrations of individual PCDDs and PCDFs which are close to or below detection limits and are typical of background levels in milk from rural areas. Samples of milk were also taken in the Askeaton area in 1995 and 2000 as part of a national surveys of the environmental levels

Table 8.7

Quantities (μg) of VOCs adsorbed on tubes exposed at sites on the Ryan and Somers farms and Ballylongford between 7/6/95 and 26/7/95.

Sample No.	2-Methyl pentane	Benzene	Iso-octane	Heptane	Toluene	Ethyl-benzene	m-Xylene	o-Xylene	Methyl ethyl ketone	1,2,3-tri Methyl benzene
Ryan										
1.1	<0.05	<0.05	<0.05	<0.05	0.11	0.055	0.179	0.085	<0.05	0.173
1.2	<0.05	<0.05	<0.05	<0.05	0.13	0.081	0.238	0.102	<0.05	0.143
1.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.079	<0.05	<0.05	0.088
1.4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.151	0.065	<0.05	0.127
1.5	No sample									
1.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.102	<0.05	<0.05	0.123
1.7	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.145	0.07	<0.05	0.129
1.8	<0.05	<0.05	<0.05	<0.05	0.084	0.064	0.242	0.11	<0.05	0.194
Backup	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.125
Somers										
2.1	<0.05	<0.05	<0.05	<0.05	0.107	0.075	0.226	0.105		0.194
2.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.084	0.045		0.136
2.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.136	0.061		0.11
2.4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.138	0.061		0.112
2.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.136	0.066		0.114
2.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.055		0.114
2.7	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.147	0.077		0.146
2.8	<0.05	<0.05	<0.05	<0.05	0.058	0.063	0.194	0.095		0.213
Backup	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		0.104
Blank	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		<0.05
Ballylongford										
3.1	<0.05	<0.05	<0.05	<0.05	0.17	0.083	0.256	0.101		0.277
3.2	<0.05	<0.05	<0.05	0.052	0.295	0.057	0.181	0.083		0.209
3.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.137	0.06		0.172
3.4	<0.05	<0.05	<0.05	<0.05	0.057	<0.05	0.105	<0.05		0.251
3.5	<0.05	<0.05	<0.05	<0.05	0.059	<0.05	0.157	0.069		0.234
3.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.161	0.067		0.268
3.7	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	0.149	0.064		0.309
3.8	<0.05	<0.05	<0.05	<0.05	0.089	0.069	0.296	0.128		0.374

of dioxins (Concannon, 1996, 2000). These samples had concentrations (0.003 – 0.018 ng/kg for total TEQs in whole milk) which were somewhat lower than those reported by the CSL laboratory. However, this appears to be due to the lower detection levels employed by the laboratories undertaking the analyses for the national surveys.

Pesticides

In view of the extent of agricultural activity in the locality, some pesticide testing for milk samples was undertaken to ensure that there was no environmental contamination from this source. Two milk samples taken from farms in the general area were tested for a range of 25 organochlorine and 48 organophosphorus pesticides (Table 8.10). In both samples all the individual compounds screened for were found to be below the analytical detection limit.

ALUMINIUM AND FLUORIDE LEVELS IN MILK

Background

In view of the suggestions made that aluminium and fluoride were potential pollutants which might be involved in the animal health problems, it was decided to check on the levels of these substances in cows' milk from the area as indicators of environmental contamination. Sampling for this purpose was carried out in May and August 1995.

Samples taken in the area earlier in 1995 by the Ballysteen/Askeaton Animal Health Committee had been assessed as having a raised level of aluminium compared to milk tested in the UK (Kirby, 1995). However,

there is a dearth of information on the background levels of these substances in milk and it was understood that the UK figures were based on very few samples; thus, their representativeness was questionable, particularly in the Irish context. The lack of background information makes it difficult to assess the significance of analytical results, particularly the possibility that the levels found indicate environmental contamination. In addition, there are difficulties in the analytical area due to the lack of a reference material for the measurement of these substances in milk. This means that there is no independent check on the accuracy of the analytical method used.

Sampling Strategy

In order to try and overcome the difficulty caused by the lack of background values, samples were taken by the Agency on a total of 12 farms, six of these located on a line east and six on a line south from the Askeaton area to the Clarina and Newcastlewest areas, respectively. It was assumed that if there was a source of fluoride or aluminium pollution in the area, the levels should fall off downwind. In addition, in the second sampling run two farms in the Wexford area were included as controls for aluminium. In order to address the analytical difficulty, to some extent, duplicate samples were taken on the later date and a set sent to each of two laboratories.

Results

The data arising from the two surveys are set out in Table 8.11. Overall these data showed the following:

- Variation of aluminium results between dates in samples from the same farms was marked; in nearly all cases the concentrations recorded on the earlier date were higher than those recorded in August. There were also differences between the results produced by the two laboratories for the duplicate samples in August
- The results for aluminium in the milk for the Wexford farms on 8/8/95 were within the range found on that date for the Limerick farms
- There was no indication of an expected decrease in aluminium concentrations with distance from the Askeaton area; in fact the highest levels found on 2/5/95 were in samples taken furthest south from the Askeaton area.
- All fluoride levels were reported as less than 1.0 mg/l as the method used by Lab A is not regarded as reliable for levels below that value. It is not possible, therefore, to make any detailed comment on this substance; however it should be noted that drinking water in public supply is required to have 0.8 to 1.0 mg/l of fluoride.

Based on the results for the 8/8/95 particularly, the surveys do not provide evidence of aluminium contamination of milk in the Askeaton area. However, the lack of data on background levels and the apparent difficulties encountered in analysis preclude a definitive statement on the position. It should be noted, however, that the measurements of rainfall quality made as part of the investigation (see Chapter 6) included aluminium and fluoride and these provide an alternative means of assessing whether there is significant contamination with these substances in the area. Furthermore, even the higher levels found in the milk, if correct, would not constitute a public health risk as they are well below those which have been associated with adverse affects on humans.

SUSPECTED POLLUTION INCIDENTS

During the course of the investigations concerns were expressed that short-term pollution events were occurring in the Askeaton area. Initially, the EPA addressed these concerns by making an agreement with the Askeaton/Ballysteen Animal Health Committee to assist in the investigation of such situations by collecting air samples for subsequent analysis by the Agency.

In 1997, this was replaced by an arrangement whereby members of the EPA's staff, based in the Limerick area, would respond, when possible, to reports of pollution incidents by travelling immediately to the area affected, taking samples of air with standard equipment and interviewing the person making the report. The sampling equipment consisted of an electrically operated air pump together with filters designed to trap sulphur dioxide and alkaline particulates in the air; these substances were considered the most likely to be involved in a pollution

event in the area. The filters would be returned to the Agency's Dun Laoghaire laboratory for analysis. The scope of the facility was limited to the farmers involved in the investigation together with any additional persons nominated by the Askeaton/Ballysteen Animal Health Committee. Each of these was given the number of the mobile phones carried by the Agency's staff members involved. In addition to the foregoing, one farmer was given a sampling device for use by himself in the event of incidents. Suitable equipment was supplied to another farmer who claimed that his property was subject on occasion to "caustic mists" so that a sample of this could be obtained for analysis.

These arrangements were availed of on only a few occasions and where air samples were taken they did not show the presence of significant quantities of either acidic or alkaline substances. Other alleged incidents of air pollution reported could not be independently verified due to their late notification to the Agency. Checks on operations at the alumina plant at the times of the reported incidents did not suggest any unusual circumstances which might have explained the impacts described.

In addition to allegations of air pollution, the Agency also received reports of the deposition of foreign matter in parts of the area during the investigations. Where it was possible to investigate these occurrences, the "deposited" material was found to be of natural origin, e.g. pollen or fungal rusts. There were also a number of instances where accumulated rainwater had taken on a reddish colour raising suspicions that red dust from the AAL lagoons was responsible. In these cases, however, the coloration was due to algae, *Haematococcus* spp, which contain a reddish chromatophore. There were some instances of red dust from the lagoons blowing on to adjacent fields during the earlier period of the investigation. Constant wetting of the lagoon surfaces has been implemented as a counter measure. Complaints of damage to vegetation in the area have been dealt with in the Soil, Herbage, Feed and Water volume and in Chapter Three of the Main Report.

CONCLUDING REMARKS

The data presented above indicate that at the time of sampling the Askeaton area was not significantly impacted by the substances measured. For the organic compounds and fluoride, this is to be expected in view of the nature of the main industrial activities in the area.

Table 8.8

VOCs in water sources on Somers farm (µg/l)

Compound	Location		
	Mains	Ditch	Stream
Dichlorodifluoromethane	<0.1	<0.1	<0.1
Vinyl chloride	<0.1	<0.1	<0.1
t-1,2-Dichloroethene	<0.1	<0.1	<0.1
1,1-Dichloroethane	<0.1	<0.1	<0.1
2,2-Dichloropropane	<0.1	<0.1	<0.1
c-1,2-Dichloroethene	<0.1	<0.1	<0.1
Bromochloromethane	<0.1	<0.1	<0.1
Carbon tetrachloride	<0.1	<0.1	<0.1
1,1-Dichloropropene	<0.1	<0.1	<0.1
Trichloroethene	<0.1	<0.1	<0.1
c-1,3-Dichloropropene	<0.1	<0.1	<0.1
t-1,3-Dichloropropene	<0.1	<0.1	<0.1
Tetrachloroethene	<0.1	<0.1	<0.1
1,1,1,2-Tetrachloroethane	<0.1	<0.1	<0.1
Styrene	<0.1	<0.1	<0.1
Isopropylbenzene	<0.1	<0.1	<0.1
n-Propylbenzene	<0.1	<0.1	<0.1
1,3,5-Trimethylbenzene	<0.1	<0.1	<0.1
tert-Butylbenzene	<0.1	<0.1	<0.1
sec-Butylbenzene	<0.1	<0.1	<0.1
1,2-Dibromo-3-chloropropane	<0.1	<0.1	<0.1
1,2,3-Trichlorobenzene	<0.1	<0.1	<0.1
1,2-Dichloropropane	<0.5	<0.5	<0.5
Chlorobenzene	<0.5	<0.5	<0.5
Bromobenzene	<0.5	<0.5	<0.5
1,2,4-Trimethylbenzene	<0.5	<0.5	<0.5
p-Isopropyltoluene	<0.5	<0.5	<0.5
n-Butylbenzene	<0.5	<0.5	<0.5
Hexachlorobutadiene	<0.5	<0.5	<0.5
Naphtalene	<0.5	<0.5	<0.5
o-Xylene	<0.5	<0.5	<0.5
2-Chlorotoluene	<0.5	<0.5	<0.5
4-Chlorotoluene	<0.5	<0.5	<0.5
1,3-Dichlorobenzene	<0.5	<0.5	<0.5
1,2,4-Trichlorobenzene	<0.5	<0.5	<0.5
Chloroform	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	<1.0	<1.0	<1.0
1,3-Dichloropropane	<1.0	<1.0	<1.0
m, p-Xylene	<1.0	<1.0	<1.0
1,1,2-trichloroethane	<1.0	<1.0	<1.0
1,4-dichlorobenzene	<1.0	<1.0	<1.0
Bromoform	<1.0	<1.0	<1.0
1,2,3-Trichloropropane	<1.0	<1.0	<1.0
Benzene	<5.0	<5.0	<5.0
1,2-dichloroethane	<5.0	<5.0	<5.0
Toluene	<5.0	<5.0	<5.0
Ethylbenzene	<5.0	<5.0	<5.0
Dibromomethane	<5.0	<5.0	<5.0
1,1,2,2-tetrachloroethane	<5.0	<5.0	<5.0
1,2-Dibromoethane	<10.0	<10.0	<10.0

Table 8.9

Concentrations (ng/kg) of PCDDs and PCDFs in samples of whole milk from the Somers and Ryan farms taken in 1995. Analyses performed by the Central Science Laboratory, Norwich, UK.

Compound	Somers	Ryan
2,3,7,8-TCDD	0.02	0.02
1,2,3,7,8-PeCDD	<0.01	<0.02
1,2,3,4,7,8-HxCDD	<0.02	0.01
1,2,3,6,7,8-HxCDD	<0.02	0.02
1,2,3,7,8,9-HxCDD	<0.02	0.02
OCDD	<1.0	<1.0
2,3,7,8-TCDF	0.02	0.02
1,2,3,7,8-PeCDF	<0.01	<0.01
2,3,4,7,8-PeCDF	0.02	0.02
1,2,3,4,7,8-HxCDF	0.01	0.02
1,2,3,6,7,8-HxCDF	<0.01	<0.01
1,2,3,7,8,9-HxCDF	<0.01	<0.01
2,3,4,6,7,8-HxCDF	<0.01	<0.01
1,2,3,4,6,7,8-HpCDF	0.01	<0.01
1,2,3,4,7,8,9-HpCDF	<0.02	<0.01
OCDF	0.06	0.07
TEQ excluding detection limit	0.03	0.04
TEQ including detection limit	0.04	0.05
Fat (%)	2.95	3.29

Table 8.10

Organochlorine and organophosphorus pesticides analysed for in samples of milk from the Askeaton area, 1995. Detection limits are indicated. Pesticides were not detected at or above these levels. Analyses carried out by the Pesticide Control Laboratory, Abbotstown, Co. Dublin.

Compound	Detection Limit (µg/l)	Compound	Detection Limit (µg/l)
Organochlorine			
Aldrin	5	Endosulfate	5
Γ-Chlordane	5	Endrin	5
Oxychlordane	5	HCB	5
Dieldrin	5	α-HCH	5
Pp'DDT	5	β-HCH	10
Op'DDT	5	δ-HCH	5
Pp'DDE	5	Heptachlor	5
Op'DDE	5	Heptachlor-epoxide	5
Pp'DDD	5	Lindane (γ-HCH)	5
Op'DDD	5	Methoxychlor	10
Dicofol	10	Quintozone	5
Endosulfan-1	5	Tecnazene	5
Endosulfan-2	5		
Organophosphorus			
Acephate	0.1	Malaoxon	0.1
Azinphos-ethyl	0.1	Malathion	0.05
Azinphos-methyl	0.1	Methacrifos	0.05
Bromophos	0.05	Methamidophos	0.1
Bromophos-ethyl	0.05	Methidathion	0.05
Chlorfenvinphos	0.05	Mevinphos	0.05
Chlorpyrifos	0.05	Monocrotophos	0.1
Chlorpyrifos-Me	0.05	Omethoate	0.1
Demeton-S-Me	0.05	Paraoxon	0.05
Demeton-S-Me-Sulfone	0.1	Paraoxon-methyl	0.1
Diazinon	0.05	Parathion	0.05
Dichlorvos	0.05	Parathion-methyl	0.05
Dimethoate	0.05	Phosalone	0.1
Disulfoton	0.05	Phosalone (oxygen analogue)	0.15
Ethion	0.05	Phosmet	0.1
Ethion-O2	0.05	Pirimifos-ethyl	0.05
Etrimfos	0.05	Pirimifos-methyl	0.05
Fenchlorphos	0.05	Propetamphos	0.05
Fenithrothion	0.05	Tepp	0.15
Fenthion	0.05	Thiometon	0.05
Fonofos	0.05	Tolclofos-methyl	0.05
Iodofenphos	0.05	Triazophos	0.05
Isofenphos	0.05	Phorate	0.05
Isomalathion	0.1	Phosphamidon	0.05

Table 8.11

Concentrations of aluminium and fluoride in milk samples from farms in the Askeaton area and in Co. Wexford.
Detection limits were as follows: Lab A – aluminium, 0.1 mg/l; fluoride, 1.0 mg/l. Lab B – aluminium, 0.01 mg/l.

Sample No.	2/5/95- Lab A only		8/8/95 – Lab A		8/8/95 – Lab B
	Aluminium mg/l	Fluoride mg/l	Aluminium mg/l	Fluoride mg/l	Aluminium mg/l
1	0.40	<1.0	<0.1	<1.0	0.05
2	0.19	<1.0	0.13	<1.0	0.04
3	0.24	<1.0	0.12	<1.0	0.04
4	0.16	<1.0	<0.1	<1.0	0.05
5	0.68	<1.0	0.15	<1.0	0.03
6	0.17	<1.0	<0.1	<1.0	0.03
7	0.75	<1.0	<0.1	<1.0	0.05
8	0.46	<1.0	0.18	<1.0	0.04
9	0.85	<1.0	0.10	<1.0	0.03
10	0.42	<1.0	0.34	<1.0	0.04
11	0.77	<1.0	<0.1	<1.0	0.06
12	1.83	<1.0	0.29	<1.0	0.04
14	No sample	No sample	0.17	<1.0	0.03
Wexford 1	No sample	No sample	0.10	<1.0	0.05
Wexford 2	No sample	No sample	<0.1	<1.0	0.06

Chapter Nine

GENERAL DISCUSSION AND CONCLUSIONS

In view of the industrial developments which have occurred in the largely rural Askeaton area over the last twenty years, it is understandable that the involvement of an environmental pollutant in the animal health problems experienced in the area figured strongly in the opinions of the farming and general community. Although the scale of these developments is moderate when compared to the situation in other areas of Europe, the ESB plants at Moneypoint and Tarbert and the nearer AAL plant, are large industrial undertakings in the Irish context. As has been pointed out in Chapter 4, these plants together generated over 50 percent of the national emissions of SO₂ in recent years. Thus, the potential impact of these relatively large emissions needed full assessment in the investigation.

The measurements made between 1995 and 1998 were mainly focused on the concentrations of SO₂ in air and sulphur levels in precipitation. This approach was considered justified on two grounds. Firstly, the information on the industrial activities in the area suggested that these parameters were by far the most likely aspects of local environmental quality to be adversely affected by the emissions from the activities. Secondly, the general advice received from outside consultants was that any impact on livestock in the area due to industrial activity was most likely to arise from atmospheric pollution. Furthermore, it was considered unlikely that the animal health problem could be caused by direct inhalation of pollutants by the cattle. If a pollutant was present, it was much more likely to be ingested in the diet and to affect the animals through that pathway. The possibility could not be ruled out that an air pollutant such as sulphur dioxide might have indirect effects, such as exacerbation of selenium deficiency, but this also would act through the diet of the animals. However, aside from the question of livestock health, there was the further consideration of local reports of human respiratory difficulties at times which might have been attributable to high concentrations of SO₂ in air.

The modelling of the dispersal of the emissions from the main sources in the area suggested that these would not result in concentrations of SO₂ in the Askeaton area greater than the existing EU limits. This was borne out by the monitoring undertaken on the Somers and Ryan farms in the 1995-1998 period. In addition, the data from the ESB and AAL monitoring networks indicated that this compliance with the limits had been achieved in the area since at least the mid 1980s. The data from the on-farm monitors showed that the more recently adopted EU limits, which are more stringent than those currently in force, were also respected in 1995-1998; continued monitoring on the Somers farm in subsequent years has shown that this remains the position at that location at least.

Of particular interest are the annual average concentrations arising from the continuous monitors on the farms and from the sampling networks operated by the ESB and for AAL. In all cases, these values are less than the limit (20 µg/m³) set for the protection of ecosystems in the more recent EU directive. This suggests that the growth of grass and other fodder crops is unlikely to be affected by the levels of SO₂ in the Askeaton area, an assessment supported by the results of studies reviewed by Brennan and Dowding (1995) and by the external assessment made by Dr N. Suttle (*see* Appendix 15, Animal Health volume).

Nitrogen oxides (NO_x) are also emitted from the various sources but in smaller amounts and would be expected to be dispersed in a manner similar to SO₂. While the levels of these compounds in air were not measured, it is considered that the data on SO₂ are an assurance that the levels of NO_x in air in the Askeaton area are relatively low and unlikely to be a factor in either animal or human health problems.

It is clear, nonetheless, that the emissions cause substantial increases of SO₂ on the two Askeaton farms over short periods. Furthermore, these farms are subject to a greater degree of such exposure than is the farm at Abbotstown, despite the proximity of the latter to Dublin City. The analysis of wind direction and hourly episodes of arbitrarily defined peaks of SO₂ concentrations (>80 µg/m³), suggested that the bulk of such occurrences on the Somers farm resulted from the AAL emissions and/or those from the ESB plants but that this was not the case on the Ryan farm. However, it is noted that for most of the hours when winds are blowing from the AAL direction towards the farms, lower concentrations were recorded.

It is conceivable that in those hours in which the average SO₂ concentration was relatively high (>200 µg/m³) there were periods of a few minutes when much higher concentrations occurred. Such concentrations could have acute effects on exposed persons or animals. There were reports of skin and eye irritation in the area during the

investigation. SO₂ is a possible cause of this but the reported levels (15,000-50,000 µg/m³) at which such effects becomes noticeable (Sax, 1975) seem very unlikely to occur in the Askeaton area in view of the maximum hourly concentrations recorded. It is also noted in this context, that the recommended 8-hour occupational exposure limit of 5000 µg/m³ (National Authority for Occupational Safety and Health, 1995) is at least an order of magnitude greater than the maximum concentrations recorded in Askeaton. However, the presence of the gas can be detected, mainly by taste, at levels as low as 800 - 2500 µg/m³ (Sax, 1975); a small number of occurrences of such concentrations, for a few minutes at a time, would not be inconsistent with the higher hourly values recorded in the Askeaton area.

The deposition rates in precipitation of sulphur and other potentially harmful substances in the Askeaton area, as measured during the investigation, were not much different to the levels found at remote and recognised unpolluted sites in Ireland and in other parts of Europe. This is a key finding since, as mentioned above, it is considered that the most likely mode of impact of the emissions on livestock would be through the contamination of fodder crops by aerial deposition of pollutants.

Suggestions have been made that the emissions in the Askeaton area are likely to lead to an artificial acidification of precipitation in the area but no evidence has been found that this is the case based on the measurements. Such an effect is, in any event, unlikely to occur in the immediate vicinity of the emission sources. There have also been claims that alkaline vapours originating from the AAL plant affect the area. Again, this is not backed up by the examination of precipitation which invariably had an acid reaction. The collection of daily samples throughout the period of the investigation increases the likelihood that any episodes of excessively acid or alkaline precipitation would have been detected.

The other potential pollutants which may be emitted in significant quantities in the area are particulate matter and metal compounds. Little evidence has been found, from either the measurements made specifically for the investigation or those by the existing monitoring networks, that these substances are present in concentrations or amounts which would be harmful. In relation to metal compounds, it is noted that the measurements made by Teagasc on soils and herbage (See Soil, Herbage, Feed and Water volume) are consistent with this assessment. Further corroboration is provided by the experimental exposure of rats to food amended with soil from the problem farms which showed no significant effects compared to controls (see Animal Health volume)

It has been pointed out that, at the start of the investigation, a variety of organic pollutants were suggested as being involved in the animal health problem. The assessment of the industrial activities in the area did not accord with the presence of many of these substances. Nevertheless, it was considered important from the point of view of public assurance that measurements be made to substantiate the prediction that these substances were absent or at background levels in the area. The data resulting from the measurements show that the involvement of these organic pollutants can be ruled out as contributing to the animal health or indeed any human health problems in the area.

The measurements on milk in the area showed no sign of contamination with pollutants emitted in the area nor with organic compounds such as dioxin. Initial results for aluminium were somewhat contradictory, probably due to difficulties with analytical methods, but follow up measurements did not indicate any difference between levels in milk from the Askeaton area and that from the Wexford area. An assessment of the aluminium data by the US-based experts indicated that none of the concentrations found would have any health implications for consumers.

To sum up, the following conclusions are drawn from the environmental measurements and investigations carried out in 1995-1998 and from existing information.

- The main pollutants emitted in the area are SO₂ and NO_x arising from the combustion of fuels in the ESB plants at Moneypoint and Tarbert and the AAL alumina production plant. In addition, particulate matter and metals may be emitted from these sources. SO₂ and NO_x are also emitted by other sources in the area but these are of minor significance. Because of its location nearest to the farms reporting animal health problems, the AAL plant is the most significant source of potential pollution in the Askeaton area.
- The levels of SO₂ measured on the farms and at the sites in the monitoring networks operated by the ESB and AAL show compliance with the existing EU and national limits set for the protection of human health. The on-farm measurements indicate, in addition, that the revised EU limits for human health protection are met.

- The annual mean concentrations of SO₂ at all locations are within the new EU limit set for the protection of ecosystems.
- In view of the position with respect to SO₂, it is concluded that the levels of NO_x in the area are also low and unlikely to have any significance for animal or human health.
- The deposition rates of sulphur and other potential pollutants measured at the Askeaton sites are comparable to those measured in unpolluted areas of Ireland and other European countries.
- The pH range of precipitation measured in the Askeaton area was within the range characteristic of unpolluted conditions and no markedly acid or alkaline reactions were observed.
- The levels of fluoride and metals in precipitation at the Askeaton sites were similar to those measured at remote sites in Ireland.
- The levels of organic compounds, such as dioxin and PAH, in soil and milk in the Askeaton area were in the ranges considered typical of background.
- Overall, therefore, the available data indicate that the Askeaton area was not subject to harmful levels of pollutants during the period of the investigation and that this was the position at least since the mid 1980s.

REFERENCES

- Anon., 1994. *Acid News*, No. 5, December 1994. Swedish NGO Secretariat on Acid Rain, Goteborg, Sweden.
- Bowman, J. 1991. *Acid Sensitive Surface Waters in Ireland*. Environmental Research Unit, Dublin.
- Brennan, M. and Dowding, P., 1995. *Ecotoxicology of Sulphur Oxides. A Literature Review for the Environmental Protection Agency*. School of Botany, Trinity College Dublin.
- CEC (Council of the European Communities), 1980. Council Directive 80/779/EEC of 15 July 1980 on air quality limit values and guide values for sulphur dioxide and suspended particulates. *O.J.* No. L 229/30.
- CEC (Council of the European Communities), 1996. Council Directive 96/62/EC of 27 September, 1996 on ambient air quality assessment and management. *O.J.* No. L 296/55.
- CEC (Council of the European Communities), 1999. Council Directive 1999/30/EC of 22 April, 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. *O.J.* No. L 163/41.
- Concannon, C., 1996. *Dioxins in the Irish Environment. An Assessment based on Levels in Cow's Milk*. Environmental Protection Agency, Wexford.
- Concannon, C., 2001. *Dioxins in the Irish Environment. A Further Assessment (Summer 2000) based on Levels in Cow's Milk*. Environmental Protection Agency, Wexford.
- DoE (Department of the Environment), 1988. *The Air Pollution Act, 1987 (Air Quality Standards) Regulations, 1987 (S. I. No. 244 of 1987)*. DoE, Dublin.
- ENVIROCON, 1995. Aughinish Alumina Ltd. *Air Quality Impact Modelling Study*.
- Fehily Timoney Weston 1995. *Air Quality Modelling Analysis. Impact of Proposed Solvent Stack Emissions - Syntex Ireland Ltd. (September 1995 to November 1997)*. Prepared for Syntex Ireland Ltd., Clarecastle, Co. Clare. by Fehily Timoney Weston, Centre Park House, Centre Park Road, Cork.
- Fowler, D. 1984. Transfer to Terrestrial Surfaces. *Phil. Trans. R. Soc. London, B* 305, pp 281-297.
- Granat, L. and Rodhe, H. 1973. A Study of Fallout by Precipitation around an Oil-Fired Power Plant. *Atmospheric Environment, Vol. 7*, pp 781-792.
- Hales, J., Thorp, J.M. and Wolf, M. A. 1970. Washout of SO₂ from the plume of a coal-fired power plant. In: *Precipitation Scavenging (1970)*, *Proc. AEC Symp*, Richland, Washington, 1970.
- Irwin, J.G. and Williams, M. L. 1988. Acid Rain : Chemistry and Transport. *Environmental Pollution*, 50, pp 29-59.
- Jones, K. C., Stratford, J. A., Waterhouse, K. S., Furlong, E. T, Giger, W., Hites, R. A., Schaffner, C. and Johnston, A. E, 1989. Increase in the Polynuclear Aromatic Hydrocarbon Content of an Agricultural Soil over the Last Century, *Environmental Science & Technology*, 23, 95-101.
- Kirby, P. S., 1995. *An Assessment of the Animal Health Problems at Issane, Ballysteen, County Limerick, Eire*. ADAS, Wolverhampton, UK,
- McGettigan. M., 2000. *Air Quality Monitoring. Annual Report for 1998*. Environmental Protection Agency, Dublin.
- McGettigan, M. and Duffy, P., 2000. *Emissions to Air 1990-1998. Estimation Methods, Trends and Challenges*. Environmental Protection Agency, Wexford.

- Mc Gettigan, M. and McGovern, F., 2001. *Air Quality Monitoring. Annual Report 1999*. Environmental Protection Agency, Wexford.
- National Authority for Occupational Safety and Health, 1995. *Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations, 1994*. Dublin, Stationery Office.
- Overrein, L.N., Seip, H.M. and Tollan, A., 1981. *Acid precipitation- effects on forest and fish*. Final report of the SNSF-project 1972-1980. NIVA, Oslo.
- Sandnes, H. and Styve, H., 1992. Calculated Budgets for Airborne Acidifying Components in Europe. *MSC-West Report No 97*. Norwegian Meteorological Institute, Norway.
- Sax, N. I., 1975. *Dangerous Properties of Industrial Materials*. New York, Van Nostrand Reinhold Company, 4th Edition.
- Schaug, J., Pedersen, U. and Skjelmoen, J.E., 1991. *Data Report 1989. Part 1: Annual Summaries*. EMEP/CCC-Report 2/91. Norwegian Institute for Air Research.
- Schaug, J., Pedersen, U., Skjelmoen, J.E., Arnesen, A. and Bartonova, A., 1992. *Data Report 1992. Part 1: Annual Summaries*. EMEP/CCC-Report 4/94. Norwegian Institute for Air Research.
- UK Department of the Environment, 1989. *Dioxins in the Environment*. Report of an Interdepartmental Working Group on polychlorinated dibenzo-para-dioxins(PCDDs) and polychlorinated dibenzofurans (PCDFs). Department of the Environment, Central Directorate of Environmental Protection, Pollution Paper No. 27. HMSO, London.
- UNECE (United Nations Economic Commission for Europe), 1989. *The State of Transboundary Air Pollution: Effects and Control*. United Nations, New York.
- Vincent, K.J., *et al.*, 1996. *Acid Deposition Monitoring in the United Kingdom: The First Ten Years*. AEAT-1825/200117001/Issue 1
- Wann, W.H., 1973. Incidence of Stability Categories for Various stations in Ireland. Meteorological Service *Technical Note No. 37*, June 1973. Meteorological Service, Dublin.
- Wild, S. R., Berrow, M. L. and Jones, K. C., 1991. The Persistence of Polynuclear Aromatic Hydrocarbons (PAHs) in Sewage Sludge Amended Agricultural Soils *Environmental Pollution*, 72, 141-147

Appendix A

DETAILS OF MAIN INDIVIDUAL EMISSION SOURCES

NOTE

The information given in this Appendix is repeated verbatim from the first Interim Report on the investigations, published in 1995. It is considered relevant as it describes the position during the period when the animal health problems were most pronounced. However, information (shaded) is added where appropriate to update the position.

1. Electricity Supply Board, Moneypoint Generating Station, County Clare

Production

Generation of electricity by coal fired boilers and steam turbo alternators. The plant is operated normally at full production of 900 MW, 24 hours per day, 7 days per week. Installed capacity is 3 x 305 megawatts giving a total capacity of 914 megawatts. Pulverised coal at the rate of 357 tonnes/hour is the fuel used.

Operations

Raw coal is delivered by ship to a purpose built jetty in batches of up to 160,000 tonnes and off loaded by grab and conveyor to the on site coal storage area. Coal storage capacity on site is approximately 1 million tonnes. Three identical boilers are fed with coal by conveyor from the storage area. From each boiler bunker the raw coal is fed to ball mills which pulverise the coal to a fine powder. This coal powder is dried and pneumatically conveyed by heated air to the boiler where it is fed into the furnace through 16 burners. The furnace is lined with water tubes and the steam produced here is further heated by passing through superheaters within the boiler before supply to the turbine. Water flue gas leaving the furnace passes through heat recovery units - superheater, reheater, economiser and air preheater. The flue gas is then ducted to the electrostatic precipitator and vented to atmosphere through the stack.

Air Quality Control

The control of emissions and ambient air quality is maintained under conditions prescribed by Planning Permissions (Reg. Ref. P8/13759, Clare Co. Co.). The general requirement is that emission standards shall be not less than those required by the Control of Atmospheric Pollution Regulations, 1970 (SI 156 of 1970). The Planning conditions do not specify emission limits for the two main pollutants emitted from the plant, SO₂ and NO_x, nor do they fix limits for the sulphur content of coal used in the boilers. The average monthly emission of particulates from each stack shall not exceed 150 ug/m³. The average daily ground-level concentration of SO₂ at any point due to emissions from the plant shall not exceed 45 ug/m³. Similarly, the daily mean concentration of NO_x and NO₂ shall not exceed 15 and 1.5 ug/m³, respectively.

Emissions to Atmosphere

(i) Stack Emission from two boilers (Nos 1 and 2) fuelled on pulverised coal (119 tonnes/hour each)

Two boilers with a capacity of 315 MW each are fuelled on pulverised coal. Coal is purchased on the world market but two sources are contracted and form the bulk of the coal used at Moneypoint. These coals are Consol/Blacksville (1.6 % to 2.6 % sulphur) and Intercor (Colombian) (0.7 % to 0.8 % sulphur). Other coals are also purchased and make up 10% to 15% of the input. These coals contain sulphur in a similar range. Coal input at any one time can be considered a mixture of the coal in storage. The overall reduction in sulphur content since 1988 is shown by Figure A.1, the higher values being for Blacksville coals. Diesel oil and heavy fuel oil are also used during start-up of the furnaces. Up to 5,000 tonnes of HFO and 5,000 tonnes of diesel oil is used per year.

Abatement employed:

Electrostatic precipitators for dust removal.

Low NO_x burners fitted on boiler No. 2 in 1992 and on No. 1 in 1994, to be fitted to No. 3 in 1995.

Monitoring carried out by the company:

Sulphur dioxide - spot monitoring weekly

Nitrogen oxides - spot monitoring weekly

% Oxygen - continuous

CO - continuous

Particulates - continuous

Dioxin measurements carried out in 1994

Monitoring by the EPA:

Emission monitored by flue gas analyser for SO_x, NO_x, and O₂ (27/04/95)

Emission sampled for organics (27/04/95)(12/07/95)

Emissions sampled for inorganics (12/07/95)

Coal sampled (27/04/95)

Bottom ash and fly ash sampled

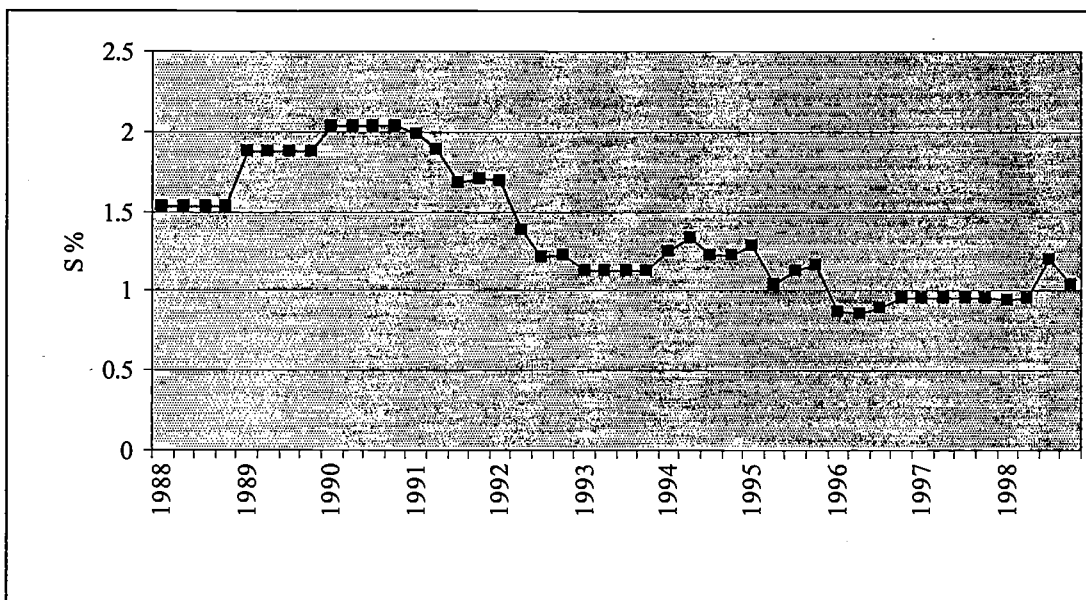


Fig. A.1 Average sulphur content of coals used at Moneypoint Power Station by quarter 1988-1998. Note that quarterly data are not available in some years and the annual average content is used instead.

UPDATE

The figure above has been modified compared to that in the 1995 report and updated to 1998

Details

Coal usage: 238 Tonnes/hour

Stack height: 220 m over ground level

Flow: 2,1600 m³/hour (dry gas and 6% O₂) (stoichiometric estimation from fuel usage).

Emissions:

SO₂: ~1700 - 2000 mg/Nm³ (6% O₂)(EPA) ~ 4320 kg/hour

using 2.6% S coal ~ 4700mg/Nm³ ~ 10,000 kg/hour

NO₂: No.1 ~ 850 mg/Nm³, No.2 ~ 1200 mg/Nm³ (EPA) ~ 2200kg/hour

Dust: ~ 50 mg/Nm³

VOC : 6mg/Nm³ (charcoal + chromosorb)

(ii) *Stack Emission from one boiler (No 3) fuelled on pulverised coal(119 tonnes/hour)*

Description as for (i).

Monitoring carried out by the company:

Sulphur dioxide - Spot monitoring weekly

Nitrogen oxides - spot monitoring weekly

% Oxygen - continuous

CO - continuous

Monitoring by the EPA:

Emission monitored by flue gas analyser for CO, SO_x, NO_x, and O₂ (27/04/95)

Emission sampled for organics (27/04/95) 12/07/95)

Emissions sampled for inorganics (12/07/95)

Coal sampled (27/04/95)

Bottom ash and fly ash sampled

Details

Coal usage: 119 Tonnes/hour

Stack Height: 220 m over ground level

Flow : 1,080,000 m³/hour (dry gas, 6% O₂)

Emissions

SO₂ ~ 1700 mg/Nm³ ~1850 kg/hour

Using 2.6% S coal ~ 4700 mg/Nm³ ~ 5,000 kg/hour

NO_x ~ 1700 mg/Nm³ ~ 1850 kg/hour

Dust ~ 50 mg/Nm³

VOC 8mg/Nm³ (charcoal + chromosorb) (EPA).

Dioxin Emission Measurements

A series of measurements on atmospheric emissions of chlorinated dibenzofurans (CDFs) and chlorinated dibenzo(p)dioxins (CDDs) were made at Moneypoint during October and November 1993. Seven separate tests covered a range of operating conditions as given in Table A.1. Organic samples were collected on XAD-2 resin packs and subsequent analysis was by HRGC/MS by the specialist laboratory Gesellschaft für Arbeitsplatz und Umweltanalytik (GfA) mBH, in Germany. The results, in terms of total concentrations of the Tetra-to Octa-CDF/CDD homolog groups, are summarised in Table A.2. The toxicity equivalents (TEQ) are also included. These are calculated by multiplying the concentrations of individual detected congeners by corresponding toxicity-equivalent-factors, proposed by NATO/CCMS, and adding the products.

The measured PCDD/PCDF content of bottom and fly-ash were about three orders of magnitude below German limits. The levels of PCB and PAH in bottom and fly ash samples were below the detection limits of 0.005 µg/l and 0.01 µg/l, respectively.

Table A.1. Details of GFA Dioxin Test Measurements at Moneypoint.

Test No	Boiler Sampled	Coal Type	Date	Load Mwe	% S in coal	% CI in coal	Sample Vol m ³
1	B3	Blacksville	29-Oct	300	1.51	0.11	4.05
2	B3	Blacksville	02-Nov	300	1.55	0.09	7.96
3	B3	Colombian	05-Nov	300	0.73	0.4	7.91
4	B2	Blacksville	10-Nov	308	1.55	0.09	8.14
5	B2	Blacksville	11-Nov	308	1.55	0.09	8.16
6	B2	Colombian	15-Nov	308	0.77	0.03	7.57
7	B2	Colombian	16-Nov	308	0.77	0.03	8.03

Table A.2. Dioxin/Furan Concentrations in Flue Gas Samples from Moneypoint (ng/Nm³).*

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Total Tetra to Octa CDFs	0.451	0.019	0.020	0.031	0.014	0.082	0.119
Total Tetra to Octa CDDs	2.029	0.016	0.010	0.024	0.013	0.105	0.134
TEQ (NATO CCMS) Excluding LOD	0.0122	0.0004	0.0004	0.0008	0.0003	0.0012	0.0041
TEQ (NATO CCMS) Including LOD	0.0123	0.0008	0.0008	0.0013	0.0011	0.0038	0.0053

LOD Limit of Detection

* corrected to flue gas conditions of 0 degrees C, 1013 hPa dry gas and 6% oxygen.

Summary

Emissions from the three Moneypoint boilers are as expected considering the fuel used and the electrostatic precipitators installed for dust removal. The Air Pollution Act, 1987 (Combustion Plant) Regulations (S.I 273 of 1992) provides for the control of certain pollutants from new large combustion plant of greater than 50 MW thermal input capacity. Licensing of such new plants is a matter for the EPA from 16 May 1994. Moneypoint is an existing plant and therefore not subject to a licence at present. However, this plant will be licensed by the Agency as new regulations are issued for existing combustion plants. The relevant emission limit values specified in S.I 273 for new coal-fired plant are:

	100MW - 500MW	>500MW
SO ₂	2400 - 4ti* mg/Nm ³	400 mg/Nm ³
NO _x	650 mg/Nm ³	650 mg/Nm ³
Dust	100 mg/Nm ³	50 mg/Nm ³

* where ti is the rated thermal input of the plant in megawatts (MW)

The measurement of dioxin emissions confirms that emissions are substantially below 0.1 ng/m³. This is the guide value which control measures should aim for under EC Directive 94/67/EEC, as referenced in the EPA BATNEEC Guidance Notes and which will become the limit value effective from 1 January 1997, subject to the establishment of harmonised measurement methods by 1 July 1996.

UPDATE

The ESB must apply to the EPA for an IPC licence for the Moneypoint plant by 2nd March, 2001

2. Tarbert Electricity Generating Station, Tarbert, County Kerry.

Production

Generation of electricity by oil fired boilers and steam alternators. The plant is operated normally at full production of 500MW 24 hours per day 7 days per week. Installed capacity is 2 x 250 megawatts and two further 60 MW oil fired units which have been out of commission since 1983 giving a total capacity of 620 megawatts. Fuel consumption - Heavy fuel oil : 2 x 56 tonnes/hour - 112 tonnes/hour total.

UPDATE

The installed capacity has been upgraded from 2 x 250 to 2 x 256 megawatts

Operations

The site contains four boiler/steam turbine and alternator units fuelled on heavy fuel oil. The first development of 2 x 60 MW units were installed in 1969. In 1976 the second development of 2 x 250 MW units were installed. In 1983 the two smaller 60MW units were taken out of service. These 60MW units are due for recommissioning in 1996.

UPDATE

The 60MW units were commissioned in June 1996

Heavy fuel oil is delivered by ship to a purpose built jetty in batches of up to 50,000 tonnes and off loaded to on site storage. Oil storage capacity on site is approximately 250,000 tonnes. Two identical boilers are fed with fuel oil from on site storage to the furnace. Steam is produced in water tubes within the furnace and further heated by passing through superheaters within the boiler before supply to the turbine. Water from the Shannon estuary is used for cooling/condensing the steam for re-supply to the furnace. The flue gas leaving the furnace passes through heat recovery units before being vented to atmosphere through the stack.

Air Quality Control

The control of emissions and ambient air quality is maintained under conditions prescribed by various Planning Permissions (Reg. Ref. 2735 and 81/72, Kerry Co. Co.). These conditions do not specify emissions limits for the two main pollutants emitted from the plant, SO₂ and NO_x, nor do they fix limits for the sulphur content of heavy fuel oil used in the boilers. The general requirement is that such treatment of emissions as may be required by the Planning Authority be undertaken in order to protect the amenities of the area and to avoid atmospheric pollution.

Atmospheric emission details

Two boilers with a capacity of 250MW each fuelled on heavy fuel oil. Oil is purchased on the world market with a sulphur specification of <3.5 percent. Data on oil usage gives oil sulphur content of up to 3.95 percent (Figure A.2). No emission abatement is employed.

Monitoring carried out by the company:

Sulphur dioxide - Calculated

Nitrogen oxides - Calculated

% Oxygen - continuous

CO - continuous

Particulate - periodic spot sampling

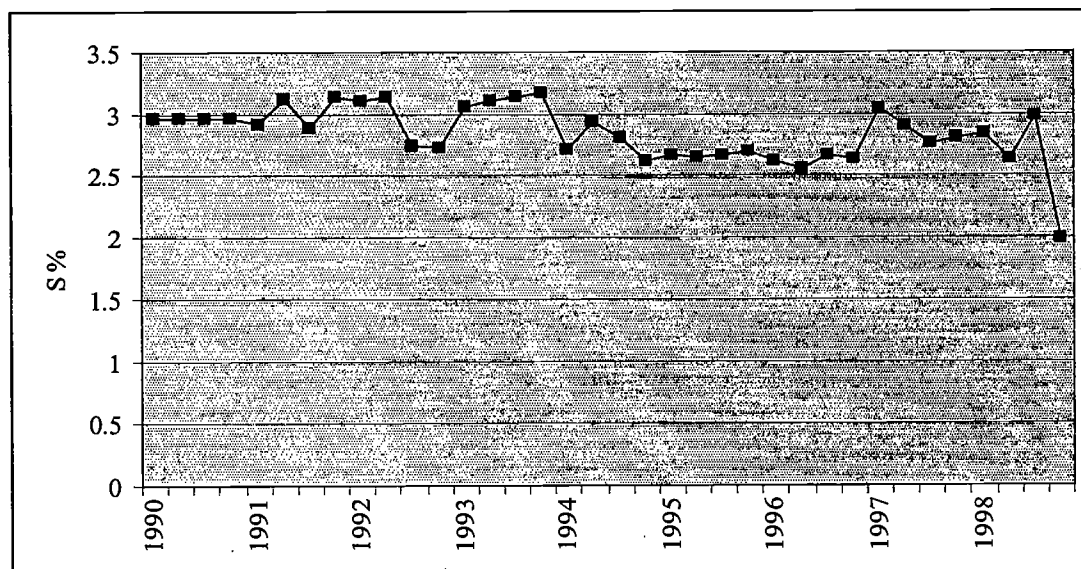


Fig. A.2 Average sulphur content of fuel oil used at Tarbert Generating Station by quarter, 1990-1998. Note that quarterly data are not available for 1990 and the annual average content is used instead.

UPDATE

The figure above has been modified compared to that in the 1995 report and updated to 1998

Monitoring by the EPA:

Emission monitored by flue gas analyser for CO, SO_x, NO_x, and O₂ (27/4/95)

Emission sampled for organics (27/04/95)

Oil sampled (27/04/95)

Details

Oil usage: 112 Tonnes/hour (56 Tonnes/hour each)

Stack height: 152 m over ground level
Flow: 1,260,000 m³ (630,000 x2) (stoichiometric estimation from fuel usage)

UPDATE

Oil usage 140 t/hr Stack heights 152 and 121 m over ground level.

Emissions:

SO ₂ ~ 3800mg/Nm ³ (Ref 3% O ₂)(EPA)	~ 4800 kg/hour
Using 3.9% S fuel oil ~ 6000 mg/Nm ³	~ 8300 kg/hour
NO _x ~800 mg/Nm ₃ (Ref 3% O ₂)(EPA)	~ 1000 kg/hour
VOC <5mg/Nm ₃ (charcoal + chromosorb)	

UPDATE

Note that above figures are based on 1995 data

Dioxin Emission Measurements

A series of measurements on atmospheric emissions of chlorinated dibenzofurans (CDFs) and chlorinated dibenzo(p)dioxins (CDDs) were made at Tarbert Generating Station during April 1995. Tests covered a range of operating conditions as given in Table A.3. Organic samples were collected on XAD-2 resin packs and subsequent analysis was by HRGC/MS by the specialist laboratory Gesellschaft für Arbeitsplatz und Umweltanalytik (GfA) mBH, in Germany. The results in terms of total concentrations of the Tetra-to Octa-CDF/CDD homolog groups are summarised in Table A.4. The toxicity equivalents (TEQ) are also included. These are calculated by multiplying the concentrations of individual detected congeners by corresponding toxicity-equivalent-factors, proposed by NATO/CCMs, and adding the products.

Emissions from the two 250MW boilers at Tarbert are as expected. The Air Pollution Act, 1987 (Combustion Plant) Regulations (S.I. 273 of 1992) provides for the control of certain pollutants from new large combustion plant of greater than 50 MW thermal input capacity. Licensing of such new plants is a matter for the EPA from 16 May 1994. Tarbert is an existing plant and therefore not subject to a license at present. However, this plant will be licensed by the Agency as new regulations are issued for existing combustion plants. The relevant emission limit values specified in S.I 273 in the case of new oil-fired plant are

	300MW - 500MW
SO ₂	3650 - 6.5ti* mg/Nm ³
NO _x	450 mg/Nm ³
Dust	50 mg/Nm ³ (100 mg/Nm ³ ; fuel ash content > 0.06%)

*where ti is the rated thermal input of the plant in megawatts (MW)

UPDATE

The ESB must apply to the EPA for an IPC licence for the Tarbert plant by 2nd March, 2001.

The measurement of dioxin emissions confirms that emissions are substantially below 0.1 ng/m³. This is the guide value which control measures should aim for under EC Directive 94/67/EEC, as referenced in the EPA BATNEEC Guidance Notes and which will become the limit value effective from 1 January 1997, subject to the establishment of harmonised measurement methods by 1 July 1996.

Table A.3. Details of GFA Dioxin Test Measurements at Tarbert.

Test	Boiler Sampler	Date	Load Mwe	O ₂ Norm Factor*	Sample Vol m ³
1	B3	10-Apr	249	1.098	8.49
2	B3	11-Apr	250	1.098	8.29
3	B3	12-Apr	201	1.084	8.70
4	B3	13-Apr	200	1.056	8.72
5	B4	19-Apr	249	1.091	7.46
6	B4	20-Apr	250	1.101	7.18
7	B4	26-Apr	200	1.101	5.41
8	B4	27-Apr	197	1.136	8.30

*normalised to 3% oxygen

Table A.4. Dioxin/Furan Concentrations in Flue Gas Samples from Tarbert (ng/Nm³).

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Total Tetra to Octa CDFs	0.010	LOD	0.010	0.010	0.020	0.020	0.060	0.080
Total Tetra to Octa CDDs	0.060	0.050	0.040	0.003	0.070	0.040	0.080	0.040
TEQ (NATO CCMS) Excluding LOD	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.003
TEQ (NATO CCMS) Including LOD	0.007	0.008	0.010	0.008	0.007	0.008	0.009	0.007

3. Aughinish Alumina Ltd., Aughinish Island, Askeaton, Co Limerick.

Production

This company is involved in the refining of alumina (aluminium oxide) from bauxite ore by the Bayer process. This plant is operated 24 hours per day, 7 days per week. Capacity : Alumina ~ 1,000,000 Tonnes/annum from bauxite processing of 2,000,000 Tonnes/annum.

Operations

Bauxite ore is delivered by ship through the purpose built jetty in loads of up to 60,000 tonnes. This bauxite is transferred to covered on-site storage by conveyor. The raw bauxite is ground in a ball mill and mixed with caustic soda solution to form a slurry. A lime slurry is added and the mixture is delivered to digesters. In the digesters alumina is dissolved in the caustic under high temperature (~ 250°C) and pressure forming sodium aluminate. This solution is then passed through a pressure reduction and heat recovery stage and then to clarification by settlement and sand filtration. This removes the iron oxides and other insoluble material. The solution is then passed to the precipitators where it is cooled and seeded with aluminium hydroxide crystals. Aluminium hydroxide (hydrate) crystallises out of the solution as it is cooled and it is removed by classifiers. The hydrate is then washed and sent to a calciner where it is converted to alumina (aluminium oxide) at ~ 1000°C. This is the finished product and it is conveyed to on-site storage silos before shipment to smelters in other countries.

Air Quality Control

The control of emissions from the Aughinish Alumina plant and ambient air quality is maintained under conditions prescribed by Planning Permissions (Reg. Ref. 8580 and 1133/93, Limerick Co Co) related to the plant and the mud stack. The most relevant requirements are

- SO₂ emissions from the boiler stack limited to 25 tonnes/day (subsequently revised to 34 tonnes/day).
- SO₂ emissions from the calciner stack limited to 10 tonnes/day (subsequently revised to 12.5 tonnes/day).

- Dust concentrations in emissions from calciner and alumina loading points limited to 230 mg/m^3 .
- Concentration of SO_2 in any place outside the site attributable to emissions from Aughinish Alumina not to exceed, for more than 0.1 per cent of the time, 2600 ug/m^3 over 30 minutes, 260 ug/m^3 over 8 hours or 130 ug/m^3 over 24 hours.
- Annual average concentrations of SO_2 in any place outside the site attributable to emissions from Aughinish Alumina not to exceed 50 ug/m^3 .
- Records of fuel oil deliveries and consumption and the sulphur content of both to be made available to the Planning Authority on a weekly basis.

UPDATE

The principal method used for controlling the impact of sulphur dioxide emissions has been by stack dispersion from the main boilerhouse stack (107 m above ground) and the calciner stack (68.6m above ground). In addition about 26% of sulphur is absorbed by the alumina in the calciner.

Dust control on the calciners is by way of Electrostatic Precipitators (ESPs) with around 99.6% removal to around 110 mg/m^3 . Dust emissions from vents 4-10 is controlled by wet scrubbers, achieving emissions of $<100 \text{ mg/m}^3$, while bag filters contain vents 11 and 12 (alumina handling) with emissions of $<50 \text{ mg/m}^3$.

Atmospheric emission details

(i) Boilers A,B, and C:

Description

Three boilers A,B and C with a capacity of 37 MW each are fuelled on heavy fuel oil. Flue gas is ducted to one stack incorporating three flues so that they may be considered as one unit of capacity 110W. Oil is purchased on the world market with a sulphur specification of $<4.0\%$. No abatement is employed.

Oil usage : 25 - 31 Tonnes/hour

Stack height: 107m over ground level

Flow: 260,000 - 360,000 Nm^3/hour

Monitoring carried out by the company:

SO_2 - Calculated daily from sulphur content of oil

NO_x - Some spot sampling carried out in 1995

CO - Some spot sampling carried out in 1995

$\text{O}_2\%$ - Some spot sampling carried out in 1995

Dust - Old continuous monitor which has been unreliable

A continuous IR monitor has been installed (May '95) on boiler C to monitor SO_x and NO_x .

Continuous monitors will be installed on boilers A and B during 1995 when they are out of service.

Olfactometric measurements were carried out in Aug/Sept '93.

Ambient monitoring of Smoke and SO_2 at five location (Forbairt)

Ambient monitoring of dust deposition at 7-8 locations (Forbairt)

Monitoring by the EPA

Emission monitored by flue gas analyser for SO_x , NO_x and O_2 (21-22/03/95)

Emission sampled for organics/inorganics Boiler B (07/07/95)

Details

Suppliers certificates of quality for heavy fuel oil shipments to Aughinish Alumina between February 1988 and July 1995 give sulphur contents in the range shown on Figure A.3, with an average of approximately three percent. These shipments averaged about 25,000 tonnes. Aughinish Alumina carried out a trial on one boiler during June and July '91 using Orimulsion (sulphur content 2.6 percent) as a boiler fuel. The historical trend in monthly SO_2 emissions from fuel oil combustion are shown on Figure A.4. The general increase reflects the approximate doubling of fuel oil use between 1985 and 1995 which corresponds to a similar increase in alumina production at the plant in that period.

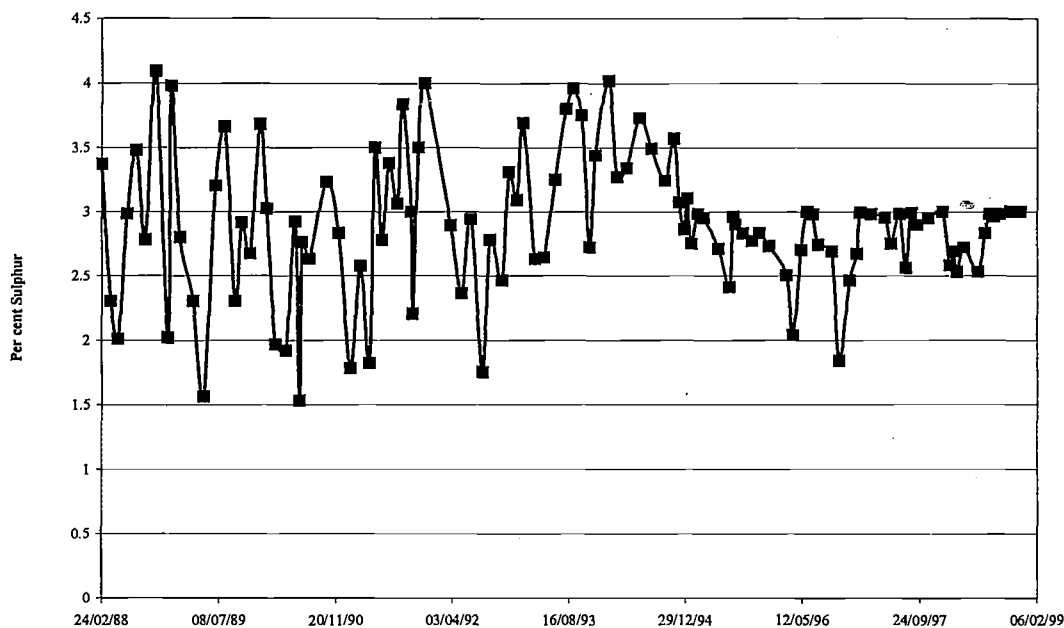


Fig. A.3. Sulphur Content of Fuel Oil Shipments to Aughinish Alumina.

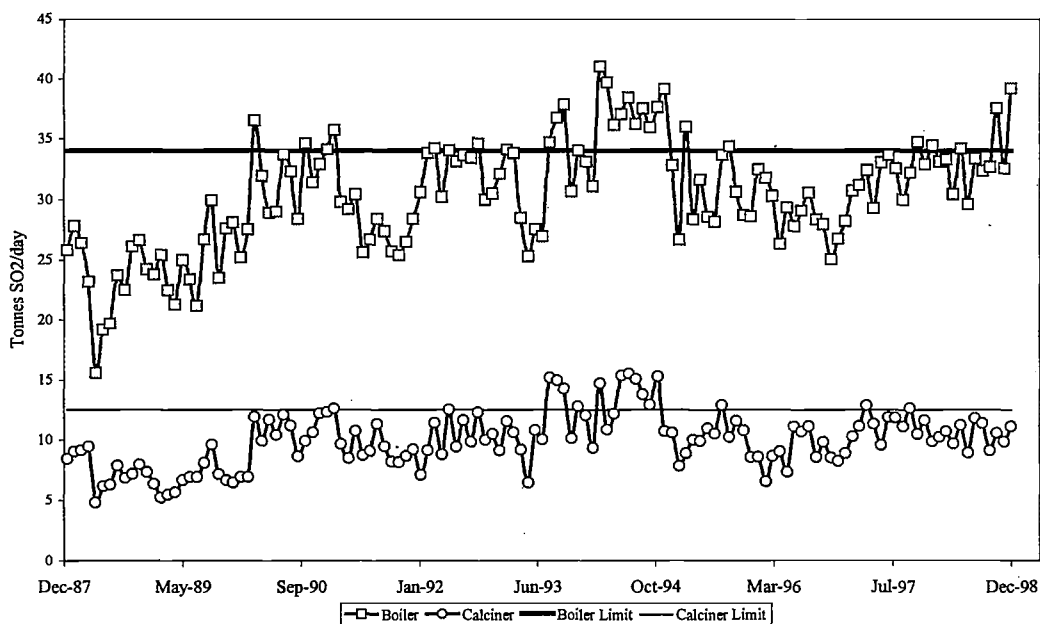


Figure A.4. Monthly SO₂ Emissions from Aughinish Alumina

UPDATE

Figs A.3 and A.4 also show more recent data for sulphur content of oil deliveries and estimated emissions from the boilers and calciner

Emissions:

SO₂ : 3,000 - 4,200mg/Nm³ (ref. 3% O₂)(EPA) ~ 1500 kg/hour
 using 4% S fuel oil ~ 6,600 mg/Nm³ (ref. 3% O₂)~2400 kg/hour
 using 3% S fuel oil ~ 5,000 mg/Nm³ (ref. 3% O₂)~1800 kg/hour

NO_x : 600 - 1,000 mg/Nm³ (ref. 3% O₂)(EPA) ~ 160 - 360 kg/hour

VOC : 5mg/Nm³ (Charcoal + chromosorb)

Dioxin : 0.0013 ng/Nm³ (see below)

Fluoride : < 1 mg/Nm³

Chloride : < 1 mg/Nm³

As a result of proposals for increased production, Aughinish Alumina has been required to apply to the EPA for an integrated pollution control licence. The application was lodged on 2 June 1995. Best available technology not entailing excessive costs (BATNEEC) will be applied in licensing the plant.

Existing emissions from the three 37 MW boilers are as expected considering the fuel used.

Emissions of dust are dependent on the quality of the fuel used, which may vary considerably. Dust emissions will be investigated further as part of examinations related to the IPC licence application and are expected to be in the range 50-100 mg/Nm³ based on fuel input.

The measurement of dioxin emissions (see below) confirms that emissions from the boilers are substantially below 0.1 ng/m³. This is the guide value which control measures should aim for under EC Directive 94/67/EEC, as referenced in the EPA BATNEEC Guidance Notes for the waste sector, and which will become the limit value effective 1 January 1996. The emissions of other volatile compounds, fluoride and chloride are not significant.

UPDATE

Aughinish Alumina was granted an integrated pollution control licence on 27 May 1998 with the following conditions for emissions to air.

Schedule 1(i) Emissions to Atmosphere

Emission Point Reference No.: 1 (Boilerhouse Stack- Area 14)

Location : 153,861N, 128,380E

Volume to be emitted: Maximum in any one day : 8,822,000 m³
 Maximum rate per hour : 367,600 m³

Minimum discharge height: 107 m above ground

Parameter	Emission Limit Value		
	Until December 31, 1999	From January 1, 2000 to December 31, 2004	From January 1, 2005
Oxides of sulphur (as SO ₂)	5,100 mg/m ³	5,100 mg/m ³	5,100 mg/m ³
Nitrogen oxides (as NO ₂)	1,000 mg/m ³	750 mg/m ³	670 mg/m ³
Particulates	n/a	n/a	50 mg/m ³

Emission Point Reference No.: 2 (Calcliner Stack- Area 10)

Location : 153,858N, 128,480E

Volume to be emitted: Maximum in any one day : 14,173,500 m³
Maximum rate per hour : 590,600 m³

Minimum discharge height: 68.6 m above ground

Parameter	Emission Limit Value	
	Until December 31, 2004	From January 1, 2005
Particulates	150 mg/m ³	50 mg/m ³
Oxides of sulphur (as SO ₂)	1,350 mg/m ³	1,350 mg/m ³

Emission Point Reference No.: 3 (Salt Cake Calcliner Stack- Area 11)

Location : 153,752N, 128,370E

Volume to be emitted: Maximum in any one day : 1,716,900 m³
Maximum rate per hour : 71,600 m³

Minimum discharge height: 56 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³
Oxides of sulphur (as SO ₂)	1000 mg/m ³

Emission Point Reference No.: 4 (Scrubber Exhaust Fan - Bauxite Crusher Building)

Location : 153,744N, 128,155E

Volume to be emitted: Maximum in any one day : 895,600 m³
Maximum rate per hour : 37,300 m³

Minimum discharge height: 27.9 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 5 (Exhaust Fan - Transfer Tower 4 & 5)

Location : 153,814N, 128,130E

Volume to be emitted: Maximum in any one day : 1,418,000 m³

Maximum rate per hour : 59,000 m³

Minimum discharge height: 18.5 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 6 (Scrubber Exhaust Fan - Bauxite Crusher and Wobbler Feeder)

Location : 153,732N, 128,155E

Volume to be emitted: Maximum in any one day : 1,343,400 m³

Maximum rate per hour : 56,000 m³

Minimum discharge height: 18.5 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 7 (Scrubber Exhaust Fan - Transfer Tower No. 1)

Location : 155,360N, 128,344E

Volume to be emitted: Maximum in any one day : 590,000 m³

Maximum rate per hour : 24,600 m³

Minimum discharge height: 9.1 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 8 (Scrubber Exhaust Fan - Transfer Tower No. 3)

Location : 154,163N, 128,264E

Volume to be emitted: Maximum in any one day : 590,000 m³
Maximum rate per hour : 24,600 m³

Minimum discharge height: 11.1 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 9 (Bauxite Unloader Dust Fan FA49AU01)

Location : 153,360N, 128,344E (Mobile)

Volume to be emitted: Maximum in any one day : 2,830,000 m³
Maximum rate per hour : 118,000 m³

Minimum discharge height: 31.3 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 10 (Bauxite Unloader Dust Fan FA49AU02)

Location : 153,360N, 128,344E (Mobile)

Volume to be emitted: Maximum in any one day : 2,830,000 m³
Maximum rate per hour : 118,000 m³

Minimum discharge height: 31.3 m above ground

Parameter	Emission Limit Value
Particulates	100 mg/m ³

Emission Point Reference No.: 11 (Alumina Loader Dust Fan FA49AL03)
Location : 153,360N, 128,344E (Mobile)
Volume to be emitted: Maximum in any one day : 1,132,000 m³
Maximum rate per hour : 47,200 m³
Minimum discharge height: 29.5 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³

Emission Point Reference No.: 12 (Alumina Loader Dust Fan FA49A-)
Location : 153,360N, 128,344E (Mobile)
Volume to be emitted: Maximum in any one day : 530,500 m³
Maximum rate per hour : 22,100 m³
Minimum discharge height: 30 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³

Vent	Minimum Discharge Height	Fuel
13 (Area 73 Boiler)	35.8 m above ground	Gas Oil (Max. 0.2% sulphur)
14 (Area 76 Boiler)	21.9 m above ground	Gas Oil (Max. 0.2% sulphur)
15 (Area 79 Boiler)	13.2 m above ground	Gas Oil (Max. 0.2% sulphur)

Emission Point Reference No.: 16 (Exhaust Fan FA12A017 – Top of Silo No. 1)

Location : 154,094 N 128,343 E

Volume to be emitted: Maximum in any one day : 360,000 m³
Maximum rate per hour : 15,000 m³

Minimum discharge height: 50 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³

Emission Point Reference No.: 17 (Exhaust Fan FA12A018 - Top of Silo No. 2)

Location : 154,140 N, 128,333 E

Volume to be emitted: Maximum in any one day : 360,000 m³
Maximum rate per hour : 15,000 m³

Minimum discharge height: 50 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³

Emission Point Reference No.: 18 (Exhaust Fan FA12A019 - Top of Silo No. 3)

Location : 154,186 N 128,323 E

Volume to be emitted: Maximum in any one day : 240,000 m³
Maximum rate per hour : 10,000 m³

Minimum discharge height: 51 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³

Emission Point Reference No.: 19 (Exhaust Fan FA12A020 - Between Silos 1 and 2)

Location : 154,117 N 128,338 E

Volume to be emitted: Maximum in any one day : 240,000 m³
Maximum rate per hour : 10,000 m³

Minimum discharge height: 50 m above ground

Parameter	Emission Limit Value
Particulates	50 mg/m ³

Monitoring for the period June 1998 to October 1999 (ie the first 17 months of the IPC Licence) as contained in the Annual Environmental Report of Aughinish Alumina show mass emissions as follows: Sulphur Dioxide - 17,942 t (IPC Licence limit 23,306 t) and Nitrogen oxides as Nitrogen dioxide - 3,967 t (IPC Licence limit 4,570 t). Sulphur dioxide data were generated by calculation based on the sulphur content of the fuel, the quantity of fuel used and the quantity of SO₂ adsorbed by the product(s). Nitrogen dioxide figures were derived from measured NO values and mass flow rates.

(ii) Calciners:

Description

Aluminium hydroxide (hydrate) is heated to ~ 1000°C in three fluid flash calciners where it is converted to alumina (aluminium oxide). The calciners are fuelled by heavy fuel oil from the same stock as the boilers above. Normal operation requires the use of two calciners to be in operation with the third put on line as required. Electrostatic precipitators are used for dust removal.
Oil usage: 9-17 Tonnes/hour
Stack height: 68.6 m over ground level
Estimated Flow : 100,000 - 190,000 Nm³/hour (ref. 3% O₂).

Monitoring carried out by the company:

SO₂ - Calculated daily from sulphur content of oil with correction for absorption by alumina dust within the calciner of about 26%
NO_x - spot sampling carried out 1/2 months
CO - none
O₂% - none
Dust - Spot sampling carried out 1/2 months, old continuous monitor on each calciner.
New continuous dust monitor installed in calciner 2 in May '95. Further monitor to be installed on calciners 1 and 3.
Olfactometric measurements were carried out in Aug/Sept '93.
Monitoring of emission by Forbairt for Chloride, Fluoride, Nitrate and Ammonia
Ambient monitoring of Smoke and SO₂ at five locations by Forbairt.
Ambient monitoring of dust deposition at 7-8 locations by Forbairt.

Monitoring by the EPA:

Emission monitored by flue gas analyser for SO_x, NO_x and O₂ (21-22/03/95)
Emission sampled for organics (9/05/95)(14/07/95)

Emissions sampled for inorganics (14/07/95)
Dust sampling (9/05/95)(5-6/07/95)(12/07/95)

Emissions:

SO ₂ : 2,500 mg/Nm ³ (ref. 3%O ₂)(EPA)	~ 500 kg/hour
using 4% S fuel oil 5,400 mg/Nm ³ (ref. 3%O ₂)	~ 570 - 1030 kg/hour
using 3% S fuel oil 4,000 mg/Nm ³ (ref. 3% O ₂)	~ 425 - 770 kg/hour
NO _x : 225 mg/Nm ₃ (ref. 3% O ₂)(EPA)	
Dust : 20-230 mg/Nm ³	
Aluminium : 12 - 120 mg/Nm ³	
Chloride : 15.9 mg/Nm ³	
Fluoride ; < 3 mg/Nm ³	
Nitrate : 5 mg/Nm ³	
Organics : ~ 6 mg/Nm ³	
Dioxins : 0.0014 ng/Nm ³ (see below)	

Emissions of dust from the calciners vary considerably from as low as 20 to more than 200 mg/Nm³. This emission consists of alumina (Al₂O₃) dust from the calcination of alumina trihydrate. The relevant EPA draft BATNEEC guidance note gives an emission limit of 50mg/Nm³ for new plant. Monitoring for fluoride, chloride and organics shows no significant emissions.

The measurements of dioxin emissions (see below) confirms that emissions from the calciners are substantially below 0.1ng/m³. This is the guide value which control measures should aim for under EC Directive 94/67/EEC, as referred in the EPA BATNEEC Guidance Notes for the waste sector, and which will become the limit value effective 1 January 1997, subject to the establishment of harmonised measurement methods by 1 July 1996. The emissions of other volatile compounds, fluoride and chloride are not significant.

UPDATE

Monitoring for the period June 1998 to October 1999 (ie the first 17 months of the IPC Licence) as contained in the Annual Environmental Report of Aughinish Alumina show particulate and sulphur dioxide mass emissions from the Calciner of 77 t (IPC Licence limit 1,101 t) and Sulphur Dioxide of 5,412 t (IPC Licence limit 9,912 t). Sulphur dioxide data were generated by calculation based on the sulphur content of the fuel, the quantity of fuel used and the quantity of SO₂ adsorbed by the product(s). Particulate figures were derived from measured particulate concentrations and mass flow

(iii) Emissions from heat exchange and pressure relief vents:

Emissions arise from the cooling and depressurisation of digested slurry which contains dissolved and undissolved impurities. In the IPC licence application, the vents have been classified as minor vents, i.e. insignificant due to size or composition of emissions. Emissions from the heat exchanger were examined by sampling Vent 5 and Vent 9 on one line (out of three lines of nine vents). The pressure relief tank vent is similar to the heat exchanger vents and emits multi-component organics and ammonia. The concentrations measured for vents 5 and 9 and the pressure relief tank vent were

	Heat exchanger Vent 5	Heat exchanger Vent 9	Tank Vent
Organics	2,000 mg/Nm ³ (dry)	6,000 - 20,000 mg/Nm ³ (dry)	1,400 mg/Nm ³ (dry)
Ammonia	36,000 mg/Nm ³ (dry)	1,000 - 4,000 mg/Nm ³ (dry)	2,600 mg/Nm ³ (dry)
Fluoride	< 1- 19 mg/Nm ³ (dry)	~ 43 mg/Nm ³ (dry)	< 1 mg/Nm ³ (dry)
Chloride	< 1 mg/Nm ³ (dry)	< 1 mg/Nm ³ (dry)	< 1 mg/Nm ³ (dry)
NO ₃	< 1 mg/Nm ³ (dry)	< 1 mg/Nm ³ (dry)	< 1 mg/Nm ³ (dry)
SO ₄			2 mg/Nm ³ (dry)

Flows and mass emissions will be determined during examinations of the IPC licence application.

(iv) Fugitive emissions from plant processing area and mud stack.

Fugitive emissions from the plant processing area consist mainly of dust from bauxite and alumina handling operations. Site inspection indicates that this fugitive dust is largely confined to the

Aughinish Alumina site but further inspection and evaluation will be carried out during determination of the IPC licence application. Fugitive emissions from the mud stack consist of dust from landfill operations and further examination is also required.

Dioxin Emission Measurements

A series of measurements on flue gas emissions of chlorinated dibenzofurans (CDFs) and chlorinated dibenzo(p)dioxins (CDDs) were made at Aughinish Alumina Plant in May and June 1995.

Similar tests were carried out on the concentrations of these compounds in the salt cake. The emission measurements covered flue gas matrices from the boiler and calciner stacks and from the digester heater vent. All samples were analysed by HRGC/MS by the specialist laboratory Gesellschaft für Arbeitsplatz und Umweltanalytik (GfA) mBH in Germany. The results, in terms of total concentrations of the Tetra -to Octa-CDF/CDD homolog groups, are summarised in Table A.5.

The toxicity equivalents (TEQ) are also included. These are calculated by multiplying the concentrations of individual detected congeners by corresponding toxicity-equivalent-factors, proposed by NATO/CCMS, and adding the products.

Table A.5. Dioxin/Furan Concentrations in Salt Cake and Flue Gases from Aughinish Alumina.

	Test 1 Salt Cake µg/kg	Test 2 Digester Vent Ng/m ³	Test 3 Boiler Stack Ng/m ³	Test 4 Calcliner Stack Ng/m ³
Total Tetra to Octa CDFs	0.187	7.559	0.018	0.022
Total Tetra to Octa CDDs	0.007	1.208	0.003	0.007
TEQ (NATO CCMS) Excluding LOD	0.0011	0.1511	0.0009	0.0009
TEQ (NATO CCMS) Including LOD	0.0018	0.1512	0.0013	0.0014

LOD Limit of Detection

UPDATE

Aughinish Alumina plan to develop a natural gas fired 300 MW nominal rating electrical output Combined Heat and Power (CHP) plant at Aughinish Island, Askeaton, Co. Limerick. The application also includes the conversion at a later stage of the CHP plant into a Combined Cycle Gas Turbine (CCGT) generating station of 390 MW nominal rating electrical output by the addition of additional components. The operation of this project requires that the existing IPC Licence must be reviewed by the Agency. This review is ongoing at present.

4. Southern Chemicals, Askeaton, Co Limerick.

Production

Production of expanded polystyrene Aerobord, packaging beans, moulded inserts and cut sheets. The plant is operated normally 24 hours per day 7 days per week with reduced work during weekend and at night. Capacity : Total beads ~1,800 tonnes/hour.

Operation

The production of expanded polystyrene began on this site in 1957. Planning permission for an extension to the existing Aerobord manufacturing plant was granted in Dec. '94 by Limerick County Council. This extension was under construction in April '95 and includes the provision of a second boiler on heavy fuel oil.

Polystyrene beads are delivered pre impregnated with pentane gas and expanded by heating to a foam like bean. These beans are then used to produce Aerobord expanded polystyrene blocks, moulded inserts or used without further treatment as packaging beans. The moulded blocks are cut as required with hot wire cutters.

Polystyrene beads which have been impregnated with pentane are purchased and brought on site in 1 tonne containers. These raw beads are expanded in a pre-expander by heating with steam. The blowing agent pentane expands within the bead and causes the bead to expand to approximately 50 times its original volume (3mm - 5mm diameter). The bead is then dried with hot air and allowed to age. The ageing process allows the vacuum created by condensing steam and pentane within the bead to be filled with air. The final bead contains approximately 96 percent air. Approximately 3% by weight of pentane is released during this process.

Moulded blocks are cut to the required shape by cutting with a hot wire. The hot wire cutters are process controlled and cut the block as it is passed through the cutters on a conveyor.

Atmospheric emission details

(i) Boiler

One boiler with a capacity of 6,810 kg steam per hour fuelled on heavy fuel oil with a specification of 3.5 % sulphur. No abatement is employed:

Oil usage : ~ 1,000 tonnes/year, 23 Tonnes/week

Stack height : 16 m above ground level

Emissions: SO₂ ~ 10kg/hour

(ii) Fugitive emissions from bead expansion:

Description

Raw beads are expanded in a pre-expander by heating with steam. This operation is carried out within the production building. Bead production of 1,800 tonnes/year with losses of 3 percent by weight of pentane gives a fugitive emission of approximately 200kg/day of pentane. For a 24-hour day operation, this gives losses of less than 10kg/hour.

(iii) Fugitive emission from Styrene hot wire cutting (Styrene)

Description

Moulded blocks of expanded polystyrene are cut with hot wire within the production building. Styrene is lost from this cutting within the building and no abatement is employed. Monitoring at a number of locations within this area covering the cutting and moulding operations have shown concentrations to be in the range of <1 ppm to 10 ppm of styrene. (Occupational Hygiene Exposure Limit is 50 ppm).

1. Wyeth Nutritionals Ireland, Askeaton, Co Limerick

UPDATE

This plant is now re-named AHPM Manufacturing B.V. Wyeth Nutritionals Ireland is part of the American Home Products Corporation and was established in Askeaton in 1973. A range of Infant Nutritional products are produced on site including canned powder baby food formula and liquid Ready-To-Feed formula in glass bottles and Tetra-Packs.

Production

Production of baby food - Infant Nutritional powders and liquids based on skim milk, whey and Soya protein. The plant is operated 24 hours per day, 7 days per week. Capacity : Powder - 30,000 tonnes/year (30 million 0.35 - 1.0 kg cans). Liquid - 1800 m³/annum.

Operations

The company started operations in 1974 producing electrodialysed whey and finished infant nutritional powders operating one dryer and two boilers. A second dryer was installed in 1976 increasing powder production to 15,000,000 lbs/annum. In 1983 the electrodialysis of whey was discontinued and production of powder increased. Can manufacturing facilities were added on site in 1985 to produce 99mm diameter cans. A major expansion was undertaken in 1991/1992. A fourth drier, a liquid production plant and a third boiler were installed bringing production to 30,000,000 lbs of powder and 15,000,000 100ml units.

The site is divided into two plants one for powder production and tin can manufacture and one for liquid production which also contains a process/product development facility. Liquid and powder operations on site are similar to milk processing operations in a dairy. Effluent from operations on site are treated in the on site effluent treatment plant before discharge to the tidal zone of the river Deel.

Ancillary operations on site include administration, engineering and laboratories. The laboratories are concerned with bacteriological control, process control and product analysis.

Powder production:

Powder protein base, Skim milk, Whey or Soya protein is reconstituted with water and compounded with edible oil, minerals and fat blend to the required formula. The formula is then filtered, clarified, pasteurised and homogenised before being dried in spray dryers. The finished product is stored in silos prior to filling into cans.

Can production:

Flat sheet tin plate (tin plated steel) is purchased pre printed. The plate is then cut, rolled and welded (continuous copper electrode) into a cylinder. The weld is then coated with a lacquer containing methyl ethyl ketone (MEK) solvent. This process is carried out automatically on a conveyor system. The lacquer is supplied to the system from two pressured canisters approximately 20 litres each. The lacquered tins pass through a heated area of the line where vapour from the drying lacquer is ducted to an extraction vent on the roof. The cans are then capped and sent to the filling line.

Liquid production:

Protein base is reconstituted with water and compounded in a similar way to powder production. The finished formula is then filled into glass jars, labelled and packed for shipment. The jar filling line contains a jar sterilisation section where each jar is washed with hydrogen peroxide before being filled. Hydrogen peroxide vapours are ducted to a vent on the roof.

Process/product development:

This facility is located in the liquid production building and contains a small scale production operation for liquid formula. Small scale batches are produced with variations in packaging and formula. Life tests and product stability trials are also conducted.

UPDATE

AHP Manufacturing B.V. T/A Wyeth Nutritionals Ireland, were granted an IPC Licence by the Agency on 14 January 1997.

Atmospheric Emissions

(i) Boilers

Three boilers with a capacity of 50,000 lbs of steam @ 18 bar each are fuelled on heavy fuel oil with a specification of 3.5% sulphur. Normal operation requires two boilers to be in use, with high steam demand three boilers may be used. The three boilers exhaust through three flues within one stack. No emission abatement is employed.

UPDATE

In normal operation the emissions from the boilers are passed through a scrubber before emission to atmosphere (emission point A1-1). A scrubber was installed in 1997 and uses the untreated dairy wastewater as the scrubber water solution. The untreated wastewater is alkaline and its pH is adjusted in the scrubber saving significant quantities of acid in the primary stages of the wastewater treatment plant. Emissions of dioxides of sulphur from

the boilers are reduced and waste heat energy recovery to boiler feed water from the exhaust gases is also achieved. In the event that the scrubber is unavailable, exhaust gases are ducted through the existing 40m boiler stack untreated. The boilers are operated on HFO with a specification for sulphur content of less than 3%w/w. HFO in use at present contains 1 - 1.5%S. Following scrubbing, emissions are equivalent to or less than those for 1%S HFO and are ducted to a new 40m stack.

Monitoring by the EPA:

Emission monitored by flue gas analyser for CO, SO_x, NO_x and O₂ (28/04/95)

Emission sampled for organics (28/04/95)

Oil sampled (28/04/95)

Details : The following details are estimated from monitoring by the EPA, oil usage and information supplied by Wyeth Nutritionals.

	Each boiler	Total of three boilers
Oil usage:	~ 17 Tonnes/day ~ 1Tonne/hour	37 Tonnes/day ~3 Tonnes/hour max
Flow:	5,000 - 10,000 Nm ³ /hour	~ 30,000 m ³ /hour

Emissions:

SO ₂ :	~ 2,600 - 5,200mg/Nm ³ (dry, 3% O ₂)(EPA) using 3.5% S fuel oil ~ 5,900 mg/Nm ³	~ 26 kg/hour ~ 59 kg/hour
NO _x :	~ 500 mg/Nm ³ (dry, 3% O ₂) (EPA)	~ 4.7 kg/hour
Dust :	~ 100 - 350 mg/Nm ³	
Organics :	<2 - 7mg/Nm ³ (EPA)	
Fluoride :	<1 mg/Nm ³	
Chloride :	< 1mg/Nm ³	

These emissions are low and as expected from the fuel used.

(ii) Four spray dryers:

Four spray dryers with a capacity of drying 1,2,3 and 4 tonnes per hour of powder. Total capacity 10 tonnes per hour. Dryers No. 1 and No. 2 are box spray dryers and dryer No. 3 and No. 4 are tower spray dryers. Dryers No. 1 and No. 2 are box spray dryers and dryer No. 3 and No. 4 are equipped with cyclones.

UPDATE

Two box dryers and three cone shaped dryers are used on site. Heated and filtered air is fed into the dryers and exhausted through either bag filters or cyclones. An agglomerator is also used on site where the dried material is wetted and re-dried to improve the bulk powder properties of the product. All the dryers and the agglomerator are housed within the main powder production building and the exhaust air following abatement is emitted from the roof of the building.

Monitoring carried out by the company:

Periodic monitoring for dust.

Monitoring by the EPA:

Emissions from the dryers consist of baby food dust and represents a loss of product for the company.

Monitoring of dust losses from the vents is carried out by the National Dairy Products Research Centre. Results confirm that emissions are not significant. The following details are estimated from inspection and information supplied by Wyeth Nutritionals.

Dryer	Flow (Nm ³)	Concentration (mg/Nm ³)	Emission (kg/hour)
1	43,000	~ 1	~ 0.04
2	100,000	11 - 26	~ 0.18 - 1.5
3	70,000	6	~ 0.40
4	120,000	4 - 8	~ 0.40 - 0.9

UPDATE

Emissions of particulate in the IPC Licence have been set in accordance with the Agency's BATNEEC guidance notes. The result of modelling indicate that maximum ground level concentrations will not be significant.

(iii) Solvent emission from tin can weld lacquering:

Organic emissions arise from the solvents dried off the lacquer used to coat the can weld. The solvent used is methyl ethyl ketone (MEK) which is a Class III Solvent. The lacquer is supplied to the system from two pressurised canisters of approximately 20 litres capacity. Estimates of emissions by measurement give about 0.6 kg/hour of MEK (flow 1,500 - 2,500 Nm³/hour and concentrations of 240 mg/Nm³ VOC). Relevant BATNEEC guidance notes consider the control of Class III organics only where the mass emission rate exceeds 3 kg/hour. Emissions from weld lacquering may therefore be considered insignificant.

(iv) Hydrogen peroxide from glass sterilisation:

Emission of hydrogen peroxide (H₂O₂) from glass jar sterilisation using 30% aqueous H₂O₂ solution. Usage is estimated at 6.3 kg/hour. Hydrogen peroxide vapour emissions are low due to its low volatility. Organic measurement employing charcoal and chromosorb samples has shown low levels which may be due to the use of ethanol for surface cleaning. Overall, emissions in the range 2 - 22 mg/Nm³, can be considered insignificant.

UPDATE

The IPC Licence contains the following conditions in relation to the emissions to atmosphere:
Schedule 1(i) Emissions to Atmosphere

Emission Point Reference No's.: A1-1 or A1-2, A1-3 and A1-4 combined

Minimum discharge height: 40 m above ground

Parameter	Emission Limit Value	
	mg/m ³	kg/hour
Oxides of sulphur (as SO ₂)	1700	100
Nitrogen oxides as (NO ₂)	750	40
CO	150	
Smoke	<1(Ringelmann Shade)	

Emission Point Reference No's.: Dryers A2-1, A2-2, A2-3, A2-4 and A2-6 and
Agglomerator A2-5
Location: Production area

Minimum discharge height: 23 m above ground

Parameter	Emission Limit Value
Total Particulates	50 mg/m ³

6. Syntex (Ireland) Ltd, Clarecastle, Co Clare.

Syntex Ireland Ltd. operate a manufacturing facility for the synthesis of bulk pharmaceutical intermediates and finished active ingredients and employ 237 on site. Syntex began operations in Clarecastle in 1975.

UPDATE

This activity is now re-named Roche (Ireland) Ltd. The plant is engaged in the manufacture of bulk pharmaceuticals used in the treatment of arthritis, high blood pressure, severe pain, organ transplant rejection, ulcers, angina and anti-fungal agents. There is one liquid/vapour incinerator on-site. This incinerator handles all the gaseous emissions and most of the waste solvents generated from the processes. The amount of waste solvent generated is minimised as far as practicable through the operation of solvent recovery on-site.

In February 1989 Syntex applied to Clare County Council for a licence under the Air Pollution Act. The following emissions were detailed in their application:

Boilers 2x7.5 MW burning HFO average 2% S ~ 1200 kg/day SO₂ - 30.0 m above ground.

Process vents

1 Flow 434,000 m³/day - 24 m above ground

Organics Acetone - 90 kg/day

Toluene - 96 kg/day

Heptane - 35 kg/day

2 Flow 114,100 m³/day - 24 m above ground

Organics Tetrahydrofuran - 100 kg/day

Toluene - 140 kg/day

Methyl chloride - 34 kg/day

3 Flow 309,700 m³/day - 24 m above ground

Organics Heptane - 35 kg/day

Toluene - 72 kg/day

Acetone - 35 kg/day

4 Methane vent - 95 kg methane vented over 4 hours - 33 m above O.D.

An Air Pollution Licence was issued by Clare County Council in May '94 setting out limits in accordance with T.A. Luft 1986. The licence stipulated that these limits were to be complied with by Dec. 1995. In August 1994 Syntex Ireland Ltd. applied to the EPA for an IPC licence. Atmospheric emissions were detailed in this application as follows:

Vent 05 Flow - 434,000m³/day - 24 m above ground

Organics : Heptane 4.3 kg/hour
Acetone 15.6 kg/hour
Toluene 2.8 kg/hour

Vent 06 Flow - 114,100m³/day - 24 m above ground

Organics : Tetrahydrofuran 7.8 kg/hour
Toluene 4.2 kg/hour
Methyl chloride 0.09 kg/hour

Vent 07 Flow - 309,700m³ - 24 m above ground

Organics : Tetrahydrofuran 40 kg/hour
Toluene 8.6 kg/hour
Benzoyl chloride 39 kg/hour
Triethylamine 16 kg/hour
Xylene 2.3 kg/hour
Acetone 3.0 kg/hour

Monitoring by the EPA:

24/10/94 IPC Process Vent 1 (105), 2(206) and 3(07) for organics -
Vent 1 ~ 12 kg/hour, ~ 100-mg/m³
Vent 2 ~ 20 Kg/hour, ~ 10000 mg/m³ (All Class II)k
Vent 3 ~ 5 kg/hour, ~ 400 mg/m³

20/06/95 Process Vent 1,2 and 3 for organics, inorganics, flow -
Dust Vents for pharmaceutical dust -

Note - Draft IPC Licence issued 04/08/95.

UPDATE

Roche Ireland Ltd. was granted an IPC licence by the Agency on 17 December 1996. There has been no significant changes to the manufacturing processes on-site since then and the company have generally been in compliance with their licence. The IPC Licence has recently been by the Agency to ensure compliance with EC Directive 94/67/EC *Council Directive on the incineration of hazardous waste*. The operation of the incinerator at Roche and the emission achieved are in compliance with the requirements of the directive, however the existing IPC licence required a review to ensure that this compliance was included as a requirement of an IPC licence.

The IPC Licence contains the following condition in relation to the emissions to atmosphere:

Schedule 1(i) Emissions to Atmosphere

Emission Point Reference No.:	No. 16
Location :	Liquid/Vapour Incinerator
Volume to be emitted:	Maximum in any one day : 720,000 m ³ Maximum rate per hour : 30,000 m ³
Incinerator operating temperature:	(i) 850°C minimum with waste input of < 1% halogenated organic substances as Cl; (ii) 1100°C minimum with waste input > 1% halogenated organic substances as Cl.

Residence time:

2 seconds minimum in the presence of at least 3% oxygen

Maximum Incineration Capacity:

11.6 MW

760 kg/hour waste solvent, 6500m³/hour waste off gas

3500m³/hour waste treatment aeration off gas

Parameter	Emission Limit Value	
	30 minute mean (mg/m ³)	24 hour mean (mg/m ³)
Volatile organic compounds (excluding Particulate matter) expressed as total organic carbon	20	10
Total particulate matter	30	10
Hydrogen chloride	60	10
Hydrogen fluoride	4	1
Hydrogen bromide	5	2
Sulphur oxides (as SO ₂)	200	50

Parameter	Emission Limit Value	
Dioxins (TEQ See "Toxic Equivalents" end of Schedule 1(i))	(6-8 hour samples)	0.1 ng/ m ³
Cadmium (as Cd) and Thallium (as Tl), and their compounds	(30 minute – 8 hour sample)	Total 0.05 mg/ m ³
Mercury (as Hg) and its compounds	(30 minute – 8 hour sample)	0.05 mg/ m ³
Antimony (as Sb), Arsenic (as As), Lead (as Pb), Chromium (as Cr), Cobalt (as Co), Copper (as Cu), Manganese (as Mn), Nickel (as Ni), Vanadium (as V) and Tin (as Sn) and their compounds	(30 minute – 8 hour sample)	Total 0.5 mg/ m ³

Parameter	The concentration of carbon monoxide after the last injection of combustion air shall not exceed the following levels
Carbon monoxide	50 mg/m ³ 24 hour mean 100 mg/m ³ 30 minute mean

Emission Point Reference No.'s: 7, 8, 9, 10, 11, 12 and 13

Parameter	Emission Limit Value
Particulates	0.1 mg/m ³ (as active ingredient)

7. SIFA Ltd., Shannon Industrial Estate, Co Clare.

SIFA Ltd. operate a manufacturing facility for the synthesis of bulk pharmaceutical intermediates and finished active ingredients and employ 136 on site. They commenced operations in Shannon in 1977 in a standard factory unit. In 1980 SIFA Ltd., expanded their operation by constructing a purpose built production facility on a near by site. In March '93 an Air Pollution Licence was issued by Clare County Council setting out limits based on T.A. Luft 1986. This licence provided for emissions as follows

Main Vent VEO79 Flow 5580 m³/hour - 17 m above ground
and
Secondary Vent VEO78 - Flow 1000 m³/hour - 17.15 m above ground level

Organics:

T.A. Luft	Class I	20mg/Nm ³ at a mass flow of 0.1 kg/hour or more.
	Class II	100mg/Nm ³ at a mass flow of 3.0 kg/hour or more.
	Class III	150mg/Nm ³ at a mass flow of 6.0 kg/hour or more.

Inorganics:

T.A. Luft	Class I	1mg/Nm ³ at a mass flow of 0.01 kg/hour or more.
	Class II	5mg/Nm ³ at a mass flow of 0.05kg/hour or more.
	Class III	30mg/Nm ³ at a mass flow of 0.3 kg/hour or more.

Two boilers - Boilers 1 and 2

Small tray drier vent - flow 180 m³/hour - organics as Vent VEO79 above.

SIFA Ltd. applied to the EPA for an IPC Licence on 30 January 1994. Monitoring returns required by the Air Pollution Licence indicated compliance with the licence. Emissions at any one time are dependent on the particular stages in batch processing. The list of emissions have been supplied in the IPC application as follows:

T.A. Luft Class	Emission
II	Toluene, Xylene
III	Ethanol, Methanol, Acetone, Isopropanol, Heptane, Methyl ethyl ketone, Diethylchloromethane, Ethyl acetate, Methyl isobuty ketone

Inorganics Bromine, Ammonia, Hydrogen chloride, others in small amounts

Monitoring by the EPA

20/01/95 IPC Main Vent VEO79 for organics ~ (< 0.1 kg/hour ~ 60 mg/m³)

23/06/95 Main Vent VEO79 organics, inorganics, Ammonia -

Secondary Vent CEO78 organics, inorganics -

Boiler 1 - SO₂, NO_x, CO, O₂

UPDATE

SIFA Ltd. were granted an IPC Licence by the Agency on 26 April 1996 with the following condition in relation to their Emissions to Atmosphere:

Schedule 1(i)

Emissions to Atmosphere

Emission Point Reference No.: Boiler vent VE-094

Location : Main site

Volume to be emitted : Maximum in any one day 56,000 m³
: Maximum rate per hour 2,400 m³

Minimum discharge height 11 m above ground level

Parameter	Emission Limit Value
	Concentration
	Mg/m ³
Sulphur Dioxide	850
NO _x (as NO ₂)	250
Carbon Monoxide	200 (Note 1)

Note¹ The concentration after the last injection of combustion air shall not exceed the emission limit value.

Emission Point Reference No. : Boiler vent VE-095

Location : Main site

Volume to be emitted : Maximum in any one day 37,000 m³
: Maximum rate per hour 1,600 m³

Minimum discharge height : 11 m above ground level

Parameter	Emission Limit Value
	Concentration Mg/m ³
Sulphur Dioxide	850
NO _x (as NO ₂)	250
Carbon Monoxide	200 (Note 1)

Note¹ The concentration after the last injection of combustion air shall not exceed the emission limit value.

Emission Point Reference No. : Boiler vent BVE-005

Location : Bay 130

Volume to be emitted : Maximum in any one day 37,000 m³
: Maximum rate per hour 1,600 m³

Minimum discharge height : 5 m above ground level

Parameter	Emission Limit Value
	Concentration mg/m ³
Sulphur Dioxide	850
NO _x (as NO ₂)	250
Carbon Monoxide	200 (Note 1)

Note¹ The concentration after the last injection of combustion air shall not exceed the emission limit value.

Emission Point Reference No. : VE 079

Location : Main Production building

Volume to be emitted : Maximum in any one day 160,000 m³
: Maximum rate per hour 7,000 m³

Minimum discharge height: 17 m above ground

Parameter		Emission Limit Value
Organic Substances (Note 1)	T.A. Luft Class I	20 mg/m ³
	Class II	100 mg/m ³ at mass flow >3 kg/hour
	Class III	150 mg/m ³ at a mass flow >6 kg/hour
Vapours or Gaseous Inorganic Substances	T.A. Luft Class I	1 mg/m ³
	Class II	5 mg/m ³
	Class III	30 mg/m ³
	Class IV	500 mg/m ³
Bromine		10 mg/m ³
Ammonia		50 mg/m ³

Note 1 Where organic substances of more than one class are present, in addition to the above limit, the sum of Classes I & II shall not exceed the class II limit and the sum of Classes I, II & III shall not exceed the class III limit.

Emission Point Reference No. : BVE - 001 Main Production extract

Location : Building B 130

Volume to be emitted : Maximum in any one day 48,000 m³
: Maximum rate per hour 2,000 m³

Minimum discharge height: 6 m above ground level

Parameter	Emission Limit Value
T.A. Luft Class II Organics	100 mg/m ³
T.A. Luft Class III Organics	150 mg/m ³
Nitrogen Oxides	300 mg/m ³

Emission Point Reference No's. : BVE - 002 and BVE - 003 Extract from pelleting pans and BVE - 022

Location : Building B 130

Parameter	Emission Limit Value
T.A. Luft Class III Organics	3 kg/hour
Total Particulates	1mg/m ³

Emission Point Reference No. : BVE - 010 extract from Alpine mill hopper

Location : Building B 130

Parameter	Emission Limit Value
Total Particulates	1mg/m ³

Emission Point Reference No. : VE 135

Location : New pharma plant, Main site

Volume to be emitted : Maximum in any one day 1248,000 m³

: Maximum rate per hour **52,000 m³**
 Minimum discharge height: **15 m above ground level**

Parameter	Emission Limit Value
T.A. Luft Class III Organics	1 kg/hour
Total Particulates	0.3 mg/m ³

8. PGP Industries (Ireland) Ltd., Shannon Industrial Estate, Co Clare.

PGP Industries (Ireland) Ltd. took over the Platina Labs operation in 1991. Since 1989 Platina Labs were involved in the processing of precious metal compounds mainly platinum, rhodium and palladium for use as catalysts. In 1992 PGP were informed that planning permission for fine chemical manufacturing was required for their operation. A planning application including an E.I.S was lodged with Clare County Council in 1994. At present throughput is in the range of 540 kg/month precious metal and the company employs 15 people. Precious metals are processed both mechanically and chemically. Chemical operations involve the digestion of the metal in acid to form a salt of the metal in solution. In 1989 Platina Labs (Ireland) Ltd. applied to Clare County Council for an Air Pollution Licence. In August 1991 an Air Pollution Licence was issued with the following limits:

(i) *main Vent Packed Tower Scrubber Exhaust no, 1 :*

Flow 6000 m³/hour - 7 m above ground.

Organics

T.A. Luft.	Class I 20 mg/Nm ³	at a mass flow of 0.1 kg/hour or more.
	Class II 100 mg/Nm ³	at a mass flow of 3.0 kg/hour or more.
	Class III 150 mg/Nm ³	at a mass flow of 6.0 kg/hour or more.

Inorganics

T.A. Luft	Class I 1 mg/Nm ³	at a mass flow of 0.01 kg/hour or more.
	Class II 5 mg/Nm ³	at a mass flow of 0.05 kg/hour or more.
	Class III 30 mg/Nm ³	at a mass flow of 0.3 kg/hour or more.
	Class IV 500 mg/Nm ³	at a mass flow of 5.0 kg/hour or more.

Organic emissions are small amounts of Acetic Acid only while inorganic emissions are as follows:

Chlorine, Hydrochloric Acid, Oxides of Nitrogen and Oxides of Sulphur

Monitoring returns indicate compliance with the licence.

Inorganic dust was also listed in the licence; however no emissions of dust were present.

(iii) *Ammonia Scrubber Vent:*

Flow - 900 m³/hour - 6.8 m above ground level.

Ammonia as NH₃ 50 mg/m³

The operations at PGP industries (Ireland) Ltd are covered by Category 3,4 of the First Schedule of the EPA Act and will be subject to an IPC Licence when determined by regulation.

UPDATE

PGP Industries (Ireland) Ltd. was granted an IPC licence by the Agency on 12 March 1997. The licence contains the following conditions in relation to the emissions to the atmosphere.

Schedule 1(i) Emissions to Atmosphere

Emission Point Reference No.: EP-1

Location : Packed Tower Caustic Scrubber

Volume to be emitted: Maximum in any one day : 144,000 m³
Maximum rate per hour : 6,000 m³

Minimum discharge height: 15 m above ground

Parameter	Emission Limit Value
Cl ₂	5 mg/m ³
HCl	30 mg/m ³
Hydrobromic Acid	100 mg/m ³
NO _x	500 mg/m ³
SO _x	500 mg/m ³
Particulates	10 mg/m ³

Emission Point Reference No.: EP-2

Location : Ammonia Scrubber

Volume to be emitted: Maximum in any one day : 120,000 m³
Maximum rate per hour : 5,000 m³

Minimum discharge height: 11 m above ground

Parameter	Emission Limit Value
Ammonia	50 mg/m ³
Acetic Acid	100 mg/m ³
Particulates	10 mg/m ³

Emission Point Reference No.: EP-3
 Location : Wet Scrubber

Volume to be emitted: Maximum in any one day : 144,000m³
 Maximum rate per hour : 6,000m³

Minimum discharge height: 15m above ground

Parameter	Emission Limit Value
TA Luft Organics Class I ^{Note 1}	20 mg/m ³
TA Luft Organics Class II ^{Note 1}	100 mg/m ³
TA Luft Organics Class III ^{Note 1}	150 mg/m ³
Cl ₂	30 mg/m ³
HCl	30 mg/m ³
NO _x	500 mg/m ³
SO _x	500 mg/m ³
Iodine	10 mg/m ³
Particulates	10 mg/m ³
CO	150 mg/m ³

Note 1: Where organic substances of several classes are emitted simultaneously, in addition to the above individual limits, the sum of the concentrations of Classes I, II and III shall not exceed the Class III limits.

Emission Point Reference No. EP-4
 Location : Bag Filter

Volume to be emitted: Maximum in any one day : 120,000m³
 Maximum rate per hour : 15,000m³

Minimum discharge height: 6m above ground

Parameter	Emission Limit Value
Inorganic Dust Particles Class I ^{Note 1}	0.2 mg/m ³
Inorganic Dust Particles Class II ^{Note 1}	1 mg/m ³
Inorganic Dust Particles Class III ^{Note 1}	5 mg/m ³
Particulates	10 mg/m ³

Note 1: Where Inorganic Dust Particles of several classes are emitted simultaneously, in addition to the above individual limits, the sum of the concentrations of Classes I, II and III shall not exceed the Class III limits.

9. De Beers Industrial Diamonds, Shannon Industrial Estate, Co Clare.

This company set up in 1961 in Shannon and produces industrial diamonds by high pressure and temperature from a graffiti/steel matrix. The diamonds are recovered by acid digestion cleaned and sorted before coating Nickel or Copper for encapsulating into grinding wheels and other tools.

UPDATE

De Beers Industrial Diamonds Division is located in Shannon Industrial Estate and has had a production facility there since 1961. Part of an international group, De Beers has sites in Sweden, Germany, South Africa and the Isle of Man. The Shannon factory produces industrial diamonds from graphite and processes the diamonds into a range of ultra hard abrasive products for industrial cutting and grinding applications. The total quantity of final product produced during 1999 was some 175 tonnes.

In Dec '92 Clare County Council issued an Air Pollution licence setting T.A. Luft limits on all emissions. Emissions are inorganic acid vapours and ammonia from diamond coating operations and dust from other operations. Continuous monitoring of SO₂ and NO_x is in place for the main emission. Monitoring returns indicate good compliance with the licence.

The Air pollution licence allows for emissions as follows:

(i) Vent 1. Ammonia scrubber exhaust from diamond cladding process:

Flow - 70000 m³/hour - 17 m above ground level

Ammonia as NH₃ 50 mg/Nm³

Inorganics

T.A. Luft	Class I 1 mg/Nm ³	at a mass flow of 0.01 kg/hour or more.
	Class II 5 mg/Nm ³	at a mass flow of 0.05 kg/hour or more.
	Class III 30 mg/Nm ³	at a mass flow of 0.3 kg/hour or more.
	Class IV 500 mg/Nm ³	at a mass flow of 5.0 kg/hour or more.

(ii) Vent 2. Acid cleaning/Recovery Scrubbing towers:

Flow - 70,000 m³/hour - 23 m above ground level

Inorganics

T.A. Luft	Class I 1 mg/Nm ³	at a mass flow of 0.01 kg/hour or more.
	Class II 5 mg/Nm ³	at a mass flow of 0.05 kg/hour or more.
	Class III 30 mg/Nm ³	at a mass flow of 0.3 kg/hour or more.
	Class IV 500 mg/Nm ³	at a mass flow of 5.0 kg/hour or more.

(iii) Five Dust Vents - capsule crushing, graphite splitting, pre synthesis, carbide manufacture and carbide

Total dust

50 mg/Nm ³	at a mass flow of more than 0.5 kg/hour.
150 mg/Nm ³	at a mass flow of up to 0.5 kg/hour.

Inorganic dust particles

T.A. Luft	Class I 0.2 mg/Nm ³	at a mass flow of 1.0 g/hour or more.
	Class II 1.0 mg/Nm ³	at a mass flow of 5.0 g/hour or more.
	Class III 5.0 mg/Nm ³	at a mass flow of 25.0 g/hour or more.

Monitoring returns for dust emissions indicate levels of less than 2 mg/Nm³ total dust. Three boilers using heavy fuel oil with mass flows of 10,000 Nm³/hour, 12,700 Nm³/hour and

12,7000 Nm³/hour. No limits on SO₂ or NO_x were set. SO₂ emissions, based on fuel oil with 3% sulphur, would be in the region of 180 kg/hour for all three boilers.

UPDATE

There are two boilers on site. The major use of the boilers is to provide space heating with very little process steam required. Fuel Oil (max 1% Sulphur) is used. There are plans to install a third boiler that will cater for plant expansion. Emissions from the boilers (existing and proposed) have been assessed and shown not to have a significant effect when compared with the Air Quality Standards for SO_x and NO_x specified in S.I 244 of 1987.

The Chemical Recovery process generates significant quantities of NO_x and SO_x fumes due to the strong acid solutions used. Small amounts of hydrochloric acid are also used and trials being carried out may result in more HCl acid being used in preference to, or in combination with, the nitric and sulphuric acids currently used. The system is divided into two streams; namely dilute and concentrated. The concentrated fumes are passed through a multi-stage scrubbing tower for abatement. They are combined with the dilute stream before discharge to atmosphere.

Hydrogen peroxide (0.5% solution), nitric acid (10-15% solution) and a dilute sodium hydroxide solution are used as scrubbing media. The system is controlled by the Building Management System and emissions of SO_x and NO_x are continuously monitored and logged by an Infra-Red system.

There is an emission of ammonia which arises from the electroless plating in the cladding process. Both the main scrubber and Ammonia emission were subjected to an Air Dispersion assessment. The model results show that predicted Ground Level Concentrations of pollutants are well below statutory and derived limits.

De Beers Industrial Diamonds were granted an IPC Licence on 25 January 2001, which contains the following condition in relation to their Emissions to Atmosphere

Schedule 1(i) Emissions to Atmosphere

Emission Point Reference No.:	SYN A 20
Location:	Bay 39H5
Volume to be emitted:	Maximum in any one day: 1,680,000 m ³
	Maximum rate per hour: 70,000 m ³
Minimum discharge height:	23.7 m above ground

Parameter	Emission Limit Value
Chlorides (as HCl)	10 mg/m ³ (at mass flows >0.3kg/h)
Nitrogen oxides (as NO ₂)	300 mg/m ³ (at mass flows >3kg/h)
Oxides of Sulphur	300 mg/m ³ (at mass flows >3kg/h)

Emission Point Reference No.: IDD A 01

Location: Bay 39H3

Volume to be emitted: Maximum in any one day: 1,680,000 m³
Maximum rate per hour: 70,000 m³

Minimum discharge height: 23.7 m above ground

Parameter	Emission Limit Value
Ammonia (as NH ₃)	50 mg/m ³

10. Shannon Aerospace and Shannon Airport.

Shannon Aerospace aircraft maintenance facility caters for general overhaul, maintenance and aircraft painting. The main complex contains two hangars, a general maintenance 10,800 m² floor area and a dedicated stripping and painting hangar ~ 5,000 m² floor area.

Clare County Council issued planning permission to Shannon Aerospace in 1990 subject to conditions on the paint stripping operations. For technical reasons the proposed system of stripping was not suitable. A study was undertaken by Shannon Aerospace on the environmental impact of alterations at the stripping operations between 1992 and 1994. The following information is taken from this study.

	1992	1993	1994	1995	1996
No. of stripping/painting operations ⁴	13	23	40	44	

Use of paint stripper is estimated as follows:

	1992	1993	1994	1995	1996
Methylene chloride (m ³)	4	5	15	22	24
Formic Acid (m ³)	0	13	12	5.5	6
Phenol/methylene chloride (m ³)	0	0	0	1.5	1.8
Total (m ³)	4	18	27	29	31.8

The stripping/painting hanger ventilation system flow is rated at 306,000 m³/hour.

The maximum rate of application of stripper is estimated at 110kg in 30 minutes i.e. 220 kg/hour, with 80% being methylene chloride (176 kg/hour methylene chloride applied).

The E.I.S states that, based on tests at Swissair, 44% of the stripper will evaporate from the plane surface giving an emission of methylene chloride in the order of 39 kg in 30 minutes i.e. 78 kg/hour.

Further evaluation of these emissions will be carried out during the determination of the IPC licence. The painting operations fall within the scope of paragraph 12.2 of the first schedule of the EPA Act. As a result of the planning application to modify the paint stripping operations the activity will be required to apply to the EPA for a licence under the terms of section 92 of the Act.

Aer Rianta operates an international airport at Shannon with passengers throughput in the region of 1 million per year (1,002,561 in 1993). Transit passengers due to stopovers amounted to 706,699 in 1993. Some flight training operations are also carried out but involve normal landings and take off only.

In common with other international airports, fuel used by aircraft at Shannon may have been purchased at any airport visited by the aircraft. Computerised records of aircraft movements are available for Shannon from 1993. The following (which includes training flights) gives an indication of the level of air traffic.

Year	Landings	Take-offs	Total	Max/month	Min/month
1993	21699	21671	43370	4740 (Aug)	2535 (Jan.)
1994	19974	19959	39933	4256 (Sept.)	2325 (Dec.)

UPDATE

The most significant emissions to air are from the paint stripping and painting operations. Emissions arise from the evaporation of solvents from the paint stripping solutions and paint. Methylene chloride a main constituent of the paint strippers has been monitored and its dispersion modelled. Predicted ground level concentrations are not significant.

The facility was granted an IPC Licence on 04 June 1997 which contains the following conditions in relation to the emissions to atmosphere

Schedule 1(i) Emissions to Atmosphere

Emission Point Reference No.: EF 8/9

Location : Paint Hangar Extract

Volume to be emitted: Maximum in any one day : 3,072,000 m³
Maximum rate per hour : 128,000 m³

Minimum discharge height: 26 m above ground

Parameter	Emission Limit Value
Total organics (as C)	50 mg/m ³
Class B compounds	20 mg/m ³

❖ Emission Point Reference No.: EF 10/11

Location : Paint Hangar Extract

Volume to be emitted: Maximum in any one day : 2,808,000 m³
Maximum rate per hour : 117,000 m³

Minimum discharge height: 26 m above ground

Parameter	Emission Limit Value
Total organics (as C)	50 mg/m ³
Class B compounds	20 mg/m ³

Emission Point Reference No's.:

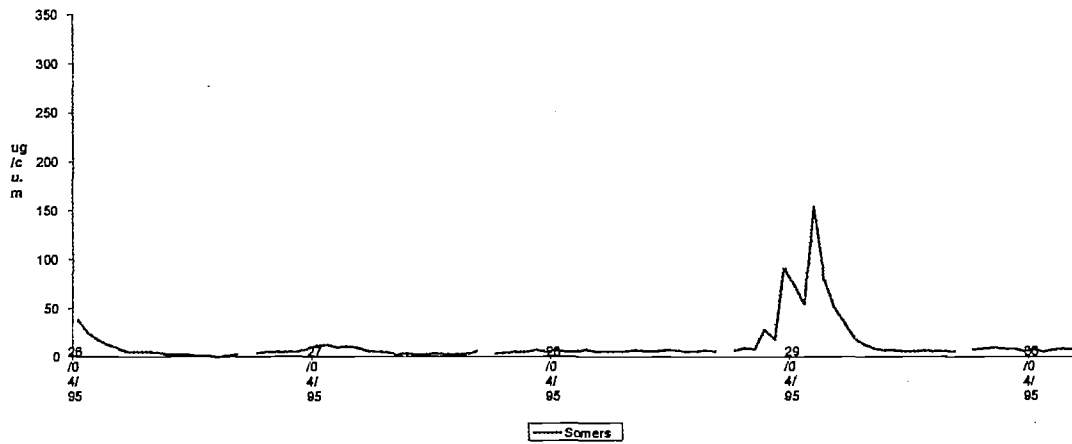
EF4.2, EF5.1, EF6.1 and EF6.6

Parameter	Emission Limit Value
Particulates	50 mg/m ³

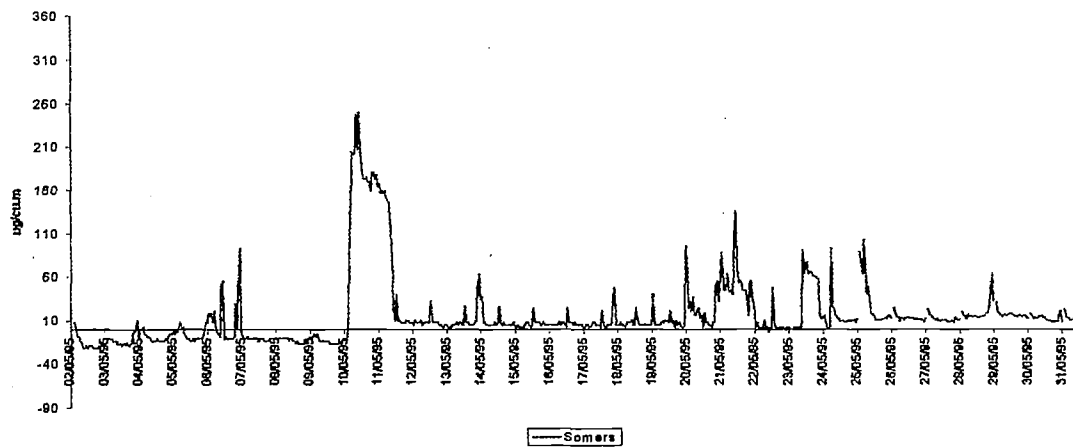
Appendix B

**RECORDS OF HOURLY AVERAGE
CONCENTRATIONS OF SO₂ ON THE SOMERS AND
RYAN FARMS, APRIL 1995 – DECEMBER, 1998**

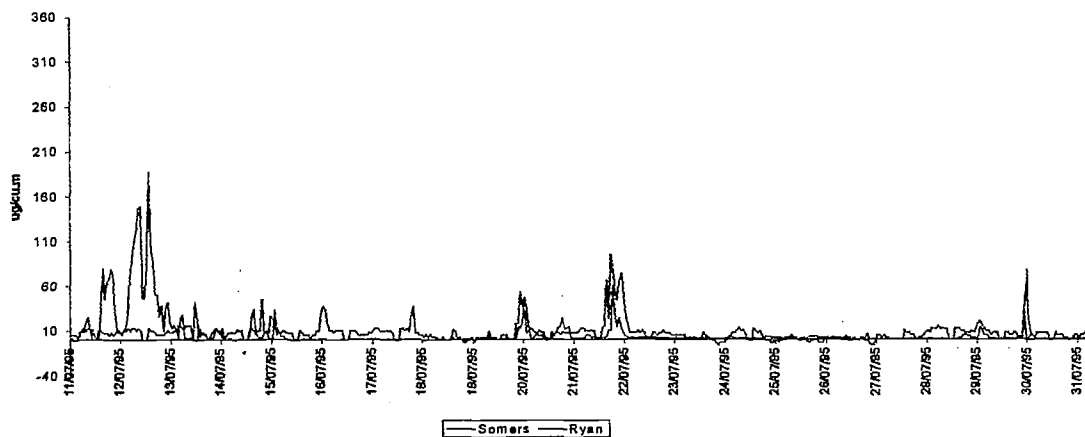
Sulphur Dioxide Hourly Averages
Askeaton Investigation
April 1995



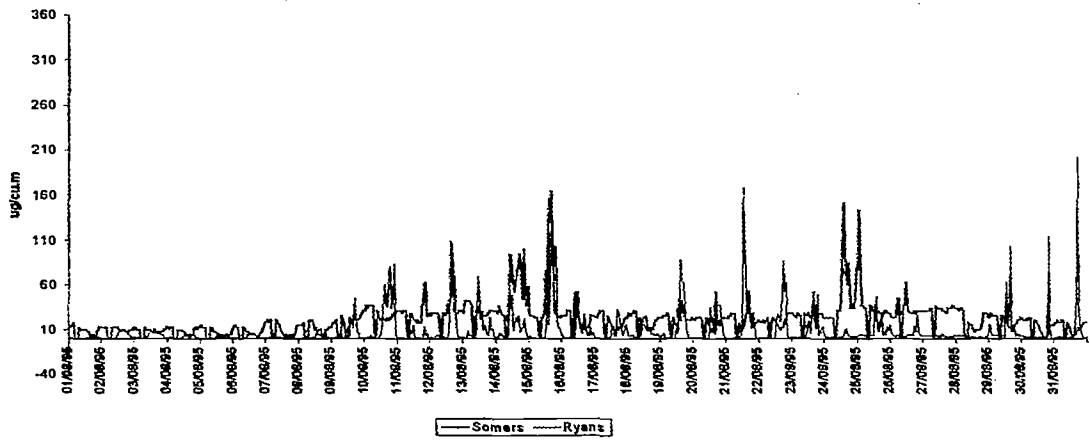
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Askeaton Investigation
May 1995



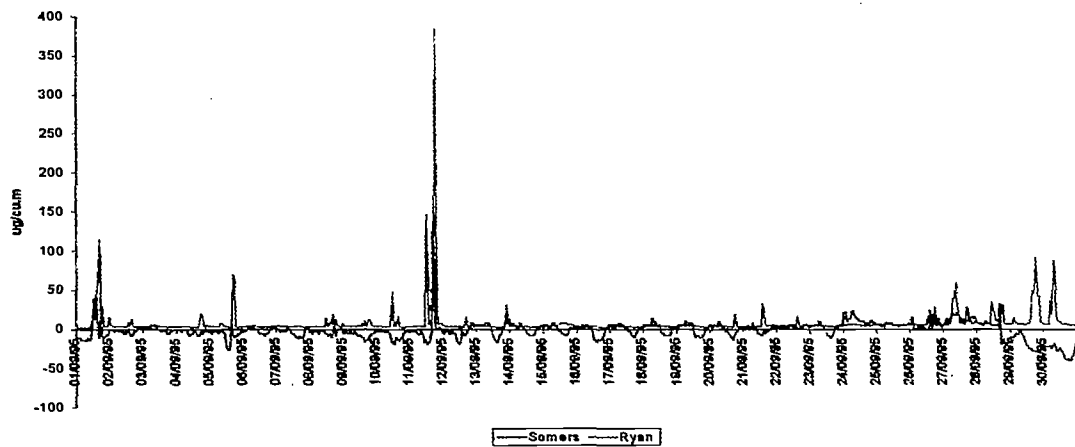
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Askeaton Investigation
July 1995



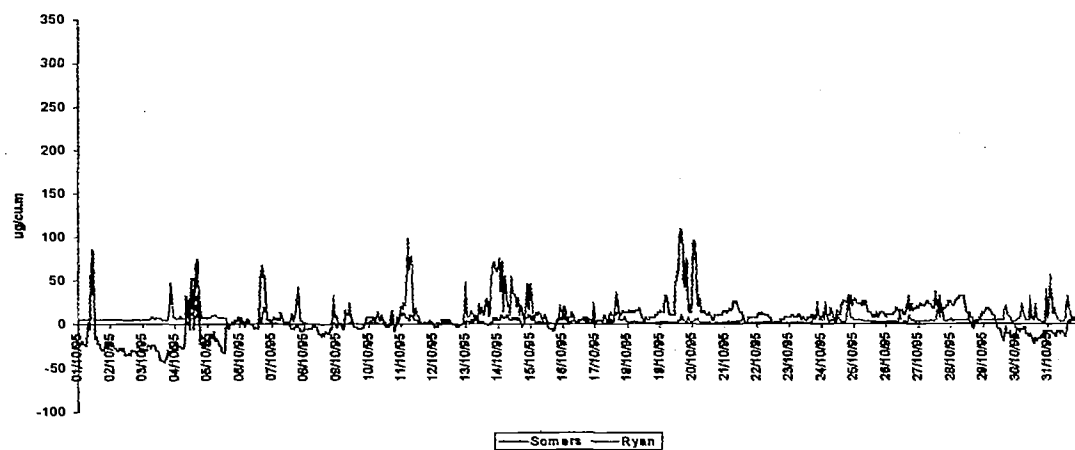
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Askeaton Investigation
August 1995



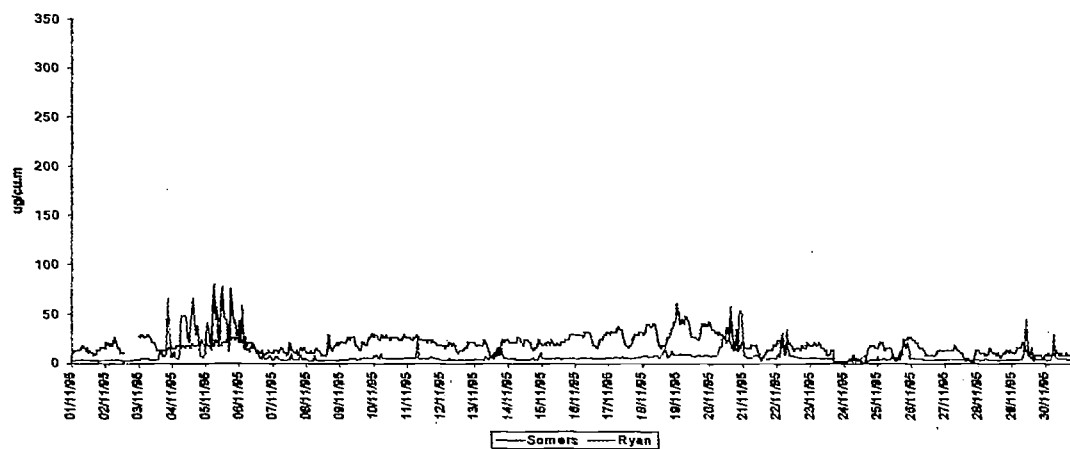
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Askeaton Investigation
September 1995



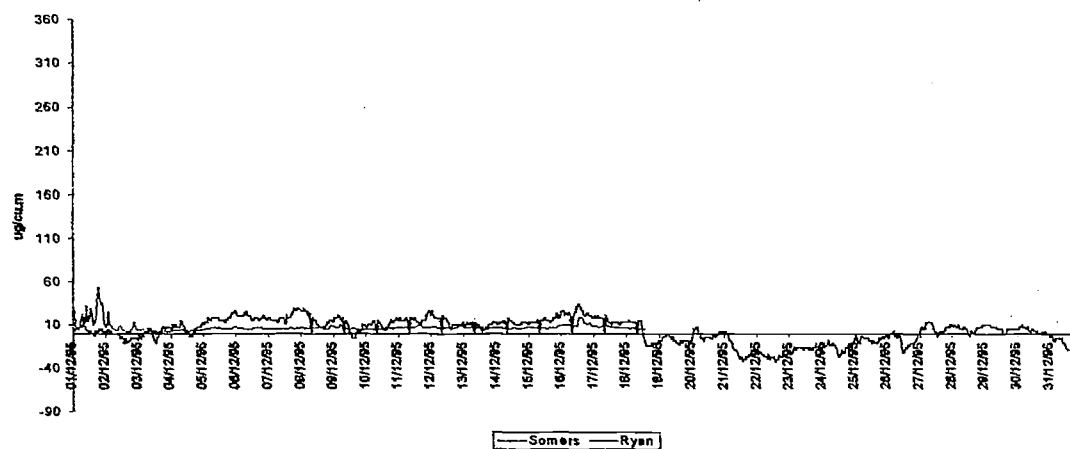
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Askeaton Investigation
October 1995



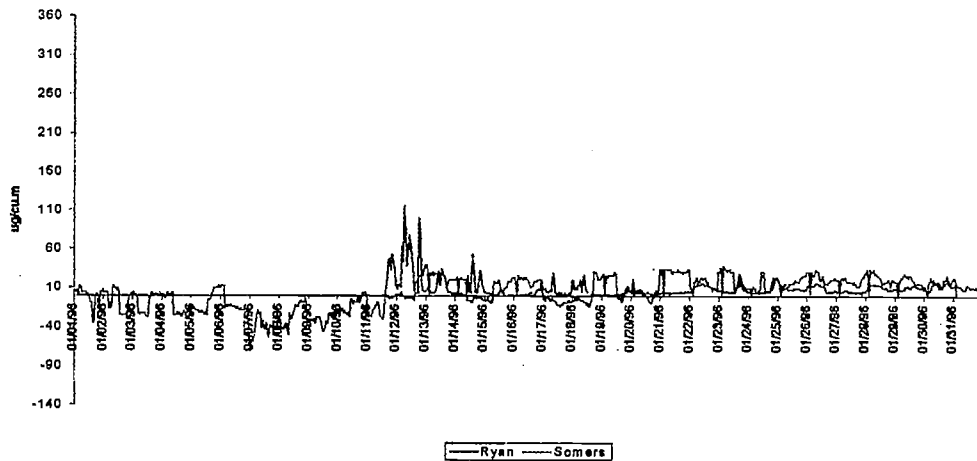
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Askeaton Investigation
November 1995**



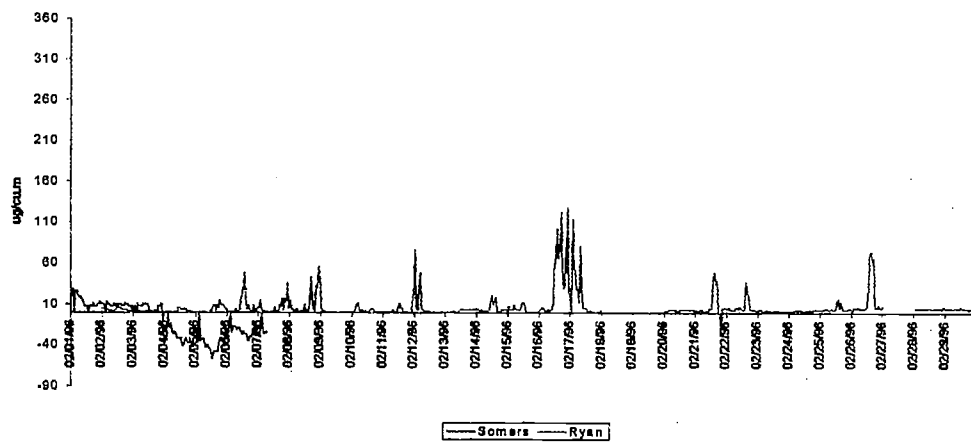
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Askeaton Investigation
December 1995**



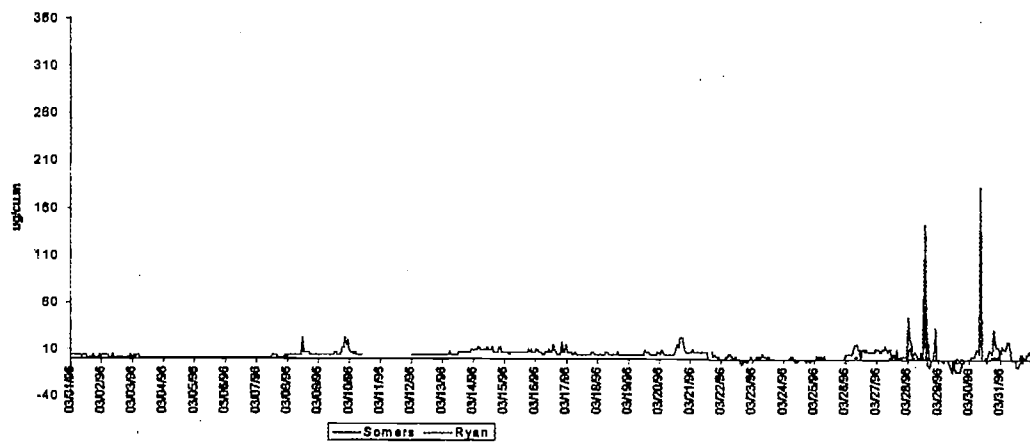
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January 1996



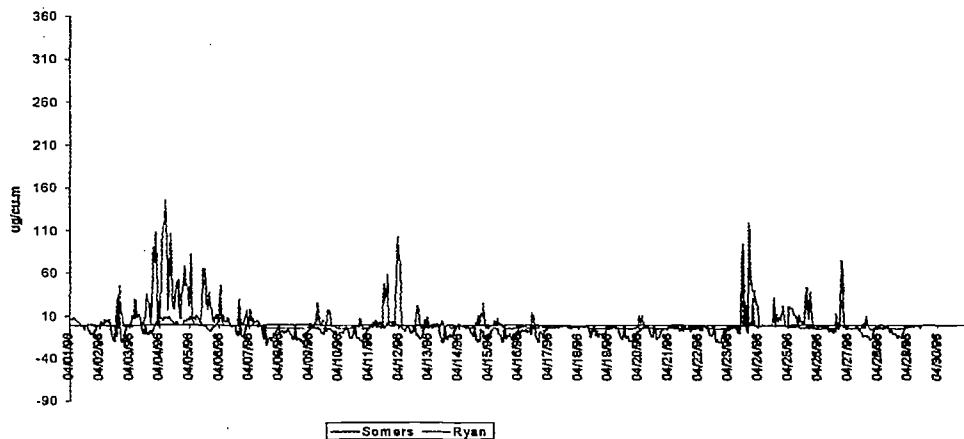
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February 1996



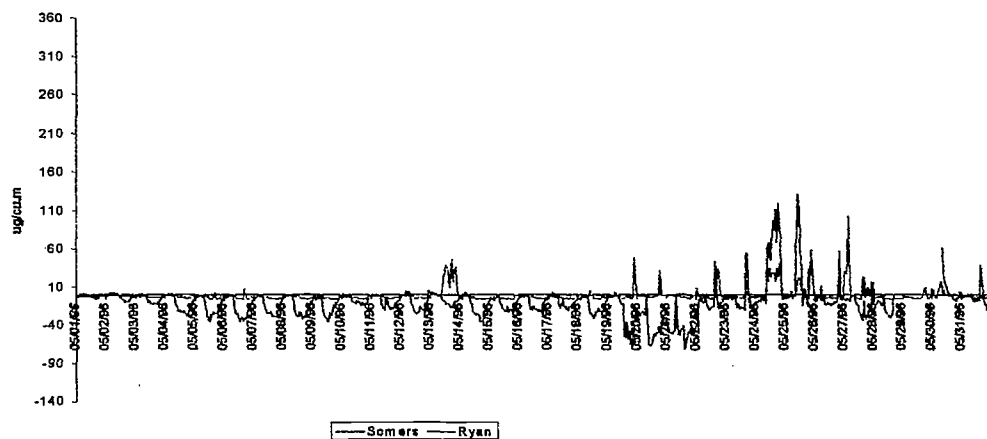
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March 1996



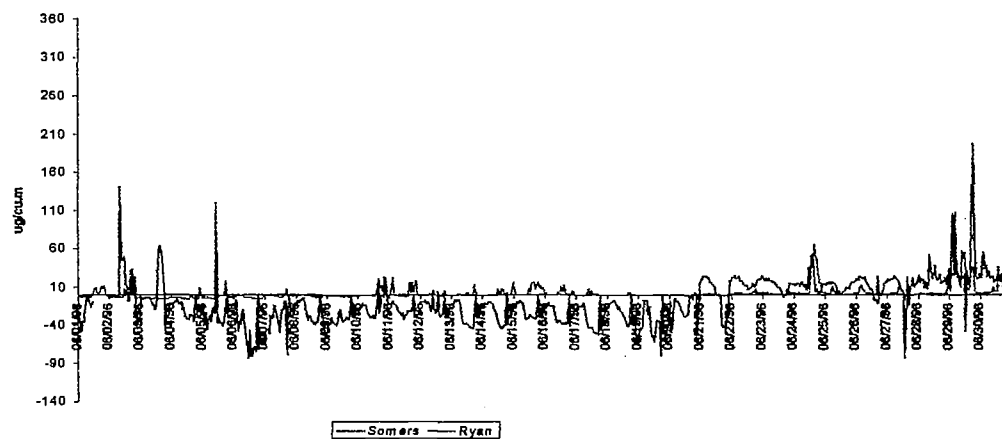
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April 1996



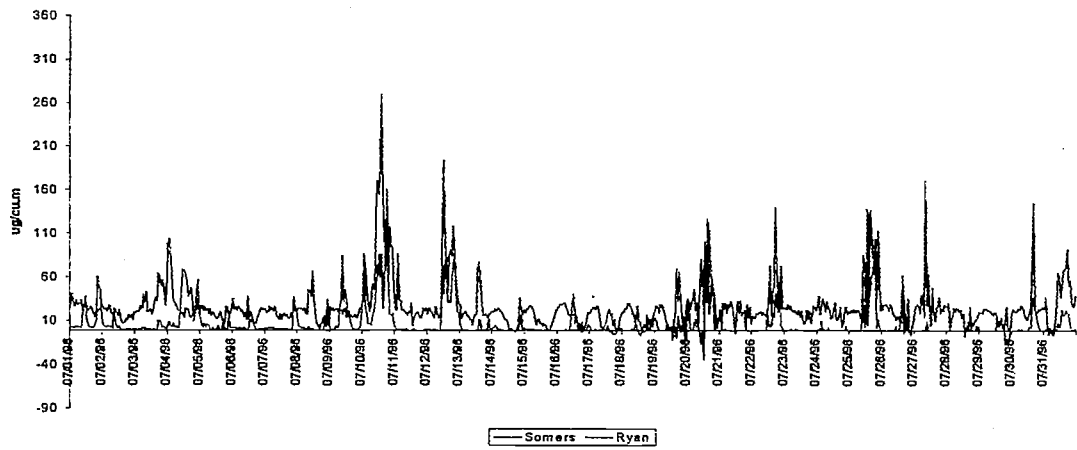
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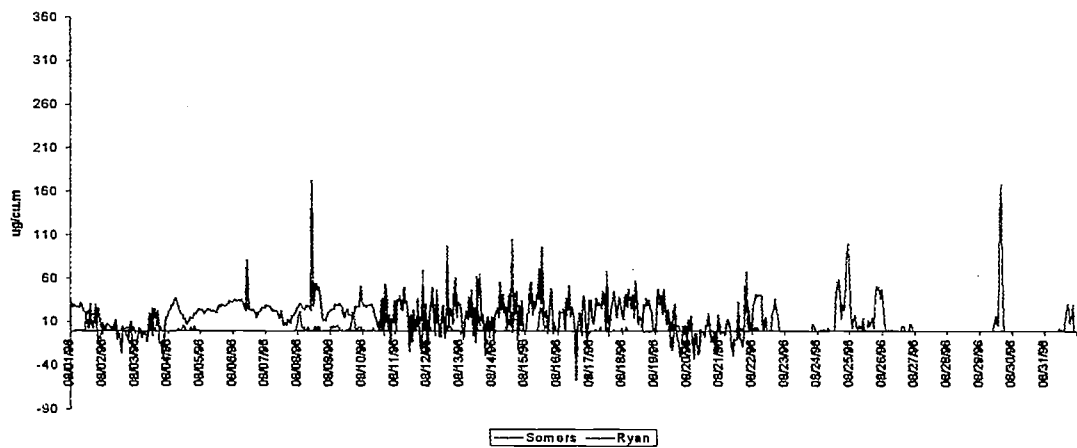
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June 1996



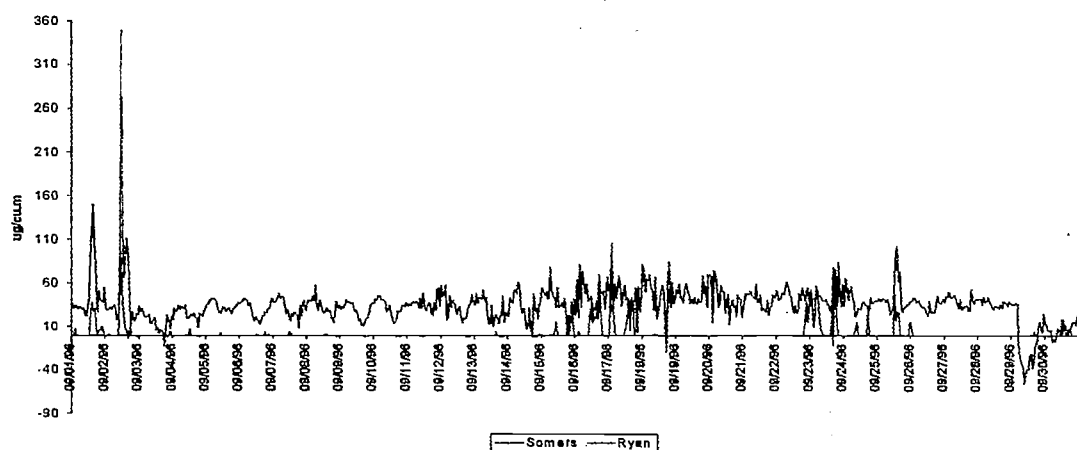
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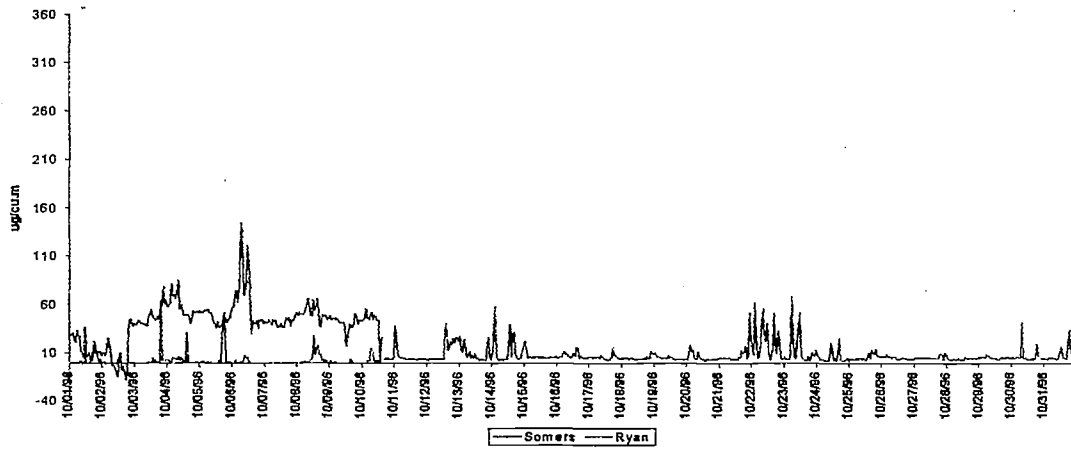
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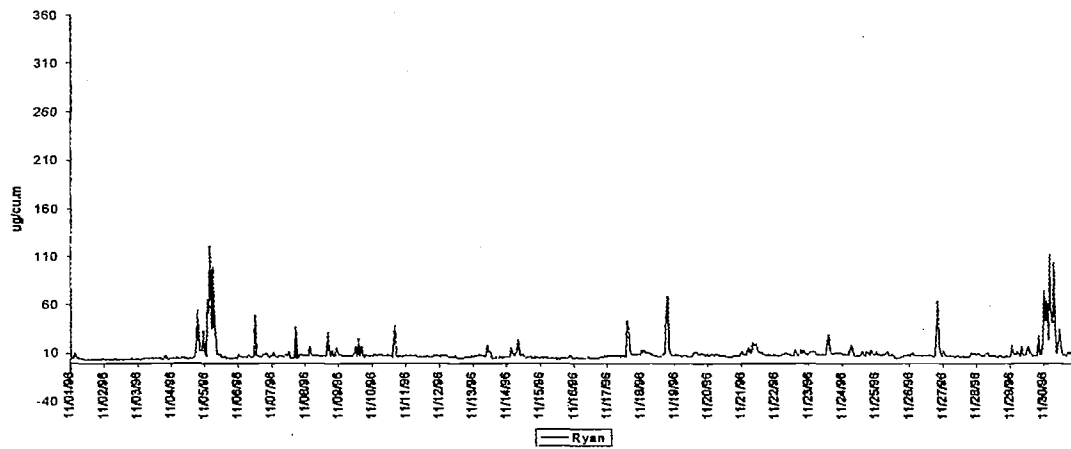
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September 1996



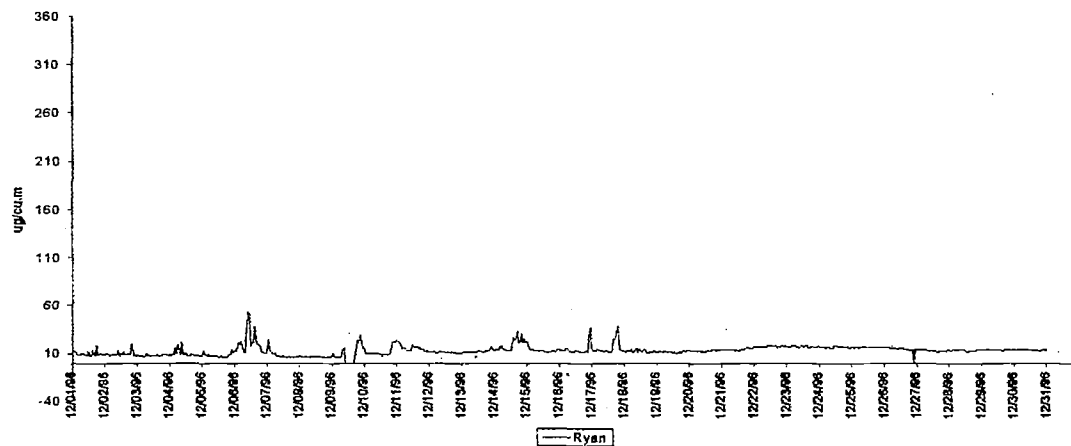
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Askeaton Investigation
October 1996



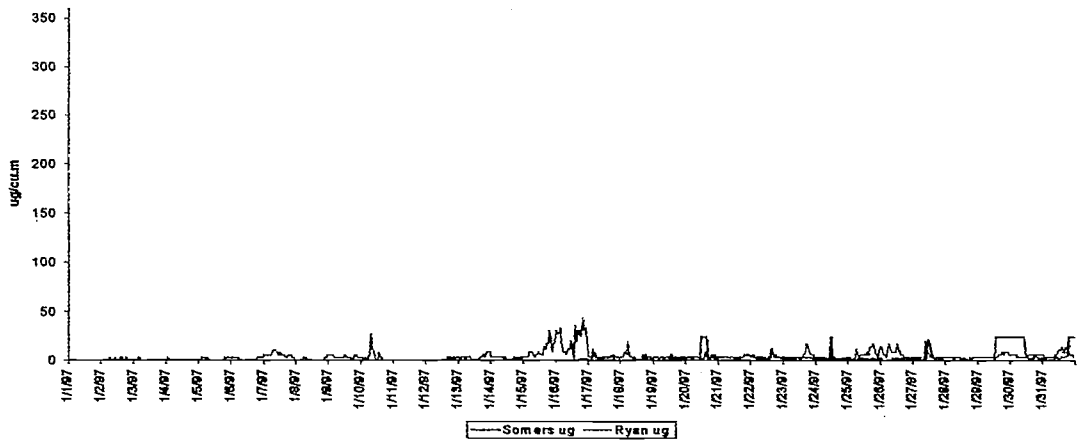
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Askeaton Investigation
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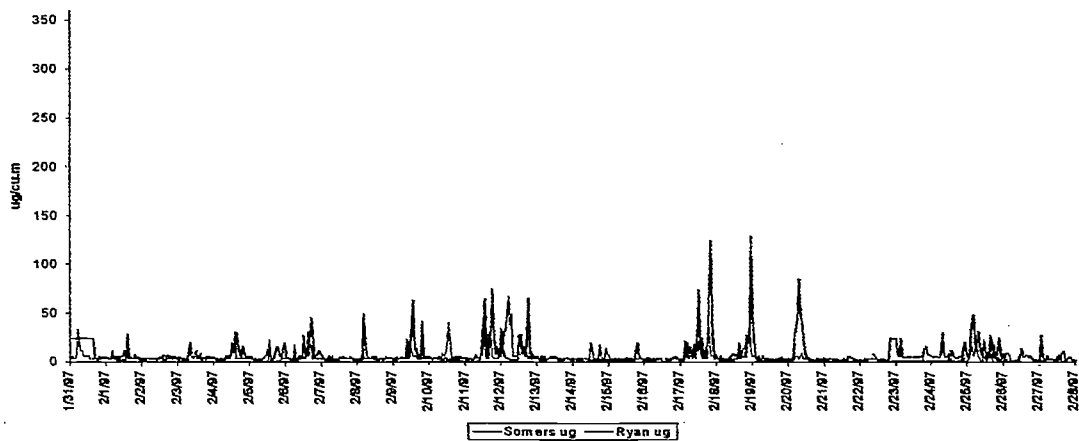
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December 1996



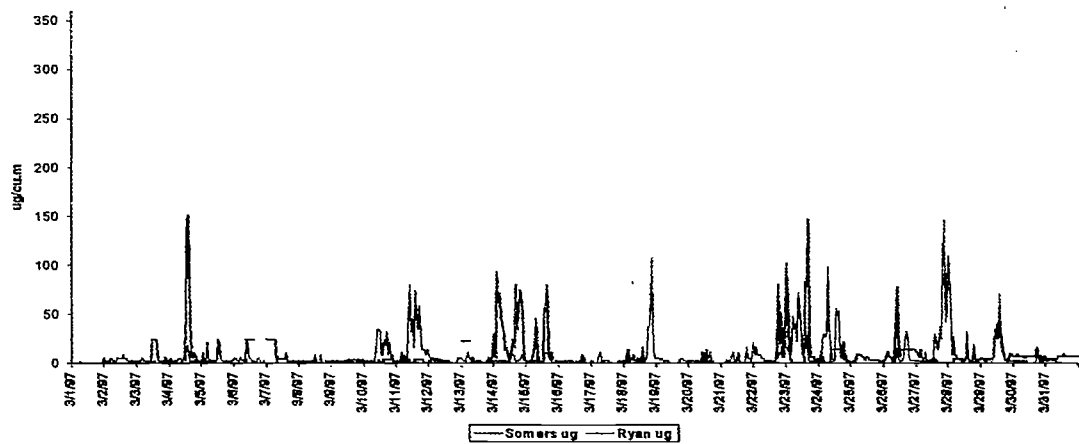
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Askeaton Investigation
January 1997**



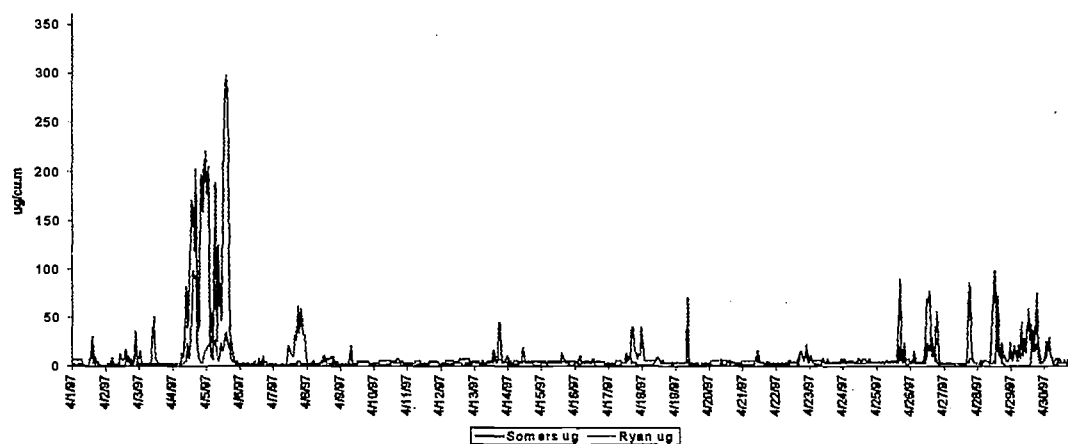
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Askeaton Investigation
February 1997**



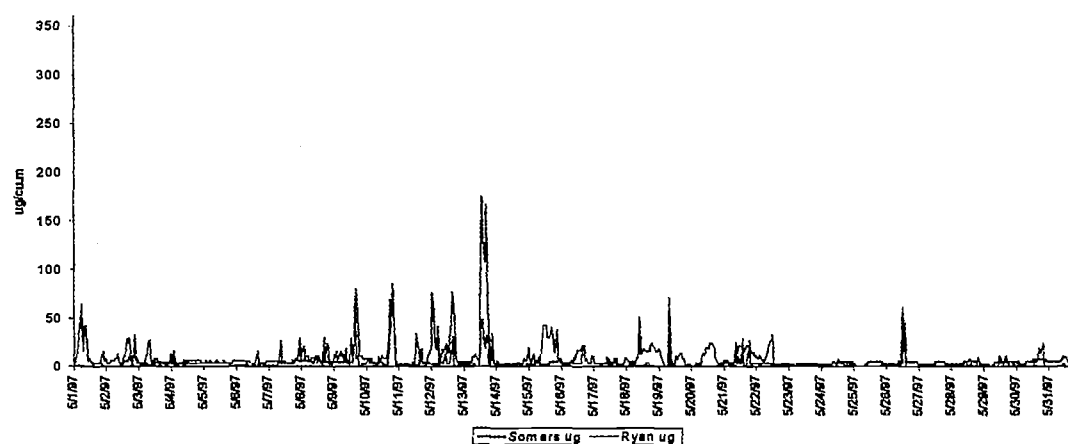
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Askeaton Investigation
March 1997**



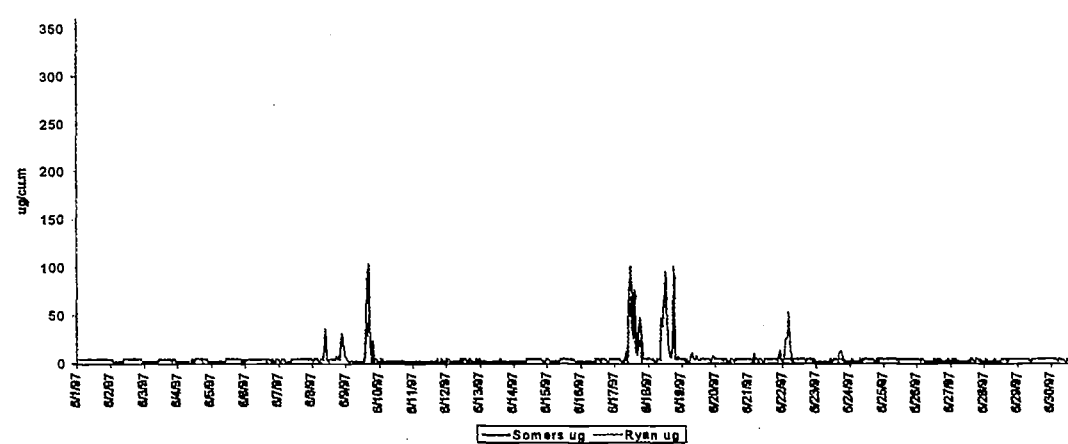
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Askeaton Investigation
April 1997**



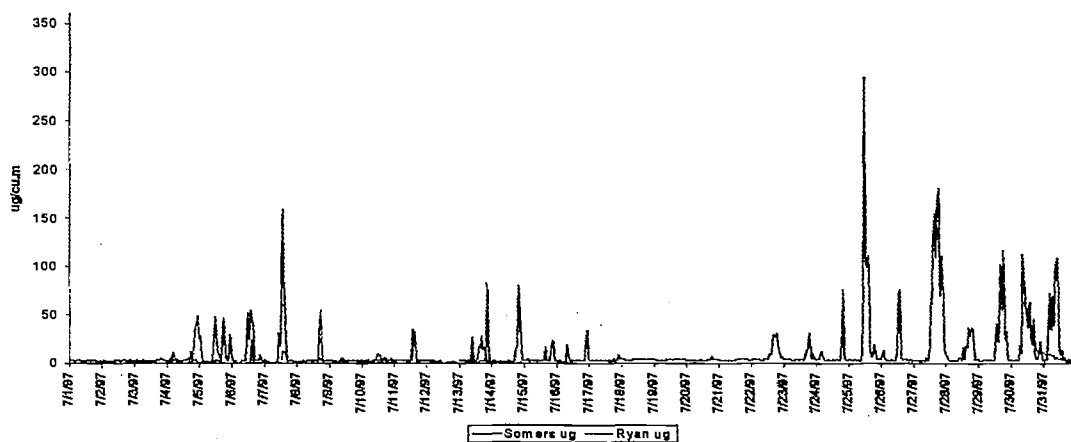
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Askeaton Investigation
May 1997**



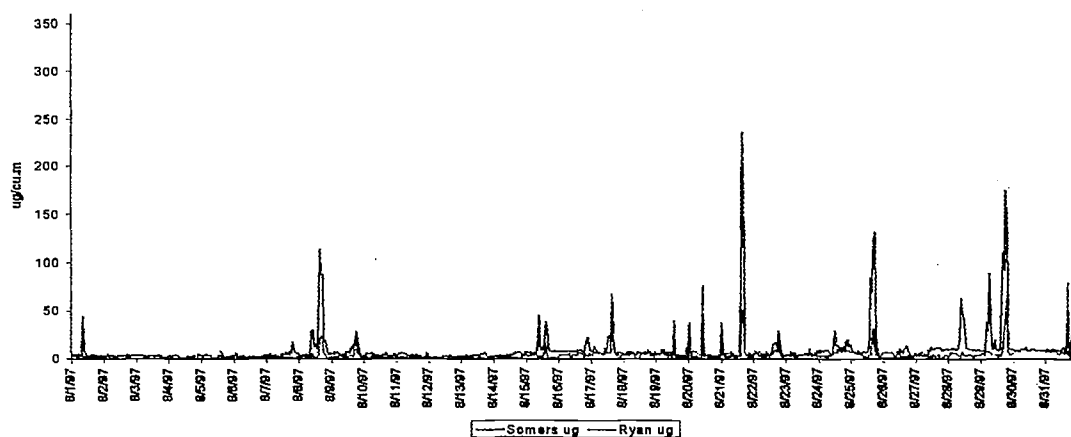
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Askeaton Investigation
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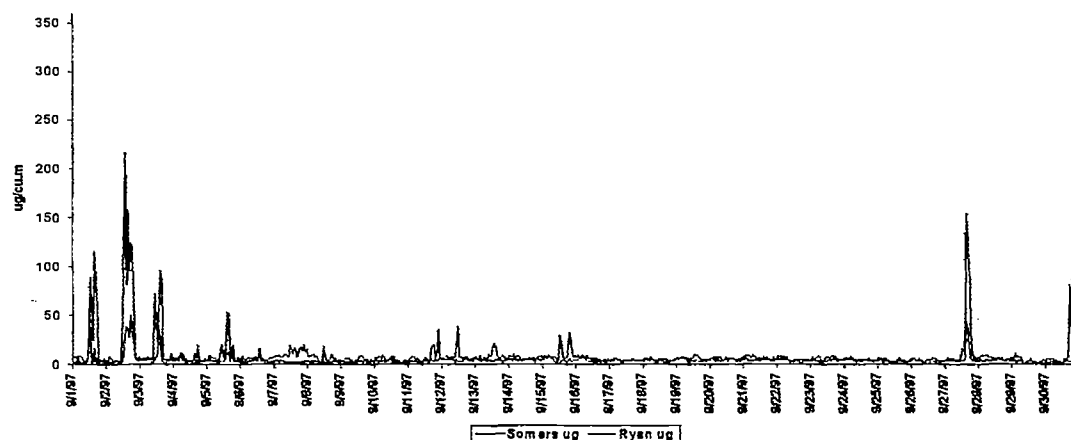
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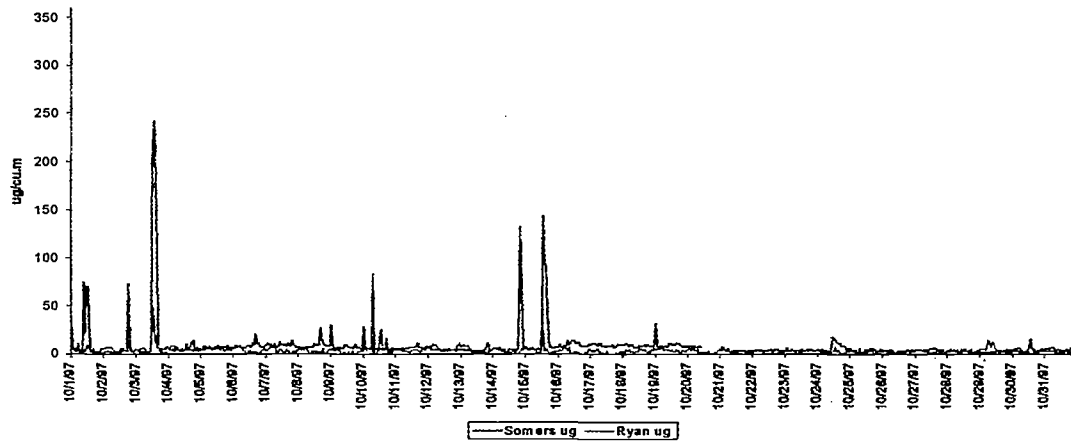
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Askeaton Investigation
August 1997



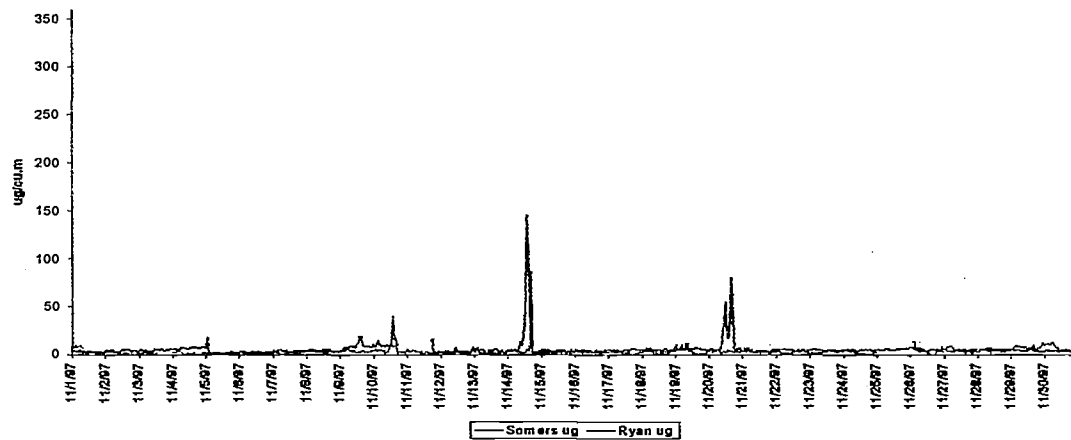
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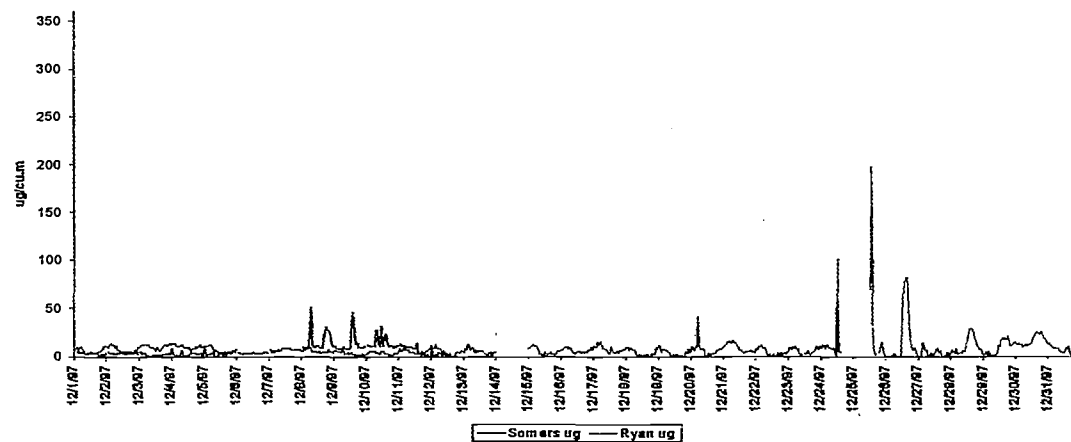
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Askeaton Investigation
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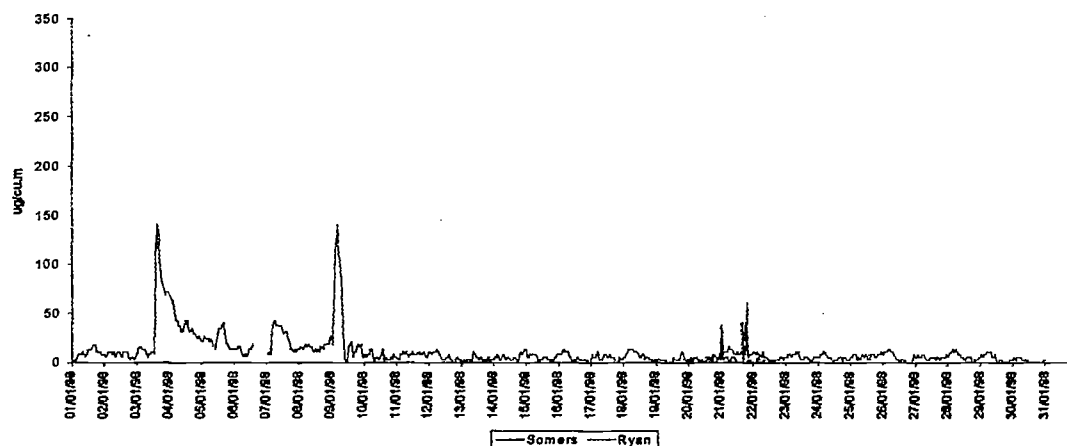
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Askeaton Investigation
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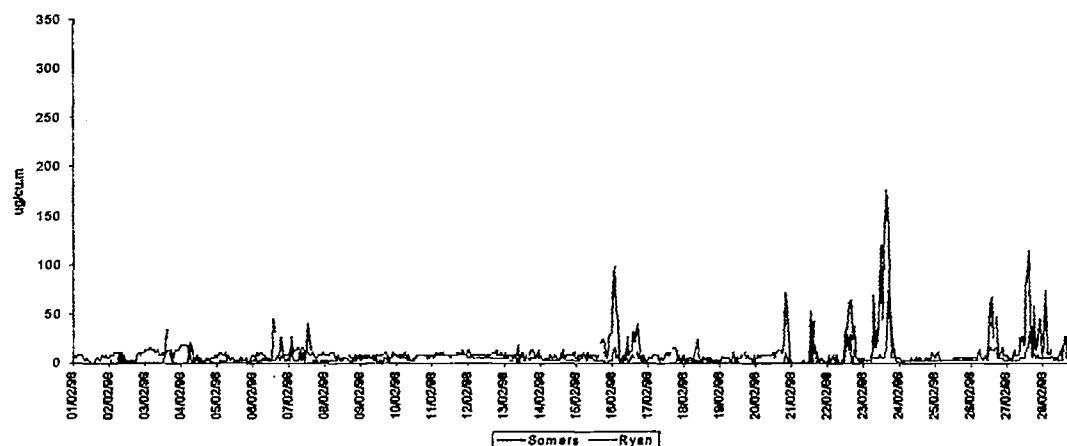
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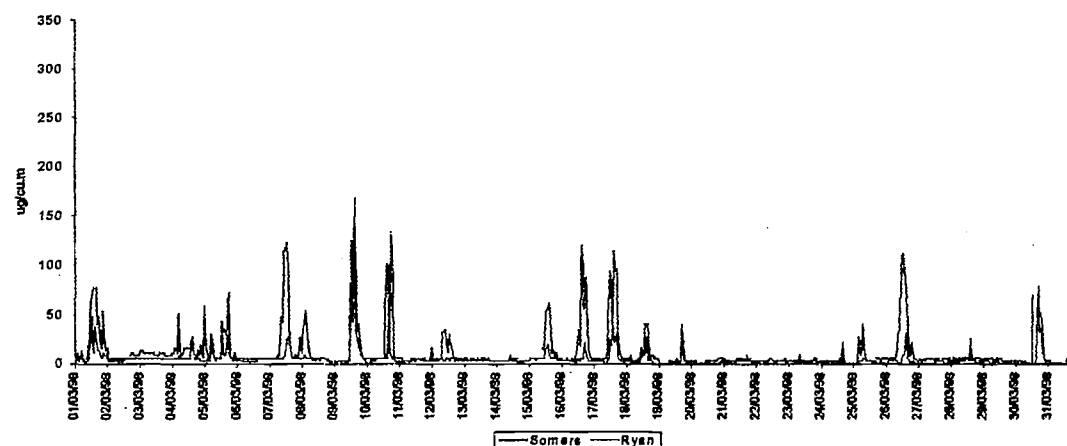
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Askeaton Investigation
January 1998



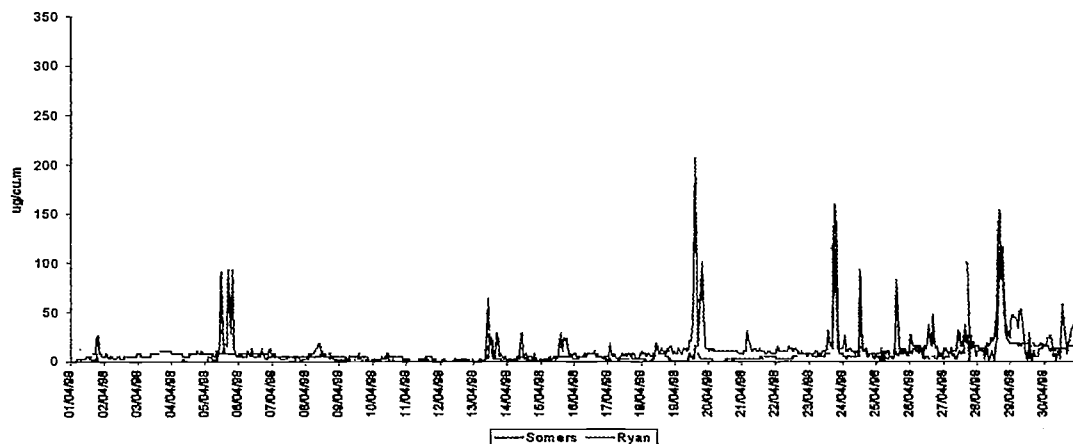
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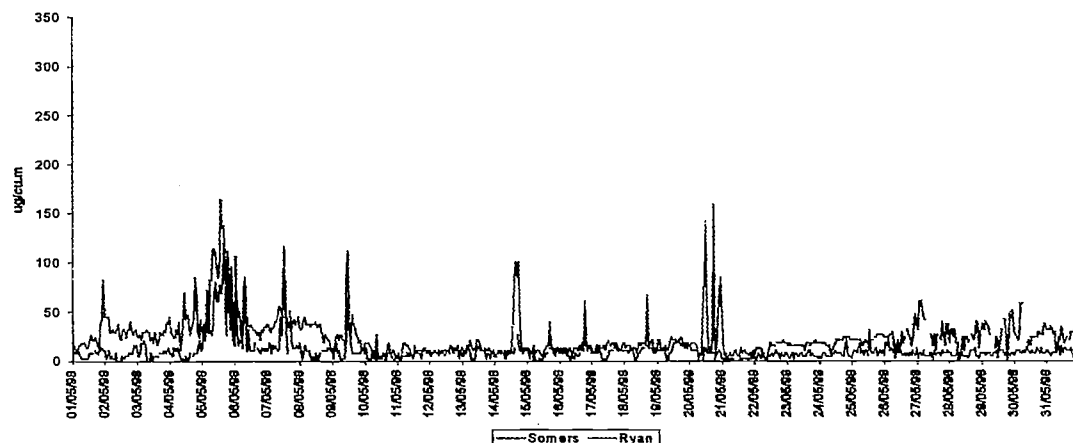
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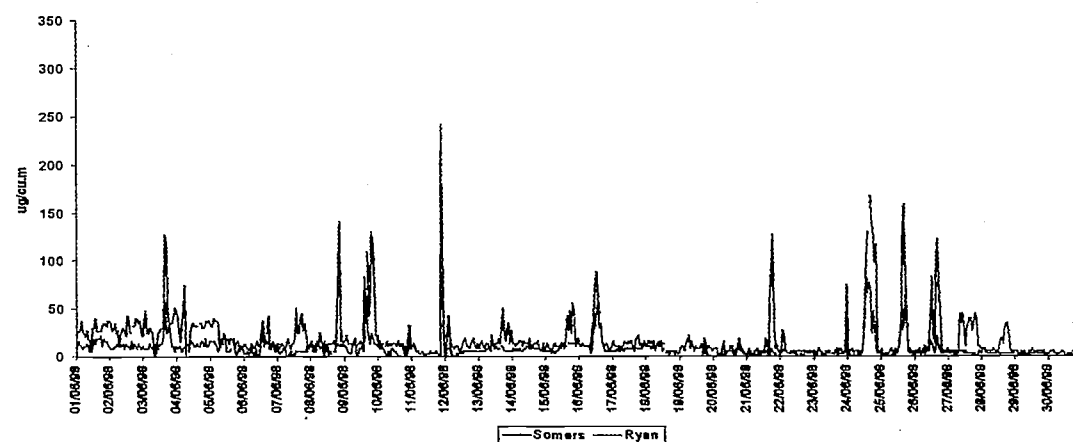
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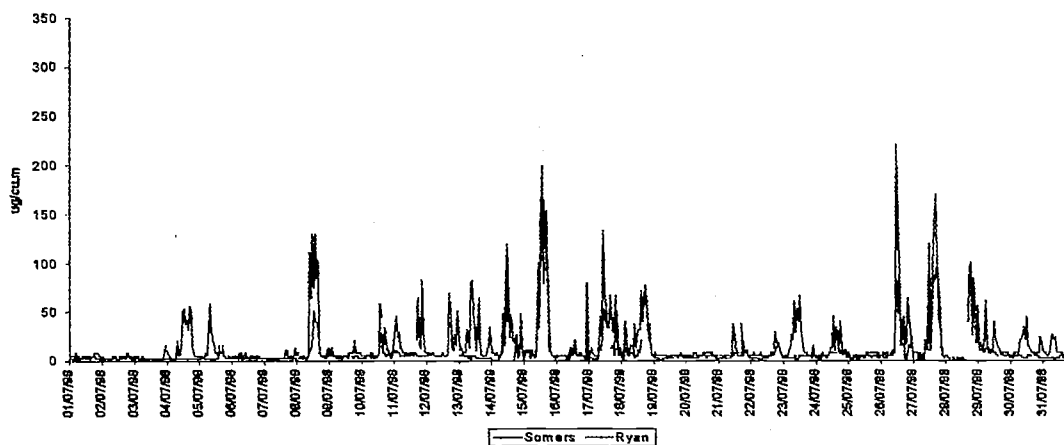
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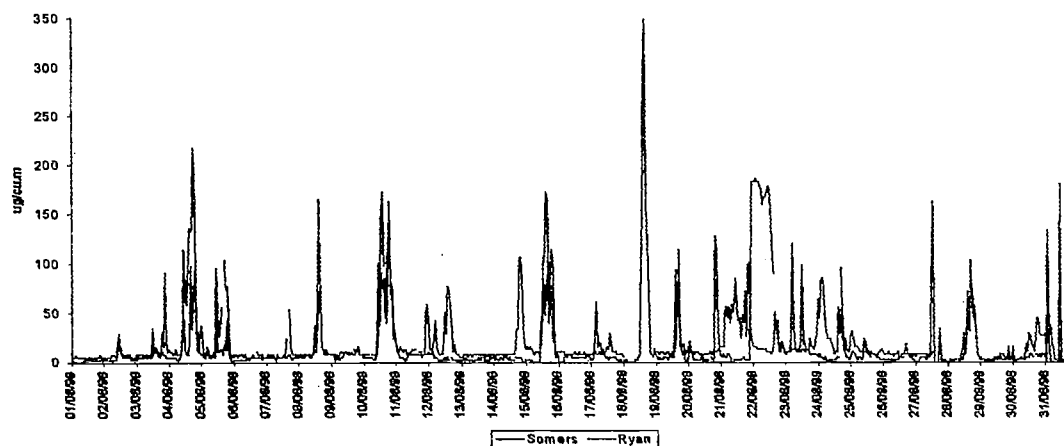
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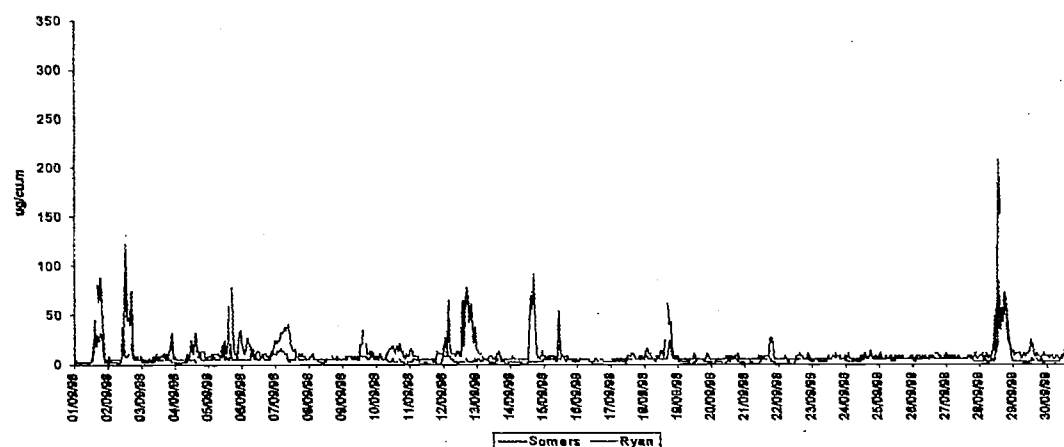
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July 1998



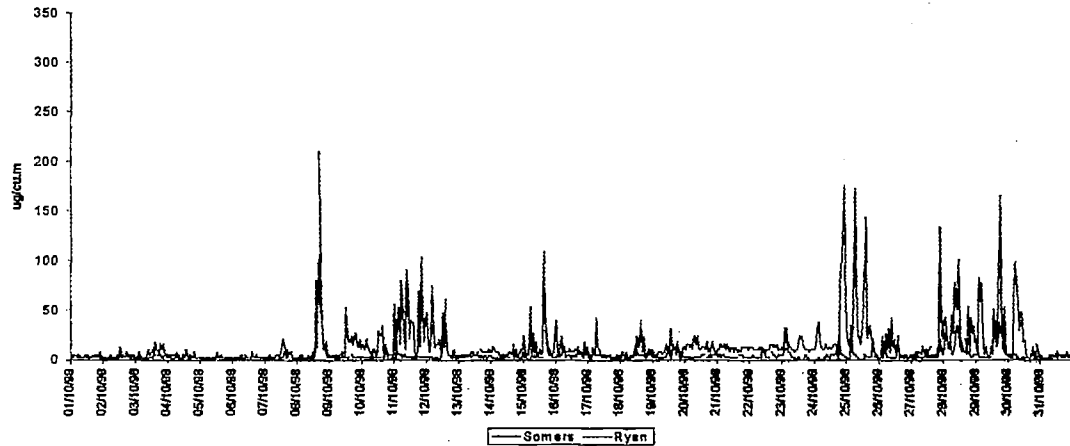
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August 1998



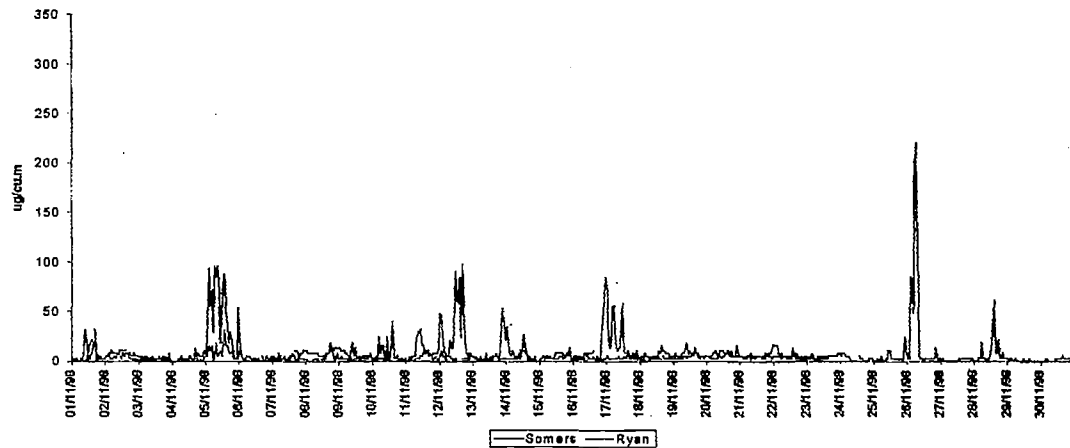
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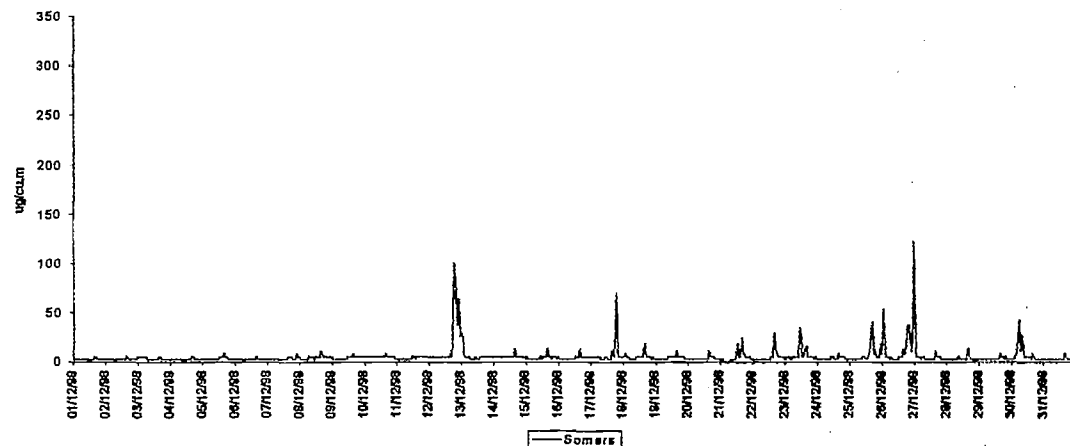
Sulphur Dioxide Hourly Averages
Askeaton Investigation
October 1998



Sulphur Dioxide Hourly Averages
Askeaton Investigation
November 1998



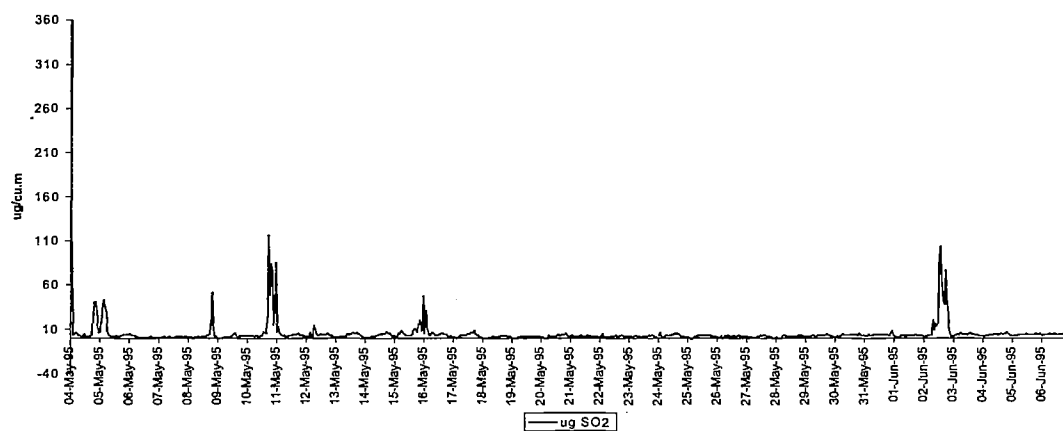
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Askeaton Investigation
December 1998



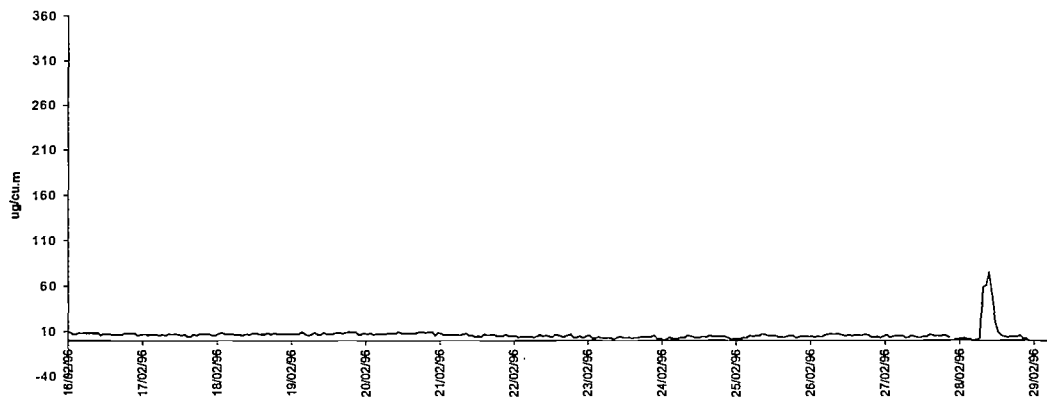
Appendix C

RECORDS OF HOURLY AVERAGE CONCENTRATIONS OF SO₂ AT BALLYLONGFORD, MAY-JUNE 1996 AND AT ABBOTSTOWN, FEBRUARY 1996 TO DECEMBER, 1997

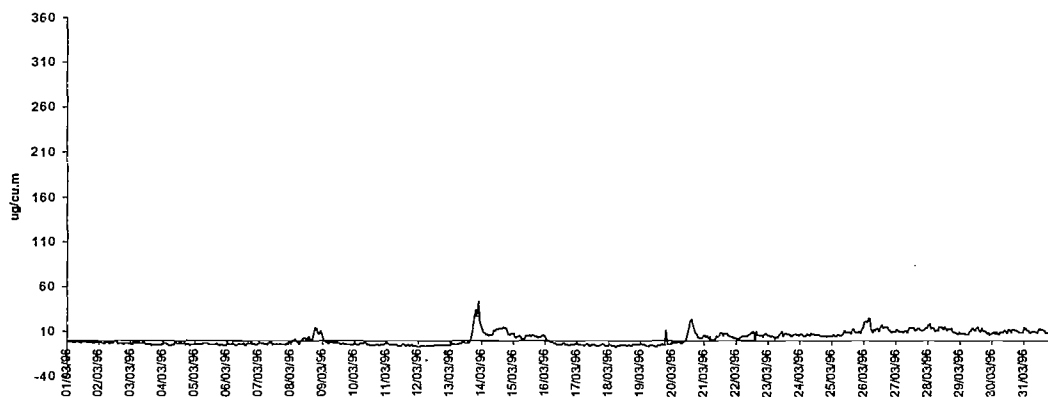
**Sulphur Dioxide Hourly Averages
Ballylongford
May-June 1995**



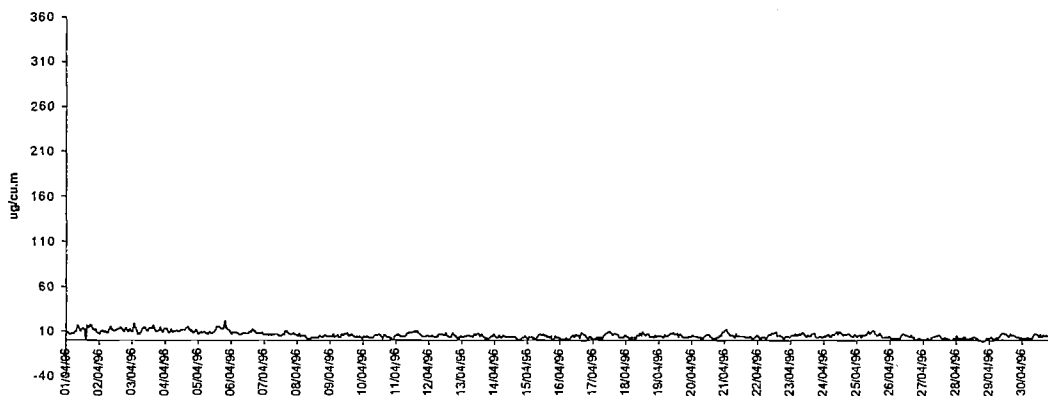
**Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown February 1996**



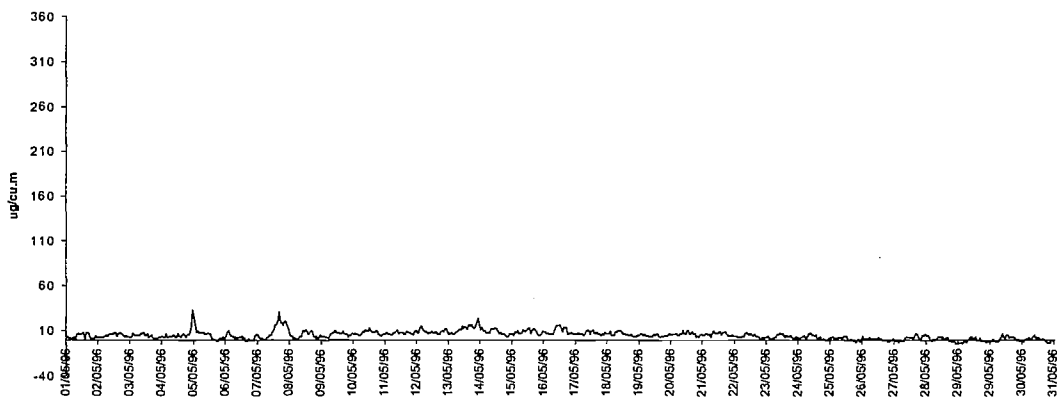
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Askeaton Investigation
Abbotstown March 1998**



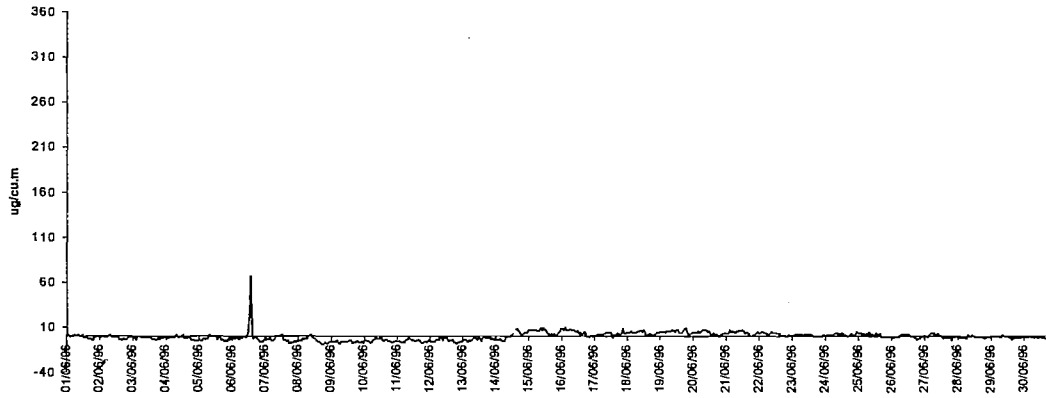
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Askeaton Investigation
Abbotstown April 1998**



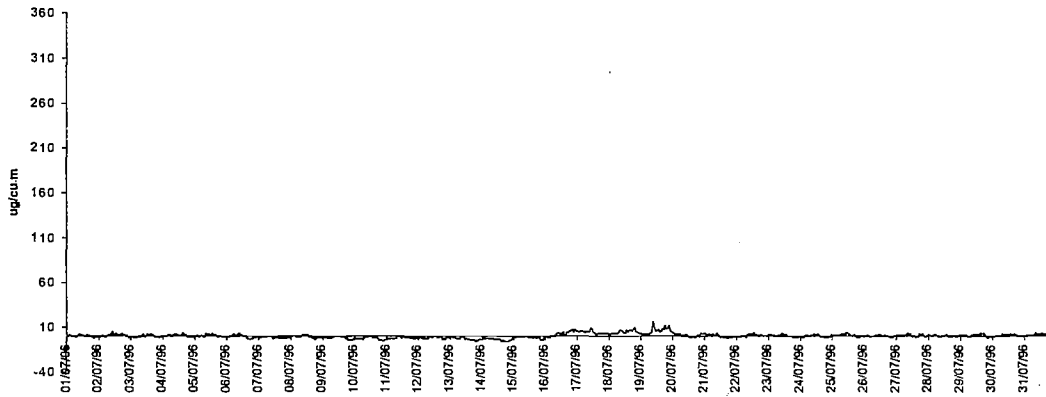
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Askeaton Investigation
Abbotstown May 1998**



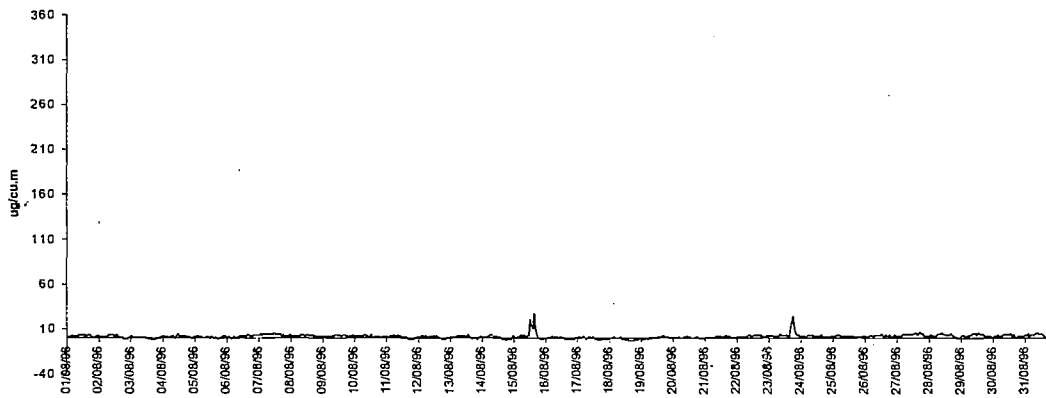
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Askeaton Investigation
Abbotstown June 1998**



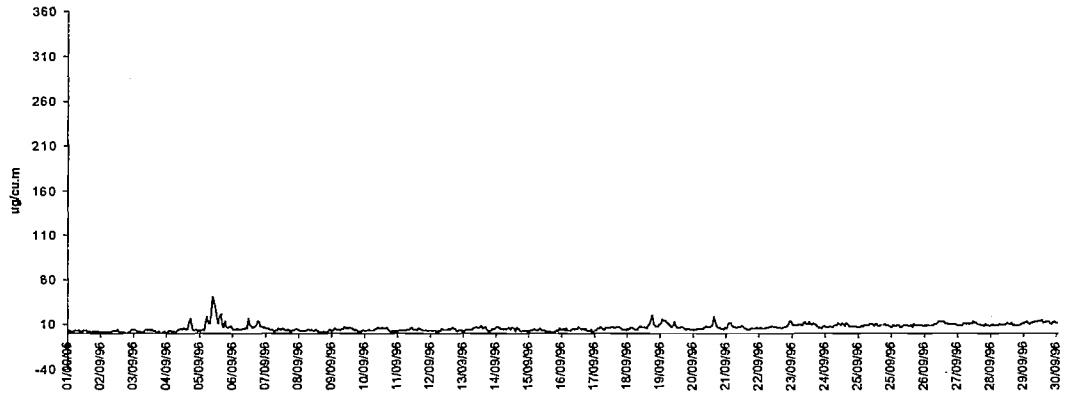
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Abbotstown July 1998**



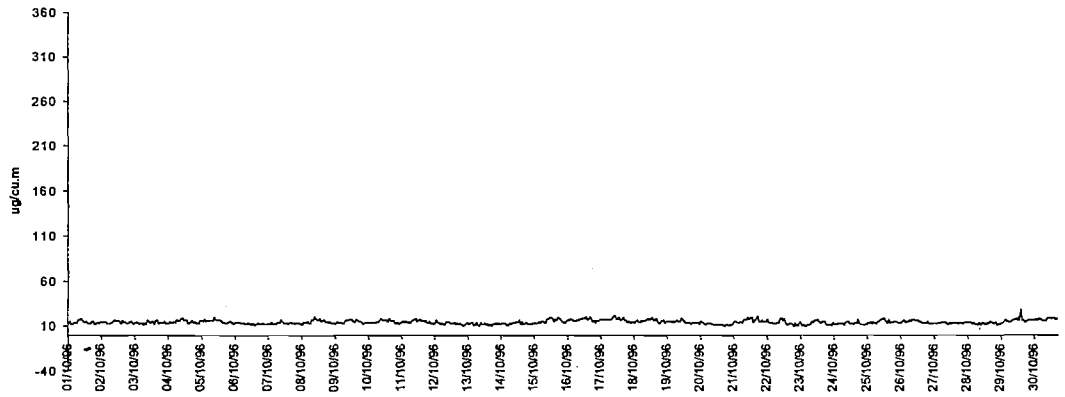
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Askeaton Investigation
Abbotstown August 1998**



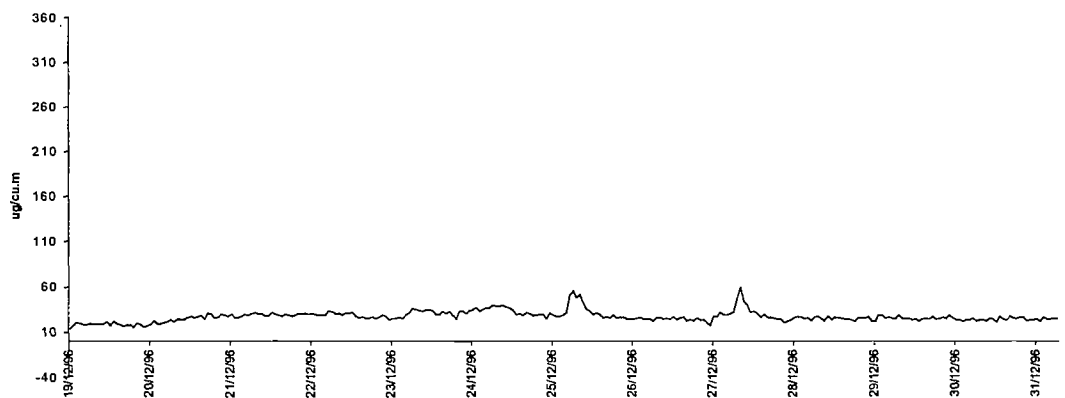
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Askeaton Investigation
Abbotstown September 1996**



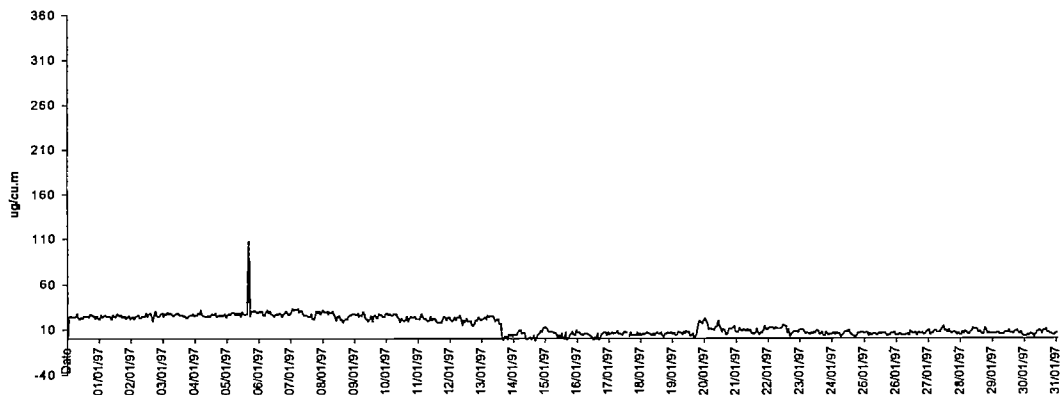
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Askeaton Investigation
Abbotstown October 1996**



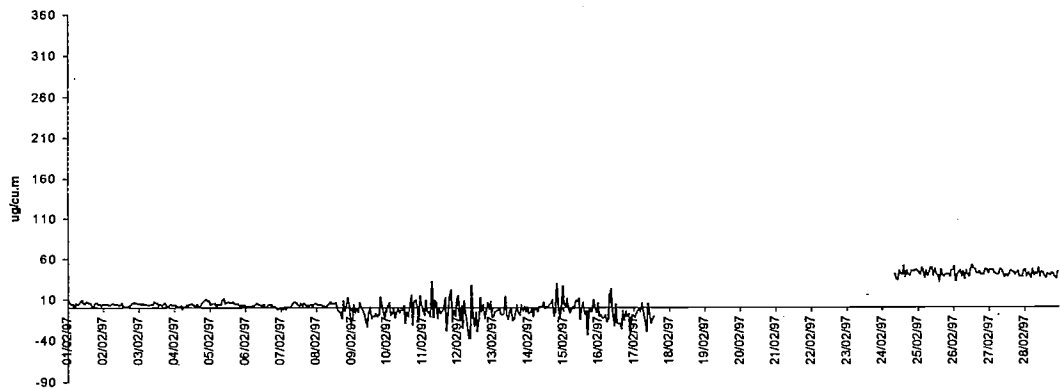
**Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown December 1996**



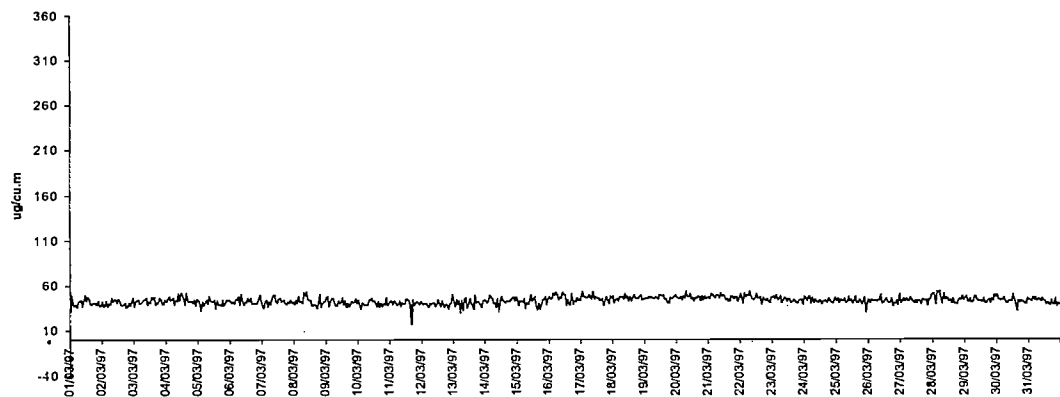
Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown January 1997



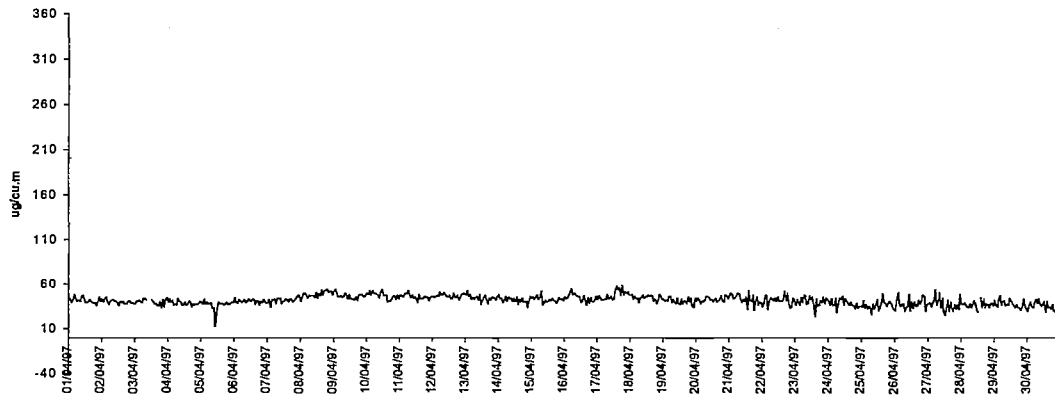
Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown February 1997



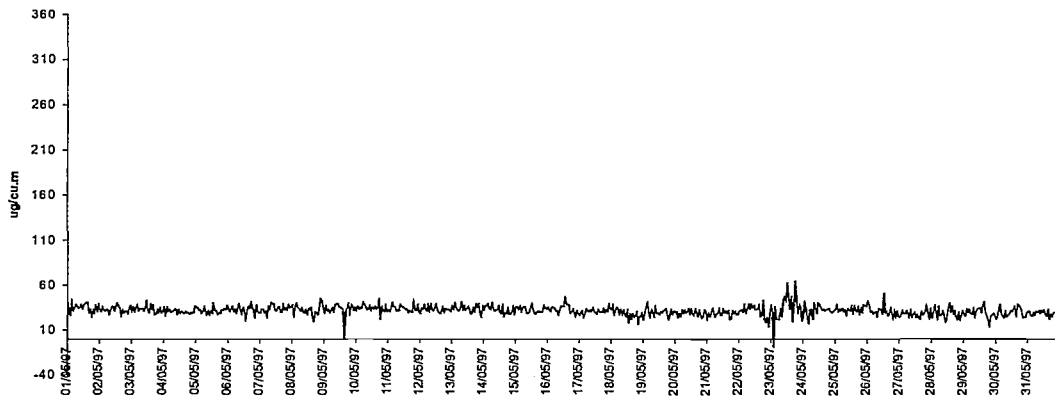
Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown March 1997



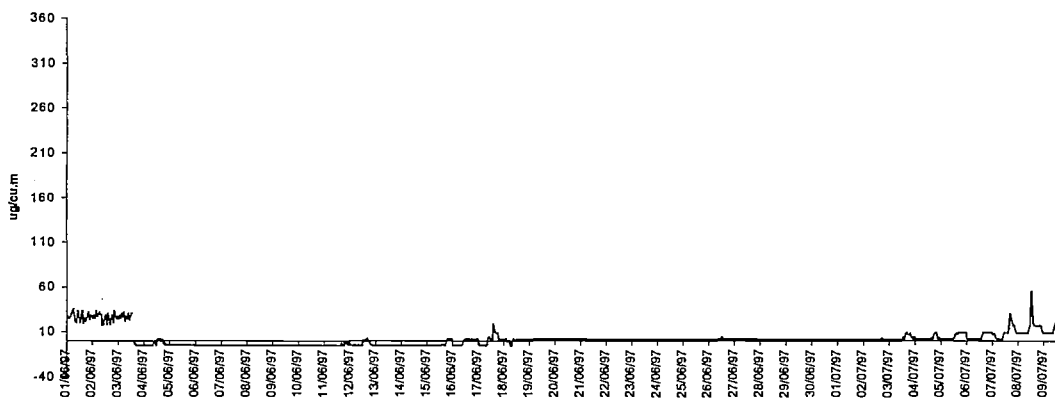
**Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown April 1997**



**Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown May 1997**



**Sulphur Dioxide Hourly Averages
Askeaton Investigation
Abbotstown June-July 1997**



Appendix D

**PM₁₀ MEASUREMENTS IN THE VICINITY OF
ASKEATON, CO. LIMERICK
17 FEBRUARY – 30 APRIL, 1998**

(Commissioned Survey)

**PM₁₀ MEASUREMENTS IN THE VICINITY OF
ASKEATON, CO. LIMERICK**

17 FEBRUARY - 30 APRIL 1998

FINAL REPORT

PROJECT LEADER

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Authors

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Executive Summary

Continuous PM₁₀ mass concentration measurements have been carried out in the vicinity of Askeaton, Co. Limerick between February 17th and April 30th 1998. The main findings from the PM₁₀ measurement campaign are as follows:

- The overall PM₁₀ mass concentration for the site in the vicinity of Askeaton is moderately low with an overall average PM₁₀ value of 11.4 µg m⁻³. These levels are comparable with background levels obtained at the Mace Head field research station.
- The distribution of PM₁₀ levels was generally independent of wind direction and wind speed.
- An analysis of PM₁₀ levels for the wind sector 270-290 degrees which encompasses the direction of the Aughinish Alumina plant with respect to the measurement site generally shows no significant elevation of PM₁₀ levels for that direction range.

PM₁₀ measurements in the vicinity of Askeaton, Co. Limerick

17 February - 30 April 1998

1 Introduction

This Interim Report gives details of PM₁₀ measurements carried out in the vicinity of Askeaton, Co. Limerick between February 17th and April 30th 1998. The PM₁₀ measurements were performed using a Tapered Element Oscillating Microbalance (TEOM), which is a continuous aerosol particulate sampler capable of yielding PM₁₀ mass concentrations, unattended for extended periods. The site where the measurements were recorded is the existing Environmental Protection Agency site on Ryan's Farm. A local ordnance survey map outlining the main features of the local area and the location of the sampling site is shown in Appendix I. Following the measurement period in Askeaton, the TEOM sampler was located at the coastal background site at Mace Head, Carna, Co. Galway, where unpolluted background PM₁₀ concentrations were measured. These values were compared with concentration levels recorded at Askeaton. The PM₁₀ concentrations at Askeaton were analysed with respect to wind direction and speed. The meteorological data used in this study was collected at Shannon Airport and was supplied by Met Eireann through the Environmental Protection Agency. Some PM_{2.5} mass concentration measurements were also taken during the measurement period.

2 TEOM PM₁₀ sampling monitor

A Tapered Element Oscillating Microbalance (TEOM) was used to determine the PM₁₀ mass concentrations. The TEOM air sampler has been given US EPA reference equivalent status for the measurement of PM₁₀ mass concentrations. The TEOM air sampler is capable of yielding continuous hourly average PM₁₀ mass concentrations, unattended. The TEOM consists of a filter cartridge attached to a hollow tapered crystal element. The element is clamped at one end and free to move at the other end. The sample air stream is drawn through the filter and then through the element. The crystal element vibrates at its natural frequency and this vibration is detected by electronic circuitry. The TEOM calculates the mass

concentration every 2 seconds and these values are used to produce a 30 minute, 1-hour, 8-hour and 24 hour average. The stated lower detection limit of the analyser is about $5\mu\text{g m}^{-3}$. Air is drawn through the standard PM_{10} inlet at a rate of 16.7 lpm. The air flow is then split into two streams: a reference bypass flow of 13.7 lpm and a sample flow 3 lpm which passes through a 16mm diameter filter connected to the top of a hollow tapered element. As the particles collect on the filter, the tube's natural frequency of vibration decreases. The change in frequency is indirectly proportional to the particulate mass collected on the filter head. Average PM_{10} mass concentration (hourly or half-hourly) based on the change in vibrational frequency of the hollow element is calculated. The inlet temperature including the sensing element is usually maintained at 50°C but it was set to 30°C during this study to minimize losses from the more volatile organic compounds.

3 Analysis of PM_{10} data

3.1 Hourly PM_{10} measurements

Continuous PM_{10} measurements were recorded at the Askeaton site from February 17th to April 30th 1998. During this period a total of 1731 hourly measurements were recorded. Figure 1 shows the hourly PM_{10} mass concentration data recorded during this period. Wind direction and wind speed measurements were also recorded during this period. Figure 2 shows the hourly PM_{10} measurements as a function of wind direction for the total period. It is seen that PM_{10} levels are fairly evenly distributed with respect to wind direction. Table 1 presents a statistical analysis of the hourly wind data with respect to wind direction. The wind direction was divided into 4 sectors, 0-80, 90-170, 180-260 and 270-360 degrees. The number of PM_{10} measurements for the different wind sector intervals is also presented in Table 1. Results for the wind direction of 270-290° is also included in Table 1 which covers the direction of the wind from the Aughinish Alumina plant to the monitoring site. The percentage of PM_{10} measurements for each of the wind sectors is presented in Table 2. It can be noted that the percentage of occurrences of the wind sector 270-290 degrees is only about 11% for the whole measurement period.

Table 1 Analysis of Askeaton PM₁₀ hourly data and wind direction

Statistical Analysis	Wind Direction (Degrees)					
	Total 0-360	0-80	90-170	180- 260	270- 360	270- 290
Number of hourly measurements	1731	113	403	602	613	196
Average PM ₁₀ concentration $\mu\text{g m}^{-3}$	11.8	12.2	12.8	11.9	11.1	11.2
No of measurements $>10\mu\text{g m}^{-3}$	850	58	208	304	280	91
No of measurements $>20\mu\text{g m}^{-3}$	235	15	74	82	64	26
No of measurements $>30\mu\text{g m}^{-3}$	66	5	13	29	19	10
No of measurements $>40\mu\text{g m}^{-3}$	12	2	8	2	0	0
No of measurements $>50\mu\text{g m}^{-3}$	3	1	2	0	0	0
No of measurements $>60\mu\text{g m}^{-3}$	2	1	1	0	0	0
No of measurements $>70\mu\text{g m}^{-3}$	0	0	0	0	0	0

Table 2 PM₁₀ hourly percentage statistical analysis

Statistical Analysis	Wind Direction (Degrees)					
	Total 0-360	0-80	90-170	180- 260	270- 360	270- 290
Number of hourly measurements	1731	113	403	602	613	196
Average PM ₁₀ concentration $\mu\text{g m}^{-3}$	11.8	12.2	12.8	11.9	11.1	11.2
% of measurements $>10\mu\text{g m}^{-3}$	49	51	52	50	46	46
% of measurements $>20\mu\text{g m}^{-3}$	14	13	18	14	10	13
% of measurements $>30\mu\text{g m}^{-3}$	4	4	3	5	3	5
% of measurements $>40\mu\text{g m}^{-3}$	1	2	2	0	0	0
% of measurements $>50\mu\text{g m}^{-3}$	0	1	0	0	0	0
% of measurements $>60\mu\text{g m}^{-3}$	0	1	0	0	0	0
% of measurements $>70\mu\text{g m}^{-3}$	0	0	0	0	0	0

3.2 Diurnal variation of PM₁₀ measurements

In addition to the averaged 1-hourly PM₁₀ mass concentrations obtained from the TEOM, averaged 1/2-hourly measurements are also obtained. These measurements are very useful in observing short term trends in PM₁₀ levels and also for observing diurnal variations at the site. The 1/2-hourly measurement capability of the TEOM permitted a study of the diurnal variation of the PM₁₀ mass concentration to be made. The PM₁₀ diurnal variation for 3 different wind sectors is shown in Figure 3. The following wind sectors of 60 - 120°, 240 - 300° and 270 - 290° were chosen to broadly represent air masses coming mainly from an easterly direction, a westerly direction, and from the Aughinish Alumina plant direction. There is no apparent marked diurnal variation in PM₁₀ levels for the easterly sector. The most elevated PM₁₀ levels over the whole measurement period occurred for the predominately westerly air mass of March 15th, 1998 as shown in Figure 3, with a daily average mass concentration of 36.7 µgm⁻³. The wind direction varied from approximately 230 to 280° on this day. It is possible that the Moneypoint power station is a source of these elevated levels for the wind sector 250-270°. The prevailing wind direction was in the range 270-290° for April 5, 1998, which lies in the direction of the Aughinish Alumina plant with respect to the measurement site. There is no marked elevation in PM₁₀ levels for that day with the exception of one peak value at 17:00, which is regarded as not being significant.

The diurnal variation in the 1/2-hourly PM₁₀ measurements averaged over all of the measuring period at the Askeaton site is presented in Figure 4. The particulate levels remain within a narrow band, between about 9 and 15 µg m⁻³, throughout the 24 hour period. The averaged diurnal variation in PM₁₀ measured at the coastal background site at Mace Head, Carna, Co. Galway during westerly wind conditions between the 06 and 10 of May 1998 is also shown in Figure 4. The higher than expected background PM₁₀ levels at the Mace Head site are associated with enhanced aerosol particulate production because of the occurrence of high wind speeds, over the range 7 to 13 ms⁻¹, on May 6th and 7th of the period.

3.3 Daily PM₁₀ mass concentration averages at the Askeaton site

The TEOM sampler also recorded the 24-hour PM₁₀ mass concentrations. These averaged levels for the period 18 February to 30 April 1998 are presented in Figure 5 and in Appendix

II. The highest daily average recorded was $36.7 \mu\text{g m}^{-3}$ on the 15th of March. The average daily concentration for the overall period was $11.4 \mu\text{g m}^{-3}$.

3.4 PM_{10} mass concentrations for the 270-290° wind sector

PM_{10} mass concentration levels were analysed for the 270-290 degree wind sector since it encompassed the direction of the Aughinish Alumina plant with respect to the measurement site. In general, no apparent significant increase in PM_{10} levels associated with the 270-290° sector was found.

3.5 The effect of wind speed on PM_{10} mass concentrations

Previous work has shown that enhanced marine aerosol particle production can occur for wind speeds in excess of about 4 m s^{-1} (~ 10 knots). This is due to mechanical wave disruption at the sea-air interface, which gives rise to the entrainment of air bubbles by the waves. The subsequent bursting of the bubbles forming jet droplets and film droplets causes an increase in marine aerosol levels. The relation between PM_{10} mass concentration levels and wind speed was investigated in order to see if marine air contributed to increases in the PM_{10} mass concentrations.

Only a weak correlation ($R^2 = 0.0086$) was found between PM_{10} mass concentrations and wind speed for the primarily marine sector direction of 180 -260° as shown in Figure 6. This suggests that wind related processes do not appear to play a major role in the enhancement of PM_{10} levels.

However, wind related enhancement of PM_{10} levels was found on a number of occasions during the measurement campaign. The rise in PM_{10} levels between about 14:00 and 18:00 on March 15th 1998 seems to covary with an increase in wind speed, as shown in Figure 7 which is evidence for enhanced PM_{10} production due to marine wind related processes. The prevailing wind direction (from about 230-280°) was from the ocean.

Similarly, only a weak correlation ($R^2 = 0.03$) was found for the 270-290 degree sector (coinciding with the Aughinish Plant direction with respect to the measurement site) between PM_{10} levels and wind speed as seen in Figure 8, again suggesting that PM_{10} values were not unduly influenced by marine related processes.

3.6 PM_{2.5} measurements

During the measurement period at the Askeaton site the PM₁₀ sampling head was replaced with a PM_{2.5} sampling head. This occurred on April 7th between 07:30 and 19:30 and again on April 19th at 18:00 until April 21st at 10:30. The PM_{2.5} data obtained on April 19-21 is presented in Figure 9. Also shown are the PM₁₀ values on the days before and after the changeover. It is difficult to intercompare PM₁₀ levels for the 2 size cuts with one sampler.

4 Overall conclusions

- The overall PM₁₀ for the site in the vicinity of Askeaton is moderately low with an overall average PM₁₀ value of 11.4 $\mu\text{g m}^{-3}$. These levels are comparable with background levels obtained at the Mace Head field research station.
- The distribution of PM₁₀ levels was generally independent of wind direction.
- An analysis of PM₁₀ levels for the wind sector 270-290 degrees which encompasses the direction of the Aughinish Alumina plant with respect to the measurement site generally shows no significant elevation of PM₁₀ levels for that direction range.
- Overall, PM₁₀ levels for the measurement period were not significantly affected by marine wind related processes.
- The averaged diurnal variation showed a steep rise in PM₁₀ levels occurring for the period from about 08:00 - 10:30, which is attributable to anthropogenic emissions.

TEOM PM₁₀ (µg m⁻³) hourly data , near Askeaton, Co. Limerick, 17 February to 30 April 1998

Figure 1

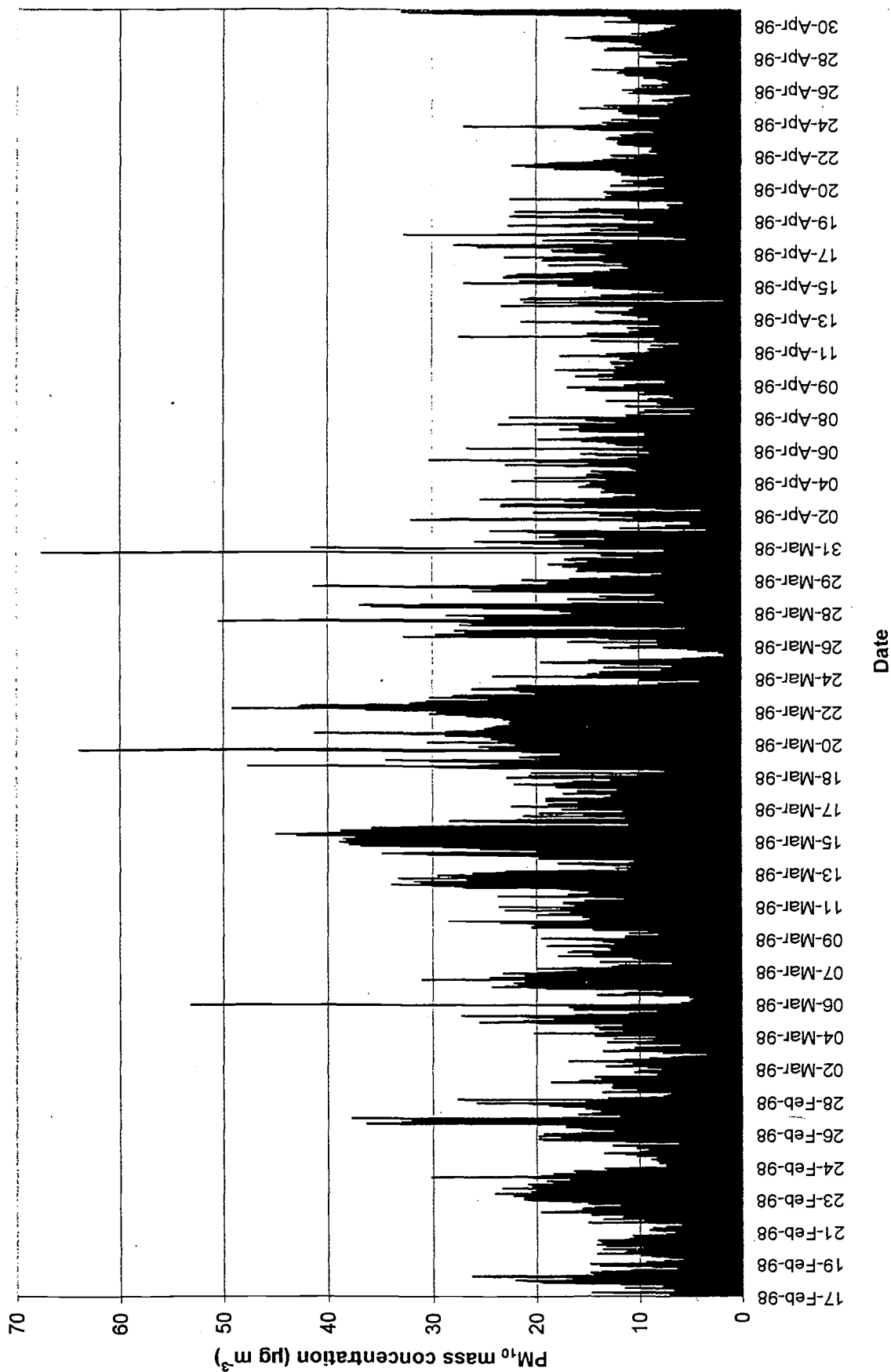


Figure 2 PM_{10} mass concentration levels over the range $0\text{--}50\ \mu\text{g m}^{-3}$, as a function of wind direction for the total measurement period (17 February - 30 April, 1998)

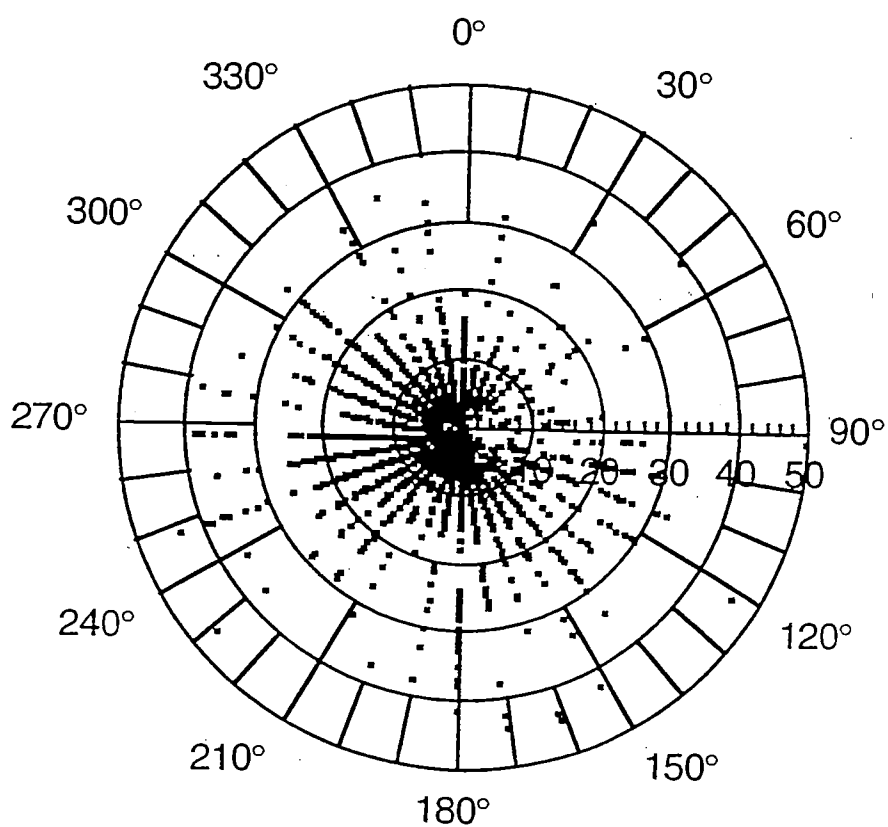


Figure 3

Diurnal variation of the PM_{10} mass concentration levels at the Askeaton site for three different wind directions

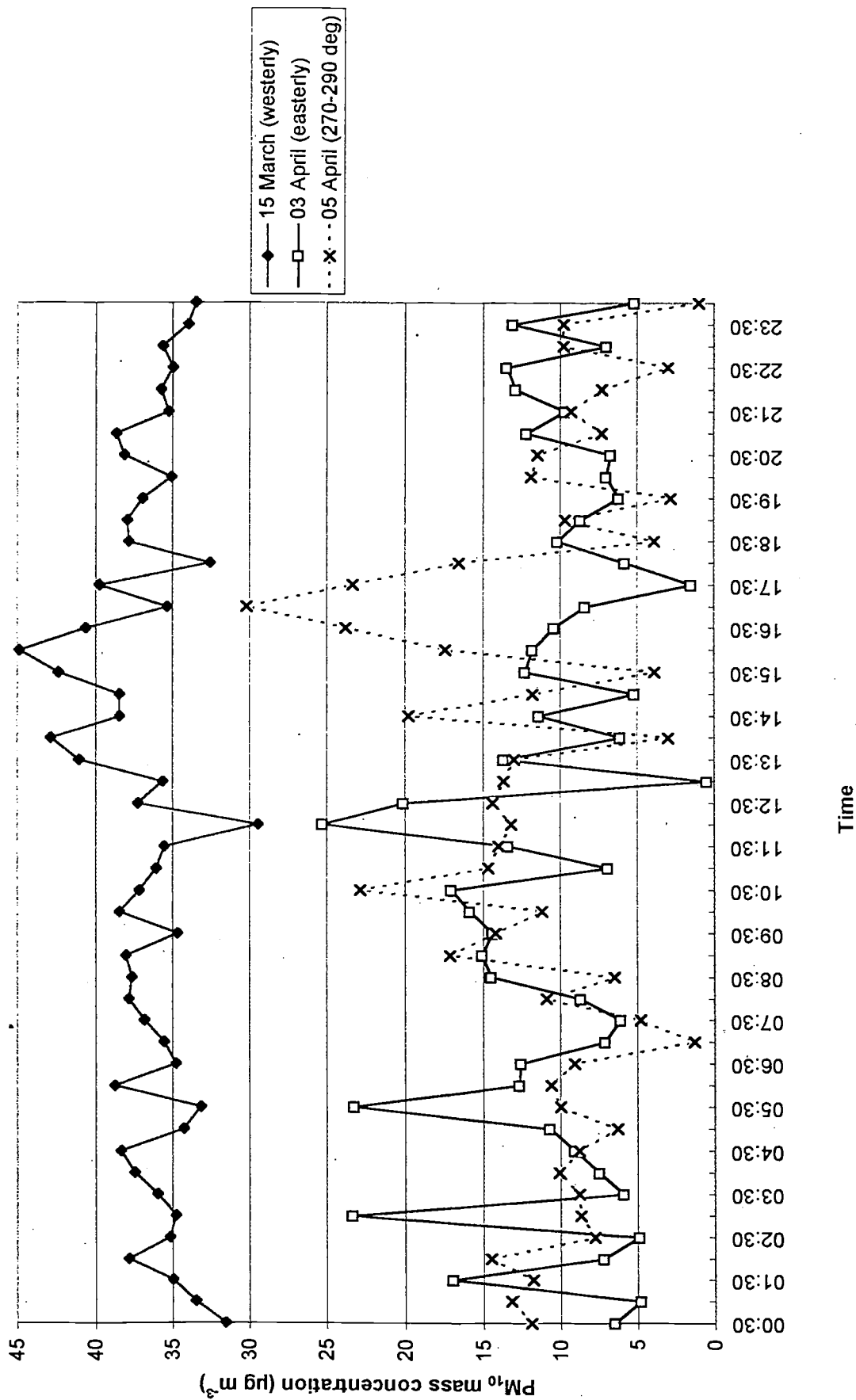


Figure 4 Diurnal variation of the averaged 1/2-hourly PM_{10} mass concentration levels at Askeaton (17 February to 30 April, 1998) and Mace Head (5-10 May, 1998)

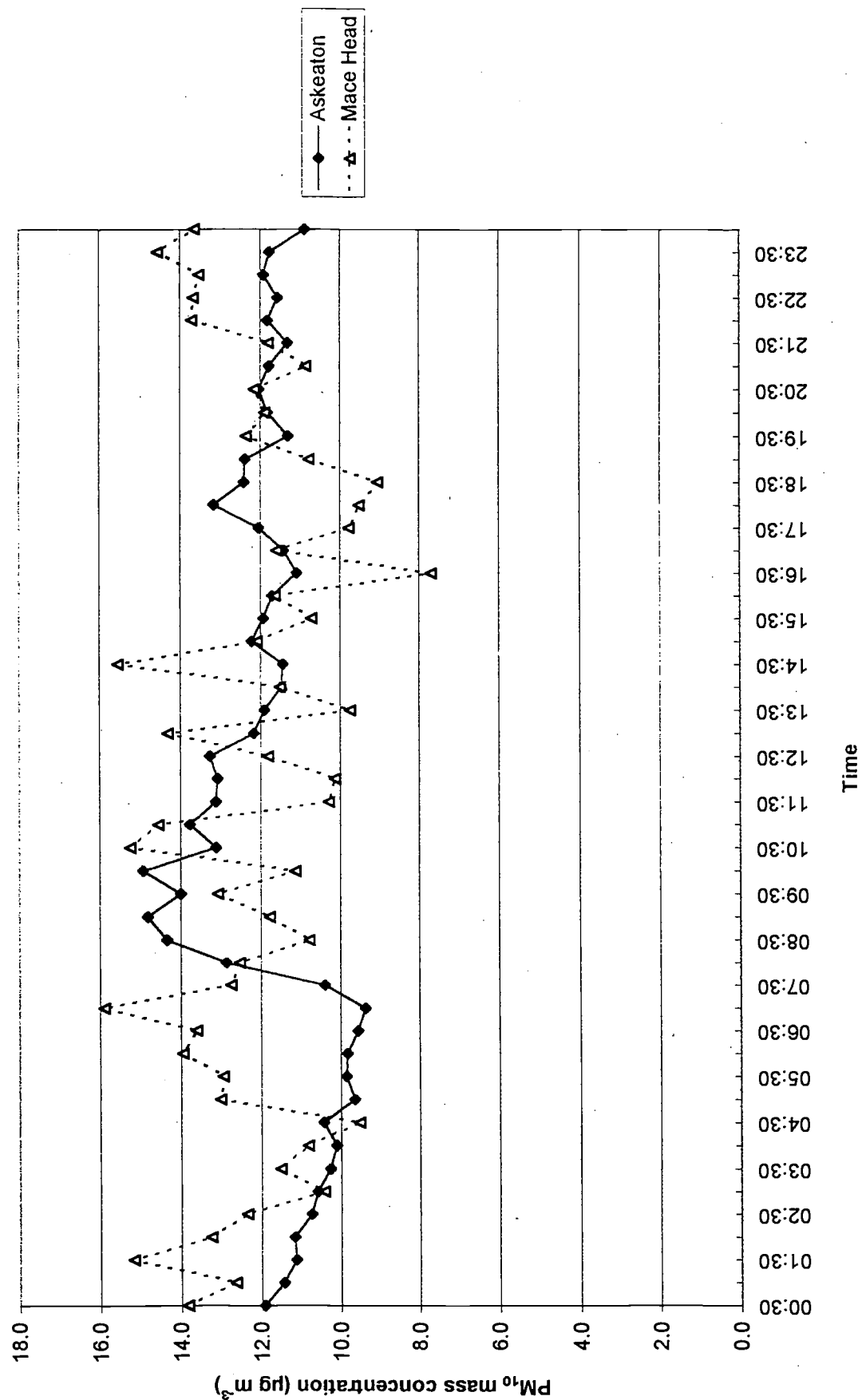


Figure 5 Daily averaged PM₁₀ mass concentrations (µg m⁻³) 18 February - 30 April 1998

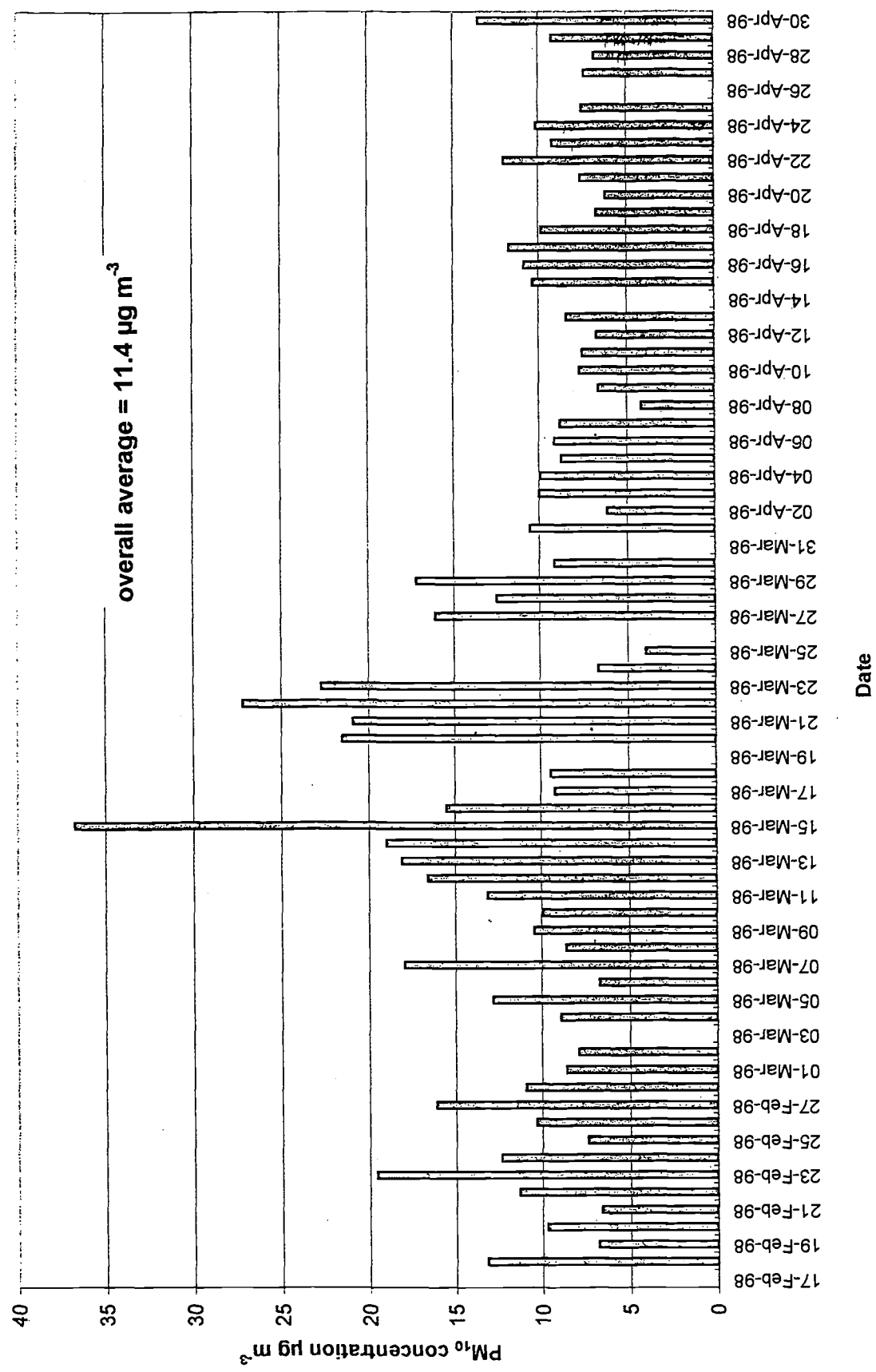


Figure 6 Wind speed (knots) versus PM₁₀ mass concentration (µg m⁻³), 180-260 degrees

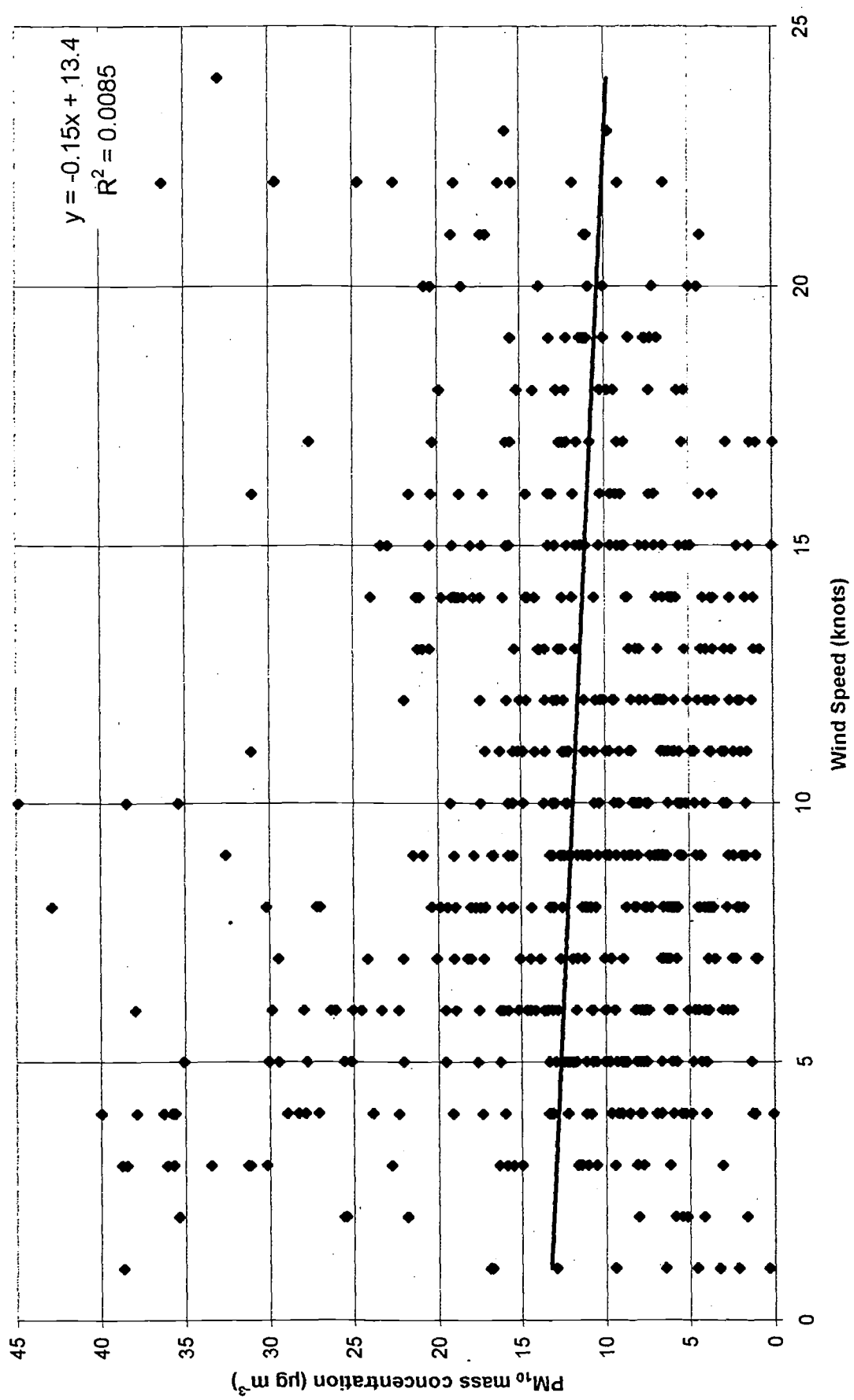


Figure 7 Wind speed (knots) versus PM₁₀ mass concentration ($\mu\text{g m}^{-3}$), 15th March 1998

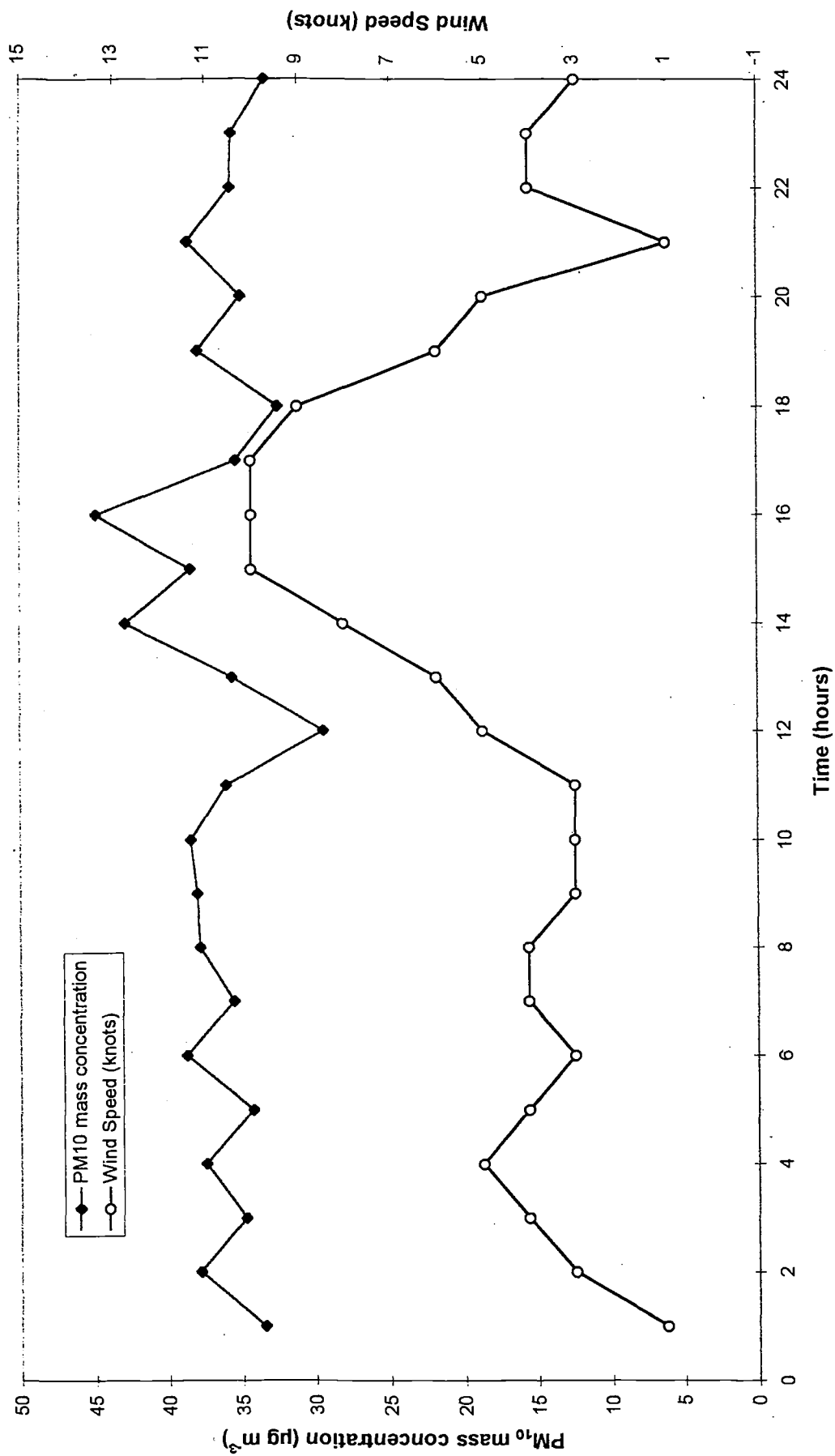
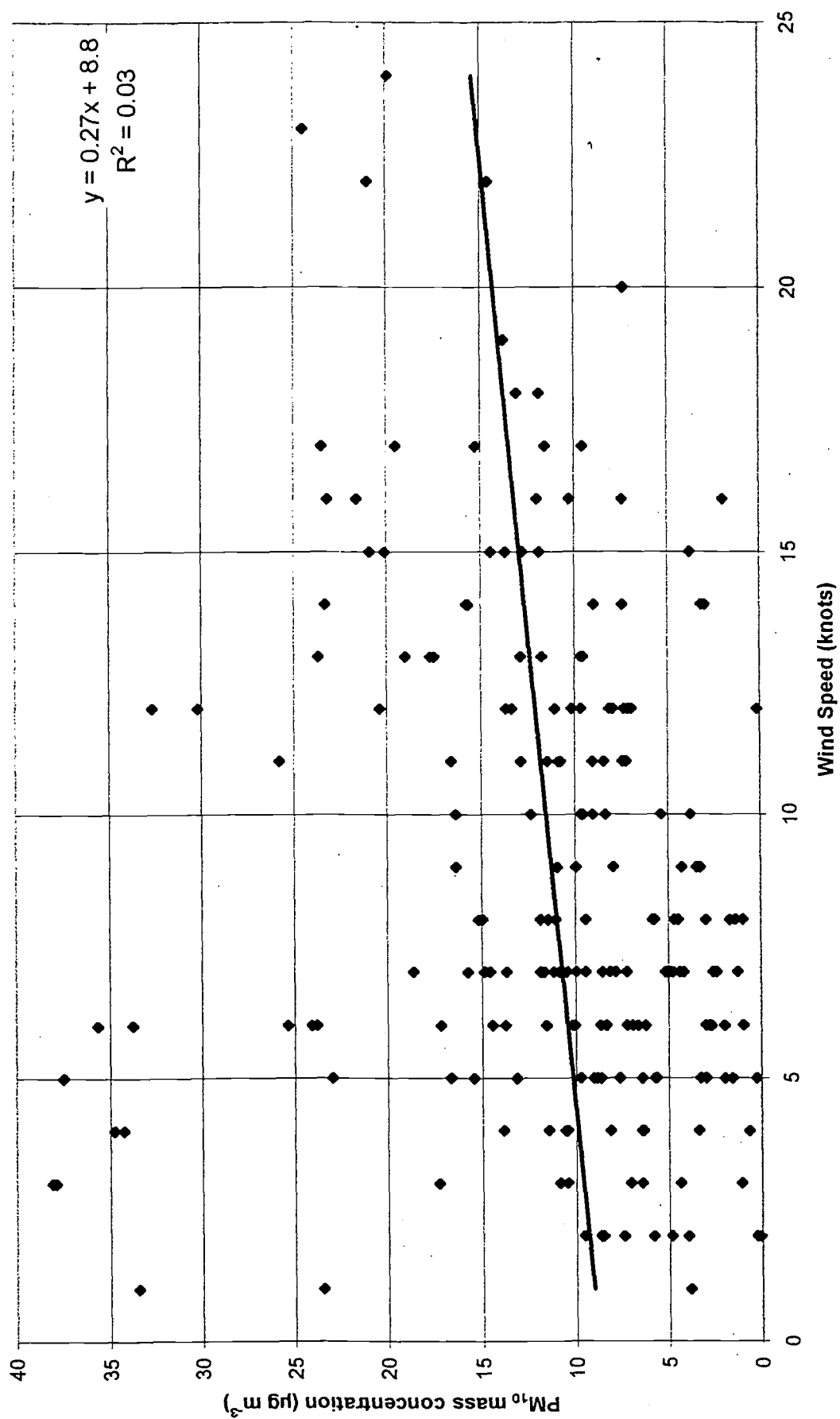
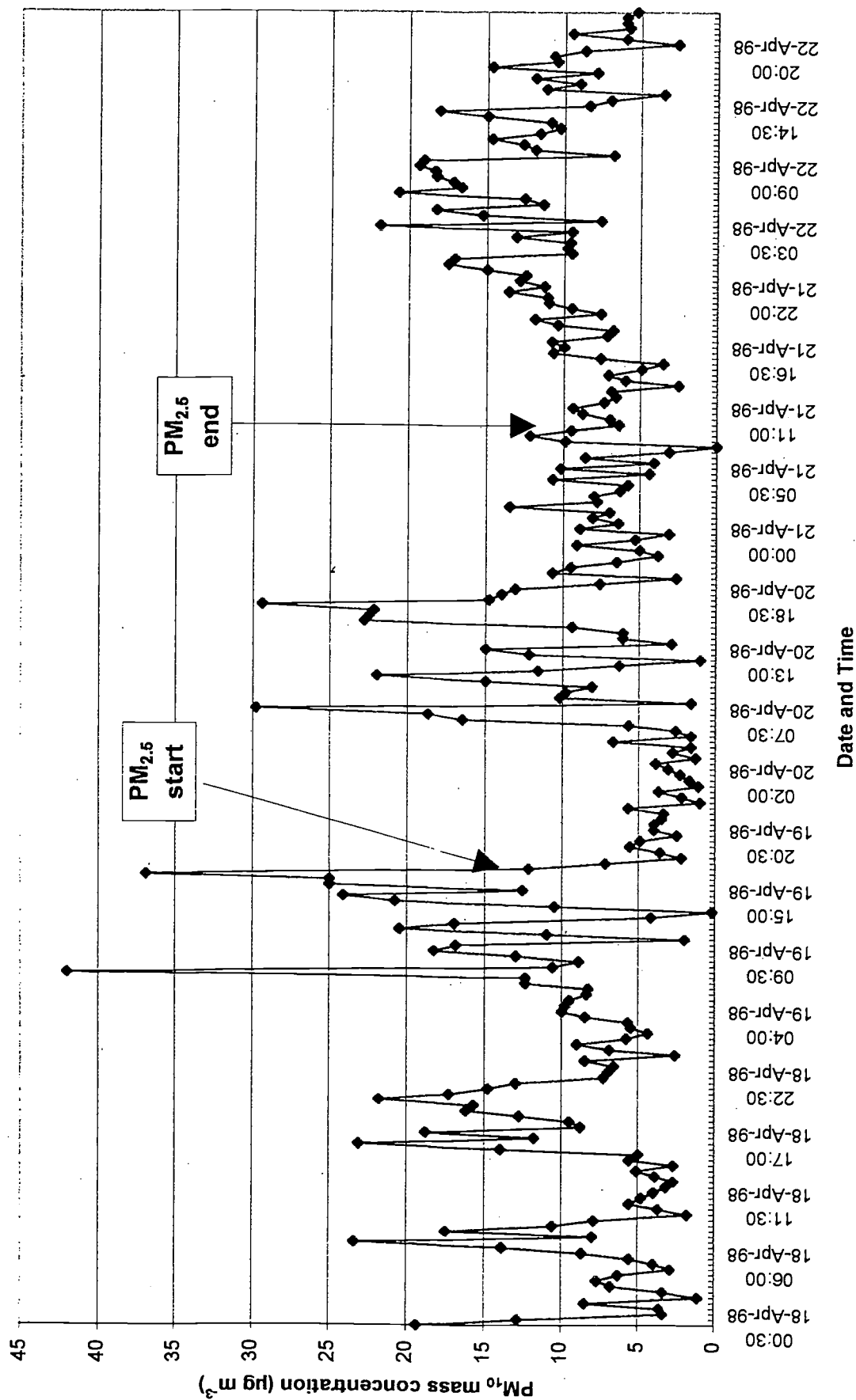


Figure 8 Wind speed (knots) versus PM₁₀ mass concentration level ($\mu\text{g m}^{-3}$), 270-290 degrees



PM_{2.5} mass concentration levels at Askeaton site, 19 - 21 April 1998



Askeaton Local Site Map



Appendix II PM₁₀ Daily averages 18 February to 30 April 1998

Date	Daily PM ₁₀ Concentrations µg m ⁻³	Date	Daily PM ₁₀ Concentrations µg m ⁻³
17-Feb-98			
18-Feb-98	13.2	01-Apr-98	10.5
19-Feb-98	6.8	02-Apr-98	6.1
20-Feb-98	9.7	03-Apr-98	10
21-Feb-98	6.6	04-Apr-98	9.9
22-Feb-98	11.3	05-Apr-98	8.7
23-Feb-98	19.6	06-Apr-98	9.1
24-Feb-98	12.3	07-Apr-98	8.8
25-Feb-98	7.4	08-Apr-98	4.2
26-Feb-98	10.3	09-Apr-98	6.6
27-Feb-98	16.1	10-Apr-98	7.7
28-Feb-98	10.9	11-Apr-98	7.5
01-Mar-98	8.6	12-Apr-98	6.7
02-Mar-98	7.9	13-Apr-98	8.4
03-Mar-98		14-Apr-98	
04-Mar-98	8.9	15-Apr-98	10.3
05-Mar-98	12.8	16-Apr-98	10.8
06-Mar-98	6.7	17-Apr-98	11.7
07-Mar-98	18	18-Apr-98	9.8
08-Mar-98	8.6	19-Apr-98	6.7
09-Mar-98	10.4	20-Apr-98	6.2
10-Mar-98	9.9	21-Apr-98	7.6
11-Mar-98	13.1	22-Apr-98	12
12-Mar-98	16.6	23-Apr-98	9.2
13-Mar-98	18.1	24-Apr-98	10.1
14-Mar-98	19	25-Apr-98	7.5
15-Mar-98	36.7	26-Apr-98	
16-Mar-98	15.5	27-Apr-98	7.4
17-Mar-98	9.2	28-Apr-98	6.8
18-Mar-98	9.4	29-Apr-98	9.2
19-Mar-98		30-Apr-98	13.5
20-Mar-98	21.5		
21-Mar-98	20.9		
22-Mar-98	27.2		
23-Mar-98	22.7		
24-Mar-98	6.7		
25-Mar-98	4		
26-Mar-98			
27-Mar-98	16.1		
28-Mar-98	12.5		
29-Mar-98	17.2		
30-Mar-98	9.1		
31-Mar-98			

An Gníomhaireacht um Chaomhnú Comhshaoil

Bunú

Achtaíodh an tAcht fán nGníomhaireacht um Chaomhnú Comhshaoil ar an 23ú lá d'Aibreán, 1992 agus faoin reachtaíocht seo bunaíodh an Gníomhaireacht go hoifigiúil ar an 26ú lá d'Iúil, 1993.

Cúraimí

Tá réimse leathan de dhualgais reachtúla ar an nGníomhaireacht agus de chumhachtaí reachtúla aici faoin Acht. Tá na nithe seo a leanas san áireamh i bpríomhfhreagrachtaí na Gníomhaireachta:

- ceadúnú agus rialáil próiseas mór/ilchasta tionsclaíoch agus próiseas eile a d'fhéadfadh a bheith an-truaillitheach, ar bhonn rialú comhtháite ar thruailliú (Integrated Pollution Control-IPC) agus cur chun feidhme na dteicneolaíochtaí is fearr atá ar fáil chun na críche sin;
- faireachán a dhéanamh ar cháilíocht comhshaoil, lena n-áirítear bunachair sonraí a chur ar bun a mbeidh rochtain ag an bpobal orthu, agus foilsíú tuarascálacha treimhsiúla ar staid an chomhshaoil;
- comhairle a chur ar údarais phoiblí maidir le feidhmeanna comhshaoil agus cuidiú le húdarais áitiúla a bhfeidhmeannas caomhnaithe a chomhlíonadh;
- cleachtais atá fónta ó thaobh an chomhshaoil de a chur chun cinn, mar shampla, trí úsáid iniúchtaí comhshaoil a spreagadh, cuspóirí cáilíochta comhshaoil a leagan síos agus cóid chleachtais a eisiúint maidir le nithe a théann i bhfeidhm ar an gcomhshaoil;
- taighde comhshaoil a chur chun cinn agus a chomhordú;
- gach gníomhaíocht thábhachtach diúscairthe agus aisghabhála dramhaíola, lena n-áirítear líontaí talún, a cheadúnú agus a rialáil agus plean náisiúnta bainistíochta um dhramháil ghuaiseach, a bheidh le cur i ngníomh ag comhlachtaí eile, a ullmhú agus a thabhairt cothrom le dáta go tréimhsiúil;
- córas a fheidhmiú a chuirfidh ar ár gcumas astúcháin COS (Comhdhúiligh Orgánacha Sho-ghalaithe) a rialú de bharr cáinníochtaí suntasacha peitril a bheith á stóráil i dteirminéil;
- na rialúcháin OMG (Orgánaigh a Mionathraíodh go Géiniteach) a fheidhmiú agus a ghníomhú maidir le húseaid shrianta a leithéad seo d'orgánaigh agus iad a scaoileadh d'aon turas isteach sa timpeallacht;

- clár hidriméadach náisiúnta a ullmhú agus a chur i ngníomh chun faisnéis maidir le leibhéil, toirteanna agus sruthanna uisce in aibhneacha, i lochanna agus i screamhuiscí a bhailiú, a anailisiú agus a fhoilsiú; agus
- maoirseacht i gcoitinne a dhéanamh ar chomhlíonadh a bhfeidhmeanna reachtúla caomhnaithe comhshaoil ag údarás áitiúla.

Stádas

Is eagrais poiblí neamhspleách í an Gníomhaireacht. Is í an Roinn Comhshaoil agus Rialtais Áitiúil an coimirceoir rialtais atá aici. Cinntítear a neamhspleáchas trí na modhanna a úsáidtear chun an tArd-Stiúrthóir agus na Stiúrthóirí a roghnú, agus tríd an tsaoirse a dhearbhaíonn an reachtaíocht di gníomhú ar a conlán féin. Tá freagracht dhíreach faoin reachtaíocht aici as réimse leathan feidhmeannas agus cuireann sé seo taca breise lena neamhspleáchas. Faoin reachtaíocht, is coir é iarracht a dhéanamh dul i gcion go míchuí ar an nGníomhaireacht nó ar aon duine atá ag gníomhú thar a ceann.

Eagrú

Tá ceanncheathrú na Gníomhaireachta lonnaithe i Loch Garman agus tá cúig fhoireann chigireachta aici, atá lonnaithe i mBaile Átha Cliath, Corcaigh, Cill Chainnigh. Caisleán an Bharraigh agus Muineachán.

Bainistíocht

Riarann Bord Feidhmiúcháin lánaimseartha an Gníomhaireacht. Tá Ard-Stiúrthóir agus ceathrar Stiúrthóirí ar an mBord. Ceapann an Rialtas an Bord Feidhmiúcháin de réir mionrialacha atá leagtha síos san Acht.

Coiste Comhairleach

Tugann Coiste Comhairleach ar a bhfuil dáréag ball cunamh don Gníomhaireacht. Ceapann an tAire Comhshaoil agus Rialtais Áitiúil na baill agus roghnaítear iad, den chuid is mó, ó dhaoine a ainmníonn eagraíochtaí a bhfuil suim acu i gcúrsaí comhshaoil nó forbartha. Tá réimse fairsing feidhmeannas comhairleach ag an gCoiste faoin Acht, i leith na Gníomhaireachta agus i leith an Aire araon.