STATE OF THE ENVIRONMENT IN IRELAND

ENVIRONMENTAL PROTECTION AGENCY

epa

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 establishment of an eco-labelling scheme, 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; 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. 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 are 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 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.

An Ghníomhaireacht um Chaomhnú Comhshaoil

STATE OF THE ENVIRONMENT IN IRELAND

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FOREWORD

Under Section 70 of the Environmental Protection Agency Act, 1992, the Agency is obliged to prepare and publish a report on the State of the Environment at intervals not exceeding five years. This is the first report on the State of the Environment in Ireland published by the Agency since its establishment in July 1993. The report mainly covers the intervening period since the publication of the first State of the Environment report for Ireland, by An Foras Forbartha, in 1985.

This report consists of a single volume, in four parts, as follows:

Part I	General Introduction and Background;
Part II	Pressures on the Environment;
Part III	Environmental Quality and Pollution;
Part IV	Management, Control and Economic Aspects.

Following the introductory part of the report, the structure of the remaining three parts reflects the pressure-state-response approach used by the Organisation for Economic Co-operation and Development (OECD), which is based on the rationale that the state of the environment interacts with the state of the economy: human activities impose pressures on the environment, such as the generation of pollution and waste, and also depend on it for natural resource inputs, e.g., water, marine, forest and land resources.

It is evident from this report that, at the present time, the range and diversity of environmental issues requiring assessment are extremely broad. The following are some key trends and issues, but it must be borne in mind that there are several others that are also of importance. There is evidence of certain positive trends over recent years, for example, reductions in smoke, sulphur dioxide and lead concentrations in air and a reduction in serious chronic pollution of rivers. There is evidence also, however, of a lack of progress, or of disimprovement in certain respects, for example, emissions of carbon dioxide, impacts of road traffic on air quality, eutrophication of rivers and lakes, increased volumes of waste consigned to landfills, overgrazing pressures and the problems of litter. While Ireland's environmental quality compares favourably with that of most other European countries, it is clear that attention must focus in particular on adverse trends which may gradually erode that favourable position.

State of the Environment reporting is still an evolving process and this report is a further step in this process. Reporting on the state of the environment is driven by the selection of appropriate environmental indicators. The indicators must be both scientifically based and also easily understood by the general public. Once indicators have been agreed upon, long term monitoring programmes to ensure the provision of data for the purposes of monitoring trends and decision-making can be developed. There are many information gaps identified in this report and much work is required in the future to develop and extend the range of environmental indicators.

Your views on the usefulness of this report are important to us. Therefore it would be appreciated if you would complete the enclosed questionnaire designed to give us your feedback.

Many organisations and individuals (duly acknowledged elsewhere in this report) assisted the Agency to bring all the data together. We are indebted to them, for, without their active support, the compilation of this report would not have been possible.

L M McCumiskey
Director-General

Wexford, February 1996

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Working Group 1, Terrestrial Environment, Coastal Zone and Conservation Aspects: Bord na Mona (Mr. Gerry McNally), Geological Survey of Ireland (Dr. Bob Aldwell), Teagasc (Dr. Michael Ryan), Department of Transport, Energy and Communications (Mr. Michael O'Mahony and Ms. Eithne Brogan), Department of the Marine (Mr. Raphael Kelly), Fisheries Research Centre (Dr. Dan Minchin and Ms. Jacqueline Doyle), Coillte Teoranta (Mr. John McLoughlin), Department of the Environment (Ms. Marie Hughes, Mr. Donal Enright and Mr. Ray O'Leary), Department of Agriculture, Food and Forestry (Mr. Paddy Drennan, Ms. Maureen O'Sullivan and Mr. Jim Boyle), National Parks and Wildlife Service (Mr. Jim Kelly and Ms. Edel Hennessey), Radiological Protection Institute of Ireland (Dr. John Cunningham) and Ordnance Survey (Mr. Harry McDermott).

Working Group 2, Noise: National Roads Authority (Mr. Michael Staunton), Forbairt (Mr. Larry Kenny), Department of the Environment (Mr. Ray McGee), Department of Transport, Energy and Communications (Ms. Pat O'Connor), Irish Aviation Authority (Mr. Jim Corby) and Fingal County Council (Mr. John Healy).

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Chapter 16:	Mr. Larry Stapleton and Ms. Kirsty Nolan.

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Chapters 10, 11 & 12:	Working Group 1
Chapter 13:	Working Group 2
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EXTENDED SUMMARY

I - GENERAL INTRODUCTION AND BACKGROUND

1. Introduction

One of the functions of the Environmental Protection Agency (EPA) is to prepare State of the Environment reports. The main objective is to assemble and evaluate the available information on the quality of the environment in Ireland. Where there are information gaps, the report aims at identifying these so that steps may be taken to facilitate more complete assessments in the future.

The report outlines, firstly, the background and the driving forces of a social and economic nature; secondly, the resulting pressures, such as emissions, which have an impact on the environment; thirdly, the present environmental quality condition and trends; and finally, the responses in terms of programmes, controls and actions for protecting the environment. The report as a whole aims at providing an integrated assessment of the environment in an overall holistic approach.

2. Background

The population of Ireland increased substantially between the mid-1960s and the mid-1980s and is now just over 3.5 million persons. Population projections for the next decade are for either little change or a modest increase. The urban population has continued to grow and it well exceeds the rural population.

Of the aggregate employment in manufacturing industry, over one third is in the metals and engineering sectors and one fifth is in the food sector. The pharmaceuticals sector has grown strongly and continues to be a target for inward investment. Current policies include the development of indigenous resource-based activities such as food-processing and timber industries.

Energy consumption per capita in Ireland is increasing. Industrial and residential use account for approximately 35 and 33 per cent of demand respectively, transport 20 per cent, and the balance (12 per cent) is commercial and institutional demand. In relation to energy supply, dependency on oil decreased up to 1990 but has since increased somewhat and now stands at around 50 per cent. Indigenous sources, mainly natural gas and peat, account for almost 33 per cent of the total; imported coal constitutes the balance of the energy supply.

Roads are the dominant mode of internal transport and account for approximately 90 per cent of goods and 96 per cent of passenger transport. The total number of vehicles has risen steadily since the mid-1980s.

The principal changes in agriculture since the early 1980s include the doubling of sheep numbers, almost a doubling of silage production, increased use of nitrogen fertilizers and decreased tillage. Forestry planting has increased substantially in recent years, particularly in the private sector.

The fishing industry has been making a growing contribution to the economy in terms of output, employment and exports. Although it includes some efficient modern vessels (for the pelagic fishery), the Irish fishing fleet consists mainly of vessels with a high age profile. Since 1980, aquaculture has expanded from negligible beginnings to a thriving industry.

Tourist numbers are now about twice what they were in the late 1970s and show a continuing steady increase.

Across all sectors environmental awareness is increasing, and there is particular concern regarding waste and litter, and air and water pollution. The Access to Information on the Environment Regulations, 1993, together with the substantial requirements in the Environmental Protection Agency Act, 1992 (EPA Act), set out the mechanisms for making information on the environment available to the public.

3. Assessing the Environment

The techniques and tools used to assess the condition of the environment may be divided into three broad categories: (a) planning and control tools, such as environmental quality objectives and standards, (b) monitoring and research tools used to measure environmental quality and sensitivity, and (c) trend tools such as indicators and indices used to assess changes in the state of the environment. Together these tools can facilitate a unified approach to guiding environmental protection and management.

II - PRESSURES ON THE ENVIRONMENT

4. Sources of Pressure

Changes to the environment are caused by both natural and human processes. Human activities, however, are now altering natural cycles at unprecedented rates. In general, pressures on the environment are in one of three forms: depletion of resources, polluting emissions, or physical structural changes.

In addition to the problems posed by resource depletion, by emissions to air and water, and by waste and litter (see sections 5 to 7 below), other factors include losses of habitat and of biodiversity, the risks posed by chemicals and genetically-modified organisms, other technological hazards, and natural disasters.

The adverse implications for Ireland of climate change resulting from the enhanced greenhouse effect could include serious damage to peatlands, more frequent winter flooding, and inundation and erosion of some coastal areas due to sea-level change.

An example of environmental problems from the use of chemicals is the severe effects of tributyl tin (TBT) on various shellfish species. TBT has been used in anti-fouling paints and preparations. Certain controls were introduced in 1987 with consequent improvements in some areas but not in all.

In relation to transboundary pollution in Ireland, the principal issue is radioactivity, for example, (a) the effects of the accident at Chernobyl and the risk of other such accidents, and (b) the contamination of the Irish Sea from the discharge of low-level liquid wastes from the nuclear reprocessing plant at Sellafield in the UK. In relation to acid deposition, although serious effects are not apparent in Ireland, it has been estimated nevertheless that 50 per cent of the annual deposition of sulphur and up to 90 per cent of the annual deposition of nitrate are imported from other countries.

5. Emissions to Air

Generally, the impacts of emissions to air may be of importance on different scales, e.g., local, national or global. Irish emissions of the more significant pollutants typically account for one per cent of EU totals.

Suspended particulates, including smoke, may have significant localised effects. National smoke emissions have decreased substantially as a result of smoke control legislation implemented in Dublin in 1990 and will decrease further owing to similar controls now in place in Cork.

Sulphur dioxide (SO_2) has effects on the respiratory system of man and animals and is also a main contributor to acid rain. Total emissions of SO_2 decreased by about 30 per cent over the period 1980-1993, mainly through switching to natural gas, through a decrease in the sulphur content of gas oil used, and through a decrease in the sulphur content of the coal burned at the large Moneypoint generating station on the Shannon Estuary. Dublin and an area on the Shannon Estuary account for two-thirds of the emissions in Ireland. Although not a signatory, Ireland has achieved the target set for SO_2 emissions reduction in the Helsinki Protocol.

Nitrogen oxides (NO_x) have similar effects to SO_2 and are involved also in the formation of ground-level ozone. Emissions have increased by about 50 per cent since 1980. Transport and power generation together account for about four-fifths of NO_x emissions. Traffic is the single most important source, and it will be some time before the benefits of catalytic converters become apparent. Certain controls in power generation (low-NO_x burners) are expected to achieve a reduction from that sector.

Volatile organic compounds (VOC) play an important role in ground-level ozone formation. Although estimates are uncertain in absolute terms, it is clear that emissions of VOC have been increasing steadily, mainly from road transport.

The three main 'greenhouse gases' (i.e., those linked to global warming) are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). While the EU target is stabilisation of CO_2 emissions by the year 2000, emissions in Ireland are limited to an increase of 20 per cent over 1990 levels. Increases are mainly in electricity generation, particularly coal-burning. Emissions of the other two gases are largely unrelated to fuel combustion and arise mainly from natural processes or processes partially influenced by man, which makes it difficult to assess trends.

6. Discharges to Waters

Discharges of waste waters to the aquatic environment arise mainly from domestic, industrial and agricultural sources. The nature of the discharge may be either as a point source (mainly domestic and industrial) or as a non-point or diffuse source (mainly agricultural).

About 68 per cent of the domestic sewage in Ireland is discharged to public sewers. Somewhat less than half of the sewerage schemes in Ireland have secondary treatment. Significant investment in sewage treatment, particularly in relation to cities and towns discharging to tidal waters, is now being made to meet the requirements of the EU urban waste water treatment Directive.

From the available information, there are 688 licences for discharges to waters and 1,086 licences for discharges to sewers issued by local authorities. The predominant types of effluent from industry in Ireland are of an organic biodegradable nature with significant biochemical oxygen demand (BOD). The BOD load from industry, as estimated on the basis of licences, is approximately

125 tonnes/day. (Checks indicate however, that the actual load discharged may be less than that licensed.) The load discharged in domestic waste water is just under 100 tonnes/day.

Of the total BOD load discharged from point sources almost four-fifths enter tidal waters with most of the remainder entering rivers.

It is estimated that the BOD load generated from the main agricultural activities is equivalent to that generated by approximately 68 million persons. It is emphasised that this is the generated BOD load and not that discharged to waters, which it has not been possible to estimate. Farm wastes have been implicated in fish kills and are linked to the enrichment of waters.

7. Waste

Comprehensive reporting on the production and disposal of waste in Ireland is hampered by the relative scarcity of complete and reliable data. A project initiated by the EPA is now underway to address this need.

On the basis of the available information, approximately 38 million tonnes of waste is generated each year in Ireland, most of which is from agricultural sources (e.g., animal manures). Of the other sectors, industry produces about 4,700,000 tonnes of general waste, households produce somewhat over 900,000 tonnes and commercial activities produce about 760,000 tonnes. Hazardous waste amounts to just over 140,000 tonnes and sewage sludge almost 44,000 tonnes.

Nearly 70 per cent of all non-agricultural solid waste produced in Ireland is either landfilled or disposed of on-site by the producer. A total of 11 per cent is either recycled or re-used, 18 per cent is dumped at sea, and a small amount is disposed of in other ways. This pattern can be expected to change in the next decade with the cessation of dumping of sludges at sea and an increase in the amount of waste recycled or re-used.

The total quantity of waste consigned to local authority landfills has been increasing at a rate of three to four per cent per annum. The Government has set targets for increased recycling of packaging wastes by the end of the decade, with a general objective of diverting 20 per cent of combined household and commercial waste away from landfill. A large proportion of waste in Ireland will continue to be disposed of in landfills for the foreseeable future. Many landfills currently in operation, however, are near maximum capacity and will close in the medium term.

In relation to toxic and dangerous waste, by far the greatest amount is made up by organic solvents (69 per cent) and chlorinated solvents (19 per cent). About four-fifths of the total is re-used or disposed of in Ireland and the balance is exported.

Incineration is mainly employed in Ireland for the disposal of hazardous wastes and healthcare wastes. Hazardous waste incinerators now require integrated pollution control (IPC) licences from the EPA and must be operated to a high standard. The Government has decided that a national hazardous waste incinerator will not be developed. In relation to healthcare waste, most operators of incinerators that would now be licensable have ceased operations and sought alternative disposal methods, while a small number have applied for IPC licences.

A consequence of the urban waste water treatment Directive will be a three-fold increase in the volume of sludges, resulting from secondary treatment of sewage. Ocean dumping of sewage sludge is due to cease by 1998. It may be noted that the disposal of industrial wastes at sea terminated in 1993 and dredge spoil will be the only significant waste for controlled dumping at sea.

The Waste Management Bill provides for licensing of waste recovery and disposal activities and for the planning, management and control of wastes and will lead to stricter controls.

Currently, virtually the sole disposal route for agricultural slurries in Ireland is land spreading. Codes of Practice have been drafted, which, when followed, can minimise the risk of water pollution.

Litter and unauthorised dumping are two of the most persistent and visible waste problems in Ireland. Plastic litter is a particular problem. Anti-litter and clean-up campaigns are organised periodically at local and national level.

III - ENVIRONMENTAL QUALITY AND POLLUTION

8. Air Quality and Acid Deposition

Air quality standards, based on EU Directives, exist in Ireland for smoke, sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and lead. The majority of sampling stations in Ireland monitor for smoke and SO_2 only. There are smaller numbers of stations in the monitoring networks for NO_2, lead, ozone, metals and rainfall chemistry. Data on air quality have been reviewed for the period up to the end of 1994.

The most important national initiative in air pollution control has been the introduction of smoke control measures (a ban on the marketing, sale and distribution of bituminous fuels) to relieve winter smog in Dublin and Cork. Concomitant economic instruments, i.e., fuel subsidies, have also been important.

Following the introduction of controls in Dublin in 1990, there has been a reduction in smoke concentrations of about 70 per cent. There have been no exceedances of EU limit values since then, in contrast with the previous several years when there was an average of ten exceedances per annum. Smoke concentrations in Cork have been approaching the limit values and controls have now been introduced. The limit value has also been approached in Dundalk.

Ambient SO_2 levels have declined in Dublin since the early 1970s due to changes in fuel usage. Levels in other areas are lower than in Dublin.

The limit value for NO_2 has been approached closely on two occasions at College Street, which is one of the two Dublin stations that monitor for this parameter. The lower 'guideline' values have been exceeded each year at College Street but have not been exceeded at the second station, Rathmines.

Unleaded petrol now accounts for over one-half of all petrol sales. Ambient lead levels have declined in Dublin and are well within the EU limit and World Health Organisation guideline value.

Continuous ground-level ozone data are available from Mace Head since 1988 and from Dublin since 1991. Maximum recorded hourly concentrations very rarely exceed the 'population information threshold' of 180 $\mu g/m^3$. Ground-level ozone levels are lower in Dublin. A new national ozone monitoring network has been installed recently, bringing the total number of stations to six.

In relation to acid deposition (acid rain) concentrations increase from west to east, and highest concentrations correlate with easterly winds. In the east of the country, particularly, the transport of air pollutants from the UK and Europe strongly influences the annual deposition rates of non-marine sulphate and oxidised nitrogen.

Overall, in relation to air pollution, road traffic is now considered to be the most significant source, with effects on NO_2, ground-level ozone, fine particulate matter (PM_{10}), carbon monoxide and a variety of organic compounds. It will be some time before three-way catalysts and other controls attain sufficient share of the vehicle fleet in Ireland to bring about substantial reductions.

A special investigation of volatile organic compounds (VOC) and PM_{10} in Dublin has commenced. The application of the 'critical loads' concept for acidifying depositions has been limited to date and is now also the subject of a new investigation.

9. Inland Waters

The full national river water quality baseline covers the larger rivers and streams (3,200 stations on 13,200 km of channel). River quality is classified, by biological assessment, into four classes. The percentages of the total baseline in each class in the review period 1991-1994 are as follows:

Class A	(unpolluted)	71.2 per cent
Class B	(slightly polluted)	16.8 per cent
Class C	(moderately polluted)	11.4 per cent
Class D	(seriously polluted)	0.6 per cent

The eastern region is the most affected by all levels of pollution. Nationally, the suspected causes of serious pollution (Class D) are as follows: industry (49 per cent), agriculture (31 per cent) and sewage (20 per cent).

A core baseline of 2,900 km has been surveyed since 1971. The results for this core baseline are inevitably somewhat different from those given above for the full baseline; nevertheless they are valuable in that they indicate long-term trends. For example, the percentages in the review periods ending in 1971 and 1994 were as follows:

	Percentages	
	1971	1994
Class A	84.3	57.5
Class B	5.1	26.8
Class C	4.6	14.5
Class D	6.0	1.2

Both the long-term (since 1971) and recent (since 1987-1990) trends show (i) a gradual reduction in serious pollution, and (ii) a distinct trend of increasing levels of slight, and to a lesser extent, moderate pollution. The latter trend is due largely to eutrophication.

In general, nitrate levels below the EU guideline value were recorded in rivers during the review period 1991 - 1994, except for short periods in some rivers during winter. Highest concentrations are measured in the tillage farming areas of the south-east. The national trend of increasing nitrate levels is also strongest there.

Recent investigations of nitrate in groundwater in the south and north-east showed that 97 per cent of samples had nitrate concentrations which were less than the maximum admissable concentrations set by the Drinking Water Regulations.

Phosphate values show a strong contrast between generally unimpacted rivers in the west and eutrophic or highly eutrophic rivers in the east and south. Sewage and agriculture are the main sources of excess phosphate in surface waters. On a national basis, much more phosphorus than is required for optimal production is being used in intensive agriculture. About £25 million or more in fertiliser costs could be saved each year without any adverse effects on farm production.

A marked upsurge in fish kills in the 1980s was followed by a substantial reduction up to 1994, which reflected considerable investment and effort at local and national levels in tackling the problem, particularly in respect of the agricultural sector. (An increased incidence of fish kills in 1995 underlines the need for a sustained effort).

The biggest threat to the water quality of lakes in Ireland is eutrophication or enrichment, beyond natural levels, by the nutrients phosphate and nitrate, particularly phosphate. The principal sources of these nutrients are agricultural activities and discharges of domestic and industrial wastes.

Data are presented on the quality of 135 lakes examined during the review period 1991-1994. Of these lakes, 104 were classified as oligotrophic or mesotrophic (i.e., unpolluted); 7 lakes were classified as moderately eutrophic while the remaining 24 were excessively enriched. The surface area of the 135 lakes examined amounted to 750 km^2 or 50 per cent of the lake surface area of the country. The 24 lakes found to be excessively enriched included two large lakes, i.e., Loughs Ree and Derg, and consequently in total they represented 38 per cent of the surface area of the water examined.

Recent trends in the water quality of lakes show little change in the numbers of lakes allocated to each trophic category as a proportion of the overall numbers of lakes examined. However, when comparison is made on the basis of the surface areas a large increase in the oligotrophic and strongly eutrophic categories and a corresponding reduction in the mesotrophic category is apparent. Of the 23 lakes examined since the mid 1970s, only three have shown a continual deterioration in water quality.

Lake waters examined for acidification have been found to be unaffected by acid rain, although inflowing rivers from afforested catchments in Counties Clare, Galway, Mayo and Wicklow showed increased acidity.

Radioactive contamination following the Chernobyl accident was found in some lakes, particularly in the north-west. The levels, in terms of radiation doses to consumers of relatively large amounts of freshwater fish, are considered of minor radiological significance.

Since first being designated in 1992, all inland bathing areas have complied with the mandatory bacteriological values, and eight of the nine areas met the more stringent guide values in the EU bathing waters Directive in 1994.

Concomitant with the expansion of farmed salmon in cages at sea, a catastrophic collapse has occurred in the sea trout populations of many western rivers, particularly in Connemara and west Mayo. Anglers report a decline in brown trout stocks in many waters, and this has been linked to eutrophication and predation. Populations of char, a pollution sensitive salmonid species, in Lough Conn and other lakes have undergone severe reductions. National and international measures are urgently required to protect salmon, particularly spring salmon, stocks of which are facing extinction in some traditional waters.

10. Estuarine and Coastal Waters

In the latest review (1991-1994) of the general condition of estuarine and coastal waters, 26 tidal waters were examined. The results indicate only limited serious pollution and little change in condition since the previous review period (1987-1990). Some pollution is in evidence, notably in the Lee Estuary, Killybegs Harbour, inner Dungarvan Harbour and Rogerstown Estuary, but the measured deoxygenation was not sufficient to impede the passage of migratory fish. However, variations in oxygen levels need further assessment.

Heavy metals in water, sediments, fish and shellfish from several locations have been measured by the Department of the Marine. Metals have been reported at elevated concentrations in six areas (Cork Harbour, Tralee Bay, Waterford Harbour, Boyne Estuary, Shannon Estuary and Mulroy Bay), with Cork Harbour having elevated concentrations of three metals, copper, zinc and mercury, but the levels are either stable or decreasing over time. The degree of organochlorine contamination was exceptionally low in the European context.

Currently, 58 shellfish waters are monitored by the Department of the Marine for microbiological contamination. Of these, 32 are in Class A (harvesting permitted for direct human consumption), 17 are in Class B (purification required) and two are in Class C (re-laying required for at least two months). In addition, seven waters have areas in two classes. Areas sampled for chemical contaminants comply with EU requirements.

Between 1987 and 1993 a number of bathing waters, mainly in the Dublin area, failed to comply with the mandatory requirements of the EU bathing waters Directive. In 1994, however, all of the seawater bathing areas in Ireland complied. Ireland was the only Member State to attain this. In recent years, between 54 and 66 bathing areas have been awarded Blue Flags.

Since the early 1980s there has been a continuous decline in radiocaesium concentrations in seawater in the north-western Irish Sea due to significant reductions in discharges from Sellafield. Results indicate that there is no significant risk to health from bathing or from consumption of fish from the Irish Sea.

Salmon farming has expanded rapidly in recent years and annual production now exceeds 12,000 tonnes. The main shellfish produced are mussels. Cultivation of native oysters in certain areas has been affected by the introduction of a disease, *Bonamia ostraea*, which affects the mature shellfish.

Movements of shellfish, some of which are non-native species, may result in the unintentional introduction of other 'exotic organisms', for example, various parasites. The hulls of ships, and ships' ballast-water, are further sources of such organisms.

Surveys of the Irish coastline are organised annually by Coastwatch Europe. Results of the 1994 survey suggested a worsening in the water quality of local inflows to coastal areas and only a marginal reduction in litter. The surveys also help raise awareness of coastal zone issues.

11. Terrestrial Environment

In contrast with past trends of decline in the quality of the built environment in some central city areas, there are more recent trends of urban renewal. Nevertheless, a survey carried out in 1994 indicated 690 derelict sites and 3,820 vacant or partially vacant buildings in Dublin's inner city, with large numbers also in other urban areas. Traffic congestion is a particular problem in Dublin and in some other urban centres.

The Irish landscape is a constantly changing mosaic, the product of interaction between the land, climate, nature and human development. As it is largely a by-product of human activities, it is vulnerable to change by these activities. The quality of landscapes in Ireland is particularly high. An early survey identified areas totalling 17.6 per cent of the area of the State as 'heritage landscape'.

Forest cover in Ireland, at eight per cent of the land area, is the lowest in Europe. However, afforestation is now one of the significant trends in the terrestrial environment. The trees planted are mainly western North American conifers, but a target has been set of up to 20 per cent broadleaf content. While an important natural resource with environmental benefits, forestry can also have some adverse consequences on the landscape and on water quality. The condition of surveyed forests is good with no evidence of pollution damage to trees.

Peatlands once covered 17 per cent of the State. The Government has set a target to conserve 10,000 ha of raised bog and 40,000 ha of blanket bog. Many areas listed for conservation and still without statutory protection are in private ownership. Uses identified for cutaway bogs include forestry, grassland and wetlands.

Soil erosion, as a result of overgrazing by sheep, is primarily a problem in certain mountain, upland and blanket bog commonages. This can lead ultimately to a gradually extending area of bare rock. As a consequence of erosion, rivers and lakes have been affected by increased silt loadings.

A survey has been undertaken of trace elements and organic micropollutants in soils in 11 counties in Ireland. The results showed that, in general, the amounts of toxic trace elements were similar to those associated with unpolluted soils elsewhere. Elevated lead levels were found in urban soils, a pattern which is found also in other countries. DDT and its breakdown products are still present at a sizeable level in some agricultural soils and especially in town soils.

The average extractable phosphorus level in soils has increased by a factor of 16 over the past 40 years and in some soils is high enough to permit optimum crop production for a number of years without further addition. About 72 per cent of nitrogen inputs may be lost to water and to the atmosphere, thus showing that the efficiency of the utilization of nitrogen is decreasing as application rates are increasing.

Radioactivity levels in sheep and sheepmeat is being monitored, as some sheep grazing on upland pastures still register high levels of radiocaesium. This is due to its persisting bioavailability on some poor quality upland soils following deposition after the Chernobyl accident. Before being slaughtered, sheep from these areas are required to be grazed on lowland pastures, where radioactivity levels in their flesh decrease rapidly.

12. Natural Heritage

Owing to its varied geology, Ireland, for its size, has a high diversity of habitats, but this is not reflected in species diversity. Ireland has proportionately the smallest area of native woodland still intact in Europe and steps for its conservation are being taken.

There are various categories of protected areas in Ireland. They include 76 Nature Reserves (of which 14 are designated as Council of Europe Biogenetic Reserves), seven Statutory Refuges for Fauna and 68 Wildfowl Sanctuaries (with 21 sites designated under the Ramsar Convention). There are five National Parks, with a feasibility study under way for another. Special Protection Areas (SPAs), comprising 75 sites, have been designated under the wild birds Directive. Two sites, Killarney National Park and North Bull Island, have been designated as Biosphere Reserves by UNESCO.

In addition, 68 species of flowering plants and ferns and their habitats are protected. Fauna species protected include bats, dolphins, porpoises, whales, seals and nine other mammal species, all wild birds, two reptile species, three amphibian species and three invertebrate species. In 1991 Ireland created the first European whale and dolphin sanctuary.

Following a nation-wide survey, 1,250 sites are being selected for designation as Natural Heritage Areas (NHAs) - areas of special interest for their fauna or flora, which will have a statutory basis under proposed legislation. The habitats Directive provides for a network of Special Areas of Conservation (including SPAs) called 'Natura 2000', the Irish elements of which will be chosen from the NHAs.

Six species of vascular plants are in danger of extinction in Ireland and 149 flowering plant species in all are under threat. Of the 25 Irish species of stoneworts (a type of aquatic algae) at least ten are considered to be threatened. Eight bird species, three fish species and one amphibian species are categorised as endangered (the most threatened category) and a further 30 vertebrate species in all are under varying degrees of threat.
Threats to wildlife conservation include overgrazing which affects upland bird species in particular, aquaculture which may cause problems of pollution and disturbance, afforestation and recreational developments, such as golf courses, in ecologically important areas, exploitation of privately owned peatlands, drainage, pollution, and competition from introduced non-native species.

Perhaps the greatest achievement in nature conservation in the past decade has been the apparent halting of the decline of two species in particular, the corncrake and the pine marten.

13. Noise

A major source of environmental noise is transport, with road traffic and aircraft being by far the most usual causes of noise disturbances to the city and suburban resident. Studies have shown that by-pass roads can result in a significant net reduction in the numbers of persons exposed to high noise levels. Vehicle engine noise has decreased in response to reductions in EU limits.

In relation to aircraft noise, the power of the source and the unobstructed transmission path may lead to disturbance over relatively wide areas. Legislation requires the progressive elimination of older, noisier, aircraft. Other noise abatement procedures have also been put in place. The orientation of a new main runway at Dublin Airport means that flight paths now avoid areas of high population density.

Fixed and identifiable sources give rise to most complaints about noise, for example, various industrial and commercial activities and construction sites.

Under Regulations made under section 108 of the EPA Act, an individual now has the power and opportunity to take action where he or she feels that any noise is giving reasonable cause for annoyance.

IV - MANAGEMENT, CONTROL AND ECONOMIC ASPECTS

14. Environmental Protection

A significant development, globally, is Agenda 21, the blueprint for global sustainable development into the next century. This was adopted at the Rio Earth Summit in 1992, along with Conventions on climate change and biodiversity. Around the same time, the EU's Fifth Environmental Action Programme identified major topics of concern and targeted industry, energy, transport, agriculture and tourism for particular attention.

In Ireland, the EPA, which was established in 1993, now implements integrated pollution control (IPC) licensing of industries and other activities having a significant polluting potential. This was one of the measures envisaged in the Government's Environment Action Programme (1990), which takes account of the following:

- the concept of sustainable development;
- the principle of precautionary action;
- the integration of environmental considerations in all policy areas.

The Government is preparing a National Sustainable Development Strategy for Ireland which will be published in 1996. Each local authority in Ireland is expected to develop a Local Agenda 21 for its area, through consultation and agreement with its local community.

Important areas for broadly-based integrated strategies include:

- land-use planning and land zoning;
- nature conservation;
- landscape conservation;
- coastal zone protection.

Significant methodologies for environmental protection and sustainable development include:

- IPC Licensing;
- Local Authority Licensing and Control;
- Environmental Impact Assessment;
- Risk Assessment and Risk Management;
- Mass Balance Inventories;
- Environmental Auditing;
- Environmental Management and Planning;
- Waste Minimisation Practices;
- Clean Production Technologies;
- Re-use, Recovery and Recycling Strategies;
- Safe Treatment and Disposal Practices.

The growing range of methodologies reflects the recognition of the need for a broadly-based approach to protecting the environment.

15. Economic Aspects

Substantial investment is made in environmental infrastructure in Ireland. Environment related expenditure is undertaken on a broad basis, both nationally and locally. The full range of 'environmental expenditure' is not clearly defined, which makes total expenditure difficult to quantify. Taking all identifiable direct spending on environmental measures into account, it has been estimated, possibly conservatively, that it amounts to about two per cent of gross domestic product (GDP).

Public investment in environmental infrastructure, inclusive of EU Cohesion and Structural Fund assistance and national resources, is planned to amount to at least £650 million over the period 1994-1999.

It has been tentatively estimated that manufacturing companies will invest upwards of £500 million in environmental protection facilities during this decade. The Rural Environment Protection Scheme (REPS), which has a budget of £230 million, is a particularly important agri-environment measure. Over the period 1994-1999 a total of £21 million will be invested by the Department of Transport, Energy and Communications and the Irish Energy Centre in energy conservation activities.

Economic instruments for environmental protection, such as taxes, charges and subsidies, have been in operation in Ireland for some time, but they are not extensively used. The importance of such instruments is recognised at European level, and there may be increased use in the future, resulting from wider application of the 'polluter pays' principle.

One example of an economic instrument is the lower level of excise tax charged on unleaded petrol. Sales of unleaded petrol as a percentage of total petrol sales rose from seven per cent in 1989 to 58 per cent by the autumn of 1995.

It has been estimated that, excluding farming, 155,000 persons are in direct employment that is significantly dependant on high environmental quality. A conservative estimate for 1987 was that 2.2 per cent of GDP was attributable to a high quality environment, and this was concentrated in high growth sectors including food processing and tourism. The Industrial Policy Review Group recognised the importance of preserving and enhancing Ireland's 'green image'. This is especially important for the agriculture and tourism sectors.

16. Sustainability - Issues and Indicators

The development of a comprehensive set of environmental and sustainability indicators for Ireland is a task which will require a special focus over the coming years. Indicators should have the value of reducing the number of parameters which otherwise would be necessary in describing a situation. They should simplify the communication process. Three main aspects of sustainable development can be distinguished: economic, social and environmental.

The main issues requiring consideration in relation to the development of environmental indicators in Ireland are those that have been mentioned in this Extended Summary. It is concluded, however, that priority should be given initially to three themes in particular; these are eutrophication, the urban environment and waste. Indicators would include those describing nutrient inputs, the extent of river length and lake waters subject to eutrophication, urban air quality in respect of emissions from traffic, and trends in waste generation and waste minimisation activities.

17. Discussion and Future Outlook

An assessment has been prepared by the European Environment Agency as part of the review process for the EU Fifth Environmental Action Programme. In Europe as a whole, successes were noted (a) in the reduction of emissions of heavy metals, sulphur dioxide and ozone-depleting substances, (b) in improved surface water quality and (c) in targeting point sources of pollution (although these successes are not necessarily reflected in each individual country). However, the overall progress made is not sufficient to improve the general quality of the environment and still less to progress towards sustainability. Without accelerated policies, the limited carrying capacity of the European environment will continue to be exceeded. Actions taken to date will not lead to sustainable development, and the report concluded that an accelerated environmental policy is needed.

The programmes in the National Development Plan (NDP) and Community Support Framework (CSF) that have particular significance for the environment include those on the following: industry, transport, energy, agriculture, forestry, fisheries and aquaculture, tourism, local development and environmental services. The provision of environmental services under the NDP/CSF will, *inter alia*, contribute to the ending of untreated sewage discharges into tidal waters from the larger population centres.

In relation to industry, the effective application of existing and evolving controls (IPC and non-IPC licensing) has the potential to achieve reduced resource use and emissions and hence minimise environmental effects. There is an emphasis on emissions reduction in IPC licensing. Transport, and in particular road traffic, is an environmental issue of growing importance which will require renewed attention, especially in relation to emissions and the general impact on the urban environment. The energy sector will also require an intensified effort along the lines of existing measures of conservation, alternative sources and reducing impacts.

Some successes have been achieved in relation to the most dramatic effects of farm wastes, e.g., as evidenced by reduced numbers of fish kills up to 1994. However, agriculture contributes to the unrelenting trend of increased slight to moderate pollution of rivers due to eutrophication. A continued sustained effort is required in order to reduce the releases to the environment of nutrients from farming activities.

Forestry, as a rapidly expanding and renewable resource-based industry with potential for both enhancement and degradation of the environment, requires special consideration in the context of an overall land use policy.

Fisheries and aquaculture also offer potential for sustainable growth but, if not managed properly, can be agents of resource depletion and environmental degradation. Environmental management in respect of these sectors is important not least because they are dependant on a high quality environment.

With tourist numbers continuing to grow, the issue of pressure from visitor numbers on sensitive sites requires close attention, particularly since, for tourism also, future success is inextricably linked to the quality of the environment.

There are various specific areas where environmental controls could be extended, for example, reduced thresholds in respect of the size of certain activities which would be subject to environmental impact assessment (EIA). Another such area is the general protection of the countryside and of heritage landscapes in particular.

Various information gaps have been identified in the course of the preparation of this State of the Environment report. There is a particular need for more information on emissions to the environment and on exposure to excessive noise levels. Further information is needed also on the extent of soil degradation and erosion caused mainly by overgrazing on hill and mountain areas. Certain information gaps, e.g., in relation to waste and specific aspects of air quality, are being addressed in projects initiated by the EPA. Work is commencing also on developing an overall integrated environmental information system for Ireland; also, the development of a co-ordinated national environmental monitoring programme, including groundwater, is at an advanced stage.

In general terms, the available data indicate that the quality of the Irish environment is good and compares favourably with most other Member States in the EU. In a period of economic growth, the environment in Ireland requires particular attention to secure its protection and to ensure that development is sustainable.

PART I

GENERAL INTRODUCTION AND BACKROUND

CHAPTER 1

GENERAL INTRODUCTION

BACKGROUND

Traditionally, environmental issues have been viewed largely in isolation. Assessments of air and water quality issues were made quite separately from each other, and scant attention was paid to other environmental 'media' such as soil and living resources. This attitude is now being replaced by a more broadly-based ecological approach which recognises that there are intricate and complex interactions within the wide field of the environment. It is now recognised that not only does each environmental medium merit due attention in its own right, but also that the interactions between it and the other media must be taken into account.

In the past, also, there was a failure to recognise the extent to which various human activities can have direct or indirect impacts on the environment. Although instances of gross pollution, of a mainly localised nature, from certain emissions to air and water were readily apparent, the emphasis in controlling them was mainly on treatment and disposal, i.e., on 'end-of-pipe' technologies. In more recent years, however, the need for a more holistic approach to assessing and controlling human impacts on the environment has come to be recognised.

Despite an increased awareness of the importance of the environment and natural resources, and a greater acceptance of the need to protect and conserve them, there is undoubtedly still a shortfall in the understanding of the full complexity of the issues involved and how they should be tackled. There is a growing awareness that a great many human activities affect the environment in diverse ways, but there is still insufficient awareness by individuals and by economic sectors about why and how particular activities should be modified in order to reduce or eliminate their adverse effects.

In recent years there has been growing concern regarding the potential impact of human activities on the global environment. The 'greenhouse effect' and damage to the ozone layer have drawn attention to the sensitivity of the global environment to human activities. In order to gain an understanding of these phenomena and their causes, it is necessary that the global environment be viewed as a single life-supporting ecosystem which is affected by the activities it supports.

The production of a State of the Environment report, which by definition should be as comprehensive as possible, has an important role to play in facilitating a more broadly-based, inclusive and integrated view of the environment. The present report is the second such report for Ireland, the first having been produced a decade previously by An Foras Forbartha (Cabot, 1985).

INTERNATIONAL CONTEXT

The Earth Summit and Agenda 21

The need to promote environmentally sustainable development was the focus of the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992. Referred to as the Earth Summit, the event brought together more heads of government than any meeting in history. It produced two international agreements:

- the United Nations Framework Convention on Climate Change;
- the Convention on Biological Diversity.

Two statements of principles were also produced:

- the Rio Declaration of Environment and Development;
- the Statement of Principles on Forests.

A further major outcome of the UNCED Conference was Agenda 21, which is a comprehensive programme of action towards the achievement of sustainable development into the next century. The objective is to achieve development that is economically, socially and environmentally sustainable. Agenda 21 deals with a wide range of issues, within a number of broad areas:

- *social and economic dimensions* - including poverty, consumption patterns, population, human settlements and human health;
- *conservation and management of resources* - including the atmosphere, oceans, freshwaters, biological diversity, aspects of land including desertification, deforestation and rural development, and also the safe use of chemicals and the management of wastes;
- *strengthening the role of major groups* - including women, young people, workers, farmers, business and industry, scientists, non-government organisations (NGOs), and local authorities;
- *means of implementation* - including financing, science and technology, legal and organisational aspects, education and information.

Agenda 21 emphasises the importance of information for decision making and stresses the need for information to be more accessible and to be presented in more useful and understandable ways.

State of the Environment Reports

The first State of the Environment reports were published by Japan and the United States in 1969 and 1970, respectively. By the early 1990s most industrialised countries had produced at least one report on the state of the environment, and some international organisations such as the European Union (EU), the Organisation for Economic Co-operation and Development (OECD), and the United Nations Environment Programme (UNEP) had also started publishing similar reports. Although originally conceived as administrative documents, the target readership for almost all of the more recent national reports in the different countries has been the general public. Most reports are targeted also towards political decision makers (Comolet, 1992).

The first report on the state of the European environment was produced in 1979. One of the more recent assessments was a 1992 report on *The State of the Environment of the European Community*. This was produced as part of the preparation of the latest in a series of action programmes at European level, the Fifth Environmental Action Programme. The title of the Programme is: *Towards Sustainability: A European Community Programme of Policy and Action in relation to the Environment and Sustainable Development.*

A series of initiatives, including ministerial conferences in Bergen and Dublin in 1990 led, in particular, to the launch of the 'Environment for Europe' process at a ministerial conference which took place in 1991 at Dobris Castle in the former Czechoslovakia. The Dobris Conference called for measures including the publication of a State of the Environment report for Europe (including the Central and Eastern European countries), which would serve as the basis for the longer-term development of an Environment Programme for Europe.

The pan-European State of the Environment report, *Europe's Environment: The Dobris Assessment* (Stanners and Bourdeau, 1995), was prepared by the European Commission's Task Force for the European Environment Agency (EEA) in co-operation with the United Nations Economic Commission for Europe (UNECE) and with the assistance of several other European and international organisations and individual European countries.

The Dobris Report, published by the EEA, focused on twelve serious environmental problems at European level (see box). These were singled out because of their pan-European character, their long-term nature, and the threat they pose to sustainability.

Serious Environmental Issues at European Level.

- *climate change:* a doubling of global carbon dioxide is expected, producing an estimated temperature rise of 1.5 to 4.5°C;
- *stratospheric ozone depletion:* concentrations have declined at mid-latitudes over Europe by 6 to 7 per cent during the past decade;
- *the loss of biodiversity:* between a third and a half of all fish, reptiles, mammals and amphibians in Europe are under threat;
- *major accidents:* the specific problems of nuclear safety in Central and Eastern Europe are being tackled by a strategy of assistance by 24 countries;
- *acidification:* severe acidification of freshwater affects southern Scandinavia;
- *ground-level ozone and other photochemical oxidants:* short-term summer peak levels of ground-level ozone affect more than 100 million Europeans;
- *the management of freshwater:* widespread over-application of fertilisers in agriculture is affecting the quality of surface waters and groundwaters;
- *forest degradation:* a 1992 survey in 24 countries showed that 24 per cent of trees were damaged as indicated by defoliation;
- *coastal zone threats and management:* marine pollution of the coastal zone is a serious problem in all of Europe's seas;
- *waste production and management:* an increasing amount of industrial waste is considered hazardous;
- *urban stress:* urban traffic is an increasingly important source of air pollution; urban transport accounts for about 30 per cent of total energy use in most cities;
- *chemical risks:* about 100,000 chemicals are marketed in the EU, and between 200 and 300 new ones appear each year.

(Based on Stanners and Bourdeau, 1995)

Some other significant findings of the report included the following:

- Europe accounts for between 20 and 30 per cent of global human-induced emissions of carbon dioxide, sulphur dioxide, volatile organic compounds and nitrogen oxides;
- on average, Europeans produce over one-third of a tonne of municipal waste per capita per annum;
- soil erosion in Europe affects 115 million hectares causing loss of fertility and water pollution;
- many bogs, fens and marshes have disappeared in western and southern Europe;
- about 113 million Europeans - 17 per cent of the population - are exposed to levels of noise that have serious impacts;
- little improvement has been made recently in energy efficiency in western Europe.

As noted above, the Dobris Report was published by the EEA. The EU Council Regulation establishing the EEA came into force at the end of 1993 with the decision to locate the Agency in Copenhagen. The main duties of the EEA include the production of objective, reliable and comparable information for those concerned with framing, implementing and further developing European environmental policy, and for the wider European public. The EEA is required to publish a report on the state of Europe's environment every three years.

NATIONAL CONTEXT

State of the Environment Report 1985

The first State of the Environment report for Ireland was produced by An Foras Forbartha (Cabot, 1985). A number of the issues and problems which that previous report addressed are summarised in the box below. Subsequently, two reports on *Irish Environmental Statistics* were produced, the most recent by the Environmental Research Unit (1993).

Some Issues Addressed in the 1985 State of the Environment Report for Ireland

urban environment: litter; dereliction of sites and of buildings; air pollution; traffic congestion;

rural environment: effects of arterial drainage; hedgerow removal; coniferous forest mono-culture; disposal of farm wastes; proliferation of one-off housing;

wildlife: 52 species of flora, 18 species of birds, three species of mammals, and one amphibian species all threatened; rapid decline of the corncrake *(Crex crex)*;

water: of the 6,928 km of river channel surveyed, two per cent was seriously polluted and 13.8 per cent moderately polluted; of the 39 lakes examined, 19 and part of another were assessed as eutrophic and five were assessed as hyper-eutrophic; of 21 tidal inlets assessed, two were of 'poor' quality;

air: smoke/sulphur dioxide levels as specified in the Air Quality Directive were breached at several sites in Dublin, particularly in 1981/82;

waste: indiscriminate dumping, shortage of data on waste generally.

(Cabot, 1985)

GREEN 2000 Report

In 1991, the GREEN 2000 Advisory Group was established by the Government to carry out a fundamental review of the key issues facing the natural environment. The terms of reference of the Group included an identification of policies and strategies which should be adopted to protect and enhance the natural environment. The report was presented to the Government in 1993. In relation to the state of the environment, the Group concluded from the available information that there had been some improvement in the following areas:

- reduction of the extent of serious pollution of freshwaters;
- improvement in air quality in Dublin;
- increased protection of some natural habitats;
- improvement in the quality of some bathing waters;
- increased public awareness of the environment.

The Group considered that while Ireland probably has the highest quality environment in the European Community, a slow steady deterioration in the following key areas has occurred which needs to be arrested:

- increase in the length of river channel in the moderately polluted category;
- decline in lake water quality;
- increase in groundwater contamination in certain areas;
- loss of natural habitats and species diversity;
- reduction in landscape quality.

The general recommendations of the Group included the following:

- as a minimum objective, any further deterioration of the natural environment must be arrested;
- environmental protection considerations must be fully integrated in all policy areas and at all levels of implementation by Government;
- the underlying theme for the subsequent round of Structural/Cohesion and other EU funds (1994-1999) should be to maximise Ireland's potential in having the highest quality environment in the European Community.

The major areas of economic and social activity examined by the Group were as follows: agriculture, aquaculture, energy generation, extractive industries, inland fisheries, forestry, manufacturing industry, nature conservation, landscape protection, tourism and transport infrastructure (GREEN 2000 Advisory Group, 1993).

In July 1994, the Department of the Environment produced a progress report in order to review the following:

(i) 'developments in environmental management and policy implementation, since April 1993, which, *inter alia,* address recommendations made by GREEN 2000', and

(ii) 'policies and activities of Departments/Agencies which address or are relevant to specific recommendations of GREEN 2000'.

The progress report (Department of the Environment, 1994) also reviewed aspects of the state of the environment, referring to its generally good condition, and made reference to the following specific aspects:

- significant smoke levels, although within the national standards, experienced in Cork; hence the introduction of smoke control measures in the city;
- a continuation of the previously established trends in relation to river and lake water quality;
- despite local instances of increased nitrates in groundwater, no evidence of significant or widespread contamination;
- planned expansion of National Parks, establishment of Nature Reserves, and designation of Natural Heritage Areas, which would contribute to the protection of landscape quality.

Recent Developments

Significant institutional changes have taken place in relation to environmental monitoring and protection in Ireland since the publication of the earlier reports referred to above. With the establishment of the Environmental Protection Agency (EPA) in 1993, both An Foras Forbartha and the Environmental Research Unit were abolished. The EPA has a much broader range of functions relating to the environment than those previous organisations. These functions include environmental monitoring, research, assessment, management, planning, advisory, licensing and control. The full range of functions of the Agency are set out in the Environmental Protection Agency Act, 1992, (EPA Act). Section 70 of the EPA Act provides for the preparation and publication of a State of the Environment report by the Agency every five years (or within other periods as may be prescribed).

The National Development Plan 1994-1999 states: 'During the period covered by this Plan the Agency will prepare and publish a report on the quality and condition of the environment. This will include an assessment of the impact of developmental policies and investments under this Plan'.

In the light of the foregoing, and in the context of a decade having passed since the preparation of the first State of the Environment report, the EPA decided to make the preparation of a report on the quality and condition of the environment one of its first priorities, and work on the project began during 1994. The Government programme announced in December 1994 endorsed the role of the EPA in reporting on the state of the environment.

A major review of perceived environmental issues and of research requirements and priorities has also been undertaken by the EPA (Fegan, 1995). This was based on consultation with more than 60 organisations, government departments and representative bodies in the industrial, tourism, forestry, fishing, planning and local authority sectors, as well as the larger environmental NGOs. The questionnaire responses were compared with the priority environmental issues as identified in the EU Fifth Environmental Action Programme and certain key issues, in the Irish context, were apparent. In the order of those most frequently mentioned by the respondents, the main issues identified were as follows:

- pollution of water resources;
- waste;
- air pollution;
- depletion of natural resources and biodiversity;
- deterioration of coastal zones;
- climate change;
- deterioration of the urban environment.

Certain priority environmental research projects, as identified in the review of research needs, are being addressed under a research and development sub-programme of the Operational Programme for Environmental Services 1994-1999 (Chapter 15).

APPROACH ADOPTED

In keeping with the practice that has developed in other countries, the aim of this report is to provide information both for the general public and for those involved in the preparation and implementation of policy in the different sectors of the economy.

It has been stated in relation to State of the Environment reports that it is not sufficient to describe the condition of the environment at a given time, but it is also necessary to diagnose problems in a way that allows a government to set priorities. However, the difficulty of making precise identification of causes and effects relating to the implementation of certain actions and their impacts on the quality of the environment was also acknowledged (Comolet, 1992). Nevertheless, there is a clear need to move beyond descriptive reports and to make such reports, as far as possible, more evaluative in relation to existing policies and actions and their efficacy. This approach is also consistent with the type of report called for in relation to the National Development Plan.

A full evaluation of all of the relevant measures in relation to the environment would of course be beyond the scope of a document such as this and would be a significant undertaking in itself. At European level the need for separate assessments of this type has been recognised, and the EEA recently commissioned a special study: *The State of Action to Protect the Environment in Europe* (IEEP, 1995).

Internationally, the structure of State of the Environment reports, following OECD recommendations, has tended to be based on three main elements: *pressure, state and response.* The pressure aspect embraces all of the discharges to the environment and other human actions directly affecting the environment. The state aspect is a description of the quality of the different environmental media. The response aspect relates to the responses from the relevant authorities in relation to policies and actions for protecting the environment. This structured approach has proved extremely valuable, although there are some limitations, particularly in relation to the social element and the context in which the various activities occur that have a bearing on the environment i.e., the 'driving forces'.

The main objective of this report is to assemble and evaluate in a single volume the available information on the state of the environment in Ireland. Where there are gaps in the available information, the report aims at identifying these so that steps may be taken to facilitate more complete assessments in the future.

It was decided to produce a report consisting of a single volume in four parts as follows:

Part I. General Introduction and Background (Chapters 1 - 3).

This Part summarises the background and driving forces both nationally and internationally, in both geographical and socio-economic terms, and outlines the methods of assessing the quality of the environment in order to guide the reader and to set the scene for the main body of the report.

Part II. Pressures on the Environment (Chapters 4 - 7).

Chapter 4 deals with the overall question of pressures on the environment from all significant sources, and Chapters 5 to 7, in turn, deal in greater detail with emissions to air, discharges to water and waste.

Part III. Environmental Quality and Pollution. (Chapters 8 - 13).

This Part provides the assessment of the quality status of different environmental media: air and precipitation quality; inland water quality; estuarine and coastal environment; terrestrial environment; as well as natural heritage and noise.

Part IV. Management, Control and Economic Aspects (Chapters 14 - 17).

This Part summarises the current situation in relation to pollution control (including integrated pollution control - IPC) and environmental protection measures, including economic aspects. Aspects of sustainability are considered. The final chapter is a summing-up of the situation and deals with each of the main environmental problems, the impact of development policies and actions under the National Development Plan, and the likely future responses needed.

INFORMATION SOURCES

The content and structure of the report, as outlined above, was decided on the basis of wide-ranging consultations. A number of working groups were established to deal with specific themes of the report such as noise, the terrestrial environment and economic aspects. Several organisations made detailed submissions in relation to the report content and these organisations are listed in the Acknowledgements.

In relation to air and water quality, the State of the Environment report summarises the findings of the Environmental Protection Agency's reviews of these environmental media and of other reviews undertaken over the past decade. These documents are referenced in the text and they should be consulted if more detailed information on these aspects of the environment is required.

It is now widely accepted that the preparation of broad assessments of this type are feasible only if they are confined to data that have already been gathered, for example in monographs on specific environmental media or in sectoral reports. To initiate specific studies, surveys and other data gathering exercises as part of the preparation of a State of the Environment report would be impracticable, resulting in undue delays. It was considered essential, therefore, that the report should highlight deficiencies in the available information on the environment. These should be rectified as far as possible in the period prior to the preparation of the next report. Accordingly, sections on 'information gaps' are included in relation to the main topic areas covered in the report .

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Slí Cualann Nua
WICKLOW WAY
Slí Cualann Nua
WICKLOW WAY

CHAPTER 2

PHYSICAL AND SOCIAL BACKGROUND

PRINCIPAL FEATURES

General Features

The island of Ireland (Fig 2.1) is bounded on the north, west and south by the Atlantic Ocean. The Atlantic waters lying off the south coast are known as the Celtic Sea. To the east lies the Irish Sea, which separates Ireland from Britain. The Irish Sea has a maximum width (between Dundalk and Heysham) of 225 km (Shaw, 1990) but is much narrower in places; for example, down to 75 km at its southern end and 30 km in the North Channel.

Ireland

Co-ordinates	
between 51.5° and 55.5° north latitude	
between 5.5° and 10.5° west longitude	
Area	
Republic of Ireland	70,282 km^2
Northern Ireland	14,139 km^2
Total	84,421 km^2
Greatest length (N - S)	486 km
Greatest width (E -W)	275 km
Highest mountain	Carrantouhill (1,041 m)
Longest river	River Shannon (370 km)
Largest lake (Republic of Ireland)	Lough Corrib (16,900 ha)
Hours of daylight	
Minimum (December)	7.0 - 7.8 hours
Maximum (June)	16.5 - 17.5 hours

Several coastal mountain ranges surround Ireland's broad central plain, whose flatness is relieved in many places by low hills and ridges. The River Shannon, the longest river in the country, rises in the Cuilcagh Mountains in Co. Cavan, flows slowly through the central plain, and reaches the tide at the head of the Shannon Estuary, which itself is the country's largest sea inlet. There are a number of other slow-flowing rivers draining the central plain, whereas the rivers on the seaward side of the mountain ranges are short and flow rapidly to the sea. There are approximately 4,000 lakes, large and small, in Ireland, covering approximately one-fiftieth of the total area of the country. Inland surface waters comprise a much higher percentage of total area in Ireland compared to many other European countries.

Ireland has one of the highest proportions of land devoted to agriculture in Europe, with the main use being grassland. In contrast, forest cover in Ireland is particularly low compared to other European countries (see Chapter 11).

Extensive bogland, including raised bogs in the midlands and blanket bog on the mountains, covers a significant proportion of the land in some parts of Ireland.

Much of the coastline is heavily indented, particularly along the entire western seaboard. Consequently, in relation to the land area, the coastline is particularly long. Determination of its exact length depends on such factors as whether estuaries and islands are included and, in particular, on the scale of the maps used for measurement. Using Admiralty charts ranging in scale from 1:150,000 to 1:200,000, the Irish Marine Data Centre has calculated the length of the coastline, including estuaries and most islands, to be as follows: approximately 7,800 km for the whole island of Ireland, and approximately 7,100 km for the Republic of Ireland (Whaley, J., pers. comm.).

Geology

Ireland's foundation or basement rocks are crystalline metamorphic and igneous. These lie beneath the sedimentary rocks of the midlands and south, and are exposed in the west and north. A great variety of metamorphic rocks occupies large areas in the north and west, including Connemara (Twelve Bens and Joyce's Country), Croagh Patrick and an area covering practically the whole of Donegal. Old Red Sandstone dominates the geology of the south and south-west - the mountains of Kerry, the Comeraghs, the Knockmealdowns and other mountain ranges in these areas. Carboniferous limestone is the dominant rock formation in Ireland, covering over one-half of the country (Fig. 2.2).

The fertile soil of Ireland owes its origin to the action of ice during two glacial periods in particular, the Midlands general glaciation and the Munsterian glaciation. Glacial activity has directly affected the way in which soils have developed and are distributed. It has also provided building materials such as sand and gravel. Some of the country's most important aquifers are found in deposits formed by the action of ice (Nevill, 1963).

Fig. 2.1 *Ireland (Source: ERA-Maptec).*

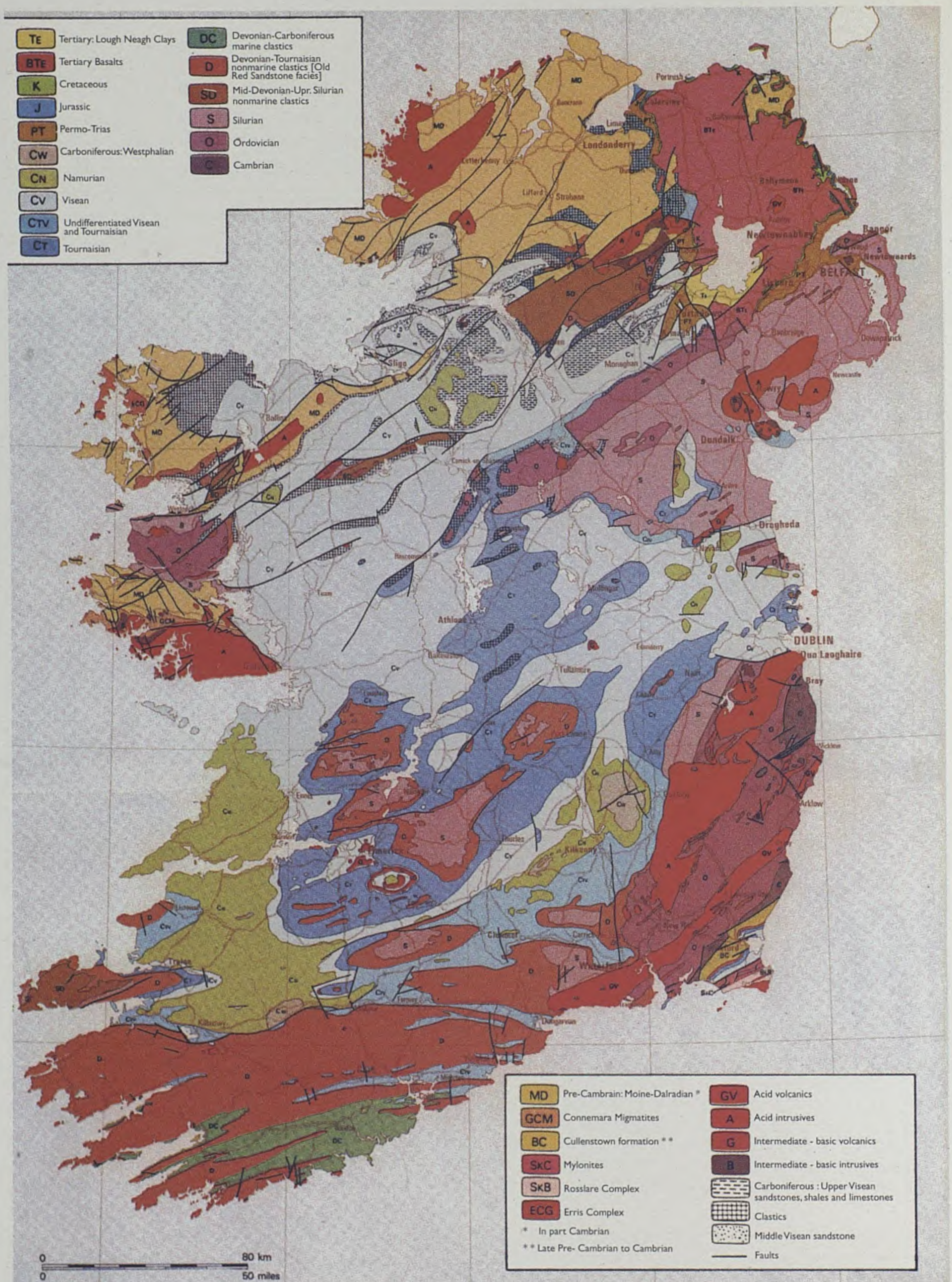


Fig. 2.2 Geological Map of Ireland (Source: Atlas of Ireland, Published by the Royal Irish Academy in 1979. Compiled by the GSI).

Climate

The climate of Ireland is influenced by a combination of the warm North Atlantic drift and the prevailing winds from the south-west. The climate, therefore, has a markedly maritime character which is strongest near the Atlantic coasts and decreases somewhat with increasing distance from the coast. However, as the island is small, with no area being more than 120 km from the sea, the range of mean temperatures over the country is relatively narrow (Fig. 2.3).

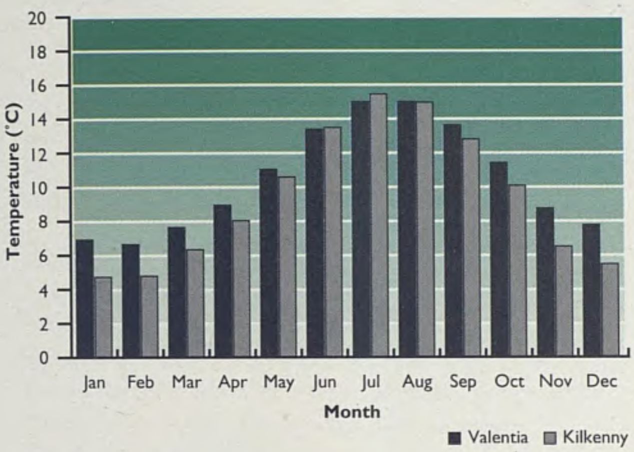


***Fig. 2.3** Mean Monthly Temperatures at Selected Stations - Valentia Observatory (SW coast) and Kilkenny (inland) 1964-1994 (Source: Meteorological Service).*

January and February are the coldest months with mean daily air temperatures between 4°C and 6°C. July and August are the warmest, with mean daily air temperatures between 15° and 16°C, although temperature values on particular days can occasionally reach or exceed 30°C.

In Ireland, average wind speeds are highest along the north, west and south coasts and decrease with increasing distance from the coast. Mean annual wind speeds for the period 1961-1990 varied from 8.2 metres/second (m/s) at Ireland's most northern point, Malin Head, Co. Donegal, to 3.3 m/s at Kilkenny in the Nore valley. January and December are the months with the highest mean wind speeds, while the lowest occur in July and August.

The mean annual rainfall (1961-1990) is estimated at between 1,150 and 1,200mm. However, rainfall is distributed unevenly across the country, with the western half of the country having a much higher rainfall than the eastern half (Fig. 2.4). Most areas in the east have between 750 and 1,000 mm/annum of rainfall, with less than 750 mm falling in the Dublin area. Rainfall in the west averages between 1,000 and 1,400 mm generally. Mean annual rainfall totals in excess of 2,000 mm are not uncommon in some mountain areas, with up to 3,000 mm at a small number of locations in the mountains of the west and south-west (Rohan, 1986; Carrigan, P., pers. comm.).

Water Resources

A minimum estimate of Ireland's renewable water resources may be derived from the 1,150 mm annual average precipitation. Estimated losses due to evapotranspiration are in the order of 450 mm giving an effective annual precipitation of approximately 700 mm. About 31,000 litres of surface water per capita per day are available, which is four times that of the most densely populated European countries. There are, however, wide variations between different parts of the country.

For various technical and economic reasons not more than 50 per cent of Ireland's total water resources can be developed. The ground water resources of the Republic of Ireland have been compiled and mapped by the Geological Survey of Ireland (GSI), and published by the Commission of the European Communities. The aquifers of Ireland have been identified only very approximately (Kenny, 1993).

There is increased demand for water, which, in the case of drinking water, must be treated to EU standards. In 1991, over 98.6 per cent of private dwellings in the State had piped water supply compared with 78.8 per cent in 1971 and 95 per cent in 1981. The State has over 800 public water supply schemes which supply about 80 per cent of the population and the remaining 20 per cent have their water supplies from private group schemes or from their own individual wells and boreholes.

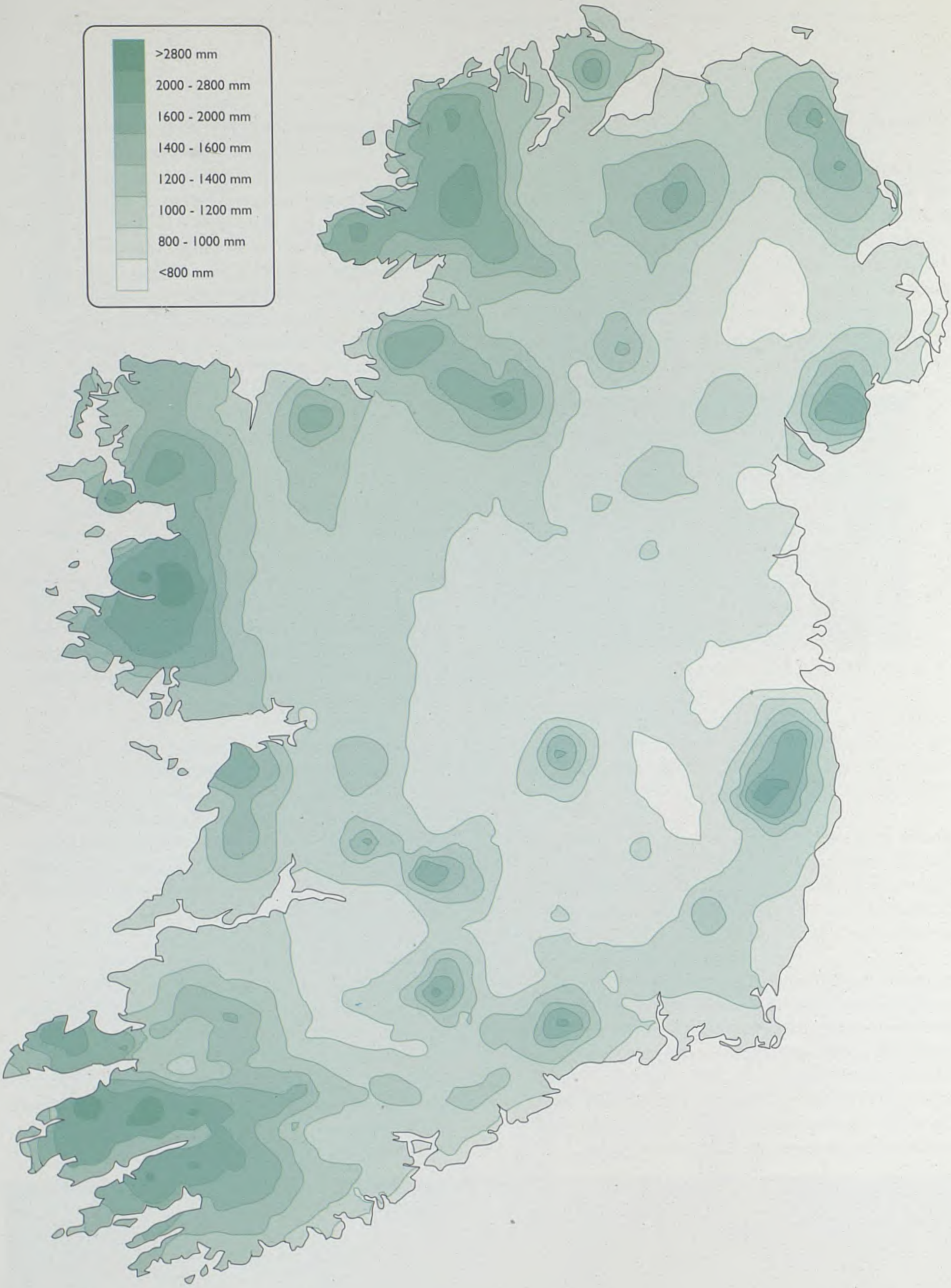


Fig. 2.4 *Mean Annual Rainfall Map 1961-1990 (Source: Meteorological Service).*

POPULATION

The changes in the population of Ireland from 1841-1991 are shown in Fig. 2.5. At the culmination of a long period of decline, in 1961 the population reached the lowest census figure on record - 2.82 million. Subsequently, the population increased appreciably (by 15.6 per cent in the period 1971-1981), and this was followed by a slight reduction:

Year	Population (million)
1971	2.98
1981	3.44
1986	3.54
1991	3.52

In 1994 the population was estimated to have increased slightly again to 3.571 million.

In relation to future trends, population projections have been made by the Central Statistics Office (CSO) using different combinations of fertility rate and migration assumptions, and the projections for the year 2006 range from a low of 3.54 million to a high of 3.72 million (CSO, 1995a) and the most likely outcome is considered to be a population of 3.62 million persons.

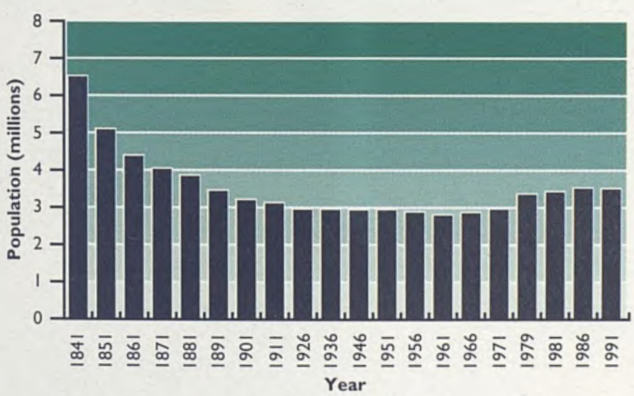


Fig. 2.5 *Population of Ireland 1841-1991 (Source: CSO).*

The average population density of 51 persons/km^2 is low relative to other countries in northwestern Europe. The population density varies from over 100 persons/km^2 in parts of the east and south to less than 25 persons/km^2 in many parts of the west (Fig. 2.6).

There have been notable changes in the distribution of population between urban and rural areas. Over the period 1901-1971 there was a strong trend of increasing town and decreasing rural populations. The decline in the rural population resulted from both emigration and migration to towns. The trend was reversed for a period when the rural population increased by approximately 180,000 between 1971 and 1986. However, it decreased again by 23,000 between 1986 and 1991.

The aggregate town population (i.e., towns of 1,500 population or greater) has continued to increase since 1971, but the rate of increase has slowed:

Year	Aggregate Town Population Increase
1971 - 1981	33,000 per annum
1981 - 1986	11,000 per annum
1986 -1991	9,000 per annum

In 1991, 57 per cent of the population lived in aggregate town areas, compared with 28.3 per cent in 1901 (CSO, 1993). Thus, over the course of the present century, Ireland has changed from having a predominantly rural population to a situation where the balance has clearly been directed towards a mainly urban population.

The broad population changes described above mask regional differences. For example, the rural population has declined more rapidly outside the province of Leinster and particularly in the west and north-west. The urban structure is very strongly biased towards Dublin, with over one-third of the country's population living in the general area of the city and its environs. While Dublin city has been losing population, the suburbs and towns around the city and the nearby countryside have been showing a strong growth trend. A pattern similar to this has occurred in the main urban growth areas elsewhere in the country: Cork, Limerick and Galway.

Despite the overall slight decline in population between 1986 and 1991, the trend of increasing population continued in some areas, particularly in areas close to these main urban centres (Fig. 2.7).

ECONOMIC SECTORS

Because this report is being prepared within the period covered by the European Union (EU) Fifth Environmental Action Programme, it addresses in particular the sectors of industry, energy, transport, agriculture (including forestry) and tourism which are identified as key sectors in the Programme. A brief outline of some of the relevant trends in these sectors is given in this chapter. This is not intended to be a comprehensive overview of the sectors, and other aspects of them are considered in the appropriate chapters of the report, notably in Chapter 15, which covers economic aspects. The present chapter also outlines some relevant aspects of the fisheries sector, which is of particular importance in the context of the environment.

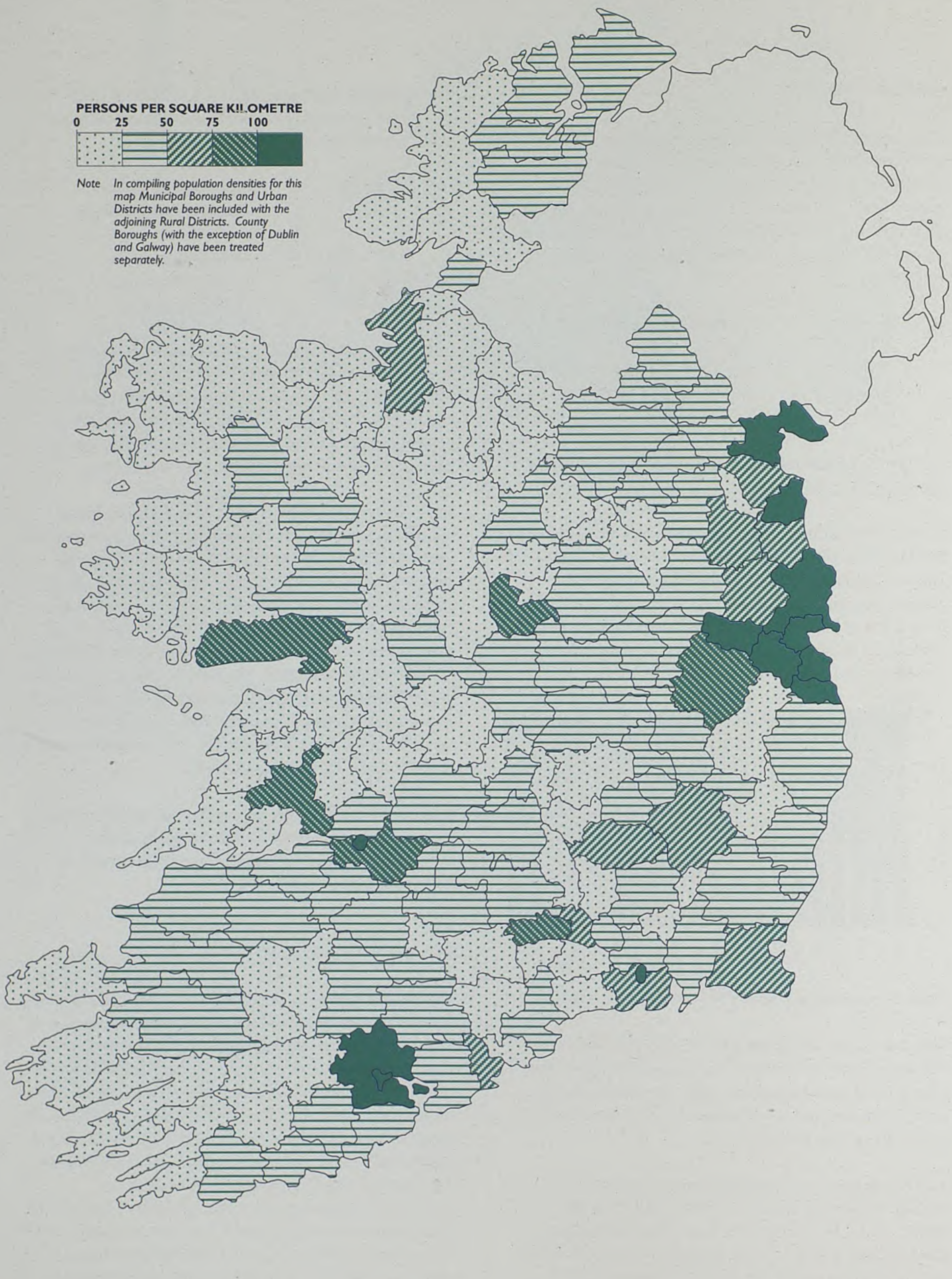


Fig. 2.6 *Population Density of Rural Districts 1991 (CSO, 1993).*

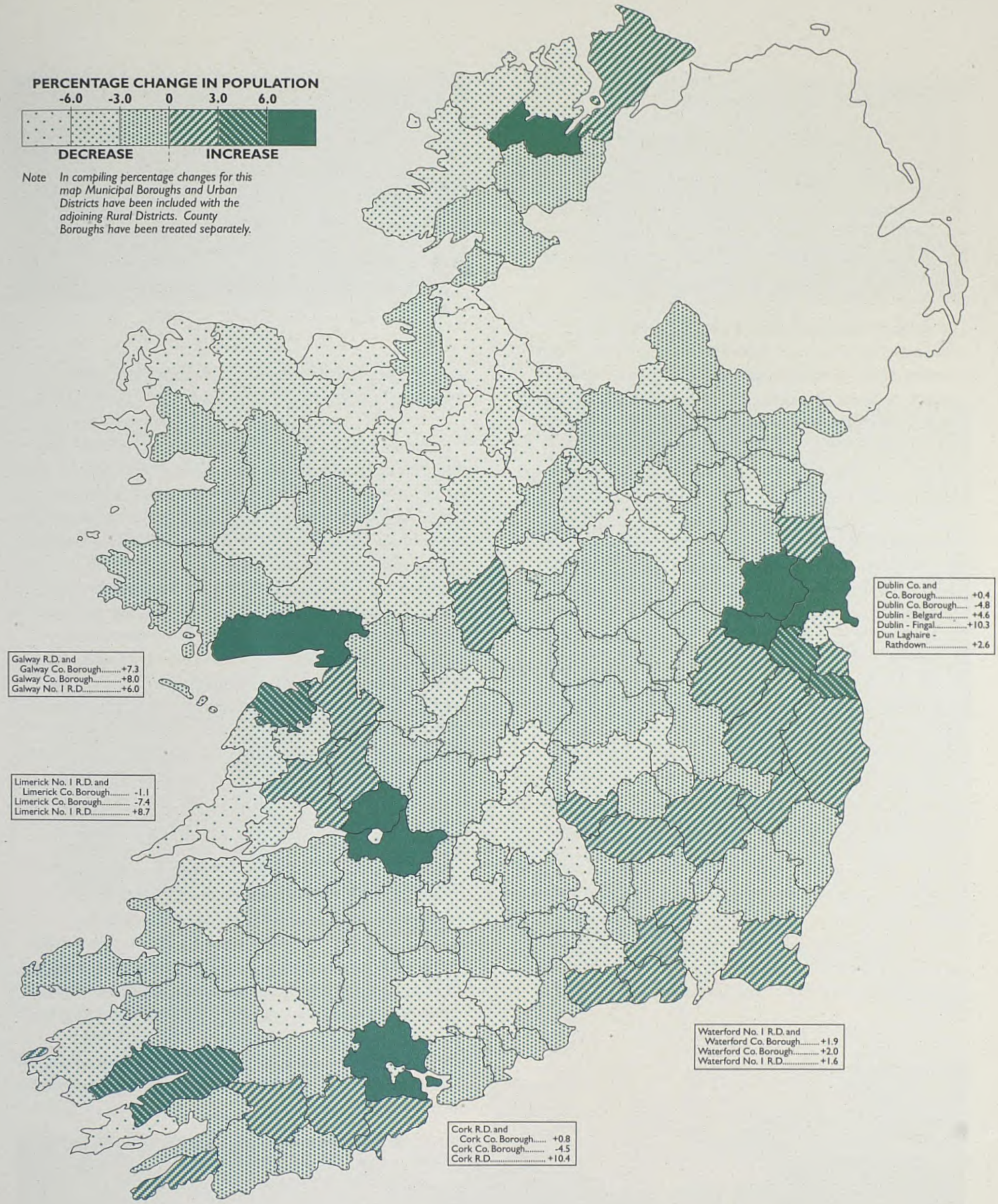


***Fig. 2.7** Population Change of Rural Districts 1986-1991 (CSO, 1993).*

Industry

Industrial development in Ireland, notably in the manufacturing sector, was minimal until the 1960s when the government began actively to promote foreign investment. Ireland's accession to the then EEC in 1973, together with an array of financial inducements, made the country a very attractive base from which to supply the much larger EU market (Breathnach, 1993).

The eastern region had previously dominated in the manufacturing sector, but between 1971 and 1981 three-quarters of the national employment gain was in eleven western counties (Breathnach, 1985). In the manufacturing sector, IDA Ireland has indicated that it is now much less able to influence the location within Ireland of new foreign controlled industries than it was in the 1970s (Walsh and Gillmor, 1993).

In the period 1982-1992 considerable growth arose in the services sector, and towards the end of the period was linked particularly to the creation of the International Financial Services Centre (IFSC) in Dublin. Over two-thirds of these services firms were in the financial sector (Breathnach, 1993).

In 1994 the aggregate employment in manufacturing industry was 204,712 persons. The percentage share of this employment in the main sectors was as follows: metals and engineering, 36.8 per cent; food, 19.2 per cent; chemicals, 8.7 per cent; paper and printing, 6.8 per cent; clothing and footwear, 5.5 per cent (O'Hagan, 1995).

The average growth rate of the pharmaceuticals industry in recent years (1985-1993) has been 13 per cent. The country has become the world's 15th largest exporter of these products which comprise 18.6 per cent of total exports. The main products are fine chemicals, drugs and hospital products (Department of Foreign Affairs, 1995).

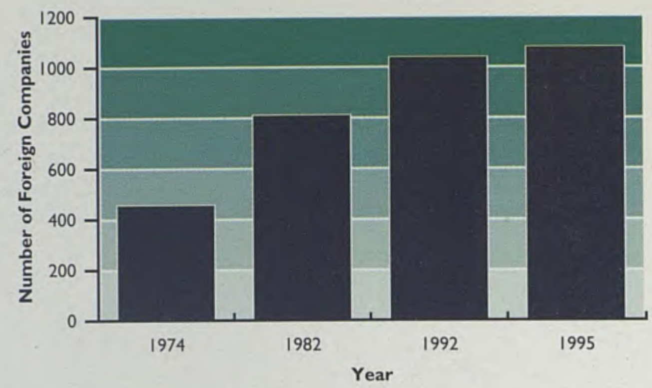
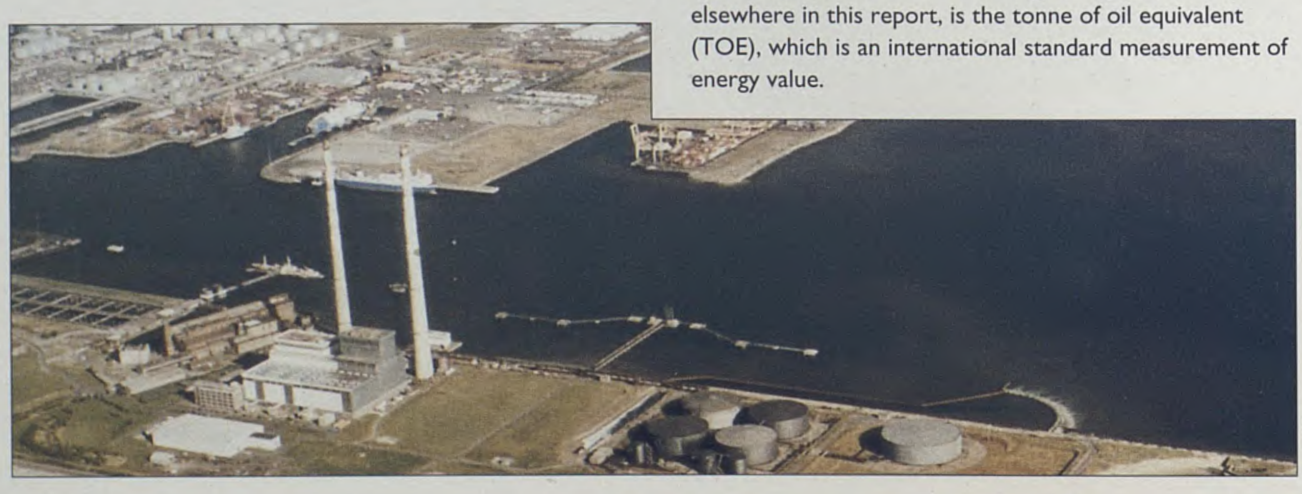


Fig. 2.8 *Growth in the Numbers of Foreign Firms (Source: Breathnach and the Industrial Development Authority).*

Indigenous industry has had to face many challenges and difficulties since, firstly, the Anglo-Irish Free Trade Agreement of 1965 and then accession to the EEC - particularly the opening up of the domestic market to free competition. As with other countries, Ireland suffered the effects of two oil crises in the 1970s and early 1980s. Although total manufacturing employment (excluding traded services) in Ireland has declined by four per cent since 1973, the numbers employed in manufacturing in many developed countries declined by substantially more over the same period. The overall performance of the indigenous manufacturing sector has shown improvement in recent years. Almost 60 per cent of such enterprises are now engaged in export activity with over 53 per cent of total sales going to export markets (O'Brien, P., pers. comm).

Energy

In Ireland, the general trend of per-capita energy consumption in recent decades has been gradually upward. This is illustrated in Fig. 2.9 which shows the per-capita energy consumption for specific years in the period 1973 to 1993, and despite some fluctuations, a general trend of increased consumption is apparent. It may be noted that the unit used for energy in Fig. 2.9, and elsewhere in this report, is the tonne of oil equivalent (TOE), which is an international standard measurement of energy value.



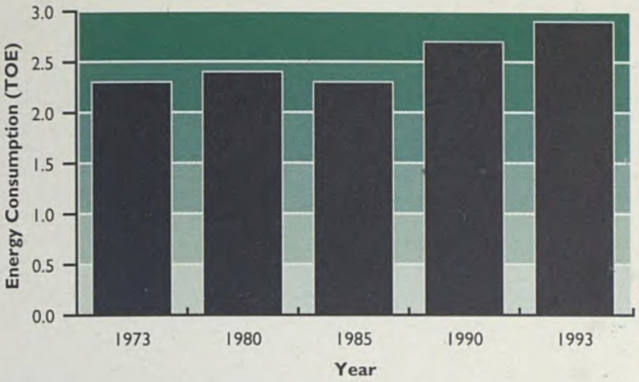


Fig. 2.9 Per-capita Energy Consumption in Selected Years from 1973 to 1993 (Source: Department of Transport, Energy and Communications and O' Rourke, 1991).

Ireland has few indigenous sources of fuel and therefore is dependent on imports to meet most of its energy requirements. Imports account for about two-thirds of the energy supply. Dependency on oil was reduced significantly through the 1970s and 1980s, but the trend has been reversed to some extent in more recent years. This is illustrated in Fig. 2.10.

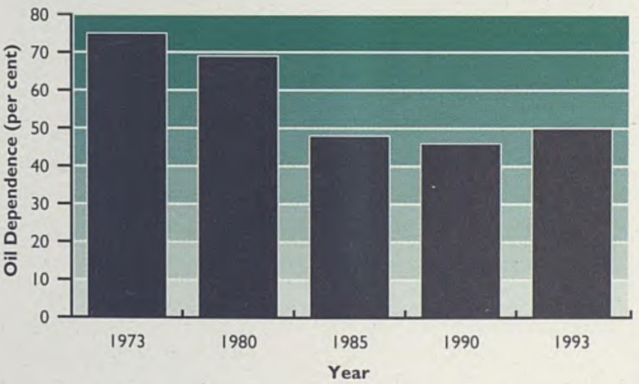


Fig. 2.10 Oil Dependence in Selected Years from 1973 to 1993 (Source: Department of Transport, Energy and Communications).

Although reduced from the levels of the 1970s, the use of oil as an energy source remains significant in comparison to other sources. This is apparent from Fig. 2.11, which shows the variation in the annual total primary energy requirement for the period from 1980 to 1994 and also the proportion of this which has been met by the various types of energy source (Myers, 1994).

The contribution of coal increased from nine per cent in 1980 to 25 per cent in 1987. The coming into operatation of the Moneypoint coal fired power generation station had a major impact on national coal consumption. Domestic usage of coal grew steadily up until 1987 but has fallen since, a contributory factor in Dublin being the

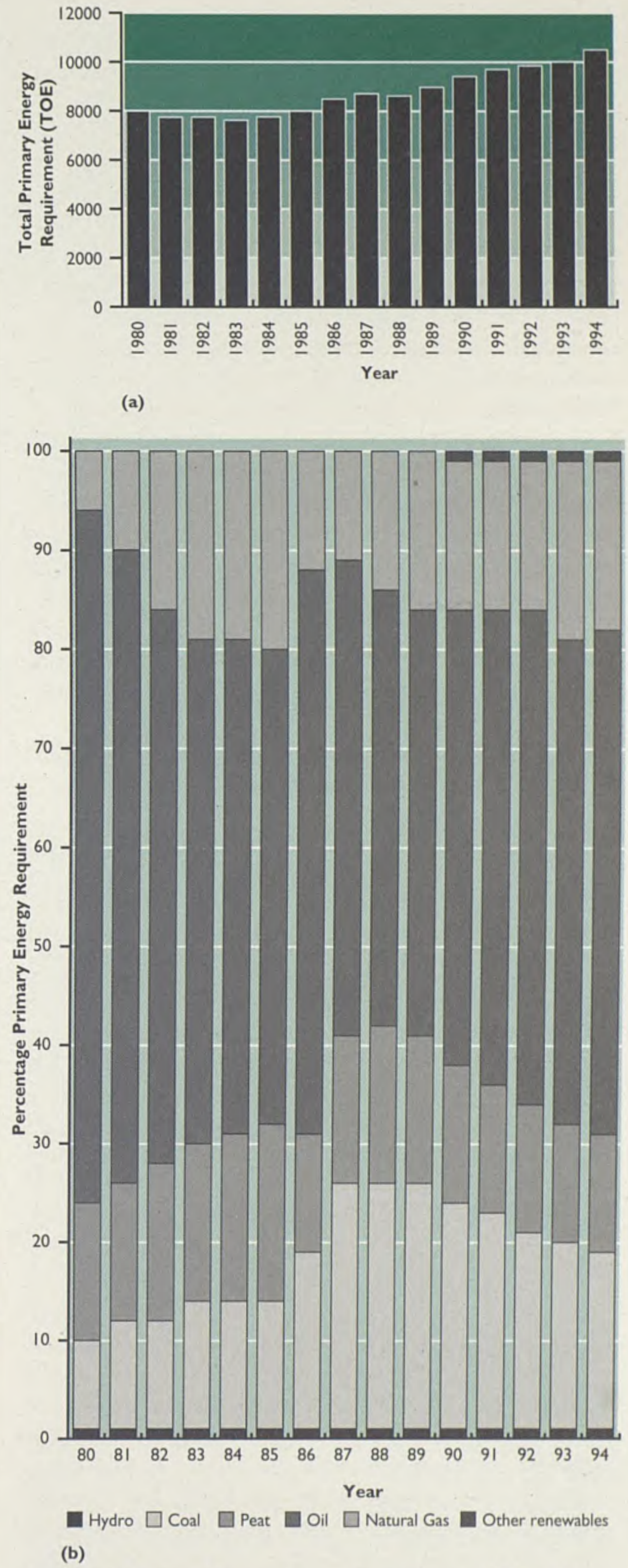


Fig. 2.11 (a) Total Primary Energy Requirement 1980-1993, by Volume ('000 TOE); (b) Percentage Primary Energy Requirement.

(Note: the length of the relevant shaded section denotes the percentage source (e.g., Peat made up 14 per cent in 1980)).

introduction of Regulations in 1990 banning the marketing of bituminous fuel to the domestic sector. The overall contribution of coal had fallen to 18 per cent in 1994.

Peat has been used as a source of fuel in Ireland for several centuries. In 1946, Bord na Mona was established to 'acquire and develop bogs, to produce and market peat and to foster the production and utilisation of peat and its products'. There are approximately 130 million tonnes of peat in its bog units. If present rates of extraction continue, the production life of these bogs is some thirty years. In recent years, between 12 and 14 per cent of the State's total primary energy requirement has been met from peat (Fig 2.11). Milled peat is used primarily for the production of electricity at five generating stations. A new 'Europeat I' power station will come on stream at the end of the decade. One million tonnes of peat are processed each year into briquettes with a further 500,000 tonnes used in the manufacture of horticultural peat products.

Owing to changes in technology and the introduction of the private bog scheme under the Turf Development Act, 1981, the production of peat by the private sector has grown significantly, from a base of 300,000 tonnes in 1982 to 1.5 million tonnes in 1994 (McNally, G., pers comm.).

Natural Gas

Commercially viable reserves of natural gas were found off the south coast (Kinsale Head) in the early 1970s. In 1978, natural gas production began, and it was initially used in industry sectors. Significant inroads were made in the domestic sector after 1985 when the Cork to Dublin pipeline was completed. It is hoped that by the end of the decade natural gas will be available to 40 per cent of Irish homes.

Natural gas is central to Ireland's strategy for reducing emissions of carbon dioxide and sulphur dioxide.

The Ireland/UK Natural Gas Interconnector was completed in 1993. This connects Ireland to the natural gas distribution networks in the UK and ultimately to the extensive supply infrastructure of continental Europe and beyond. The pipeline will initially be used to access alternative emergency supplies in the event of a disruption in supply from the Kinsale Head platform and to augment production as fields decline. In the event of further indigenous supplies being discovered, the pipeline can be used to export any gas which is surplus to national requirements.

(Source: Department of Transport, Energy and Communications).

In 1990, Forbairt began collecting information on all renewable energy resources. The technologies included are solar, geothermal, heat pumps, biomass, and wind energy, which in total gave rise to 113,477 tonnes of oil equivalent (TOE) in 1994. Details of the Alternative Energy Requirement (AER) scheme are given in Chapter 15.

Ireland does not have a nuclear power generating capacity.

Combined Heat and Power

In 1993 a number of Combined Heat and Power (CHP) units were installed in Ireland as part of the EU funded Thermie programme. Market interest in CHP is growing rapidly. The chief attraction of this application is to reduce energy costs by utilising the heat which is produced in the process of generating electricity. The savings over conventional costs of purchasing electricity from the grid and of fuel for heating can often provide a very attractive return on the capital investment in a CHP scheme.

(Source: Department of Transport, Energy and Communications)

The distribution of energy demand among the different sectors has been consistent in recent years and is shown in Fig. 2.12. Residential buildings account for about one third of the demand, but when buildings in the other sectors are taken into account, overall energy use in buildings accounts for about 50 per cent of the national total (O'Rourke, 1991).

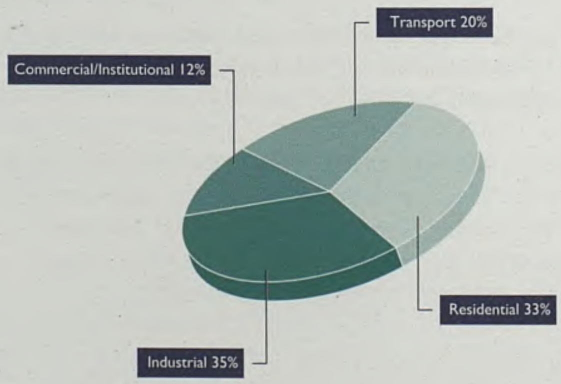


Fig. 2.12 *Sectoral Energy Demand (Source: O' Rourke, 1991).*

Transport

For its population size, Ireland has a very extensive system of public roads compared to other European countries. There are 92,300 km of roads (which amounts to about 1.3 km/km^2). This is equivalent to just over 26 km per thousand people - high by European standards - roughly twice as much as Belgium, Denmark and France, and over three times as much as in Italy, the Netherlands and Spain. The public roads are classified into three broad categories: national primary and national secondary roads - the principal long distance inter-urban routes linking the main ports, airports, and urban areas; regional roads - the main feeder routes into national roads and the main links between them, and local roads which are the balance of the public road network, including both county roads and urban roads. National roads (primary and secondary) comprise only six per cent of the total network in the State but carry almost 37 per cent of road traffic. National primary roads which account for less than three per cent of total road mileage, carry over one quarter of all road traffic.

Studies undertaken in the 1980s identified major deficiencies in the road system which was then attempting to cope with increasing traffic volumes and heavier goods vehicles which impose major demands on road structure. Many towns and cities were experiencing serious traffic congestion, resulting in both noise and air pollution. The congestion was also impeding commercial and social activities in the areas concerned. Industry relying on the road system to transport goods to ports for export had to contend with unpredictable journey times and increased transport costs. Over the past ten years a number of motorways, dual carriageways and ring roads have been completed.

Roads account for 90 per cent of all goods transport and for 96 per cent of all passenger transport. The changes in the numbers of mechanical vehicles since 1975 are shown in Fig. 2.13.

* Motor tax was abolished for most private cars in 1977 and was re-introduced in 1981.

** Figures based on reference date of 31 Dec. Figures for previous years based on reference date of 30 Sept.

Mechanically propelled vehicles include motorcycles, agricultural tractors, road tax exempt vehicles, off-road dumpers, excavators, as well as other mechanically propelled vehicles.

Fig. 2.13 *Mechanical Vehicles 1975 to 1993 (Source: Department of the Environment, Vehicle Registration Section).*

Railways account for less than three per cent of passenger transport. From the 1950s, the emphasis rested on linking the major urban centres, with Dublin at the hub of the network. The mid 1980s saw the opening of the Dublin Area Rapid Transit (DART) suburban line. Passenger numbers on this line have grown from 7.5 million in 1984 to 16.1 million in 1992. Mainline rail passenger numbers showed a gradual upward trend over much of that period (ERU, 1993). A new service, the Arrow, has been introduced between Kildare and Dublin. A development plan provides for upgrading and replacement of trackwork and signalling equipment and purchase of new locomotives. Rail carries significant volumes of bulk and other freight traffic, much of which is unsuited to transport by road. Up to 85 per cent of rail freight is import/export traffic. As with passenger traffic, freight traffic flows are small by European standards.

Because of Ireland's peripheral island location, sea and air routes fulfil the same role for this country as cross-frontier land transport links for central EU Member States. Sea is the dominant mode of access transport for trade, with ports accounting for 76 per cent of trade in volume terms and 60 per cent of exports by value. Even these figures underestimate the importance of ports as most of the remaining trade is via ports in Northern Ireland.

Sea traffic accounts for 35 per cent of passenger traffic to other countries. Passenger ferries operate from the main ports on the east and south coasts: Dublin to Holyhead; Dun Laoghaire to Holyhead; Rosslare to Fishguard,

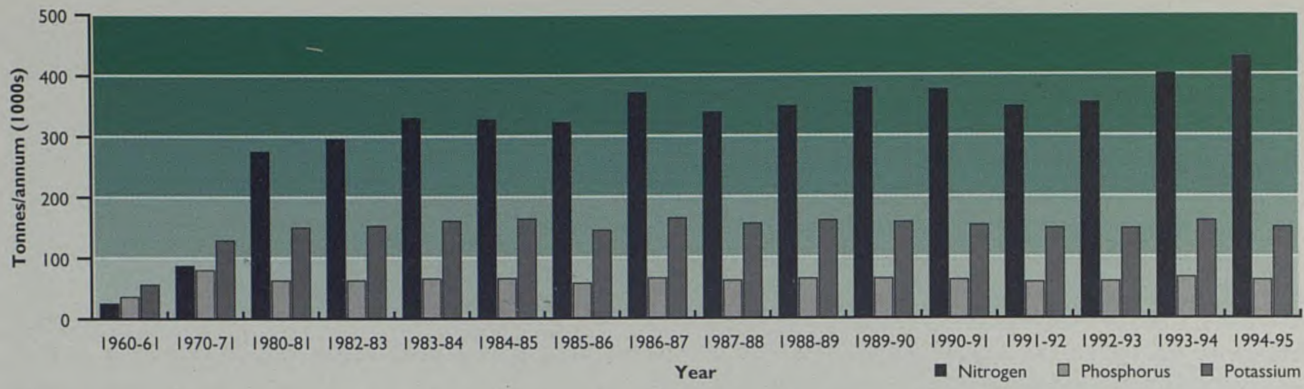


***Fig.2.14** Sales of Artificial Fertilizers (1000s tonnes/annum) (Sources: ERU, 1993; J. Caffrey, IFI, Dublin).*

Pembroke, Cherbourg and Le Havre; and (seasonally) Cork to Swansea, Roscoff and Le Havre. These routes are heavily used, particularly during the tourist season when demand exceeds supply on the continental routes (Nowlan, 1992).

There are also internal ferry systems on some sea inlets, e.g., on the Shannon estuary, Waterford Harbour and on the river Lee in Cork. The inland waterways system of canals linking the major navigable rivers has long ceased to have any commercial transport function but is now regarded as a major tourism and recreational asset.

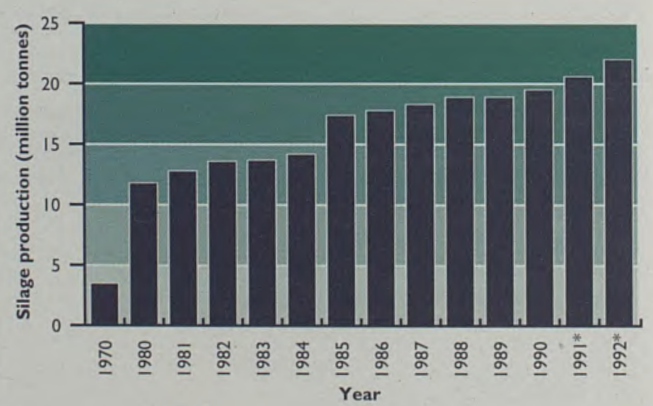
Ireland is served by three international airports, in Dublin, Cork and Shannon, which are owned by the semi-state company Aer Rianta, and six private regional airports. The total number of passengers carried (both internally and externally) increased from almost four million in 1981 to 8.6 million in 1993. Air now accounts for 65 per cent of total passenger traffic to and from Ireland. It accounts for less than one per cent of merchandise trade in volume terms but for 18 per cent of merchandise trade in value terms, thus reflecting the significance of this mode of transport for the export of goods with high value/weight ratio (Department of Transport, Energy and Communications, 1994).

Agriculture

The total area utilised for agriculture is estimated by the Central Statistics Office to be about 4.41 million ha with another 0.45 million ha in commonage. Since the accession of this country to the then EEC in 1973, which gave access to guaranteed markets and prices, under the Common Agricultural Policy (CAP), there has been a substantial growth in output, from £343 million in 1970 to £3,405 million in 1994. Agriculture accounted for 11.9 per cent of total employment in 1994, which is relatively high by EU standards where the average for all Member States is just over half that level (Department of Agriculture, Food and Forestry, 1995). The traditionally mixed character of Irish farming has given way to specialisation and increased mechanisation. There has been a significant decrease in tillage area, with approximately balancing increases in land used for pasture and hay. CAP reform in respect of grain in 1993 introduced 'set aside' and also put a limit on the total grain-growing area in the country.

As can be seen from Figure 2.14, the annual sales of phosphorus and potassium have in general remained relatively constant since the early 1980s, while sales of nitrogen have increased over this period.

There has also been an increase in the production of silage (Fig. 2.15). In 1990 it was estimated that 65 per cent of farms had silage pits and two to three per cent had silage baled in plastic covers. By 1994 these figures had changed to 76 per cent and 56 per cent respectively. The introduction of baled silage cut down on the risk of silage effluent leakage but introduced another problem of plastic waste (Power, R., pers comm).



* Estimates

***Fig. 2.15** Silage Production 1970 and 1980-1992 (Source: CSO and Teagasc).*

There have been some significant changes in farm livestock populations (Fig. 2.16). These have occurred in response to measures from the EU which were

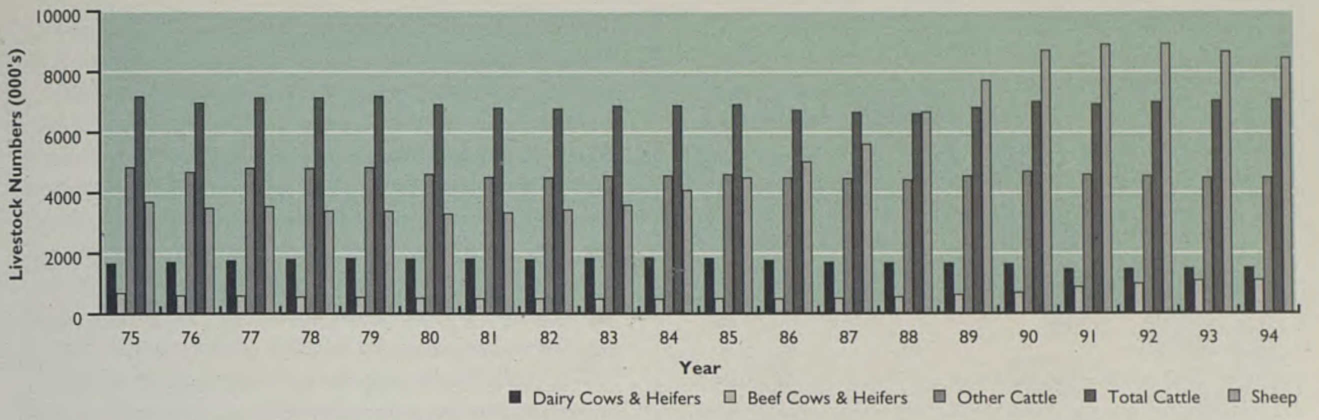


Fig. 2.16 Livestock Numbers 1975-1994 (Source: CSO).

introduced to curtail expansion of sectors which were in surplus. Sheep numbers showed the most dramatic change, with a particularly significant increase in numbers during the 1980s. The total number of dairy cows and heifers has decreased slightly in recent years. However, provisional estimates for 1995 (CSO, 1995b) show these trends tending to reverse somewhat. In general, recent trends have also shown some expansion of beef cattle numbers. Diversification into alternative areas, such as forestry, agri-tourism, deer farming and cultivation of oilseed rape has also occurred.

The variations in the number of pigs and poultry are summarised below:

	1975	1980	1991
Pigs	795,600	1,030,500	1,303,700
Poultry	9,620,000	9,903,200	1,2052,800

As can be seen, numbers have increased appreciably (ERU, 1993).

Forestry

The total forest area in the State amounts to eight per cent of the total land surface. There are 127,000 ha in the private sector and 402,000 ha in the public sector. Approximately 90 per cent of forests are coniferous and the remainder are broadleaved (COFORD, 1994).

In January 1989, responsibility for state forests was transferred to the State forestry company, Coillte Teoranta, which now owns over 400,000 ha of forest. The Forestry Act, 1988, states that Coillte must have due regard at all times for the environmental and amenity consequences of its operations. The Forest Service of the Department of Agriculture, Food and Forestry has national responsibility for overall forest policy.

Land planted by Coillte Teoranta during the period 1989-1993 averaged 11,000 ha annually, an increase of 43 per cent on the average area planted each year in the previous five year period (Coillte Teoranta, 1993). Increasing financial incentives, both EU and national, have led to increased annual planting in the private sector, with an increase from 327 ha in 1983 to 9,432 ha in 1993. It is estimated that up to 8,000 people are directly employed in forestry with an additional 3,000-4,000 people employed in downstream industry (see Chapter 11 for further details).

Tourism

Ireland has many assets in relation to tourism: people renowned for friendliness, a clean environment, an attractive countryside, the solitude of sparsely populated coasts and uplands, uncluttered waterways and open roads (Buchanan, 1991).

Since 1988, tourist numbers have substantially increased (see Fig. 2.17). This occurred when the government (supported by the EU) pledged major additional investment, while at the same time setting the industry a five year objective of achieving substantial increases in revenue and employment (Department of Foreign Affairs, 1995).

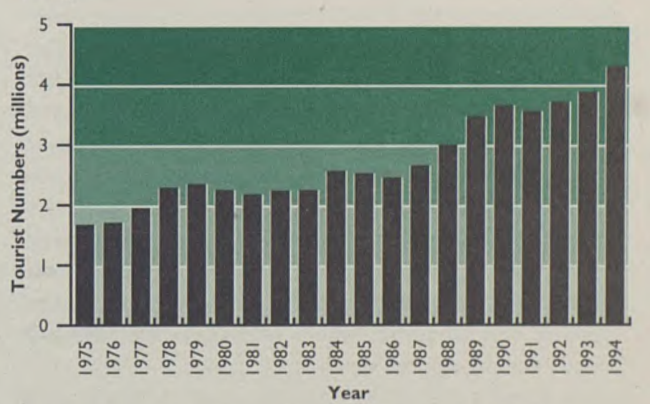


Fig. 2.17 Trends in Tourist Numbers (Source: Bord Failte).

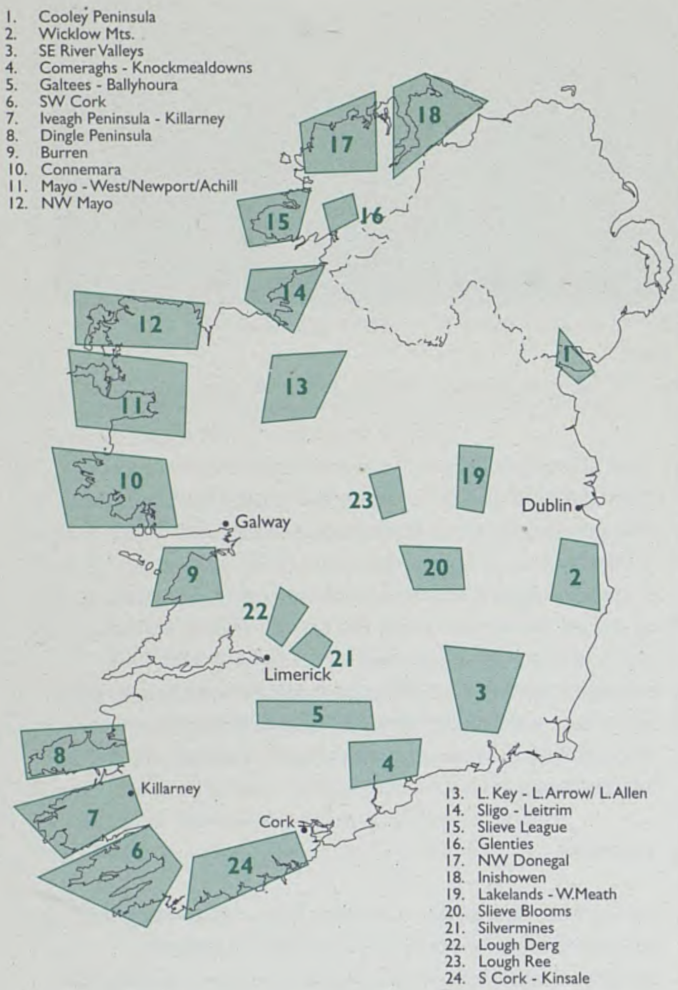


***Fig. 2.18** National Scenic Landscapes (Source: Bord Failte).*

Ireland's natural attractions lend themselves to a wide range of outdoor pursuits. The quality of sightseeing and scenery available in Ireland continues to be the most important motivation for visiting tourists - cited by 72 per cent of respondents in a recent survey. In this survey various factors were described as 'very important', 'fairly important' or 'not important' when considering Ireland as a holiday destination. Those with highest 'very important' scores were 'scenery' (81 per cent), 'friendly people' (71 per cent), 'easy pace of life' (59 per cent), 'nature/wildlife/ flora' (58 per cent) and 'pollution free' (55 per cent). However, litter and pollution are irritants, with 12 per cent and 9 per cent respectively of those giving bad ratings mentioning these items (Bord Failte, 1993).

Bord Failte, the Irish Tourist Board, is responsible for the marketing of the industry abroad. There are seven Regional Tourism Organisations which provide a network of information offices.

For its continued success, tourism depends on the quality of the environment. Bord Failte has identified 24 areas of great natural beauty which it considers demand special management attention (see Fig. 2.18). National parks are located in five of these areas. Bord Failte proposes that each of these be designated as a Country Park and that appropriate management processes be established. The proposal is put forward, not for 'freezing' great tracts of the countryside as 'tourist reserves' but rather recognising that the countryside is a functional unit which remains in the ownership of those who live and work in it. The EU LIFE Programme has funded a demonstration project to test the practicality of this proposal in three pilot areas and to make recommendations on how it could be extended nationwide.

In terms of spatial spread of tourist flows and tourism activity, Bord Failte distinguishes between established, developing and rural tourism areas. The emphasis is on planned growth in each region through regional planning, but it is acknowledged that some areas will achieve faster growth through the exploitation of unrealised potential. By focusing on tourism development in designated centres, it is possible to plan for its impact on the physical and social environment more effectively than if development is spread around the country in an unplanned manner.

Fisheries

The fishing industry has been making a growing contribution to the economy. The fish processing sector comprises about 120 firms, including fishermen's co-operatives, which are particularly concentrated in counties Donegal, Galway, Kerry, Cork, Wexford and Dublin. The bulk of the landings for processing are made into Killybegs, Co. Donegal. The total employment in the fishing industry in 1992, either full-time or part-time, including those employed on fishing vessels, in aquaculture, in fish processing and in ancillary activities, was 15,470 persons (Department of the Marine, 1994).

Seafishing

The seafishing industry contributes significantly to employment and the generation of economic activity in coastal and island areas where there are few alternative sources of employment. The numbers employed in the fishing fleet in recent years have been relatively constant at around 7,700 (Department of the Marine, 1994).

Analysis of the figures for 1992 showed that 76 per cent of the catch consisted of pelagic species, such as herring, mackerel and horse mackerel; 13 per cent consisted of demersal species, such as dogfish, monkfish, whiting, megrim, hake and cod; and the remaining 11 per cent consisted of shellfish, including crabs, shrimps, mussels and periwinkles (Department of the Marine, 1994).

About 25 harbours service the bulk of the fleet. The principal fishing ports are Killybegs (Co. Donegal), Casteltownbere (Co. Cork), Dunmore East (Co. Waterford), Rossaveal (Co. Galway), Howth (Co. Dublin), and Dingle (Co. Kerry). These harbours are the home ports for more than half of the boats on the Irish fishing register. The Irish pelagic fleet contains some of the most modern and efficient fishing vessels in the EU. The demersal fleet, by contrast, has a high age profile and consists mainly of inshore and mid-water vessels which rarely stay at sea for more than a few days at a time. Under the Operational Programme for Fisheries 1994-1999 there is a scheme for the decommissioning of older fishing vessels.

The seafishing fleet operates in an environment of total allowable catches (TAC) and national quotas. The TACs are decided on among Member States of the EU. Ireland is entitled to invoke a preference in respect of a number of stocks in line with the Hague Agreement, and this means, in effect, that while the TAC does not change, Ireland's share increases (Department of the Marine, 1994).

Aquaculture

Ireland's coastal waters provide suitable conditions for aquaculture activities. Aquaculture provides additional employment and income in remote and disadvantaged areas. The aquaculture industry in Ireland expanded rapidly throughout the 1980s from negligible beginnings at the commencement of the decade to a thriving industry by the end. The objective has been to promote the development of salmonids (salmon and trout), musssels and oysters. Investigations and trials have also been undertaken on the potential for some other species (Department of the Marine, 1994).

In 1993, this sector provided full or part-time employment for 2,600 persons (compared with 1,228 persons in 1985) with additional employment in downstream industry. Farmed Atlantic salmon account for about three-quarters of the total production in value terms. The main finfish farm locations in Ireland are shown in Fig. 2.19. Details of shellfish growing areas are presented in Chapter 10.

The growing contribution made by the fishing industry to the national economy has been illustrated in the Operational Programme for Fisheries 1994-1999 with the following returns:

	(£ million)	
	1989	**1992**
Seafish landings	90	98
Aquaculture	24	41
Exports	154	186*

(* includes foreign landings)

ENVIRONMENTAL AWARENESS AND PUBLIC ATTITUDES

There is now much media attention given to environmental matters. This has led to increased awareness among the general public and the business community. A particular area of concern is the management of wastes. Surveys have been carried out to determine which issues are perceived to be the most important.

The Department of the Environment (1990) produced a report on the results of a survey of attitudes to the environment. The majority of people and businesses surveyed consider the protection of the environment to be an urgent and immediate problem. Teenagers are twice as likely as the rest of the population to cite the environment as an issue of concern to them. Adults with children aged between 11-15 in the household are more likely to say they are well informed than those without children or those with only younger children. For one in ten adults, children have been the source of environmental information. Those in the 25-44 age group, and women more than men, are more aware of 'environmentally friendly' alternative products.

Despite the wide awareness of relatively complex issues such as damage to the stratospheric ozone layer, the majority of people admit to being 'confused' about what is good or bad for the environment. There is some ambivalence in people's attitudes towards the cost of dealing with environmental problems.

Rubbish and litter on beaches and in open spaces are the main concern for one in five people. Smog and atmospheric pollution come second, while pollution from farms and factories is third. For many people what is happening locally is often of more pressing concern than the wider global issues. The majority of the people surveyed feel that the quality of the environment is threatened rather than being improved. A large majority also said they would be willing to separate refuse for collection into materials that can be recycled and materials that cannot.

For industry the key environmental issues are atmospheric and water pollution, emission of effluents and disposal of

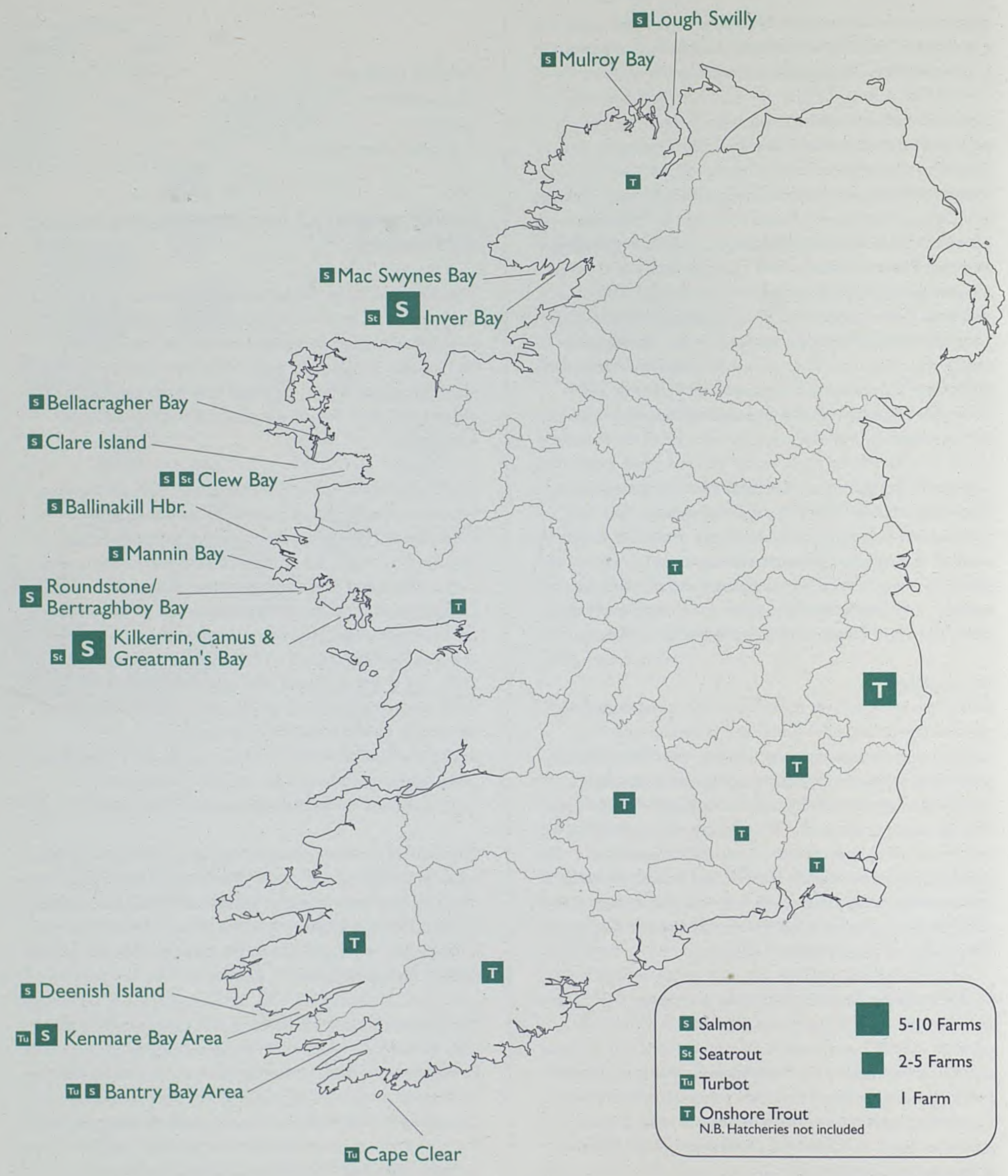


Fig. 2.19 *Main Fin Fish Farm Locations in Ireland (Source: Bord Iascaigh Mhara).*

toxic or hazardous waste material. The sectors with the highest profile in terms of their capacity to inflict environmental damage are also the most conscious of the impact of these issues on their business. Eighty per cent of companies surveyed have invested in environmentally friendly technology, and over two-thirds have changed processes to minimise waste.

Silage effluent is the most important source of pollution in the view of most farmers, while issues such as pollution by milk dumping and sheep dips are rarely mentioned. With regard to other potential pollutants on the farm, small farmers are more worried about slurry pollution when compared to large farmers, as small farms are less likely to have storage facilities for such pollutants. Waterways, rivers and lakes are seen by the majority of farmers to be the most vulnerable elements of the environment to farm pollution. Air pollution and odour are mentioned as secondary types of damage. Only one in ten mentions the soil as an element that could be damaged by farming (Department of the Environment, 1990).

ACCESS TO INFORMATION

The Access to Information on the Environment Regulations, 1993, set out the mechanisms for information on the environment to be made available to the public. At national level there has been a policy of increasing the output and quality of environmental publications and reports.

A public information service on environmental matters, ENFO, was established in September 1990. The service is provided by the Department of the Environment, and gives easy public access to wide-ranging and authoritative information on the environment. The aim of ENFO is to help protect and enhance the environment by promoting a wider understanding and awareness. It provides information through its query answering service, the provision of information leaflets, a video lending service, exhibitions and a reference library.

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NORTH BULL ISLAND
INTERPRETIVE CENTRE
Parks Department Dublin Corporation
INTERPRETIVE CENTRE

CHAPTER 3

ASSESSING THE ENVIRONMENT

INTRODUCTION

Assessing and managing the natural environment and resource base are critical functions of national planning. They provide objective boundaries within which economic and social development can take place without causing undue stress on the environment. The protection of public health and the development of a sustainable economy are dependent on the maintenance of a clean environment.

To understand the environment and the impact of pressures imposed by domestic, industrial and agricultural activities, it is necessary to measure changes in its condition. Likewise, it is necessary to evaluate changes in the state of the environment resulting from societal responses to those pressures.

In this chapter, some of the tools used to assess and manage the environment are introduced and an overview of their uses is presented. This is not intended to be an exhaustive review but rather to provide the reader with an understanding of the range of tools required to assess and manage the environment. Those used include the following:

- *'planning and control'* tools such as environmental quality objectives (EQOs), environmental quality standards (EQSs) and emission limit values (ELVs), which are used to set standards and to control anthropogenic inputs to the environment;
- *'monitoring and research'* tools such as the many biological, physical and chemical methods used to measure environmental quality and sensitivity;
- *'trend'* tools such as environmental indicators and indices used to assess changes and measure trends in the state of the environment.

Public Health Issues

The European Charter on Environment and Health states as follows:

'Good health and well-being require a clean and harmonious environment in which physical, physiological, social and aesthetic factors are all given their due importance. The environment should be regarded as a resource for improving living conditions and increasing well-being' (WHO, 1990).

There is an obvious link between the state of the environment and the health of the populations supported by it. Therefore, a primary quality objective for any environmental medium, be it air, water or land, is its suitability in relation to human health.

In Ireland, particular attention has been paid to the potential health effects of air and water-borne pollutants. Traditionally, environmental protection strategies tended to concentrate on reducing potential health risks associated with these media. The introduction of sanitation practices, for instance, which led to the elimination of many water-borne diseases, was one of the largest contributors to improved public health in this century. More recently, the ban on the marketing of bituminous coal in Dublin has resulted in the elimination of localised smog in the city, which is expected to lead to a reduction in the number of respiratory complaints.

Ireland has largely escaped the serious land use contamination problems of industrialised countries where heavy industry operated for many years before the need for environmental protection was fully acknowledged. Nevertheless, it is necessary to guard against the potential contamination and erosion of soils. Furthermore, recent environmental protection strategies, in Ireland as elsewhere, have tended to concentrate on reducing emissions to air and water. This has left soil as the least regulated disposal option and it is therefore increasingly exposed to pollution threats. Integrated pollution control (IPC), where applicable, is designed to prevent this from happening in the future.

Setting Environmental Quality Standards for Dangerous Substances

The 1976 Dangerous Substances Directive (76/464/EEC) provided a framework for the identification and control of toxic substances discharged into the aquatic environment and created the so-called 'black list' (List I) and 'grey list' (List II) of substances. The objective is to eliminate pollution by black list substances and to reduce inputs of grey list substances to the environment. Substances, or families of substances, appear on the lists by virtue of their acute, sub-acute or chronic toxicity, environmental persistence and bioaccumulation potential. The two classes of substances receiving priority attention are selected metals and organochlorine compounds.

In 1982, the EU created a priority list of 129 compounds requiring evaluation. To date, the EU, through the Scientific Advisory Committee on Toxicity and Ecotoxicity of Chemicals (CSTE) has assessed 84 of these compounds. Environmental quality standards (EQSs) have been recommended for 74. A further three have been assigned preliminary EQSs. The remaining seven are considered as candidates for List I, as it had not been possible to establish EQSs for them.

Pollution and Chronic Health Effects

Air, water, food, beverages and the many substances that come in contact with skin can all act as pathways for toxic materials. Some substances of concern, such as radon gas occur naturally. In cases of brief, intense exposure which cause severe and acute symptoms a definitive cause and effect relationship can usually be established. However, the assessment of human, animal and plant exposure to environmental contaminants at very low concentrations is considerably more difficult.

Adverse health reactions may take a variety of forms, ranging from psychological or physical discomfort to varying intensities of clinical disease. An individual's response to environmental exposure may also be related to personal behaviour and genetic susceptibility. For instance, the risk of developing lung cancer as a result of exposure to asbestos fibres is known to be higher for smokers than for non-smokers. Similarly, the risk of developing respiratory illnesses, such as emphysema, as a result of exposure to air pollution, is higher in individuals genetically predisposed to the disease than in those who do not have such a predisposition.

Cause and effect relationships between chronic illness and causative factors are investigated by conducting epidemiological studies. There are two major approaches to such studies (Manahan, 1994). The first is to investigate diseases known to be caused by particular agents in areas where exposure to such agents is considered likely. The second is to investigate clusters consisting of an abnormally large number of cases of a particular disease in a limited geographical area.

In many instances, the existence of a disease cluster draws attention to the possibility of a link to a particular cause. For instance, the high incidence of serious birth defects including Down's Syndrome, spina bifida, heart defects and deafness amongst the children of women who as schoolgirls attended the same schools in Dundalk, drew attention to a possible link between the birth defects and a fire at Windscale/Sellafield in the United Kingdom in 1957. The common factor amongst the women in question was that they attended the same schools in Dundalk at the time of the fire.

Until recently, environmental protection and public health strategies tended to deal mainly with acute or life-threatening public health risks. There is a growing awareness, however, of the potential long-term or chronic health risks associated with the many toxic organic and inorganic compounds that enter the environment in trace amounts. The importance of setting stringent standards to prevent or minimise the release of such materials into the environment is increasingly recognised. In the European Union (EU), the control of such substances in the aquatic environment is governed by the Dangerous Substances framework Directive 76/464/EEC and its subsequent daughter Directives (see box on previous page).

Chronic health effects are considerably more difficult to detect than acute effects and continuous research is required in this area to increase understanding of this important subject (see box opposite).

There is also increasing awareness regarding the impact of noise on public health and well-being. Regulations have recently been introduced (June 1994), which *inter alia,* greatly simplify the procedure for bringing forward complaints about noise (Chapter 13).

Economic Development Issues

Ireland is, in many ways, staking its claim to the future as a clean country with a high quality environment. Agriculture, tourism and much of industry, in particular, depend for their continued development on the protection and maintenance of a clean environment. Many foreign-owned companies have chosen to locate plants in Ireland partly because of the image derived from operating in a clean environment.

Integrated environmental management will provide one part of the framework for sustainable economic development in Ireland and will set the boundaries within which such development can take place.

ASSESSMENT TOOLS

Planning and Control Tools

EQOs, EQSs and ELVs

Emission standards provide a basis for the control of point-source emissions. The setting of overall ambient environmental quality objectives (EQOs), however, can provide a basis for managing all significant inputs to a medium, including those from diffuse or non-point sources. Generally, for such objectives to be realised, an integrated approach is required.

Environmental quality objectives describe the intended use of an environmental medium or media; the use to which the medium is to be put defines the quality that is required to be maintained. For example, water uses include bathing, fishing, recreational use and, in particular, abstraction of drinking water. A typical EQO for a water body might be that the water be fit for abstraction for human consumption or that it be capable of supporting salmonid fish. The EQO is then met through the application of environmental quality standards (EQSs).

EQSs are media-specific standards for chemical, physical or biological parameters required to be met for an intended use. To ensure that the standards are met, inputs to the medium must be controlled through the assignment of emission limit values (ELVs) to point-source discharges and the management of diffuse or non-point discharges. A practical example is provided in the box below.

Typical EQOs for selected environmental media with multiple uses are presented in Table 3.1 (for air, see next section). The Environmental Protection Agency Act, 1992 (EPA Act), empowers the EPA to specify and publish quality objectives for any environmental medium. The media for which EQOs are planned include water, air, soils, land-use/landscape and the built environment. EQOs are also planned for noise. The setting of EQOs and EQSs for these media is discussed in the following sections.

Preventing Eutrophication By Setting EQOs, EQSs and ELVs

The risk of a water body becoming eutrophic generally increases with increasing nutrient concentration. The limiting nutrient in freshwater is usually phosphorus while in marine waters the limiting nutrient is usually nitrogen. The EQO for a typical water body, say a freshwater lake, might be that the water be suitable for multiple uses such as bathing, fishing and recreation. This objective requires, among other things, that the water body does not become eutrophic. The EQSs for the lake, therefore, will include specified maximum allowable concentrations in the lake for the nutrients that cause it to become eutrophic (in all probability phosphorus). These EQSs, in turn, will require emission limit values (ELVs) to be assigned to any point-source discharges entering the lake, such as urban waste water and industrial effluents, to ensure that the concentration of phosphorus and other controlled substances in the lake do not exceed the EQSs.

***Table 3.1** Examples of EQOs For Selected Environmental Media.*

Water	Soil	Noise	Land-use/ Landscape
drinking	agricultural	residential	urban
fisheries	horticultural	commercial	residential
bathing	residential	industrial	agricultural
shellfish	recreational	work-place	industrial
boating	commercial		national park
agricultural	industrial		wilderness
amenity			protected area
			tourism

Water

Waters in and around Ireland are put to many uses. A summary of the principal beneficial uses for different aquatic environments is presented in Figure 3.1.

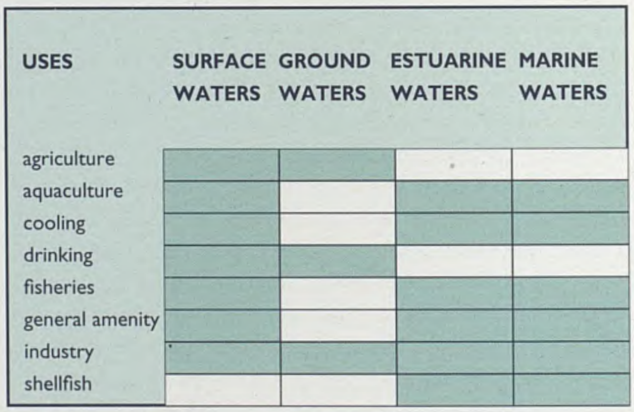

***Fig. 3.1** The Aquatic Environment and its Principal Beneficial Uses (shaded areas).*

For obvious reasons, in respect of most parameters, the most stringent environmental quality standards are required for raw water abstracted for human consumption.

By and large, EQOs and EQSs in Ireland are based on national Regulations and EU Directives. At present, EQOs are set only for waters for which a specific use has been identified, or where a water quality management plan has been prepared and adopted. For this reason, there is a wide body of waters in the State for which no formal EQOs and EQSs have been determined.

In its first discussion document on EQOs and EQSs, the EPA (1994) proposed that EQOs should be assigned on a national basis throughout the State and its territorial waters as appropriate. This course of action is recommended both as a basic element of environmental protection and as a way to prevent any diminution of present satisfactory quality. Such a broad spectrum assignment of EQOs would be matched by the setting of appropriate EQSs. It is further proposed that the general, non location-specific EQO for all freshwaters in the State be either the salmonid fishery EQO or, in certain cases, the cyprinid (coarse) fishery EQO, i.e., that the waters be capable of supporting salmonid species or cyprinid species, respectively. The majority of waters in the State would be assigned the stricter salmonid fishery EQO.

Air

The situation is less complex for air than for water as the quality objective for all ambient air is that substances emitted into the atmosphere do not pose an unacceptable risk to human health or the environment. Air EQSs, therefore, are set, following risk assessment, at levels which are designed to protect higher-risk groups such as children, the elderly and people suffering from respiratory ailments.

As with water, air EQSs are based on national Regulations, EU Directives, and guidelines prepared by the World Health Organisation (1987).

In Ireland, EQSs or air quality standards have been set for sulphur dioxide (SO_2), suspended particulates (black smoke), lead and nitrogen dioxide (NO_2). Emission limit values (ELVs) have been set for a range of pollutants that may be emitted by industrial plants, large combustion plants and waste incinerators. ELVs also apply to emissions from certain categories of motor vehicles. Stringent emission levels also apply to asbestos fibres. Emission control policies increasingly account for the link between the level of emissions and ecosystem response (see box opposite).

In future, there is likely to be a greater focus on diffuse or non-point sources of pollution, such as motor vehicle emissions and agricultural ammonia emissions.

Soils

EQOs for soils have yet to be introduced in Ireland with the exception of provisions in the national Regulations controlling the use of sewage sludge on agricultural land. The primary objective of these Regulations is to prevent the application to land of sludge that is contaminated with heavy metals and to minimise health risks associated with the use of sewage sludge. In other countries, soil quality objectives usually relate to intended use with the strictest criteria applying to soil intended for agricultural, horticultural and residential use and less stringent criteria applying to categories such as commercial or industrial land-use.

Critical Loads and Critical Levels: A New Approach to Environmental Assessment and Emission Control

In the past, the level of air emissions control was not adequately related to the capacity of ecosystems to tolerate high pollutant concentrations or buffer the effects of acidification. Increased pressure to apply effects-based and cost-effective abatement strategies have led to the development of the critical loads/critical levels approach to environmental assessment and emission control. In this approach, 'load' refers to a quantity of acidifying substances deposited on an area of land and 'level' normally specifies a concentration of a pollutant in air. This approach considers that for both of these parameters and all ecosystems, there is a quantifiable threshold below which no damage occurs. The determination of critical loads for a particular ecosystem, when compared with actual loads, provides a simple means of environmental assessment for areas at risk from acidification. Similar assessments regarding the direct effects of air pollutants on forests, crops, other vegetation, and materials, can be achieved using critical levels.

Critical loads for acidity depend on the buffering capacity of soils, i.e., the rate at which minerals are released, to neutralise the deposited acid. The concept has been developed to address total acidity, the acidity due to either sulphur or nitrogen alone, and the eutrophication potential of nitrogen. It is most widely used in relation to forest soils and surface waters but is applicable to a wide range of terrestrial and wetland ecosystems. Critical levels for forests, crops and natural vegetation, determined on the basis of dose-response relationships, have been published for the most common air pollutants such as SO_2, NO_2 and ozone (Ashmore and Wilson, 1994; Fuhrer and Acherman, 1994).

In 1988, the Convention on Long-Range Transboundary Air Pollution adopted the critical load concept, making it a basic element in the formulation of international agreements on the emissions of air pollutants. Its first application in this regard was in providing the scientific support to the negotiations on the Oslo Protocol on sulphur emissions, adopted in 1994. Critical loads for nitrogen, in relation to both acidification and eutrophication, are likely to play a major role in the revision, currently underway, of the Sofia Protocol on nitrogen oxides (NO_X) emissions.

As stated earlier, Ireland has not inherited the serious land contamination problems common in countries with large industrial economies where expensive soil remediation programmes are now required to clean up contaminated soil and groundwater. As a country with a relatively large agricultural economy, the principal historical pressure on soils has been the application of chemical fertilisers and, to a lesser extent, pesticides. However, it is important to emphasise that residual levels of pesticides in agricultural soils are very low. More recently, the massive increase in sheep numbers has led to soil erosion problems, in particular, in hill areas and mountain commonages.

Land-use, Landscape and Nature Conservation

Natural landscapes and habitats, that is, those that are untouched by human presence, are a rare phenomenon in Ireland, as in the rest of Europe. Very few natural habitats in Ireland have been surveyed in sufficient detail to allow an overall assessment of rate of loss. However, the exceptions, woodlands and peatlands, suggest that the rate of loss has been of major proportions and that only small and isolated fragments of the original resource remain. For instance, it is estimated that less than seven per cent of raised bog in Ireland remains intact (GREEN 2000 Advisory Group, 1993).

Deforestation, agriculture, wetlands drainage, coastal defence construction, mining, road construction, urbanisation and the myriad human interventions over the centuries have moulded the landscape into an image which reflects human economic and social development. Many natural habitats have been replaced by others created by man, such as pastures and croplands. This has had a profound effect on plants and animals, with some species threatened with extinction and other species thriving in the new environment. In Europe as a whole, however, biological diversity is on the decline (Stanners and Bourdeau, 1995).

In future years, it can be expected that EQOs will be required for both land-use and landscape in Ireland. These will define the use or uses for particular areas. EQOs are likely to be set within the context of regional planning and will need to balance development needs with nature conservation requirements. For economic development to become sustainable, nature conservation must be fully integrated into the planning process because, among other things, conservation and biodiversity indicators will provide a measure of whether or not development is, in fact, sustainable. The protection of biodiversity, as measured by the numbers of threatened species and the integrity of specific habitats, will become an increasingly important indicator of the success of sustainable development strategies.

Where an important habitat or ecosystem is under threat and requires protection, ecological quality objectives for the habitat or ecosystem may also be set. The consequence of such objectives might be the setting up of nature reserves and wildlife corridors, and the establishment of biogenetic and biosphere reserves. There is also likely to be increased emphasis on the protection of wildlife in the developed rural environment through better landscape management. This, in common with the management of all environmental media, will best be addressed through an integrated approach.

The Built Environment

In Europe as a whole, over two-thirds of the population now live in cities and towns and the trend towards increased urbanisation is likely to continue. As noted elsewhere in this report, this trend has also been apparent in Ireland. As many regional and global environmental problems originate in the built environment, the continuing growth in urban population is a cause for concern.

The bulk of the world's natural resources are consumed in and around cities and towns and the development of a sustainable economy and environment will depend on cities and towns becoming sustainable themselves, both in the local and the global sense. This means developing a better understanding and appreciation of the impacts of cities and towns on both their own local environment and the regional and global environments. It has been estimated, for example, that a city of one million inhabitants in Europe, that is, a city the size of Dublin, consumes 11,500 tonnes of fossil fuels, 320,000 tonnes of water and 2,000 tonnes of food every day. Each day it also produces 1,500 tonnes of air pollutants, 300,000 tonnes of waste water and 1,600 tonnes of solid waste (Stanners and Bourdeau, 1995). This pattern of consumption and production is not sustainable.

EQOs for the built environment need to address both local and global issues: local issues which directly affect inhabitants such as urban air quality, water quality, noise, green space and aesthetic factors, and regional and global issues such as water use and natural resource consumption.

Integrated Planning

Air, water and land can be considered to be the primary environmental compartments, or media, each of which consists of a number of sub-compartments.

An integrated approach to environmental management requires that the inter-relationships and interactions between the different environmental compartments or media be considered (Fig. 3.2).

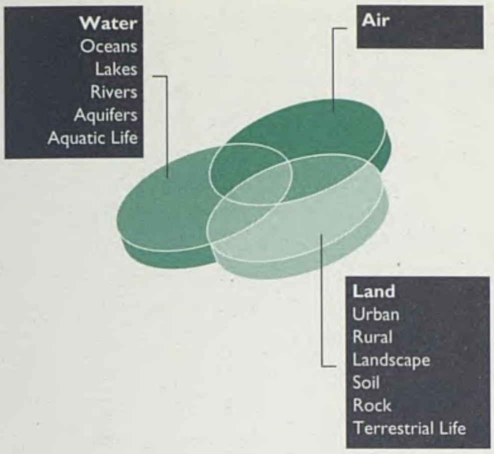

***Fig. 3.2** Primary Environmental Compartments.*

In the context of integrated environmental management, the setting of quality objectives and standards for different media within a region should be co-ordinated where possible, preferably under the umbrella of an integrated plan. The integrated approach to environmental management requires an appreciation and understanding of the complex web of inter-relationships that exist within the environment.

At present, in Ireland, EQOs are often set within the context of either an air or water quality management plan. The Local Government (Water Pollution) Acts, 1977-1990, and the Air Pollution Act, 1987, empower local authorities to prepare water and air quality management plans for their areas. An example of such a plan is the Dublin Bay Water Quality Management Plan which is one of the most comprehensive plans prepared to date (see box).

Monitoring and Research Tools

Monitoring

Having established objectives and standards for a particular medium or, indeed, for all environmental media or compartments, a monitoring programme is required to establish whether or not such objectives and standards are being met. For the more complex issues, special programmes of research may be needed. The Irish Sea has been the subject of an integrated planning exercise which recently resulted in the publication of a proposed integrated science programme for the Irish Sea (see box).

Dublin Bay Water Quality Management Plan

In 1986, the then three Dublin local authorities: Dublin Corporation, Dublin County Council and Dun Laoghaire Corporation, agreed to prepare jointly a water quality management plan for Dublin Bay in response to widespread public concern about the deteriorating quality of the Bay. Extensive studies were carried out with a view to developing a comprehensive understanding of both the quality of the Bay and its sensitivity to anthropogenic inputs.

Based on these studies the following general objectives were defined for the Plan area:

1. to prevent and abate pollution and so to safeguard public health and to protect and enhance the environment of the plan area;

2. to ensure an acceptable quality of water for various beneficial uses of the plan area, and in particular for recreational uses;

3. to ensure that the ecological balance of the area is not adversely affected, and, in particular, to protect areas of importance for wildlife conservation;

4. to provide a framework for management, including monitoring, and for conflict resolution - and so to facilitate balanced urban, industrial and port development, and to help ensure that the environmental dimension is an integral part of development and related policies and actions;

5. to ensure that the available finances for pollution control are used in the most effective manner, and to increase the effectiveness of actions to protect the environment;

6. to assess the options for the treatment and disposal of the major sewage discharge at Ringsend, and the options in relation to other discharges to the Bay and estuary, and to make appropriate recommendations concerning these.

The plan was adopted by the three participating Local Authorities in 1993. Since then, the various options for secondary and tertiary treatment of sewage at Ringsend have been reviewed in the context of the plan and its objectives.

An Integrated Science Programme for the Irish Sea

The Irish Sea Science Co-ordination Group (ISSCG) was established in 1992 by the Governments of Ireland and the United Kingdom to provide advice on a co-ordinated marine science programme for the Irish Sea. The project specification called for a systematic evaluation of existing and planned research and monitoring activities, identification of gaps and deficiencies, and advice on projects and arrangements that would enable a more co-operative approach to improving the scientific knowledge needed for protection and management of the Irish Sea.

General objectives for the investigation of environmental change and quality in the Irish Sea were identified. These provided a framework for an integrated science programme for the Irish Sea by identifying the principal scientific areas relevant to the management and assessment of the marine environment as follows:

- hydrographic properties;
- chemical and sedimentary properties;
- bio-processes;
- marine life;
- contamination;
- human health risks.

Under each heading, general objectives relevant to assessing environmental quality and change were defined (Boelens, 1994). Particular attention was paid to environmental changes caused by human intervention. Current research and monitoring activities were then evaluated within this framework, that is, their contribution to meeting the general objectives was assessed. This exercise was used to evaluate the relevance of current research and monitoring activities, to identify gaps and deficiencies and to set priorities for future research and monitoring.

The importance of a planned and co-ordinated science programme for the Irish Sea was stressed, both to integrate research, monitoring and assessment activities and to optimise the use of scientific resources (Boelens, 1995).

Many different tools are available to monitor environmental quality and sensitivity. They can generally be classified as being either biological, physical or chemical in nature and range from the relatively simple, such as temperature or pH measurement, to the relatively complex, such as trace organics analyses, chronic toxicity evaluations, remote sensing and population studies of flora and fauna. Monitoring activities generally include a sampling step, where a sample is taken for subsequent analysis, and an analysis step where the sample is analysed for one or more parameters. Sampling can be either continuous or intermittent and sampling strategies are devised to suit specific monitoring requirements. For activities such as flora and fauna population studies, monitoring includes estimating the population size of a target species under particular conditions. Examples are the monitoring of species threatened with extinction and the counting of fish populations in important salmonid rivers.

Environmental monitoring is time-consuming and expensive. New techniques are continually being developed to improve monitoring capability (i.e., the number and frequency of samples that can be taken and analysed) to make monitoring more cost-effective (i.e., reducing the unit cost of analysis).

Ground-level Ozone Monitoring Network

The Directive 92/72/EEC on air pollution by ozone (CEC, 1992) establishes a harmonised procedure for monitoring, exchanging information, informing and warning the public with regard to air pollution by ground-level ozone. In response to the Directive, a national network of six ozone monitoring sites was established in Ireland during 1994 and is operated by the EPA. The network consists of four new stations along with two others which have been in operation for a number of years. All ozone monitors are linked to a telemetry system which transfers the measured data over telephone lines from the monitoring stations to a computerised network control centre at the EPA Laboratory in Pottery Road, Dublin. Data are also acquired from a station in Northern Ireland, which is part of the UK ozone network.

Daily records of hourly mean ozone values are automatically sent to the Meteorological Service every 24-hours. In the event of exceedence of the EU population information or warning thresholds, the Meteorological service immediately receives hourly information from the control centre by an automatically-triggered report.

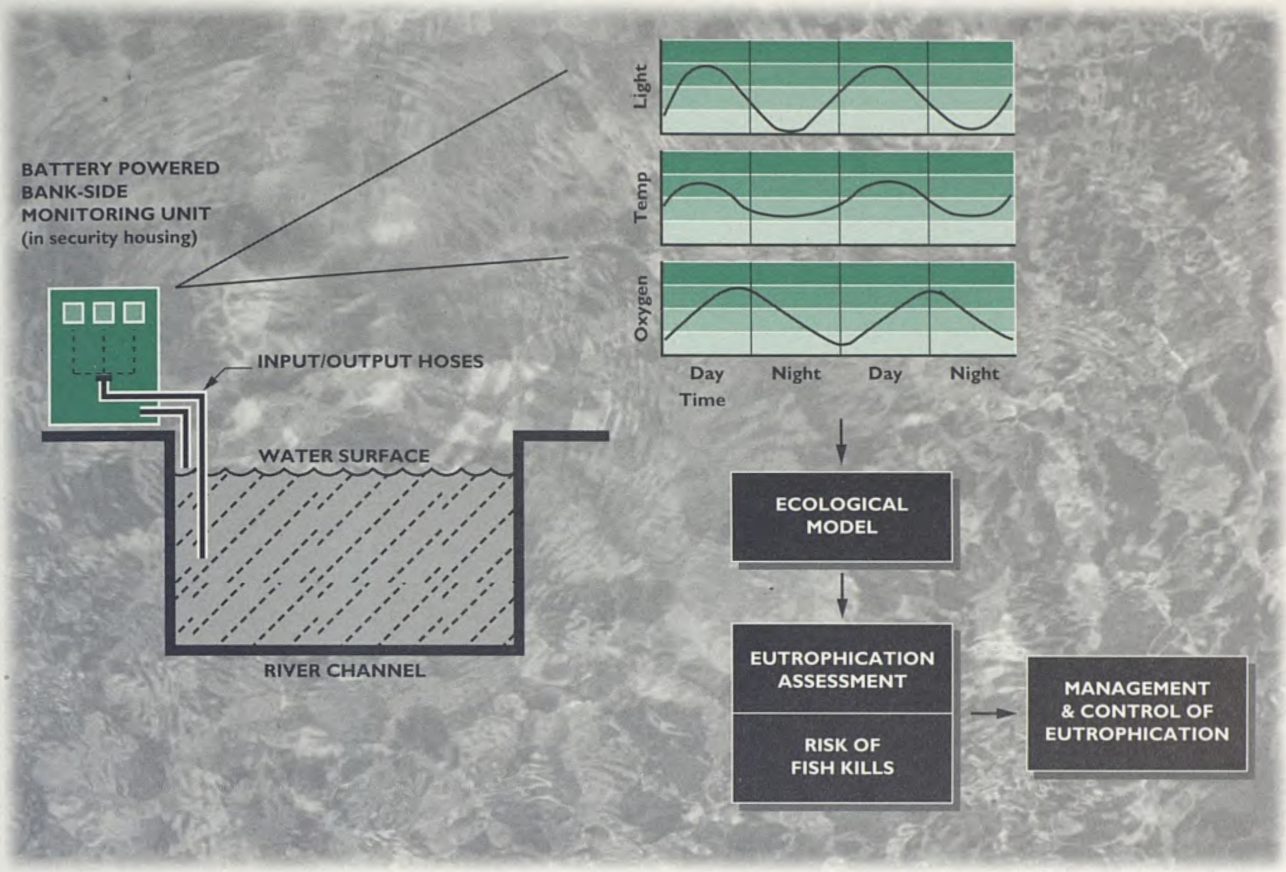

***Fig. 3.3** Automatic Water Sampling and Measurement System.*

The development of remote monitoring systems linked by telemetry to central locations is receiving much attention at present. Such systems provide the ability to gather 'real-time' data as the information can either be stored in an on-site data logger or relayed directly from the sampling site to the laboratory by modem. Examples of remote monitoring systems in use and in development by the EPA are presented in the boxes on this page and on the previous one. In Ireland, improved monitoring capability at a national level has been identified as a priority (Department of the Environment, 1994).

The acquisition of reliable monitoring data requires the implementation of a quality assurance programme. Quality assurance is a set of operating principles that, when followed during sample collection and analysis, will produce data of known and defensible quality. That is, the accuracy of the analytical result can be stated with a high degree of confidence (APHA, 1992).

Eutrophication Effects Monitoring System

A consequence of eutrophication, particularly in rivers and streams, is a reduction of dissolved oxygen levels. If the dissolved oxygen concentration falls below a certain level, fish become stressed and fish kills can occur. A practical problem associated with eutrophication monitoring is that oxygen levels in rivers are lowest at night. This makes measurement using conventional field methods difficult due to factors such as anti-social hours, safety and cost considerations. The EPA is developing a remote-monitoring system for dissolved oxygen in Irish rivers which overcomes this problem by allowing for continuous and round the clock remote monitoring of dissolved oxygen levels to be conducted. A schematic representation of the system is shown in Figure 3.3.

A bank-side monitoring unit continuously measures variations in oxygen and temperature in the river, as well as incident light levels. The data are stored in a data logger which is subsequently down-loaded into a computer and used to calibrate a model of the river. The model can be used to assess the degree of eutrophication of the river based on measured oxygen levels, and to predict the risk of fish kills. If a significant risk exists, action can be taken to prevent oxygen levels from falling below critical levels.

Research

The EPA Act gives the Agency responsibility for the promotion and co-ordination of environmental research and for the provision of assistance and advice in relation to research.

The overall aims of the environmental R & D programme proposed by the EPA are as follows:

- to generate knowledge and information which will be of practical use to policy and decision makers for the protection of the environment and for sustainable development;
- to contribute to economic development through improved environmental knowledge, information and management;
- to strengthen co-ordination between the various sectors through recognition of inter-related responsibilities and to promote co-operation in addressing environmental problems;
- to promote multidisciplinary research and to encourage, where possible, input to international research efforts;
- to provide priority information to all sectors and user groups which identified needs for environmental research and services;
- to gather, assimilate, manage and help interpret environmental information and to make this information available to others.

The EPA carried out a survey at the end of 1993 to establish current environmental issues and to determine how research could help to solve environmental problems. Using the responses to the enquiry combined with its own knowledge and information on the state of the environment, the EPA drew up a framework for environmental research. This framework consists of:

- ecosystems research;
- monitoring capability;
- waste reduction;
- cleaner production;
- socio-enviro-economics.

The programme is constructed so that it will involve the relevant players at local, regional and national level and in all sectors, in the development of solutions to environmental issues, principally in the areas of pollution prevention and control and environmental management (Fegan, 1995).

Trend Tools

The third category of environmental management tools is 'trend' tools. These are interpretative tools which use the data gathered in monitoring programmes to assess trends or changes in environmental quality and sensitivity. Increasingly important tools in this category are environmental indicators and indices.

A core set of environmental indicators has recently been published by the Organisation for Economic Co-operation and Development (OECD, 1994). An indicator is defined by the OECD as a parameter, or a value derived from parameters, which provides information about a phenomenon (or area), with a significance extending beyond that directly associated with the parameter value. For instance, the concentration of dissolved oxygen (DO) in a well-oxygenated river is an indicator of the general health of the river. If the DO concentration falls below a certain level it is known that fish will become stressed. The parameter, in this case DO, is therefore providing us with information that extends beyond that directly associated with the parameter value. The principal indicator for measuring changes in biodiversity is numbers of known threatened species. Other indicators linked to biodiversity include loss of and changes to natural habitats and changes in land use.

An index is defined as a set of aggregated or weighted parameters or indicators. For instance, 'biotic indices' are used world-wide to measure and assess the effects of pollution on rivers by assessing changes in flora and fauna in response to pollution.

In Ireland, a five point scale of values (Q values) is used where the top value, Q5, indicates pristine, unpolluted waters while at the other end of the scale, Q1 indicates severe pollution. Intermediate values indicate varying degrees of pollution (Chapter 9).

As noted in Chapter 1, the Pressure-State-Response (PSR) framework, has been adopted by the OECD for choosing environmental indicators. This framework is illustrated in Fig. 3.4.

In Ireland, many of these indicators will be used to monitor progress. While it is important to integrate the country's system into those used internationally, it is also necessary to develop national sector-specific indicators for specific purposes. For instance, up until recently, there has been a large increase in the numbers of sheep grazing on hillsides and it has become apparent that the current stocking density in some locations is not sustainable. This is leading to soil erosion and damage to watercourses. Actions, such as the preparation of codes of good practice and the designation of environmentally sensitive areas, are required.

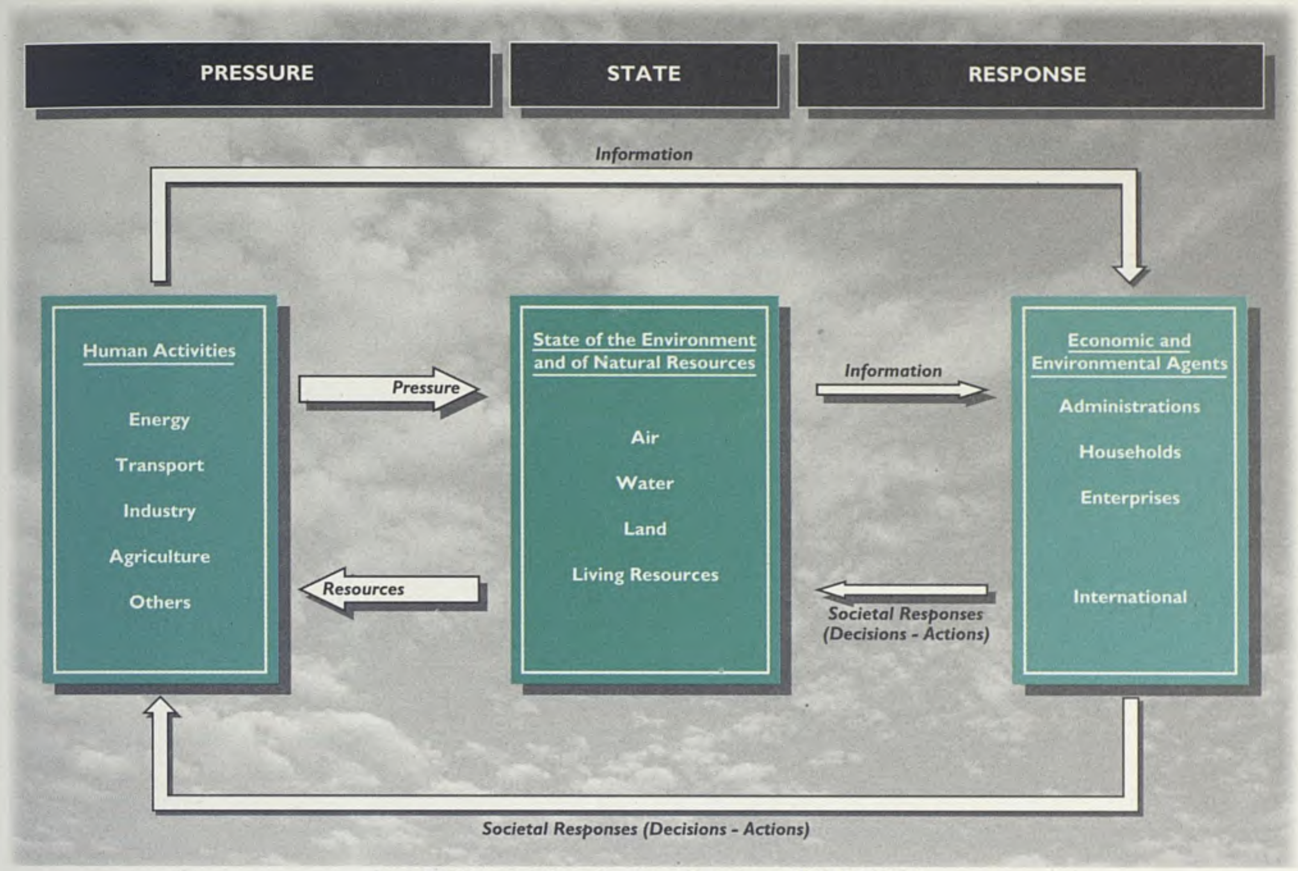

Fig. 3.4 *Pressure-State-Response Framework (OECD, 1994).*

Indicators will be needed to monitor the results of such actions so that progress (or lack of progress) towards more sustainable farming practices can be measured.

The question of indicators is addressed in greater detail in Chapter 16. Together with EQOs and EQSs, indicators and indices provide the necessary tools to begin to measure progress towards a sustainable environment.

INFORMATION GAPS

The two major constraints on assessing the quality and sensitivity of the environment are the availability of resources to conduct the necessary monitoring and the absence of a nationally accepted set of environmental indicators and indices. The enforcement and measurement of EQOs, EQSs and ELVs, and the monitoring of environmental indicators, all require data collection and analysis. An integrated national environmental information system is planned for Ireland which will help streamline the processing of information generated through assessment and monitoring.

Owing to the inherent complexity of the environment, the range of tools required for its assessment and management is, of necessity, broad and will need further expansion. The assessment of the aquatic, terrestrial and atmospheric environments and their various sub-compartments all require specialised tools and specialist knowledge. The need for increased knowledge of chronic health effects has been referred to previously.

The inter-relationships within the environment, between its various compartments, is now widely recognised and this calls for an integrated approach to its assessment and management. The adoption of the Pressure-State-Response framework for the State of the Environment report reflects this need. The issue of integrated assessment is now receiving attention at international level, notably in the work programme of the European Environment Agency, and it is likely to provide an important range of tools for environment assessment in the future (Chapter 17).

SUMMARY

This chapter illustrates how the many tools available for assessing and managing the different compartments of the environment can be used in a unified approach to its assessment and management. Specific tools and methods are described later in the report in more detail. In Part II of the Report, some of the tools presented here are used to evaluate the pressures imposed on the environment through emissions to air, discharges to water and management of waste. In Part III, monitoring and assessment tools in particular are used to evaluate the quality status of different environmental media, while Part IV of the report includes the use of trend tools with particular emphasis laid on the adoption of sectoral indicators.

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PART II

PRESSURES ON THE ENVIRONMENT

CHAPTER 4

SOURCES OF PRESSURE ON THE ENVIRONMENT

INTRODUCTION

Changes to the environment are caused by both natural and human processes, through the transformation and movement of energy and matter. Natural systems are constantly changing through various processes known as biogeochemical cycles. For example, there are the carbon, nitrogen, phosphorus and sulphur cycles. Human activities, directed towards transforming matter and energy into products and services for human consumption, affect these natural cycles. This human transformation of matter and energy, when compared with natural processes, has been relatively insignificant for the greater part of human history. However, since the industrial revolution, and particularly in the last fifty years, this situation has changed radically. Human activities are now altering natural cycles at unprecedented rates. This chapter is intended to provide a general overview of sources of pressures on the environment, while further details on emissions to air and water and on waste are given in the chapters which follow.

Increased economic activity brings many benefits for society such as the alleviation of poverty and the improvement of living standards, but it also generates pressures on the environment. Different sectors of activity, such as industry, energy production, transport, tourism, agriculture, forestry, mining and domestic activities, give rise to a variety of impacts. The pressures arise from the production and consumption of goods and services, from the generation and treatment of wastes, and from the impact of those activities which deplete and degrade the Earth's natural resources.

If the Earth is considered as a single ecosystem, its 'carrying capacity' could be defined as the maximum rate of resource consumption and waste production that can be sustained without impairing its ecological integrity and productivity, that is, the ability of the ecosystem to support its population. However, there is considerable uncertainty about the capacity of the earth and its various sub-systems to absorb pressures. There was a tendency in the past to over-estimate the carrying capacity of different environmental media. At present, the rate of consumption of natural resources is far greater than the rate of their regeneration. It is increasingly apparent also that the rate of production of emissions and waste is greater than the rate at which they can be assimilated without causing harm.

There are many disparate pressures on the environment. In addition to the problems posed by the overuse of natural resources and by emissions to air and water bodies, there are several other factors to be considered. These include loss of habitat and biodiversity, the risks posed by chemicals and by genetically modified organisms, other technological hazards, and natural disasters.

It is evident that these pressures adversely affect the environment and, consequently, the health and well-being of humans. For example, the built environment, where society spends a large portion of its time, can be affected by smells, noise, air pollution and hazards from traffic.

How well the pressures on the environment are controlled by society can be determined by assessing and monitoring changes in the quality of air, inland waters, marine and coastal waters, and soil, and by monitoring the uses made of the natural resource base.

The term 'emissions' as used in this report may include agents ranging from chemical substances, to radiation and noise, which are released into the environment. Emissions can be released to air (atmospheric emissions), to water bodies (waste water) or to land (waste). In addition to direct emissions, there are various other pathways by which contaminants may enter the environment.

EMISSIONS TO AIR

Emissions to air are dealt with in detail in Chapter 5. The following sections provide a brief introduction to some of the main categories of emissions which cause concern, starting with various primary air pollutants.

Suspended Particulates

Suspended particulate material includes airborne dust, smoke and aerosol emissions. The burning of solid fuels is a major source of suspended particulates. Diesel-engined motor vehicles are the other major source. Dust consists of relatively large solid particles that arise from the handling and mechanical processing of various materials, e.g., cement dust and sand from sandblasting. An aerosol is a suspension of very fine solid or liquid particles in a gaseous medium. Aerosols are attracting attention particularly in relation to waste incinerators and energy production.

Smoke consists of fine solid particles suspended in air which mainly arise from the incomplete burning of fossil fuels such as coal, oil and peat, in the domestic, industrial or transport sectors. Open fires in dwelling houses are a major source of much of the particulate material emitted to air as smoke. The main concern in relation to particulate materials is their potential effect on human health, notably the functioning of the respiratory system, as particulates of small size can be inhaled into and deposited in the respiratory system and remain there for long periods of time.

Concern has been expressed in recent times about the health effects of very fine particulate emissions as measured by the parameter PM_{10} (particulate matter less than ten microns in diameter). Emissions from diesel engines in particular are considered to be an important source of these very fine particles.

Sulphur Dioxide

Sulphur dioxide (SO_2) emissions are produced when sulphur-containing fossil fuels are burnt. In particular, electricity power generation plants are the largest source of SO_2. Different fuels such as coal and oil, produce varying amounts of SO_2, while natural gas produces negligible amounts. Like suspended particulates, SO_2 has effects on human health with respect to the functioning of the respiratory system. SO_2 when inhaled can constrict the bronchi and reduce the protective mechanism of the respiratory tract. In addition, SO_2 is a main contributor to the 'acid rain' phenomenon (see below).

Nitrogen Oxides

Nitrogen oxides (NO_X) include two gases: nitric oxide (NO) and nitrogen dioxide (NO_2). Power generation plants and motor vehicles are the principal sources of NO_X, through high temperature combustion. Thus, some of the most relevant monitoring locations for these gases are located in urban areas and other situations where large numbers of vehicles are likely to be concentrated. NO_2 is harmful to the respiratory system. In addition, NO_X contribute to the formation of acid rain and are of further concern as they are involved in the formation of ground-level ozone (see below) .

Other Primary Pollutants

Other primary air pollutants of particular concern include carbon monoxide, volatile organic compounds (VOC) and metals. Carbon monoxide is a product of incomplete combustion and gasoline cars account for the bulk of emissions. A wide range of reactive hydrocarbons and similar compounds are encompassed by the term VOC. Sources include, in particular, road traffic, petroleum distribution and evaporation of solvents.

Some of these pollutants are discussed below in the context of particular environmental problems in which they play a significant role. In relation to metals, recent studies have highlighted the emission of platinum from car catalysts, but most attention during recent years has focused on lead.

The chief source of airborne lead is vehicle exhaust emissions. The presence of lead in air is a potential health hazard, particularly for growing children in whom an above normal body burden of the metal has been linked to retarded mental development. The main danger arises in urban areas with high traffic densities. In recent years, the realisation of this connection has given rise to campaigns to reduce the addition of lead to petrol. Follow-up studies of this control measure in several countries have shown its efficacy in reducing the concentrations of lead in air.

Transfers and Transformations

Primary air pollutants are important in relation to their direct effects, for example on the human respiratory system as noted above. Some substances are of significance because of their role in relation to complex chemical reactions. The atmosphere may contain a large number of secondary pollutants resulting from interactions between primary emissions and a variety of atmospheric components. There are also significant transfers of substances between the air and the other environmental media, soil and water.

Airborne pollutants in the form of gases, aerosols and particulate materials, can be removed by rainfall and deposited onto terrestrial surfaces (wet deposition), deposited directly onto terrestrial surfaces downwind of emission sources (dry deposition), or deposited in cloud and fog droplets by impact with vegetation or other surfaces (occult deposition).

GROUND-LEVEL OZONE

Ozone (O_3), the tri-atomic form of oxygen, is the most prevalent of the atmospheric compounds known as photochemical oxidants. When present in the troposphere, the lowest 10-15 km of the atmosphere, it is referred to as ground-level ozone. Ozone is a secondary pollutant as it is not emitted directly into air but is produced mainly by the action of ultra-violet light (photochemical reaction) on the precursor pollutants, nitrogen oxides (NO_X) and volatile organic compounds (VOC).

The Formation of Ground-level Ozone

Nitrogen oxides (NO_X) are emitted principally from traffic and mainly in the form of nitric oxide (NO). This combines with atomic oxygen (O) to produce nitrogen dioxide (NO_2). This reaction involves the consumption of background ozone as the atomic oxygen (O) is made available by the breakdown of ozone by the action of ultra-violet light. However, the NO_2 is also broken down by ultra-violet light to provide atomic oxygen (O) which is available to combine with free oxygen (O_2) to produce ozone (O_3). Therefore, these reactions tend to balance each other and the presence of concentrations of NO_X alone does not result in a significant overall increase in ozone.

Concentrations of ozone increase above background levels only when the combination of NO with atomic oxygen (O) to produce NO_2 is accomplished without the consumption of background ozone. This occurs if appreciable amounts of volatile organic compounds (VOC), derived from solvents in industrial processes, refineries and traffic, are also available. The breakdown of VOC by complex photochemical reactions enhances the combination of NO with atomic oxygen (O), increasing the rate at which NO_2 is made available to form ozone (O_3). Thus, the combining of NO with atomic oxygen (O) to produce NO_2 is accomplished without the consumption of background ozone, and so the concentration of ozone increases.

Higher concentrations of ozone in the troposphere have adverse implications for human health, and for crops and other vegetation. With respect to human health, high concentrations of ozone affect the functioning of the respiratory system which may cause pulmonary congestion, oedema and haemorrhage. Severe pollution by ozone will occur in areas subject to large emissions of NO_X and VOC and which obtain sufficient solar radiation to drive the photochemical reactions. Ground-level ozone is discussed futher in Chapter 8.

ACID RAIN

Acid rain can adversely affect surface water areas which have a low buffering capacity, that is, having sediments and bedrock such as granite devoid of the calcium carbonates which are needed to neutralise acidity. This can result in the acidification of surface waters causing deterioration in water quality, so that aquatic life may be affected.

Acid Rain

The presence of CO_2 in the atmosphere along with naturally occurring SO_2 combine to maintain the long-term mean acidity of rain in the range pH 5.0 to pH 5.6 in the absence of human activity. Acid rain may be defined as that which is more acidic than this, i.e., pH less than 5.0, which results from man-made emissions of SO_2 and NO_X.

The term acid rain is commonly applied to refer to the total deposition of acidic compounds from the atmosphere. As such, it is something of a misnomer as the deposition of these compounds takes place by a variety of pathways in addition to removal by rain alone.

TRANSBOUNDARY AIR POLLUTION

Acid deposition can result from national emissions and/or from emissions imported from other countries. It has been estimated that in Ireland at least 50 per cent of the annual deposition of sulphur and up to 90 per cent of nitrate are imported from other countries, with the UK being the main contributor in each case. Acid deposition in Ireland is discussed in more detail in Chapter 8.

The NO_X and VOC which contribute to ozone formation may also undergo considerable long-range transport. Therefore, emissions of these ozone precursors in one country may result in ozone pollution in a neighbouring country.

A major potential source of transboundary pollution is nuclear accidents as evidenced by the aftermath of the Chernobyl accident. Other aspects of radioactivity are considered briefly later in this chapter.

GREENHOUSE GASES AND CLIMATE CHANGE

Although the sun is the source of heat that warms the Earth's surface, it is the presence of naturally-occurring 'greenhouse gases', such as carbon dioxide (CO_2), water vapour, methane (CH_4) and ozone, in the atmosphere that maintains the temperature at the Earth's surface and lower atmosphere, so that animal and plant life can exist. The trapping of solar heat radiation by greenhouse gases prevents this radiation from escaping back to space, thus warming the Earth's surface. This is referred to as the 'greenhouse effect'.

On a global scale, the increase in economic development, has resulted in the emission of large quantities of man-made greenhouse gases into the atmosphere from human activities. Such activities include the combustion of fossil fuels releasing CO_2 the main greenhouse gas, the increase in cattle numbers in agriculture producing CH_4, and the use of industrial products emitting chlorofluorocarbons (CFCs). These man-made emissions of greenhouse gases are enhancing the greenhouse effect which leads to an increase in the mean temperature of the Earth's surface. This process is referred to as 'global warming'. Worldwide, global warming is expected to affect sea levels, forests, and agricultural areas, with differing effects in tropical and high latitude regions. The issue of emissions of greenhouse gases in Ireland is discussed in Chapter 5.

THE STRATOSPHERIC OZONE LAYER

The concentration of ozone in the stratosphere, i.e., the upper levels of the atmosphere lying some 20 to 30 km above the Earth's surface, is commonly referred to as the 'ozone layer'. Normally, a natural process, involving the formation and breakdown of stratospheric ozone by the action of ultraviolet radiation, operates to maintain the ozone concentration at a constant level. This process absorbs most of the solar ultraviolet radiation and thus prevents exposure of the Earth's surface to these harmful rays.

Climate Change - Implications for Ireland

A series of expert studies was undertaken to establish the impact of possible climate change resulting from global warming on specific aspects of the Irish environment. The report on the studies noted that there was considerable uncertainty as to whether or not the enhanced greenhouse effect would affect global climate but that a growing body of scientific opinion subscribed to the view that it would. The studies assumed that the Irish climate would change, and assessed the impact of this hypothetical change in an Irish context as follows:

- the agricultural production potential of Ireland would be enhanced;
- it was considered to be too soon to predict with any confidence the biological or economic effects of global warming on Irish forests, or the forest products industry;
- peatlands would suffer serious damage; this would perhaps be the most deleterious outcome of climatic change in Ireland;
- serious winter flooding would occur more frequently;
- lower average summer flow rates in river catchments would result in less recharge for reservoirs during the summer period;
- water quality in some areas could be expected to deteriorate periodically in summer droughts and higher temperatures;
- higher soil moisture deficits would decrease the risk of surface and groundwater contamination from agricultural waste;
- in relation to sea-level change, firstly there is the possibility of the gradual inundation of low-lying lands and secondly, storms and storm surges would have a major impact;
- a general warming of the coastal waters, would probably result in shifts in the range and distribution of commercial fish species;
- in the case of shellfish, the consequences of climatic change might be expected to be generally beneficial.

These are just some of the conclusions of the studies, and the issues are addressed in detail in the report (McWilliams, 1991). It may be noted that other scenarios have also been put forward recently.

The increased concentrations of chlorofluorocarbons and halons in the atmosphere are responsible for the depletion of the stratospheric ozone layer. In the troposphere, i.e., the lower levels of the atmosphere, CFCs and halons are very slow to break down. In the stratosphere, however, ultraviolet radiation breaks down these compounds releasing free atoms of chlorine and other halogens which destroy ozone molecules causing depletion of the ozone layer.

Stratospheric ozone depletion is greatest at polar regions, especially in Antarctica. During the past decade, 6-7 per cent of ozone concentrations have been depleted at mid-latitudes over Europe, and even with the implementation of the London Protocol to the Vienna Convention, ozone depletion is not expected to halt for at least 70 years (Stanners and Bordeau, 1995).

The depletion of the stratospheric ozone layer allows the penetration of harmful ultraviolet-B radiation which can adversely affect animal and plant life. The main concerns with regard to human health are increases in skin cancer and effects on immune response systems.

INLAND WATERS

The pollution of inland waters is caused mainly by incorrect disposal of farmyard slurries, sewage and industrial effluent. These liquid wastes contain large quantities of organic matter which deplete the oxygen in the water, nutrients which cause eutrophication and some metals and persistent substances. Such discharges can result in the destabilisation of aquatic ecosystems and a decline in the number of species. Salmonid waters can be seriously affected. Persistent substances such as metals and pesticides which are applied to land can build up in sediments at the bottom of rivers, lakes and the estuaries of large rivers. They can also build up in the food chain.

Sources of water pollution can be point or non-point sources. Point sources consist of municipal and industrial waste water discharges, storm sewer outfalls, and any other waste discharges which join water bodies directly through pipes and channels. Non-point sources include runoffs, atmospheric precipitations, and other diffuse sources. Point sources can usually be quantified and controlled before discharge whereas non-point sources are more difficult to manage.

There are several hundred sewerage schemes in the country and a large proportion of them serve small towns and villages. A summary of the numbers of sewerage schemes in different categories is given in Chapter 6. Some industries discharge into urban sewerage systems, whereas others have their own treatment plants and discharge directly to waters.

A recent review noted that there are over 300,000 septic tank systems in Ireland, serving approximately one-third of the population. Much of the effluent ultimately enters groundwater, and there are areas where, owing to poor soakage, it enters ditches and small streams. The review concluded that the disposal of domestic sewage in septic tanks is a major environmental issue (Daly *et al.,* 1993).

There is increasing concern about the effects of agriculture on the aquatic environment. Excessive applications to land of fertilisers and livestock waste, and poor management of farm wastes and silage liquor can cause serious damage to surface water and groundwater. These issues are further addressed in subsequent chapters.

MARINE AND COASTAL WATERS

Ireland's estuarine and coastal waters directly receive around four-fifths of the country's sewage and industrial waste water discharges as well as agricultural and other wastes carried down by rivers. In all, there are some 57 estuarine and coastal water bodies which receive appreciable waste loads. There are 17 estuaries of rivers with a catchment area of 500 km^2 or more and having towns in excess of 1,000 people on them. There are 21 estuaries of smaller rivers with towns of 1,000 people or more on them, and there are 19 other coastal water bodies receiving effluent from large populations.

Coastal waters with poor exchange of water can become polluted from a build-up of contaminants such as synthetic organic compounds, microbial organisms, oil, nutrients, heavy metals, radionuclides and litter. Harbours and boating marinas can be polluted by tributyl tin from anti-fouling paints.

Microbiological contamination comes from sewage and agricultural runoff. Oil pollution is carried in by rivers or comes from shipping operations. Nutrients are carried in by rivers and by outfalls discharging sewage and industrial effluents. Heavy metals can accumulate in the sediments of estuaries, as can radionuclides from radioactive waste disposal. Other pressures on the marine and coastal areas can come from dumping activities (including past dumping of munitions), from over-exploitation of resources, from the introduction of non-indigenous species, and from sea level rise and coastal erosion.

The main impacts of pressures such as these are considered in Chapter 10.

Tributyl Tin (TBT)

TBT has been used since the 1960s as the biocide in antifouling paints for use on vessels and salmon-cage nets. In Ireland, the first evidence of TBT contamination was from shell thickening in Pacific oysters near a marina in the Crosshaven Estuary in 1985, which affected the normal opening of the shells so that many oysters died. Subsequent investigations of TBT contamination through the use of small oysters in culture, demonstrated that it was a general problem in Ireland. In Mulroy Bay, scallops and various other molluscs had poor settlements during the years 1981-1982 and 1983-1985, and this decline was attributed to high levels of TBT as shown from the analysis of the soft tissues of molluscs. The fish farmers, when requested, ceased to use TBT and consequently, scallop settlement returned in 1986.

In 1987, a bye-law banning the use of TBT on all vessels under 25 m and on structures in water was imposed. Studies monitoring TBT levels in many areas along the coastline in 1987 and 1993, showed that TBT contamination had declined significantly in areas of aquaculture and smallboat activity, but had increased in shipping and large fishing-vessel ports, due mainly to large painted surface areas. TBT accumulates in fine sediments and therefore, dredge spoil from port areas must be disposed of to avoid damage to aquaculture and spawning or nursery grounds. In Cork Harbour, some populations of dog whelk have been eliminated due to TBT.

(Source: Department of the Marine)

SOIL

Pressures on soil quality, which in turn affects groundwater, comes from a variety of sources, including agriculture, the increase in urban areas, acid rain, motorway and road building, location of industries, erosion by wind and water, and overgrazing.

Intensive farming and the application of fertilisers can result in the soil, groundwater and small surface water bodies becoming overloaded with the nutrients nitrogen, phosphorus and potassium. High nitrate concentrations are

a threat to drinking water and can lead to eutrophication, for example, of coastal waters. Phosphate accumulates in the soil, and when soil is overloaded it can break through to local water bodies. The use of pesticides and various agri-chemicals can also result in their accumulation in soil. Particular care is required in relation to sheep dips and their disposal.

Soils can become loaded with metals (e.g., cadmium and copper) from the use of fertilisers, the disposal of animal slurries, the disposal of sewage sludge and by deposition from the air. The disposal of solid waste on land poses a threat to soil and groundwater.

Further information on solid waste disposal and its impact on the environment is given in Chapter 7 and the issue of soil quality is addressed in Chapter 11.

ACCIDENTS AND HIGH RISK ACTIVITIES

Accidents which cause damage to the environment arise mainly from transport or storage of potential pollutants and fire or explosions at industrial complexes. Nuclear accidents, giving rise to transboundary pollution, are a particular cause of concern. Spillages of oil and other dangerous substances can cause environmental damage and may contribute significant quantities of contaminants to the environment, especially the marine environment.

Certain activities involve risks to man and the environment should accidents occur during their operation. These activities include transport of dangerous substances, bulk storage of dangerous substances and the use of dangerous substances in manufacturing processes. Shipping through Dublin Port, for example, carries potential pollutants which include oil, liquefied petroleum gas (LPG), acrylonitrile and lead and zinc concentrates. Accidents, such as fires, explosions or major emissions, can lead to personal injury and danger to the environment. The development and use of genetically modified organisms may also pose risks to the environment.

Very few accidents involving dangerous substances have occurred in Ireland. A particularly serious accident was the explosion and fire on a ship and offshore jetty at Whiddy Island in 1979. Accidents involving road tankers carrying dangerous substances occur from time to time.

Accidents at fixed installations, mainly explosion followed by fire, have occurred. Such an accident occurred in August 1993 at the Hickson PharmaChem Ltd. chemical manufacturing plant, located near Ringaskiddy in Cork Harbour and its environmental effects were the subject of a detailed investigation (EPA, 1993).

Emergency plans are in existence throughout the country to deal with major incidents. Such plans identify the agencies and institutions that could provide technical expertise/advice on assessing hazards and appropriate response to threats to people and the environment.

Maritime local authorities and harbour authorities have contingency plans for clearance of oil pollution from beaches and immediately offshore. In the event of a major spillage which is beyond the local response capacity, overall direction and co-ordination of the incident is assumed by the National Operations Group under the aegis of the Department of the Marine.

RADIOACTIVITY

As shown by the effects of the accident at Chernobyl, nuclear accidents can give rise to dispersal of radionuclides on a continental scale.

The principal man-made source of radioactive contamination in the Irish Sea is the discharge of low-level liquid wastes from the nuclear reprocessing plant at Sellafield in the UK. Since the mid-1970s the quantities discharged have been progressively reduced by new waste treatment and improved operating procedures. The distribution of radioactivity in the Irish Sea and in Irish coastal waters generally is monitored by the Radiological Protection Institute of Ireland (RPII). The results show that the possible doses to members of the Irish public through the consumption of sea food are very low and do not represent a significant hazard.

Within Ireland the main sources of radioactive waste arise from use of radionuclides in medical and research establishments. The quantities discharged via sewerage systems are small and may only be discharged in accordance with limits laid down by the RPII.

AFFORESTATION

The development of forestry is considered to be of vital importance for Ireland because of the contribution it makes to economic development as a renewable resource. Afforestation, however, can be a threat to the environment, for example, through the drainage of large tracts of marginal lands and the application of slow release phosphorus. A further potential threat is acidification of waters containing the runoff from areas of evergreen afforestation. Habitats, particularly blanket bog, can be threatened by afforestation. These issues are addressed further in Chapters 11 and 12.

GENERAL DEVELOPMENT

General development includes a broad range of human activities which interact with and are dependent on the land around us: housing, infrastructural development, industries, waste disposal, farming and farmyard development, land drainage and reclamation, extraction of raw materials such as fuels, minerals and building materials, and leisure and tourism projects. Such development may involve changes in land use and the character of the rural landscape. It has impacts on natural habitats and populations of species of wild flora and fauna.

Impacts on the environment from agricultural activities, such as intensive stock farming, include nutrient enrichment of surface waters and groundwaters, overgrazing and soil erosion in some hill areas, change in the number of species of vegetation and reclamation of wetlands. With increasing mechanisation of agriculture, the tendency towards larger fields and changes in crops produced has resulted in changes to the appearance of the countryside. Hedgerows which are considered a visual amenity and are important as a wildlife habitat have been removed (see Chapter 11).

Development often involves reclamation of land from the sea, wetlands, or boglands. For example, around Dublin Bay there are a number of locations where future development of infrastructure and amenities may involve reclamation.

Fisheries interests have expressed concern about the cumulative effects on river systems of various developments affecting river channels and adjacent land surfaces, and have emphasised the need for a land use strategy and measures for the management and control of activities directly affecting river systems.

Roadside hedges and trees can be a hazard to road users and may have to be removed for visibility or for road widening. The correct timing of such activities can minimise the impact on wildlife.

Development of golf courses in seaside areas may involve reclamation of dunes and wetlands, and golf course development may have other impacts on the natural environment. Planning permission is now required for new golf course developments.

COASTAL EROSION

The coastline of Ireland is one of the most scenic in Europe, and is recognised as being a resource of great importance and value. About 3,000 km of the coastline is classified as soft, which includes sandy beaches and glacial cliffs. Some 1,500 km of this is considered to be at risk. About 700 km are classified as sandy beaches which are most susceptible to erosion damage from natural causes and human activities. Erosion of sand dunes is seen as a major problem in counties where these are prevalent. Coastlines currently experiencing erosion are those in Wexford, Wicklow, Cork, Clare, and Mayo.

Increased recreational use, such as horse trekking, cycling and public paths, causes or assists erosion of dunes. In many coastal areas erosion is threatening property, beaches and areas of high amenity. The causes of erosion are storm waves, littoral drift, the removal of beach material and the interruption of natural supply of beach material. Pressures on this environment also come from recreation facilities such as caravan parks located in sand dune areas.

Conflicts of interest can arise between bodies promoting the scientific and educational values of coastal areas and the promotion of tourism and the development of recreation facilities involving car parking, picnic areas and parking of caravans. Effective coastal zone management and planning can help to minimise such conflicts.

SEA LEVEL CHANGE

Tide gauges around Ireland indicate that the processes of changing sea levels in response to the last Ice Age are still occurring. The natural pattern of relative sea level change around the Irish coast is one of falling levels against coasts in parts of the north, such as the area of Malin Head, where the land continues to lift in response to earlier ice melt and unloading. Southward, land levels appear to be stable or sinking gradually, with relative sea level rise at rates of less than 0.5 mm per annum (Devoy, 1990).

Any increase in global temperature would result in a rise in sea level. The best estimate of the average rate of sea level rise by 2030 AD is about 2 mm per annum. How long this rise will last cannot be predicted. The impact of a sea level rise in Ireland has been assessed under the Environment Action Programme. Three scenarios were examined: a mean sea level rise of 18 cm, and best and worst cases of 9 cm and 30 cm rises.

Approximately 176,000 hectares (2.5 per cent of the Republic of Ireland) are believed to be at risk from sea level rise. As noted earlier, the risks are divided into two. Firstly, there is the possibility of gradual inundation of low-lying lands. The areas most sensitive to this are in estuaries, bays or behind protective barriers and reclaimed tracts of land. Secondly, there is a more widespread problem arising from the increased frequency of storms. These could result in increased flooding, destabilisation of sand dunes and shoreline erosion. Remobilisation of coastal sediment could lead to siltation in estuaries (McWilliams, 1991).

MINERAL EXPLOITATION

The extraction of base metals can have localised effects: air pollution, traffic generation, noise, and leachate from spoil heaps and tailings ponds. Dewatering can affect the surrounding groundwater regime. Liquid effluent disposal can affect streams, water supplies and fisheries. Dust, depending on its composition, can affect people, agriculture and wildlife. Sediments in harbours can become contaminated during the loading and unloading of mineral ores. Exploitation of sand and gravel deposits can change the local topography, and the sites can develop into local dumping grounds unless they are fenced and controlled.

Mineral exploitation may be damaging to the landscape, especially if carried out in scenic areas. The impacts on wildlife and habitats also require consideration.

A recent seminar on oil and gas exploitation included consideration of its effects on the environment and practical experience on limiting impacts (Irish Sea Forum, 1994).

FLOODING

Flooding can put lives at risk and can cause damage and losses to property. It can also cause damage to various economic sectors such as agriculture, transportation and infrastructural facilities.

Pressures on the environment as a result of flooding include overflows from sewers, septic tanks, farmyards and slurry pits into streams and rivers. The effects of flooding on fauna can include death from drowning, loss of habitat and loss of feeding ground.

Flooding generally occurs where watercourses have not sufficient capacity to convey the water without over-topping the banks. Development has progressively encroached on the flood plains of rivers and, in order to protect life and property, it has been necessary to build engineering structures such as levees, embankments or walls to contain the flood waters.

Various attempts to improve the lands of Ireland through drainage and other reclamation works occurred in the eighteenth and nineteenth centuries under a number of drainage Acts. It was not until the Arterial Drainage Act was enacted in 1945 that a comprehensive attempt was made to relieve the flooding problem and improve land drainage. The Arterial Drainage Act was amended in 1995 to allow local flood relief works to be carried out. Of particular concern are the karstic areas of the West where lands depend on interconnected underground channels to carry away flood waters.

WATER ABSTRACTION

Abstraction of water may put pressure on the environment because of consequent reduction in flow in rivers and streams, changes in lake levels, and lands flooded for storage. Water abstracted is discharged after use, with reduced quality, or, in the case of cooling water with raised temperature.

About 20 per cent of public abstractions and 60 per cent of private abstractions come from groundwater. In addition there are over 70,000 wells supplying groups and individual houses and farms in rural areas. Some further aspects of water supply in Ireland are summarised in Chapter 6.

Reduction in water use would have benefits for sewerage schemes, treatment plants, the quality of receiving waters and the availability of good quality water for domestic and recreational uses.

SOURCES OF NOISE

A quiet environment is regarded as an asset and something to be enjoyed. Development may change such an environment. Continued exposure to excessive noise can cause stress and/or endanger health. Noise at work is a health and safety issue and is not covered in this report.

Noise sources may be mobile or fixed. Fixed sources include factories, quarries, mines, or any activities associated with fixed locations or buildings. Mobile sources include traffic. Noise is liable to lead to complaints when it exceeds background levels.

The causes of noise pollution include road and rail traffic, aviation, industry, the construction industry and other economic activities. Road traffic noise can seriously affect living conditions in towns and working conditions in offices. The level of vehicle maintenance, the road surface, and the volume and type of vehicle are factors that affect the level of noise. The noise from railways which affects people living near them is caused by passing trains, shunting, hooters, and engineering works.

Aircraft noise complaints come from farming and horse breeding areas, and areas overflown during take off and landing, and also during training flights and helicopter flights. Neighbourhood noise comes from a variety of sources such as factories, construction, roadworks, sports and entertainment facilities, car doors slamming, unattended burglar alarms and barking dogs. There is an increasing trend towards more noise at night. Factories work continuously and road transport starts early to avoid traffic problems. The issue of noise is addressed in greater detail in Chapter 13.

RECREATIONAL PRESSURES AND LITTER

Noise can be one of the environmental pressures from recreational activities, particularly from motor sports, for example, power boats and jet skiing.

Recreational activities may damage sensitive ecosystems, cause disturbance to wildlife, such as roosting or nesting birds, and contribute significant amounts of litter. Day trippers to coastal areas can also cause damage to sand dune areas, to other habitats and to ancient monuments .

Litter affects beaches and the coastline, streets in cities and towns, and the countryside. Litter around the coast may arise from many sources including commercial and industrial operations, dumping from ships and boats, people visiting recreation areas, deliberate dumping of refuse, unscreened sewage and wind-blown material. Litter and street sweepings make up a large proportion of the domestic waste disposed of by local authorities. In the countryside one can see old cars dumped, plastic sheeting blown from farming activities and unauthorised dumping of household refuse (see Chapter 7).

AQUACULTURE

Large abstractions of water for inland fish farms can reduce the flow in streams to unacceptable levels. Inland waters can be polluted by waste from fish farms and contamination of surface waters with drugs and disinfectants can occur. The high concentrations of fish in farm situations produces conditions where diseases and parasites can multiply thus creating a reservoir of infection for local native fish populations.

Caged salmon farming can cause pollution of the sea bed with organic matter from faeces and food, although in recent years improved management and the siting of cages in more exposed locations has helped to minimise this. The question of links between the proliferation of sea lice on caged fish and the decline of sea trout numbers returning to rivers has been the subject of intensive study in recent years (Chapter 9). The use of chemicals to treat salmon for sea lice can have harmful effects on other non-target crustacean species such as the lobster and the prawn. Antifoulants on nets and structures pose toxicity threats. Other pressures from caged salmon farming can include breeding between escaped farmed fish and wild fish, conflict with anglers and conflict with shellfish growers. Salmon cages are sometimes regarded as being visually intrusive on the coastline.

The free movement of trade in shellfish throughout the European Union can result in the introduction of exotic pest species as well as diseases to shellfisheries in Ireland.

Wildlife, e.g., seals, otters, herons, cormorants and shags, may come into conflict with aquaculture because of interference with stocks. Some species can suffer because of shooting or by accidental drowning after becoming entangled in nets and cages (see Chapter 12).

OTHER PRESSURES

There is increasing concern, internationally, about the growing number of chemicals in use for various purposes. Some examples of specific problems that have arisen in recent years are given in this chapter, e.g., in particular, from TBT anti-fouling paints. The general questions of the use of chemicals, the various pathways whereby they may enter the environment, and their effects on human and animal health will require greater attention in the future.

It is acknowledged that the full range of pressures on the environment is extremely broad, and to attempt to outline all of them in this chapter would cause it to become unwieldy. There are uncertainties concerning certain issues such as electromagnetic fields. Many additional factors are considered at the appropriate stages in this report.

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CHAPTER **5**

EMISSIONS TO AIR

INTRODUCTION

Awareness of atmospheric pollution first arose as a result of the local effects of winter smog on human health, usually in urban or heavily industrialised areas. Then came an appreciation of regional influences and environmental damage caused by acid rain due to man-made emissions of sulphur and nitrogen. Awareness developed, too, of photochemical pollution related to unprecedented growth in road traffic. More recently, the importance of global impacts has been recognised and, at this scale, the adverse effects of greenhouse gases such as carbon dioxide (CO_2), originally considered harmless, are now causing widespread concern. The emission of pollutants into the atmosphere is arguably now the greatest of all pressures on the global environment.

A wide range of measures is now being applied to reduce the concentrations of primary air pollutants, to control acid deposition and photochemical smog, and to address the problems of global warming and stratospheric ozone depletion. A common feature of many of these measures is the need for reliable information on the mass emissions of the substances concerned. Important international emissions control agreements are currently in place for some pollutants such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x). Implementation of the agreements requires a knowledge of the annual emissions of these pollutants and imposes a basic obligation for the parties concerned to report emissions annually. National responsibilities in this area are increasing as control strategies are developed for other pollutants and individual greenhouse gases.

EMISSION INVENTORIES AND REPORTING REQUIREMENTS

An air pollutant emissions inventory is a database of emission source activities, activity statistics, emission factors, emission measurements and the emission estimates derived from these data. Because measurement data are limited to a few individual sources, emission estimates are largely derived using activity statistics and emission factors appropriate to the activity and pollutant concerned. As many abatement strategies for air pollution are pursued within the framework of international agreements, there is a number of ongoing activities aimed at harmonising emission inventories among countries. This harmonisation is taking place through CORINAIR, initiated in 1987 under the European Union (EU) CORINE programme, the work of the European Monitoring and Evaluation Programme (EMEP) and the Intergovernmental Panel on Climate Change (IPCC). CORINAIR inventories for EU countries are undertaken at five-year intervals and the programme has now been extended beyond the EU to more than 30 countries. At the EU level specifically, Member States must report emissions of SO_2 and NO_x from existing large combustion plants on an annual basis from 1990 as part of the implementation of the Directive on Large Combustion Plants (LCP) (CEC, 1988). Emissions data and reduction strategies for greenhouse gases, such as CO_2, methane (CH_4) and nitrous oxide (N_2O), must be reported under the Monitoring Mechanism for CO_2 (CEC, 1993).

On a wider scale, national emissions data on SO_2, nitrogen oxides (NO_x) volatile organic compounds (VOC), CH_4, carbon monoxide (CO) and ammonia (NH_3) must be submitted annually to the Executive Body of the Geneva Convention on Long-Range Transboundary Air Pollution as part of reporting obligations related to the various Protocols adopted under the Convention (UN, 1985, 1988 and 1991). These data constitute an important input to EMEP dispersion models used for assessing emission/deposition relationships of pollutants in Europe and for calculating pollutant import/export budgets for United Nations Economic Commission for Europe (UNECE) countries. Also under the ambit of UNECE, current and projected emissions of several greenhouse gases and related pollutants are required for the implementation of the Framework Convention on Climate Change (FCCC).

It is partly to meet these needs that emission inventories of all major air pollutants and greenhouse gases are produced annually in Ireland. The data are also required to assess historical trends, to identify the most important emission sources, and for use in the interpretation of air quality and acid deposition measurements. In addition, emission inventories form the basis for emissions projection and for developing national control strategies.

The format and content of Irish emission inventories are largely dictated by the data needs of the international organisations. The methodology used is based mainly on the CORINAIR system, except in the case of greenhouse gases where more recent guidelines of IPCC are taken into account. These developments have resulted in a considerable increase in the range of emission sources covered.

Inventories have not been developed in the case of ozone-depleting substances, such as chlorofluorocarbons (CFCs), due to the lack of information available and, in any event, having regard to the objective of a complete phase-out of their use under the Montreal Protocol and its subsequent amendments and adjustments.

EMISSIONS OF PRIMARY POLLUTANTS

Estimates of the emissions of SO_2, NO_x, VOC, CO and smoke in the years 1980, 1985, 1990 and 1993 are presented in Table 5.1. The emissions of most pollutants in Ireland are determined largely by the combustion of fuels. Therefore, a simple source-sector classification, based on that used by the Department of Energy for compiling national energy balances, has been adopted for the purposes of this report. The use of the more detailed source-sector classifications developed for supplying emissions data to international inventories such as CORINAIR and FCCC (OECD, 1991) is not considered appropriate here. This is because they did not apply before 1990 and therefore would not allow for comparisons with earlier years.

Total emissions of SO_2 decreased by about 30 per cent over the period 1980-1993. The reduction has been achieved mainly through switching to low-sulphur fuels in all stationary combustion source categories. Emissions of SO_2 from industrial combustion have decreased by more than 60 per cent since 1980, reflecting both a major switch to natural gas consumption at the expense of heavy fuel oil and a decrease in the sulphur content of gas oil.

The emissions of SO_2 from power plants were less than 40,000 tonnes in 1985, due to the large consumption of natural gas before the commissioning of the Moneypoint coal-fired power station. Subsequently, Moneypoint quickly became the principal source of SO_2 emissions in the country and total emissions from power plants increased again to return to their 1980 level by 1990. The decrease in emissions from this sector between 1990 and 1993 results mainly from progressive reduction in the sulphur content of the coal burned at Moneypoint.

Unlike those of SO_2, emissions of NO_x have increased steadily over the past 15 years and it is only now that abatement strategies for this pollutant are beginning to show some results. The greatest increases have been in the power generation and road transport sectors which together account for more than 80 per cent of NO_x emissions in Ireland, with traffic being the single most important source. Emissions of NO_x from other sectors have remained relatively unchanged. The installation of NO_x control technologies in power generation in recent years is expected to bring about a significant reduction in NO_x emissions from that sector.

Emission estimates for VOC remain highly uncertain in absolute terms. Nevertheless, it may be stated that the emissions of these compounds in Ireland have also been increasing steadily for many years. The main source of VOC emissions is road transport. It is now known that VOC emissions play an important role in episodic ground-level ozone formation. Agreements for the control of VOC (UN, 1991) have been a relatively recent development, compared with those for SO_2 and NO_x. The achievement of large-scale reductions from traffic sources appears just as difficult as in the case of NO_x. Emission controls related to the use of organic solvents, the other most important man-made source of VOC, will need to be in place for several years before there is any substantial decrease in emissions.

Table 5.1 *Emissions of Primary Pollutants, 1980, 1985, 1990 and 1993 (tonnes) (McGettigan and O'Donnell, 1995).*

Pollutant	Year	Power Plants	Residential/ Commercial Combustion	Industrial Combustion	Transport	Other Sources	Total
	1980	101500	34700	78600	5400	2200	222400
SO_2	1985	39340	39730	55450	4380	2290	141190
	1990	103030	30375	38000	5790	700	177910
	1993	87190	32030	29785	7275	590	156870
	1980	27300	4100	8200	34800	8300	82700
NO_x	1985	29040	6710	8180	35450	5710	85090
	1990	46370	6710	10760	48980	2890	115720
	1993	46500	7440	8760	57110	2630	122450
	1980	100	12400	200	34800	31800*	79200
	1985	80	16540	570	24300	22240*	63730
VOC	1990	250	7950	340	63490	124990*	197020
	1993	250	6650	170	68600	126080	201750
	1990	3300	79560	890	308420	38880	431050
CO	1991	3320	79630	670	314790	29500	427920
	1993	3350	66650	430	316550	29500	416480
	1990	11480	23320	1250	4810	0	40860
Smoke	1991	13020	22080	960	4055	20	40140
	1993	12290	17550	1000	4430	10	35270

* The apparent increase in VOC emissions from 'other sources' between 1980 and 1990 is due to changes in the methodology used.

Approximately 75 per cent of CO emissions emanate from traffic sources and, while the trend for CO from this sector is again upward, total emissions in Ireland are also dependent on the amount of peat and coal used in residential heating. Emissions of CO from vehicle exhausts are subject to ongoing control under EU Directives. The evolution in total emissions will depend almost entirely on the effectiveness of current and future abatement technologies for exhaust emissions from gasoline cars.

Smoke emission estimates given in this report have been compiled using emission factors determined by EOLAS (O'Rourke and Reilly, 1989) and are not directly comparable with published estimates for years prior to 1990. Total emissions of smoke are currently less than 40,000 tonnes annually, 50 per cent of which emanate from solid fuel combustion in the residential sector.

While some uncertainty remains in relation to the values given here, it may be stated that national smoke emissions have decreased substantially as a result of smoke control legislation implemented in Dublin in 1990 and will decrease further due to similar controls now in place in Cork.

EMISSIONS IN IRELAND IN THE CONTEXT OF INTERNATIONAL CONTROLS

Under a number of current international emission control agreements, national limits apply to both the total emissions of certain primary pollutants and the emissions from specified source categories. These agreements include the Directive on Large Combustion Plants (CEC, 1988) and Protocols to the Geneva Convention on Long-Range Transboundary Air Pollution, and they have an important bearing on national emission abatement strategies.

The LCP Directive sets emission limits for SO_2 and NO_x from existing combustion plants (licensed for construction or operation before 1 July 1987) of greater than 50 MW capacity, to be achieved on a phased basis over a specified time-frame. The ceilings for Ireland are equal for all phases and are 124,000 tonnes for SO_2 until 2003 and 50,000 tonnes in the case of NO_x until 1998, with Phase 1 limits applying in 1993. The ceilings are based on the level of emissions in 1980 and would actually represent allowable increases of 25 and 79 per cent in the emissions of SO_2 and NO_x, respectively, from the group of plants concerned.

International Emissions Reduction Targets for Acidifying Pollutants and Ozone Precursors

The reduction in emissions of acidifying compounds and ozone precursors (various compounds which play a part in the formation of ozone) is an important objective of the Executive Body of the Geneva Convention on Long-Range Transboundary Air Pollution. The Helsinki Protocol on sulphur emissions (UN, 1985), the first in a series under the Convention, imposed a uniform emission reduction of 30 per cent for signatory nations by 1993 over 1980 levels. Much greater reductions were actually achieved over this period by some countries. The Helsinki Protocol was replaced by the Oslo Protocol in 1994 which is not based on uniform reduction targets. Instead, it sets targets for each country broadly in accordance with the contribution their sulphur dioxide (SO_2) emissions make to exceedance of critical loads, i.e., the rate of sulphur deposition above the threshold for adverse effects. In the case of nitrogen oxides (NO_x), the Sofia Protocol (UN, 1988) required signatories to stabilise their emissions at the 1987 level by 1994. The critical loads concept, relating in this case to both acidification and eutrophication, also forms the main scientific basis for revision of the Sofia Protocol now under way. However, other complicating factors, such as the role of ammonia in soil acidification and the importance of NO_x in ozone formation, also need to be taken into account.

Under the volatile organic compounds (VOC) Protocol (UN, 1991), a party has three options for meeting the basic obligations in regard to reductions in non-methane VOC emissions as follows:

(i) reduce the 1988 level of emissions (or those of any other specified year between 1980 and 1990) by 30 per cent by 1999;
(ii) achieve a standstill by 1999 at 1988 levels if the emissions in that year were lower than (a) 500,000 tonnes, (b) 5 tonnes/km² and (c) 20 kg/inhabitant;
(iii) in the case where the country operates tropospheric (low level) ozone management areas and VOC emissions originating in such areas contribute to tropospheric ozone concentrations in another country, it can reduce the emissions from the areas concerned as under (i) and ensure that total national emissions do not exceed 1988 levels by 1999.

The Directive on Large Combustion Plants (LCP) (CEC, 1988) is the only one in the wide range of Directives concerning air pollution which incorporates specific emission reduction targets. The LCP Directive sets out, for a specified set of stationary combustion sources, ceilings for the emissions of SO_2 and NO_x in each Member State and the percentage reduction over 1980 levels to be achieved on a phased basis up to 2003 for SO_2 and 1998 for NO_x. Overall, the emissions of SO_2 and NO_x from the plants concerned will decrease by 60 per cent and 30 per cent, respectively, under this Directive.

The Helsinki Protocol (UN, 1985) on sulphur emissions imposed a uniform emission reduction target of 30 per cent for signatories by 1993 over 1980 levels. Ireland was not a signatory to the Protocol but nevertheless achieved the target, largely through switching to low-sulphur fuels, as already mentioned. The Helsinki Protocol was replaced by the Oslo Protocol in 1994. Instead of equal percentage reductions, the new Protocol sets targets for each country broadly in accordance with the contribution their SO_2 emissions make to exceedance of critical loads, i.e., the rate of sulphur deposition above the threshold for adverse effects. Ireland has signed the Oslo Protocol, with a commitment that SO_2 emissions in the year 2000 will again be 30 per cent lower than in 1980. This gives a national target in that year equal to the level of emissions in 1993 of some 157,000 tonnes.

As all but one of the combustion plants in Ireland covered by the LCP Directive are power plants, the achievement of the emission ceilings set by the Directive depends almost entirely on the level of emissions from power plants. Reductions in emissions from power plants through fuel switching has therefore favoured compliance with the LCP ceilings in respect of SO_2. Emissions of SO_2 from large combustion plants in 1993 were 99,100 tonnes (Table 5.2), which is very close to the corresponding value in 1980, and therefore well within the Phase I limit under the LCP Directive.

***Table 5.2** Emissions of SO_2 and NO_x from Large Combustion Plants (McGettigan and O'Donnell, 1995).*

	SO_2 (tonnes)			NO_x (tonnes)		
Year	50-300MW	>300MW	All Plants	50-300MW	>300MW	All Plants
1990	19360	94890	114250	5640	39980	45620
1991	17490	97890	115380	5560	40750	46310
1992	18890	89470	108360	5830	47130	52960
1993	17720	81380	99100	5080	42130	47210

In contrast to SO_2, the trend in total NO_x emissions has been clearly upward and therefore, compliance with the relevant emission limits has not been so readily attainable. For large combustion plants, NO_x emissions increased in the years up to 1992 when the total reached 52,960 tonnes (Table 5.2). It was only as a result of retro-fitting low-NO_x burners at several power plants that the LCP Phase I ceiling of 50,000 tonnes was not exceeded in 1993. Further controls of this type are being implemented in this area. All of these power plants are expected to require integrated pollution control (IPC) licences to be issued by the Environmental Protection Agency (EPA). Licensing will be undertaken on a site-by-site basis but overall adherence to the above figures is expected to be the minimum requirement.

The Sofia Protocol (UN, 1988) required NO_x emissions in signatory countries, which include Ireland, to be stabilised at the 1987 level by 1994. Accordingly, total emissions of NO_x in Ireland in 1994 were required to be no more than the 1987 value of 105,400 tonnes but the total is expected to be marginally in excess of this amount when estimates become available. This is partly due to an underestimate of the expected increase in emissions from traffic generally at the time of signing the Protocol. It is also partly due to the numerical differences given by changes in the methodology for estimating emissions from road traffic (Eggleston *et al.*, 1989 and Eggleston *et al.*, 1991).

International Emissions Reduction Targets for Ozone-depleting Substances and Greenhouse Gases

The 1987 Montreal Protocol to the Vienna Convention for the protection of the ozone layer originally aimed at reducing the 1986 level of chlorofluorocarbons (CFCs) production by 50 per cent before 1999. The Protocol has since been very much strengthened at London (1990) and Copenhagen (1992) with the aim of halting global emissions of CFCs, carbon tetrachloride and methyl chloroform by 1996 and controlling the use of CFCs replacements.

The United Nations Framework Convention on Climate Change (FCCC), signed by 160 countries, came into force in March 1994. The ultimate objective of the Convention is to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system (IUCC, 1993). The Convention covers carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) which contribute directly to the enhanced greenhouse effect, as well as nitrogen oxides (NO_x), carbon monoxide (CO) and non-methane VOC which may influence the concentration of some greenhouse gases in the atmosphere.

Emission control strategies to date have concentrated on carbon dioxide (CO_2) with a general objective of returning emissions in developed countries to 1990 levels by the year 2000. At the first session of the Conference of the Parties (COP-1) in early 1995, it was acknowledged that much more action is required to meet the Convention objective. The Berlin Mandate, adopted at COP-1, establishes a process for strengthening developed country commitments after the year 2000 for all greenhouse gases and will consider setting objectives for limiting and reducing emissions within specified time-frames.

EMISSIONS OF GREENHOUSE GASES

Since 1992, many signatories have developed and implemented strategies to control or reduce emissions of one or more of the three main greenhouse gases, CO_2, CH_4 and N_2O. Emissions reduction strategies are concentrated on CO_2, for which the objective of emissions stabilisation at 1990 levels by the year 2000 is being pursued by the EU. To this end, a Council Decision for a monitoring mechanism of CO_2 and other greenhouse gases was adopted in 1993 (CEC, 1993). An abatement strategy for CO_2 emissions in Ireland, developed to meet obligations under both the EU and the Framework Convention on Climate Change objectives, was published by the Department of the Environment (1993). While the EU target is stabilisation of CO_2 emissions by the year 2000, emissions in Ireland are to be limited to an increase of 20 per cent over 1990 levels.

The simplified source-sector classification previously adopted for other pollutants is used again to show how total CO_2 emissions in Ireland increased between 1985 and 1993 (Fig. 5.1). The changes in contributions of the main fuel types since 1980 are shown in Fig. 5.2. Emissions of CO_2 have increased by approximately 20 per cent since 1985 to approximately 33 million tonnes in 1993 and no significant change in the rate of increase is expected over the next ten years. Most of the increase has occurred in the electricity generating sector, where coal is the major contributor. A slight increase has also taken place in the transport sector, while emissions from the other sectors have remained relatively unchanged.

Methane (CH_4) and nitrous oxide (N_2O) are other important greenhouse gases for which inventories have only recently been developed. Unlike those of other pollutants, the emissions of these gases are largely unrelated to fuel combustion activities. While a small number of human activities can contribute directly to significant emissions of either CH_4 or N_2O, the bulk of emissions arise from processes which are either completely natural, or only partially influenced by man. The nature of the sources involved means that estimates of total CH_4 and N_2O emissions are highly uncertain and any national total is highly dependent on the range of sources covered by the inventory. It is for this reason that the IPCC, in particular, is insisting on a standard source nomenclature for inventory purposes (IPCC, 1994).

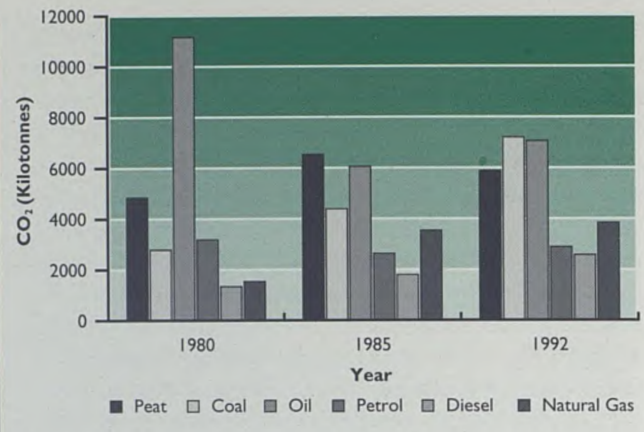

Fig. 5.2 CO_2 Emissions by Principal Fuel Category.

The most important global sources of CH_4 are enteric fermentation in ruminant animals, anaerobic decomposition in wetlands and rice paddies, biomass burning, waste decomposition in landfills and fossil fuel extraction. Denitrification of soils is the principal source of N_2O, with emission rates being dependent on agricultural practices, biogenic processes, soil properties and climatic conditions. The application of mineral fertilisers provides an additional source of nitrogen thereby increasing the emissions of N_2O from soil. Adipic acid production is the only significant industrial source of N_2O.

Based on the available data on emission rates, CH_4 and N_2O emissions in Ireland in 1990 were estimated at 850,000 and 45,000 tonnes, respectively, (McGettigan, 1993). Given the uncertainties in these totals, it is considered unrealistic to

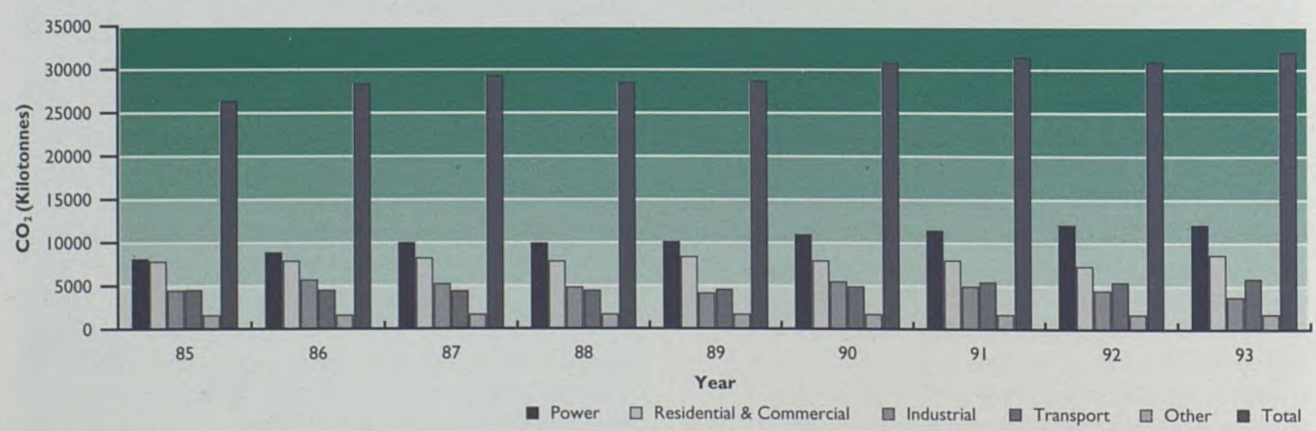

Fig. 5.1 CO_2 Emissions by Principal Source Category.

assess trends in the emissions of these particular gases on a year-to-year basis.

SPATIAL REFERENCING OF EMISSIONS

Emissions data for pollutants such as SO_2, NO_x, VOC, CO and NH_3 are required to be reported not only as national totals but also, increasingly on a more detailed scale. They are being requested as subtotals for various spatial units, mainly for use in pollutant transport models. These more detailed emissions data are also being integrated with other data forms in applications to allow more complete analysis of environmental problems related to traffic management, episodic ozone formation and some agricultural activities.

CORINAIR emissions data are normally compiled according to the NUTS (National Units for Territorial Statistics) system. Across Europe, CORINAIR uses Level 0 through Level 3 regions in each Member State, e.g., Fig. 5.3a and 5.3b for Ireland. Level 3 is the smallest territorial unit for which statistics are compiled and Level 0 is the total country. (In the case of Ireland, NUTS Level 1 and Level 2 also refer to the whole country). The data are then re-allocated to the Organisation for Economic Co-operation and Development (OECD) 50 km x 50 km grid (Fig. 5.3c) which is a sub-grid of the 150 km x 150 km grid used in current EMEP long-range transport models (Fig. 5.3d). National emissions data being submitted to EMEP are required to be referenced to both the EMEP and the OECD grids.

Mapping at all these spatial scales was achieved for the first time for Ireland using the CORINAIR 1990 emissions data. Gridded emissions values for the OECD grid were derived from the totals for NUTS regions using appropriate statistics, such as population. The OECD grid results for SO_2, NO_x, VOC and NH_3 are presented on Fig. 5.4. The results for the EMEP grid were then determined simply by summing the values in the nine relevant grid-cells of the OECD sub-grid.

These reference frames give a good indication of how emission densities for the various pollutants vary depending on the mapping unit selected, particularly in the case of pollutants for which point sources contribute a large proportion of total emissions. For example, approximately two-thirds of SO_2 emissions in Ireland can be allocated to just two OECD 50 km by 50 km grid-cells, one of which overlies the Shannon Estuary, where the largest point sources of SO_2 are located, with the other overlying Dublin. This means that SO_2 emission densities at this resolution are very low indeed (less than one tonne/km^2) for the remainder of the country generally.

The spatial emission pattern for NO_x is similar to that for SO_2, where a small number of point sources again account for a large proportion of total emissions. The patterns for VOC and NH_3 are similar to each other, with largely uniform emission densities in the range 1-4 tonnes/km^2, but quite different from those for SO_2 and NO_x, reflecting the different type and distribution of sources.

CONCLUSIONS

Given Ireland's small population and lack of heavy industry, the level of pollutant emissions is low compared to most European countries. Irish emissions of those pollutants receiving most attention, e.g., SO_2, NO_x and CO_2, account for typically one per cent of the respective totals for EU countries as a whole. Trends in emissions in Ireland are broadly similar to those in other countries and there is general compliance with emission limits imposed by a variety of international emissions reduction agreements.

National emissions of some pollutants and greenhouse gases increased in the past 15 years, but there have been notable reductions in the case of SO_2 and smoke. It is clear that, during the late 1980s and early 1990s, the increases which occurred in total emissions have been largely due to the traffic sector, while emissions for other sectors remained relatively stable, or decreased in some cases.

In 1993, emissions of SO_2 were about 30 per cent lower than their highest levels around 1980. Power stations remain the largest source of SO_2, accounting for almost two-thirds of total SO_2 emissions in 1993. The emissions of NO_x have increased steadily in recent years. The upward trend in NO_x emissions from power stations has been reversed by retro-fitting NO_x controls at a number of the larger stations since 1992. As in most countries, it is likely that it will take some years before the benefits accruing from catalytic converters are sufficient to achieve a similar result in the case of emissions from traffic. National emissions of CO_2, the main greenhouse gas, continue to increase with little change expected in the foreseeable future due to the heavy reliance of energy requirements on high carbon-content fuels.

Emission inventories are an important element of air quality assessment and emission abatement strategies. Continued development of inventories is therefore necessary and much more emphasis is needed on the issue of emission projection, especially in relation to important sectors such as road traffic and electricity generation. The improvements and development of emission estimates for greenhouse gases will be guided by the international organisations already involved in this issue. The establishment of a national emission register for industry and major emitters is being undertaken as a necessary step towards improving current emission estimates for NO_x and VOC from a number of important source categories.

(a) NUTS Level 0

(b) NUTS Level 3

(c) OECD Grid (50 x 50 km)

(d) EMEP Grid (150 x 150 km)

Fig. 5.3 *Spatial Reference Frames for Emissions Data.*

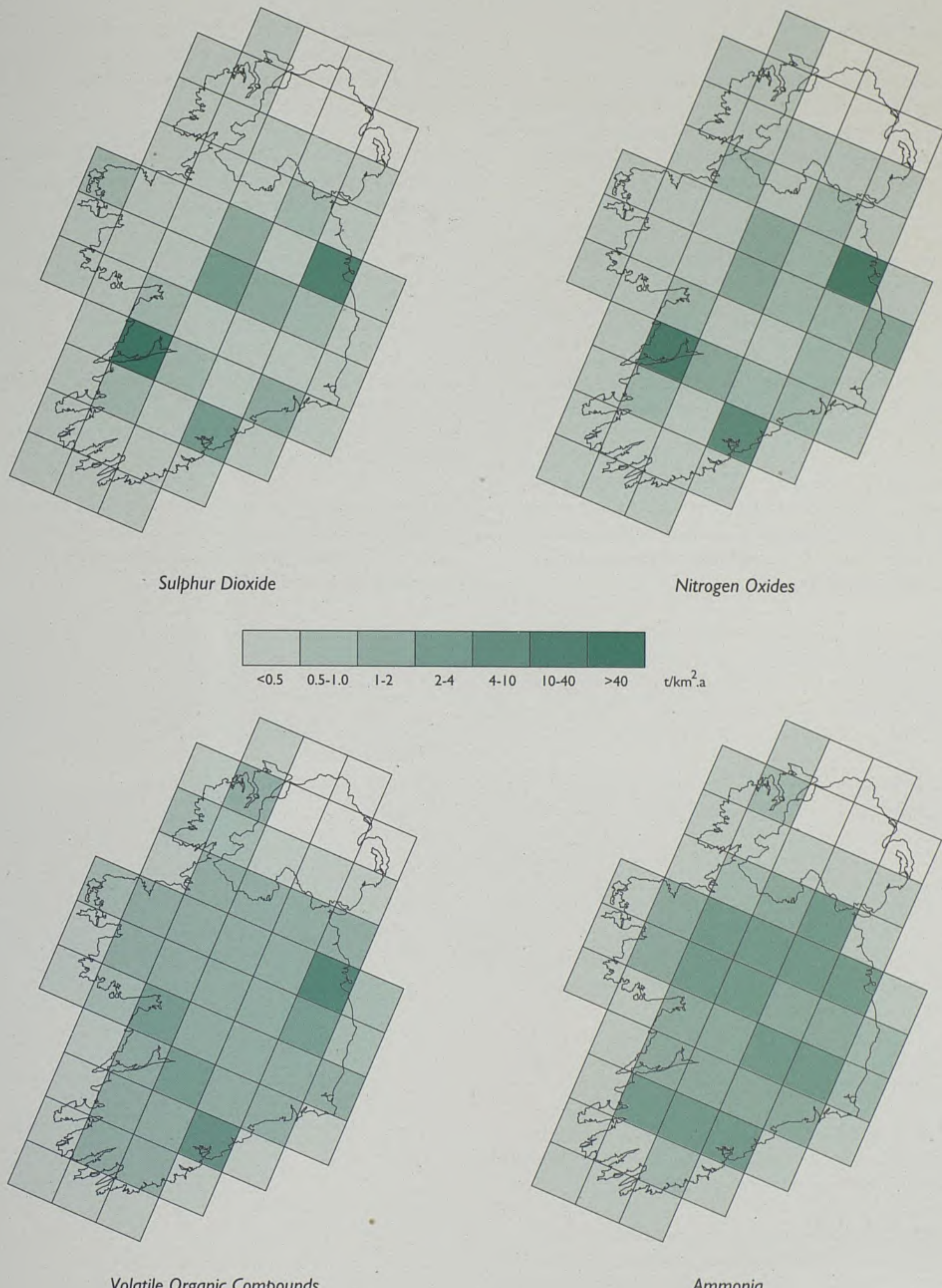

Fig. 5.4 *Emission Rates in 1990 on the OECD Grid (Source: EPA).*

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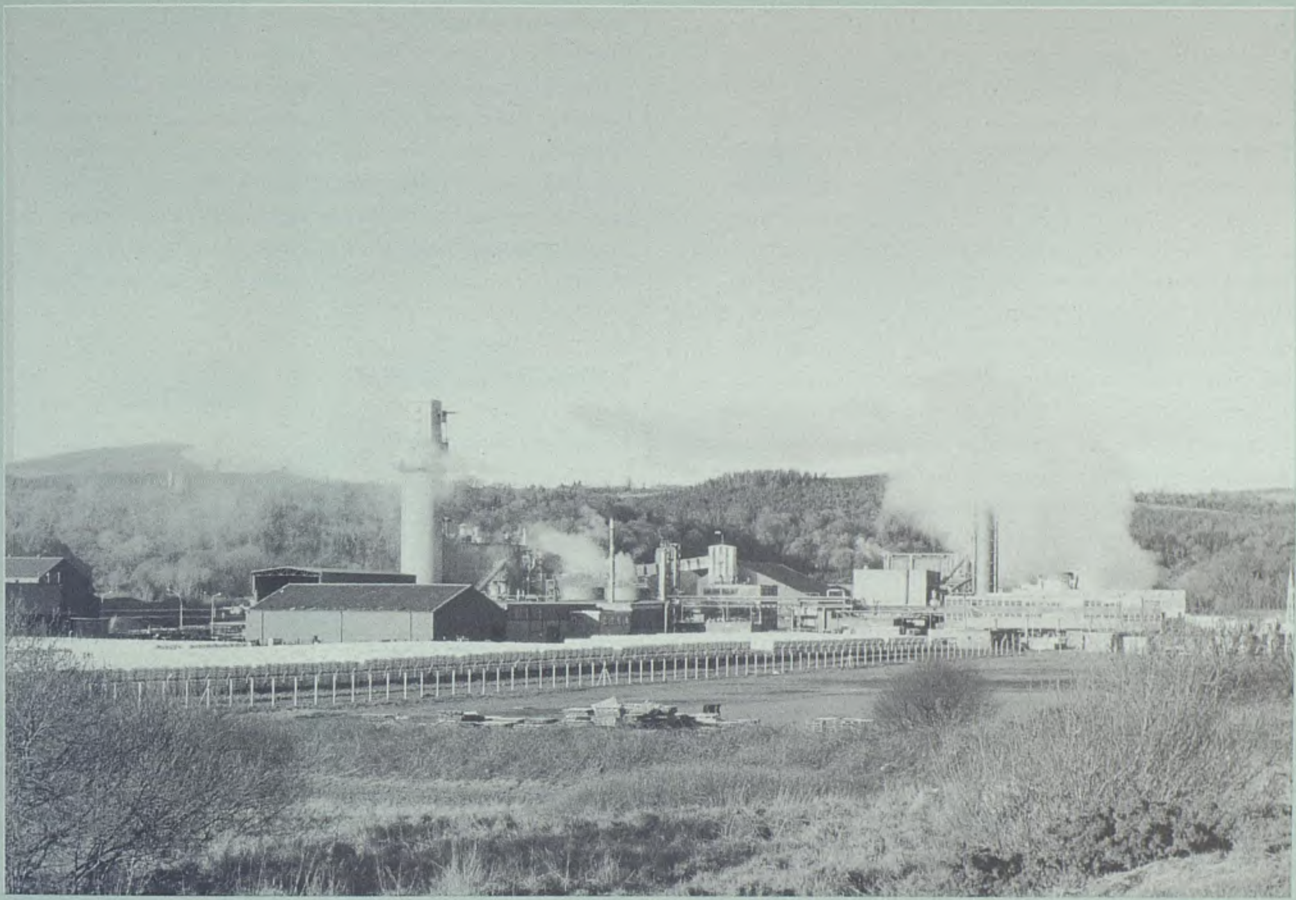

CHAPTER 6

DISCHARGES TO WATERS

INTRODUCTION

Most of the water supplies abstracted for domestic, industrial or agricultural use are returned to the environment as waste waters, with their quality impaired. Carrying pollutants which may be in either dissolved or suspended form, the waste waters are discharged into various types of 'receiving waters' - rivers, lakes, groundwaters, estuaries or the sea.

The bulk of the emissions, or discharges, of waste waters in Ireland originate from the three types of activity referred to above - domestic, industrial and agricultural. As noted in Chapter 4, the discharges can reach inland and tidal waters in a number of ways. There are three ways in particular. The first is as a point source, i.e., directly through a pipe or outfall. The second is as runoff across the land surface and into streams. The third is by leaching through soils and rocks and into groundwaters. Sources of pollutants entering the aquatic environment via the latter two routes are referred to as non-point or diffuse sources.

Estuaries and the sea, in addition to receiving direct discharges, mainly of sewage and industrial effluents, and some diffuse sources, also receive significant amounts of pollutants indirectly via inflowing rivers. Another indirect source of contaminants is the atmosphere. For example, the estimated nitrogen input to the Irish Sea from the atmosphere is about 2.5 times that from industry and domestic sewage combined (Irish Sea Study Group, 1990). The present chapter, however, concentrates in particular on liquid effluents or discharges to the aquatic environment.

The bulk of the waste waters that arise in this country contain substances that are mainly of an organic biodegradable nature. The concentration of biochemical oxygen demand (BOD) in effluents and in receiving waters is a useful indicator of the extent of pollution potential and actual pollution from discharges of such wastes.

In urban areas, domestic waste water is collected in sewerage systems. It is usually then given appropriate treatment and discharged into rivers, estuaries or the sea. Waste water from industry in urban areas is generally discharged into the same sewerage system. Alternatively, certain industries have their own treatment and disposal systems. In rural areas, domestic waste water is collected in septic tanks from which the supernatant liquid seeps into the ground.

In relation to the treatment of sewage, and of industrial waste water containing organic biodegradable matter, the terms primary, secondary and tertiary are used for different levels of treatment. Primary treatment consists of the physical removal of settleable and floating solids from the waste water in settling tanks. In the secondary, or biological, treatment stage, non-settleable suspended and dissolved solids are converted into biological sludges which, in turn, are removed by settling. In some cases, the treatment is upgraded to remove nutrients or other pollutants. This is done by installing additional processes (tertiary treatment) or incorporating advanced waste water treatment technology into the existing plant.

In order to quantify the waste loads carried into receiving waters, one needs to have information on the quantity of water discharged and the concentration of pollutants it contains. Point discharges of waste water, whether domestic or industrial, can be monitored both for quantity and for quality. It is impossible, however, to quantify accurately non-point pollution loads, but their impact can be assessed through regular monitoring of the receiving waters.

DOMESTIC SEWAGE

Urban Population Distribution

The distribution of population in the State clearly has a significant bearing on the volumes and locations of sewage discharges to water bodies. Trends relating to population and its distribution in Ireland have been outlined briefly in Chapter 2. The strong trend of increasing urban population has been noted. With particular reference to the urban population, some further details of the distribution, based on the 1991 Census, are outlined below (CSO, 1993).

Some 26 per cent of the population of the State lives in the Greater Dublin area, with five per cent in Cork city and suburbs and 2.1 per cent in Limerick city and suburbs. Thus, the three largest cities account for about one-third of the population, although it is Dublin which mostly accounts for this.

The combined population of all 'aggregate towns', accounts for almost 57 per cent of the total population. Aggregate towns are those having a population, including suburbs or environs, amounting to 1,500 inhabitants or over. When towns smaller than this are taken into account, the total urban population amounts to 64.6 per cent, which leaves the population outside towns amounting to 35.4 per cent.

The distribution of the population of the State, in relation to the sizes of population centres, is shown in Fig. 6.1, using a number of broad population categories.

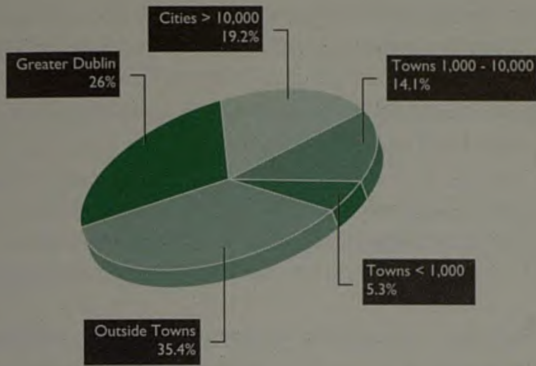

Fig. 6.1 *1991 Population Distribution Based on Broad Categories of Population Centres (CSO, 1993).*

Including the Greater Dublin area and the cities of Cork, Limerick, Galway and Waterford, the total number of cities, towns and villages in Ireland is 634. The breakdown of these, by population size is given in Fig. 6.2.

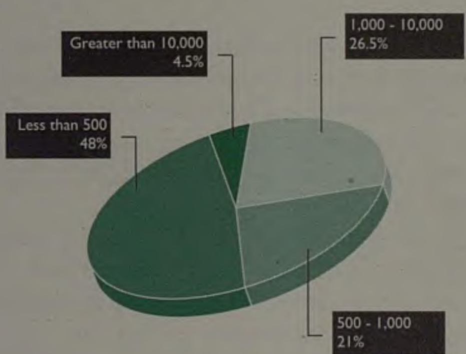

Fig. 6.2 Percentages of Towns in Specific Population Categories (CSO, 1993).

Water Supply

Of the State's population of about three and a half million persons, 80 per cent are served by public water supply schemes and the remainder are served by private group schemes or individual wells. The amount of water produced by public water supply schemes is about 1,290,000 m^3/day, and that produced by group water supply schemes is more than 50,000 m^3/day. Not all of these total amounts are used as losses also occur through leakage. Domestic and commercial water requirements, in urban areas, amount to approximately 250 litres per person per day and most of this is discharged to sewers after use. The volume of water required by manufacturing industry has been estimated in the past to be about 242,000 m^3/day, a figure which does not include the large quantities of cooling water used in industry (IIRS, 1983). There is a need for a more up-to-date assessment of the present-day needs.

Sewerage Schemes

About 2.4 million persons (68 per cent of the population) are connected to public sewers. There are 619 sewerage schemes in the country serving populations greater than 200. All sewerage schemes discharging to inland waters have treatment plants. Of the 619 schemes, 17 have treatment to tertiary level, 289 have treatment to secondary level, 218 have primary treatment only, and 95 (discharging to tidal waters) have no treatment (Fig. 6.3).

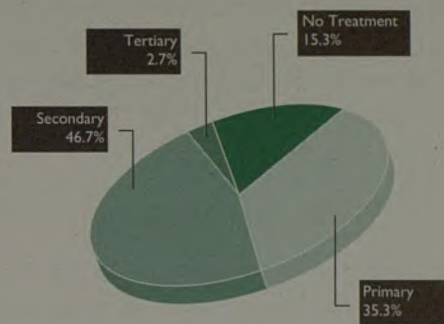

Fig. 6.3 Percentages of Sewerage Schemes in Each Treatment Category.

The percentages, of the total number of sewerage schemes, which serve particular population categories are shown in Fig. 6.4. A little over a third of the 619 sewerage schemes (213) serve towns with a population of more than 1,000 people. Of those 213 schemes, 14 have tertiary treatment, 98 have secondary treatment and the remainder (101) discharge to estuaries and coastal waters with primary treatment or no treatment.

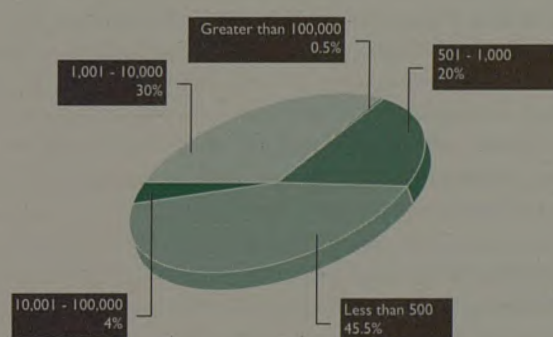

Fig. 6.4 Percentages of Sewerage Schemes in Each Population Category.

Urban Waste Water Treatment Directive

Clearly, schemes serving large communities generally have the greater potential for impact on environmental quality. Some of the requirements under the terms of the urban waste water treatment Directive (91/271/EEC), are as follows. 'Agglomerations' (i.e., urban areas) with a population equivalent of 2,000 and over are required to have collecting systems and secondary treatment by 31 December 2005, if the effluent is discharged to inland waters or estuaries. If the discharge is to coastal waters, the population equivalent criterion is 10,000. (Population equivalent takes into account the waste water from industries as well as the domestic and commercial waste water loads. One population equivalent is defined in the urban waste water treatment Directive as the organic biodegradable load having a BOD of 0.06 kg of oxygen per day).

Significant upgrading of sewage treatment, particularly in relation to cities and towns discharging to tidal waters, will be necessary in order to meet the various requirements of this Directive.

Total Domestic Waste Water Load

The total domestic waste water load, in terms of BOD generated, based on the unit load of 0.06 kg/person per day, and on the population (2.4 million persons) served by sewerage schemes, amounts to 144 tonnes of BOD/day. Treatment of the sewered waste load removes about 45 tonnes of BOD, which leaves about 99 tonnes discharged to the aquatic environment. A further 67 tonnes of BOD/day go to septic tanks in rural areas.

INDUSTRIAL WASTE LOADS

A survey of water abstractions and of discharges to waters, which included public bodies, private industry and others, was carried out by An Foras Forbartha in 1977. A total of 580 private dischargers of waste water in amounts exceeding 5 m^3/day to inland waters was identified. (These did not include discharges to septic tanks for houses in rural areas). Among the 580 discharges were many small creameries and milk collecting stations which have since closed. Under the 1977 Water Pollution Act, discharges to waters are required to be licensed.

From the available information to the end of 1993, there were 688 licences issued for discharges to waters, and 1,086 licences issued for discharges to sewers. A large number of those licences provide for very small amounts of effluent.

A previous study (IIRS, 1983) identified 4,367 manufacturing companies of which 947 (22 per cent) were 'wet' industries, i.e., giving rise to liquid effluents. Waste water from these industries was categorised as follows (with the number of industries in each case given in parentheses):

- organic/biodegradable (549);
- metal (134);
- chemical (65);
- miscellaneous, inert or organic in content (199)

Organic biodegradable waste water arises from a range of industrial sectors: food processing, pharmaceutical or fine chemicals, textiles and brewing. Of the 549 companies, giving rise to organic/biodegradable effluents, only 198 were sources of significant loads.

Metals are associated with electroplating and photo-lithographic processes. The 134 such companies were mainly located in urban areas and discharged to sewers.

A wide range of industrial operations gives rise to effluents contaminated with non-biodegradable chemicals. These consist of minor product losses in rinse waters and spent process solutions. Of the 65 such effluents identified in the survey, 55 discharged to sewers.

In the final category, about 70 companies, including pottery, glass cutting and cement, were found to generate effluents with inert materials and 129 companies generated effluents with less than 1kg BOD/day.

The total organic load generated, in terms of BOD was estimated to be 264 tonnes/day, and this was reduced by treatment to 120 tonnes/day (55 per cent reduction). The survey found that manufacturing industry had 81 secondary treatment plants and 110 primary treatment plants together with land treatment and other systems.

Since that survey was carried out, some changes have occurred. For example, some industries have closed. In the Cork Harbour area, waste load generated by the pharmaceutical and chemical industries has increased but the discharged waste load has decreased.

Receiving Waters for Licensed Discharges

Estimates of the pollutant amounts discharged by industry can be made by examining the licences issued and calculating the amounts of pollutants that could be discharged, after treatment, to the aquatic environment.

As mentioned above, from the available information, there are 688 licences for discharge to waters issued by local authorities. Details of 623 were examined recently by the EPA for the licensed BOD loads, which amounted in total to 22,862 kg/day. Of those, the following are the numbers of discharges and the total loads discharged to the different receiving waters:

438 (BOD 7,730 kg/day) to rivers;
31 (BOD 84 kg/day) to lakes;
61 (BOD 18 kg/day) to groundwater (land);
35 (BOD 14,550 kg/day) to estuaries;
58 (BOD 480 kg/day) to the sea.

Of the 1,086 licences to sewers, 886 were examined and in total they amount to a BOD discharge load of 102,480 kg/day.

Combining the industrial BOD loads discharged to sewers with that discharged directly to receiving waters, yields a total of over 125,000 kg/day (125 tonnes/day), and this can be compared with the figure of 120 tonnes/day estimated by the then Institute for Industrial Research and Standards (IIRS) in 1983.

An examination was undertaken by the Environmental Protection Agency (EPA) of the results of compliance monitoring at 30 companies with large organic waste loads, situated in the south-east. The results were compared with the licensed discharges. In only one case did the discharged load for BOD exceed the licensed load and most were less than the limit. If this survey is representative of the country as a whole, then it would appear that using the information contained in licences overestimates the amounts of waste discharged to the aquatic environment.

The introduction of integrated pollution control (IPC) licensing by the EPA with the emphasis on cleaner technology is expected to result in a strong downward trend in the overall load discharged from industry.

TOTAL DISCHARGES FROM POINT SOURCES

Overview

To summarise, the estimated total BOD load discharged (point sources) by domestic and industrial activities is 220 tonnes/day. Of this, 45 tonnes go to rivers, 171 tonnes go to estuaries and coastal waters, 2 tonnes go to lakes and 2 tonnes go to land. In addition, there is the septic tank domestic load of about 67 tonnes/day. This distribution is shown in Fig. 6.5.

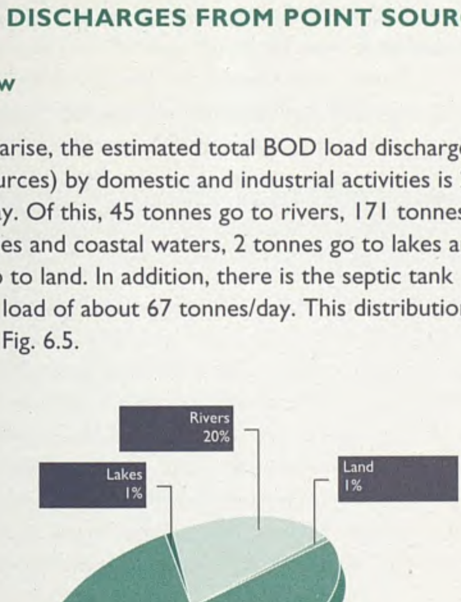

***Fig. 6.5** Total Waste Load Discharged to Receiving Waters and Land from Point Sources.*

Major Catchments

As part of the preparation of water quality management plans, detailed assessments were made of point sources discharging to certain river catchments, estuaries and bays. Table 6.1 gives estimates of the domestic and industrial waste loads (a) generated and (b) discharged (i.e., after treatment) in selected river catchments.

***Table 6.1** Estimated Waste Loads Generated and Discharged in Selected River Catchments.*

(a) Waste Load Generated (kg BOD/day)		
Receiving Water	Domestic	Industrial
R. Suir	2224	37321
R. Barrow	2724	12234
R. Nore	1752	12132
R. Slaney	1735	11233
Upr. Shannon	5009	20031
Lr. Shannon	1810	2239

(b) Waste Load Discharged (kg BOD/day)		
Receiving Water	Domestic	Industrial
R. Suir	1800	12322
R. Barrow	1605	7597
R. Nore	1055	3590
R. Slaney	1410	9308
Upr. Shannon	2713	4035
Lr. Shannon	426	213

The figures shown in Table 6.1 are the totals of a large number of point discharges and do not include waste from diffuse sources such as agricultural activities.

Dublin Bay

As part of the studies for developing the water quality management plan for Dublin Bay (ERU, 1992), estimates were made of the waste loads generated in Dublin for treatment at Ringsend. This work yielded the following totals: 30,500 kg BOD/day domestic and 39,770 kg BOD/day industrial. For the separate outfall at Howth the corresponding figures are 17,000 and 15,000 kg BOD/day respectively.

In addition to organic matter and nutrients, there are small quantities of heavy metals and other pollutants in sewage. The loads of a number of substances discharged from Ringsend Treatment Works were estimated from the results of analyses of the effluent quality and the rate of flow from the treatment plant. The estimated daily loads for a number of parameters discharged are shown in Table 6.2.

Table 6.2 *Estimated Daily Loads for a Range of Parameters Discharged from the Ringsend Sewage Treatment Works, Dublin.*

BOD	53000 kg	
Suspended Solids	29000 kg	
Ammonia	5000 kg	N
Oxidised Nitrogen	30 kg	N
Total Nitrogen	11000 kg	N
Phosphate	1100 kg	P
Total Phosphorus	1800 kg	P
Copper	10 kg	Cu
Lead	4 kg	Pb
Zinc	81kg	Zn
Cadmium	0.08 kg	Cd

Cork Harbour

A 1989 review found that the waste waters discharged daily through the Cork City sewers to the Upper Lee Estuary contained about 12,000 kg BOD (7,000 kg/day domestic and 5,000 kg/day industrial). In contrast, industries in the Lower Harbour area were licensed to discharge BOD loads ranging from 1,000 to 13,000 kg/day. The total BOD load discharged to Cork Harbour was estimated to be about 46,000 kg/day (ERU, 1989). Subsequent changes in relation to industry are likely to have brought about a significant reduction in this figure.

AGRICULTURAL WASTES

In order to present a reasonably complete picture of the waste waters generated from the three main sources, domestic, industrial and agricultural, some consideration is given below to the latter. It may be noted, however, that the categories of 'waste' and 'waste waters' are not so easily separated when considering agricultural arisings. Accordingly, this section is related closely to the corresponding section in Chapter 7 which deals with the question of waste.

Grazing animals produce some 28 million tonnes of manure during the indoor winter period which must be stored and spread on land. Pig and poultry manure is estimated to be in excess of two million tonnes making a total of 30 million tonnes to be managed by farmers each year. The pig and poultry units are highly concentrated among a very small number of producers. Almost 50 per cent of the poultry flock is situated in County Monaghan. The highest concentration of pigs occurs in Counties Cork and Cavan and accounts for 32 per cent of the national herd. Pig production is becoming more concentrated as units become larger. Particular concern has been expressed by fisheries interests in relation to the expansion of the pig herd in the Erne River catchment, which includes a large proportion of Co. Cavan.

Between 1960 and 1990 the quantity of silage produced increased from 0.3 million tonnes to over 20 million tonnes (Lee, 1995).

Agricultural discharges to waters arise from land spreading of slurries, silage leachate, and dirty water runoff from farm yards. Intensive animal rearing operations and silage making are generally regarded as having a relatively high pollution potential because of the liquid nature of the wastes. The only effective method available at present for the disposal of animal manures is to spread them on productive agricultural land during the growing season. It is not possible at present to quantify the amount of agricultural liquid waste disposed of in any particular area.

In contrast to the situation regarding the discharge of domestic and industrial effluents, most of which enter estuaries and coastal waters, most of the waste discharges to water from agricultural activities are likely to enter fresh waters. The involvement of farm wastes in pollution incidents, particularly silage leachate and stored liquid waste, resulting in fish kills or the pollution of water supplies has been a particular cause for concern over the past number of years, and measures have been taken to reduce the risks.

The 1982 quantities (tonnes/annum) of BOD, nitrogen and phosphorus in wastes generated by livestock and by silage production were estimated by An Foras Forbartha (1983). Based on the increases in livestock numbers and silage production between 1982 and 1991 (CSO, 1991), the corresponding 1991 amounts have also been estimated. The results are given in Table 6.3 for the various categories.

The total estimated BOD load, generated from the agricultural activities listed in Table 6.3, in 1991 amounts to 1.48 million tonnes per annum. Based on the per capita BOD load for the human population of 0.06 kg/day, this agricultural load is the equivalent of that generated by about 68 million persons. It is emphasised that this is the generated BOD load, and not that discharged to waters.

It is not possible to estimate how much of this waste gets into the aquatic environment. Considerable efforts are being made to prevent silage liquor, especially, from getting into surface and ground waters. Ideally, slurries from intensive farming and silage liquor are stored so that they can be spread in dry weather during the growing season. This ideal situation is not always achieved, and the result can be fish kills and enrichment of rivers, lakes and estuaries.

Table 6.3 *Estimated Quantities of BOD, Nitrogen and Phosphorus Generated by Livestock and by Silage Production in 1982 and 1991.*

Quantities (thousands of tonnes/annum)

Source	BOD		Nitrogen		Phosphorus	
	1982	1991	1982	1991	1982	1991
Cattle	770	925	293	352	59	71
Sheep	60	220	2	8	0.4	1.6
Pigs	40	48	9	11	3.6	4.3
Poultry	17	22	5	6	1.7	2.1
Silage	156	265	6	11	1.3	2.2
Totals	**1043**	**1480**	**315**	**388**	**66**	**81.2**

COOLING WATER

The Electricity Supply Board (ESB) has two thermal generating stations operating on the shores of Dublin Bay: Poolbeg (538 MW) and North Wall (250 MW). Daily usage of cooling water at Poolbeg can vary from 1.5 m^3/s to over 12 m^3/s, and the increase in temperature is about 7.0°C. The corresponding figures for the North Wall generating station are 1.2 m^3/s and 7.0°C.

Table 6.4 *Quantities of Cooling Water and Temperature Differentials for Selected ESB Generating Stations in 1993.*

Station	Temperature Differential °C	Quantity $m^3 x 10^6$/annum
Aghada	8.6	185
Bellacorick*	7	1.3
Caherciveen*	10	0.1
Ferbane*	6.9	1.9
Great Island	7.6	16.4
Gweedore	7.8	1.9
Lanesboro	7	99
Marina	8.3	19.4
Moneypoint	11	598.4
Rhode*	8	1.6
Shannonbridge	7	127.7
Tarbert	8.6	196.3

* denotes recirculation

Details of the quantities of cooling water and its temperature differential for the other ESB generating stations are given in Table 6.4. Most of the stations use the once-through system of cooling; others, as indicated in the table, use recirculation.

Cooling water is also used in industry, sometimes in significant amounts, but recent figures for those discharges are not available.

RIVERINE INPUTS

Regular measurements are made of the quality and flow rates of the major rivers at their freshwater limits.
The purpose of the measurements is to make estimates of the annual loads of certain pollutants carried by rivers into their estuarine reaches. These estimates are required in relation to environmental aspects of the Irish Sea and for the Oslo and Paris Conventions. Measurements are made of the concentrations of a number of potential pollutants, i.e., BOD, phosphates, oxidised nitrogen, suspended solids, cadmium, copper, lead, zinc, total phosphorus, ammonia and organic nitrogen.

The annual report to the Paris Commission on Direct and Riverine Inputs to Convention Waters during the year 1990 gives estimated loads for the following sea areas:

- Irish Sea (from the Northern Ireland border to Hook Head;
- Celtic Sea (from Hook Head to Loop Head);
- Atlantic Coastline (from Loop Head to the border).

The waste loads of selected substances discharged directly to estuarine and coastal waters from sewers and carried in rivers and streams were estimated as shown in Tables 6.5 to 6.7.

Table 6.5 *Waste Loads to the Estuaries of the Irish Sea in 1990 (tonnes/annum).*

Parameter	Domestic	Industry	Main Rivers	Smaller Rivers
BOD	19608	18931	NA	NA
SS	21443	16685	72758	56815
Total N	3706	3127	23537	10133
Total P	866	709	468	315
Cadmium	0.023	0.04	0.67	0.15
Copper	3.4	4.1	20	7
Zinc	29	34	162	32
Lead	1.5	1.8	5.7	2.6

Table 6.6 *Waste Loads to the Estuaries of the Celtic Sea in 1990 (tonnes/annum).*

Parameter	Domestic	Industry	Main Rivers	Smaller Rivers
BOD	7352	10064	NA	NA
SS	8570	10023	476700	178045
Total N	1323	1348	58118	26129
Total P	387	267	1996	881
Cadmium	0.006	0.013	1.2	0.4
Copper	1.1	2.1	39	14
Zinc	9.2	12.3	331	112
Lead	0.5	3.9	28	6

Table 6.7 *Waste Loads to the Estuaries of the Atlantic in 1990 (tonnes/annum).*

Parameter	Domestic	Industry	Main Rivers	Smaller Rivers
BOD	2222	1631	NA	NA
SS	2579	1744	77052	120536
Total N	414	288	13515	15322
Total P	120	86	284	359
Cadmium	0.002	0.005	0.38	0.48
Copper	0.35	0.48	13.5	19.4
Zinc	3.1	4.6	52	55
Lead	0.17	0.22	6	7

INFORMATION GAPS

The information on discharges to the aquatic environment contained in this chapter is based on the results of a number of studies undertaken over the years for various purposes. Some of these studies are quite old. Although some updating has been done as part of the work for this report, it has not been possible, for the reasons stated in Chapter 1, to implement a full investigation in order to provide updates and a more complete overview of all aspects of this issue.

A thorough review of discharges to the aquatic environment is recommended to be implemented in advance of the preparation of the next report on the State of the Environment. This should include, in particular, updated assessment of the discharges of nutrients and of toxic and persistent substances to the aquatic environment.

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CHAPTER **7**

WASTE

INTRODUCTION

This chapter summarises existing knowledge about solid waste management in Ireland, in particular, the quantities and types of waste being generated, the manner in which these wastes are disposed of and the potential impacts accruing from current practice. Comprehensive reporting on the production and disposal of waste in Ireland is hampered by the relative scarcity of complete and reliable data. It is generally acknowledged that a uniform methodology for compiling waste statistics needs to be developed and applied so that a more accurate picture of waste management in Ireland can be obtained.

The chapter, therefore, describes what is currently known of the pressures imposed on the environment through current waste management practices and the environmental impacts those pressures have. Some of the responses required to relieve the pressures and reduce the impacts with a view to contributing to the development of a sustainable waste management strategy for Ireland are also presented.

The management and control of liquid effluents have been outlined in Chapter 6.

The Context

In common with other developed countries, Ireland is still experiencing annual growth in the production of all kinds of waste: household, commercial, industrial, agricultural and hazardous. While the generation of waste is an inevitable consequence of domestic and economic life, it is now well recognised that the quantities of waste produced by developed countries, including Ireland, are unsustainable. So too is the manner in which these wastes are disposed of. Reversing the trend of ever increasing quantities of waste is, however, a formidable challenge which will require the participation and co-operation of all parties.

The future development of solid waste management in Ireland will be strongly influenced by European Union (EU) policy. During the past two decades, European countries have agreed on various strategies for the management of waste, giving increasing attention to waste prevention. In 1976, the Organisation for Economic Co-operation and Development (OECD) countries adopted a hierarchy of preferred options for waste management. More recently, the EU adopted a strategy for waste management (CEC, 1990) in which emphasis is placed primarily on waste prevention, i.e., preventing the generation of non-recoverable waste, followed by the promotion of recycling, recovery and re-use and, finally, on the safe disposal of any remaining non-recoverable waste (see box). The strategy also includes guidelines for the safe transportation of waste and for the remediation of waste disposal sites.

EU Waste Management Guidelines

1. **Prevention**
   - *clean technologies*
   - *clean products*
2. **Recycling and re-use**
   - *R&D on re-use and recycling techniques*
   - *optimal segregation and sorting*
   - *reduction of external costs*
   - *creation of market for recycled products*
3. **Optimisation of final disposal**
   - *reduction of disposal*
   - *stricter standards*
   - *ensure safe disposal*
4. **Regulation of transport**
   - *reduction of waste movements*
   - *monitoring*
5. **Remedial action**
   - *R&D on techniques for site mapping and clean up*
   - *development of financial instruments*

While these principles are laudable, the reality throughout Europe is that waste production is still increasing with, for example, a 13 per cent increase in municipal waste between 1988 and 1992 (CEC, 1992). This draws attention to the gap that exists between policy and action, and serves to illustrate the magnitude of the challenge.

Legislation

The legal framework for the management and safe disposal of waste consists mainly of Regulations made under the European Communities Act, 1972. A list of the relevant Regulations is provided in the box below together with relevant domestic Acts. Under these Acts and Regulations, local authorities are responsible for the planning, authorisation and supervision of waste operations in their areas. Their obligations, however, with respect to waste collection, are limited to the collection of household and trade or commercial wastes, vehicles and scrap metal (Scannell, 1995). The collection and disposal of industrial wastes is, by and large, conducted by private companies operating in accordance with permits issued by a local authority.

Waste Legislation in Ireland

Summary of Principal Acts and Regulations Governing the Management of Wastes in Ireland

The legal framework for the management and safe disposal of waste is contained in a number of Regulations made under the European Communities Act, 1972, together with relevant domestic Acts. These are:

European Communities (Waste) Regulations, 1979 (S.I. No. 390 of 1979)

European Communities (Toxic and Dangerous Waste) Regulations, 1982 (S.I. No. 33 of 1982)

European Communities (Waste) Regulations, 1984 (S.I. No. 108 of 1984)

European Communities (Asbestos Waste) Regulations, 1990 (S.I. No. 30 of 1990)

European Communities (Use of Sewage Sludge in Agriculture) Regulations, 1991 (S.I. No. 183 of 1991)

European Communities (Waste Oils) Regulations, 1992 (S.I. No. 399 of 1992)

Council Regulation (EC) No. 259/93 of 1 February 1993 on the shipment of wastes within, into and out of the European Community.

European Communities (Transfrontier Shipment of Waste) Regulations, 1994 (S.I. No. 121 of 1994)

European Communities (Batteries and Accumulators) Regulations, 1994 (S.I. No. 262 of 1994)

European Communities (Asbestos Waste) Regulations, 1994 (S.I. No. 90 of 1994)

Foreshore Act, 1933

Local Government (Water Pollution) Act, 1977

Dumping at Sea Act, 1981

Litter Act, 1982

Waste legislation in Ireland is currently undergoing reform with the publication of the Waste Bill in May, 1995, recently renamed the Waste Management Bill following its passage through the Dáil. This, when enacted, will strengthen the modern legislative framework for environmental protection in Ireland with appropriate provisions to regulate the generation, movement and disposal of waste and to give effect to new waste policy initiatives (Department of the Environment, 1994c). Under the proposed legislation, the Environmental Protection Agency (EPA) will be designated the sole licensing authority for all significant waste recovery and disposal activities, including landfills and hazardous waste disposal facilities. The EPA will also be charged with the preparation of a national hazardous waste management plan, for implementation by the relevant public authorities, including local authorities.

Priority Waste Streams

Waste streams identified by the EU and the Irish Government as requiring priority attention include municipal waste, packaging waste, healthcare waste, construction and demolition waste, used tyres, end-of-life vehicles, halogenated solvents, batteries and accumulators, and electric/electronic waste.

SOLID WASTE IN IRELAND

Overview

It is estimated that between 37 and 38 million tonnes of solid waste are generated each year in Ireland (see Figs. 7.1 and 7.2).

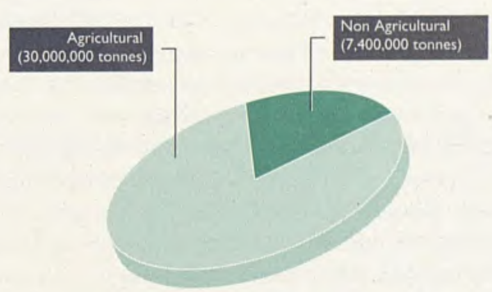


Fig. 7.1 *Total Waste Arising in Ireland (Lee, 1995 and sources as listed for Fig. 7.2).*

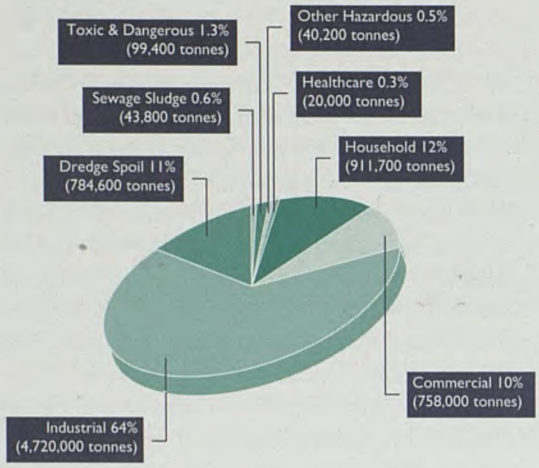


Fig. 7.2 *Total Non-agricultural Wastes Arising in Ireland (DoE, 1994a, 1994b; Boyle 1986, 1987, Weston FTA, 1993; Dept. of the Marine, 1995; Dept. of Health, 1995).*

Of this, approximately 30 million tonnes originate from agricultural sources, mainly animal manure (Lee, 1995). Seven to eight million tonnes of waste per annum is therefore produced by the municipal, commercial and industrial sectors in Ireland. The Department of the Environment estimates that in the past decade, the total quantity of waste consigned to local authority landfills increased by over 30 per cent (Department of the Environment, 1994a), i.e., an annual increase of three to four per cent in the amount of waste collected for disposal at public landfills. This is similar to increases that occurred throughout Europe over the same time period (CEC, 1992).

The first comprehensive attempt at quantifying waste production and disposal practices in Ireland was undertaken by An Foras Forbartha (AFF) with the publication of a National Database on Waste in 1986. The only category for which it was considered that complete and reasonably accurate returns were received was household and commercial waste collected by the local authorities. In areas outside the direct control of local authorities such as waste disposal by private firms and hazardous waste arising, the data were considered incomplete and less reliable. Since publication, the National Database on Waste has been only partially updated; the toxic and dangerous waste survey, which formed a part of the National Database on Waste, was repeated both in 1988 and 1992 by the Department of the Environment. Further surveys of waste arisings have since been conducted by and on behalf of the Department of the Environment (ERL, 1993; MCOS, 1994; Department of the Environment, 1994a). Surveys on the generation and disposal of industrial waste have also been conducted by Forbairt, formerly EOLAS (AFF, 1986; ERU, 1993).

Household and Commercial Waste

Household waste is solid waste arising from the normal occupancy of a premises used as a house, educational establishment, hospital or similar institution but excluding wastes (e.g., septic tank sludge or bulky items) not collected by the normal domestic waste collection service.

Commercial (Trade) waste is all non-hazardous waste, other than household waste, arising from the use of premises, either wholly or in part, for the purposes of trade, business or leisure activities.

Amounts Arising and Waste Composition

The quantities and composition of household and commercial waste arising in Ireland are illustrated in Figs. 7.3 and 7.4.

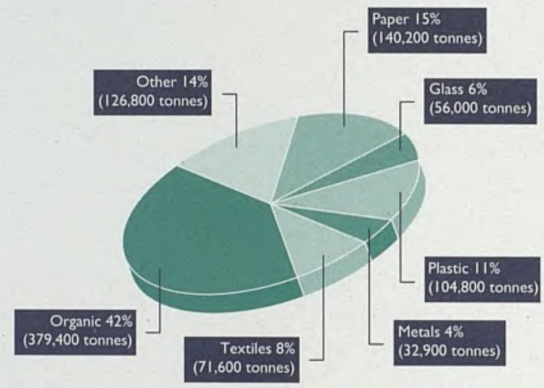


Fig. 7.3 *Quantities and Composition of Household Waste in Ireland (DoE, 1994a).*

Fig. 7.4 *Quantities and Composition of Commercial Waste in Ireland (DoE, 1994a).*

These figures are for waste arising in 1993 and show that approximately 1,680,000 tonnes of household and commercial waste arose in that year. In 1984 962,700 tonnes of household and commercial waste was estimated to have arisen (Boyle, 1986), while this suggests an apparent increase in household and commercial waste of the order of 50 per cent in less than ten years, as illustrated in Fig. 7.5, it should be noted that different methodologies were employed to estimate 1984 and 1993 arisings which makes comparison unreliable. This, again, highlights the need for a uniform methodology for data collection.

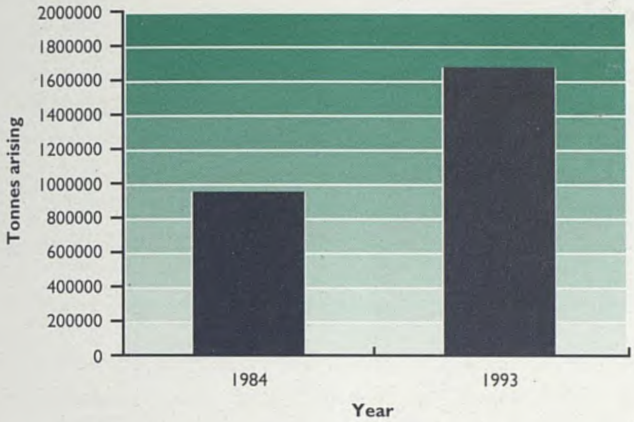


Fig. 7.5 Estimated Household and Commercial Waste Arisings (Boyle, 1986; DoE, 1994a).

In recent years there has been increased emphasis on attempting to establish the composition of municipal waste, in particular, the quantities of recyclable and reusable material. The Directive on packaging and packaging waste (94/62/EC), which imposes targets on EU Member States for the recovery and recycling of packaging materials, has served to focus attention on waste composition analysis.

Many local authorities are now compiling statistics on waste composition and the EPA, as part of its development of a new National Database on Waste, is developing a standard methodology for conducting waste composition surveys which both the public and private sector will be expected to adopt.

The most comprehensive surveys to date have been conducted by Dublin Corporation, Dublin County Council, Wicklow County Council and Kerbside Dublin, which, taken together, provide a useful guide to both rural and urban waste composition. Results obtained by Wicklow County Council and Dublin Corporation, respectively, for rural and urban household waste are illustrated in Fig. 7.6.

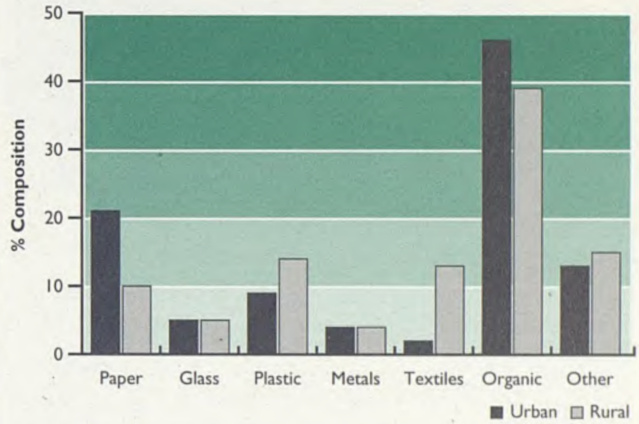


Fig. 7.6 Composition of Urban and Rural Household Waste in Ireland (MCOS , 1994).

The regional distribution of household waste collected in Ireland by local authorities is presented in Fig. 7.7.

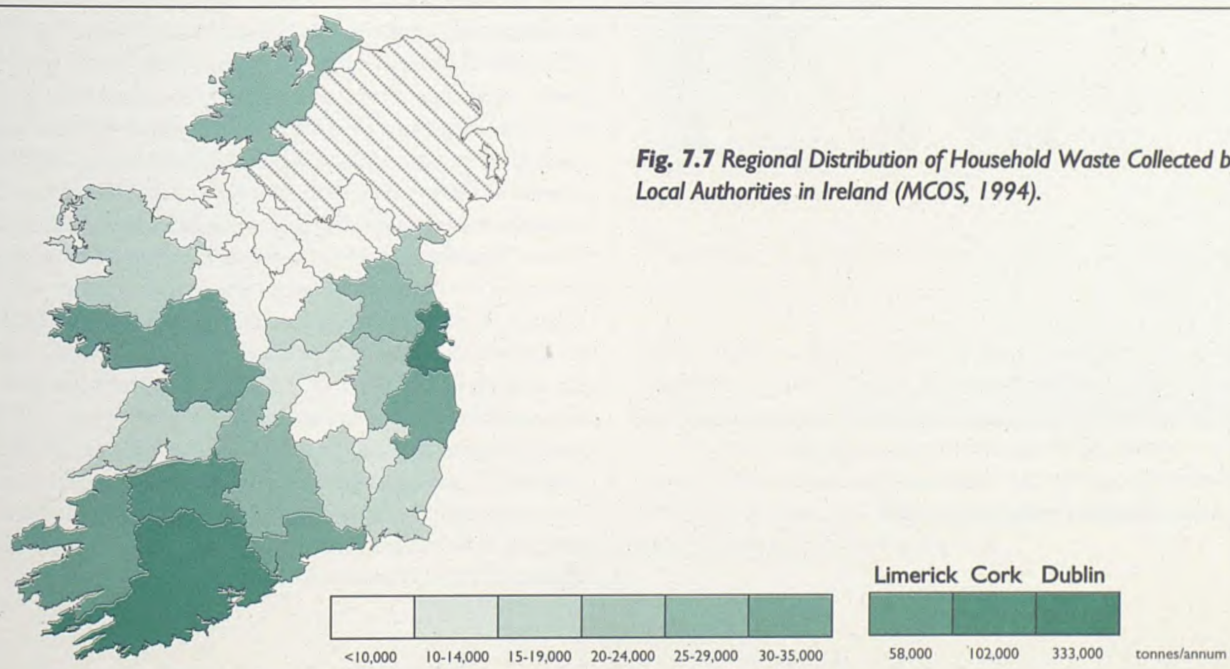


Fig. 7.7 Regional Distribution of Household Waste Collected by Local Authorities in Ireland (MCOS, 1994).

Disposal Routes

The disposal routes for household and commercial waste are illustrated in Figs. 7.8 and 7.9. In 1993, 92.6 per cent of household and commercial waste was consigned to landfill with 7.4 per cent recycled. For household waste, only 1.4 per cent was recycled with the balance landfilled. The recycling rate for commercial waste was somewhat higher at 14.5 per cent with the balance landfilled.

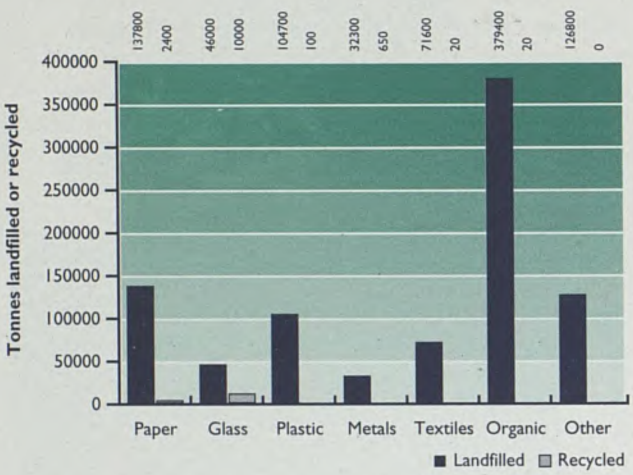


Fig. 7.8 *Methods of Disposal of Household Waste in Ireland (DoE, 1994a).*

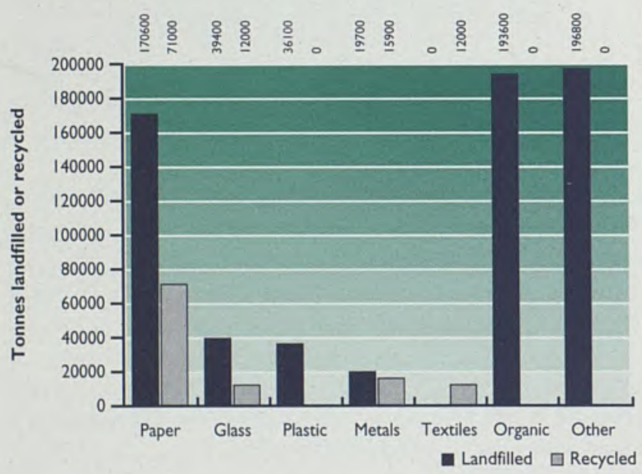


Fig. 7.9 *Methods of Disposal of Commercial Waste in Ireland (DoE, 1994a).*

The primary route of disposal of household and commercial waste in Ireland is consignment to landfill. The government has set targets for increased recycling of packaging wastes by the end of the decade with a general objective of diverting 20 per cent of combined household and commercial waste away from landfill.

Priority Components

The entire municipal waste stream has been identified as a priority. The packaging fraction, in particular, has been singled out as one where significant reductions in the quantity for disposal can be achieved. The municipal waste stream also contains a small hazardous waste fraction which needs to be handled and disposed of in a safe manner.

Industrial Waste

Industrial waste is defined here as all non-hazardous waste of a solid or semi-solid nature originating from industrial or public utility premises or from the following:

mines and quarries: any open-cast or sub-surface mining or quarrying for the extraction of stone, gravel or minerals, including over burden, degraded rock, fine sand, crushed rock or mud;

construction and demolition sites: building demolition, site clearance and development operations (e.g., waste containing mortar, stone, concrete, slate, wood, glass and spoil);

food processing premises: waste arising from any food processing plant (e.g., discarded milk products, abattoir wastes, fish waste).

Amounts Arising and Waste Composition

The primary sources of data for industrial waste arising in Ireland are the National Database on Waste and updates (Boyle, 1986, 1987), and Irish Environmental Statistics (AFF, 1986; ERU, 1993), which presents data on manufacturing sector industrial wastes.

In the National Database on Waste and updates, statistics are presented under three headings: waste disposed of by local authorities, waste disposed of by private firms, and special waste. Special waste is defined as waste which is or may be so dangerous or difficult to dispose of that special provision is required for its disposal. Of the waste disposed of by private firms almost all falls within the definition of 'industrial waste' given above. It was reported in 1987 that about 4.86 million tonnes of waste is disposed of by large producers of waste and by waste disposal firms each year. Of this, 4.72 million tonnes could be classified as 'industrial' waste, the balance being septic tank sludges (120,000 tonnes wet weight), medical wastes (10,000 tonnes) and abandoned cars (10,000 tonnes) disposed of by private firms. A 'tentative' categorisation of this industrial waste is provided in Table 7.1. It is important to note the author's consideration at the time that the national totals for waste disposed of by private firms 'must be significantly under-estimated', due to omissions in survey returns.

***Table 7.1** Estimated Annual Industrial Waste Arisings in Ireland (Boyle, 1987).*

Waste Category	Quantities (tonnes)
Organic problem wastes	220,000
Mining and quarrying wastes	1,930,000
Unclassified industrial process waste	920,000
Boiler and power plant slag	130,000
Construction and demolition debris	240,000
Forestry and wood processing waste	270,000
Sludges from trade effluent treatment	440,000
Metal scrap	250,000
Paper and packaging	90,000
Glass	30,000
Plastics	40,000
Rubber	20,000
Other wastes	140,000
Total	**4,720,000**

Manufacturing-sector industrial waste estimated to have arisen in Ireland in 1981 and 1991 is presented in Fig. 7.10. A breakdown of the composition of these wastes for 1991 is presented in Table 7.2. In 1991, it was estimated that 1,306,000 tonnes of manufacturing-sector industrial waste arose in Ireland compared with 1,600,000 tonnes in 1981. These figures do not include waste arising from mines and quarries or from construction and demolition sites.

In 1981, of the 1,600,000 tonnes estimated to have arisen, only 1,200,000 was accounted for as disposed, suggesting that the remaining quantity was disposed of illegally. In 1991, the disposal of all waste estimated to have arisen was accounted for. While the total amount of waste appears to have dropped over the ten year period, the total disposed of by known routes has risen from 1,200,000 tonnes in 1981 to 1,306,000 tonnes in 1991.

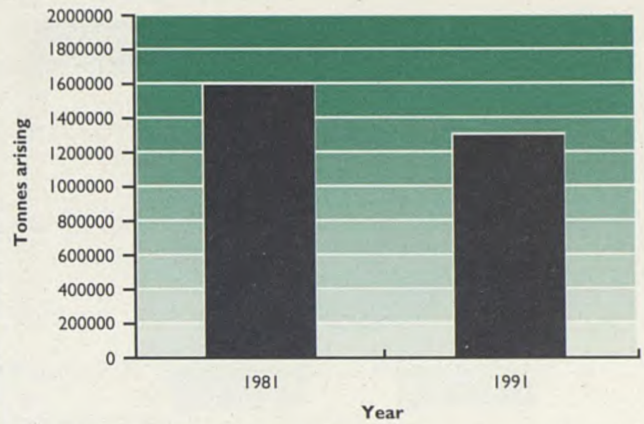


***Fig. 7.10** Total Estimated Manufacturing-Sector Industrial Waste Arising in Ireland in 1981 and 1991 (AFF, 1986; ERU 1993).*

***Table 7.2** Estimated Manufacturing-Sector Industrial Waste Arising in Ireland in 1991 by Category (ERU, 1993).*

Waste Category	Quantities (tonnes)
Ferrous metals	29,000
Non-ferrous metals	7,000
Chemicals	26,000
Rubber	2,000
Lubricating Oil	1,000
Glass	3,000
Paper	30,000
Plastics	7,000
Food waste	461,000
Sawdust and wood	181,000
Treatment plant sludges	264,000
Process sludges and cakes	59,000
Concrete product, pipe and brick waste	38,000
Unclassified process waste	106,000
Other waste	92,000
Total	**1,306,000**

Disposal Routes

The disposal routes for industrial waste in Ireland in the mid-1980s are illustrated in Fig. 7.11.

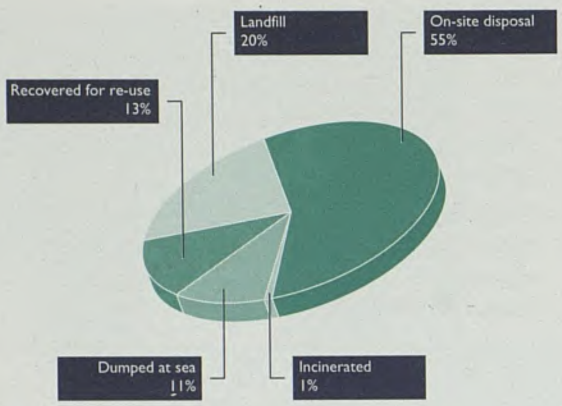


Fig. 7.11 Disposal Routes for Industrial Waste in Ireland (Boyle, 1987).

These data indicated that a considerable quantity of industrial waste, in the region of 55 per cent (2,673,000 tonnes), was disposed of on-site by the producer. This was true, for example, in the case of mining and quarrying wastes and power plant slag. Approximately 20 per cent (972,000 tonnes) was disposed of either at local authority or private landfills, 13 per cent (631,800 tonnes) was recovered for re-use, 11 per cent (534,600 tonnes) was dumped at sea and less than one per cent (< 48,600 tonnes) was incinerated.

Of the 1,306,000 tonnes of industrial waste produced by the manufacturing sector in 1991, 664,000 tonnes (50.8 per cent) were recovered for re-use as secondary raw materials. Comparing these figures with those published in the National Database on Waste and given above, the bulk of industrial waste recovered for re-use would appear to be produced by the manufacturing sector. The types and quantities of wastes recovered for re-use are illustrated in Fig. 7.12.

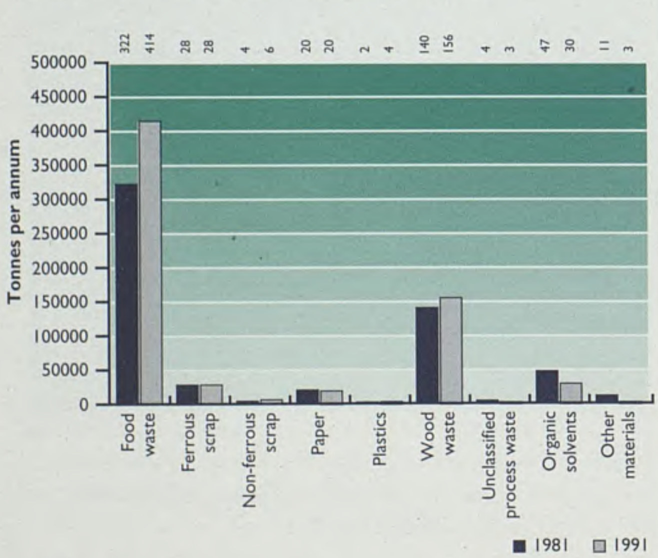


Fig. 7.12 Waste Recovered from the Manufacturing Industry for Re-use (ERU, 1993).

Of the remaining 49.2 per cent (642,000 tonnes), 452,000 tonnes were disposed of by the producing company, 129,000 tonnes by waste contractors, 14,000 tonnes by local authorities, 29,000 tonnes exported overseas and the remainder by unknown routes (see Fig. 7.13).

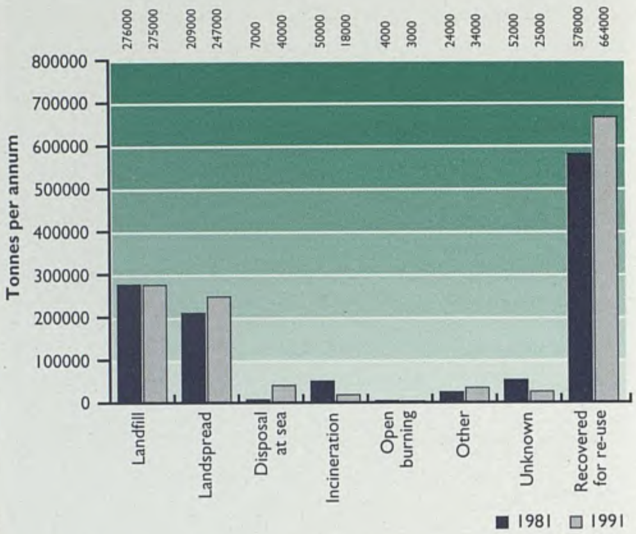


Fig. 7.13 Methods for Disposing of Manufacturing-Sector Industrial Wastes (ERU, 1993).

Priority Components

The principal priority component of the non-hazardous industrial waste stream is construction and demolition waste. An estimate of construction and demolition waste arisings for 1984 was 240,000 tonnes/annum, which in all probability seriously underestimates contemporary arisings. Recent estimates are as high as 2,500,000 tonnes per annum (Barrett and Lawlor, 1995). There is an urgent need for accurate information about this priority waste stream. The industrial waste stream also contains a significant packaging fraction.

Hazardous Waste

There is no simple way of defining hazardous waste. Indeed, any waste can become hazardous, in the widest sense of it being potentially harmful to either human health or the environment, if not treated and disposed of properly. The most recent 'definition' available is that provided in Directive 91/689/EEC and adopted in the Waste Management Bill which describes physical, chemical and biological properties which render a waste hazardous. These properties are listed in the box on the next page.

Properties of Waste Which Render it Hazardous

1. "Explosive": substances or preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

2. "Oxidizing": substances or preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.

3. "Highly flammable":

   (a) liquid substances or preparations having a flash point below 21°C (including extremely flammable liquids), or

   (b) substances or preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or

   (c) solid substances or preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or

   (d) gaseous substances or preparations which are flammable in air at normal pressure, or

   (e) substances or preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.

4. "Flammable": liquid substances or preparations having a flash point of not less than 21°C and not more than 55°C.

5. "Irritant": non-corrosive substances or preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.

6. "Harmful": substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.

7. "Toxic": substances or preparations (including very toxic substances or preparations) which, if they are inhaled or ingested or if they penetrate the skin, may cause serious, acute or chronic health risks or death.

8. "Carcinogenic": substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.

9. "Corrosive": substances or preparations which may destroy living tissue on contact.

10. "Infectious": substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in humans or other living organisms.

11. "Teratogenic": substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.

12. "Mutagenic": substances or preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.

13. "Ecotoxic": substances or preparations which present or may present immediate or delayed risks for one or more sectors of the environment.

14. "Residuary hazardous property":

    (a) substances or preparations which release toxic or very toxic gases in contact with water, air, or an acid, or

    (b) substances or preparations capable by any means, after being disposed of, of yielding another substance which possesses any property referred to above.

(Source: Directive 91/689/EEC)

For the purposes of reporting quantities of hazardous waste arising and disposal routes, the following categories will be considered in this report:

- *toxic and dangerous wastes as defined under the toxic and dangerous waste Directive 78/319/EEC;*
- *metal and chemical treatment plant sludges;*
- *chemical oils and other problematic wastes not defined by Directive 78/319/EEC;*
- *asbestos waste;*
- *waste oils;*
- *end-of-life vehicles;*
- *batteries and accumulators;*
- *polychlorinated biphenyls (PCB) wastes;*
- *used tyres;*
- *healthcare waste;*
- *radioactive waste.*

It should be noted that the household waste stream can contain many hazardous materials such as paints, solvents, garden pesticides and waste oils which need to be disposed of in a safe manner.

Amounts Arising, Waste Composition and Disposal Routes

The primary sources of information on hazardous waste arisings in Ireland are the National Database on Waste and updates, which provide data on toxic and dangerous wastes, as defined in the EC (Toxic and Dangerous Waste) Regulations, 1982. The digest of Irish Environmental Statistics reports data on hazardous industrial waste not defined by the aforementioned Directive. The National Database on Waste also contains data on the generation and disposal of waste oils in Ireland, the generation and disposal of healthcare wastes and the numbers of abandoned vehicles. Data on radioactive waste arisings were obtained from the Radiological Protection Institute of Ireland (RPII) and recent data on healthcare waste arisings were obtained from the Department of Health.

Toxic and Dangerous Waste

The most comprehensive data available for hazardous waste in Ireland relate to the twenty-seven substances or families of substances regulated by the Toxic and Dangerous Waste Regulations (see Table 7.3). Under the Regulations, local authorities are required to prepare a special waste plan indicating, *inter alia,* the types and quantities of toxic and dangerous waste to be disposed, the methods of disposal and suitable disposal sites.

Surveys of local authorities were conducted in 1984, 1988 and 1992. The amounts of regulated waste reported in each of these years are illustrated in Fig. 7.14. In 1992, a total of 99,393 tonnes of regulated waste was reported to

Table 7.3 *Toxic and Dangerous Waste Categories as Defined Under the EC (Toxic and Dangerous Waste) Regulations, 1982 and Waste Arisings in 1992 (DoE, 1994b)*

Category	Description	1992 Arisings (tonnes)
1	Arsenic; arsenic compounds	60
2	Mercury; mercury compounds	405
3	Cadmium; cadmium compounds	1
4	Thallium; thallium compounds	0
5	Beryllium; beryllium compounds	0
6	Chrome 6 compounds	101
7	Lead; lead compounds	4802
8	Antimony; antimony compounds	240
9	Phenols; phenol compounds	111
10	Cyanides: organic and inorganic	89
11	Isocyanates	145
12	Organic-halogen compounds, excluding inert polymeric materials and other substances referred to in this list or covered by other Directives concerning the disposal of toxic and dangerous waste	114
13	Chlorinated solvents	19320
14	Organic solvents	68238
15	Biocides and phyto-pharmaceutical substances	375
16	Tarry materials from refining and tar residues from distilling	585
17	Pharmaceutical compounds	1286
18	Peroxides, chlorates, perchlorates and azides	1
19	Ethers	0
20	Chemical laboratory materials, not identifiable and/or new, whose effects on the environment are not known	12
21	Asbestos (dust and fibres)	850
22	Selenium; selenium compounds	0
23	Tellurium; tellurium compounds	0
24	Aromatic polycyclic compounds (with carcinogenic effects)	1
25	Metal carbonyls	74
26	Soluble copper compounds	273
27	Acids and/or basic substances used in the surface treatment and finishing of metals.	2310
TOTAL		**99393**

have arisen. This compares with 72,850 tonnes in 1988 and 52,500 tonnes in 1984. Whether this is a real increase in the amount of waste arising or an indication of more complete reporting is not altogether clear. However, it is clear that at least 100,000 tonnes of hazardous waste, as defined in the Toxic and Dangerous Waste Regulations, are now arising in Ireland each year.

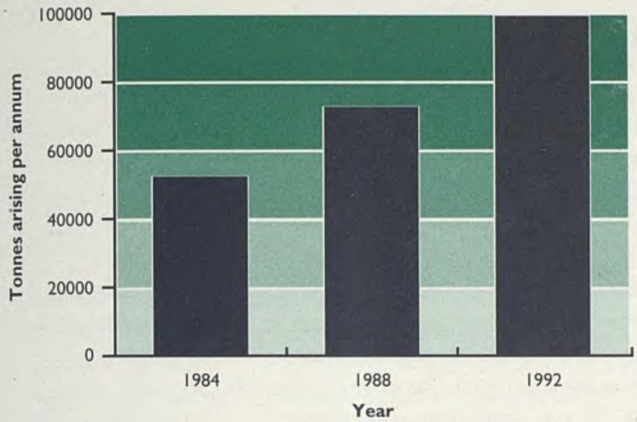


Fig. 7.14 Hazardous Waste Arisings as Defined by the Toxic and Dangerous Waste Regulations in Ireland (Boyle, 1986; DoE, 1994b).

A breakdown of toxic and dangerous wastes arising in 1992 by category is presented in Table 7.3. Organic solvents (68.7 per cent) and chlorinated solvents (19.4 per cent) together accounted for 88.1 per cent of the total reported to have arisen in 1992. Other categories for which amounts greater than one per cent of the total arose were lead and lead compounds (4.8 per cent), acids and alkalis used in the surface treatment and finishing of metals (2.3 per cent), pharmaceutical compounds (1.3 per cent) and asbestos dust and fibres (1.0 per cent).

Regional distribution of regulated toxic and dangerous waste arisings in Ireland in 1992 is presented in Fig. 7.15. Of the 99,393 tonnes of regulated wastes reported in 1992, 76,905 (77.4 per cent) arose in Cork, of which 98.3 per cent was either organic solvents (59,580 tonnes) or chlorinated solvents (16,021 tonnes). This reflects the concentration of chemical and pharmaceutical manufacturing industries in the Cork region.

The management of regulated toxic and dangerous wastes arising in Ireland in 1988 and 1992 is illustrated in Fig. 7.16. Over 80 per cent of waste arising was managed in Ireland with the balance exported. The amount of waste recovered for re-use or recycling has increased from 34,572 tonnes in 1988 (47 per cent) to 54,100 tonnes in 1992 (54 per cent).

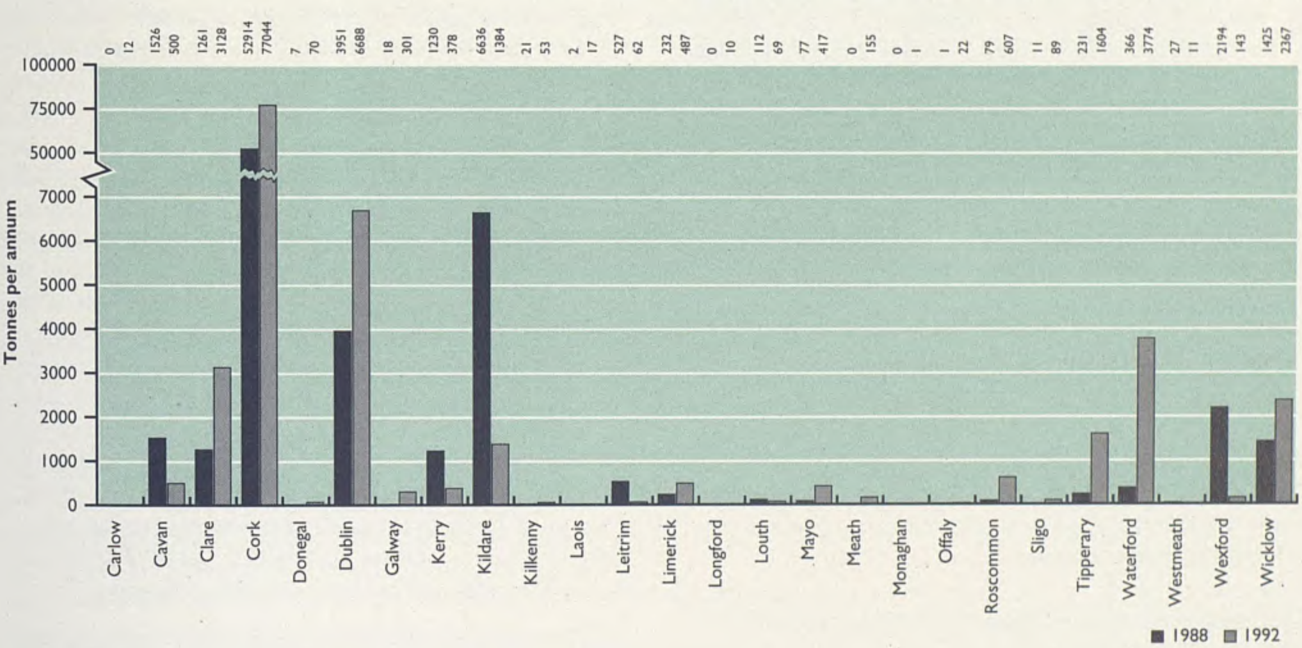


Fig. 7.15 Regional Distribution of Toxic and Dangerous Waste Arising in Ireland by County (DoE, 1994b).

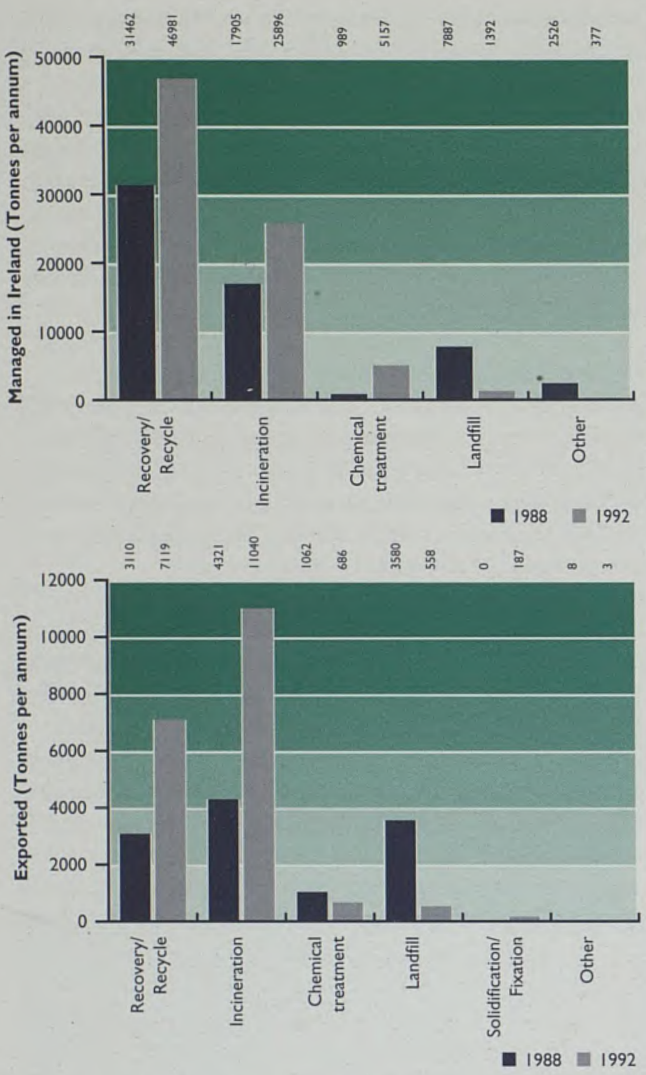


Fig. 7.16 *Management of Toxic and Dangerous Waste Arisings in Ireland (DoE, 1994b).*

Metal and Chemical Treatment Plant Sludges

Approximately 9,200 tonnes of metal and chemical treatment plant sludges are estimated to arise in the Irish manufacturing sector each year (ERU, 1993). Approximately 70 per cent of this material is consigned to landfill, two per cent recovered for re-use and the remainder disposed of through unspecified routes.

Chemical Oil and Other Problematic Wastes not Defined by EC Directive 78/319/EEC

Approximately 16,000 tonnes of waste in this category arise each year in the manufacturing sector in Ireland (ERU, 1993). The disposal routes are as follows: 57 per cent consigned to landfill, 14 per cent incinerated, 4 per cent recovered for re-use and the remainder disposed of through unspecified routes.

Asbestos

The handling and disposal of asbestos wastes is covered by a number of national Regulations, in particular, the EC (Toxic and Dangerous Waste) Regulations, 1982, and the EC (Asbestos Waste) Regulations, 1990 and 1994. The latter Regulations specify handling and disposal procedures for asbestos to prevent the release or migration of asbestos dust or fibres into the environment.

In the EC (Toxic and Dangerous Waste) Regulations, 1982, asbestos dust and fibre is listed as a toxic and dangerous waste. In 1988 and 1992, respectively, amounts reported to have arisen in Ireland were 6,305 tonnes and 850 tonnes, with almost all of this total arising in Co. Kildare.

The practical problems associated with the disposal of asbestos wastes highlight the need for a coherent national strategy for dealing, in Ireland, with the hazardous wastes that are produced through domestic, industrial and agricultural activities. At present, virtually no public authority in Ireland will accept asbestos waste and no dedicated disposal facility exists in the State. Holders of large amounts of this waste are therefore obliged to store the waste in a safe manner while searching for a disposal route in other jurisdictions. There is an urgent requirement for a national strategy to deal with hazardous wastes that are generated in Ireland. Provision for the preparation of a national hazardous waste management plan is included in the Waste Bill (1995).

Waste Oils

The handling and disposal of waste oil in Ireland is regulated by the EC (Waste Oils) Regulations, 1984 and 1992. It is estimated that about 35,000 tonnes of lubricating oil is used annually in Ireland. With losses, consumption and burning at source, the collectable market for waste oil is thought to be about 15,000 tonnes/annum. Of this, approximately 9,000 tonnes, or 60 per cent, is recovered.

End-of-Life Vehicles

The estimated number of cars and goods vehicles scrapped during the period 1980-1988 is illustrated in Fig. 7.17. Most of the metal from discarded vehicles is recovered for re-use. The apparent increase in discarded cars in 1982 is due to the re-introduction of motor tax the previous year.

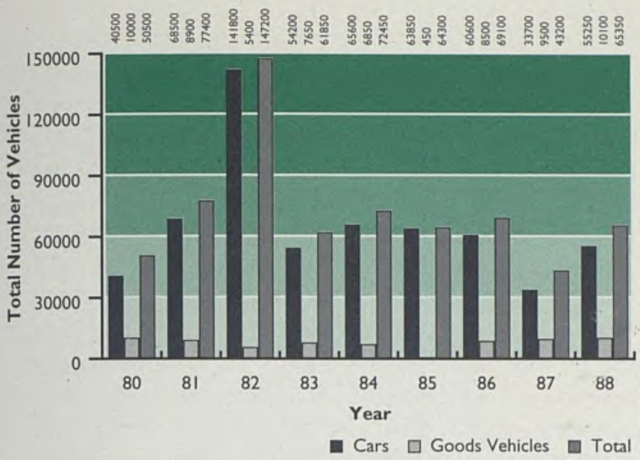


***Fig. 7.17** Estimated Number of Cars and Goods Vehicles Scrapped between 1980 and 1988 (ERU, 1993).*

Batteries and Accumulators

Directive 91/157/EEC on batteries and accumulators containing dangerous substances was implemented in Ireland by the EC (Batteries and Accumulators) Regulations, 1994. The Regulations set out manufacturers' responsibilities in relation to the marking of regulated batteries and accumulators. The manufacturer must ensure that regulated batteries and accumulators can be removed readily following use, that the appliances are marked visibly, legibly and indelibly so as to indicate the heavy metal content of the battery or accumulator, that such batteries or accumulators should be collected separately from other wastes for the purpose of disposal or recycling and, where appropriate, that they are suitable for recycling. The Regulations cover both primary (non-rechargeable) and secondary (rechargeable) batteries which contain specified minimum amounts of mercury, cadmium and lead. No reliable national data on the amounts of batteries and accumulators generated, disposed of or recycled are currently available.

Polychlorinated Biphenyls (PCBs)

Directive 76/403/EEC on polychlorinated biphenyls and polychlorinated terphenyls was implemented in Ireland by the EC (Waste) Regulations 1984. These provide for the safe disposal of and the transformation operations necessary for regenerating polychlorinated biphenyls (PCBs), polychlorinated terphenyls and mixtures containing one or both substances. At present, there are no suitable disposal facilities for PCBs in Ireland and PCB waste is either stored or exported for disposal.

Used Tyres

Waste tyres, from both private cars and commercial vehicles are the most significant source of waste rubber generated. Average composition includes rubber hydrocarbon (48 per cent), carbon black (22 per cent), steel (15 per cent), textile (5 per cent), zinc oxide (1.2 per cent) and sulphur (1 per cent). If not stored in proper conditions they can pose a serious fire risk.

No reliable national data on the amounts of used tyres generated or disposed of in Ireland are available. In 1984 it was estimated that approximately 1.1 million tyres were discarded each year (Cabot, 1985). Of these, approximately 0.25 million were re-treaded and the remainder disposed of by exporting or dumping. A percentage is also re-used for various purposes. It is probably safe to assume that at least this number of used tyres is generated each year in Ireland. Considerable research is being conducted in other countries to identify ways in which used tyres can be recycled and re-used.

Healthcare Waste

Healthcare waste, which is defined as all solid and liquid waste arising from healthcare activities, consists of general domestic-type waste such as kitchen wastes, paper and packaging, which is similar to household and commercial waste, and healthcare risk waste, which consists of biological wastes, infectious wastes, chemical, toxic or pharmaceutical wastes, sharps (needles, scalpels and other sharp broken materials) and radioactive waste.

The Department of Health estimates national healthcare waste arisings to be in the region of 20,000 tonnes/annum with roughly half of this total arising in Dublin. Of this, the Department estimates that approximately 4,000 tonnes is healthcare risk waste (the hazardous waste fraction of the healthcare waste stream). The remaining waste is considered by the Department to be non-hazardous waste with similar characteristics to household and commercial waste.

Until recently, approximately 50 per cent of healthcare waste was incinerated and 50 per cent landfilled (ERU, 1993). All hazardous waste arisings were incinerated on-site. There has been considerable pressure on the healthcare sector to shut down hospital incinerators and find alternative ways of dealing with wastes. In response to this, the Department of Health has recently adopted a Health Services Waste Policy for Ireland which applies the principles of waste prevention and minimisation to the problem. All available treatment options for final disposal of non-recoverable residues were evaluated and a non-incineration technology chosen for pilot testing.

Radioactive Waste

A survey by the Radiological Protection Institute of Ireland (RPII) has found that there are at least 600 redundant sealed sources of long-life radioactive material in storage in Ireland, some of which were imported before a licensing system came into force in 1977. The RPII has expressed itself satisfied that all the sources currently in storage in the country are being stored in a manner which does not pose a hazard to people or the environment, but believes that long-term storage of radioisotopes is far from ideal.

A permanent solution to the problem of the storage and disposal of these sources is needed.

Priority Waste Components

The priority waste components in the hazardous waste stream are healthcare waste, used tyres, end-of-life vehicles, halogenated solvents, batteries and accumulators, and electric/electronic waste. Information on each of these, where available, has been provided. No information is currently available for batteries and accumulators or waste from the electronics industry.

Agricultural Waste

Agricultural solid waste consists mainly of animal manure (grazing stock, pigs and poultry) and silage effluent which are normally combined in a slurry holding-pit prior to landspreading. Other wastes produced on a farm include household and commercial waste, waste oil from machinery, chemicals, pesticides, plastics and other miscellaneous wastes.

In recent years there has been an increasing awareness of the importance of good agricultural waste management practices. This is reflected in the introduction of the Rural Environment Protection Scheme (REPS), described in Chapter 14. Farmers enrolled in REPS implement, among other things, a comprehensive waste management plan for the farm and farmyard.

Amounts Arising & Waste Composition

As noted in Chapter 6, grazing animals produce approximately 28 million tonnes of manure during the indoor winter period which must be stored and spread on land. Pig and poultry output is estimated to be in excess of 2 million tonnes, resulting in a total of approximately 30 million tonnes of animal manure per annum (Lee, 1995). About 1.4 million tonnes of silage effluent are also produced which is normally combined with slurry (Boyle, 1987).

The agricultural sector generates greater amounts of organic waste than any other sector. The total organic load generated from agricultural activities in Ireland is equivalent to that generated by about 68 million people (Chapter 6).

Disposal Routes

Essentially the sole disposal route for slurries in Ireland is landspreading. When slurry is applied to land as a fertiliser in line with soil nutrient requirements, then land-spreading is more correctly described as re-use. However, if slurry is applied to land in excess of soil nutrient requirements, then the excess nutrient will infiltrate the soil or runoff to adjacent watercourses causing either groundwater contamination or surface water eutrophication in some cases. Over the past 40 years, phosphorus levels in Irish soils have increased dramatically through the application of chemical fertilisers. The phosphorus status of some soils is now high enough to allow optimum crop production for a number of years without further chemical fertilisation. For such soils, proper application of farm slurries will provide sufficient phosphorus for optimum plant growth.

The Department of Agriculture, Food and Forestry and Teagasc provide advice and Codes of Good Practice on the correct application of slurry to land, which, when followed, minimise the risk of pollution. The EPA is currently preparing guidance notes for best available technology not entailing excessive costs (BATNEEC) for the intensive pigs and poultry sectors which will be licensed by the Agency in due course.

Sewage Sludge

Sewage sludge is a product of sewage treatment and different forms of treatment produce different types of sludge. In Ireland, both primary and secondary sludges are generated. Primary sludge consists of settleable solids carried in the raw waste water. Secondary sludge consists mainly of biological solids generated through the biological oxidation of raw waste water. Where removal of phosphorus prior to discharge is required, chemical sludges may also be generated which are generally removed and disposed of in combination with the secondary sludge.

Amounts Arising and Composition

Approximately 850,000 m^3 of sewage treatment sludges are produced in Ireland each year of which over 40 per cent is currently generated in Dublin (Weston-FTA Ltd., 1993). This wet volume which has a solids content of about 4-5 per cent is equivalent to a dry weight of about 38,000 tonnes. Septic tanks result in the production of a further 5,000 to 6,000 dry tonnes of sludge for disposal per annum (Boyle, 1986). The total volume of sludge produced in the country is expected to increase three-fold over the next ten years as Ireland complies with the requirements of national Regulations implementing the urban waste water treatment Directive (91/271/EEC). This Directive requires that a minimum level of sewage treatment be provided for population centres of a certain size depending on their location. The practical consequence of the Directive will be the construction of secondary treatment plants throughout the country. While this will provide a higher level of treatment and higher quality effluents, it will also result in a large increase in the volume of secondary sludges to be handled.

A breakdown of current sludge type is given in Fig. 7.18. Approximately 50 per cent of sludge produced is secondary sludge. Of the 42 per cent primary sludge produced, almost all arises at the Ringsend plant in Dublin. The regional distribution of sludge arisings in Ireland by county as tonnes of dry solids (TDS)/annum is illustrated in Fig. 7.19.

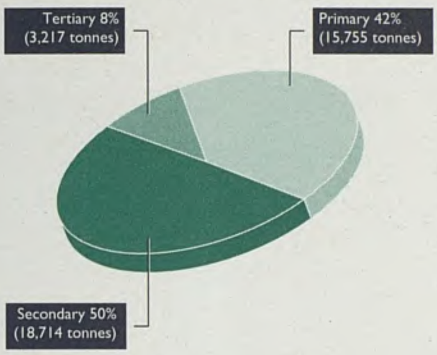


***Fig. 7.18** Sewage Sludge Arisings in Ireland (Weston-FTA Ltd., 1993).*

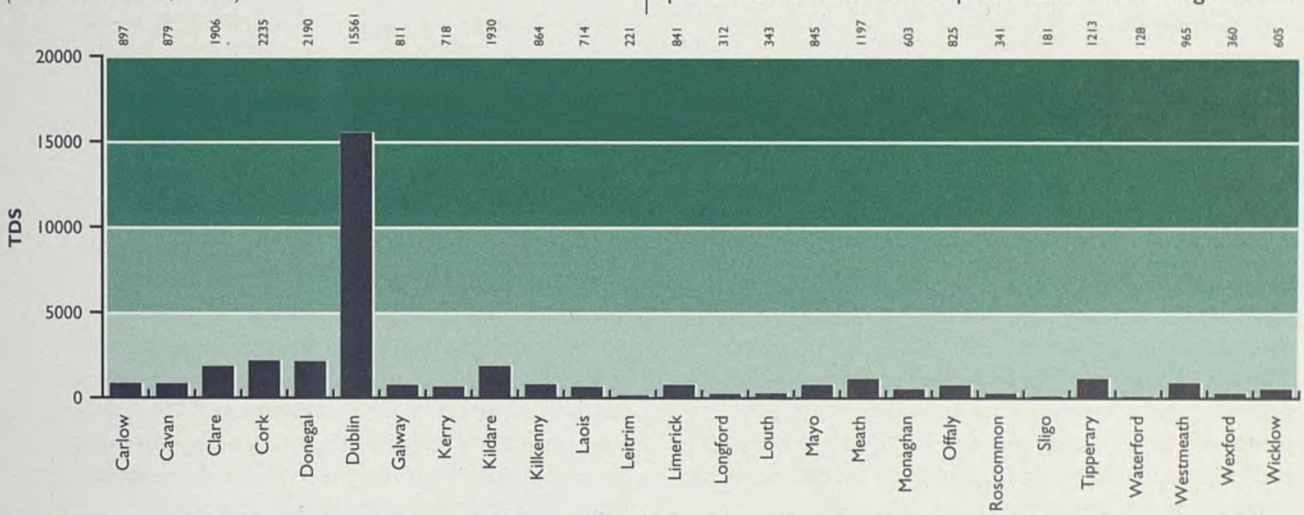


***Fig. 7.19** Regional Distribution of Sewage Sludge Arisings by County expressed as tonnes of dry solids (TDS) (Source: Weston-FTA Ltd., 1993).*

Disposal Routes

Current disposal practice consists either of dumping at sea, landfilling or landspreading on agricultural land (see Fig. 7.20). Forty-two per cent of sludge produced is currently landfilled, 12 per cent is spread on agricultural land, 36 per cent is dumped at sea and the remainder is disposed of by a variety of different methods.

Dredge Spoils

Dredge spoil arises mainly from harbour development and maintenance operations. Between 1985 and 1993, a total of 7,061,400 tonnes arose for disposal ranging from a low of 204,000 tonnes in 1985 to a high of 1,610,159 tonnes in 1989. From the records of the Department of the Marine 784,600 tonnes arise each year, on average. Almost all dredge spoil arising in Ireland is disposed of at sea.

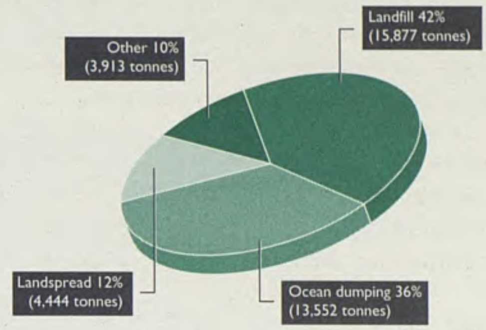


***Fig. 7.20** Sewage Sludge Disposal Practice in Ireland (Weston-FTA Ltd., 1993).*

Litter

Litter and unauthorised dumping are two of the most persistent and visible waste problems in Ireland. Legislative controls in relation to litter are contained in the Litter Act, 1982. Under the Act, local authorities are required to take measures for the prevention of litter and are responsible for dealing with the effects of litter in their areas, and may make arrangements with other organisations or persons for that purpose. These measures may include the collection and disposal of litter, the encouragement of public participation in litter control, the promotion of recycling and the provision of publicity, advisory and educational services relating to the prevention of litter.

Provision is made for an on-the-spot fine system to be operated by local authorities using litter wardens. In 1994, 512 on-the-spot fines were issued by local authorities employing 89 litter wardens on a full or part-time basis. A range of offences incur a maximum fine on summary conviction of £800. These include littering, graffiti, fly posting and the abandonment of vehicles. Occupiers of land on which a vehicle has been abandoned may also prosecute in this regard. A total of 187 prosecutions under the Act were taken by local authorities in 1993 resulting in 118 convictions. Occupiers of land are obliged to keep the land free of litter which is in, or visible from, a public place, and local authorities may make bye-laws requiring occupiers to keep adjoining public roads and paths free of litter.

Local authorities have powers to secure the removal and disposal of abandoned vehicles and are required to make provision, according to need, for places at which vehicles and scrap metal may be abandoned.

Anti-litter Campaigns

Anti-litter and general clean-up campaigns are periodically organised by local authorities to increase public awareness and tackle litter and dumping black spots. The local authorities' efforts in this area have been assisted by campaigns instituted by the Department of the Environment on a national basis. The voluntary sector, youth and community groups and schools are also actively involved in anti-litter and clean-up campaigns and, in many instances, are the key to the success of such campaigns.

Local authority expenditure on anti-litter activities, street cleaning etc., amounts to £20 million per annum.

Plastics

Approximately 500 million plastic bags are used in Ireland per annum. Plastics can be particularly intrusive visually, e.g., supermarket bags which get blown onto hedges and trees or these and other plastics marking flood water levels on river banks. Plastic litter is also a serious hazard to wildlife and can disrupt drainage systems and water flow. Large plastic sheeting is now widely used in the countryside, mainly for wrapping silage, and can cause serious problems if not disposed of properly.

A recent study showed that the major use categories for polyethylene film in Ireland are the commercial/distribution sector (55 per cent), the agricultural sector (35 per cent), the horticultural sector (3 per cent) and the peat extraction sector (1.5 per cent) (EMA, 1993).

WASTE DISPOSAL PRACTICE AND IMPACTS

Overview

Current solid waste disposal practice in Ireland, based on available information for all wastes, with the exception of those of agricultural origin (see Fig 7.2), is summarised in Fig. 7.21. Nearly 70 per cent of all solid waste produced in Ireland is either landfilled or disposed of on-site by the producer. A total of 11 per cent is either recycled or re-used and 18 per cent is dumped at sea. This pattern can be expected to change in the next decade with a marked reduction in ocean disposal, owing to the banning of the disposal at sea of industrial wastes and sewage sludge, and an increase in the amount of waste recycled or re-used. However, as in much of the rest of Europe, a large percentage of the waste stream in Ireland is likely to be disposed of in landfills for the foreseeable future.

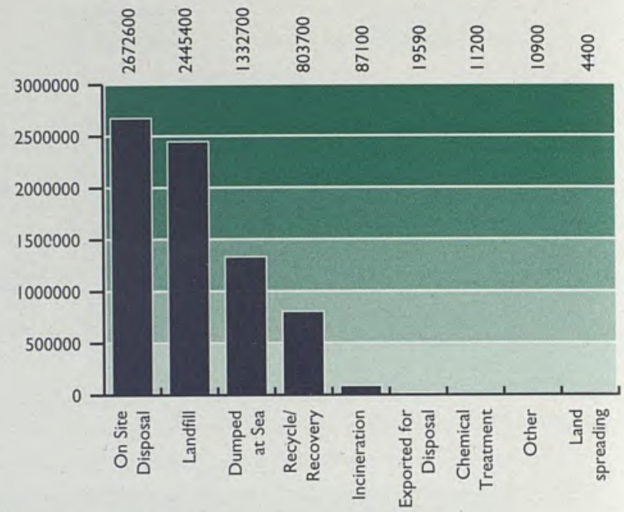


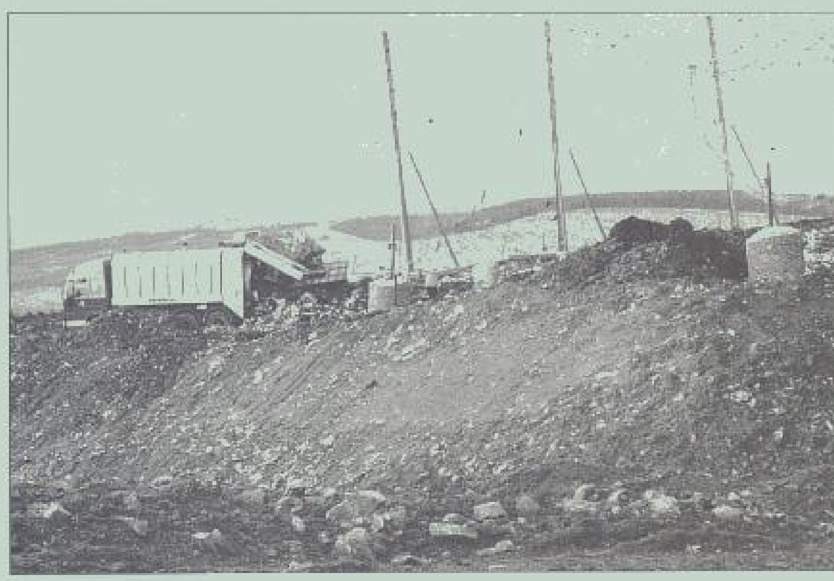
Fig. 7.21 *Summary of Solid Waste Disposal Practice in Ireland (not including agricultural wastes).*

Landfill

It is now known that there are many potential environmental problems associated with the landfilling of waste. These include the potential contamination of ground and surface waters by leachate, the generation and migration of landfill gases, the contamination of land and aesthetic nuisances. These environmental threats can be greatly reduced through good engineering and environmental management practice. It is important to note that landfills and other waste disposal facilities need to be planned, designed, constructed and managed with the same degree of skill as other engineered structures (Boyle, 1987). Much work remains to be done to upgrade existing landfills so that they will satisfy future operational criteria.

Disposal of waste by landfill is the principal waste disposal route in Ireland, as it is in Europe. On average, more than 60 per cent of municipal waste and about 70 per cent of hazardous waste was disposed of in landfill sites in OECD countries in 1989 (Stanners and Bourdeau, 1995).

Generally, the landfills constructed in the past ten years have been built to higher standards than the many small landfills and tip sites of the past. The EPA is currently preparing detailed criteria and procedures for the selection, management, operation and restoration of landfill sites for domestic and other wastes.



Trends

The distribution, size and estimated remaining capacity of local authority landfills currently operating in Ireland is presented in Fig. 7.22. A total of 125 landfills were in operation in 1994 of which 99 were publicly operated and 26 privately operated. This compares with a total of 205 operating landfills in 1984 of which 164 were publicly operated and 41 privately operated. Many of the landfills currently in operation are close to maximum capacity and will close in the medium term.

It is likely that the trend of reduced numbers of landfills will continue with new landfills being designed, constructed and operated to higher standards than existed in the past. New landfills will be engineered to specified containment standards which will incorporate measures for control and treatment of leachate and landfill gases. Routine monitoring of groundwater, surface water and meteorological data will also be required to provide assurance that pollution control measures are working. Facilities such as weighbridges, reception areas for recyclables and other site services will also need to be provided.

The Waste Management Bill provides for licensing of landfills, along with other waste recovery and disposal operations, with the EPA designated as the sole licensing authority. It can be expected that design and operational requirements for the landfilling of waste in the future will be far stricter and more comprehensive than those that applied in the past.

While the disposal of wastes to land is considered the least desirable option under the waste hierarchy, it will continue to be the major disposal route for wastes which are neither re-used nor recycled. The emphasis will be on ensuring that the disposal of wastes by landfilling is done in such a way as to minimise impacts on the environment.

The relative success of national waste minimisation strategies will be measurable through the changes in the amount and type of waste consigned to landfill. The tracking of this information will be possible through the implementation of a National Database on Waste.

Incineration

The major potential environmental impacts associated with incineration technologies derive from the handling and disposal of the ash residue and the atmospheric emission and dispersion of persistent and toxic substances such as heavy metals and organic products of incomplete combustion (PICs), which may include dioxins and furans.

It should be noted that dioxins, furans and other chlorinated PICs can be produced only through the incineration of chlorinated compounds such as PVC or through the presence of chloride ions in the process. If the feedstock is uncontaminated with chlorinated compounds and chloride ions, dioxins and furans will not be found. The EPA has issued a Waste BATNEEC Guidance Note which covers emissions to the atmosphere.

Incineration is employed in Ireland mainly for disposing of hazardous wastes and healthcare wastes. All hazardous waste incinerators now require an integrated pollution control (IPC) licence to operate and this licence requirement has been extended as of October 1995 to both the incineration of hospital waste and the incineration of any wastes other than hazardous and hospital, in plants with a capacity exceeding one tonne/hour.

There are currently six sites at which hazardous waste incinerators are located in Ireland all of which are dedicated to the disposal of waste generated on the site at which it is produced. In 1992, of the 79,800 tonnes of hazardous waste managed in Ireland, some 25,900 tonnes were incinerated. A substantial fraction of this waste is the by-product of waste solvent recycling. The remainder is made up of aqueous waste-contaminated solvents, the residues from chemical reactions and waste packaging material (Leech, 1994).

With regard to healthcare or hospital waste, the Department of Health has adopted a strategy for managing healthcare waste in Ireland. The Department recognises that it is impractical for each hospital to have its own advanced waste disposal facility on-site and has proposed that four plants be constructed to handle all healthcare risk waste. The preferred option of the Department at present is a non-incineration technology.

Incineration with energy recovery ranks higher than disposal to land as a waste management option. It is, though, a highly technical and costly operation. More stringent pollution control requirements will further increase the capital and operating costs of the technology. This, together with problems associated with the variable nature of the feedstock, makes it unlikely that incineration will be considered as a viable option for municipal solid waste disposal in Ireland in the near future. There is also considerable public opposition to the siting of incinerators.

Trends

It is likely that incineration of hazardous wastes at levels similar to those reported in 1992 will continue in Ireland. All hazardous waste incinerators are now licensed by the EPA and are operated to a high standard. There has been considerable public opposition to the proposed siting of a national hazardous waste incinerator to deal with hazardous wastes currently disposed of in on-site incinerators. The Government has decided that a national hazardous waste incinerator will not be developed in Ireland.

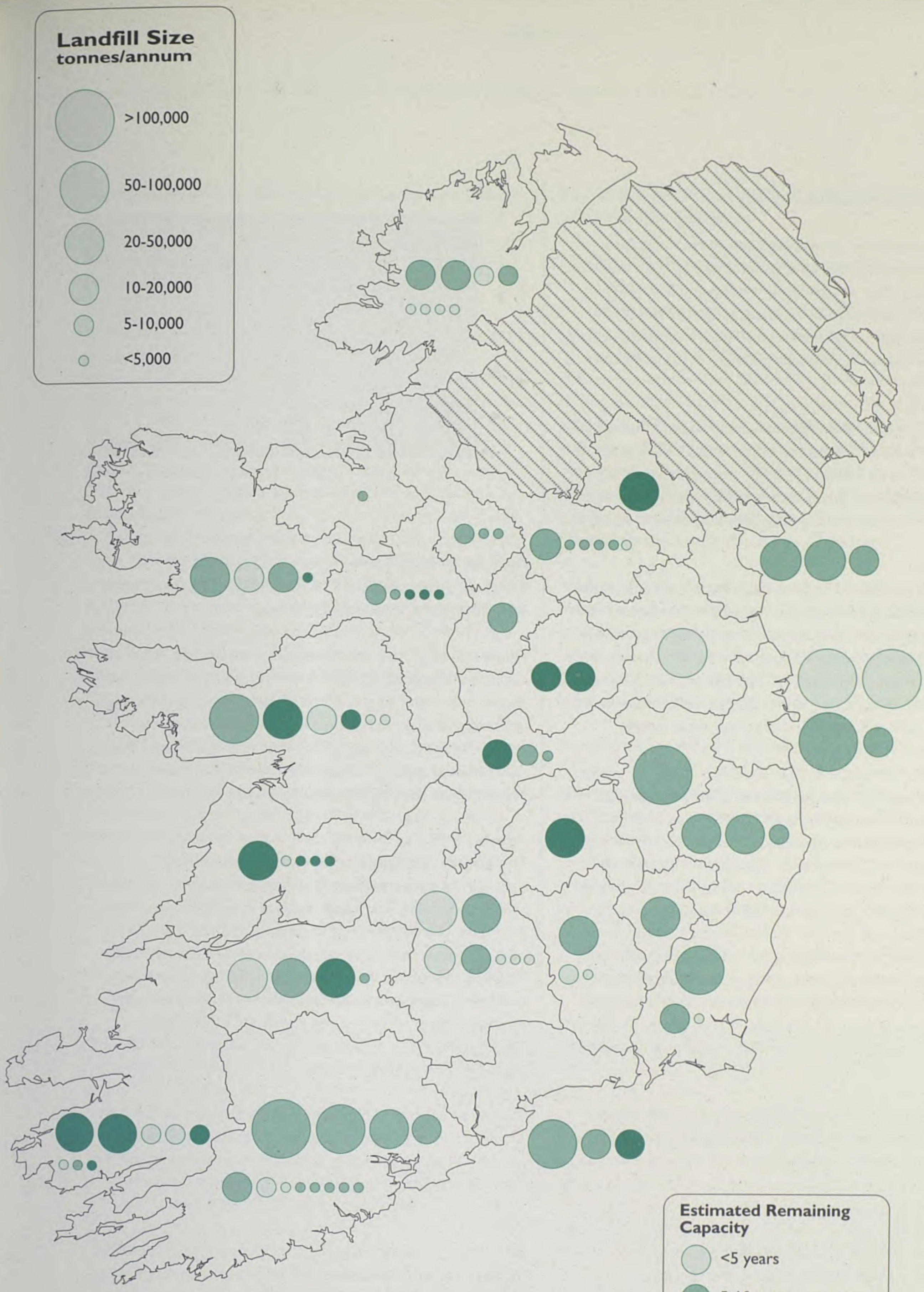


Fig. 7.22 *Regional Distribution, Size and Estimated Remaining Capacity of Currently Operating Local Authority Landfills in Ireland (Source: EPA).*

Recycling, Re-use and Recovery

Most waste streams contain large amounts of material which can be recovered, re-used or recycled. For instance, it is estimated that, theoretically, between 70 and 80 per cent of the household and commercial waste stream is either recyclable or re-usable. This figure reduces to about 60 per cent when the practical problem of contamination is accounted for.

The Department of the Environment estimates that only 7.4 per cent of the household and commercial waste generated in Ireland is currently recycled. For packaging wastes, i.e., paper, glass, plastics, ferrous and non-ferrous metals and aluminium, the current recycling rate is estimated to be 10.3 per cent.

Targets for increased recycling rates have been set in the national recycling strategy (see Fig. 7.23). The Government aims to increase the overall rate of recycling of packaging materials (paper, glass, plastics, metals, ferrous metal and aluminium) from 1994 levels of 10.3 per cent to 33 per cent by 1999, and, by so doing, divert 20 per cent of combined household and commercial waste away from landfill.

Recycling of municipal waste in Ireland is currently carried out by a number of commercial and voluntary agencies. The infrastructure consists mainly of collection points that centre on bottle banks, the majority of which are located in urban areas. The Government has adopted a target of increasing the number of collection sites from the current level of about 200 up to about 500. This would provide approximately one site per 5,000 persons in urban areas. 'Civic amenity' sites will also be provided by some local authorities for the reception of segregated waste from the public. Curb-side recycling has been operated with high participation rates on a pilot basis in south-west Dublin by Kerbside Dublin Ltd. About 33,000 households are served at present.

With industrial and hazardous wastes, the percentage recycled, re-used or recovered is considerably higher than that for household and commercial wastes, which reflects the relatively higher market value of the materials. In the industrial sector, several industries, such as steel manufacturing, metal foundries and animal feed production, are well established with a long history of recycling, re-use or recovery. Within the manufacturing sector, approximately 50 per cent of industrial wastes generated are either recycled, re-used or recovered (ERU, 1993). For wastes defined in the EC (Toxic and Dangerous Waste) Regulations, the recycling and recovery rate was 54 per cent in 1992.

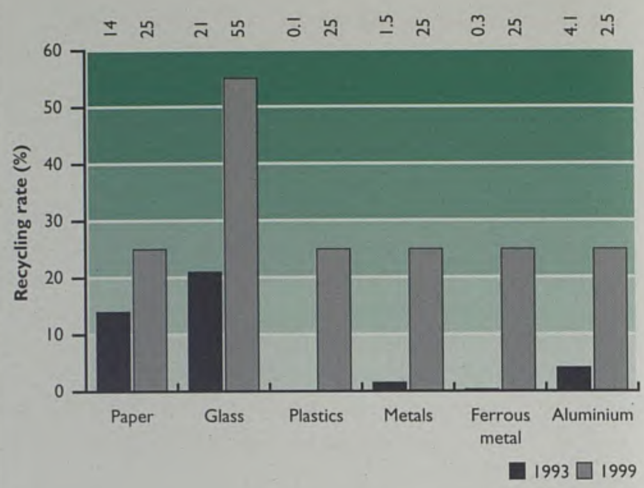


Fig. 7.23 Present Recycling Rates (1993) and Target Recycling/Recovery Rates (1999) for Individual Materials in the Packaging Waste Stream (DoE, 1994a).

While recycling, re-use and recovery are considered more desirable management options than incineration with energy recovery or landfilling, it is nonetheless important to point out that the energy requirements and environmental impacts of recycling, re-use and recovery operations may sometimes outweigh the benefits. Waste minimisation and prevention is the preferred option in the long-term.

Trends

The level of recycling activity in the household and commercial sector in Ireland is low compared to other OECD countries. For instance, glass recycling rates range from just over 20 per cent in Great Britain to over 70 per cent in Switzerland, with Ireland currently at 21 per cent. There is, therefore, considerable room for improvement and this is being addressed through the national recycling strategy. We are likely to see significant increases in recycling activity in the domestic and commercial waste sector in the coming years.

While the success of schemes such as that run by Kerbside Dublin Ltd. are testament to the fact that Irish householders are willing to separate recyclable materials at source, when provided with adequate support services, there are, however, considerable technical, market and societal barriers to be overcome before recycling can be developed to its full potential. The Waste Management Bill, 1995, presents mechanisms and instruments that will encourage recycling by making it more economically attractive.

In the industrial sector, the introduction of IPC licensing will create a climate for improved waste minimisation practices as licensed facilities conduct environmental management planning and auditing as part of the process.

The industrial sector will continue to evaluate recycling, re-use and recovery from an economic view point and as it becomes more economical to conduct waste minimisation and recycling practices, industry is likely to respond with increased activity in these areas .

Ocean Dumping

Over the past decade, each year almost 13,600 tonnes dry weight (306,400m³) of sewage sludge, over 500,000 tonnes wet weight of industrial waste, mainly sludges, and almost 800,000 tonnes of dredge spoil were dumped at sea in Ireland. Dumping at sea of industrial waste ceased in 1993. Dumping at sea is regulated by the Department of the Marine under the Dumping at Sea Act, 1981 which is soon to be repealed and re-enacted. Internationally, dumping at sea is governed by the Oslo and London Conventions which are implemented in Ireland under the Dumping at Sea Act. Applications for permits to dump at sea are assessed by the Department's Marine Licence Vetting Committee which must be satisfied that no viable land-based alternative to dumping at sea exists before considering an application.

Trends

Disposal of industrial waste at sea has not been permitted in Ireland since July, 1993 and the disposal of sewage sludge at sea is being phased out and will be terminated by the end of 1998. Dublin Corporation is the only authority permitted to dump sewage sludge at sea. Dredge spoils will continue to be disposed of at sea and it is unlikely that the amounts disposed of will decline for the foreseeable future.

FUTURE PERSPECTIVES - RESPONDING TO THE PRESSURES

The Waste Management Hierarchy

Irish policy seeks to reflect the primacy accorded in EU policy to waste prevention, reduction and re-use. This policy direction was reinforced by the Environmental Protection Agency Act, 1992 and is further developed in the Waste Management Bill, 1995. IPC licensing, to which all processes with significant polluting potential will be subject, embodies criteria which reflect the need for prevention and elimination of waste. The Waste Management Bill proposes that all significant waste recovery and disposal facilities be subject to licensing and provides for measures to reduce production and promote recovery of waste.

Along with new strategies for waste minimisation and waste recovery, the Government is also preparing a National Sustainable Development Strategy which will provide a framework for sustainable development in Ireland. The production and management of wastes are key indicators for measuring the progress of sustainable development.

Strategies for Waste Minimisation and Prevention

Waste prevention has been recognised world-wide as a priority objective to reduce the pressure on the environment from production and consumption processes. Developing and implementing effective waste minimisation strategies in Ireland is a complex task and will require the adoption of several strategic approaches. They include:

- Material Life-Cycle Analysis: cradle to grave analysis of materials to determine environmental impacts and energy requirements at each stage of their life (Fig. 7.24);

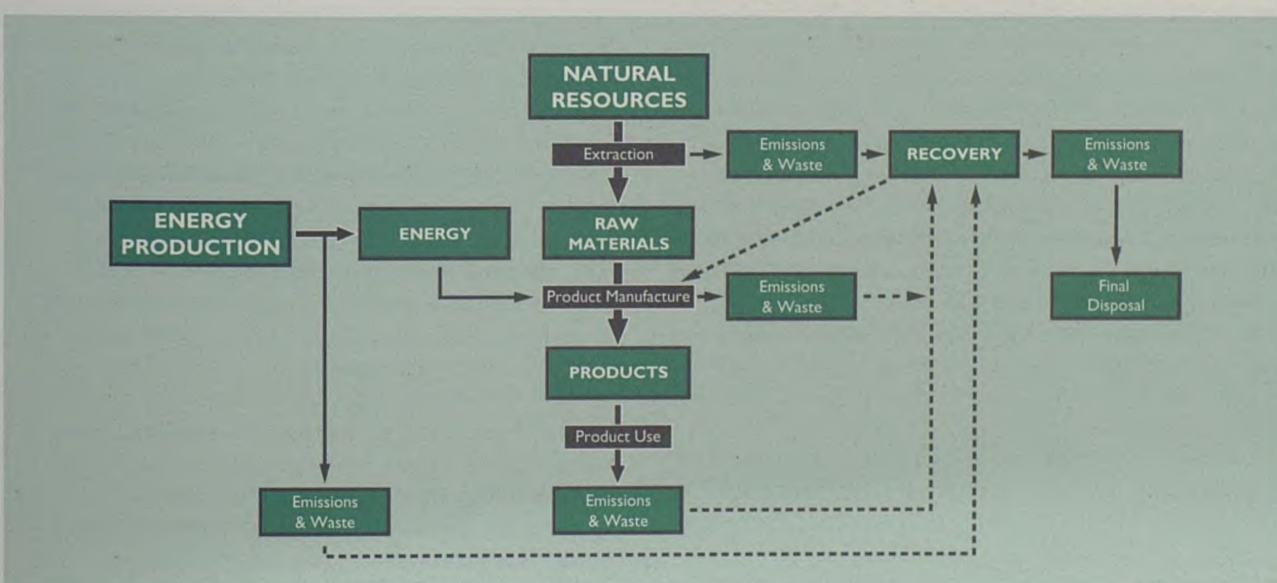


Fig. 7.24 *Material Life-Cycle Analysis.*

- Clean Production Processes: the development of technologies and processes that consume less energy and/or raw materials and/or generate less waste than an existing technology or process, and the minimisation of 'end-of-pipe' emissions through recycling and re-use (Duffy, 1994).

- Integrated Waste Management Planning by:
  Local Authorities;
  Industries;
  State-Sponsored Bodies;
  Farmers.

Developing a Sustainable Solid Waste Management Strategy

The key to measuring progress along the path of sustainable development is to have realistic plans with reliable indicators. The development of solid waste management planning is hampered by the lack of uniform and reliable measuring systems to inform the decision making process. This chapter has drawn together the disparate strands of information available about solid waste management in Ireland so that gaps in information can be identified and the task of planning made easier.

Indicators need to be adopted so that progress in the areas of waste prevention, recycling, re-use and safe disposal of non-recoverable residues can be measured. For example, the recently published Government strategy for increased recycling of domestic and commercial waste sets targets for the recycling of packaging materials to be met by 1999. Table 7.4 presents some indicators that can be used to measure progress towards a sustainable waste management strategy in Ireland.

Public Attitudes to Waste

In a survey on attitudes to the environment conducted by the Department of the Environment (1990), the litter problem was seen to be of greatest concern. A large majority also said they would be willing to separate refuse for collection into materials that can be recycled and those that cannot. This latter finding has been borne out in the past three years by the very positive attitude to recycling by residents in Dublin provided with the opportunity to conduct curb-side recycling where participation rates are in the region of 70-90 per cent.

***Table 7.4** Proposed Waste Management Indicators.*

Indicators	Type of Indicator [1]
Waste Production (tonnes & tonnes/capita)	Pressure
• municipal	
• commercial	
• industrial	
• hazardous	
• agricultural	
Waste Handling	Response
• % recycled	
• % recovered	
• % disposed	
• landfilled	
• incinerated	
• other	
Facilities/Infrastructure	Response
• recovery	
• recycling	
• disposal	

(1) Type of indicator determined by its position within the Pressure-State-Response framework, i.e., human activities exert pressures on the environment which affect the state of the environment and the natural resource base; society responds to these changes in state through environmental, general economic and sectoral policies (the societal response).

Waste disposal continues to be a matter of public concern with opposition to both landfilling and incineration regularly voiced. Almost everybody in Ireland contributes to the growing waste stream and so must bear a share of responsibility for what is produced. However, few communities will volunteer to have a waste disposal facility built in their locality. While the Government is committed to implementing waste prevention, reduction and re-use strategies, as detailed in the Waste Management Bill, it needs to be recognised that a considerable quantity of waste will continue to require safe disposal and that adequate and safe waste disposal facilities are as essential a part of our economic infrastructure as water services, road building and electricity generation.

Much local opposition to landfills and waste disposal in general is based on past operational practices which lead to fears about reduction in property values and concern about impacts on health and the local environment (Boyle, 1987). Modern landfill design and operational practices, if implemented properly, alleviate many of these potential impacts. However, more stringent design and operational requirements will also increase the cost of waste disposal and how these costs will be met needs to be addressed.

INFORMATION GAPS

Reporting on the production and disposal of waste in Ireland and the routes of its disposal is seriously hampered by the scarcity of reliable, complete and up-to-date data. With the possible exceptions of household municipal waste and toxic and dangerous waste, as defined by Toxic and Dangerous Waste Regulations, data on waste arisings in Ireland are unreliable. A simple, reliable and agreed reporting system for waste generation, recovery and disposal by both the public and the private sector is needed so that a National Database on Waste can be kept up to date.

In response to this need, the EPA recently initiated a project on the compilation of national waste statistics and the creation of a new National Database on Waste. The Database will include information on household and commercial municipal waste, hazardous and non-hazardous industrial waste and priority waste streams, as well as geographically referenced information on the locations of waste recovery, recycling and disposal facilities throughout the country.

It is only through the availability of reliable statistics on waste generation, recovery and disposal that we can measure progress towards agreed targets for waste reduction and increased levels of recycling.

There is also an urgent need for a survey of abandoned and private landfill sites. In particular, sites used for the deposit of hazardous wastes need to be surveyed.

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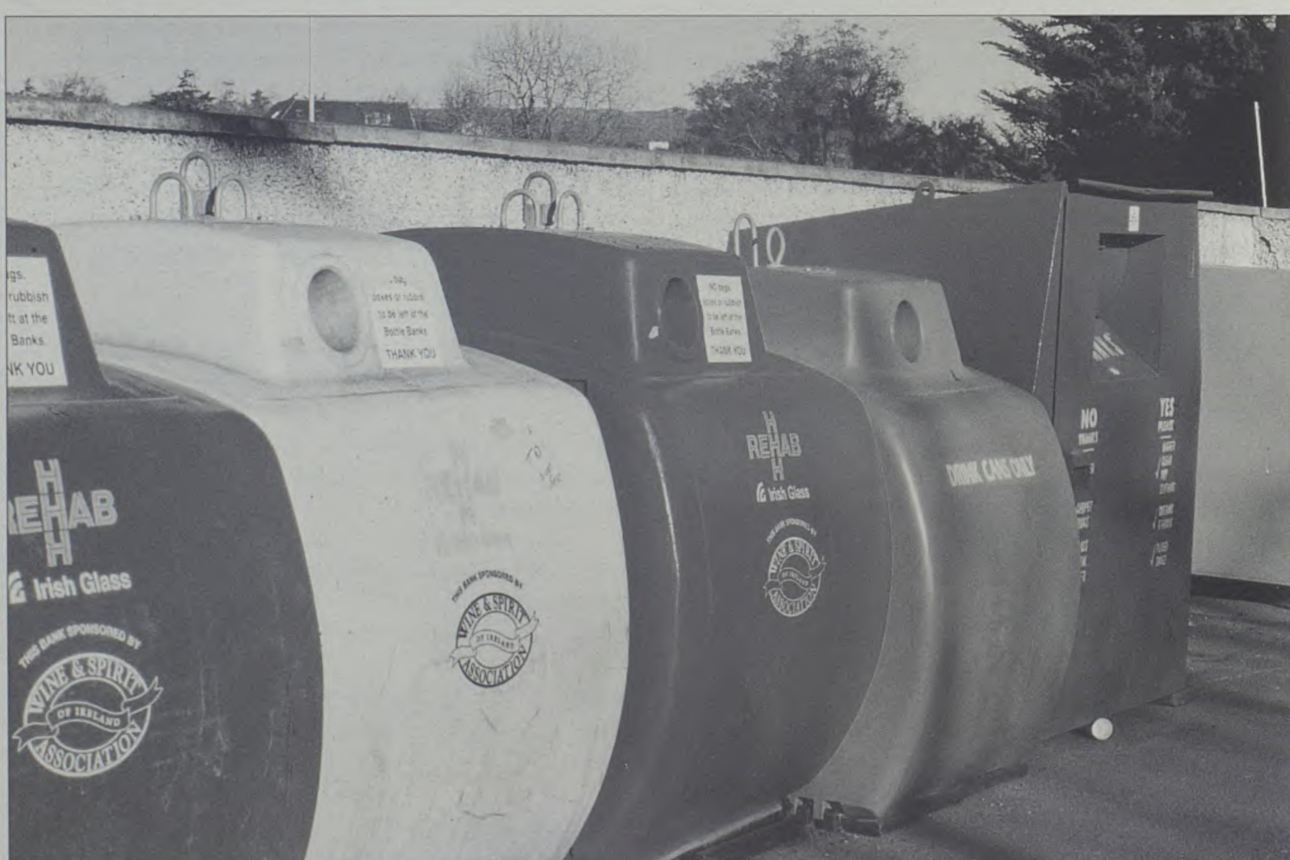


PART III

ENVIRONMENTAL QUALITY AND POLLUTION

CHAPTER 8

AIR QUALITY AND ACID DEPOSITION

INTRODUCTION

The underlying legislative framework for air pollution control and abatement in Ireland was provided by the Air Pollution Act, 1987 (Chapter 14). Many of the legislative controls introduced under the Act, in relation to air quality and emissions of air pollutants, are derived mainly from a need to comply with European Union (EU) legislation. In this regard, air quality standards for several pollutants, limits on the pollution potential of some fuels, and a licensing system to control emissions of pollutants from industrial plants, are among a range of specific measures introduced by way of Regulations under the Act. The Environmental Protection Agency Act, 1992 (EPA Act), provides for integrated pollution control (IPC) licensing by the Agency in respect of major industries and other activities with a significant potential to cause pollution, including air pollution. Regulations introduced under the Road Traffic Acts give effect to the variety of EU Directives aimed at reducing emissions from motor vehicles.

The most important national initiative in air pollution control has been the introduction of smoke control measures to alleviate problems of winter smog in the larger urban areas. These measures take the form of a ban on the marketing, sale and distribution of bituminous fuels in designated areas. They were introduced in Dublin and Cork in 1990 and 1995, respectively. Economic instruments, such as those relating to the price of unleaded petrol and fuel subsidies necessary on foot of smoke control measures, also play a part in environmental protection (Chapter 15).

AIR QUALITY STANDARDS AND GUIDELINES

Air Quality Standards

Air quality standards exist in Ireland for smoke and sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and lead. These standards correspond exactly to the standards and limit values set by EU Directives for these pollutants as shown in Table 8.1 (CEC, 1980, 1982 and 1985). Standards are usually expressed as medians or as percentiles, which allow for exceedance of the limits by a proportion of recorded values. For example, the 98-percentile standard for smoke allows a total of only seven values exceeding 250 µg/m^3 in a full year. In addition, more than three such values on consecutive days would also result in non-compliance for this pollutant. In the case of NO_2, no more than 175 hourly mean values in a full year should exceed 200 µg/m^3, which means that one exceedance every two days would be sufficient to breach the limit.

Air Quality Guidelines

Although air quality in Ireland is assessed with respect to the standards given in Table 8.1, some of the various Directives on which they are based also propose 'guide values' intended for the further protection of human health and the environment, and which serve as useful additional references. The guide values for both SO_2 and smoke are 100-150 µg/m^3 for the maximum daily mean and 40-60 µg/m^3 for the annual mean. In the case of NO_2, the guide value is 135 µg/m^3 for the 98-percentile and 50 µg/m^3 in respect of the median.

Table 8.1 *Air Quality Standards in Ireland.*

Pollutant	Air Quality Standard (µg/m^3)	Statistical Parameter
Smoke	80	Annual median of daily mean values
	130	Winter median of daily mean values
	250	98-percentile of daily mean values
	250	No more than three consecutive days
SO_2	80 if smoke > 40	Annual median of daily mean values
	120 if smoke = or < 40	
	130 if smoke > 60	Winter median of daily mean values
	180 if smoke = or < 60	
	250 if smoke > 150	98-percentile of daily mean values
	350 if smoke = or < 150	
	250 if smoke > 150	No more than three consecutive days
	350 if smoke = or < 150	
NO_2	200	98-percentile of hourly mean values
Lead	2	Annual mean

Table 8.2 *EU Thresholds and WHO Guide Values for Ozone.*

Body	Purpose	Parameter	Threshold/Guide Ozone (µg/m³)
EU	Protection of Human Health	8-hour mean*	110
EU	Protection of Vegetation	1-hour mean	200
		24-hour mean	65
EU	Population Information	1-hour mean	180
EU	Population Warning	1-hour mean	360
WHO	Protection of Human Health	1-hour mean	150-200
		8-hour mean	100-120
WHO	Protection of Vegetation	1-hour mean	200
		24-hour mean	65
		mean over the growing season**	60

* the mean over 8 hours is a moving average calculated four times per day from the eight hourly values between 00.00 and 9.00, 8.00 and 17.00, 16.00 and 01.00, 12.00 and 21.00

** 1 April to 30 September

Thresholds for Ground-level Ozone

The Directive on air pollution by ozone (CEC, 1992) establishes a harmonised procedure for monitoring, exchanging information, and informing and warning the public with regard to air pollution by ground-level ozone. Unlike the other Directives on air pollutants, it sets no air quality limit values. Instead, it defines thresholds for ozone in air above which there may be effects on human health and vegetation, in addition to thresholds for informing and warning the public in the event of ozone pollution episodes. The thresholds (Table 8.2) are broadly consistent with guide values promulgated by the World Health Organisation (WHO) and are an appropriate reference for assessing ozone concentrations where no air quality standard exists.

AIR QUALITY MONITORING NETWORKS

Air quality monitoring in Ireland is undertaken largely to assess compliance with national air quality standards, to implement relevant EU Directives and to maintain arrangements under EU exchange of information decisions. Other objectives are to assess population and ecosystem exposure to air pollutants, to inform the public of the state of air quality, and to identify long-term trends in air quality. The vast majority of sites used for these purposes are operated by local authorities and most of these monitor smoke and SO_2 only (Table 8.3).

A variety of industrial plants throughout the country are required to conduct such air quality monitoring as is specified under the terms of planning permission or air pollution licence. In recent years, the Environmental Protection Agency (EPA) has become involved in air quality monitoring, mainly through the operation of automated sites such as the ozone monitoring network, for the Department of the Environment (DoE). The EPA is in the course of preparing a national monitoring programme for air quality.

Smoke and SO_2 Networks

The measurement of smoke and SO_2 is based exclusively on non-automatic techniques, with smoke being determined by reflectance (i.e., staining of a filter through which it is passed) and SO_2 calculated from total acidity. A number of local or regional monitoring networks are in operation where measurements by statutory bodies are also concentrated on smoke and SO_2.

Table 8.3 *Air Quality Monitoring, Pollutants, Networks and Sites in 1995.*

Pollutant	Networks	Local Authority Sites		Other Sites	
		Automated	Sampler	Automated	Sampler
Smoke	20		65		22
Sulphur Dioxide	20		59		22
Nitrogen Dioxide	4	2		3	
Lead	2		10		
Ozone	1			6	
Rainfall Chemistry	3				15

Nitrogen Oxides Network

The level of monitoring for nitrogen oxides (NO_x) in Ireland is still quite limited. In urban areas, there are currently only two full-time measurement sites employing continuous monitors, both of which are in Dublin. In non-urban areas, a small number of continuous NO_x monitors are located near point sources, such as power stations, or at ozone measurement sites to provide information on the interaction between NO_x and ozone. Passive sampling is becoming more widely used by some monitoring authorities to determine average NO_2 concentrations in both urban areas and areas likely to be affected by emissions from large point sources. To date, this method has been applied mainly in short term measurement studies and monitoring networks are still to be established.

Ozone Network

A new national network of six ozone monitoring sites was established in Ireland during 1994 pursuant to the 1992 Directive on ozone. The network consists of four new sites and two other stations which had been in operation for a number of years. All ozone monitors are linked to a data telemetry system which allows the continuous transfer of the measured data over standard telephone lines from the monitoring stations to a computerised network control centre at the EPA Laboratory in Pottery Road, Dublin. Data are also acquired from one additional site in Northern Ireland, belonging to the UK ozone network.

During ozone pollution episodes, the public can be informed of general conditions by daily bulletin. In the event of exceedance of the EU population information or warning thresholds, the public can be alerted by the Meteorological Office which receives the information from the EPA control centre in real time by an automatically-triggered fax report.

Other Parameters

There are no established site networks for the monitoring of PM_{10} (particulate matter less than 10 microns in diameter), volatile organic compounds (VOC) or carbon monoxide. An investigation of VOC and PM_{10} in Dublin is now being funded under the Environment Monitoring Research & Development (R&D) Sub-programme of the Environment Services Operational Programme. There are two sites in Ireland which are part of the European Monitoring and Evaluation Programme (EMEP) network where a wide range of parameters in air and rainfall are measured. A total of 15 sites for assessing the chemistry of rainfall are operated by several different organisations. Measurements for metals in air are conducted on the basis of non-automatic filter techniques in the Dublin urban area.

SMOKE AND SO_2 CONCENTRATIONS

Air quality monitoring results for the pollutants and sites summarised in Table 8.3, together with the air quality standards and guidelines listed in Table 8.1 and Table 8.2, provide the basis for air quality assessment in the following sections. Given that smoke and SO_2 are the air pollutants most intensively monitored in Ireland and that both have led to pollution in the past, they are considered in some detail in this section. The levels recorded in the main urban areas of Ireland in the period from 1985/86 to 1993/94 are reviewed.

Smoke and SO_2 in Dublin

The Dublin Corporation network of 15 sites covering city-centre and suburban locations is used as the basis for the review for Dublin. Summary smoke statistics for this network during the review period are presented in Fig. 8.1 in relation to the limit values of Directive 80/779/EEC. The reduction in smoke concentrations since 1990 has been quite dramatic, underlining the effectiveness of the smoke-control regulations introduced in the Greater Dublin area on 1 September 1990. The 98-percentile smoke value for the Dublin Corporation network averaged 77 µg/m³ between 1990/91 and 1993/94, compared to 256 µg/m³ over the four years prior to 1990/91. In the case of the winter smoke median value, the corresponding decrease has been from 49 µg/m³ to 15 µg/m³. This represents a 70 per cent decrease in smoke concentrations overall in terms of these parameters. The trend for individual sites was broadly similar.

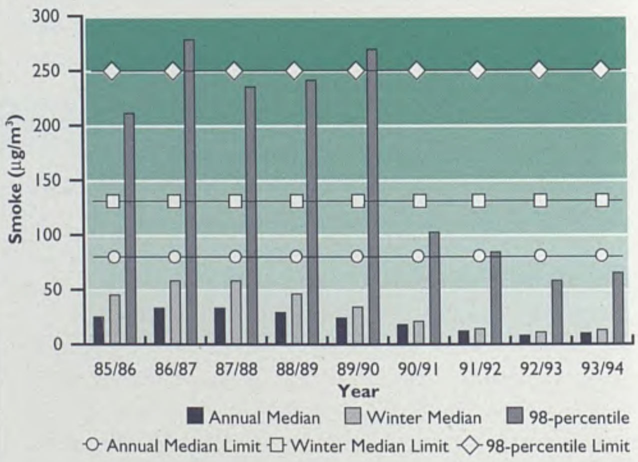


Fig. 8.1 Smoke Concentrations in the Dublin Corporation Network.

An assessment of the performance of individual sites in the Dublin Corporation network in terms of compliance with the limit values for smoke is summarised in Table 8.4. This summary also clearly shows how concentrations have decreased since 1990. Over the seven years from 1983/84 through 1989/90, there was an average of ten exceedances

Table 8.4 *Exceedances of EU Limit Values for Smoke in Dublin.*

Annual Period	No. of Sites in the Network	No. of Sites Exceeding Limit Values				Number of Daily Smoke Values		
		Annual Median	Winter Median	Annual 98%ile	More than 3 consec. days	>150	>187*	>250
1983/84	14	0	1	5	1	264	171	101
1984/85	14	0	0	6	4	369	245	125
1985/86	11	0	1	3	1	198	122	71
1986/87	12	1	1	7	4	334	211	125
1987/88	12	0	0	5	3	309	191	110
1988/89	14	0	0	4	12	240	154	96
1989/90	14	0	0	6	1	195	140	98
1990/91	15	0	0	0	0	49	27	5
1991/92	15	0	0	0	0	25	11	3
1992/93	15	0	0	0	0	14	4	1
1993/94	15	0	0	0	0	3	1	0

* approach threshold in respect of the 98-percentile, 75 per cent of 250 μg/m^3

per annum of the Directive limit values for smoke, most of which related to the daily reference period. In 1986/87, seven sites failed to comply with the 98-percentile requirement for daily values. In 1988/89, there was non-compliance at 12 sites by virtue of smoke levels greater than 250 μg/m^3 on four or more consecutive days.

For the first time in ten years, there was no exceedance of any Directive smoke limit value in 1990/91, and there were none for any reference period in the three subsequent years. A total of only nine occurrences of smoke greater than 250 μg/m^3 were recorded in the 1990/91 through 1993/94 annual reference periods. Smoke concentrations were particularly low in 1993/94 with only three recorded daily mean values in excess of the WHO guideline of 150 μg/m^3 and no occurrences of smoke concentrations greater than 250 μg/m^3.

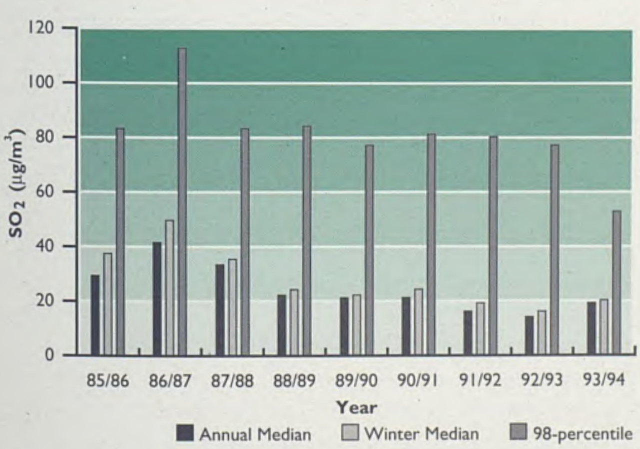


Fig. 8.2 *SO_2 Concentrations in the Dublin Corporation Network.*

The city of Dublin experienced some pollution by SO_2 in the early 1970s (Cabot, 1985) but ambient concentrations have declined steadily since around 1973. The SO_2 levels recorded in the Dublin Corporation network have apparently stabilised following this decrease with very similar results for all annual periods since 1988/89 (Fig. 8.2). The corresponding winter median SO_2 concentrations for these periods were consistently around 20 μg/m^3 compared to the highest values of approximately 100 μg/m^3 in the early 1970s.

The progressive decrease in SO_2 levels is due to the combined effects of the change from fuel oil to natural gas in Dublin power stations, a decrease in the sulphur content of gas oil, a decrease in fuel oil combustion in industry, and the conversion of solid fuel heating systems to gas-fired or oil-fired units in private dwellings.

Smoke and SO_2 in Cork

Summary smoke and SO_2 results for Cork, the second largest city in Ireland, are given in Figs. 8.3 and 8.4, respectively. While SO_2 levels in the city are low and give no cause for concern, there has been a noticeable increase in smoke concentrations recorded at some stations in this network since the mid-1980s. The 98-percentile smoke limit has been approached on several occasions since 1988, as shown by the values for individual stations in Table 8.5.

No occurrences of smoke greater than 250 μg/m^3 were recorded in Cork city prior to 1986. However, smoke concentrations greater than 250 μg/m^3 were measured on 23 occasions in 1988/89 and on 22 occasions in both 1990/91 and 1992/93, with six of these recorded at one site in both cases. This trend indicated a need for control of

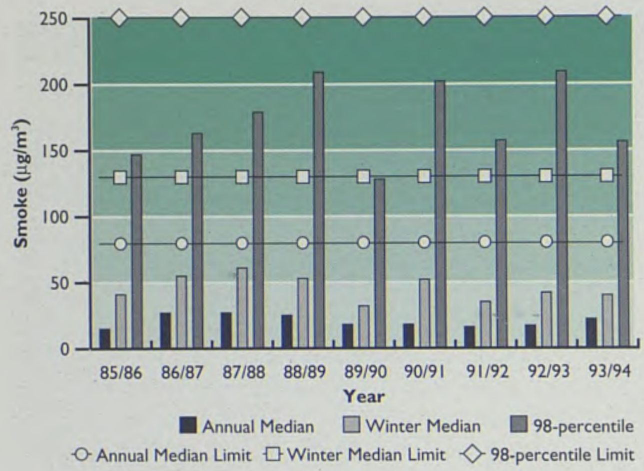


Fig. 8.3 Smoke Concentrations in the Cork Corporation Network.

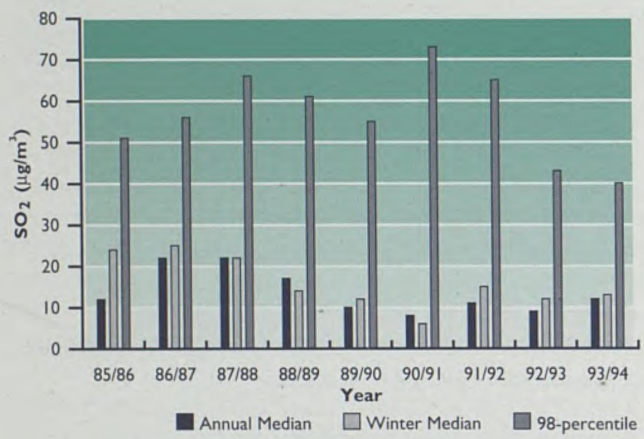


Fig. 8.4 SO_2 Concentrations in the Cork Corporation Network.

smoke emissions in Cork city, a location where poor dispersion conditions are often exacerbated by the topographical location of the city. Accordingly, smoke control legislation, similar to that in force in Dublin, was introduced in Cork city having effect from February 1995 (Department of the Environment, 1994).

Smoke and SO_2 in Other Areas

Apart from the Dublin and Cork networks already described, there is a total of 28 other smoke and SO_2 monitoring sites operated by local authorities throughout the country. These also cover mainly urban centres but some sites are located in quite small villages. Winter median and 98-percentile smoke concentrations recorded in recent years are given in Table 8.6 for a number of centres experiencing the highest concentrations of smoke outside Dublin and Cork. For those centres which have more than one monitoring site, the values given are for the site with the highest concentrations.

The values are generally well within the limits but there is the potential for high concentrations of smoke to occur in some of the centres monitored. The 98-percentile limit value for smoke has been approached on a few occasions at some sites, even in the case of some years with very mild winters. The levels of SO_2 recorded at all local authority sites outside Dublin and Cork are very low and are in compliance with the standards. Overall, winter means are generally less than 30 µg/m³ and 98-percentiles are less than 80 µg/m³ with many sites having much lower values.

Table 8.5 *Cork Corporation 98-percentile Smoke Concentrations (µg/m³).*

Annual Period	Princes St	Blackpool	St Josephs	Spangle Hill	St Finbarrs	Mahon House
1985/86	147	184	98	155	169	126
1986/87	134	166	172	165	146	114
1987/88	137	185	202	184	125	124
1988/89	213	211	187	216		190
1989/90	81		111	181	139	93
1990/91	208	190	225	212	168	156
1991/92	76	141	151	207	114	124
1992/93	168	229	215	219	190	103
1993/94	98	198	149	184	78	112

Underlined values approach the limit value for smoke.

***Table 8.6** Smoke Concentrations in Various Urban Areas (µg/m³).*

Annual Period	Drogheda		Dundalk		Waterford		Wexford		Limerick		Galway	
	Winter Median	98%ile	Winter Median	98%ile	Winter Median	98%ile	Winter Median	98%ile	Winter Median	98%ile	Winter Median	98%ile
1984/85	-	-	-	-	-	-	36	134	-	122	20	123
1985/86	54	156	40	132	32	89	41	146	31	104	22	92
1986/87	69	147	35	88	38	104	-	-	48	112	14	67
1987/88	35	132	61	179	27	75	37	127	53	124	20	70
1988/89	37	126	53	<u>209</u>	30	127	45	150	-	-	16	57
1989/90	29	163	32	128	30	86	38	130	44	111	15	38
1990/91	37	135	52	<u>202</u>	27	124	46	157	40	107	27	88
1991/92	37	118	26	168	30	114	39	139	61	142	11	78
1992/93	-	-	38	<u>230</u>	28	133	48	171	81	183	22	65
1993/94	40	160	26	168	30	114	39	139	38	112	21	62

Underlined values approach the limit value for smoke.

NO_2 CONCENTRATIONS IN DUBLIN

Summary NO_2 results for the period 1988 through 1993 for the two Dublin sites monitoring NO_x are presented on Figs. 8.5 and 8.6 in relation to the limit and guide values of the NO_2 Directive. No breaches of the limit value have occurred at either site, but it has been approached closely on two occasions at College Street, with the highest value of 195 µg/m³ occurring in 1989. The Directive guide value in respect of the 98-percentile has been exceeded at this location in each of the six years since the site was established, and the median guide value was exceeded in 1993. Thus, relatively high levels of NO_2 are occurring at this city-centre site subject to heavy traffic.

In relation to changes over time (Fig. 8.5), the 98-percentile values of NO_2 for 1990 through 1993 at College Street showed little variation from year to year and were, on average, almost 20 per cent lower than those in 1988 and 1989. This was probably due to the favourable meteorological conditions and good dispersion characteristics which were such a feature of those winters. As a result, there were very few episodes of high hourly-mean NO_2 concentrations in winter months.

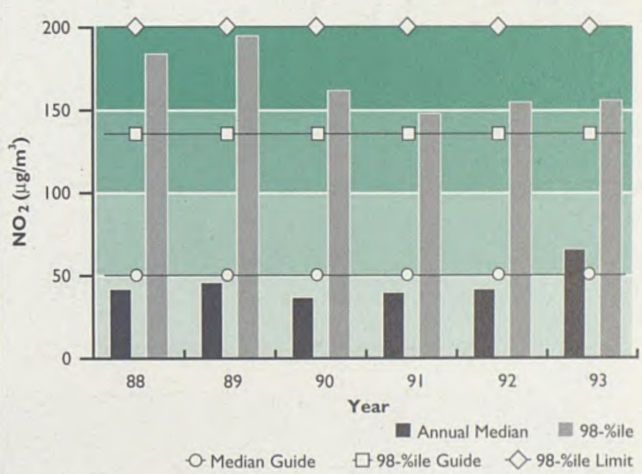


***Fig. 8.5** NO_2 Concentrations at College Street 1988-1993.*

The levels of NO_2 recorded at the Rathmines site are consistently lower than at College Street, reflecting lower NO_x emissions locally due to lower traffic density at this location. The NO_2 results for all years for which data are available are very similar, with annual median and 98-percentile concentrations well within their respective Directive guide values. The highest 98-percentile value to date at Rathmines is 119 µg/m³, recorded in 1988.

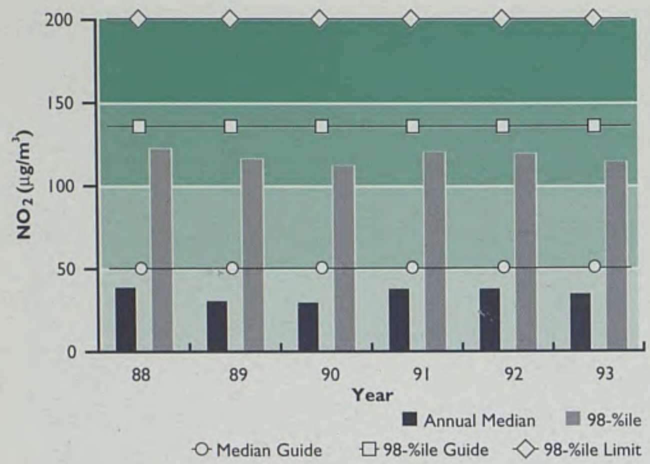


Fig. 8.6 *NO_2 Concentrations at Rathmines 1988-1993.*

LEAD

Petrol combustion is the primary source of lead emissions in Ireland. Major reductions in lead emissions have occurred since the mid-1980s through progressive reduction in the lead content of leaded petrol and a very significant increase in the use of unleaded petrol. Unleaded petrol currently accounts for approximately one half of total petrol sales (Chapter 15). A limited amount of data on the concentrations of lead in the air is included here to complete the review in respect of pollutants for which air quality standards have been adopted.

The resulting decrease in ambient lead levels is readily apparent from the trend in annual mean concentrations of airborne lead measured at eight sites in Dublin over the period 1988 through 1993 (Dublin Corporation, 1994), as shown on Fig. 8.7. Annual mean lead concentrations for most sites are currently less than half the WHO guideline value of 0.5 µg/m³ and are clearly well within the air quality standard of 2 µg/m³ which is also the limit set by Directive 82/884/EEC (CEC, 1982).

GROUND-LEVEL OZONE

Ground-level ozone (as distinct from stratospheric ozone which lies some 20-30 km above the earth) is of concern because of potential adverse effects of high concentrations of this pollutant on human health, forests, crops and other vegetation. The average concentration of ground-level ozone in unpolluted northern mid-latitudes is typically 70 µg/m³ which is maintained largely by a balance with background nitrogen oxides (NO_x) levels and ozone inputs from the stratosphere. Increases over this value are produced by photochemical processes (i.e., involving the action of ultra-violet light) involving NO_x and volatile organic compound (VOC) emissions which arise mainly from traffic sources.

Emissions of NO_x, mainly in the form of nitric oxide (NO), combine with atomic oxygen (O) (formed by the breakdown of ozone by ultra-violet light) to produce nitrogen dioxide (NO_2). During this process, ozone already present in the atmosphere is consumed. Conversely, the breakdown of the NO_2 by ultra-violet light makes atomic oxygen (O) available to combine with free oxygen (O_2) to produce ozone (O_3).

Concentrations of ozone only increase when the oxidation of NO to NO_2 is achieved without the consumption of background ozone concentrations. This occurs if appreciable amounts of VOC are also available. The breakdown of VOC by complex photochemical reactions enhances the oxidation of NO, thus increasing the rate at which NO_2 becomes available to form ozone. This results in increased ozone concentrations.

For brevity, the above description has been simplified as the process involves numerous chemical components and reactions. However, it is evident that the most severe ozone pollution will occur in areas subject to large emissions of both NO_x and VOC, and receiving sufficient

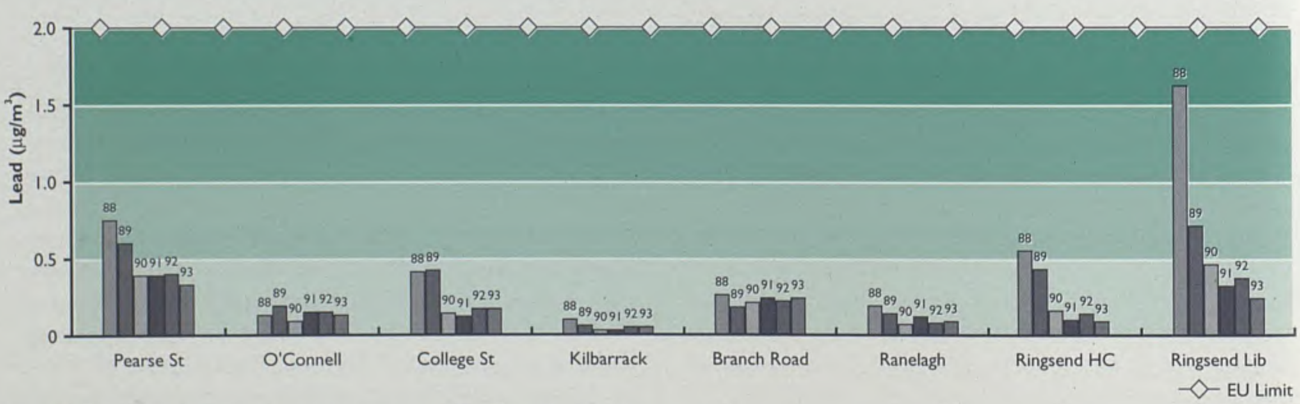


Fig. 8.7 *Annual Mean Lead Concentrations in Dublin 1988-1993*

solar radiation to drive the chemical reactions. Severe episodes of high ozone concentrations in summer have been a common occurrence throughout southern and central Europe for many years. As a result, reduction in the emissions of the ozone precursor pollutants, NO_x and VOC, has become one of the primary environmental objectives of international bodies concerned with emission control.

Continuous data on ozone concentrations are now available from the Mace Head Co. Galway station for a period of more than six years and provide a good indication of typical ozone levels in rural Ireland in recent years. Summary annual statistics for the period 1988 through 1993, together with an assessment of the levels in relation to the thresholds and guide values for ozone listed in Table 8.2, are given in Table 8.7.

The ozone levels at Mace Head are typical background values, with very similar results for all years for which records are available. Annual medians of 1- hour values are generally about 70 µg/m³ and 98-percentiles are around 100 µg/m³. Maximum recorded hourly concentrations very rarely exceed the population information threshold of 180 µg/m³.

Despite the low levels of ozone at this rural location, exceedances of some of the guideline and threshold values given in Table 8.2 do occur, particularly in respect of the longer averaging periods. As the 24-hour mean of 65 µg/m³ for effects on vegetation is close to the background level for ground-level ozone in northern mid-latitudes, it is often exceeded for up to 60 per cent of days in the year at Mace Head. During the six-year period given, the population information threshold was exceeded for only three hours on one day in 1989.

Ozone measurement commenced in Dublin in 1990 when a monitor was installed at Rathmines and was subsequently relocated at the EPA Laboratories in Pottery Road in early 1992. The annual results to date for Dublin are given in Table 8.8. Concentrations recorded in the city are significantly lower than at Mace Head. Annual medians of hourly concentrations may be only half those at Mace Head, hourly mean values show greater variability and there are much fewer exceedances of the thresholds for the 8-hour and 24-hour averaging periods. The present review covers the period prior to the establishment of the new ozone monitoring network. The first series of results from that network will be included in the next review.

Table 8.7 *Ozone Concentrations at Mace Head 1988-1993.*

Summary Annual Statistics Ozone (µg/m³)

Year	1-hour means			8-hour means[a]			24-hour means[b]			% Data Capture
	med	98%ile	max	med	98%ile	max	min	med	max	
1988	66	94	130	67	92	128	19	63	120	87
1989	70	106	198	71	105	179	7	67	134	91
1990	70	108	164	71	108	140	27	70	131	97
1991	68	110	172	68	108	150	7	67	119	97
1992	66	100	166	67	99	158	16	64	128	99
1993	66	92	124	66	90	114	10	71	99	91

Number of Exceedances of Ozone Threshold and Guide Values

Year	150 µg/m³		180 µg/m³		200 µg/m³		110 µg/m³		65 µg/m³
	1-hour	days[c]	1-hour	days	1-hour	days	8-hour[d]	days	days
1988	0	0	0	0	0	0	5	3	173
1989	11	3	3	1	0	0	19	9	219
1990	1	1	0	0	0	0	26	15	227
1991	6	3	0	0	0	0	28	12	219
1992	7	1	0	0	0	0	17	8	196
1993	0	0	0	0	0	0	2	2	178

a 8-hour rolling average ; 24 values per day

b 24-hour period 00.00 to 24.00

c The days count is the number of days on which one or more exceedances of the relevant short-term threshold/guide value occurred.

d 8-hour values calculated 4 times per day from the eight hourly values between 00.00 and 9.00, 8.00 and 17.00, 16.00 and 01.00 and 12.00 and 21.00

ACID DEPOSITION

The deposition of acidity is an important impact to be considered in relation to certain emission sources. The indicators usually considered are sulphate (SO_4), nitrate (NO_3), ammonium (NH_4) and total acidity (hydrogen ion). Detailed cartographic description of deposition patterns is also a key requirement. This is necessary for the application of the critical loads concept to emissions control, in which actual deposition loads are compared with thresholds for adverse effects.

The established monitoring networks for the chemistry of rainfall in Ireland are not ideal for quantifying acid deposition on the national scale. However, data from a number of sites in operation for one or more years during the period 1986 through 1990 (McGettigan and O'Donnell, 1995) have been used to assess the deposition of acidifying compounds in Ireland for this report. Details of these sites are given in Table 8.9 and their locations are shown in Fig. 8.8. A summary of the annual volume-weighted mean data generated at these sites, based on bulk sampling, is presented in Table 8.10.

Concentrations in Rainfall 1986-1990

Maps depicting the mean annual concentration of non-marine sulphate, nitrate, ammonium and hydrogen ion (H+) for the period 1986-1989, derived from the data in Table 8.10 are shown in Figs. 8.9a, 8.10a, 8.11a and 8.12a, respectively. An overall west-to-east gradient of increasing concentrations is apparent for most ions. Average concentrations at sites near the west coast were typical of background values associated with rainfall arriving on Atlantic air masses (10-17 µeq/l for SO_4, 10 µeq/l or less for NO_3 and NH_4, and 10-20 µeq/l for H^+). Significantly higher mean annual concentrations are indicated for the eastern part of the country (24-48 µeq/l for SO_4, 15-26 µeq/l for NO_3 and 25-46 µeq/l for both NH_4 and H^+). At most monitoring stations the highest ion concentrations of non-marine sulphate and nitrate in rainfall have been correlated with easterly winds (Bowman and McGettigan, 1994).

Deposition Rates 1986-1990

Maps depicting the corresponding mean annual deposition of non-marine sulphate, nitrate, ammonium and hydrogen ion (H^+) for the period 1986-1989, derived from the concentration data on Table 8.10 and mean rainfall, are shown on Figs. 8.9b, 8.10b, 8.11b and 8.12b, respectively. The west-to-east gradient of increasing concentrations is less apparent in the deposition maps. This is because deposition is determined by combining ion concentration with rainfall amount and, in Ireland, these generally have opposing gradients. The mean deposition of non-marine sulphate was less than 0.4 g S/m² over much of the country and highest depositions, approximately 0.9 g S/m², occurred in the eastern part of Northern Ireland. Mean annual nitrate deposition was less than 0.2 g N/m² over a large part of the country with highest values of about 0.5 g N/m² occurring in the mountainous areas on the east coast.

Table 8.8 *Ozone Concentrations in Dublin 1991-1994.**

Summary Annual Statistics Ozone (µg/m³)

Year	1- hour means			8-hour means[a]			24-hour means[b]			% Data Capture
	med	98%ile	max	med	98%ile	max	min	med	max	
1991	32	74	117	32	70	90	3	31	82	76
1992	44	93	149	43	91	140	5	41	98	68
1993	36	72	180	36	70	98	6	36	74	94
1994	52	90	116	51	86	107	3	48	94	83

Number of Exceedances of Ozone Threshold and Guide Values

Year	150 µg/m³		180 µg/m³		200 µg/m³		110 µg/m³		65 µg/m³
	1-hour	days	1-hour	days	1-hour	days	8-hour	days	days
1991	0	0	0	0	0	0	0	0	6
1992	0	0	0	0	0	0	12	6	5
1993	2	2	1	1	0	0	0	0	13
1994	0	0	0	0	0	0	0	0	64

* Rathmines for 1991, Pottery Road for other years

While the concentration and deposition maps for ammonium also show the west-to-east gradient typical of nitrate and non-marine sulphate, the effects of ammonia from intensive farming activities in the south and south-east of the country are also apparent. Volume-weighted mean concentrations in the east were typically three times those in the west during the 1986-1990 period. Highest depositions of ammonium were around 0.5 g N/m^2 and occurred over large parts of the south and east of the country and in the eastern part of Northern Ireland.

Concentrations in Rainfall 1990-1993

More recent data on the chemistry of rainfall, covering the period 1990 through 1993, are given in Table 8.11. These data relate to some of the sites which were in operation during the 1986-1990 period and a small number of other new sites whose locations are also shown on Fig. 8.8.

If it is assumed that the Cloosh and Brackloon sites represent the west of Ireland for the 1990-1993 period, a comparison can be made for much of the country between the results for the 1986-1990 and 1990-1993 periods using Table 8.10 and Table 8.11, respectively. This comparison shows no marked differences overall in the mean concentrations of non-marine sulphate, nitrate or ammonium for both periods, beyond what would be expected from normal variability. However, mean concentrations of hydrogen ion show a general decrease, particularly in the case of sites in the east of the country.

This appears somewhat inconsistent with the results for the other ions but is not unusual for this parameter which may be highly variable and subject to considerable measurement error.

The overall similarity between the data on Table 8.10 and Table 8.11 is to be expected, considering that national emissions have remained relatively unchanged over the period concerned, the importance of long-range transport to deposition in Ireland and the effect of averaging over several years.

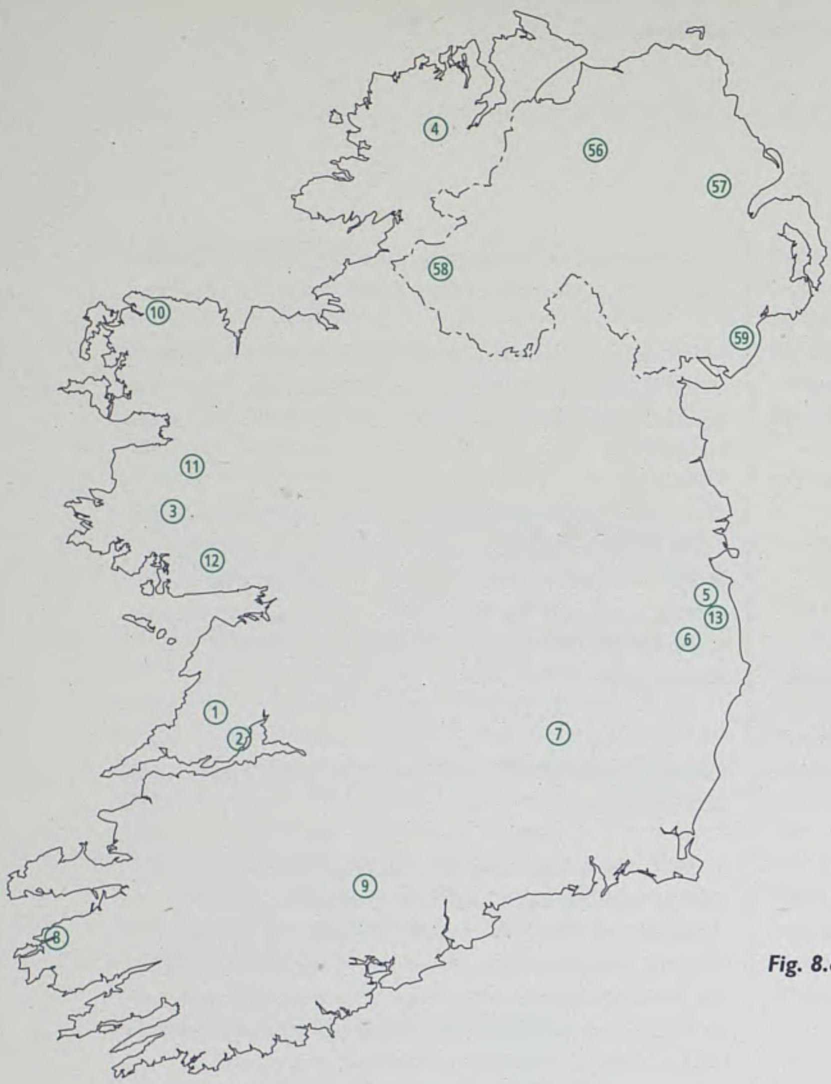
LONG-RANGE TRANSPORT OF SULPHUR AND NITROGEN

It is well known that long-range transport of sulphur and nitrogen contributes significantly to annual average deposition of the major acidifying compounds in Ireland. This has been mentioned above and is also well shown by the annual budgets for the principal air pollutants produced by EMEP. These are based on long-range transport models used in routine assessment of emission-deposition relationships for Europe. According to EMEP model estimates for 1988 through 1991 (Sandnes and Styve, 1992),

Table 8.9 *Monitoring Sites for Rainfall Chemistry 1986-1990.*

Site No.	Site Name	Operating Body	Grid Reference	Elevation m OD	Sampling Frequency
1	Doo Lough	ERU	R114 722	88	Daily
2	Gortglass	ERU	R225 590	80	Daily
3	Maam Valley	ERU	L938 548	30	Daily
4	Glenveagh	ERU	C035 232	30	Weekly
5	Glencree	ERU	O160 170	240	Daily
6	Turlough Hill	ERU	T075 985	440	Weekly
7	Radestown	ERU	S520 600	100	Daily
8	Valentia	MET	V460 780	9	Monthly
9	Ballyhooly	UCD	W714 981	70	Weekly
10	Glenturk	UCD	F880 335	100	Daily
56	Altnaheglish	NI FBIU	C698 041	244	Fortnightly
57	Fourmile Burn	NI FBIU	J227 897	110	Fortnightly
58	Lough Navar	NI FS	H065 545	130	Weekly
59	Silent Valley	NI FBIU	J306 243	170	Fortnightly

ERU Environmental Research Unit
MET Meteorological Office
UCD University College Dublin
NI FBIU Northern Ireland Freshwater Biological Investigations Unit
NI FS Northern Ireland Fisheries Service
Site numbers for Northern Ireland retained as adopted in the UK network (UKRGAR,1990).



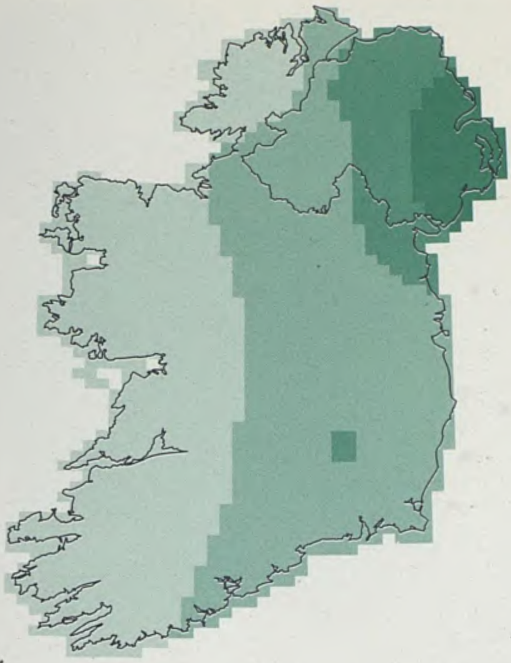
Site No.	Site Name	Operating Body
Period 1986-1990		
1	Doo Lough	ERU
2	Gortglass	ERU
3	Maam Valley	ERU
4	Glenveagh	ERU
5	Glencree	ERU
6	Turlough Hill	ERU
7	Radestown	ERU
8	Valentia	MET
9	Ballyhooly	UCD
10	Glenturk	UCD
56	Altnaheglish	NI FBUI
57	Fourmile Burn	NI FBUI
58	Lough Navar	NI FS
59	Silent Valley	NI FBUI
Period 1991-1992 [new sites]		
11	Brackloon	UCD
12	Cloosh	UCD
13	Roundwood	UCD

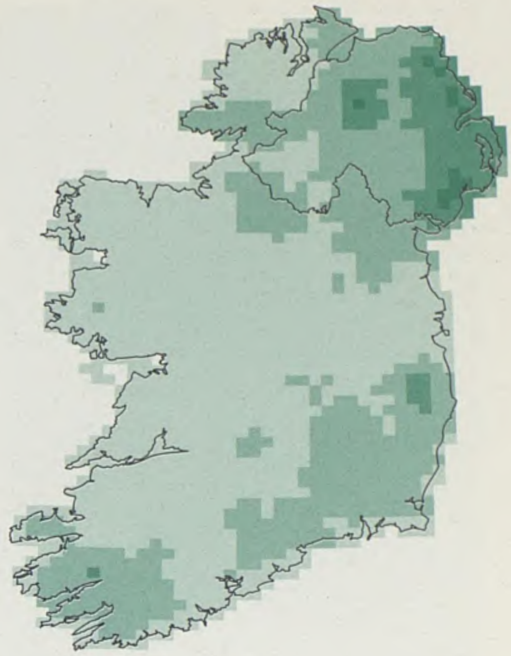
Fig. 8.8 *Monitoring Sites for Precipitation Chemistry (Source: EPA).*

Table 8.10 *Volume-Weighted Mean Ion Concentrations in Rainfall 1986-1990 µeq/l*

Site No.	Site Name	Period	H+	SO_4*	NO_3	NH_4	Source
1	Doo Lough	1987-1989	19	12	7	10	Bowman, 1991
2	Gortglass	1987-1989	17	17	8	15	Bowman, 1991
3	Maam Valley	1987-1989	16	10	8	9	Bowman, 1991
4	Lough Veagh	1988-1989	17	7	9	9	Bowman, 1991
5	Glencree	1987-1989	18	24	16	25	Bowman, 1991
6	Turlough Hill	1987-1989	27	26	24	46	Bowman, 1991
7	Radestown	1989-1990	15	30	15	31	Flanagan *et al*, 1993
8	Valentia	1986-1990	5	15	6	5	Meteorological Office
9	Ballyhooly	1989-1990		10	10	28	Farrell & Boyle, 1990
10	Glenturk	1989			7	4	Farrell, 1990
56	Altnaheglish	1986-1988	11	33	16	15	UKRGAR, 1990
57	Fourmile Burn	1986-1988	8	48	18	31	UKRGAR, 1990
58	Lough Navar	1986-1988	10	16	8	9	UKRGAR, 1990
59	Silent Valley	1986-1988	21	45	26	28	UKRGAR, 1990

* Non-marine sulphate.





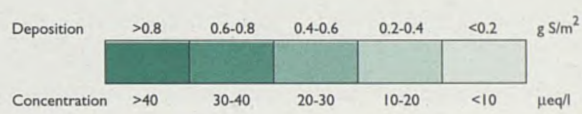
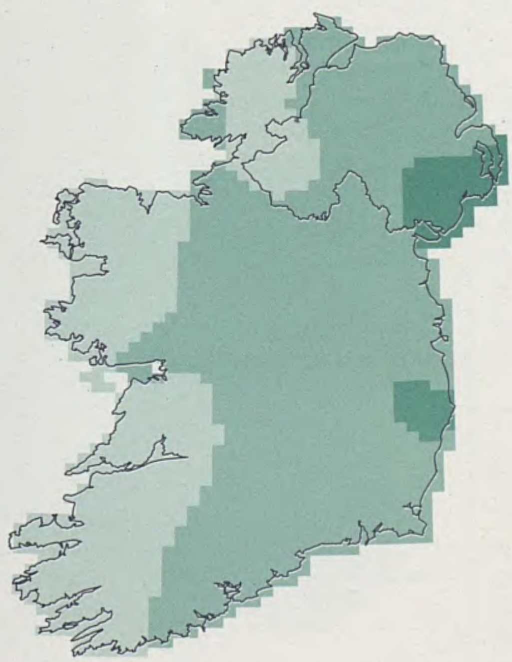
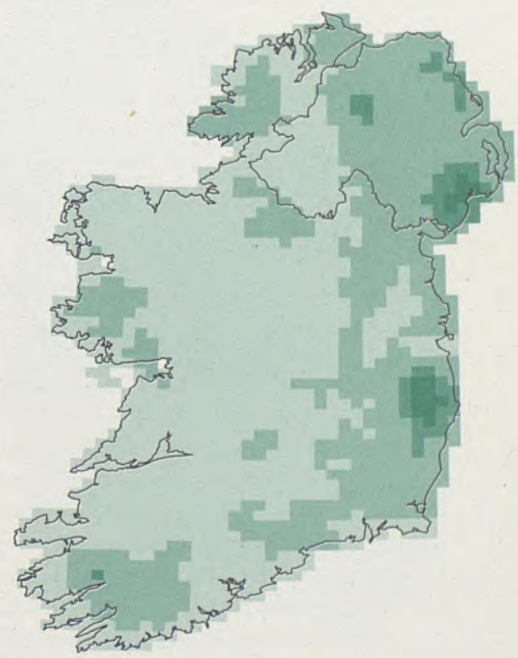


Fig. 8.9a *Precipitation Weighted Mean Concentration of Non-marine Sulphate 1986-1989 (µeq/l) (Source: EPA).*

Fig. 8.9b *Annual Deposition of Non-marine Sulphate (g S/m²) (Source: EPA).*





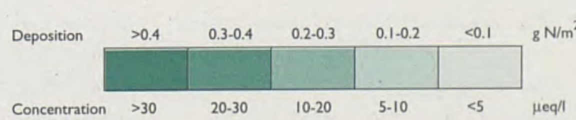


Fig. 8.10a *Precipitation Weighted Mean Concentration of Nitrate 1986-1989 (µeq/l) (Source: EPA).*

Fig. 8.10b *Annual Deposition of Nitrate (g N/m²) (Source: EPA).*

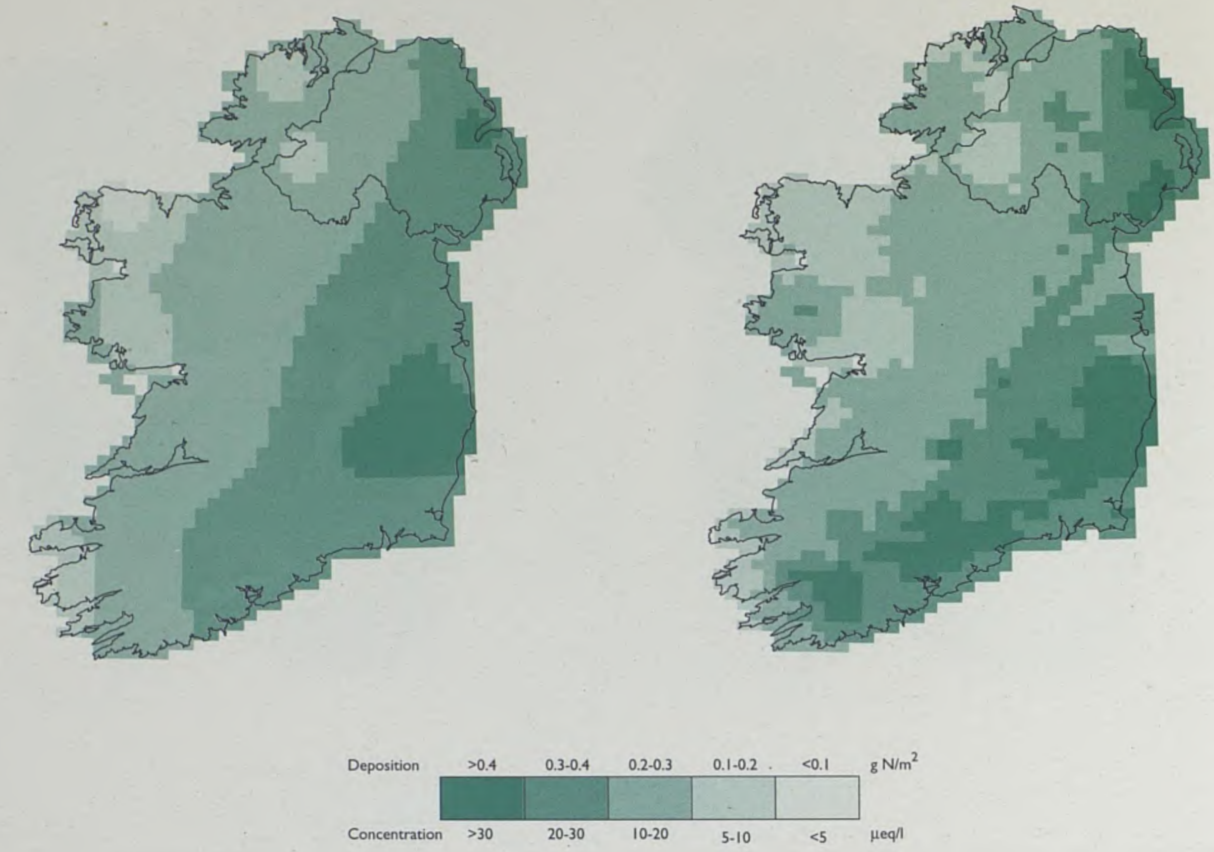


Fig. 8.11a Precipitation Weighted Mean Concentration of Ammonium 1986-1989 (μeq/l) (Source: EPA).

Fig. 8.11b Annual Deposition of Ammonium (g N/m²) (Source: EPA).

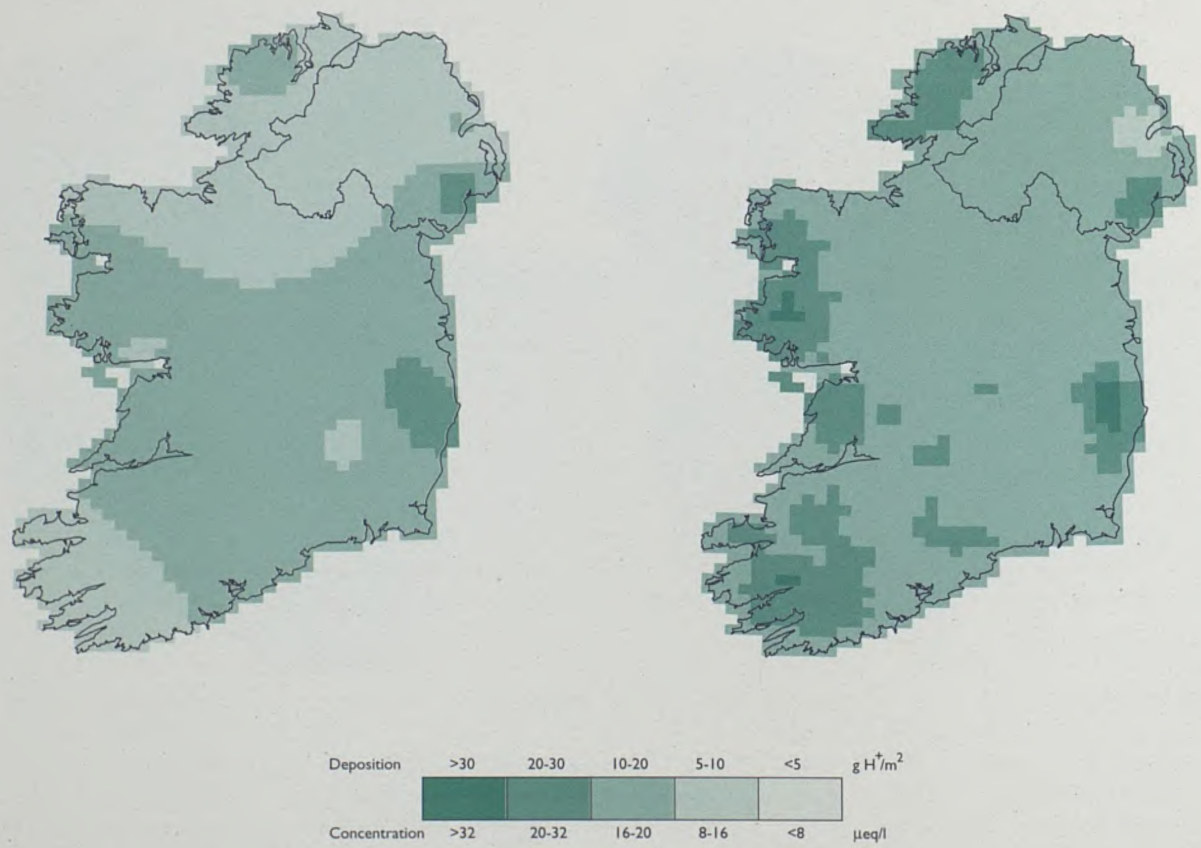


Fig. 8.12a Precipitation Weighted Mean Concentration of Hydrogen Ion 1986-1989 (μeq/l) (Source: EPA).

Fig. 8.12b Annual Deposition of Hydrogen Ion (g H^+/m^2) (Source: EPA).

Table 8.11 Volume-Weighted Mean Ion Concentrations in Rainfall 1990-1993 (μeq/l).

Site Name	Period	H^+	SO_4*	NO_3	NH_4	Source
Altnaheglish	1990-1993	5	29	18	16	Jordan, 1994
Lough Navar	1990-1993	8	17	9	12	Jordan, 1994
Silent Valley	1990-1993	5	38	26	25	Jordan, 1994
Turlough Hill	1992-1993	14	30	20	33	EPA
Roundwood	1991-1992	33	32	21	29	Farrell *et al*, 1994
Cloosh	1991-1992	14	18	8	11	Farrell *et al*, 1994
Brackloon	1991-1992	13	17	7	11	Farrell *et al*, 1994

* Non-marine sulphate.

approximately 40 per cent of the sulphur deposition in Ireland can be attributed to national emissions, a further 25 per cent to emissions in the United Kingdom, 10-15 per cent to emission sources in other countries and 15-20 per cent is of indeterminate origin.

In the case of nitrate, up to 90 per cent of annual deposition may be imported, the principal contributor again being the UK but with a larger proportion of the total coming from more distant countries than in the case of sulphur. Ammonia is quickly deposited close to source and does not undergo the same degree of long-range transport as nitrate and sulphur. Accordingly, the EMEP estimates show that about 90 per cent of ammonia deposition in Ireland is attributable to emissions in Ireland.

CONCLUSIONS

Overall, air pollution associated with SO_2 and smoke emissions from stationary combustion sources has been almost eliminated in Ireland. There is now wide-scale compliance with national air quality standards and EU limit values for these pollutants.

Road traffic has become potentially the greatest source of air pollution generally, and attention in urban areas has clearly shifted to a range of pollutants associated with this source. With lead in urban air having been reduced to very low levels, the most important of these pollutants are NO_2, ground-level ozone, PM_{10}, carbon monoxide and a wide variety of organic compounds including carcinogens such as benzene. These pollutants will require more work in the near future in terms of monitoring and air quality control. The EU guide values for NO_2 have been consistently breached and the limit value has been approached on a number of occasions at one site in Dublin.

The available information on ozone indicates no problems due to this pollutant in Ireland. Annual mean values are about 70 μg/m^3 in non-urban areas with a depression in the concentration field of up to 30 μg/m^3 over major urban centres. Maximum hourly concentrations very rarely reach the EU population information threshold of 180 μg/m^3 for one-hour values and there are few occurrences of eight-hour mean values in excess of the 110 μg/m^3 threshold for effects on human health.

While the necessary hot and sunny conditions may occur occasionally in Ireland, the emissions of NO_x and VOC are small and insufficient to generate ozone levels similar to those in countries where ozone pollution is a particular problem. However, the meteorological conditions which can lead to enhanced ozone production in Ireland also favour the transport of both ozone and its precursors from Europe. When increased concentrations persist over several days, such transport usually contributes as much to ozone concentrations as ozone production locally from pollutants emitted in this country.

The quality of urban air in the future will depend very much on the evolution of total emissions of NO_x and hydrocarbons from motor vehicles. It is clear that, as vehicle numbers and mileage driven both continue to increase, emissions of these pollutants will continue to increase over the next five years before three-way catalysts and other controls attain sufficient share of the fleet to bring about substantial reductions. Moreover, actual reductions may be less than expected, given the uncertainties which still exist over the durability of the performance of the three-way catalyst and the efficiency of evaporative emission controls.

The deposition of sulphur and oxidised nitrogen from man-made sources remains low over the greater part of Ireland but is appreciable in some eastern areas. Ammonium deposition is quite significant in large areas of the south and east as a result of the relatively high level of ammonia emissions in these areas. Total nitrogen deposition is therefore quite considerable in some areas. This is probably the most important parameter to be considered in terms of adverse effects, since both nitrate and ammonium can lead to acidification of soils and, unlike sulphur, the emissions responsible are unlikely to decrease for some time. While there are the usual year-to-year variations, there has been very little change overall in annual mean deposition amounts over recent years. It is clear that the transport of air pollutants from the UK and Europe still has a considerable influence on the annual deposition rates of non-marine sulphate and oxidised nitrogen, especially in the east of the country.

INFORMATION GAPS

No information is available on the levels of petroleum-based organic compounds or PM_{10} in Dublin city. Air quality monitoring needs to be expanded to adequately cover these pollutants. As a first step, a project, funded under the Environment Monitoring (R&D) Sub-programme of the Environment Services Operational Programme, involving an investigation of these parameters in the city, will provide information on the occurrence of these substances.

The impacts of acidifying depositions in Ireland are generally examined only through small-scale studies over short time scales. A more complete national assessment could be achieved by application of the critical loads concept, where actual loads are compared with thresholds for adverse effects. To date, the concept has received only limited study in Ireland. This concept contributed to the formulation of the Oslo Protocol for the control of sulphur emissions, signed by Ireland, and is also the scientific basis for re-negotiation of the Sofia Protocol on NO_x emissions which has been ratified by Ireland. More detailed studies of critical loads, particularly in relation to nitrogen deposition, would provide another useful means of environmental assessment for the country. A research project on critical loads in Ireland is being funded under the Environmental Monitoring R&D Sub-Programme of the Environment Services Operational Programme.

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CHAPTER **9**

INLAND WATERS

INTRODUCTION

The social and economic changes which have taken place in Ireland over the last thirty years have imposed considerable pressures on the freshwater resources of the State. The raised standard of living of an expanding urban population, increased industrialisation and intensification of agricultural activities during this period have led, on the one hand, to a greater demand for water and, on the other, to greater levels of waste discharged to the aquatic environment. In view of the growing appreciation of the importance of clean water for potable and industrial abstractions and of the amenity value of lakes and rivers, particularly for fisheries, the need for systematic management of the use of water resources is clear. This need relates mainly to quality issues as the relative abundance of water resources in the State reduces the potential for problems in supply.

This chapter summarises the recent information compiled by the Environmental Protection Agency (EPA) (Bowman *et al.*, in press) on the quality of surface freshwaters. Information is presented on the water quality of the 13,200 km of river channel and the 135 lakes surveyed in the period 1991-1994. The main causes of pollution are addressed and long-term water quality trends are shown. The information available mainly arises from surveys undertaken by the local authorities and the fishery agencies together with the work of the Agency itself and of its predecessor, the Environmental Research Unit (ERU) of the Department of the Environment.

Following the review of the quality of surface freshwaters, a brief overview of the present situation in respect of the main freshwater fish species is presented at the end of the chapter. This is based on information supplied by the Central Fisheries Board.

RIVER AND STREAM WATER QUALITY

Survey Work to Date

National river quality surveys have been carried out since 1971 by An Foras Forbartha (AFF) and, following its abolition, by the ERU and latterly by the EPA. Since 1978, this work has been complemented by the activities of the local authorities through the survey work carried out by their own laboratories or, in certain cases, through the three regional laboratories at Castlebar, Kilkenny and Monaghan, which are now operated by the EPA.

The first (1971) national river quality survey carried out in this country covered some 2,900 km of channel and was confined to the larger rivers and their more important tributaries (Flanagan and Toner, 1972). Since then the survey has been broadened considerably and several national reports have been published (Flanagan, 1974; Lennox and Toner, 1980; WPAC, 1983; Toner *et al.*, 1986 and Clabby *et al.*, 1992). By 1990, virtually all of the rivers and streams depicted on the Ordnance Survey Map entitled 'Rivers and their Catchment Basins' had been surveyed and, although there are very many smaller streams which are not shown on this map, those which are shown are considered to form an acceptably representative national baseline.

The total length of channel in this baseline is 13,200 km and the number of survey locations is in the region of 3,200. Sampling sites are typically located at intervals of approximately 5 km, as well as above and below towns and known point source discharges. Existing resources permit a complete reappraisal of the national baseline every three years. All of this channel length has been assessed on the basis of biological characteristics but chemical measurements are available at this stage for less than half of the length.

Quality Classification

All types of pollution cause physico-chemical and biological changes in receiving waters and so water quality may be assessed by either chemical or biological methods. It is widely considered that a combination of both techniques is preferable to either on its own as each method tends to compensate for the shortcomings of the other. Ideally, therefore, river quality classification schemes should be based on a combination of biological and chemical criteria. However, because of the much greater extent of the coverage by the biological surveys and because of the need for a consistent approach nationally, the system adopted for the classification of national river quality in Ireland is a biological system. Four biological water quality classes are recognised as described below:-

Class A waters (Unpolluted) are those in which water quality problems relating to existing or potential beneficial uses are unlikely to arise. They are high quality waters which are suitable for game fisheries and abstractions and they are usually of high amenity value. Such waters are, therefore, regarded as being in a 'satisfactory' condition. The remaining three water quality classes are regarded as unsatisfactory to lesser or greater degrees.

An important characteristic of ***Class B*** (Slightly Polluted) and especially of ***Class C*** (Moderately Polluted) waters is eutrophication. In such waters, excessive growths of rooted weeds and/or filamentous algae occur, and these may interfere with amenity, abstraction or fisheries uses. Game fish (salmon and trout) are particularly at risk as they can be killed by very low levels of Dissolved Oxygen (DO) occurring at night or by the high pH (alkaline) conditions which may accompany enhanced photosynthetic activity in the daytime. Fish fry of all kinds seem to be susceptible to this aspect of eutrophication.

In ***Class D*** (Seriously Polluted) stretches, excessive waste inputs typically cause deoxygenation of the waters, blanket the substratum with anaerobic sludges or stimulate unsightly slime ('sewage fungus') growths. In such cases only the most tolerant of higher organisms may be found (e.g., sludge worms), and most beneficial uses are lost.

The classification system is designed mainly to identify pollution by wastes such as sewage. These, being biodegradable, tend to cause deoxygenation of the water and to release phosphates and nitrates, thereby inducing eutrophication. However, pollution by potentially toxic substances, such as metals and pesticides, is also taken into account in assigning the quality class.

National River Quality : Current Status

The 13,200 km of channel recently (1991-1994) surveyed constitute a highly representative national baseline against which future trends may be deduced. The results of this survey are summarised in Fig 9.1.

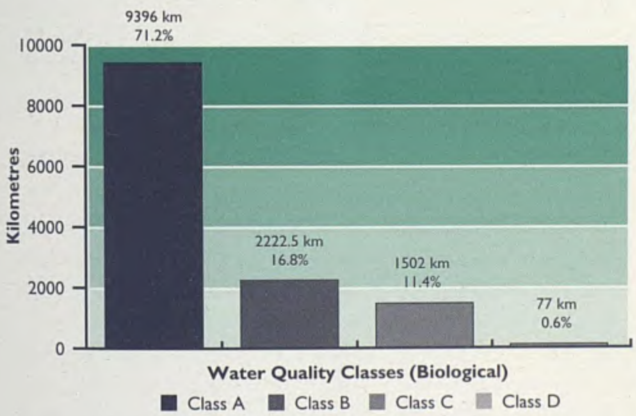

Fig. 9.1 *National River Quality : Current Status. Total Channel Length Surveyed - 13,200 km. Based on biological surveys in the period 1991 to 1994 (Source: Bowman* et al., *in press).*

These results indicate that the bulk (71 per cent) of river and stream channel surveyed is in an unpolluted condition but that a considerable length is in a less than satisfactory condition, some 17 per cent being classed as slightly polluted and a further 11 per cent as moderately polluted. Just 77 km (0.6 per cent) are currently seriously polluted.

River Quality: Regional Situation

A regional analysis of river quality is presented in Table 9.1 and Fig 9.2, which show, for each of the Water Resource Regions, the surveyed channel length apportioned to the four Biological Water Quality Classes.

This analysis shows that the Donegal-Sligo area (i.e., North Western (b)) is least affected by river pollution (90 per cent in Class A) while the Eastern Region, with just 45 per cent of rivers in Class A, is the area most affected by all levels of pollution. The rivers and streams of the Southern and Western Regions are also well above the national average (>71 per cent) in terms of satisfactory river quality but those in the other areas are below average in this respect, due to extensive slight and moderate pollution (mainly eutrophication).

Above average (>17 per cent) levels of slight pollution are recorded in the North Western (a) (Cavan-Monaghan), South-Eastern and Shannon Regions while above average (>11 per cent) levels of moderate pollution are on record in the North Western (a) (Cavan-Monaghan), Mid-Western and South-Eastern Regions. In the Shannon Region this degree of pollution is just below the average at 10.5 per cent.

Serious pollution is relatively most widespread in the Eastern Region where some 2.3 per cent of surveyed channel is affected; less than 1 per cent of channel is seriously polluted in the Mid-Western (0.8 per cent), Shannon (0.6 per cent), North Western (b) (Donegal-Sligo) (0.5 per cent), South-Eastern (0.4 per cent) and Western (0.2 per cent) Regions while the Southern and North Western (a) (Cavan-Monaghan) Regions are currently free of serious pollution.

It is important to point out that "once-off" type pollution events, as for example those caused by waste spillages or releases of short duration, are unlikely to be accurately reflected in the data in this report. This is because of the necessity, for logistical reasons, to spread the survey over three or four years. Regular or intermittent or longer lasting (i.e., chronic) pollution, however, should be reliably represented here.

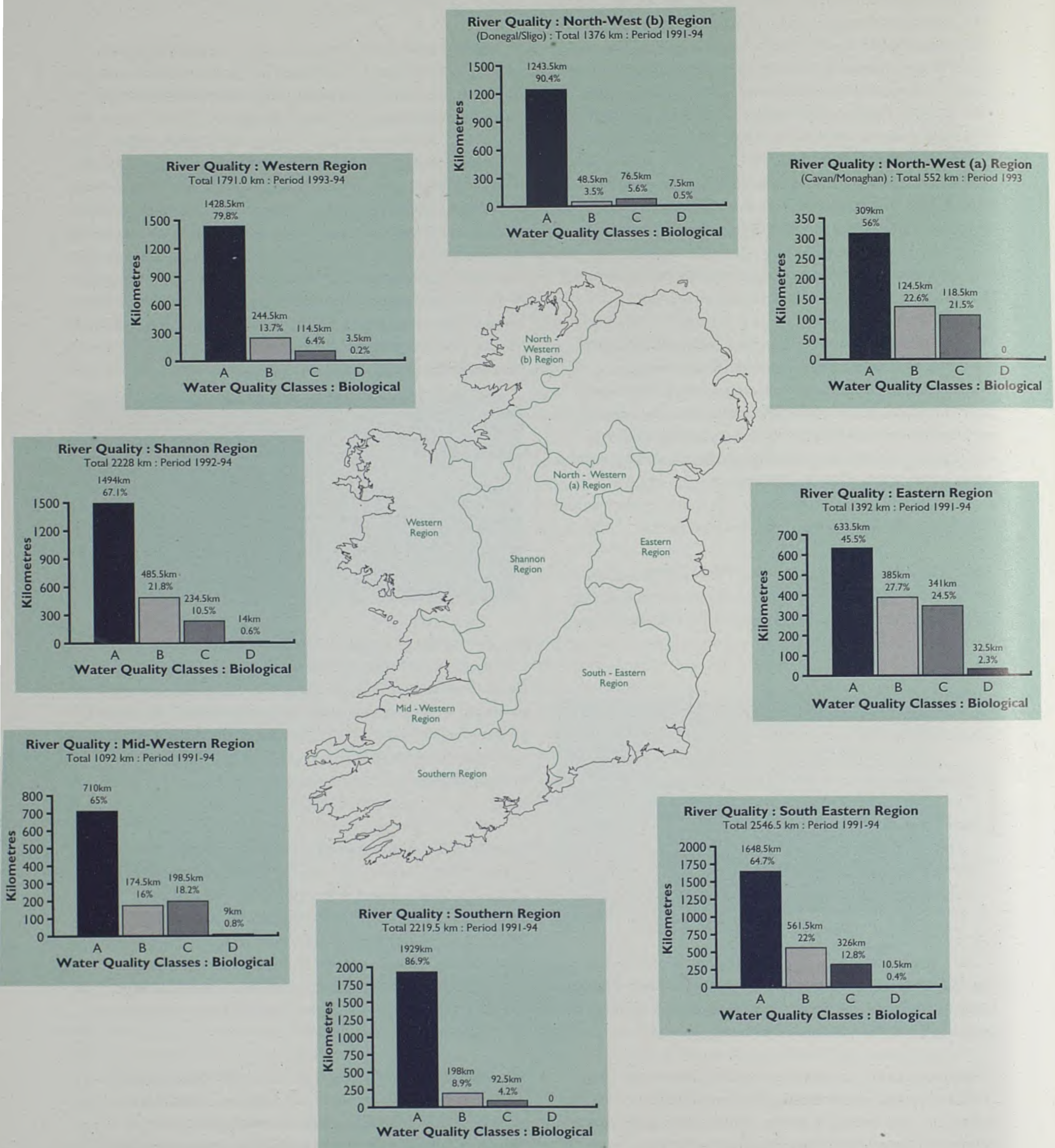

Fig. 9.2 *A Regional Analysis of River Quality Showing for Each of the Eight Water Resource Regions, the Surveyed Channel Length (km) Apportioned to the Four Biological Water Quality Classes:- A Unpolluted, B Slightly Polluted, C Moderately Polluted and D Seriously Polluted (Source: EPA).*

Table 9.1 The 1991-1994 Baseline (13,200 km) Analysed by Water Resource Region Showing the Surveyed Channel Length Apportioned to the Four Biological Quality Classes:- A Unpolluted, B Slightly Polluted, C Moderately Polluted and D Seriously Polluted. (Bowman et al. in press).

Water Resource Region		**Channel Length (km) in Class**				**Total**
		Class A	**Class B**	**Class C**	**Class D**	**km**
Eastern Region	km	633.5	385.0	341.0	32.5	1392.0
	%	*45.5*	*27.7*	*24.5*	*2.3*	
South-Eastern Region	km	1648.5	561.5	326.0	10.5	2546.5
	%	*64.7*	*22.0*	*12.8*	*0.4*	
Southern Region	km	1929.0	198.0	92.5	0.0	2219.5
	%	*86.9*	*8.9*	*4.2*	*0.0*	
Mid-Western Region	km	710.0	174.5	198.5	9.0	1092.0
	%	*65.0*	*16.0*	*18.2*	*0.8*	
Shannon Region	km	1494.0	485.5	234.5	14.0	2228.0
	%	*67.1*	*21.8*	*10.5*	*0.6*	
Western Region	km	1428.5	244.5	114.5	3.5	1791.0
	%	*79.8*	*13.7*	*6.4*	*0.2*	
North-West (a) Region	km	309.0	124.5	118.5	0.0	552.0
(Cavan-Monaghan)	%	*56.0*	*22.6*	*21.5*	*0.0*	
North-West (b) Region	km	1243.5	48.5	76.5	7.5	1376.0
(Donegal-Sligo)	%	*90.4*	*3.5*	*5.6*	*0.5*	
Totals	**km**	**9396.0**	**2222.5**	**1502.0**	**77.0**	**13197.0**
	%	***71.2***	***16.8***	***11.4***	***0.6***	

Suspected Causes of Recorded Serious Pollution

The great bulk of serious pollution in question here is chronic (as distinct from 'once-off' type) pollution. While the causes of the observed serious pollution have not been specifically proven, these are quite clear in most cases. The term 'suspected' is used in order to indicate the status of this analysis. The position in regard to serious pollution is in marked contrast to the other levels of pollution where non-point sources of waste are likely to be of importance and where, therefore, it is more difficult to give an analysis of causes.

Of the 13,200 km of river and stream channel surveyed, just 77 km (0.6 per cent) are estimated to be subject to serious pollution. The suspected causes (Table 9.2) are summarised to show the national situation in Fig. 9.3. The table shows various types and combinations of causes but, in the interests of simplicity, the figure shows just three principal causes, Industrial (I), Agricultural (A) and Sewage (S). Combinations such as sewage and industrial (S+I) have been apportioned equally to each contributing source (i.e., half to

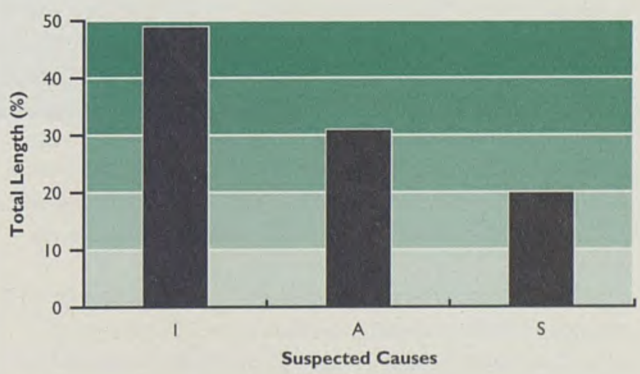

***Fig. 9.3** Proportions of Seriously Polluted Stream Channel Assigned to Three Major Suspected Causes:- I = Industrial (including 11.5 km or 15% due to the Avoca mines), A = Agricultural and S = Sewage. Combinations (e.g, Sewage & Industrial) are apportioned equally to each contributing source. Unknown causes are apportioned equally to the above three main suspected sources.*

***Table 9.2** Suspected Causes of Observed Serious Pollution in Irish Rivers and Streams. Data refer to the year 1994 in most cases. (Source: Bowman et al., in press).*

Rivers	Location	km	Cause(s)	Since	Symbol
Avoca	Avoca Mines area	11.5	Mining	1850's	I
Broadmeadow	U/s & d/s Ratoath	6.0	Sewage & Agric.	1981	S+A
Lung	Lower reaches	6.0	Industrial	1994	I
Camac	D/s Saggart & Inchicore	5.5	Sewage & Indust.	1983	S+I
Doonaha	Widespread	5.0	Agricultural	1985	A
Santry	Widespread	5.0	Unknown	1988	U
Moyle	Mocklerstown area	4.5	Indust. & Agric.	1981	I+A
Dalgan	D/s Ballyhaunis	3.5	Industrial	1979	I
Swilly Burn	Lower reaches	3.5	Agricultural	1985	A
Figile	Ticknevin area	3.5	Unknown	1989	U
Hind	In & d/s Roscommon	3.0	Sewage & Indust.	1980	S+I
Moyarta	Widespread	3.0	Agricultural	1988	A
Black (Westmeath)	U/s & d/s Mostrim	2.5	Sewage & Indust.	1982	S+I
Donagh	D/s Carndonagh	2.0	Sewage	1980	S
Blackwater (Kells)	Above Bailieboro	1.5	Industrial	1971	I
Corbally Stream	Kilcormick area	1.5	Agricultural	1987	A
Laurencetown Stream	Sycamorehill area	1.5	Industrial	1994	I
Tolka	Dunboyne Area	1.0	Unknown	1971	U
Roosky	Lower reaches	1.0	Agricultural	1987	A
Kill of the Grange	Upper reaches	1.0	Industrial	1990	I
Wood	Kilcarroll area	1.0	Agricultural	1991	A
Feorish (T'barry)	Ballymoylin area	1.0	Unknown	1992	U
Proules	D/s Carrickmacross	0.5	Sewage	1971	S
Ballaghdoo	In Kilcar	0.5	Industrial	1984	I
Bredagh	In Moville	0.5	Sewage & Agric.	1987	S+A
Nore	Thomastown	0.5	Sewage & Indust.	1987	S+I
Clover	Turnpike area	0.5	Peat Silt	1988	I
Lyreen	In Maynooth	0.5	Unknown	1991	U
Totals		**77.0**			

u/s = upstream; d/s = downstream; I = industrial; S = sewage; A = agriculture; U = unknown.

sewage, half to industrial) and the "unknown" (U) category has been apportioned equally to the three main causes.

Fig. 9.3 shows that the greatest single cause is industrial activity which is estimated to affect some 37.5 km (i.e., almost half of the total) of channel, mainly in the Eastern Region. However, the position is distorted to some extent by the inclusion in this figure of the seriously polluted length of the Avoca River. This river has been seriously polluted by toxic mining-spoil leachate since the mid-1800s; some 11.5 km continue to be affected in this way.

Agricultural activities of all kinds are next in importance and account for approximately one third (31 per cent) of recorded serious pollution (i.e., 24 km). The bulk of this is in the Mid-Western (9 km) and North-Western (b) (Donegal-Sligo) (5 km) Regions.

Sewage discharges seriously pollute an estimated 15.5 km of river channel located mainly in the Eastern (7 km) and Shannon (3 km) Regions.

Long Term Trends: 2,900 Km Baseline

As stated above, some 2,900 km of river/stream channel were surveyed in 1971 and this baseline has been re-examined at regular intervals since then. Trends in this baseline are set out in Fig.9.4.

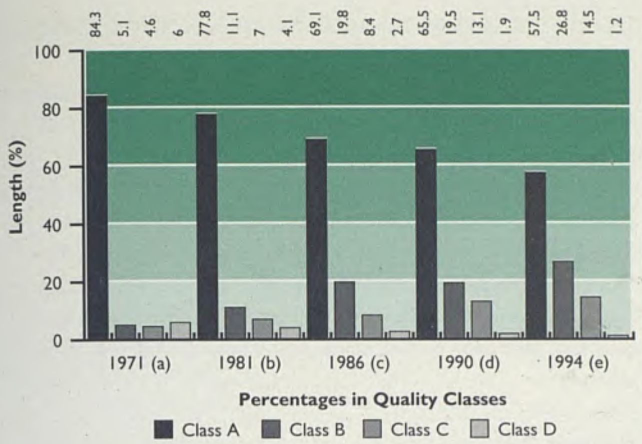

Fig. ***9.4*** *Long-term Trends. Channel Length - 2,900 km. Percentage of Channel Length in Four Biological Quality Classes:- A Unpolluted, B Slightly Polluted, C Moderately Polluted and D Seriously Polluted (Sources: (a) Flanagan & Toner, 1972, (b) Clabby* et al., *1982, (c) Toner* et al., *1986, (d) Clabby* et al., *1992 and (e) Bowman* et al., *in press).*

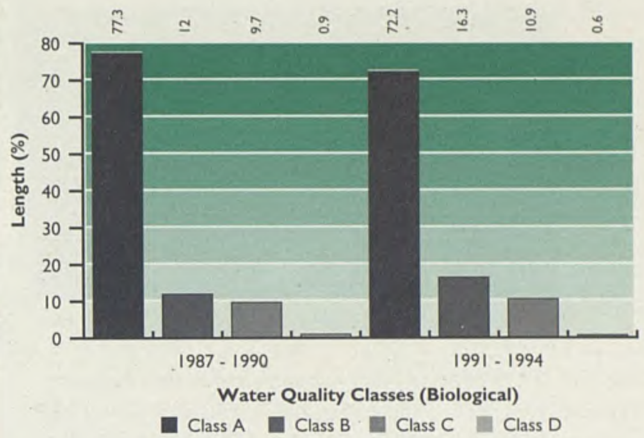

Fig. ***9.5*** *National River Quality : Recent Trends. Percentage of Channel Length in Four Biological Quality Classes - A Unpolluted, B Slightly Polluted, C Moderately Polluted and D Seriously Polluted. Total Channel Length 12,700 km. (Clabby* et al., *1992 and Bowman* et al., *in press).*

The figure shows a distinct trend of a continuing decline in the length of Class A waters, from 84 per cent of the total surveyed in 1971 to just 57 per cent now. Also apparent is a marked reduction in the length of channel affected by serious pollution (Class D) which has fallen from 6 per cent in 1971 to approximately 1 per cent currently. The most striking trends are the five fold increase in the extent of slight pollution (i.e., in Class B) and the three-fold increase in moderate pollution (Class C).

Recent Trends: 12,700 Km Baseline

Some 12,700 km of river and stream channel were surveyed and assessed in the period 1987-1990 and again in the period 1991-1994; the results of the two surveys are compared in Fig. 9.5. This baseline is considered to be much more representative than the 1971 (2,900 km) baseline for two reasons: firstly, the 1971 baseline was designed to reflect the pollution situation in the country at that time and so it was mainly designed to cover all of those rivers and streams then known to have been in receipt of significant waste inputs. For this reason many of the smaller, cleaner rivers, particularly along the western seaboard, were not included. Secondly, smaller streams, in general, were under-represented as the survey concentrated to a large extent on the larger ('main') rivers.

The data in Fig. 9.5 show that, in recent years, there has been a 5 per cent reduction in the length of the unpolluted Class A channel; this has been due mainly to an increase (4.3 per cent) in the extent of slight pollution (Class B). Changes in the lengths of channel in Classes C and D between the two periods have been minimal.

Comment on Trends in River Quality

Both the long-term (since 1971) and recent (since 1987-1990) trends show :-

a) a gradual reduction in the extent of seriously polluted channel and

b) a distinct trend of increasing levels of slight and, to a lesser extent, moderate pollution.

Both data sets indicate a trend towards a stabilisation in the extent of moderate and serious pollution while slight pollution continues its upward trend. The gradual abatement of serious pollution may be attributed to the installation of new or improved waste treatment facilities for point source discharges, in particular sewage, and, in some instances, to the cessation of seriously polluting industrial activities. The upward trend in the extent of slight and moderate pollution is largely due to eutrophication by point and diffuse source discharges.

Fish Kills

Fish kills are a symptom of extreme environmental disruption and are, therefore, a matter of grave concern not only from the purely ecological aspect but also from the economic and amenity perspective. Such occurrences have, more than any other aspect of water pollution, brought the problem to public notice and acted as a spur for national and local efforts to improve the position.

The total numbers of fish kills reported in four 4-year periods (1971-1974, 1983-1986, 1987-1990 and 1991-1994)

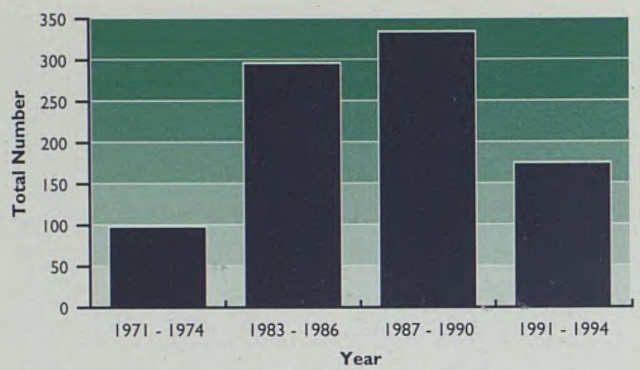

Fig. 9.6 The Numbers of Fish Kills Reported in the Four-year Periods 1971-1974, 1983-1986, 1987-1990 and 1991-1994 (Sources: McCarthy, 1988 and Moriarty, 1991, 1993 and 1994).

are set out in Fig. 9.6. An analysis of these data is given in Table 9.3 in which fish kills are grouped under the five main suspected causes of the kills:- Agricultural, Industrial, Municipal, Civil Works and Other. The data show that a marked upsurge in fish kills in the 1980s was followed by a very substantial reduction in recent years, i.e., from some 334 in 1987-1990 to 175 in the current period. The trend up to 1994 indicates the success of the considerable efforts by central and local government and by the Central and Regional Fisheries Boards in tackling the problem, particularly that from the agricultural sector. This sector, as Table 9.3 shows, has been, and continues to be, a major cause of fish kills reported annually by the Department of the Marine.

Of equal importance are incidents, grouped under the heading 'Other', which includes unexplained fish kills and those attributed to deoxygenation and eutrophication of unknown cause. Some 67 incidents were included in this category in the 1991-1994 period and 89 in the previous period. The relatively high number of incidents in this category may reflect the considerable proportion of river/stream channel which is subject to slight and moderate pollution (Classes B and C, respectively) and, as Fig 9.5 shows, these levels of pollution and, in particular, of slight pollution continue to increase. (Note that the numbers of reported fish kills for 1995 at 82 was the highest since the late 1980s; almost half were attributed to enrichment or deoxygenation.)

Nutrient Concentrations in Rivers and Groundwater

Since the main type of pollution now affecting inland waters is eutrophication, the key physico-chemical parameters of interest are nitrates and phosphates, particularly phosphates, which are the main stimulants of plant and algal growth in freshwaters. Most of the nitrate and phosphate found in natural waters comes from external organic and inorganic sources, principally sewage and industrial waste discharges and from the run-off from agricultural land of 'artificial' fertiliser and of land-spread animal manure slurries.

Nitrates

In addition to its role in contributing to eutrophication, nitrate, unlike phosphate, is of considerable public health significance. Owing to its potential to impair significantly the oxygen transporting functions of the blood, high nitrate concentrations in drinking waters constitute a health risk, to babies in particular. High nitrate in drinking water is also of concern due to its possible role in the promotion of cancers.

For the protection of human health, National Drinking Water and Surface Water Regulations require that nitrate concentrations in drinking water and in raw water to be treated for human consumption must not exceed 11.3 mg/l N (or 50 mg/l NO_3). Directives (CEC, 1975 and CEC, 1980) additionally recommend a guideline value of half this limit (i.e., 5.65 mg/l N or 25 mg/l NO_3). Setting the same limits for both raw and treated water reflects the fact that conventional treatment processes do not remove nitrate.

In rivers, excessive levels of nitrate are usually associated with the higher applications of artificial fertilisers on arable land. By European standards the use of artificial nitrogen fertilisers is still relatively moderate in this country but relatively high applications are made in areas of tillage farming (e.g., in the south-east) and water quality surveys generally reflect this situation. This is apparent from the data presented in Fig. 9.7 which contrasts annual median nitrate values from representative rivers in different parts of the country. The figure clearly highlights the contrast

Table 9.3 *Reported Fish Kills Grouped by Confirmed or Suspected Cause (Sources: McCarthy, 1988 and Moriarty, 1991,1993,1994).*

Period	Agricultural	Industrial	Municipal	Civil Works	Other*	Total
1971-'74	15	37	25	0	21	98
1983-'86	159	35	25	0	77	296
1987-'90	159	46	24	16	89	334
1991-'94	66	26	8	8	67	175

* The Category 'Other' includes kills attributed to unknown causes including unexplained deoxygenation and eutrophication.

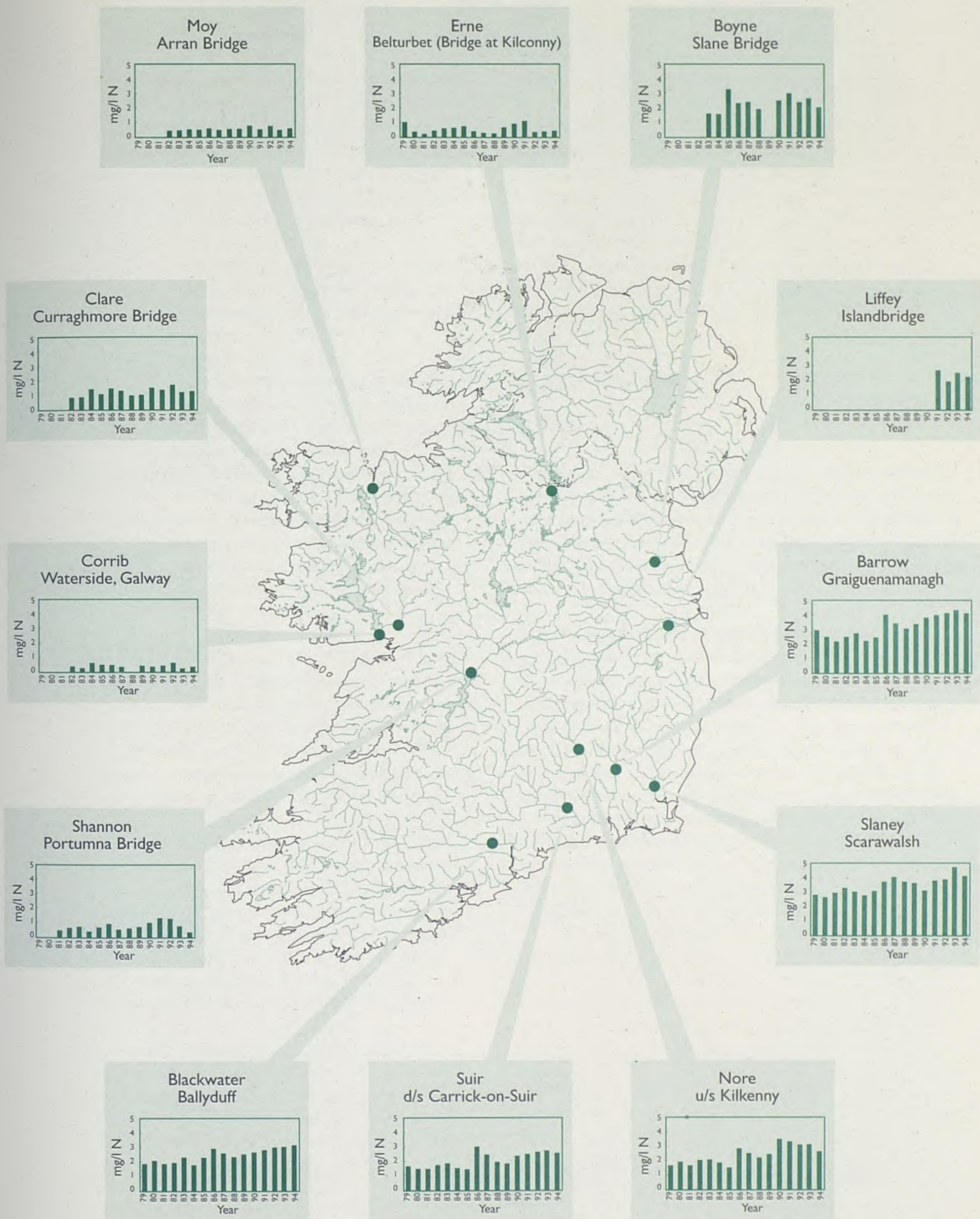

Fig. 9.7 *Annual Median Values for Nitrate (mg/l as N) at Selected Sampling Stations for the Period 1979-1994. All the vertical axes have the same scale (0 to 5 mg/l as N) (Source: EPA). Note that records for the full period are not available in all cases, with some commencing later than 1979.*

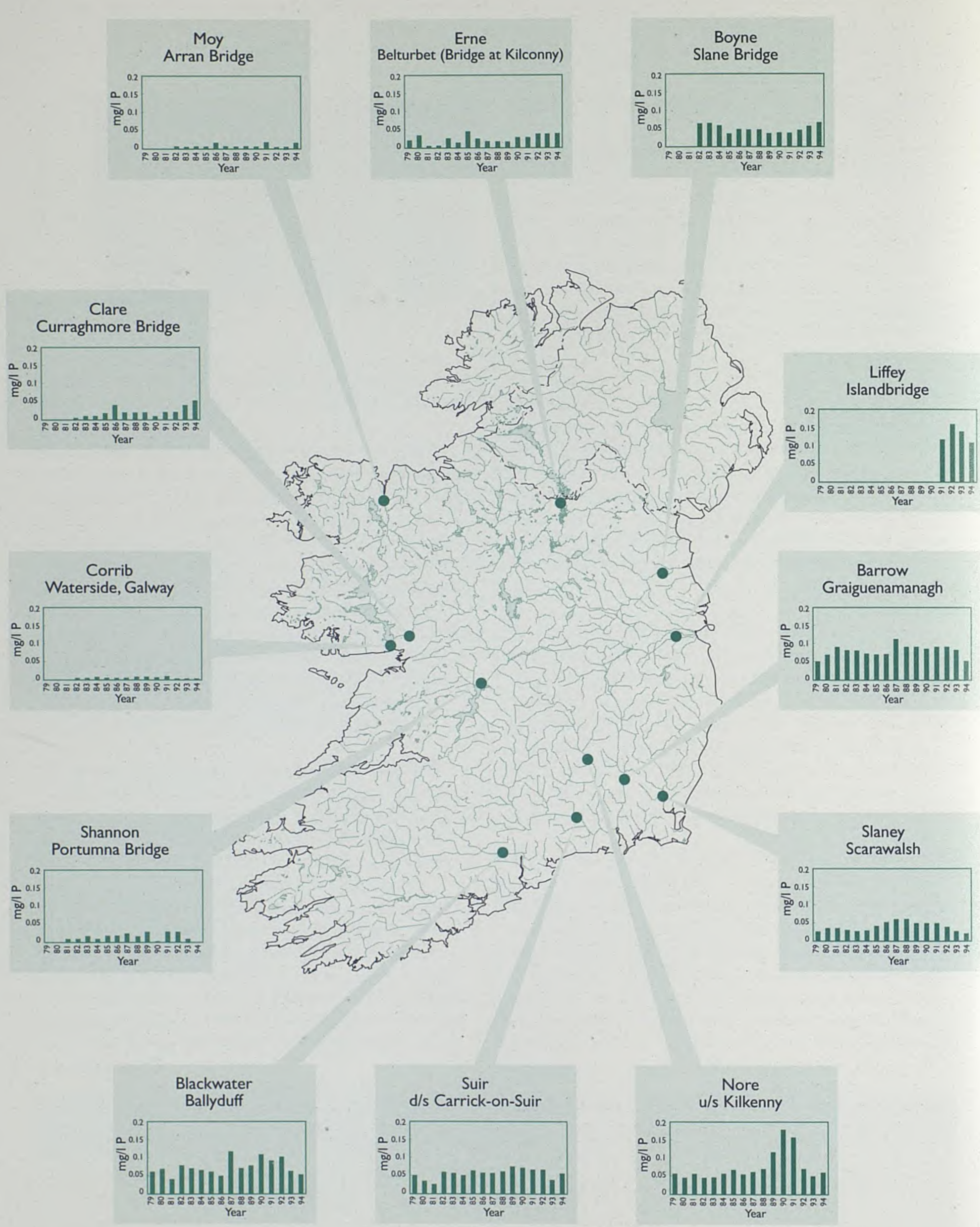

***Fig. 9.8** Annual Median Values for Phosphate (mg/l as P) at Selected Sampling Stations for the Period 1979 to 1994. All the vertical axes have the same scale (0 to 0.2 mg/l as P) (Source: EPA).*

between the relatively unimpacted rivers of the west and those in the east and south-east of the country. While the bulk of the surface waters surveyed in the current review period had nitrate concentrations below the EU guideline value, this value was exceeded in some rivers during the winter months for short periods and, as expected, highest concentrations were measured in south-eastern rivers.

With regard to trends, nitrate concentrations in surface waters continue to increase in many rural areas and the rate of increase is greatest in the south-east region where concentrations are highest.

In an investigation of groundwater nitrate concentrations in in the south and north-east of the country in the survey period, 97 per cent of samples had nitrate concentrations which were less than the maximum admissable concentration (MAC) set by the Drinking Water Regulations. The information suggests that nitrate contamination occurs in individual boreholes and wells, probably due to the proximity of waste sources such as silage and slurry pits, but that the general bodies of groundwater are relatively free of this contamination.

Phosphates

Although mandatory phosphate limits of 0.22 to 0.3 mg/l P are specified in the Surface Water Regulations, these values relate to the suitability of water for treatment and have no environmental significance. Sustained values of even one tenth of these would be expected to give rise to eutrophication in surface waters and would be particularly undesirable in rivers and streams which flow into lakes.

Annual median phosphate values recorded in the larger rivers, over the period 1979 to 1994 in most cases, are analysed in Figure 9.8. This figure graphically illustrates the contrast between the generally unimpacted rivers of the west of Ireland (i.e., the Clare, Corrib and Moy) and the eutrophic or highly eutrophic rivers in the rest of the country, in particular the lower reaches of the Liffey, Barrow, Nore, Suir, Boyne and Blackwater (Munster).

Sewage and agriculture, as stated above, are the main sources of phosphate in surface waters. That the role of sewage in eutrophication is very considerable is now generally accepted and, as a consequence, phosphorus is now being removed at several sewage treatment plants in the country with more planned.

As regards agriculture, recent studies strongly suggest that loss of phosphorus from land makes a significant contribution to the eutrophication problem (Tunney *et al*, 1994). Mass balance studies show that, on a national basis, much more phosphorus than is required for optimal production is being used in intensive agriculture and significant reductions can be made without reducing production on many farms. In many cases, this situation is likely to arise from the failure to take into account the phosphorus content of manure slurries applied to the land when assessing the need for artificial fertiliser. The authors suggest that chemical P fertiliser inputs could be reduced by about IR£25 million per year, on a national scale, without any adverse effects on production. Even greater savings could be made over a number of years if farms where high soil P reserves have been built up over the years were to draw down these reserves to a more acceptable level.

LAKE WATER QUALITY

Introduction

The biggest threat to the water quality of lakes in Ireland is eutrophication. In lakes, this nutrient enrichment process most often results in the excessive production of planktonic algae (the microscopic free-floating forms) but may also increase the growth of larger algae attached to the lake bottom and of the rooted plants.

The principal nutrients controlling algal and plant growth are phosphates and nitrates. Since phosphate is usually less abundant than nitrate in the freshwater aquatic environment, relative to plant needs, its concentration is often reduced to very low levels; this nutrient usually acts, therefore, as the "growth limiting" factor regulating the extent of algal and plant development. Increased input of phosphate alone to a lake will normally result in an increase in algal and plant biomass although the most prolific growth may not be possible without further additions of nitrate. However, where both nutrients are already present in abundance, other factors, such as light, silica and trace elements, may limit the extent of plant growth.

Increased growths of algae and other plants in lakes, as a result of nutrient enrichment, may lead to a reduction in the quality-dependent uses of the waterbody. In the worst instances, excessive growths of attached macrophytes (water weeds) and algae occur on shorelines rendering them unsuitable for most recreational uses. However, the commonest problems in eutrophic lakes arise from the proliferation of the planktonic algae. These organisms have many damaging effects on the water quality, not least a marked reduction in water transparency which may have a detrimental effect on angling and amenity use. In addition, the presence of large concentrations of planktonic algae may cause problems in the treatment of water drawn from the affected lake, including the creation of tastes and odours in the supply.

Survey Work to date

There are some 4,000 lakes in the country but, to date, only a few hundred of these have been assessed for their water quality status. This is due mainly to the greater resources needed to sample lake waters compared to rivers and streams. However, the great majority of lakes are located in areas such as the west and north west where the risk of pollution is relatively low. Furthermore, most of those in the areas of greater pollution potential and the larger waters in general have been the subjects of investigation over the last 25 years.

The first systematic investigations of lake water quality were undertaken by the then Inland Fisheries Trust, now the Central Fisheries Board, in the late 1960s and early 1970s. They were concentrated on the lakes being developed for angling, particularly those in the Midlands, some of which were the first in the country to show the effects of eutrophication. These initial investigations were later complemented by the work of An Foras Forbartha which commenced in 1973 and which is now being continued by the Environmental Protection Agency.

At present, lake monitoring is being undertaken mainly by the aforementioned bodies, with some of the local authorities also involved. However, the extent of this monitoring is limited; less than 50 lakes are subject to regular surveys, although this number includes most of the larger waters. The EPA is currently preparing a national monitoring programme for lakes as part of its general brief in the environmental monitoring area. This programme will cover a much greater proportion of the State's lakes than the surveys to date and will require the participation and co-operation of all of the bodies currently involved in lake monitoring.

Investigations have been carried out in recent years to assess the feasibility of using remote sensing techniques to complement the conventional survey work on lakes. Remote sensing has the potential to obtain useful information on a large number of lakes in a short period. While this information cannot wholly replace the ground-based measurements, it does offer a means of maintaining surveillance over a considerable fraction of the lakes in the State and of highlighting those waters where more detailed investigations are required.

The work to date has involved the analysis of data from satellite systems, such as the LANDSAT series, and from an aircraft-borne spectrometer to obtain a measure of the concentration of algal pigment and other features of the surface waters of lakes. Such features can give a measure of the extent of algal growth and thus of the degree of eutrophication. Further research is at present being undertaken to improve the use of the aircraft-borne spectrometer; this approach is favoured since, being carried out from low-flying aircraft, it is not as restricted by cloud cover as is the use of satellite data.

Assessment of Lake Water Quality

The lake water quality classification system currently used in Ireland is based on a scheme proposed by the OECD (1982). This scheme (Table 9.4) defines the traditional trophic categories, which indicate increasing levels of nutrient enrichment - oligotrophic and mesotrophic (unpolluted), eutrophic (moderately to highly polluted) and hypertrophic (grossly polluted) - in terms of annual statistics for total phosphorus, chlorophyll and water transparency. The first two parameters are, respectively, measures of the main nutrient and the amount of algal biomass, while the last is an indirect measure of algal abundance as well as being an important feature of lake waters in its own right.

Because of the wide limits set for the eutrophic category in the original OECD scheme, three arbitrary sub-divisions have been made, viz., moderately, strongly and highly eutrophic. In addition, because of the often limited data available for any one lake in a year, it is not possible to define annual mean values for all of the key parameters. As a compromise, the classification currently used has been based mainly on the summer values for chlorophyll concentrations. These are often the only data available and are taken to be an approximation of the annual maximum value for this parameter. Thus, the lakes are classified into six water quality categories by reference to the maximum chlorophyll levels measured during the period. The arbitrary modification of the OECD scheme is set out in Table 9.5.

Table 9.4 *Trophic Classification Scheme for Lake Waters (Source: OECD, 1982).*

Lake Category	Total Phos. mg/m^3 Mean	Chlorophyll mg/m^3 Mean	Chlorophyll mg/m^3 Max.	Transparency m Mean	Transparency m Min.
Ultra-Oligotrophic	<4	<1.0	<2.5	>12	>6
Oligotrophic	<10	<2.5	<8.0	>6	>3
Mesotrophic	10-35	2.5-8	8-25	6-3	3-1.5
Eutrophic	35-100	8-25	25-75	3-1.5	1.5-0.7
Hypertrophic	>100	>25	>75	<1.5	<0.7

***Table 9.5** Modified Version of the OECD Scheme Based on Values of Annual Maximum Chlorophyll Concentration mg/m³. (Source: Toner et al., 1986).*

	Oligo-trophic	Meso-trophic	Eutrophic Moderately	Eutrophic Strongly	Eutrophic Highly	Hyper-trophic
	O	M	m-E	s-E	h-E	H
Annual maximum Chlorophyll	<8.0	8-25	25-35	35-55	55-75	>75

Water Quality of Lakes in the Period 1991-1994

Information on the water quality of 135 lakes is available for the period 1991-1994 (Bowman *et al.,* in press) compared to the information on 172 lakes presented in the previous period, 1987-1990.

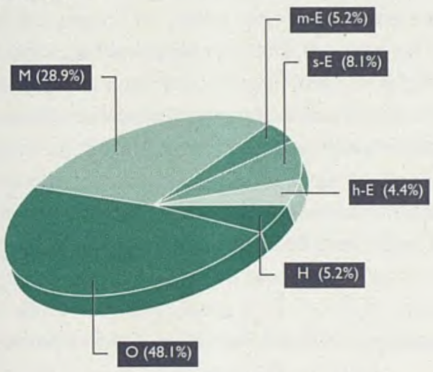

***Fig. 9.9** Trophic Status of 135 Lakes 1991 - 1994 (Source: Bowman* et al., *in press).*

On the basis of annual maximum chlorophyll concentrations, 104 (77 per cent) of the 135 lakes examined have been assigned a trophic status (oligotrophic or mesotrophic) compatible with a low probability of pollution (Fig. 9.9). Seven lakes (5 per cent) were classified as moderately eutrophic, indicating a moderate level of artificial enrichment. In these lakes, the adverse effects on beneficial uses are not likely to be of great significance. The extent of algal development recorded in the remaining 24 lakes examined (18 per cent) suggests a strong to very high level of eutrophication and a consequent likelihood of impairment of their beneficial uses. These lakes have been classified as strongly eutrophic, highly eutrophic or hypertrophic.

In many instances the principal sources of nutrients, resulting in the enriched state of these lakes, are thought to be non-point discharges of agricultural origin. Single point sources, such as the discharges from municipal and industrial sewage treatment plants, are also partly responsible for the enriched status of some lakes in these categories.

The surface area (Fig. 9.10) of the 135 lakes examined amounts to 750 km², or approximately 50 per cent of the lake surface area in the country. Of this 750 km², lakes accounting for 456 km² (61 per cent) were in the unpolluted oligotrophic or mesotrophic categories. The surface area of lakes classified as moderately eutrophic was 5 km² (0.7 per cent). The areas of the lakes categorised as strongly eutrophic, highly eutrophic and hypertrophic were, respectively, 245 (32.7 per cent), 13 (1.7 per cent) and 25 km² (3.3 per cent). The area of lakes classified as strongly eutrophic is considerably enhanced by the presence of Loughs Ree (105 km²) and Derg (110 km²) in this category.

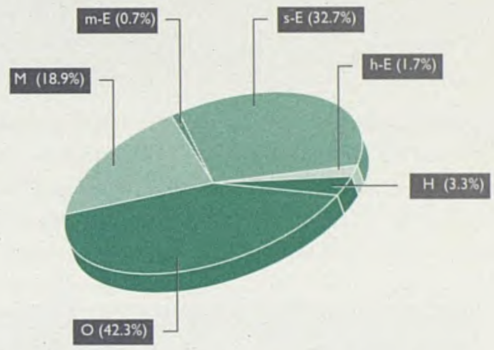

***Fig. 9.10** Trophic Status of 135 Lakes by Surface Area 1991-1994 (Source: Bowman* et al., *in press).*

The areas in Ireland with the greatest number of lakes are Galway, Mayo and Donegal along the western seaboard, and the counties of Leitrim, Cavan and Monaghan in the north-midlands. Elsewhere in the country, lakes are relatively scarce. The regional distribution of the lakes examined according to their designated trophic status is shown in Fig. 9.11.

In the west of Ireland, the 53 lakes examined during this period were all found to be unenriched and were classified as oligotrophic or mesotrophic. Of the 47 lakes investigated in the north midlands area, 24 (51 per cent) were assigned to the unenriched oligotrophic and mesotrophic categories, seven were classified as moderately eutrophic and 16 lakes (34 per cent) were in the categories indicating polluted conditions. These account for 67 per cent of the lakes in such categories. In the remaining areas of the country over 80 per cent of the 30 lakes examined were in the oligotrophic or mesotrophic categories.

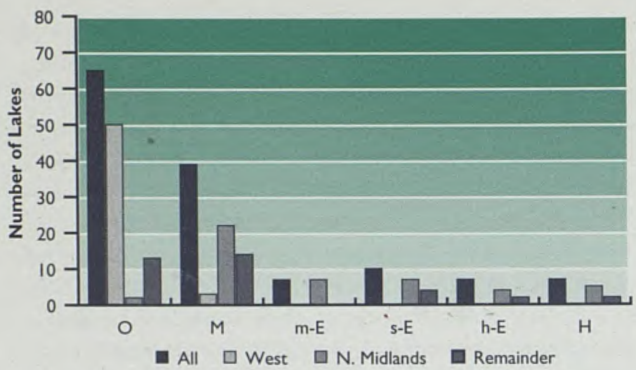

Fig. 9.11 *Trophic Status of Lakes. Regional Classification 1991-1994 (Bowman* et al., *in press).*

Recent Trends in Lake Water Quality

The recent trends in the water quality of lakes are shown in Figs 9.12 and 9.13 which compare the situation in lakes examined in the period 1987-1990 (Clabby *et al*, 1992) with the situation in the current period of review (Bowman *et al.*, in press).

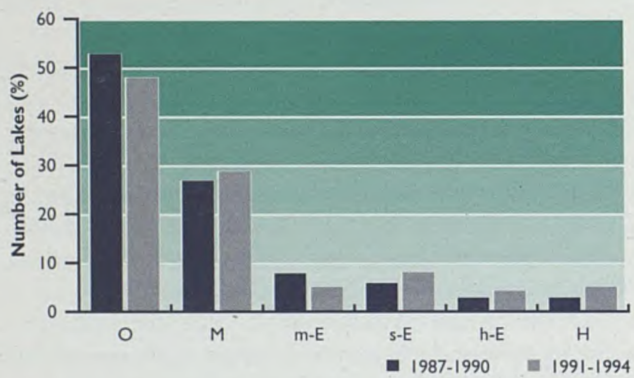

Fig. 9.12 *Recent Changes in Water Quality: Number of Lakes (Bowman* et al., *in press).*

When the trophic status of the lakes is expressed in terms of the percentage of the overall number examined allocated to each trophic category (Fig. 9.12), little change is apparent. However, when this comparison is made by reference to the surface areas examined (Fig. 9.13) considerable changes are apparent. A marked increase in the percentage of surface water in the oligotrophic category and a reduction in the mesotrophic category in the recent period is evident. These changes are due largely to the upgrading of Lough Corrib (170 km^2) from a mesotrophic category in the earlier period to an oligotrophic category in the 1991-1994 period and the downgrading of Lough Ree (105 km^2) from a mesotrophic to a strongly eutrophic status. The change in the assessment of the water quality of Lough Ree is a result of investigations during the period 1993-1994 (Bowman, in prep.).

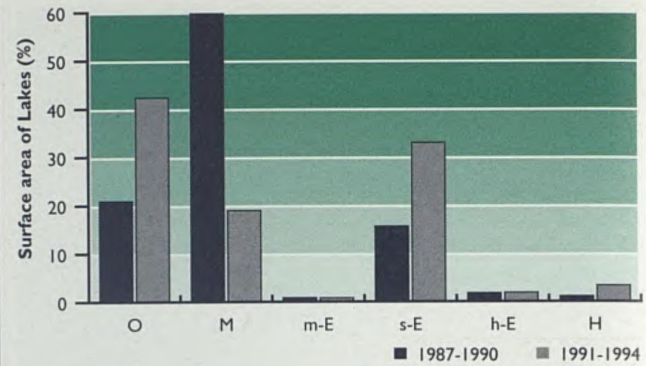

Fig. 9.13 *Recent Changes in Water Quality: Surface Areas of Lakes (Bowman,* et al., *in press).*

Of the 39 lakes on which an assessment of the water quality was made in the period 1976-1981 (WPAC, 1983), 23 have been re-examined in the periods 1982-1986, 1987-1990 and 1991-1994. In the case of most of these lakes, no appreciable change in water quality has occurred. A marked improvement in the water quality of Loughs Leane, Muckno, Kinale, Derravaragh, Sheelin and Ennel has occurred as a result of the implementation of waste management strategies in the catchments of these lakes. Recently, however, deteriorations have been observed in the latter two lakes. A continuous deterioration in the water quality of Carrigadrohid and Inniscarra Reservoirs on the River Lee and of Lough Derg has been observed since the 1976-81 period.

Investigation of Acid Sensitive Lake Waters

In Ireland the principal areas with acid sensitive water bodies lie on granite and other base-poor rocks along the western seaboard and in Co. Wicklow. The surface waters in these and similar areas are characterised by their low alkalinity and consequently poor capacity to neutralise acid inputs.

A detailed baseline study of the chemical and biological characteristics of five acid-sensitive lake systems - Loughs Veagh (Co. Donegal), Maumwee (Co. Galway), Glendalough Lake Upper (Co. Wicklow) and Doo and Naminna (Co. Clare) - and of similar headwater streams in the Slieve Bloom mountains was carried out by the ERU in 1987-1989. Complementary, though less detailed, examinations of 125 other lakes in these areas were made as part of the study.

The results (Bowman, 1991) indicated that Loughs Veagh and Maumwee and the Slieve Bloom streams were unaffected by artificial acidification. However, evidence of acidification was found in inflowing rivers, with heavily afforested catchments, to Loughs Doo and Naminna, and was particularly pronounced in the Lugduff River at Glendalough where the paucity of brown trout *(Salmo trutta*

L.) in the river was related to the acid conditions (Bowman and Bracken, 1993). While Allott *et al.* (1990) described increased acidity due to afforestation in a number of poorly buffered headwaters in Galway and South Mayo, the majority of the lakes examined less intensively on the west coast (Bowman, 1991) did not show signs of being adversely affected by acidification. However, a small number of lakes in Galway, located adjacently, had higher levels of acidity which were attributed to high levels of humic acids in the run-off from their peaty catchments.

The results to date of a biological and physico-chemical monitoring programme, operated by the EPA as a follow-up to the foregoing study, do not show any significant change in the situation at the sites examined at Loughs Veagh and Maumwee. The highly acid conditions persist in the catchment of the Lugduff River, a tributary of Glendalough Lake Upper. The adjoining Glenealo River, draining a non-afforested catchment, does not show evidence of being adversely affected by acidification.

Radioactivity in Irish Lakes

A post-Chernobyl monitoring programme of the concentrations of radionuclides in fish and lake sediments in 24 Irish lakes in 12 counties was carried out by the Nuclear Energy Board (now the Radiological Protection Institute of Ireland) in the period 1988 to 1992 (O'Sullivan *et al.*, 1995). The investigation found that some lakes, particularly those in upland areas in the north-west of the country, were significantly contaminated following the Chernobyl accident. Lakes in the west, south-west and east were also contaminated but to a noticeably lesser extent. The results of the monitoring programme on fish indicate that radiocaesium levels in salmonid species have fallen over the five years of the programme.

The estimated annual radiation doses to consumers of relatively large amounts of freshwater fish, fell from 39 μSv (a measure of dose equivalents) in 1988 to 15 μSv in 1992. These estimated doses are less than 5 per cent of the International Commission on Radiological Protection recommended dose limit of 1,000 μSv per year for members of the public from artificial sources of radiation. They represent approximately 1 per cent of the average annual dose of about 3,000 μSv received by members of the Irish public from all sources of radiation, natural and artificial and, as such, are of minor radiological significance.

Bathing Water Quality in Lakes (see also Chapter 10)

Since first being included in the 1992 bathing season, all the inland bathing areas, which are located on lakes, have complied with the mandatory values laid down for total and faecal coliforms in the Bathing Water Regulations and compliance with the guide values for these parameters ranged between 80 and 100 per cent, with eight of the nine areas meeting the requirements in 1994. Three of the areas, Lough Rea, Lough Lene and Lough Ennell were awarded Blue Flag status in 1994 and 1995 (Table 9.6).

Table 9.6 *List of Freshwater Bathing Areas Designated Under Directive 76/160/EEC (CEC, 1976) in 1994 with the Responsible Local Authority. The areas which were awarded Blue Flag status in 1994 and 1995 are shown with an asterisk (*).*

Bathing Area	Local Authority
Ballyallia (Ennis)	Clare CC
Ballycuggeran Lake (Killaloe)	Clare CC
Lough Derg (Mountshannon)	Clare CC
Lough Derg (Portumna)	Galway CC
Loughrea Lake*	Galway CC
Keeldra Lake (Cloone)	Leitrim CC
Lough Lene (The Cut)*	Westmeath CC
Lough Ennell (Lilliput)*	Westmeath CC
Lough Owel (Portnashangan)	Westmeath CC

FRESHWATER FISHERIES

Introduction

There has been no significant change in the freshwater fish fauna over the past twenty or more years. At twenty species (Fitzmaurice, 1984) the Irish fish fauna list is less than the U.K. and considerably less than on the European continent. However, fish stock surveys on many of the major river systems, over the past fifteen years, have identified a variety of problems, e.g., fish kills, eutrophication and reduced habitat suitability which impact adversely on salmon and trout stocks. Concern is also expressed at the impact of illegal importation of fish species on our resident fish populations. Other factors which militate against optimum production of fish species include imbalanced riparian zones, prolonged periods of low flow and elevated velocities at peak discharge associated with land reclamation, acidification of poorly buffered headwaters, afforestation and overgrazing (O'Grady and Gargan, 1994).

Salmonids

Salmon *(Salmo salar)*
Salmon angling is an important resource which is influenced by the commercial exploitation of the species at sea. Any

commentary, therefore, must consider influences on the species in the marine and freshwater environment.

The expansion of an offshore drift net fishery during the 1970s and 1980s has accounted for the bulk of the commercial catch. Recent data (Fig. 9.14) show a reduction in salmon gross tonnage and numbers; this is particularly apparent for spring salmon over the past twenty years (Whelan, pers. comm.). Subtle ecological changes and indiscriminate exploitation at sea are likely factors contributing to the decline.

Life Cycle of Salmon

Salmon begin life in freshwater. In the spring of their second or third year the bulk of the young fish undergo physiological changes and take on a silvery appearance (smoltify). These smolts (ranging in length from 10 to 15 cm) then migrate to the sea on their way to the rich marine feeding grounds. The majority return as grilse after one winter (mean weight of about 3 kg) ascending their rivers of origin in summer and autumn. Those that travel further to their feeding grounds (e.g., off Greenland) spend two or more winters at sea before returning as large fish (mean weight 5.0 kg) in spring - hence the description 'spring salmon'.

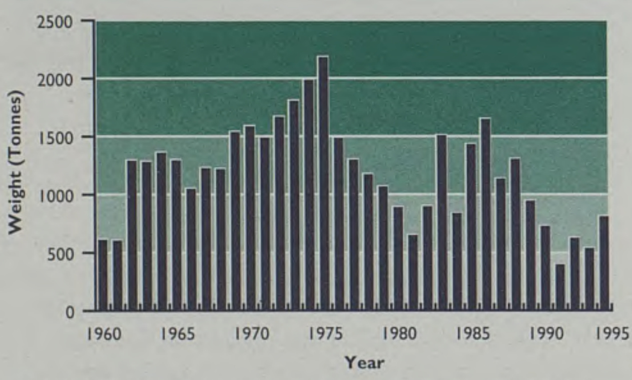

***Fig. 9.14a** Total Salmon Catch (Tonnes) in Ireland for the Period 1960-1994 (Source: Internal CFB Report).*

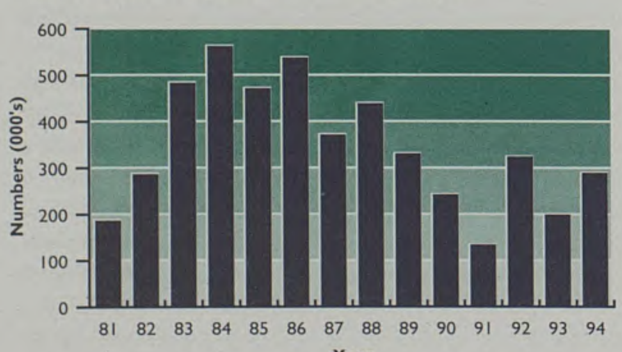

***Fig. 9.14b** Total Salmon Catch (Numbers) in Ireland for the Period 1981-1994 (Source: Internal CFB Report).*

Trout *(Salmo trutta)*
Concomitant with the expansion of farmed salmon in cages at sea, a catastrophic collapse has occurred in the **sea trout** populations of many western rivers particularly in Connemara and west Mayo (Fig. 9.15). In the Burrishoole fishery the sea trout spawning stock declined from 800 to 30 fish between 1987 and 1989 (Whelan, pers. comm.). A special Sea Trout Task Force which studied the problem concluded that scientific investigations "point to infestation of sea trout [by sea lice] in the vicinity of sea farms as the factor most closely associated with the marked incidence of adverse pressure on sea trout stocks in recent years" (Anon., 1994). The recommendations in the report dealt in the main with techniques to eliminate the sea lice.

Anglers report a decline in **brown trout** stocks in many waters. Surveys have been completed on numerous rivers which show the absence of juvenile trout or low numbers in ideally suitable locations. Unfortunately no previous data exist for many of the rivers studied. In those for which historical data are available (many of the Shannon tributaries) trout numbers are considerably reduced. Predation by increasing pike stocks may be a contributing factor since the reduction of predator control in the mid-1980s.

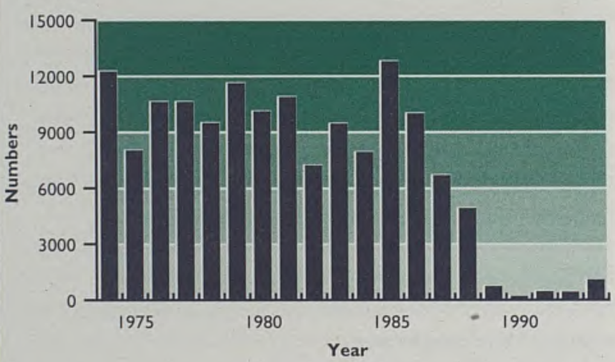

***Fig. 9.15** Annual Sea Trout Rod Catch in Connemara for the Period 1974 to 1993 (Source: Anon., 1994).*

Many trout lake stocks have demonstrated dramatic changes. The populations in Loughs Ennell and Sheelin collapsed when both lakes were highly eutrophic. Lough Ennell responded positively to eutrophication control measures in 1979 and 1983 and the trout stock there has recovered again (*circa* 22,000 trout >19.8 cm, O'Grady, pers. comm.). Lough Sheelin has also responded, albeit more slowly, to a reduction in phosphorus inputs. The trout population in Sheelin, having collapsed from approximately 100,000 (>19.8 cm) in 1979 to *circa* 20,000 in 1989, has recovered again climbing to about 80,000 over the past four years (O'Grady, pers. comm.). Increased enrichment in Lough Conn has resulted in an increase in the average weight of rod caught fish while numbers have remained fairly stable (McGarrigle *et al.*, 1994). Trout stocks in neighbouring Lough Mask and Lough Corrib, although never quantified, appear to be very much lower in recent years based on angling success. However, predator control was suspended on these lakes prior to the rod licence dispute (1988 to 1990). Preliminary netting surveys indicate that pike have increased in these waters, which combined with reduced recruitment from the feeder streams (R. Robe is very eutrophic and the Owenbrin is badly eroded), are the suspected causes of the decline in these waters.

Char *(Salvelinus alpinus)*

This is a pollution sensitive salmonid species which disappeared from Lough Owel and Lough Ennell earlier this century (Champ, 1977). Populations in Lough Leane (Went, 1945; O'Maoileidigh, pers. comm.; O'Grady, unpublished) and more recently in Lough Conn (O'Grady, unpublished; McGarrigle *et al.*, 1994) have demonstrated alarming reductions, and similar occurrences have been observed by the fisheries agencies in other lakes (Champ, 1977) which are considerably less eutrophic than the lakes specified under the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994 (S.I. 419 of 1994) e.g., Lough Leane, Lough Derg, Lough Ree and Lough Oughter. These latter waters have been correctly identified as "eutrophic sensitive" albeit at a more advanced stage of enrichment. It may be necessary therefore to consider a two or multi-tiered system of eutrophic sensitivity based on fish fauna e.g., (a) char, (b) trout/salmon and (c) other less sensitive fish such as perch *(Perca fluviatilis)*, bream *(Abramis brama)* and roach *(Rutilus rutilus)*.

Cyprinids

Roach

Amongst the cyprinid (coarse fish), roach *(Rutilus rutilus)* numbers increased dramatically in rivers systems to which they were illicitly introduced in the 1970s (Fitzmaurice, 1981). This species achieved very high population densities in many waters during the eighties but stocks have declined in recent years. Relative to the 1950s, therefore, when roach were confined to the Munster Blackwater and a small ornamental lake in the Foyle system, this species is now widely distributed and while not as abundant as in the eighties the species continues to provide good angling in many waters with a slight increase evident in average size.

Rudd

During the height of the roach expansion they impacted adversely on rudd *(Scardinius erythrophthalmus)* which they displaced from often shared spawning locations. Roach also interbred with rudd. However, the rudd population has recovered and again produces good angling in selected waters.

Bream

Bream *(Abramis brama)* stocks have been exhibiting problems on the River Shannon, River Erne and River Barrow. Mortalities of juveniles and adults have been reported in recent years. Many of the larger fish have exhibited a high incidence of external lesions especially during the summer months. Exceptionally large catches of bream have been reported recently at Portumna and the fish have been in particularly good condition. Very good quality bream stocks now occur in the Lee Reservoirs and other small lakes in the Lee system after introduction in the late 1960s. The species is quite widely distributed in Ireland.

Carp and Tench

Carp *(Cyprinus carpio)* and tench *(Tinca tinca)* are also good angling species but their distribution is somewhat limited. Irish waters appear to be more suitable for the tench. Selective introductions of tench were carried out over the past forty years and they are now fairly widely available to anglers.

Traditionally water temperatures have limited the reproductive efforts of the carp which only spawn, with any regularity, in a limited number of shallow, sheltered lakes. This is a very sought after angling species and it is hoped to extend its range and availability to angling by judicious stockings.

Canal Stocks

A comprehensive five-year research and development programme has recently been completed on the Royal, Grand and Barrow Canals by the Central Fisheries Board on behalf of the Office of Public Works (1990-1995). The Canals contain excellent stocks of mixed coarse fish populations. The Grand Canal stocks are dominated by bream (47.6 per cent) and the Royal Canal is dominated by roach. Excellent stocks of rudd, pike and tench occur in both the Grand and Royal Canals; carp while present exhibit a limited distribution.

Other Economically Important Freshwater Species

Eel

The freshwater eel *(Anguilla anguilla)*, which feeds in freshwater and goes to sea to reproduce, is also a significant revenue earner. This species is on the decline in recent years with fewer juveniles arriving to Irish and European rivers from the spawning grounds in the Sargasso Sea. The precise cause of the decline is unknown but over-exploitation of the species in freshwater and/or changing sea temperatures are thought to be implicated. The eel has limited angling appeal but is very valuable commercially with substantial quantities being exported to the U.K. and the European mainland.

Pike

Pike *(Esox lucius)* are piscivorous and feed all their adult life on fish. They are highly sought after by Irish and foreign anglers. The species is widely distributed occurring in almost all moderately to highly alkaline water systems in the State (Bracken and Champ, 1971). The Irish record rod caught pike (19.05 kg) was captured in the River Barrow in 1964. The heaviest authenticated rod caught lake specimen weighed 17.77 kg and was captured in Lough Key in 1993.

The species is very vulnerable to heavy angling pressure. For a time in the 1980s when anglers pursued this species on a semi-commercial basis, numbers declined dramatically in the areas most heavily fished. In order to discourage this practice, and to conserve stocks in pike angling waters, legislation was introduced (Pike Bye-Law No. 667 of 1990) limiting the number of fish and the weight of pike flesh an angler may have in his possession. This encourages anglers to return pike live to the water. Depleted stocks quickly recovered and pike are very numerous in most waters today.

Traditionally pike have been culled in managed trout and salmon lake fisheries but, with the exception of Loughs Conn, Arrow, Sheelin, Owel and Ennell, cropping efforts have not been maintained over the past decade. Consequently pike numbers have also increased in waters which were traditionally managed as salmonid fisheries (e.g., Loughs Corrib and Mask).

CONCLUSIONS

The data presented above indicate that 71 per cent of the river and stream channel length and 61 per cent of the lake surface area examined in the period 1991-1994 were in a satisfactory condition. Less than 1 per cent of the river length examined was assessed as being seriously polluted while the corresponding figure for lake surface area examined was 5 per cent. It is considered that these statistics are more representative of the national position in the case of rivers than they are of lakes. In the latter case, it is likely that the national position is more favourable than it is for the group of lakes reported on here. The most widespread form of pollution encountered in the rivers and lakes is eutrophication resulting from inputs of wastes with a high nutrient content and over use of fertilizers.

The trends observed in the water quality of rivers and streams indicate a marked reduction in the unpolluted and seriously polluted channel length and an increase in the levels of slight and moderate pollution. It is more difficult to assess the trends in lake water quality as data are available on a continual basis for only 23 such waters since 1976. However, it is apparent that no marked change has occurred in 14 of these lakes. Substantial improvements in water quality were recorded in the case of six lakes where waste management strategies were implemented and only three lakes showed a continuous decline during this period.

While the number of freshwater fish species in Irish waters has not been reduced, a number of factors which adversly impact on fish stocks have been identified. National and international measures are urgently required to protect salmon, particularly the spring salmon, stocks of which are facing extinction in some traditional waters. Over the past decade some progress has been achieved on the international front through the pursuit of a buy-out policy for the high seas fisheries.

The implementation of catchment oriented pollution control strategies, incorporating specialised eutrophication abatement measures in specific waters, is particularly encouraging. The adoption of more integrated and environmentally sensitive policies by the Department of Agriculture, Food and Forestry (the control of farmyard pollution scheme and the publication of the Forestry and Fisheries Guidelines in 1992) has helped to curtail many of the problems experienced by fisheries attributable to agriculture. The recent introduction of the Rural Environmental Protection Scheme and the adoption of sustainability as a key element in current development policy are expected to deliver further benefits to the aquatic environment and the fish stocks therein.

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CHAPTER 10

ESTUARINE AND COASTAL WATERS

INTRODUCTION

Ireland's coastline, because of its indented nature, particularly on the Atlantic side, is long relative to the country's size (see Chapter 2) and consists of some large inlets and innumerable small bays, points and islets. Most of the major cities of the world are situated on estuaries and Ireland's are no exception with the five main cities as well as many other large towns having estuarine or coastal locations. Ever since man first colonised Ireland, settlements were along coasts and rivers and today a sizeable proportion of the population lives in coastal areas. Some coasts and estuaries are important locations for industry, e.g., Cork Harbour and the Shannon Estuary. Aquaculture activities are mainly along the western seaboard while fishing ports are situated all around the coast.

This chapter summarizes information on the estuarine and coastal waters of Ireland with the emphasis on assessing environmental quality. As with the quality and management aspects for the other media of air, land and fresh water, data collection pertaining to the estuarine and marine environment has been largely driven over the past decade by the State's commitments as a member of the European Union (EU). A review of the general quality conditions as well as the levels of toxic contaminants, classification of shellfish production areas and levels of compliance with the EC 'shellfish' and bathing water Directives is undertaken. Levels of radioactivity in the marine environment, coastal zone management and recent developments in the aquaculture industry are also discussed. Coastal zone protection is dealt with in Chapter 14.

QUALITY OF ESTUARINE AND COASTAL WATERS

Approximately four-fifths of the combined industrial and municipal discharges are to estuarine and coastal waters (Chapter 6). The main types of discharges to these waters are sewage and other biodegradable wastes, which lead to organic enrichment and deoxygenation. The deoxygenating effects of such wastes are, *inter alia,* of concern in regard to the passage of migratory fish, particularly salmonid species, through the estuaries. Other effects of these wastes include microbiological contamination of bathing waters and shellfish rearing areas, which has implications for public health. Contamination by toxic and radioactive material must also be considered.

General Quality Conditions

In the past ten years, a general assessment of the quality of estuarine and coastal waters has been made on three occasions: for the period 1982-1986 by Toner *et al.* (1986), for 1987-1990 by Clabby *et al.* (1992) and for 1991-1994 by Bowman *et al.* (in press). The areas covered in the most recent review are shown in Fig. 10.1. The surveys undertaken were largely designed to assess the impact of organic wastes and employed the conventional parameters, dissolved oxygen (DO), biochemical oxygen demand (BOD), ammonia, oxidised nitrogen and phosphate. In some cases, however, surveys were more broadly based and included other measurements. Since 1992/93 the emphasis has been on the collection of data in relation to two directives, the urban waste water treatment Directive (CEC, 1991a) and the nitrate Directive (CEC,1991b), and a monitoring programme for this purpose initiated by the Environmental Research Unit (ERU) is being continued by the Environmental Protection Agency (EPA).

In the latest review (Bowman *et al.,* in press) 26 tidal waters were assessed (Fig. 10.1). The results indicated that serious pollution was of very limited occurrence with little sign of any major change in condition since the previous period of review. While a degree of deoxygenation has been recorded in some estuarine waters, it would not be such as to impede the passage of migratory fish species. However, in most cases the full degree of deoxygenation was not established as measurements were not carried out in the hours of darkness when oxygen levels may be lowest. Thus there is a need for diurnal variation studies to be carried out in Irish estuarine waters. The degree of deoxygenation recorded at depth in the Lee Estuary, downstream of Cork city, at dawn in September 1994 was the worst of any of the surveys; Killybegs Harbour continues to be polluted to a moderate degree while the Rogerstown Estuary, as well as being moderately polluted, has areas, near a tiphead and sewage outfall, which are seriously polluted. The inner part of Dungarvan Harbour showed significant organic enrichment, faecal coliform contamination and elevated levels of certain metals, particularly chromium. Macro-algae deposits have caused problems in Dublin Bay and localised slight pollution or eutrophication tendency was recorded at a number of locations, mainly in the upper reaches of estuaries (Bowman *et al.,* in press).

Monitoring of Toxic Contaminant Levels

The concentrations of heavy metals (mercury, cadmium, copper, lead and zinc) and chlorinated hydrocarbons (PCBs and the pesticides lindane, dieldrin, DDTs and chlordanes) in mussels and oysters from 26 estuarine and coastal locations and in fin fish landed from all coasts, as well as heavy metals in water and sediments from nine estuaries, were measured by the Department of the Marine (DoM) between 1978 and 1988 (O'Sullivan *et al.,* 1991). These and some nutrient data were collected to comply with the Joint Monitoring Programme of the Oslo and Paris Commissions

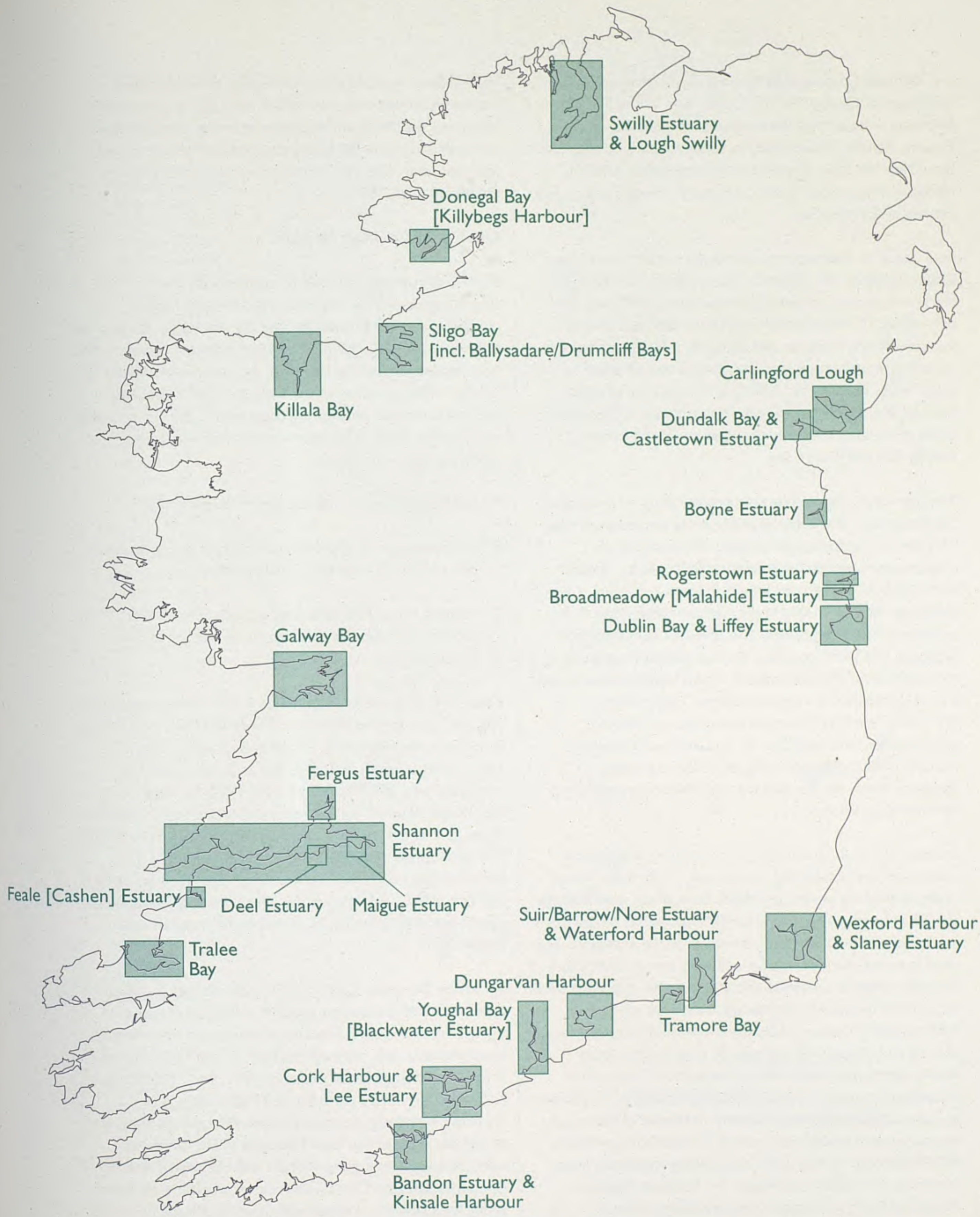


***Fig. 10.1** Estuarine and Coastal Waters which were Assessed for General Water Quality Conditions in the Period 1991-1994.*

and with the Co-operative Monitoring Programme of the International Council for the Exploration of the Sea. The following were among the locations sampled: Barrow Estuary, Bandon Estuary, Boyne Estuary, Clarinbridge, Clew Bay, Cork Harbour, Dublin Bay, Kilkieran Bay, Killary Harbour, Mulroy Bay, Shannon Estuary, Slaney Estuary, Suir Estuary and Tralee Bay.

Four cases of elevated concentrations of cadmium (Boyne Estuary, Mulroy Bay, Shannon Estuary and Waterford Harbour), two of copper (Cork Harbour and Tralee Bay), two of zinc (Cork Harbour and Tralee Bay) and two of mercury (Cork Harbour and Waterford Harbour) were reported. It was found that the general overall trend in metal levels was one of stability or, in the case of more marked contamination, of reduction over time. Decreasing levels of metals have been observed in Cork Harbour, Mulroy Bay and Tralee Bay.

The degree of organochlorine contamination was low in all the estuaries and shellfish growing areas sampled and was very low in the European context. No instances of contamination exceeding tolerance limits set for shellfish and fin fish for human consumption were recorded. It was concluded that with very few exceptions Irish coastal waters carried exceptionally low levels of contamination. Although this work confirms the non-polluted nature of most of Ireland's coastal waters, it also highlights the limited extent of the monitoring undertaken. The authors (O'Sullivan *et al.*, 1991), in reviewing the monitoring programmes, have called for an expansion of these to include more regular sampling, in order to provide a database which can be used for the effective protection of the marine environment.

Sources of metal contamination in estuarine and coastal waters include anti-fouling paints used on ships and other craft; particularly severe problems have arisen from tributyl-tin (TBT) based paints (Chapter 4). Most paints containing mercurial preservatives, such as water-based emulsions, are used in homes for decorating, and because containers and brushes/rollers are washed under the kitchen tap, they pass to the river or sea via the sewage treatment works. Mercury, which occurs naturally in the earth's crust, can also be introduced into the aquatic environment from mining, agricultural and industrial activities. Once in the aquatic environment, mercury is concentrated in fish tissues and, for physiological reasons, certain species concentrate mercury more readily than others. In accordance with the EC Decision of 19 May 1993 determining maximum limits for mercury in fishery products, the Fisheries Research Centre of DoM set in place a mercury monitoring programme for fish landed at the major fishing ports and shellfish growing areas and has reported the results for 1992 (Nixon *et al.*, 1993), 1993 (Nixon *et al.*, 1994) and 1994 (Nixon *et al.*, 1995a). The results show that total mercury concentrations in fin fish from the commercial catch and shellfish from the major growing areas are low and well within the EU tolerance levels for protection of the consumer, thus confirming previous studies (e.g., O'Sullivan *et al.*, 1991).

Quality of Shellfish Waters

EU Member States have had to comply with the requirements of a Directive 'laying down the health conditions for the production and the placing on the market of live bivalve molluscs' (CEC, 1991c) before 1 January 1993. The Department of the Marine is the responsible authority for the implementation of the Directive and it operates a shellfish sanitation monitoring programme, the aim of which is to classify shellfish growing waters according to the following three categories:

A can be collected for direct human consumption;

B purification in an approved plant for 48 hours required prior to sale for human consumption;

C relaying required over a long period (at least two months) in clean sea water prior to sale for human consumption.

Currently, 58 areas are monitored in the DoM programme (Fig. 10.2) under the Directive. Of these 32 are classified as A, five are partly A and B, 17 are in B category, one is categorised as partly A and C, one as B and C and the remaining two are classified as C. In 1990, 25 were monitored of which three were categorised as A, 15 as B, three as C and four were not classified (Clabby *et al.*, 1992). The situation in 1986 (Toner *et al.*, 1986) was that 13 locations were sampled of which five were A, seven were B and one was C. A full list of the sites with their most recent classification (O'Driscoll, M., pers.comm.) is given in Fig. 10.2.

An earlier Directive (CEC, 1979), requires that Member States monitor designated shellfish waters to ensure that the quality of the edible species is maintained or enhanced. In accordance with the requirements of this Directive four areas were designated in October 1981, viz. Clarinbridge, Kilkieran Bay, Killary Harbour and Mulroy Bay. The Directive was designed to protect shellfish *per se* but prior to the adoption of the later Directive (CEC, 1991c) the microbiological limit given therein was used as an interim consumer safeguard for shellfish eaten directly. Regulations giving legal effect to national standards under the Directive were issued in 1994 (Quality of Shellfish Waters Regulations, S.I. No. 200 of 1994) when a further ten locations (Bantry Bay, Glengarriff Harbour, Roaringwater

Shellfish Production Areas

1 Carlingford Lough (A; C)
2 Dundalk (C)
3 Ganderstown (A)
4 Mornington (C)
5 Wexford Harbour (B; C)
6 Bannow Bay (A)
7 Waterford Harbour (B)
8 Dungarvan Bay (B)
9 Youghal Harbour (B)
10 Cork Harbour (B)
11 Belgooly (A)
12 Courtmacsherry (A)
13 Rosscarbery (B)
14 Turk Head (A)
15 Sherkin Island (A)
16 Roaringwater Bay (A)
17 Dunmanus Bay (B)
18 Bantry (Inner) Bay (B)
19 Glengarriff (A)
20 Bearhaven (A)
21 Cleandra (A)
22 Ardgroom Harbour (A)
23 Kilmakilloge Harbour (A)
24 Templenoe (Kenmare Bay) (A)
25 Castlemaine Harbour (B)
26 Ventry Harbour (A)
27 Tralee Bay (A; B)
28 Ballylongford (B)
29 Poulnasherry (A)
30 Carrigaholt (A)
31 Galway Bay (A; B)
32 Kilkieran (A)
33 Mannin Bay (A)
34 Clifden (Derrygimbla) (B)
35 Derryinver (B)
36 Ballynakill (B)
37 Killary Harbour (B)
38 Clew Bay (A; B)
39 Mulrany (A)
40 Achill (B)
41 Belmullet (B)
42 Drumcliff Bay (A)
43 Ballysadare Bay (B)
44 Sligo Bay (A)
45 Laghy (A)
46 Bruckless (A)
47 Teelin (B)
48 Loughros (A)
49 Gweebarra (A)
50 Traweenagh (A)
51 Dungloe (A)
52 Carrickfin (A)
53 Gweedore (A)
54 Ballyness (A)
55 Sheephaven (A)
56 Mulroy Bay (A; B)
57 Lough Swilly (A)
58 Lough Foyle (A; B)

Classification where

A = can be collected for direct human consumption;
B = purification in an approved plant for 48 hours required prior to sale for human consumption;
C = relaying required over a long period (at least two months) in clean sea water prior to sale for human consumption.

***Fig. 10.2** Shellfish Production Areas Monitored and Classified by the Department of the Marine (DoM) Under Directive 91/492/EEC (CEC, 1991a).*

Bay, Bay at Aughinish, Cromane, Maharees, Kilmakilloge, Carlingford Lough, Clew Bay and Bannow Bay) as well as the above mentioned four were statutorily designated. The Minister for the Marine is the responsible authority for the implementation of this Directive. However, Article 5 of the Regulations requires that, in the event of non-compliance, local and sanitary authorities take all steps as may be appropriate under the Water Pollution Acts to secure conformity.

In 1994, water and shellfish samples were analysed from 19 sites (the above 14 as well as a site in Wexford Harbour, Cork Harbour, Kenmare Bay and two sites in each of Tralee Bay and Lough Foyle) for physico-chemical parameters and chemical contaminants respectively by DoM (Nixon *et al.,* 1995b). As in previous years, the water quality was good and complied with the requirements of the Directive. Petroleum hydrocarbons were not observed in any of the shellfish waters nor as deposits on shellfish; chlorinated hydrocarbon levels were low as were mercury and lead; but the level of cadmium in oysters from a number of areas was elevated. With regard to an explanation for the seemingly high cadmium levels, it has been suggested that oysters accumulate metals more readily than mussels and it has been concluded that the cadmium is not anthropogenic in origin (Nixon *et al.,* 1995b).

Quality of Bathing Waters

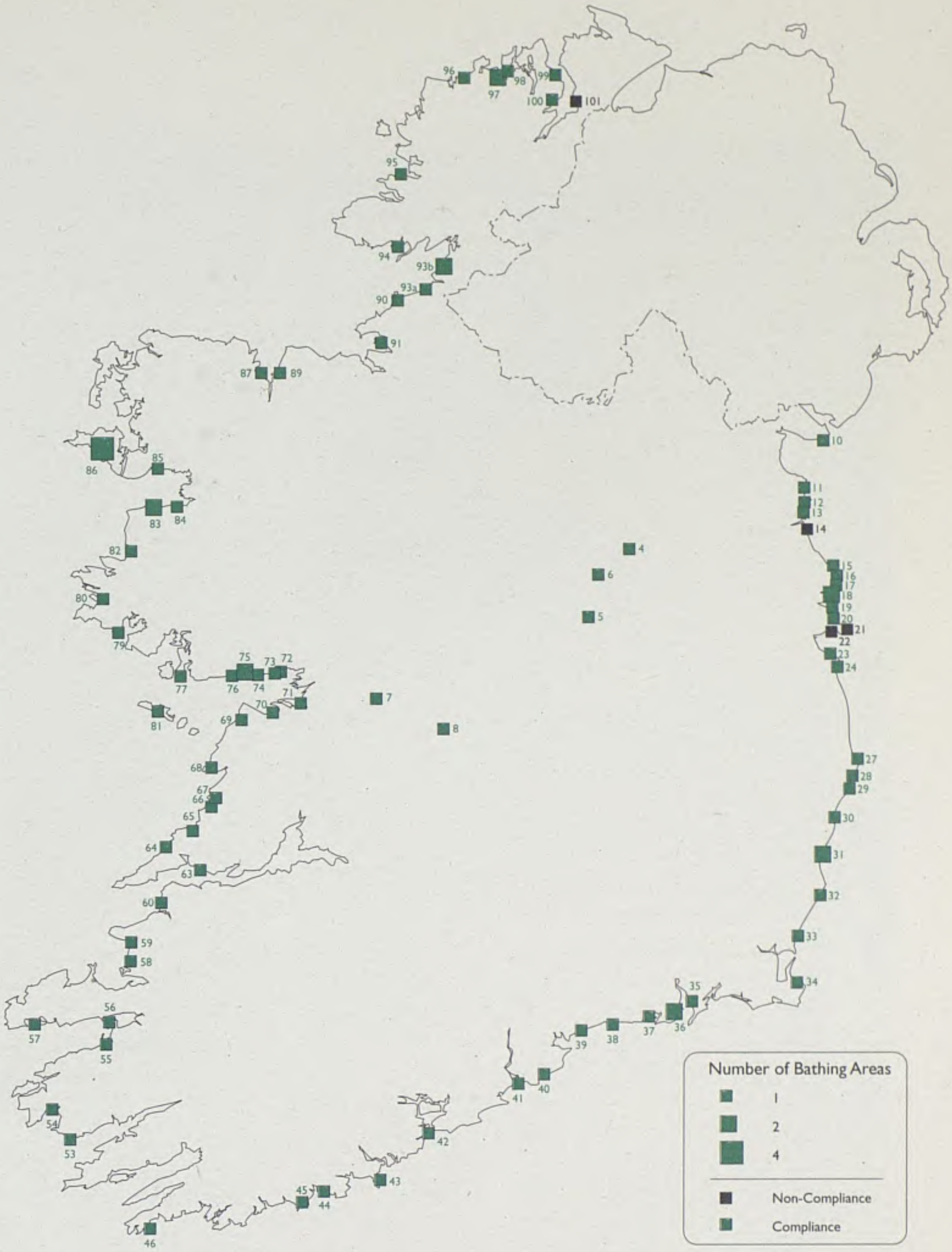
In accordance with the requirements of the 'bathing water' Directive (CEC, 1976) national standards, called national limit values (NLVs), were set in 1979 by the Minister for the Environment. These have been used since then as the basis for assessing the sanitary acceptability of bathing waters. Regulations were set in 1988 and in 1992 and there were further amendments in 1994. In an annex to this Directive, the European Commission provides both guide and mandatory levels for various microbiological and physico-chemical parameters. The Member States were given a ten-year period after notification - until 1985 - to bring their bathing waters up to the quality required by the Directive. For the purposes of the Directive the bathing season in Ireland lasts from the beginning of June to the end of August with sampling starting in mid-May and continuing until the close of the season.

The locations sampled under the Directive are listed in Table 10.1, according to local authority area, with the results for the more important microbiological analysis in 1991-1994 shown in Table 10.2 (see Figs. 10.3a and 10.3b for delineation of sites sampled in 1993 and 1994). The overall quality of bathing waters in Ireland remains high. The monitoring programme to assess compliance with national quality standards has been progressively extended in application, from 64 bathing areas in 1990 to 117 in 1994 (including nine located in fresh water (see Chapter 9)). In 1994, all of the 108 sampling points (at 107 seawater bathing areas) complied with the mandatory standards of the bathing waters Directive. Ireland was the only Member State to attain this at its seawater bathing areas (see Table 10. 3).

In previous years certain areas have failed to comply, e.g., Dollymount in 1987, Dollymount, Donabate and Sutton in 1988, Dollymount, Donabate, Loughshinney, Portrane and Suttton in 1989; Dollymount in 1990; Malahide in 1991; Dollymount, Sutton, Portmarnock, Loughshinny and Clifden in 1992; Dollymount, Sutton, Laytown/Bettystown and Lisfannon in 1993.

Bathing Water Areas

4 Lough Lene (The Cut)
5 Lough Ennell (Lilliput)
6 Lough Owel (Portnashangan)
7 Loughrea Lake
8 Lough Derg (Portumna)
10 Shelling Hill/Templetown
11 Lurganboy (Port)
12 Clogherhead
13 Seapoint
14 Laytown/Bettystown
15 Skerries
16 Loughshinny
17 Rush (South Beach)
18 Donabate
Portrane
19 Malahide
20 Portmarnock
21 Sutton (Burrow Beach)
22 Dollymount
23 Seapoint
24 Killiney
27 Silver Strand
28 Brittas Bay (North)
29 Brittas Bay (South)
30 Clogga
31 Courtown
Ballymoney
32 Morriscastle
33 Curracloe
34 Rosslare (Strand)
35 Duncannon
36 Dunmore East (Counsellors Strand)
Dunmore East (Dunmore Strand)
37 Tramore
38 Bonmahon
39 Clonea
40 Ardmore
41 Youghal (Main Beach)
42 Fountainstown
43 Garrylucas (White Strand)
44 Inchydoney
45 Owenahincha
46 Barley Cove
53 Derrynane
54 Ballinskelligs
55 Rossbeigh (White Strand)
56 Inch
57 Ventry
58 Banna Strand
59 Ballyheigue
60 Ballybunnion (White Strand)
63 Kilrush (Cappagh Pier & Beach)
64 Kilkee
65 Doonbeg
66 Spanish Point
67 Milltown Malbay
68 Lahinch
69 Fanore
70 Bishopsquarter
71 Traught
72 Salthill
73 Silver Strand
74 Na Forbacha
75 An Spideal
Spiddal Pier
76 Spiddal (An Cnoc)
77 Ceathru Rua (Tra na Doilin)
79 Cloch na Ron (Gortin)
80 Clifden
81 Inis Mor (Cill Muirbhtigh)
82 Louisburgh (Silver Strand)
83 Carrawmore
Louisburgh (Old Head)
84 Bertra
85 Mulranny
86 Achill (Golden Strand)
Achill (Keel)
Achill (Keem)
Doogort
87 Killala (Ross Strand)



89 Enniscrone
90 Mullaghmore
91 Rosses Point
93a Bundoran
93b Rossnowlagh
Murvagh
94 Fintra
95 Portnoo/Naran
96 Drumnatinny
97 Marble Hill
Portnablagh
98 Downings
99 Portsalon
100 Rathmullan
101 Lisfannon

***Fig. 10.3a** Bathing Water Quality in 1993 Showing Compliance with Mandatory Criteria of Directive 76/160/EEC at 91 of the 95 Sites (based on EC, 1994).*

Bathing Water Areas

1 Ballyallia Lake (Ennis)
2 Ballycuggeran Lake (Killaloe)
3 Lough Derg (Mountshannon)
4 Lough Lene (The Cut)
5 Lough Ennell (Lilliput)
6 Lough Owel (Portnashangan)
7 Loughrea Lake
8 Lough Derg (Portumna)
9 Keeldra Lake (Cloone)
10 Shelling Hill/Templetown
11 Lurganboy (Port)
12 Clogherhead
13 Seapoint
14 Laytown/Bettystown
15 Skerries
16 Loughshinny
17 Rush (South Beach)
18 Donabate
Portrane
19 Malahide
20 Portmarnock
21 Sutton (Burrow Beach)
22 Dollymount
23 Seapoint
24 Killiney
25 Bray
26 Greystones
27 Silver Strand
28 Brittas Bay (North)
29 Brittas Bay (South)
30 Clogga
31 Courtown
Ballymoney
32 Morriscastle
33 Curracloe
34 Rosslare (Strand)
35 Duncannon
36 Dunmore East (Counsellors Strand)
Dunmore East (Dunmore Strand)
37 Tramore
38 Bonmahon
39 Clonea
40 Ardmore
41 Youghal (Main Beach)
Youghal (Claycastle)
42 Fountainstown
43 Garrylucas (White Strand)
44 Inchydoney
45 Owenahincha
46 Barley Cove
47 The Warren
48 Coolmaine
49 Garretstown
50 Garryvoe
51 Tragumna
52 Redbarn
53 Derrynane
54 Ballinskelligs
55 Rossbeigh (White Strand)
56 Inch
57 Ventry
58 Banna Strand
59 Ballyheigue
60 Ballybunnion (White Strand)
61 Kells Bay
62 Castlegregory (Maharabeg)
63 Kilrush (Cappagh Pier & Beach)
64 Kilkee
65 Doonbeg
66 Spanish Point
67 Milltown Malbay
68 Lahinch
69 Fanore
70 Bishopsquarter
71 Traught
72 Salthill
73 Silver Strand
74 Na Forbacha
75 An Spideal
Spiddal Pier
76 Spiddal (An Cnoc)
77 Ceathru Rua (Tra na Doilin)
78 Tra Chaladh bhFuinnse
79 Cloch na Ron (Gortin)
80 Clifden
81 Inis Mor (Cill Muirbhtigh)
82 Louisburgh (Silver Strand)
83 Carrawmore
Louisburgh (Old Head)
84 Bertra
85 Mulranny
86 Achill (Golden Strand)
Achill (Keel)
Achill (Keem)
Doogort
87 Killala (Ross Strand)
88 Bellmullet (Mullaghroe, Elly Bay)
89 Enniscrone
90 Mullaghmore
91 Rosses Point
92 Strandhill
93a Bundoran
93b Rossnowlagh
Murvagh
94 Fintra
95 Portnoo/Naran
96 Drumnatinny
97 Marble Hill
Portnablagh
98 Downings
99 Portsalon
100 Rathmullan
101 Lisfannon
102 Fanad (Ballyhernan)
103 Culdaff
104 Derrybeg (Port Arthur Strand)
105 Buncrana (Lady's Bay)

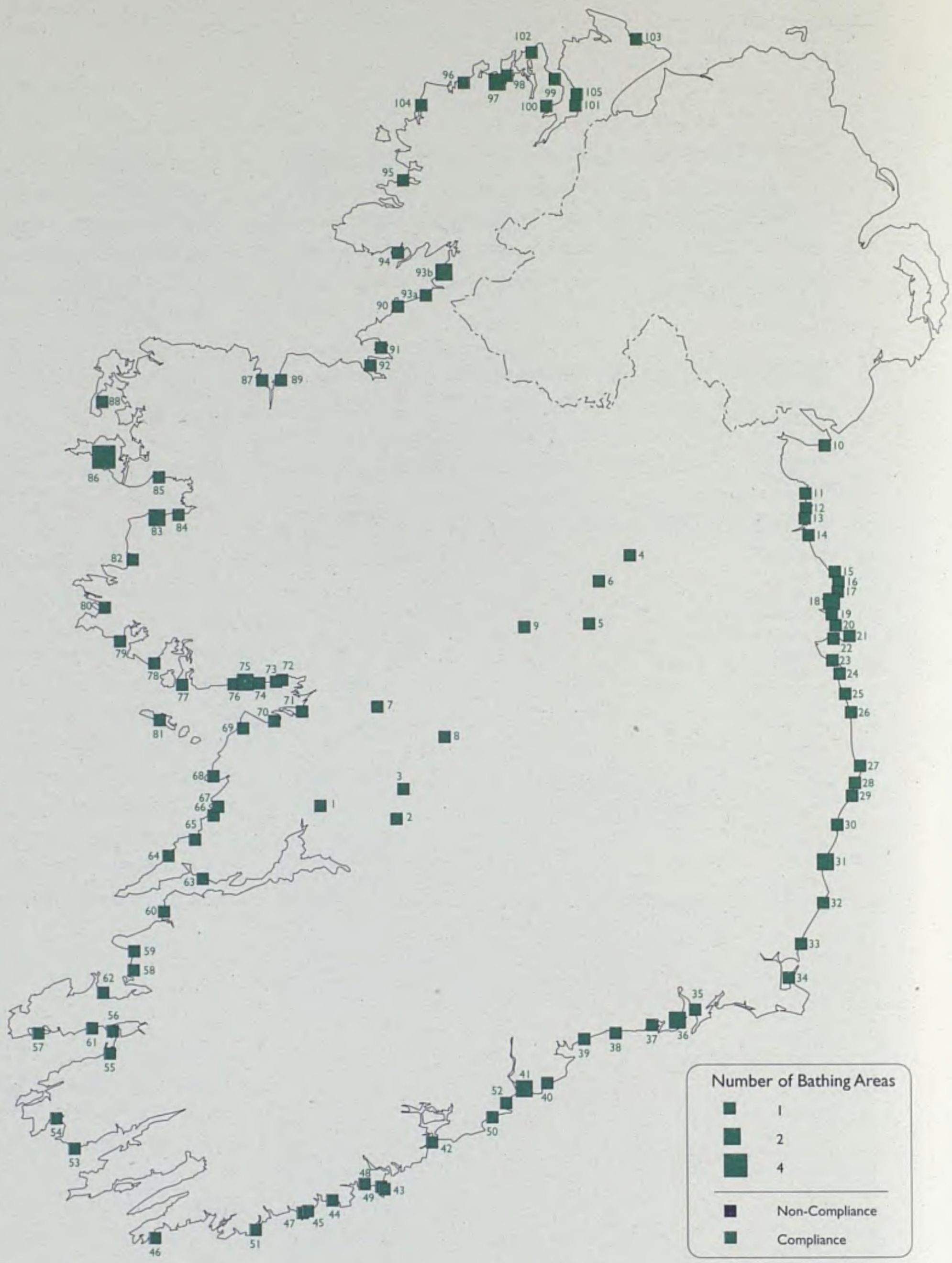


***Fig. 10.3b** Bathing Water Quality in 1994 Showing Compliance with Mandatory Criteria of Directive 76/160/EEC at the 117 Sites (based on EC, 1995).*

***Table 10. 1** List of Seawater Bathing Areas, Designated Under Directive 76/160/EEC (CEC, 1976) which were Sampled in 1994, with the Responsible Local Authority. Beaches which were Awarded Blue Flag status in 1995 are shown with an asterisk (*).*

Local Authority	Bathing Areas
Clare CC	Bishopsquarter
	Doonbeg
	Fanore
	Kilkee*
	Kilrush (Cappagh Pier & Beach)
	Lahinch*
	Miltown Malbay*
	Spanish Point*
Cork CC	Barley Cove*
	Coolmaine
	Fountainstown
	Garretstown
	Garrylucas (White Strand)*
	Garryvoe*
	Inchydoney*
	Owenahincha*
	Redbarn
	Tragumna*
	The Warren*
	Youghal (Main Beach)*
	Youghal (Claycastle)*
Donegal CC	Buncrana (Lady's Bay)
	Bundoran*
	Culdaff
	Derrybeg (Port Arthur Strand)
	Downings
	Drumnatinny
	Fanad (Ballyhernan)
	Fintra
	Lisfannon
	Marble Hill*
	Murvagh
	Portnablagh
	Portnoo/Naran*
	Portsalon*
	Rathmullan*
	Rossnowlagh*
Dun Laoghaire/ Rathdown CC	Killiney*
	Seapoint
Fingal CC	Donabate
	Loughshinny
	Malahide
	Portmarnock
	Portrane
	Rush (South Beach)*
	Skerries*
	Sutton (Burrow Beach)
Galway CC	Ceathru Rua (Tra na Doilin)*
	Clifden
	Cloch na Ron (Gortin)
	Na Forbacha
	Inis Mor (Cill Muirbhtigh)*
	Spiddal (An Cnoc)*
	Spiddal Pier
	An Spideal*
	Tra Chaladh bhFuinnse
	Traught*
Kerry CC	Ballinskelligs*
	Ballybunion (White Strand)*
	Ballyheigue*
	Banna Strand*
	Castlegregory (Maharabeg)*
	Derrynane*
	Inch*
	Kells Bay*
	Rossbeigh (White Strand)*
	Ventry*
Louth CC	Clogherhead*
	Lurganboy (Port)
	Seapoint
	Shelling Hill/Templetown*
Mayo CC	Bellmullet (Mullaghroe, Elly Bay)*
	Bertra*
	Carrawmore*
	Doogort*
	Achill (Golden Strand)*
	Achill (Keel)*
	Achill (Keem)*
	Killala (Ross Strand)*
	Louisburg (Old Head)*
	Louisburg (Silver Strand)
	Mulranny*
Meath CC	Laytown/Battystown*
Sligo CC	Enniscrone
	Mullaghmore*
	Rosses Point*
	Strandhill
Waterford CC	Ardmore
	Bonmahon
	Clonea*
	Dunmore East (Counsellors Strand)*
	Dunmore East (Dunmore Strand)*
	Tramore
Wexford CC	Ballymoney
	Courtown (North Beach)*
	Curracloe*
	Morriscastle
	Duncannon*
	Rosslare (Strand)*
Wicklow CC	Brittas Bay**
	Bray
	Clogga
	Greystones
	Silver Strand
Dublin Corp.	Dollymount Strand
Galway Corp.	Salthill*
	Silver Strand*

** Two sample locations

Blue Flag Beaches

The Blue Flag Awards Scheme was launched in EU Member States in 1987. It is organised by the Foundation for Environmental Education in Europe (FEEE) and supported by the European Commission. An Taisce (the National Trust for Ireland) took over the administration of the Blue Flag Scheme from the Irish Coastal Environment Group in 1993 (Department of the Environment, 1995). The blue flags are awarded by an independent non-national jury and assessment criteria require beaches to comply with the very high guideline standards of the bathing waters Directive, as well as meeting other requirements such as facilities for visitors, coastal management, environmental education and information display facilities. Blue flags were awarded to 66 beaches in 1991, 54 in 1992, 61 in 1993, 55 in 1994 and 66 in 1995. Three of the bathing areas awarded blue flags in 1994 and 1995 were fresh water (see Chapter 9).

Table 10.2 *Seawater Bathing Quality Monitoring Results 1991-1994 Showing Percentage Compliance with the Mandatory and Guide Values for Total and Faecal Coliforms (Source: Department of the Environment).*

Year	No. of sampling points	Compliance (%) Mandatory	Guide
1991	65	96.9	83.1
1992	90	94.4	86.7
1993	90	95.6	75.6
1994	108	100.0	89.8

Table 10.3 *Seawater Bathing Quality Monitoring Results for the EU Member States in 1994 Showing Percentage Compliance with the Mandatory and Guide Values (Source: Department of the Environment).*

Member State	No. of sampling points	Compliance (%) Mandatory	Guide
Belgium	39	92.3	30.8
Denmark*	1190	95.1	84.3
France	1870	90.3	69.4
Germany	444	80.2	59.0
Greece	1282	94.9	91.0
Ireland	108	100.0	89.8
Italy	4543	86.4	81.0
Netherlands*	52	63.5	46.2
Portugal	315	83.2	74.3
Spain	1490	96.1	83.4
United Kingdom	457	82.3	33.7

* Member States for which only data on faecal coliforms are taken into account.

Radioactivity Monitoring

The Radiological Protection Institute of Ireland (RPII) is the statutory authority responsible for monitoring radioactivity in the Irish environment. Included in its programmes is the ongoing surveillance of the Irish marine environment. The RPII and its predecessor, the Nuclear Energy Board, have issued three reports on monitoring in the Irish marine environment, covering the period 1987-1992 (O'Grady and Currivan, 1990a; O'Grady *et al.,* 1991; McGarry *et al.,* 1994) which are discussed below.

The major source of radioactive contamination of Irish marine waters is the discharge of low-level radioactive effluents to the Irish Sea from Sellafield, by British Nuclear Fuels, on the north-west coast of England. These discharges have been occurring on a routine basis since the early 1950s. Other discharges from the UK and elsewhere are of no measurable influence. Isotopes of caesium, particularly caesium-137 are of particular interest as they account for a substantial part of the Sellafield discharges, are widely dispersed in the sea and are readily taken up by aquatic flora and fauna.

Since the early 1980s there has been a continuous downward trend in radiocaesium concentrations in sea water in the north-west Irish Sea due to significant reductions in discharges from Sellafield (Fig. 10.4). It has also been shown that radiocaesium concentrations decrease with increasing distance from the point of discharge from this site, with concentrations along the south and west Irish coasts similar to levels from global fall-out.

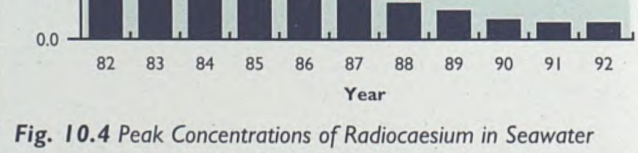


Fig. 10.4 *Peak Concentrations of Radiocaesium in Seawater from the North-west Irish Sea 1982-1992 (adapted from McGarry* et al., *1994).*

Contamination from the Chernobyl reactor accident in April 1986, had a transitory and, in the long-term, minor effect on the levels of man-made radionuclides in the Irish marine environment. Radionuclides used for diagnostic and other medical purposes, e.g., Iodine-131, can give rise to traces of radioactive contamination in some coastal waters close to discharge points. However, such discharges are very minor when compared with nuclear fall-out and discharges from Sellafield (O'Grady and Currivan, 1990b) and are regarded as being of no radiological significance in terms of overall effect.

Radiation doses due to the consumption of seafood have been calculated and show that these account for less than one per cent of the recommended annual dose limit set by the International Commission on Radiological Protection. These results thus indicate that there is no significant risk to health from consumption of fish from the Irish Sea. Contamination of water and sediments along the coast are also regarded as an insignificant source of radiation exposure to bathers and others.

Dumping at Sea

The disposal of industrial wastes at sea terminated in July 1993 and the target date for the ending of disposal of sewage sludge at sea is December 1998. In order to meet the latter requirement, alternative arrangements for the disposal of sludge from the Ringsend (Dublin) treatment plant and from those in other coastal cities and towns, due to be built over the next decade, will have to be made. By 1998, dredged materials from capital and maintenance works at harbours will be the only waste of any significance being dumped in Irish coastal waters and these, in accordance with obligations under the Oslo Convention, will be subjected to more detailed analysis than hitherto (Department of the Environment, 1995).

Waste Disposal in Harbours

The Sea Pollution Act, 1991, and Regulations made under this act in 1994, relating to the prevention of pollution by oil, the control of pollution by noxious liquid substances in bulk and the prevention of pollution by garbage from ships, enable Ireland to meet obligations under the MARPOL Convention. In January 1995 Ireland ratified this Convention which came into force in April 1995 (Department of the Environment, 1995).

Convention for the Protection of the Marine Environment

A major new Convention for the Protection of the Marine Environment of the North East Atlantic was agreed by 15 countries, including Ireland, and by the European Commission on behalf of the EU, in Paris in 1992. The Convention establishes a wide environmental protection regime for the marine environment in the north-east Atlantic and updates the provisions of the Oslo and Paris Conventions dealing with the prevention of marine pollution caused by dumping from ships and aircraft, and from discharges from land-based sources respectively. For this reason, it is known as the OSPAR Convention. A Quality Status Report for the seas covered by the Convention, including the seas around the Irish coast, will be completed by the year 2000. The Convention also provides for a permanent prohibition on the dumping at sea of high-level radioactive waste and for a prohibition, for 15 years, on the dumping of low and intermediate level radioactive waste. The Department of the Environment is leading an examination, by all Departments concerned, of measures necessary to implement the Convention's requirements and anticipates that Ireland will ratify the Convention in 1996.

AQUACULTURE

Aquaculture has evolved rapidly due to the development of new technologies, improved husbandry and a better market distribution network. Although home consumption of aquaculture products has increased, the main production is exported. Employment in the aquaculture sector has increased and many sheltered areas around the coast support some form of cultivation; the species cultured depends on local conditions. The aquaculture industry is sufficiently large to have established two representative organisations, the Irish Salmon Growers Association and the Irish Shellfish Association.

Fin Fish

Much of the technology for salmon farming evolved from the cultivation of rainbow trout in sheltered coastal areas. Rainbow trout production has remained relatively static, while salmon production has expanded rapidly (Fig. 10.5) with the development of offshore cages, now in general use. The salmon are harvested within 7 to 24 months of being introduced to the sea.

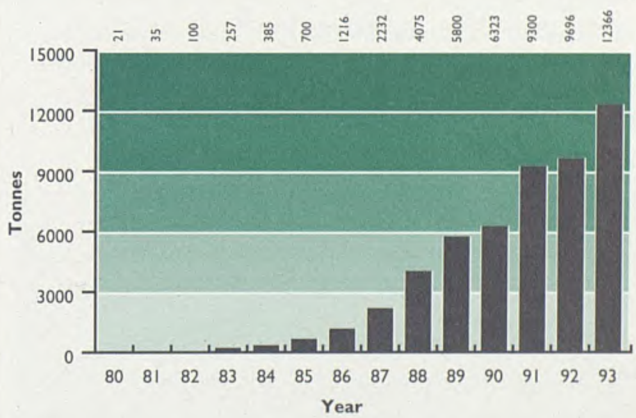


Fig. 10.5 Salmon Production 1980-1993 (Source: Central Fisheries Board).

Salmon production has been affected by sea-lice infestations, which cause skin erosion, resulting in the fish becoming susceptible to disease and osmotic stress. Sea-lice are monitored throughout the year to ensure that infestations are kept under control. Mean sea-lice levels have declined at most salmon sites during 1993 and 1994 due to the more effective use of therapeutants.

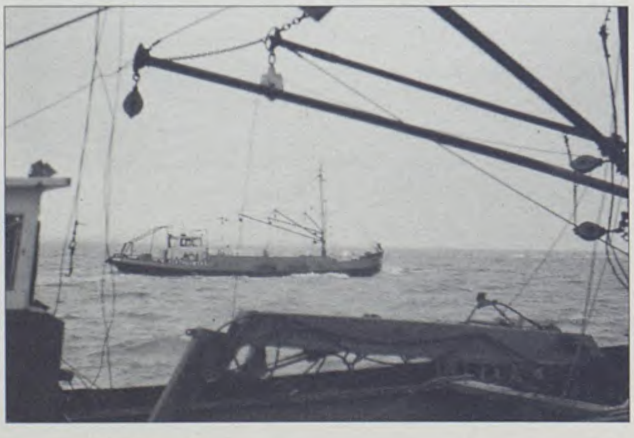
There are currently some experimental projects involving turbot cultivation; the first production took place in 1994 on Cape Clear Island. There is also some interest in bass cultivation.

Shellfish

The Pacific oyster was acquired from Wales following quarantine in the 1970s. Cultivation mainly consists of growing oysters within plastic mesh bags on trestles at the lowest water level in sheltered shallow bays. Oysters are tended during low water spring tides. Pacific oysters are normally harvested following 2-3 summers' growth.

With the introduction of the oyster blood-disease, *Bonamia ostraea,* which affects native oysters once they become mature, the production of and the demand for this species has fallen in Europe. The disease was first recorded in Ireland in 1987 in Cork Harbour and subsequently in Clew Bay. There is still some production in Cork Harbour but it is necessary to cultivate at low densities in order to avoid excessive mortalities. Settlement of oysters in ponds is now less actively pursued.

Mussel cultivation is practised in deep-water sheltered areas around the coast. In many cases, the mussels are grown on lines hanging vertically from head ropes suspended from barrels. Mussels are not in marketable condition when they are spawning and during the summer some areas may be subject to algal blooms which can result in mussels or oysters becoming toxic, causing diarrhoetic shellfish poisoning (DSP), when consumed (see box). Small mussels dredged off the east coast are re-laid on the bottom in Wexford Harbour, for ongrowing and are harvested subsequently.



Monitoring of Shellfish Production Areas for Phycotoxins

Some phytoplankton groups can produce compounds (phycotoxins) which are toxic to animals and humans. Because bivalve molluscs, such as clams, mussels and oysters, can filter large volumes of water, these phycotoxins may become concentrated in the shellfish. Since 1984 the Fisheries Research Centre of the Department of the Marine has operated a national monitoring programme for the detection of phycotoxins in shellfish and for the presence of the toxin-producing phytoplankton in water (McMahon, 1994). When a production area gives a positive result for the toxins then, under the terms of Directive 91/492/EEC (CEC, 1991c), restrictions on the harvesting and sale of the shellfish are put in place. Only when a negative result for two consecutive weeks is obtained will the area be reopened.

Phycotoxins have been associated with illness in humans, known as diarrhoetic shellfish poisoning (DSP), following consumption of shellfish. A potentially more serious condition known as paralytic shellfish poisoning (PSP) is apparently not a problem in Irish shellfish waters, although the causative organisms as well as PSP toxins have been recorded at low levels here in the past (e.g., from Cork Harbour in 1987); subsequent tests have all given negative results (McMahon, 1994). There are no antidotes available for any of the toxins involved nor can they be destroyed by cooking or processing methods and the only recourse is to take preventative measures such as prohibition of sale and to allow the shellfish to detoxify naturally. While most coasts in Ireland can be occasionally affected, the south-west is most liable to suffer from this seemingly natural phenomenon (although the scale can be enhanced by nutrient enrichment). In some years the shellfish production areas can be closed for extended periods. It is emphasised by the authorities here that the risk of contracting shellfish poisoning is minimal because of the efficacy of the monitoring and testing procedures in place.

Sea-urchins

Sea-urchins have been subjected to high rates of exploitation during the 1960s and 1970s by divers, principally in Bantry, Kenmare and Galway Bays; as well as being a food delicacy, these echinoderm species are collected for their 'tests' (skeletons) which are used for decorative purposes such as in lampstands. Population numbers are at present low and they are currently gathered from shore pools as well as by diving.

Mollusc Fisheries

There are several fisheries for molluscs in Irish waters, many of which are close inshore and subjected to high rates of exploitation.

The main production is from mussels, collected as seed, re-laid in growing areas and then dredged. The largest of these operations is in Wexford Harbour; seed mussels that settle on banks in the southern Irish Sea are removed and re-laid in Wexford Harbour.

There is interest in enhancement of the shellfish production of some sheltered shallow bays, where scallop growth is known to be fast, by sowing half grown cultivated scallops on the sea floor. These are later recovered with other scallops normally dredged in the fishery. This technique is currently under study at six sites on the south-west to north-west coasts.

The flat or native oyster occurs in sheltered shallow bays. Oysters occurred on all Irish coasts but owing to various land developments and high rates of exploitation, their populations are considerably reduced. The largest fishery for this species in Europe was off Arklow but this population was extinguished from over-exploitation during the last century. The oyster fishery depends on warm undisturbed summers for good settlement. The largest fishery is in Tralee Bay.

Clams were heavily exploited in the mid to late 1970s leaving sparse populations; some of these have been exploited recently but overall production is low.

Periwinkles provide a labour intensive and low capital cost fishery; they are gathered at low water, stored in sacks and exported. Much of what is exported is now graded. The rearing of the small periwinkles to market size is now being examined as an additional means to raise production.

The principal fishery for whelks is on the south-east Irish coast. Whelk harvesting has increased in recent years.

Squid and octopus are obtained as a by-catch in the demersal fishery and production levels are low.

(Source: Department of the Marine)

Exotic Organisms

As in agriculture, many of the aquaculture species are not native to Ireland. Currently rainbow trout, Pacific oysters and Pacific clams are produced for export. Further species in small scale culture include a Japanese and a European abalone.

Candidates for culture are screened carefully for diseases, pests and parasites before introduction. The International Council for the Exploration of the Sea (ICES) has a code of practice for intended aquaculture species to control irresponsible introductions that could give rise to ecological interference. Ireland has abided by this code. Fortunately, because Ireland is an island, few undesirable organisms have established themselves.

Earlier movements of shellfish have resulted in unintended introductions. These include the Chinese hat limpet *(Calyptraea chinensis)* to Clew Bay and Ballinakill Bay, and possibly a copepod, *Hermanella duggani,* which damages native oyster gills, and is generally distributed. In 1993 under the Directive (91/67/EEC), half grown oysters from France were re-laid at several sites in Ireland. This Directive permitted transfers of Pacific oysters which previous Irish legislation had controlled. These oysters were screened for two principal oyster diseases. Ecological implications had not been considered and at least four non-native species were introduced. One of these, a parasitic copepod, *Mytilicola orientalis,* has become established in Pacific oysters in Dungarvan Bay.

Fouling on the hulls of ships has resulted in the movement of many exotic species throughout the world. The tubeworm *Mercierella enigmatica* has caused serious fouling to water pipes in brackish water areas elsewhere in the world but in Cork Harbour it is sparsely distributed. However, the New Zealand barnacle, *Elminius modestus,* is commonly distributed in Ireland and in some areas is the dominant fouling organism.

More recently it has been recognised that ships ballast water discharge can result in serious ecological consequences, which include the transfer of toxic algal blooms either in the ballast water or ballast sediment. With the siting of shipping ports further downstream towards the sea, together with reduced crossing times, organisms from different biological zones have an increased risk of becoming transferred. The issue of ballast water is currently of concern to the International Maritime Organisation and ICES.

(Source: Department of the Marine)

COASTAL ZONE MANAGEMENT

Consultants were commissioned in 1995 by the Minister for the Environment, the Minister for the Marine and the Minister for Arts, Culture and the Gaeltacht to prepare a strategy document on Coastal Zone Management in Ireland. The strategy is intended to provide a coherent framework for the co-ordinated management of coastal areas. This is with a view to developing an integrated national policy for Coastal Zone Management which will promote environmentally sensitive, sustainable use of the coastal zone, balancing the demands for coastal resources and promoting environmentally sensitive use of, and strategic planning for, the coastal zone. Relevant developments at international (particularly EU) level are to be reviewed. A conference on Coastal Zone Management, with the subtitle 'from needs to action', was held in Dublin in September 1994 (Carroll and Dubsky, 1995).

A study, commissioned by the Office of Public Works (OPW) in 1994, is currently assessing the effects of intertidal shellfish culture within Special Protection Areas. A major project entitled ECOPRO (Environmentally Friendly Coastal Protection), which is partly funded by the EU LIFE programme, is being undertaken by DoM and Forbairt with the involvement of universities, local authorities and Coastwatch (see below) as well as foreign research institutes (Department of the Environment, 1995). Amongst the project outputs, a 'code of practice' is being drafted to provide a guide to the assessment of a coastline's sensitivity to erosion and of the suitability of various protection methods.

The BioMar project is a joint marine and coastal management initiative involving the identification, description and mapping of marine and maritime habitats and communities. The work on this project is being carried out by the National Parks and Wildlife Service and TCD, along with the Joint Nature Conservation Committee (JNCC), Newcastle University and the Dutch conservation organisation AIDEnvironment. The objectives are to develop a clearly defined classification system for marine habitats and communities, to make a European inventory of marine areas with statutory protection and to develop a list of candidate sites for inclusion in Natura 2000 under the habitats Directive (CEC, 1992). The BioMar project runs from 1993 to 1996 and is being partly funded by the EU Life programme.

Coastwatch Europe is an international environmental NGO project co-ordinated from Ireland which has been running for six years. In 1994 it involved 22 countries. It provides a snap-shot survey of the coastline, in which areas are surveyed simultaneously and in a similar manner, thereby producing comparable results. This gives a general overview of the state of the coastline. In Ireland, the Coastwatch Europe survey is carried out from 1-14 October by volunteers comprising local people, school children, scouts and other members of the public. It involves filling out questionnaire forms in the field, on allocated survey areas, which are subsequently returned to the Coastwatch Europe office for compilation, analyses and interpretation.

In the 1994 survey, approximately 12 per cent of the Irish mainland coast was surveyed in this manner. Results suggested a worsening in the water quality of local inflows to coastal areas and only a marginal reduction in litter (Dubsky and Carroll, 1995). There also appeared to be some changes to coastal biota, e.g., increase in jellyfish. However, these results were very tentative and would require more detailed research to confirm the results obtained. Further research, information and management needs can be based upon the results generated from these surveys. These surveys also help to raise public awareness of coastal zone issues, they provide an indication of the problems and threats to the coastline and also aid interdisciplinary environmental education.

MARINE RESEARCH AND DEVELOPMENT

The Marine Institute (Foras na Mara) is the national agency whose functions, as defined by the Marine Institute Act 1991, are: "to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to marine research and development that in the opinion of the Institute will promote economic development and create employment and protect the marine environment". It now includes the Fisheries Research Centre.

ISMARÉ - The Irish Marine Data Centre was established in 1993 by DoM and now comes under the direction of the Marine Institute. It has developed a computerised directory of sources of marine environmental data in Ireland known as 'the Extended EDMED for Ireland'. Based on the original EDMED (European Directory of Marine Environmental Data) the directory aims at identifying and describing the various types of marine data available in Ireland, the form in which these data are held and how they may be sourced. Although the directory describes over 300 data collections, from a large cross-section of the marine community, it is reckoned that this is only a small representation of the actual data holdings in existence in Ireland (Irish Marine Data Centre, 1994). Recently, requests for new submissions and updates of existing ones have been made. Other projects, undertaken by the Data Centre, include a database of published material on marine observations (Moriarty, 1995); this already contains 600 records from the *Irish Naturalists' Journal* (Kelly *et al.*, 1995). Other journals and library sources will be scanned in due course. The database is being compiled by the BioMar group at Trinity College Dublin (TCD).

CONCLUSIONS

As most collected sewage is discharged to estuarine or coastal waters, with only some five per cent receiving secondary treatment at present, it is not surprising that localised pollution adjacent to coastal towns and cities is in evidence. Secondary treatment is the standard requirement for larger coastal towns (of 10,000 or more population equivalent) under the Urban Waste Water Treatment Regulations 1994. Opposition to the siting of treatment works, however, can lead to prolonged delays in sewerage schemes. The Department of the Environment (1995) envisages that the EU Cohesion Fund will support schemes at the following locations: Dublin, Cork, Drogheda, Dundalk, Limerick, Greystones, Tramore and Westport, most of which can be identified as having localised pollution problems (Bowman *et al.*, in press).

Almost one-half (26) of the 58 shellfish areas assessed did not achieve the highest quality rating, thus implying that they are affected to some degree by faecal pollution. This, however, reflects the very stringent microbiological requirements in place for the marketing of shellfish that are to be consumed directly, in order to safeguard public health.

Perhaps the greatest achievement in the past decade regarding quality of waters was when, in 1994, Ireland was the only Member State with all its designated bathing areas complying with the mandatory requirements of the EU bathing water Directive. Maintaining this positive development should be an objective for future years, along with alleviation of the localised pollution problems from urban sewage.

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TERRESTRIAL ENVIRONMENT

INTRODUCTION

The terrestrial environment, for the purposes of the present chapter, comprises the land (including rocks and soil), natural and artificial landscapes, and rural and urban settlements. Certain other aspects of the terrestrial environment are dealt with elsewhere in the report. Flora and fauna are considered in Chapter 12, and aspects of the coastal margin are dealt with in Chapter 10.

Ireland is still frequently regarded as a rural society but, as noted in previous chapters, the process of urbanisation has been proceeding apace since the 1960s. In the urban environment itself there have been large shifts of population leading to the development of satellite towns around the larger cities. The rural environment has also changed with increased specialisation and mechanisation in farming.

LAND COVER AND LAND USE

Land Cover

The nature of land cover in Ireland is a result of factors such as the climate, past and present, geological history, the uses to which land has been put in the past, and also its current uses. For example, there was a time when a large part of the country was covered by forests. By the beginning of the present century, forest cover had been virtually eliminated. At present, after significant re-afforestation programmes, forests, mostly coniferous, account for about eight per cent of land cover.

In 1985 the Commission of the European Communities (CEC) set up the CORINE Programme, an environmental information system comprising a series of thematic databases, including one on land cover. In 1992 a CORINE Land Cover Project Team was established and was jointly co-ordinated by the Ordnance Survey of Ireland with the Ordnance Survey of Northern Ireland with the objective of producing a land cover map for the whole island of Ireland.

The methodology was based on visual interpretation of satellite imagery. CORINE Land Cover has a hierarchical classification system involving three different levels. At level 1, there are five categories as follows:

- artificial surfaces;
- agricultural areas;
- forest and semi-natural areas;
- wetlands (including bogs);
- water bodies.

Each of these is sub-divided at the subsequent levels, e.g., wetlands are divided into inland and maritime wetlands at level 2, and these in turn are then further subdivided at level 3. The CORINE Land Cover Map of Ireland has been produced on two sheets at 1:500,000 scale. The final product is also available as a digital land cover database in geographic information system (GIS) format. The varied uses of the CORINE Land Cover database for Ireland have recently been summarised (O'Sullivan, 1995). These uses include, *inter alia,* the provision of information of relevance to water resources management, air pollution and land use management.

The preliminary CORINE land cover statistics for Ireland have also been summarised (O'Sullivan 1994). The statistics for Ireland (excluding Northern Ireland) for the five main categories are shown in Fig. 11.1.

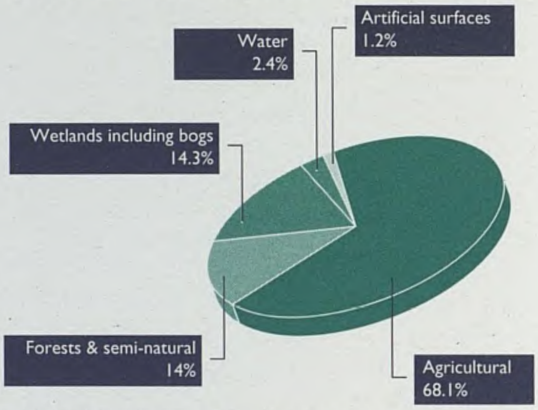


***Fig. 11.1** CORINE Land Cover Statistics for Ireland, excluding Northern Ireland (O'Sullivan, 1994).*

It is important to note that consideration of the results of the CORINE project must take into account the methodology used in deriving the database. For example, because it is based on satellite imagery (1989-1990), only forests above a certain level of maturity are included. There has been an appreciable amount of new planting in recent years and therefore the percentage of land cover for forests is acknowledged to be significantly under-represented in the database. The 1991 Census of Agriculture shows that just over 63 per cent of Ireland's land area is used for agriculture (69 per cent when commonage is included). Conceptual differences between 'land cover' and 'land use' must be noted also in this context. It is difficult, therefore, to be precise, and the CORINE statistics as presented in Fig. 11.1 may be taken as giving an approximate distribution of land cover in Ireland around 1989-1990.

General Aspects of Land Use

The transformation of land resources into land uses is influenced by several factors which may be broadly categorised as physical, historical, behavioural, economic and political. Social patterns of ownership and control of land are reflected in farm sizes, field patterns and levels of fragmentation. The most important influences on recent changes in agricultural production are the changing international market conditions which have also resulted in major changes in European Union (EU) policies.

A comprehensive system of land use planning has been in operation in Ireland since 1964. Under the Local Government (Planning and Development) Acts, 1963 to 1993, each of the country's planning authorities is obliged to prepare, at least once every five years, a Development Plan setting out the development objectives for its area. Provisions of the Plan must be taken into account when all applications for development consent are being considered by the relevant authorities. Decisions by planning authorities may be appealed to An Bord Pleanala by individuals or organisations, as well as by those seeking consent.

The Government is drawing up a series of guidelines covering land use issues associated with agriculture, industry, forestry, aquaculture and tourism. These guidelines are intended to provide a comprehensive national and local framework for land use planning. A proposal for a land use policy was prepared by the Irish Farmers Association (1995).

The forces of change in land use in Ireland have been noted in a recent policy statement by the Irish Landscape Institute (1994). Urbanisation has created new demands on the countryside as a visual amenity, a place for recreation, a location for second homes and a repository of cultural, historical and other values. The somewhat reduced influence of agriculture as the principal factor affecting the landscape is creating a vacuum which other forms of land use or land management are seeking to fill. These include lowland forestry, organic farming and agri-tourism.

LANDSCAPE QUALITY

Landscape is a constantly changing mosaic, the product of interaction between the land, climate, nature and human development. It is not only attractive usually to the eye, but also a place in which to live and work, for example, at farming and forestry. The landscape supports two of Ireland's three largest economic activities, i.e., tourism and agriculture. The management of land, water and air quality are integral to the use and maintenance of this natural resource.

As the landscape is largely a by-product of human activities, it is vulnerable to change by these activities. Altered farming practices, for example, can transform the countryside. These can cause changes such as underpopulation, loss of natural habitats and altered scenery. The goal of optimised production from the countryside is not always compatible with the maintenance of its scenic attraction.

Agricultural landscapes, which have crop and non-crop features, comprise a variety of habitats. These include arable land, grassland, aquatic and riparian zones and a variety of boundary and woodland habitats. The landscape is also a natural resource which provides habitats for wild species of plants and animals. The preservation of endangered species and natural habitats and the ability to maintain biological diversity is closely linked to protection of the landscape and its diversity.

In 1977, An Foras Forbatha, with the assistance of the International Union for the Conservation of Nature and Natural Resources (IUCN), compiled a national inventory of landscapes of outstanding value. These landscapes were classified into the following categories:

(i) high relief terrestrial;
(ii) low relief terrestrial;
(iii) lakes;
(iv) rivers;
(v) high relief marine;
(vi) low relief marine;
(vii) islands.

The total area covered at that time by what was termed the heritage landscape was about 17.6 per cent of the State. Some of the more important landscapes are now within the areas of National Parks (see Chapters 2 and 12).

THE RURAL ENVIRONMENT

The rural environment is considered to be all areas outside urban settlements of more than 1,500 persons. Some significant aspects relating to the state or quality of the rural environment and its natural resources are considered below.

Agricultural Land

As noted earlier, agricultural land constitutes by far the greater part of the terrestrial environment in Ireland. Therefore the environmental quality of agricultural land is a particularly important issue, both in itself and in its interactions with other environmental media such as air and water. The key concerns relating to agriculture and the environment have been listed by the CEC (1992), and in relation to the terrestrial environment, include the following:

- human health consequences of residues in food, water and soil due to the use of pesticides, fertilisers, hormones, veterinary products, and feed supplements;
- loss of fauna and flora;

- soil compaction, erosion and pollution due to inappropriate farming methods;
- habitat loss;
- landscape change;
- odours.

Thus there are many large issues involved. The questions of soil quality and the degradation of land are considered in separate sections later in this chapter; flora, fauna and biotopes are considered mainly in Chapter 12. The issues regarding the amounts of residues in food and in drinking water do not fall within the scope of the present report, although the issues of environmental contamination and related factors giving rise to such residues are considered in the relevant parts of the report.

The various strong odours deriving from typical farming activities are for the most part regarded as a normal aspect of the rural environment. Significant problems may arise from intensive livestock units or from particular practices, such as the landspreading of slurry and blood, unless proper guidelines are followed, for example, those being developed for best available technology not entailing excessive costs (BATNEEC) by the Environmental Protection Agency.

Throughout the 1970s, substantial increases in agricultural production in Ireland were associated with greater specialisation in farming systems and increases in the scale of each enterprise at farm level (Walsh, 1994). By the late 1970s, it was evident that the policy of encouraging increased output through high price supports could not be sustained indefinitely. Beginning in the 1980s, the Common Agricultural Policy (CAP) was reformed and various measures were adopted to make European agriculture more market orientated. These included

- quota restriction on output volumes;
- reduced levels of price support for products in surplus;
- a limit on the quantities of production for which prices are guaranteed;
- less open-ended and more selective use of the intervention system;
- the introduction of 'set-aside' land and other measures (Walsh, 1994).

Under EU policy, alternative non-food producing uses for set-aside land have been defined, such as the growing of crops for energy production (bio-fuels, vegetable oil or biomass).

Structural factors, for example, the low incidence of long-term leasing and late inheritance of land impose restrictions on land use. To help redress these defects a scheme was introduced in the mid-1980s to encourage the earlier transfer of farms to young farmers. In January 1994 an early retirement scheme for farmers was introduced.

The principal changes in agricultural land use in the period from 1980-1990 were as follows (Walsh, 1994):

total agricultural area:	1 per cent reduction;
area of arable crops:	24.9 per cent reduction.

Most of the land withdrawn from tillage was used for hay or pasture. In the livestock sectors, the main trends were the expansion in sheep numbers over the entire decade and the switch from dairying to beef enterprises after 1984 (see Chapter 2). These macro-scale adjustments indicate that a high level of enterprise substitution has taken place in response to changes in the operation of CAP.

Potential Roles of Semi-natural Habitats in Good Agricultural Practice

Increased mechanisation has led to the removal of hedgerows which are semi-natural habitats. In supporting insect-eating wildlife, these habitats can assist in the reduction in usage of pesticides. They are part of the farming landscape and their potential role in the context of sustainability has been summarized as follows:

- promotion of ecological stability in crops;
- reducing pesticide use: exploiting pest predators and parasitoids;
- enhancing crop pollinator populations;
- buffering pesticide drift;
- reducing fertiliser and other pollutant movement, especially in runoff;
- reducing soil erosion;
- promotion of biodiversity and farm wildlife conservation;
- maintaining landscape diversity;
- promotion of game species;
- encouragement of "countryside" enterprise.

(Marshall, 1993)

Forestry

Forestry and the Environment

Forest cover in Ireland (Fig. 11.2), at eight per cent of the land area, is the lowest in Europe. In Europe as a whole, forests cover about 33 per cent of the land, with the highest cover occurring in Finland at 66 per cent (Stanners and Bourdeau, 1995).

The total planting levels in Ireland are now almost 30,000 ha per annum (including re-afforestation) which was the target in the National Development Plan 1994-1999. The most dramatic change in relation to planting has been private

Fig. 11.2 *Forest Cover in Ireland (Source: Coillte).*

sector planting which has risen from under 300 ha per annum in the early 1980s to around 10,000 ha per annum in the early 1990s (Fig. 11.3). The rate of planting of trees per capita in Ireland is very high by comparison with other developed countries. Forest cover as a percentage of total land area is increasing at a rate of about a third of one per cent every year. Forestry is thus one of the significantly changing aspects of the terrestrial environment in Ireland.

The National Development Plan recognises forestry as a land using enterprise suitable to many parts of Ireland which represents an increased resource for employment and recreation. In this decade Ireland will become a net exporter of timber.

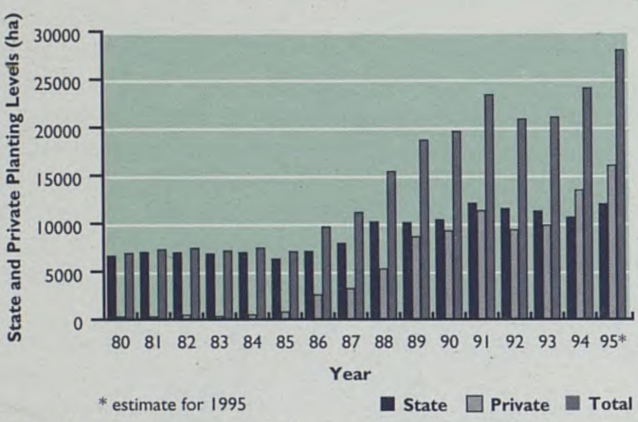


Fig 11.3 Forestry: State and Private Planting Levels 1980 -1995 (Source: Coillte and DAFF).

Trees planted are mainly Western North American conifers with increased planting of broadleaf trees in recent years. The proportion of broadleaf species in Irish forests, at 10 per cent, remains much lower than in any other EU country, with the UK, the next lowest, having 27 per cent. This is attributed largely to the poor quality of land that has been available to the State for afforestation (COFORD, 1994). A target has been set of up to 20 per cent broadleaf content (higher payment is made for broadleaves in the grant scheme).

Irish forests are free of the most serious forest pests and diseases that afflict the forests of other EU countries. Accordingly, Irish forests are a disease-free source of forest products which do not threaten the health of European forests.

Trees are of immense benefit to the environment. For example, they absorb carbon dioxide from the atmosphere and store it in the form of timber. Managed plantation forests are more efficient at carbon fixation than natural forests. It has been estimated that four tonnes of carbon can be absorbed by one hectare of trees per annum. Forests act as an atmospheric filter in removing pollutants from the atmosphere. However where forests are on poor soil types, there can be consequential effects on watercourses, and, in some countries, a deterioration in forest health. Forests also reduce soil erosion by wind and water, and control land-slips.

Forest Parks

	areas (ha)
Ards, Co. Donegal	491
Avondale, Co. Wicklow	212
Curragchase, Co.Limerick	230
Dun-a-Ri, Co. Cavan	227
Farran, Co. Cork	44
Gougane Barra, Co. Cork	141
Killykeen, Co. Cavan	240
Lough Key, Co. Roscommon	340
Portumna, Co. Galway	606
Rossmore, Co. Monaghan	263
Donadea, Co. Kildare	50

The combined numbers of visitors to these Forest Parks has exceeded half a million annually in recent years.

(Source: Coillte)

It has been stated that many new forests planted since the second World War have little environmental value because they have been designed to fulfil commercial objectives only, and that many plantations have damaged some of Ireland's important landscapes and wildlife habitats (An Taisce *et al.*, 1994).

The issue of the relationship between afforestation and biodiversity is a complicated one. Monoculture, by definition, is the opposite of biodiversity. Views on the value of conifers as opposed to broadleaves vary. Recent studies in Britain, show that conifer plantations may contain 18 times as much insect life as the same area of native broadleaf woodlands. This insect life supports an entire food chain going up to birds and mammals (Tickell, 1994). On the other hand, the avian fauna of conifer plantations is considered to be sparse. The age of forests is a particularly important factor, and it is necessary to take a long-term view on the changes which occur over different phases of growth and felling.

The planting of conifers can have an effect on the visual quality of the landscape and, if not sensitively designed and managed, there can be considerable devaluation of landscape quality. The practice of developing plantations with straight-line boundaries in landscapes which otherwise have a natural appearance has been considered to be particularly intrusive. The normal practice of clear-felling can leave areas with a very unattractive appearance, in the short-term at least.

On poor soils in upland areas, afforestation with conifers may have the potential to increase soil acidification with consequential impacts on watercourses. A further concern in relation to forestry, as with agriculture, is the potential for the release of pesticides to sensitive aquatic environments which would affect fish and spawning beds downstream (Christie *et al.,* 1994).

All forest developments must now adhere to guidelines issued by the Forest Service, and these deal, in particular, with the relationship between forestry and each of the following: landscape, fisheries and archaeology. Grant aid will not be given where afforestation is likely to affect the environment adversely. This is expressly stated to include areas of peatlands notified to the Forest Service by the National Parks and Wildlife Service (NPWS) as being of national or international importance for conservation. The views of local authorities are also to be considered by the Forest Service. Planning permission and an Environmental Impact Statement are required for initial afforestation of more than 200 ha.

Forest Condition

Ireland is included in a series of surveys carried out as part of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests under the Convention on Long-range Transboundary Air Pollution. The report on the 1994 survey (EC-UN/ECE, 1995) notes that no evidence of pollution damage has been observed since the surveys started in Ireland in 1987. Improvement in the condition of particular tree species, between 1993 and 1994, was attributed to reduced incidence of a harmful aphid species. Wind exposure and shoot die-back due to a fungus caused deterioration in the colour of the tree species examined.

The absence of evidence of pollution damage in a broad survey of this nature does not mean that damage to trees, possibly of a localised nature, does not occur in Ireland, or has not occurred in the past. Clearly, however, pollution damage to general forest condition is not a significant problem in relation to the environment of the country.

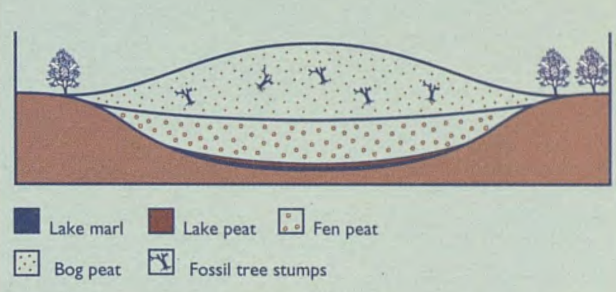
Peatlands

Peatlands (Fig. 11.4) are unique ecosystems. Ireland has the best remaining raised bogs in Europe and awareness of the value of this unique resource has increased in the last decade. Peatlands once covered 1.18 million ha (17 per cent) of the State. Three broad categories of peatland are recognised: the blanket peatlands of the western coast and higher mountainous regions, the raised bogs of the midlands and fen peats. The following are the original areas accounted for by each type of peatland:

blanket peatlands	770,000 ha
raised bogs	310,000 ha
fens	100,000 ha
total	**1,180,000 ha**

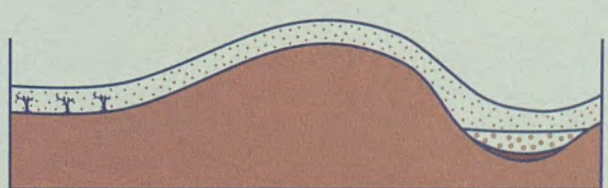
The Formation of Bogs

Raised Bogs



At the end of the glacial period, 10,000 years ago, the midlands of Ireland took the form of a low-lying plain, covered by undulating glacial deposits in which depressions were largely lake filled. Peat began to form in these basins. Initially it formed as fen peat within the hollows, but eventually, the hollows filled and developed into dome shaped raised bogs. These bogs can attain thicknesses of 12 m, with average depths of about 7 m.

Blanket Bogs



Owing to the development of a climatic pattern dominated by cool, wet summers with very high humidity, blanket peat began to form on the higher mountains in all parts of the country and also on lower ground on the western seaboard. Initiation of this type of peat, which can attain thicknesses of 6 m and averages about 2.5 m took place at various localities in the period between 4,150 and 2,150 years ago.

(Source: Geological Survey of Ireland)

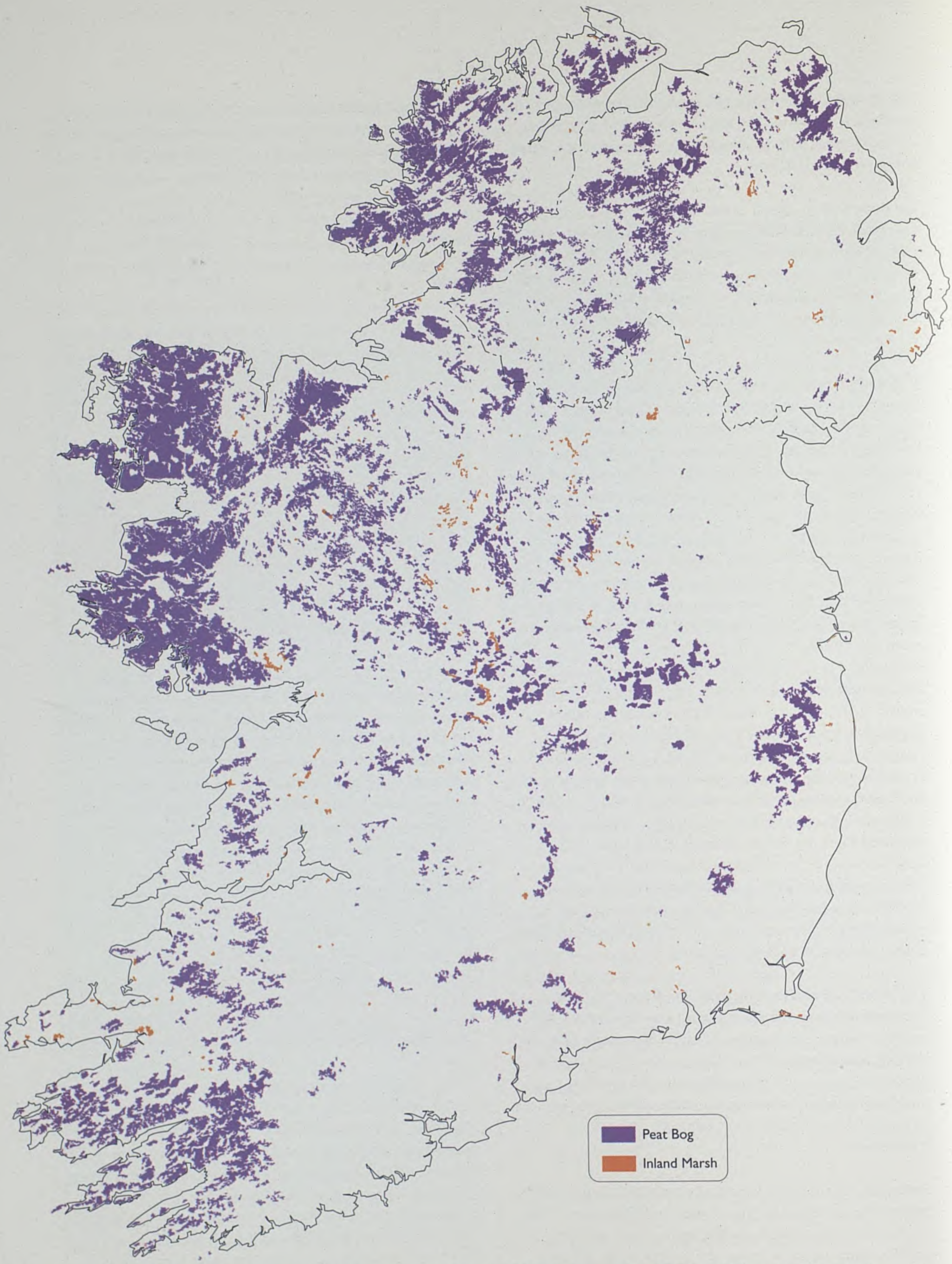


Fig. 11.4 CORINE Inland Wetlands Land Cover in Ireland (Source: EEA Task Force and CORINE Land Cover (Ireland) Team).

As noted in Chapter 2, peat has long been used in Ireland as a source of fuel. Bord na Mona, the Irish Peat Board, has acquired some 88,000 ha of peatland mainly in the midland counties. Over five decades, it has produced some 130 million tonnes of peat which has been used as a fuel for both electricity production and domestic heating and as horticultural peat mainly for export markets. Until recently, the mechanical extraction of peat was confined mainly to lowland areas, but in some mountain areas a change from the traditional practice has occurred with the commencement of mechanical extraction.

The Government set a target in 1987 to conserve 10,000 ha of raised bog and 40,000 ha of blanket bog. Most areas within the ownership of Bord na Mona worthy of conservation have been acquired by the National Parks and Wildlife Service and the Bord does not acquire bog units listed for conservation. Many areas listed for conservation and still without statutory protection are in private ownership.

Research and pilot developments over the past 30 years have clearly identified the future uses appropriate to various cutaway areas (the term used to describe the peatland area left after peat extraction). Cutaways are extremely complex areas and no single use is appropriate to all areas. Cutaways contain varying peat types and depths overlying complex soils in areas with differing drainage potentials. Surveys suggest that the likely future uses of cutaway areas are as follows:

coniferous forestry:	40-50 per cent
hardwood forestry:	10-20 per cent
grassland:	20-30 per cent
wetlands:	20-30 per cent

Wetlands Created from Cutaway Bog

The potential of cutaway bogs as forestry and grassland sites has been recognised for a number of years but only in recent years has it been possible to demonstrate the potential to create wetlands which are proving to be high quality wildlife habitats, especially for migrating waterfowl.

An example of this is Turraun Bog, Co. Offaly where large numbers of Whooper Swans *(Cygnus cygnus)* have been counted in recent years.

Minerals Exploration and Development

Mining has been carried out in Ireland since the Bronze Age but until the twentieth century this was only on a small scale. Most of the old workings, while sometimes still visible, are environmentally insignificant. They have become a part of the landscape and are sometimes of current or potential tourist and/or archaeological significance.

As noted in Chapter 4, modern mining, which may involve the extraction of millions of tonnes of material every year, has the potential for a wide range of significant impacts. These can include ground and surface water pollution, air emissions, noise, vibration, visual impact, traffic, loss of habitat, loss of water supplies, and the generation of large volumes of solid waste which could cause long-term pollution problems.

The issues of most concern relate to possible long-term effects after the closure of mines and to ensuring that mines are designed to prevent such problems developing. A number of sizeable mines were opened during the 1960s and closed in the 1980s. In some cases, the long-term rehabilitation of the sites is complete. Studies are underway in relation to the Avoca area to investigate possible mitigation options at the old mine workings.

Mining wastes have accumulated at various mining sites. The main sites are at Navan (Tara), Avoca, Silvermines including the Magcobar barytes open-pit, Tynagh and Gortdrum, where the tailings impoundments and dumps contain several tens of millions of tonnes of waste, but there are many smaller sites from earlier periods of mining. The major issue is the long-term rehabilitation of both tailings and coarse waste so that they are not a source of pollution either by airborne dust or by leachates containing heavy metals. They can also constitute a significant source of visual intrusion.

The two main current operations at Navan, Co. Meath, and Knocknacran, Co. Monaghan, operate under strict planning and licensing controls. Both are widely regarded as examples of best mining practice. Permission has been granted recently for an underground zinc-lead mine at Galmoy, Co. Kilkenny.

New mining developments are now subject to integrated pollution control (IPC) licensing. Terms and procedures for prospecting licenses under the Minerals Development Acts, 1940 to 1979, were produced in 1994 by the Department of Transport Energy and Communications. The general principle is for environmentally responsible management as an integral component of all exploration programmes. Revised guidelines for good environmental practice in mineral exploration were issued in September 1995.

THE BUILT ENVIRONMENT

Although cities and towns are centres of social, economic and cultural activities, they are also the places where problems affecting the environment become obvious. Water, energy and materials are imported, used to produce goods and services, and are then returned to the environment as emissions and waste. The demand for space and other resources arises from the density of urban populations, mobility and lifestyles (Stanners and Bourdeau, 1995). Some new habitats are created in the process of urbanisation. These include parks and gardens which may act as refuges for fauna and flora, and have led to increases in populations of species that benefit by living alongside man.

In the 1970s and 1980s there was a reduction in population of the inner areas of the large urban centres and a rapid increase on the periphery of such centres. There was also an increase in individual houses in rural areas within commuting distance of towns and cities. There was a trend towards building office blocks in city centre areas.

As noted in earlier chapters, the urban structure is very strongly biased towards Dublin, with over one-third of the country's population living in the area influenced by this city. While Dublin city itself has been losing population, the suburbs and towns around the city, and the nearby countryside have been showing a strong growth trend. The most marked increase in urban population is in towns around Dublin with a population of 10,000 - 20,000. In particular, the development of three 'western towns', Clondalkin/Lucan, Tallaght and Blanchardstown has allowed Dublin to expand.

Outside Dublin growth in the urban areas and their environs is concentrated particularly in the areas of Cork, Limerick and Galway. Satellite towns that have developed around the larger cities in Ireland include Ballincollig in Cork.

Much new housing has been built in low density suburbs, which has set the pattern for housing development in Ireland. Of the estimated one million houses in the country, approximately one-third were built by local authorities and sold to tenants under various purchase schemes.

In contrast with past trends of decline in central areas of cities there are recent signs of urban renewal. Since 1991 about 4,000 apartment units per annum have been built in the city centre area of Dublin. There has been an upsurge in public housing in areas at or near the city centre. Since 1986 various urban renewal schemes of tax incentives have given impetus to this revival of city centres. In 1994, following a comprehensive review, the scheme was re-launched with substantial changes. The revised incentives were weighted more in favour of residential development than previously and in favour of refurbishment rather than redevelopment.

Various inner-city land use surveys in Dublin and Cork have indicated complete vacancy rates as high as 30 per cent in secondary commercial streets. In central Dublin it has been estimated that there are as many as 10,000 vacant units over business premises.

The results of a survey carried out early in 1994 are summarised in Table 11.1. For the towns surveyed, a total of 1,619 derelict sites were identified covering 143.3 hectares. As these towns contain about 17 per cent of the urban population, it is considered reasonable to assume a national total of the order of 9,500 derelict sites.

Issues of air quality are of particular importance in the urban environment (Chapter 8). In addition, traffic congestion is a particular problem in Dublin and in some other urban centres. The question of indicators for the urban environment is addressed in Chapter 16.

***Table 11.1** Urban Renewal: Scale of Need 1994.*

Town/City	No. of Derelict Sites (ha)	No. of Vacant or Partially Vacant Buildings
Dublin (Inner City)	690 (61.5)	3820
Limerick	323 (19.4)	332
Waterford	65 (4.0)	214
Sligo	23 (10.9)	54
Drogheda	29 (2.0)	57
Kilkenny	131 (11.3)	88
Clonmel	20 (2.8)	200
Dundalk	40 (1.6)	50
Bray	56 (12.0)	56
Letterkenny	12 (5.3)	58
Ennis	89 (0.8)	80
Tullamore	76 (8.1)	40
Portlaoise	11 (3.6)	28
Tralee	54 (17.4)	103
TOTAL	**1,619 (160.7)**	**5,180**

(Source: Department of the Environment)

DEGRADATION OF LAND

Soil is a matrix of organic and mineral constituents enclosing a network of voids and pores which contain liquids and gases; it is formed so slowly in nature that it can be considered essentially as a non-renewable resource (Stanners and Bourdeau, 1995).

Land in Ireland was not intensively used for the greater part of the present century. With accession to the EU, however, grants of various types became available which encouraged intensive and specialised farming developments. It was not foreseen at the time that such specialisation would lead to damage to the land.

Soil erosion, as a result of overgrazing by sheep, is primarily a problem on mountain, upland and blanket bog commonages. Steep slopes, high rainfall and peaty soils are characteristic features of the west and south-west coastal areas. In recent years, severe overgrazing has taken place in these areas. Overgrazing diminishes the cohesive presence of plant roots, with the result that the covering layers of thin soil and blanket bog are eroded by rain and wind, and over time, a gradually extending area of bare rock, almost devoid of vegetation becomes exposed.

Peat, because of its low bulk density, suffers compaction from trampling by animals, and this alters the oxygen conditions and affects plant roots. Removal of biomass by grazing, the destruction of the sphagnum moss cover and the compaction of the soil surface results in faster runoff of surface water. Damage to freshwater systems in overgrazed catchments has been noted. Insufficient vegetation remains to mesh the soil which can then be readily washed away into watercourses exposing the underlying bedrock. Peat silt washed into lakes reduces light thereby inhibiting algal growth and hence salmon and trout productivity (Douglas, 1995).

The overgrazing problem has arisen because of the increase in mountain sheep numbers resulting from income support measures. Mountain ewe numbers increased from 0.7 million in 1975 to 2 million in 1992 but have declined somewhat since then (Chapter 2). In these areas much land is farmed in common and the effect of the income support measures has been that many farmers built up their flocks irrespective of whether or not the land could sustain the increased numbers.

In 1992, with the CAP reform, the numbers of sheep in the country eligible for ewe premium payments was set at the 1991 figure by the introduction of a sheep quota. There should, therefore, be no increase in sheep numbers in the future as a result of the limit on premium payments.
The division of commonage is not necessarily a part of the solution as it may result in other undesirable environmental changes.

The Rural Environment Protection Scheme (REPS) seeks to address the problem of the degradation of privately owned and commonage areas by overgrazing. It provides for an annual area payment for five years of £122 per hectare up to a maximum of 40 hectares to farmers who carry out a range of measures for managing their land in an environmentally friendly manner, including avoiding degradation of land. This payment includes compensation for loss of income for complying with this latter measure.

Regarding commonages in specific areas of counties Mayo, Donegal, Leitrim, Galway, Kerry and Sligo, REPS provides a generous extra incentive to farmers for removing all their sheep from the designated commonages for the six month period, November to April (the most vulnerable period) each year. Where it is not possible to bring the stock down for the six month period, REPS has recently been revised to allow farmers to reduce stock numbers to sustainable levels, which may then be allowed on the commonage land throughout the year. Extra incentives are also available for group participation. While the Department of Agriculture, Food and Forestry expects that the various measures introduced will go a considerable way towards solving the overgrazing problem, the matter will be kept under close review.

It has been demonstrated also that soil erosion in arable lowland areas and soil susceptibility to erosion has increased under modern arable farming systems. There has been an increase in the problem by the elimination of ditches and dykes under land reclamation (Lee, 1995).

ENVIRONMENTAL QUALITY OF SOIL

Soil may be degraded either through contamination, from a variety of sources, or through physical changes such as erosion and compaction. It has been noted that because legislation aimed at environmental protection in most countries started with water and air, this has left soil increasingly exposed to threats, e.g., from increases in the disposal of wastes on, or in, soil, once this was banned in other environmental media (Lee, 1995).

Trace Elements

All trace elements occur in variable amounts in soils. A survey (Table 11.2) was undertaken of soils in 11 counties in Ireland (McGrath, 1995). The results of the survey showed that in general the amounts of toxic trace elements were similar to amounts associated with unpolluted soils elsewhere. However, one soil had elevated contents of nearly all trace elements. This was attributed to geochemical factors rather than human induced contamination.

The trace element content of town soils (Wexford town), particularly garden soils, exceeded that of agricultural soils. Lead in particular was elevated in urban soils from both garden and amenity areas. Aerial deposition was strongly