Action in Partnership

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Background document

WATER AND HEALTH IN EUROPE

ETC IW

UNDER CONTRACT TO THE EUROPEAN ENVIRONMENT AGENCY

Foreword

There are profound pressures on Europe's water resources that impact upon health, economy and sustainable development. Industrialisation, intensification of agriculture, growing populations and increases in recreational demands accentuate the necessity for a sufficient quantity of good quality water resources. Conflicts between uses and users coupled with the occurrence of natural disasters such as droughts and floods highlight the need for sustainable management of water. Universal access to safe drinking water and sanitation protective of human health and the environment is a primary concern in the pursuit of health and development. Nevertheless, water-related diseases occur throughout Europe to which rural populations, the socially excluded and populations in areas affected by armed hostilities are particularly vulnerable.

Although improvements have been made in some aspects of water quality and supply in some countries over the last decade, progress has been variable and the 1990s has been a decade of renewed emphasis on microbiological quality and acknowledgement of previously unrecognised and re-emerging microbiological and other hazards. Many of the suggested solutions are as applicable today as they were in 1989. However, major changes in administrative arrangements have affected many countries of Europe in the 1990s resulting in impacts on the supply of water and sanitation services, land-use activities, pollution control and public health surveillance-related activities.

In 1984 the Member states of WHO/EURO adopted a Health for All Policy. Target 20 of that Policy states that *'By the year 2000, all people should have access to adequate supplies of safe drinking water'*. In the same time scale *'pollution of groundwater sources, rivers, lakes and seas should no longer pose a threat to health'*. The European Union Fifth Environmental Action Programme of 1993 sets targets for groundwater protection up to 2000. These include the prevention of permanent overdraft and all pollution by point sources and reduction of diffuse source pollution. Water resources across Europe are shared and connected across national boundaries and therefore in order to sustain Europe's water resources and to provide safe water for its inhabitants it is necessary to promote international co-operation.

Partnerships and action are key themes of the Interministerial Conference, London, 1999. To this end WHO Regional Office for Europe in partnership with UN/ECE have prepared a new protocol to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes. The protocol requires signatories to take account of human health, water resources and sustainable development. 'Water Resources and Human Health in Europe' provides information on many of the issues covered by the draft protocol such as adequate supplies of drinking water and sanitation, water for irrigation and recreational use, monitoring of hazards and public participation in decision-making. The evidence presented in this publication was collected through an extensive co-ordinated data-gathering process in which many organisations and individuals throughout the European Region have co-operated.

This publication is the second in a planned series of joint productions by the European Environment Agency (EEA) and WHO Regional Office for Europe concerned with the environment and health. It takes forward some of the issues raised in the first publication 'Environment and Health 1, Overview and Main European Issues' which highlighted the importance of the quality and availability of water in improving health effects. It is aimed at a broad readership and is intended to present the key issues in a format that can be appreciated by policy-makers, sector professionals and the general public alike.

The twenty-first century will no doubt present a number of challenges in the water environment. A co-ordinated approach to data collection, processing and management in Europe to support decision-making and to improve the reliability of environmental information will be essential to meet these challenges. We look forward to continuing successful co-operation between WHO and EEA into the year 2000 and beyond.

Executive Summary

Shortage of water may currently be the most urgent health problem facing some European countries, exacerbated by geography, geology and hydrology. In addition, climate change is predicted to have an influence especially in coastal areas where flooding may cause disruption of sanitation infrastructure and resultant contamination of watercourses. While many parts of Europe are currently well provided with freshwater, the water resources are unevenly distributed between and within countries, leading to shortages in many areas. Those countries that are heavily populated and receive only moderate rainfall are particularly affected. Groundwater and surface waters have a limited capacity for renewal and pressures from agriculture, industry and domestic users impact on the quantity of water resources. It is thus essential that both water quality and availability must be integrated in long-term planning and policy implications concerning water management.

The extent of provision of piped drinking water supplies to households varies across Europe and between urban and rural populations, with rural populations in the East of the continent least well provided. Continuity of supply is also a problem in some areas. Inefficient use of water, due to factors such as network leakage and inappropriate irrigation, appears to be a significant problem.

The utilisation of water for irrigation and for industry exert pressures on water resources which vary widely between countries and regions. One of the biggest pressures is agriculture and the changes in irrigation practices. In terms of water use agriculture accounts for approximately 30% of total water abstractions and around 55% of consumptive water uses in Europe.

Changes in population, population distribution and density are key factors influencing the quantity of water resources through increased local demand for water in areas of high population density or limited precipitation.

Although high standards have been reached in some countries, outbreaks continue to occur across the continent and small supply problems are encountered in all countries. The immediate area of public health concern across the continent is microbiological contamination, which can affect large numbers of people. The standard of treatment and disinfection of drinking water is inconsistent across Europe and, particularly where economic and political changes have led to infrastructure deterioration, can be insufficient. It appears that an increased number of outbreaks of water-borne diseases have occurred in these countries. However, there is a lack of reliable data on the quality of source and drinking waters and outbreak detection and investigation is generally poor in most countries. Inadequate sewerage systems are a significant threat to public health. Private and small public supplies are identified, by a number of countries, as those most liable to receive insufficient treatment, or protection in the case of groundwater sources, and thus to be of poor quality. Incidents of waterborne disease occur predominately in areas with poor infrastructure resulting in a discontinuous supply. Poor infrastructure may be associated with financial constraints and/or organisational disruption. However, the installation of advanced treatment works in large supplies is increasing in many countries although even in countries with high standards of supply occasional outbreaks of water-borne diseases are reported. No clear trends are detectable however, and there is poor international

comparability of data, hindering development of regional assessments and evaluation of progress.

A wide range of chemicals are found throughout the aquatic environment, but often evidence of any impact on human health, except for impacts arising from accidental releases, is difficult to obtain. Problems of significant chemical contamination are often localised and may be influenced by geology or anthropogenic contamination. Concern about the impact of agriculture on the quality of water resources is often related to diffuse sources - contamination by agrochemicals, nutrients and microbiological pathogens in particular.

One of the major threats to European surface waters is eutrophication. Common fertilisers contain varying proportions of nitrogen, phosphorous and potassium. The use of fertilisers varies between countries, depending on the economic situation and predominant agricultural practices. Although point sources of pollution, such as sewage discharges may contribute significantly to nutrient enrichment in some regions diffuse sources - such as agriculture - are the major contributors and in some countries the proportion of water pollution due to diffuse sources is steadily increasing.

Industrial demand and effects on water quality may be especially pertinent to urban areas with high populations, due to the traditional location of industry in these areas. The amount of water used by industry and the proportion of total abstraction varies greatly between countries although since 1980 there appears to be a trend of decreasing abstraction for industrial purposes in Europe. Industrial processes produce contaminated wastewaters that may be, either directly or following treatment, released into marine and fresh surface waters. Contamination may persist for several decades.

Considerable evidence has been accrued linking the quality of bathing waters with minor illnesses. The use of water for recreational activities is intrinsically linked to economics through the tourism industry and thus the quality of such waters is of considerable importance to tourism-dependent communities.

Although some improvements have been made over the past decade co-ordinated efforts are still needed to ensure that Europe's population is supplied with wholesome and clean drinking water and have access to safe recreational water. These include measures to control demand and prevent, contain and reduce contamination through improving water and sanitation management at international, national and local level. One particular problem that has been highlighted through the compilation of this publication is the need to harmonise monitoring procedures where possible. Pivotal to the success of improved and harmonised monitoring programmes and ensuring the safe use of water is the incorporation of education and awareness initiatives.

Additional efforts are required to sustain the Regions water resources and to provide safe water for its inhabitants, both for drinking and other purposes. Irrigation, drinking water supply, industry, agriculture and leisure make competing demands upon quality and quantity of resources, in addition to the needs for water to maintain the aquatic ecosystem *per se*. Fragmented management of water has arisen because of the existence of diverse stakeholders and regulatory perspectives. Pollution control measures have traditionally targeted point sources of pollution rather than diffuse sources.

Trends in water management in Europe include moves towards catchment-level management and improved inter-sectoral co-ordination and co-operation and frameworks facilitating stakeholder participation. This approach is developed by the EU in the Water Framework Directive that sets targets of good ecological status for all types of surface water bodies, and good quantitative status for groundwater.

A radical reappraisal of the roles of government and especially private sector participation in water management and in drinking water supply and sanitation in particular are occurring. The extent of this varies across the continent. International action plans and conventions have been agreed upon, with targets for the reduction of pollution and measures necessary to reach the targets.

There is a need for partnerships and co-operation between the environment and health sectors at all levels of government in order to disseminate technology, improve management and to provide financial and institutional support in order to ensure access to safe water and sanitation to all. Integrated management systems must be adopted to ensure the conflicting uses are managed in an effective manner to ensure safe use. It is not only long-term management that should be considered, responses are required to unexpected events such as natural disasters or accidents with large-scale impacts that can heavily influence the quality and quantity of water used for consumption.

Experience suggests that international management agreements develop most rapidly when the water body is shared or bordered by a small number of States at a similar level of economic development. The United Nations/Economic Commission for Europe Convention on Protection and Use of Transboundary Waters and International Lakes provides a strong future focus for integrated management of water bodies.

The aim of this publication is to integrate this information on the state of the raw water sources, with information gathered on the quality and provision of potable water, and the impact on human health. The state of water resources in Europe has been reviewed, considering both availability and quality. It assesses the accessibility and quality of potable supply across the Region and describes the public health implications of inadequate and contaminated sources.

Representatives of all Member States of the WHO's European Region were invited to complete a questionnaire on aspects of drinking water quality and waterborne diseases and to provide national reports, where available. Responses were received from approximately half of the Member States. Information on aspects of water resources and infrastructure and general data relating to land use and population were also requested. During development of this report extensive use was made of published literature and previous assessments made by the EEA, although the area currently covered by this organisation does not coincide with that of WHO/EURO (Table 1.1). Preparation of this document involved the participation of 17 countries in the European region. Member States plus further experts were invited to review the first draft of the publication. The work of the individuals concerned was central to completion of the work and is much appreciated.

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Table 1.1: Members of the WHO/EURO and EEA (✓) and responses received (x)

Country	WHO		EEA		Country	WHO		EEA	
Albania	✓	x			Liechtenstein		X	✓	
Andorra	✓	x		x	Lithuania	✓	X		X
Armenia	✓				Luxembourg	✓	X	✓	
Austria	✓	x	✓	x	Malta	✓	X		
Azerbaijan	✓				Republic of Moldova	✓	X		
Belarus	✓	x			Monaco	✓	X		
Belgium	✓	x	✓		Netherlands	✓	X	✓	X
Bosnia & Herzegovina	✓	x			Norway	✓	X	✓	X
Bulgaria	✓				Poland	✓			
Croatia	✓	x			Portugal	✓		✓	
Czech Republic	✓	x			Romania	✓	X		
Denmark	✓		✓	x	Russian Federation	✓			
Estonia	✓	x			San Marino	✓			
Finland	✓	x	✓	x	Slovakia	✓	X		X
France	✓	x	✓		Slovenia	✓	X		X
Georgia	✓				Spain	✓	X	✓	X
Germany	✓	x	✓	x	Sweden	✓	X	✓	X
Greece	✓	x	✓		Switzerland	✓	x		
Hungary	✓	x			Tajikistan	✓			
Iceland	✓	x	✓		The Former Yugoslav Republic of Macedonia	✓			
Ireland	✓	x	✓	x	Turkey	✓	x		
Israel	✓				Turkmenistan	✓			
Italy	✓		✓		Ukraine				
Kazakhstan	✓				United Kingdom	✓	x	✓	X
Kyrgyzstan	✓				Uzbekistan	✓			
Latvia	✓	X		x					

Note: Data is also collected by the EEA from countries in addition to the official 18 members (e.g. the countries of the PHARE Programme).

Glossary of Abbreviations

AOC Assimilable organic carbon
BOD Biochemical oxygen demand
BP Biological production
CAP Common Agricultural Policy
CAS Central Asian States
COD Chemical oxygen demand
DWI Drinking Water Inspectorate
E. coli Escherischia coli
ECPA European Crop Protectiom Agency
EEA European Environment Agency
EFTA European Free Trade Association
EPA Environmental Protection Agency
ETC/IW European Topic Centre on Inland Waters
EU European Union
FAO Food and Agriculture Organisation of the United Nations
GAC granulated activated carbon
GDP Gross Domestic Product
IARC International Agency for Research on Cancer
IP Integrated Production
IPCC Intergovernmental Panel on Climate Change
IPM Integrated Pest Management
MAC Maximum Admissible Concentrations
MRL Minimum Required Levels
NFP National Focal Point
NIS Newly Independent States
NSA Nitrate Sensitive Areas
PAC Powdered activated carbon
PAHs Polycyclic aromatic hydrocarbons
PCB Polychlorinated biphenyl
PCE Tetrachloroethene
STW Sewage Treatment Works
TCA 1,1,1 trichloroethane acid
TCE Trichloroethene
TDS Total dissolved solids
THMs trihalomethanes
UN/ECE United Nations Economic Commission for Europe
uPVC Unplasticised polyvinyl chloride
WHO World Health Organisation
WHO/EURO European Region of the World Health Organisation

Contents List **PAGE**

INTRODUCTION

Water – the basis for development and wealth

Developments and improvements in health across the European region over the centuries have been possible on the basis of proper management of the vital resource water. Effectively managed, water supply and resource protection systems, generate the inevitable basis for agricultural and industrial production. Healthy urban and rural development occurred throughout the region, where effective water source management has taken place. While in many growing cities in the Region this process started as early as the 15^{th} and 16^{th} century, at least five decades of the 19^{th} century saw water as a central occupation of all State and industrial leaders. As a result, and in the course of the first half of the 20^{th} century, life expectancy increased, food supply became more healthy and infant mortality decreased. A number of major diseases no longer posed a serious threat to the health of European people. Scientific and technical development has made excellent water supply feasible for public, farming and industrial purposes all over the region. With only a few exceptions, the region as a whole was, by the mid-1970's, on the way to eradicating water-related diseases and to guaranteeing safe water to all.

It is obvious that industrial development and wealth has been dependent upon safe and reliable water supply and management. It has been demonstrated as the single most effective investment in economic and social development, and no other part of socio-economic development has continued to be as incredibly cost-effective in relation to the wealth created. Over a wide range of income distributions, citizens in rich and poor countries have to invest less than 1 per cent of the average income to ensure excellent water supply and resource management. This may be perceived as a major success. But, on the other hand, it may also be the reason for the loss of focus on the central role of water in societies' development and well-being: Always present and cheap, water supply has been taken for granted, and efforts to build and maintain both technical and human resources have lost their visibility and political weight. Instead of sustainable development, progressive erosion of responsibility by individuals, industry and civil servants has been realised. The withdrawal of public and governmental responsibility, gave room for privatising attractive portions of the available funds while basic elements were ignored or left to the public. While this happened mainly in the west of the Region, the eastern part failed to encourage local responsibility and accountability, with the sole result that locally visible processes of decay and lack of maintenance were omitted from the agenda of political and economic decision-makers. Thus, east and west clashed in the early 1990s with two accelerating processes of destabilisation, in public services in general, and in water management in particular.

Combating the creeping freshwater crisis - in competition or partnership?

The competition amongst agriculture, industry and urban areas for limited water supplies has intensified with populations increase and economies growing. The intensification of agriculture, modern forestry practices and the diversions of water for irrigation are key areas that place additional stresses on water resources. Widespread mismanagement of water resources in the past amongst all sectors – industry, farmers, large urban populations and small communities has contributed to the creeping freshwater crisis silently threatening the European Region. Little recognition has been given to the worsening local conditions in the privatised water supply of the United Kingdom, while water abuse in cotton farming under the Soviet regime was publicly accused. The continuous water crisis in southern European farming regions remained largely unchanged, even though, considerable quantities of water diverted or pumped for irrigation is wasted. Abuse of large bodies of water such as the two big rivers feeding 60 billion cubicmeters annually into the Aral Sea basin, the irreversible deterioration in surface water quality by urban and industrial waste, saline intrusion of coastal aquifers and contamination of groundwaters by nitrates, are all examples of avoidable stress on water resources that are available and suitable for required uses. Poor recognition of relations between quality and quantity of water bodies increases the potential for water-related diseases.

The past has seen considerable economic resources invested in water borne sanitation such that the tools needed to maintain water resources of good quality and quantity are available. To meet the continued demands for high quality water well focussed investment of little additional money is still required to be spent to treat water to an acceptable quality and handle it in a sustainable way. Increasing costs of municipal and industrial wastewater disposal for pollution abatement accelerates the need for alternative technologies for protecting drinking water resources without producing sewage. Effective management of water is essential to reverse the reducing availability of suitable resources.

Public or private ? Take responsibility!

Inconsistent legislation on one hand and ineffective implementation of existing laws on the other hand, together with loss of responsibility and staff in public supervising agencies, in eastern Europe the weakening or destruction of the Sanepid institution, accelerated the destruction of resources. At the same time, collapsing industries in eastern Europe released rivers, lakes and groundwater from some of the continuouslyflowing pollutants. Non-coherent and inconsistent EU directives, together with varying national policies of implementation, created a huge administrative burden, but only reduced the speed of destruction of water resources. Despite a broad variety of political action, the Aarhus – report of the EEA could not identify substantial improvement of Europe's water quality.

Technical requirements in legislation were far behind what has been proven to be cheap and effective wherever local awareness and interest has resulted in excellent performance. Examples such as resolving the ecological crisis in the Ruhr-Gebiet (Germany) between 1910 and 1960, implementation of advanced sewage treatment in Sweden or Switzerland in the 1970s and '80s, and co-operatives between water supplies and farmers in several areas across the region gave rise to hope.

Price or value – the precious public good

Economic efficiency, rather than a simplifying attitude to focus every political action on economic growth, is an important development objective in many countries. The financial burden on users to pay for water together with sanitation is incredibly low in comparison to the health cost incurred in the case of failure. In the overall context of increasing and health cost, water has to be highlighted as a central political issue. Over 30 million cases of water-related disease could be avoided annually through water and sanitation interventions. Investing in water supply and sanitation has produced benefits far above those directly related to cost of treatment for water related diseases.

The organisational structure in water services throughout the region has seen an increasing trend towards private sector participation - varying from a wholly privatised water industry in England and Wales, a part private system in France, and a variety of other approaches ranging from direct operation and management by local authorities, to economic enterprises governed separately by public administrations. However the effectiveness of some of the privatizing approaches in terms of public health as well as in economic terms, still need to be evaluated, while publically provided water services over many decades have proven to be most effective – world-wide!

Services in central and eastern European countries are now predominately run by local administrations, who have lost recognition and resources. It seems to be difficult for the international funding agencies, to invest into local sustainable water and sanitation services. This is not only due to the fact, that low (or no) water prices cannot help to raise enough funds for the needed reconstruction of damaged networks and treatment facilities. Basic issues still need to be addressed such as the provision of a continuous supply of water of adequate microbiological quality.

Public valuation and participation

The willingness by consumers to pay for water of good quality is huge – the growing consumption of bottled water in a number of countries – Austria, France, Spain, Italy and Switzerland for example is one way to illustrate this. Due to lack of confidence in the quality of their tap water, many individuals have invested a lot into household filtering devices – not knowing that most of these filters do not effectively control contaminants or pathogenic germs. Public pressure and a greater awareness have helped to create and conduct to a number of pollution control programmes in the past decades in several European countries. But increasingly people are seeking cleaner waters for recreation and are prepared to pay in the form of travel, to recreational waters of good quality. The internalisation of external costs thus challenges the existence of the ‘polluter pays principle’: at least in the area of water quality, the “consumer pays principle” is valid. As globalisation of trade increases, internalising the costs will be more and more complicated.

It is clear that the detachment of activity from responsibility is accelerating the crisis. Participation by NGOs and other private sector groups is crucial to improving the management of water resources. Many NGOs originate from local initiatives and are independent and self managed. Their knowledge of local issues and conditions as well as their local contacts aid the motivation and awareness of local communities to advocate change. The co-operation of such organisations with public efforts at community or national level is essential to providing an improved environment for human health. Public policies need the consent and sometimes the active participation of individuals. Accepting responsibility is an important and basic element.

New commitment building up

Having recognized the impeding force of non-coherent legislation, the member States of the European Union agreed to develop the 5th Framework Directive in order to produce an instrument for integrated water management, aiming to create a holistic framework for the protection of inland surface waters, transitional water, coastal waters and groundwater. At the same time, the obvious need for action also outside the EU resulted in the European Member States decision to embark on a pan-European legally-binding instrument. Focussing on health and wellbeing targets in all member states, this ‘Water Protocol’ will foster partnerships in order to improve the outcome of water supply and resource management with a focus on Health for All. Intersectoral action has been placed in the centre of the new health 21 Policy by all Member States of the EURO Region at the Regional Committee Meeting in Copenhagen 1998.

This type of action needs a well-established and widely agreed database – not only about health concerns, but much more about ways of developing sustainable, healthy and economically sound water management systems. This publication on the one hand gives an overview from many perspectives:

- Comparison between countries of availability of water resources
- Variations in data collection and density in various parts of the region
- Different types of stress on water quality and quantity
- Differences in economic valuation and pricing of water use and services

The compilation of country reports is hiding a most important aspect of water management and health in Europe: In almost every country, we can identify a large variety of good and bad approaches – to solve or to create problems related to water and health. Further work is needed to elaborate the general essence coming out of many case studies of ‘environmental excellence’.

May this publication be a starting point for identifying excellent approaches. Most of these have been proven to be not only good for health and wellbeing, but also economically sound and sustainable. There is no reason to implement the ‘average’ bad performance mechanisms, but good chances to develop awareness and engagement for best solutions. The motivation and expectations of individuals is high and must be encouraged and realised - the successful management of water resources will depend on the ability and willingness of the regulators to meet those expectations.

2. EUROPEAN WATER RESOURCES

2.1 Distribution of resources

2.1.1 2.1.1 Geographical distribution

The water resources of a country are determined by a number of factors, including the amount of water it receives from precipitation; inflow and outflows in rivers, and the amount lost by evapotranspiration. The potential for storage in aquifers and surface water bodies is important in facilitating the exploitation of the resource. These factors depend on geography, geology and climate.

Freshwater resources are continuously replenished by the natural processes of the hydrological cycle. Approximately 65 per cent of precipitation falling on land returns to the atmosphere through evaporation and transpiration (evaporation of water through plants); the remainder, or runoff, recharges the aquifers, streams and lakes as it flows to the sea.

Methods for calculating the availability of freshwater resources vary considerably from country to country, making comparisons difficult. In order to overcome this, a Rees *et al.*, (1997) has developed a method to estimate the renewable freshwater resources across the EU. This uses data from hydrometric (river gauging) networks supplemented by an empirical freshwater balance model which relates runoff to precipitation and potential evaporation. Freshwater resources vary considerably across the European region, annual runoff ranging from over 3000 mm in western Norway to 100 mm over large areas of eastern Europe and less than 25 mm in inland Spain (Figure. 2.1).

It has been calculated that the average annual run-off for the EEA European Region is approximately 3100 km^3 (314 mm/year). This equates to 4500 m^3 per capita per year for a population of 680 million (EEA, 1995). The population in the WHO/EURO Member States totals 870 million, but figures for the total run-off are not available.

Sustainable use of the freshwater resources can only be assured if the rate of use does not exceed the rate of renewal; the total abstractions must not exceed the net water balance (precipitation plus inflow minus evapotranspiration) of the country. An excess of water abstraction over water use is especially prominent in Central Asia, Kazakhstan, the Russian Federation and the Ukraine (Chernogaeva *et al.,* 1998). In order to achieve the correct balance between use and renewal a reliable quantitative assessment of the water resource and a thorough understanding of the hydrological regime is required. Careful management of available resources, to ensure that the abstractions to satisfy the various demands for water do not threaten the long-term availability of water, is essential. Sustainability also implies management to protect the quality of the water resource, which may include measures such as preventing contaminants from entering the water and maintaining river flows so that any discharges are sufficiently diluted to prevent adverse impacts on water quality and the ecological status.

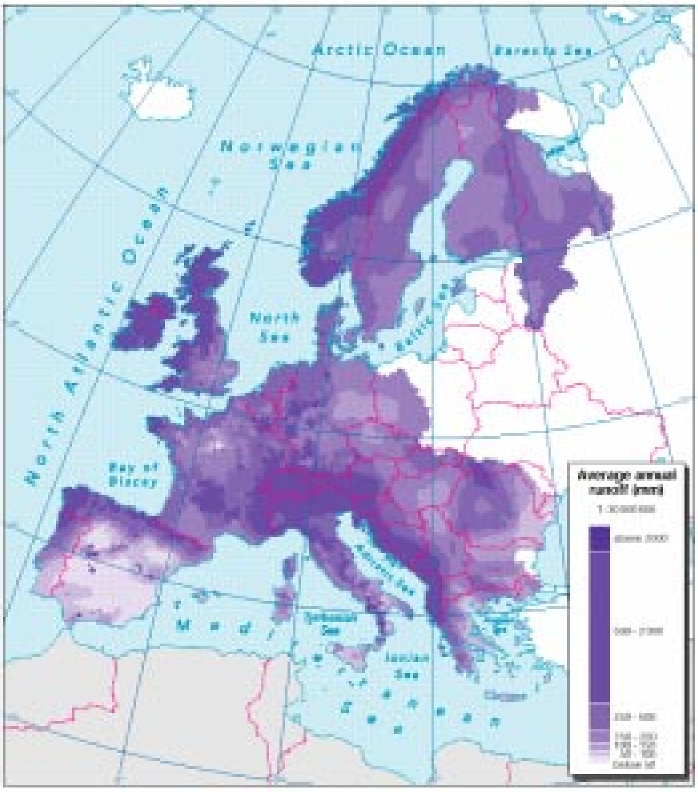

Figure 2.1 Long term average annual run-off (expressed in mm) in the European Union
From: EEA (1998)

Disclaimer: The designations and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organisation concerning the legal status of any country, territory, city or area or its authorities or concerning the delimitation of its frontiers or boundaries.

Population density also determines the availability of water per person. Population densities vary widely across Europe, from less than 10 inhabitants per km^2 in Iceland, the Russian Federation and some of the Central Asian States (Kazakhstan and Turkmenistan) to over 300 per km^2 in the Benelux countries and San Marino and over 1000 per km^2 in Malta (Figure 2.2).

At the continental scale, it would appear that Europe has abundant water resources. Latvia for example consumes only 1.3 per cent of natural renewable resources annually. However, these resources are unevenly distributed, both between and within countries (Gleick, 1993). Once population densities are taken into account, the unevenness in distribution of water resources on a per capita basis is striking.

A significant proportion of European countries have relatively low availability of water. Southern countries are particularly affected, with Malta having only 100 m^3 per capita per year (an annual water availability of less than 5000 m^3 per capita is regarded as low, and less than 1000 is extremely low and is commonly used as a bench mark of water scarcity. Conversely, above 20,000 m^3 per capita is considered high). Heavily populated countries with moderate rainfall in western Europe, such as Belgium, Denmark and the UK are also affected, as are the Czech Republic and Poland in Central Europe. Water resources are unevenly distributed and reported to be declining in regions of the Russian Federation (State Committee of the Russian Federation on Environmental Protection, 1998). Areas of insufficient water availability occupy 27 per cent of the former Soviet Union (Shiklmanov *et al.*, 1998) Insufficient water resources are reported in the southern Ukraine, Moldova, middle and lower reaches of the River Volga, the Caspian lowland, southern parts of West Siberia, Kazakhstan and the Turkmenistan lowland (Chernogaeva *et al.*, 1998). Only the sparsely populated Nordic countries with high rainfall have high water availability.

Precipitation varies between seasons and years. Countries or areas that usually have access to adequate water resources may suffer shortages at certain times of the year or in certain years.

(Plate to be inserted: Large scale collection of rain water for water supply (Gibraltar)

Local demand for water in areas of high population density or limited precipitation may exceed the local availability of water. Over-exploitation of groundwater sources in such cases not only threatens the future adequacy of the water supply, but also has effects on the local environment such as the loss of wetlands, desertification, low river flow and, in the case of coastal aquifers, salt water intrusion.

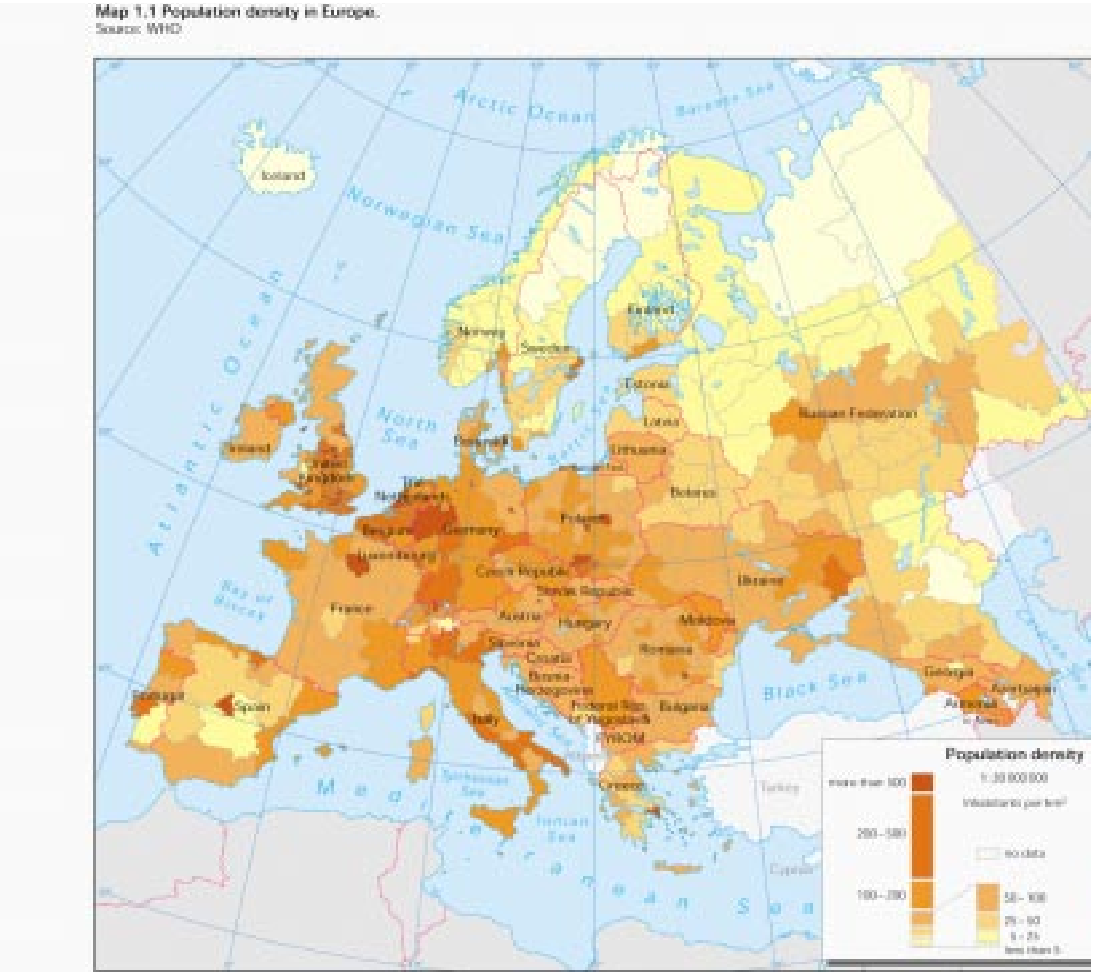

Figure 2.2 Population density in Europe (Source: WHO)

The majority of water used for all purposes in Europe is abstracted from surface water sources (OECD, 1997). Groundwaters make up the majority of the remainder, with only a minor contribution from desalination of seawaters principally in Spain, Italy and Malta.

There are some exceptions: the extensive groundwater reserves of Denmark, for example, are the source of 99 per cent of the total water abstracted. In Latvia, ground and surface waters are abstracted in approximately equal quantities. Where sufficient groundwater reserves are available, these are generally used as a preferential source for public water supplies and, in many countries, provide the majority of drinking water. Groundwaters are generally of higher quality than surface waters and, therefore, require less treatment before being suitable for public water supply (section 4.2). Their protection against contamination and over-exploitation is, therefore, of great strategic importance.

2.1.2 2.1.2 Distribution in time - floods and droughts

The occurrence of extreme hydrological events, such as floods and droughts, is a natural characteristic of hydrometeorological variability. Despite the progress in science and technology and increasing expenditure on drought amelioration and flood control, people are still vulnerable to extreme hydrological events that occur both in developed and less developed countries.

Floods

Floods are extreme hydrological events that can cause heavy damage to civilisations. Seasonal fluctuations of water level and discharge as well as inundation of riparian areas are natural features of running waters. However, the areas liable to flooding are often occupied and flooding interferes with human land use activities; damages can be enormous and there can be great loss of life (section 6.5 and box 2.1).

Flood events have been reported since ancient times, but during the last decade in Europe and other parts of the world there seems (the trends have yet to be established unequivocally) to have been an increase in large flood events threatening human lives, property and infrastructure, made worse by the expansion of human settlements and infrastructure to flood-prone areas. Serious floods in Europe during the 1990s are shown in Table 2.1.

Table 2.1 Serious floods in Europe during the 1990s

Flood events (river/year)	Fatalities	Estimated damage costs (billion ECU)	Remarks
Tazlau (Romania) 1992	107	0.05	Tazlau dam burst
Ouveze 1992	41	Not known	Campsite
Rhine/Meuse 1993/94	10	1.1	
Po 1994	63	10	Catchment area covered by up to 60cm of mud
Rhine 1995	None	1.6	Evacuation of 240,000 people in NL
Glomma and Trysil (Norway) 1995	None	0.3	Largest flood since 1789
Pyrenean river 1996	85		Campsite
Oder and Vistula 1997	105	5.9	195,000 people evacuated, great material losses

Risk of flooding results from natural influences on the frequency of floods and man-made interventions in the hydrological cycle that has impacts on the consequences of flooding.

Box 2.1. The flood of 1997

What happened?
In July 1997, Europe experienced one of the most disastrous floods in its history. Vast parts of southern Poland, the eastern Czech Republic and western Slovakia were flooded after exceptionally heavy rain. At worst-hit locations, as much water fell in a few days as usually falls in an entire year (e.g. 585mm in five days at one Czech monitoring point). Many streams in the water sheds of the Oder, Lab, Vistula and Morava rivers flooded and overflowed their banks. The surges moved downstream, floofing communities and destroying houses and bridges. Industrial waste and sewage entered the floodwater, contaminating everything it touched: agricultural soils, stores, offices and homes.

The flooding affected a quarter of Poland – an area populated by 4.5 million people – in nearly 1,400 towns and villages. The cities of Opole, Klodzko and Wroclaw were devastated. In Poland, 400,000 ha of agricultural land were affected, 50,000 homes destroyed, 5,000 pigs and a million chickens lost, 170,000 telephone connections cut, 162,000 people evacuated and 55 were killed. Infrastructural damage included 480 bridges, 3,177 km of road and 200 km of rail track. Total damages to Poland were estimated at US$ 4 billion.

In the Czech Republic, the flood caused US$ 2.1 billion damages, 40 people were killed in the floodwater and 10 people died subsequently (of heart attack, infections). About 2,150 homes were destroyed, 18,500 damaged, and 26,500 people were evacuated. In Germany about 6,500 people were evacuated. And costs in the worst affected German State of Brandenburg were estimated at US$ 361 million.

Underlying causes
The flood was caused by extremely heavy rain but the effect was intensified by human changes to the surroundings. In particular, the water retention potential of several of the flooded watersheds has been reduced by human interventions. Destruction of forests and riverine wetlands, engineering of mountain streams and rivers, destroying waterside vegetation, removing natural water-retention features and draining of agricultural land all reduced the absorptive capacity. Straightening and shortening of the Oder and Vistula made them additionally susceptible to flooding.

Lessons learned
A change of attitude is required. Hazard prevention and response has to be seen as part of a dynamic interaction between people and nature. There must be more awareness and understanding of the interactions between human activities and natural systems.

Drought

The characterisation of the phenomenon drought includes concepts, which are not strictly meteorological or hydrological, such as social, economic or agricultural considerations.

It is important to distinguish between a drought, being an extreme hydrological event, and aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Recent European droughts have emphasised that the hazard is not just one of semi-arid countries and is a normal part of climate in all countries. It has a number of impacts: loss of human lives (directly through thirst or indirectly through starvation or disease), loss of crops, loss of animal stock, water supply problems: shortages and deterioration of quality, increased pollution of freshwater ecosystems by concentration of pollutants, regional extinction of animal species by the absence of biotopes in drought periods, forest fires, wetland degradation, desertification, impacts on aquifers and other environmental consequences.

2.1.3 2.1.3 Climate change

Although regional differences are relatively high, most of Europe has experienced increases in temperature of about 0.8°C on average in this century (Schoenwiese *et al.*, 1993, Brazdil *et al.*, 1996; IPCC 1996; WG I, Chapter 3; Onate and Pou, 1996; Schuurmans, 1996). Annual precipitation trends in this century have been characterized by enhanced precipitation in the northern half of Europe (i.e. north of the Alps to northern Fennoskandia) with increases ranging from 10 per cent to close to 50 per cent. The region stretching from the Mediterranean through central Europe into European Russia and Ukraine, by contrast has experienced decreases in precipitation by as much as 20 per cent in some areas.

Predictions of climate change are subject to huge uncertainties and, even where the likely global trend appears to be clear, the response in individual regions may vary substantially from this. Thus, although global temperatures are predicted to increase by 1-3.5 ^{o}C by the year 2100 (IPCC, 1996), the actual rise in individual areas will differ significantly and some regions may become cooler.

Similarly, global average precipitation is predicted to rise, but this increase is also likely to be regionalised. It is predicted for that winter and spring precipitation will increase in Europe, meanwhile summer precipitation will decrease although the Mediterranean and Central and eastern Europe are expected to experience reduced precipitation (Kovats *et al.*, 1999). Therefore the incidence of droughts and heavy precipitation events (leading to floods) is also predicted to increase, which suggests implications not only for increased contamination due to run-off, but also decreased groundwater recharge and increased incidences of flooding.

Effects of climate change on the quantity of water resources

Complex interactions in time and space between precipitation, evaporation, discharge, storage in reservoirs, groundwater and soils make it difficult to model and analyse the influences of climate change on the hydrological cycle.

One of the basic mechanisms is that higher temperatures lead to higher potential evaporation and decreased discharge (which also is a function of precipitation, storage and topography). The storage in the soil serves as a buffer; in winter and spring normally increasing precipitation generates higher discharges because the buffer is full and evaporation is low (Beniston *et al.*, 1997). During the summer, storage is reduced by evapotranspiration and must be refilled before discharge begins. Changes in the hydrological cycle are much more variable than changes in other climatic factors. Seasonal to inter-annual variability in precipitation and temperature also accounts for some of the variability in hydrological characteristics in European river basins. Predictions on hydrology are difficult in Europe because anthropogenic factors, such as changes in land-use patterns and drainage conditions of rivers, and increase of the proportion of impermeable areas strongly influence the European hydrological cycle (Beniston *et al.*,1997).

Predictions of the effect of climate change on river flow are uncertain and the results of different models are highly variable. Arnell and Reynard (1996), for example, modelled UK river flows under various climate change scenarios and found that, under all scenarios, there was a greater concentration of flow in winter. The models predicted that monthly flows would change by a greater percentage than annual flows, and different catchments would respond differently to the same scenario. The models indicated that progressive change would be small compared with variability over a short time-scale, but that it would be noticeable on a decade-to-decade basis (Arnell and Reynard, 1996).

Cooper *et al.*, (1995) found that the effect of various climate change scenarios on aquifer recharge depended on the aquifer type, and that a scenario incorporating high evaporation produced the greatest change in hydrological regime.

The IPCC central emission scenario predicts a rise in sea level of 0.5 m by the year 2100. However, the predicted rise will not be uniform around the world. Flatlands, such as lowlands in The Netherlands and northern Germany, will be submerged. Catchment areas in flatlands depend on groundwater recharge and changes in percolation can change the size of catchments (Hoermann *et al.*, 1995). On a local catchment scale distribution of water in the landscape can change even if annual discharge remains unchanged: whereas hilltops are severely stressed by droughts, areas with high groundwater levels may remain largely unaffected (Beniston *et al.*,1997).

Although the debate about changes in the frequency of floods is still open an increase in rainfall during periods when soils are saturated (i.e. winter and spring) could increase the frequency and severity in floods. An increase in large-scale precipitation might lead to increased flood risks on large river basins in western Europe in winter (Beniston *et al.*,1997).

Hotter summers would lead in already sensitive regions, to increased demand for water for irrigation purposes (e.g. the Mediterranean basin and Central Asian States), especially for soils with low storage capacities to summer water shortages (Beniston *et al.*,1997).

Water demand is likely to increase in some countries due to increasing irrigation, population growth or increased use of domestic appliances. If decreased water availability, due to climate change, is also considered, then an imbalance of supply and demand is likely. The potential influence of climate change on water resources (m^3/year per capita) in some European countries is demonstrated in Table 2.2, although the variation between different climate scenarios should be noted.

Table 2.2 Estimated water availability (m^3/capita per year) for 2050 based on present climate conditions or three transient climate change scenarios.

Country	Present climate 1990	Present climate 2050	Climate scenarios range 2050
France	4110	3620	2510-2970
Poland	1470	1250	980-1860
Spain	3310	3090	1820-2200
Turkey	3070	1240	700-1910
Ukraine	4050	3480	2830-3990
United Kingdom	2650	2430	2190-2520

From: McMichael *et al.*, (1996)

2.2 Rivers

Surface waters are vulnerable to contamination from many sources (section 3.1.2). Potential contaminants include agrochemicals and micro-organisms in run-off from agricultural land, chemicals in industrial discharges and nutrients and pathogens from domestic sewage. Surface waters are often used for many purposes other than provision of water supplies (e.g. transport, irrigation, leisure) and these may impact on the water quality, for example as a result of fuel leakage from boats with potential harmful effects on the aquatic life of the river and to users of the water for recreation or consumption.

If a toxic contaminant adsorbs strongly to sediment its impact may not be immediately apparent, except on bottom-dwelling organisms, as the concentration in the water column will be reduced by the adsorption. However, contaminated sediments can act as a reservoir for the subsequent, gradual release of chemicals into the water column. This may apply, for example, to historical releases of heavy metals by industry, organochlorine compounds such as PCBs and the sheep dip chemical cypermethrin. Release of chemicals bound to sediments is particularly likely when the sediments are disturbed.

The release of nutrients (particularly nitrogen and phosphorus) which predominantly originate from agriculture and domestic sewage may result in eutrophication of vulnerable water bodies. Such nutrient-enrichment can cause significant changes in the balance of the aquatic ecology, often resulting in a bloom of algae (section 2.3.5).

In rivers, contamination from point sources is diluted and carried away from the polluting source. However, multiple discharges along the course of a river can result in higher levels of contamination in downstream stretches.

2.1.4 2.2.1 Microbiological contamination

Every effort should be made to achieve water quality as high as practicable. Protection of water supplies from contamination is the first line of defence. Microbiological quality of surface waters varies widely both temporally and spatially, reflecting variations in pressures. European countries report different trends without any consistent geographical pattern. Many rivers in Europe are significantly contaminated with microbes arising from municipal wastewater and/or animal husbandry that are of concern for public health. In the water bodies situated around the Aral Sea, especially in the Kzyl Orda region of Kazakhstan and Karakalpakistan in Uzbeckistan, the high total microbe numbers present a risk to the populations of infectious waterborne diseases (Abakumov and Talayeva, 1998). A comparative study (1981-1985 and 1986-1990) of the microbiological pollution of the River Danube, revealed that it is characterised by a high percentage of frequencies exceeding 100,000 coliforms/l. The high frequency of non-conforming drinking water samples and presence of entero bacteriophages were coincident with the incident of acute diarrhoea and viral hepatitis type A in the localities of Turnu Magurele, Braila, Tulcea and Cernavoda (WHO/UNDP, 1993).

Water borne sewage without exhaustive treatment inevitably means a resource which requires treatment for drinking and irrigation and may be unsuitable for recreational use. As far as possible, water sources must be protected from contamination by human and animal waste which can contain a variety of viral, bacterial, and protozoan pathogens and helminth parasites. Failure to provide suitable protection and adequate treatment will expose the community to the risks of outbreaks of intestinal and other infectious diseases (section 5).

2.2.2 Organic matter

The organic matter content of water is usually measured as the BOD and/or the COD. These terms are not directly comparable but faced with the dual approach across Europe general comparisons have to be attempted. In undisturbed rivers, typical values of BOD/COD are less than 2 mg O_2/l and 20 mg O_2/l respectively.

In the rivers of Nordic countries, organic matter content of anthropogenic origin is generally low. In many other countries of the European region BOD measurements exceeding 5 mg O_2 /l (compared with <2 mg O_2 /l in undisturbed rivers) have been recorded, especially in rivers subject to intense human and industrial use (EEA, 1998). In a recent assessment an average BOD of >5 mg O_2 /l, indicating significant organic pollution, was recorded at 11 per cent of river stations throughout Europe. Nonetheless, 35 per cent of all river stations had an average BOD of less than 2 mg O_2 /l, indicating an acceptable organic matter content (EEA, Figure 2.3).

Map 9.6 Annual average organic matter concentration in rivers

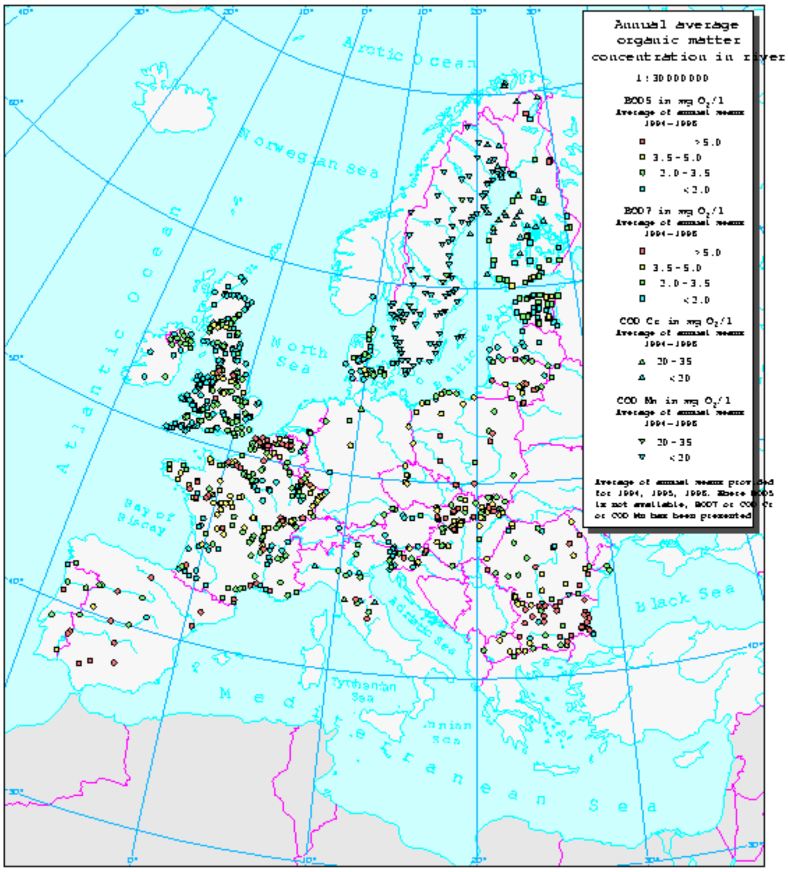

Figure 2.3 Organic matter in some European rivers 1994-96
Source: Compiled by ETC/IW from multiple sources (EEA, 1998)
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Data on COD and BOD values in the former USSR show variation in different hydrographic regions. In the Baltic hydrographic region the Neman river is considerably polluted with an obvious trend for COD and BOD showing increased pollution in the late 1980s and 1990s compared with the 1970s. High BOD and COD values are found in the River Lena in the East Siberian Sea region and there has been no obvious decrease in organic pollution trends reported over time (Petrosyan *et al.*, 1998).

A decrease in the concentration of organic matter has been observed in some European rivers since 1981 (Table 2.3). The decrease has occurred particularly in the most polluted rivers, and the maximum BOD values recorded have dropped. Significant reductions have been recorded in countries where the highest maxima were previously observed, such as Belgium, Bulgaria, the Czech Republic, Estonia, France, The Former Yugoslav Republic of Macedonia, Hungary and Latvia. Poland also reports a decrease in the concentration of BOD in the Oder and the Vistula rivers and most of their tributaries. The River Kura in the Caspian Sea hydrographic region has shown a reduction in BOD and COD values since 1985 (Petrosyan *et al.*, 1998). These decreases are likely to reflect improvements in the treatment of domestic sewage and industrial wastes before discharge to the environment and, in some countries, reduction of economical (or industrial) activities due to either disruption of the economical systems or to armed conflict.

Table 2.3 Descriptive statistics for averages of annual mean and maximum BOD concentrations in European rivers 1975-1980 and 1992-1996. Data from 29 countries.

	Number of stations	**Percentage of river stations with concentrations not exceeding (mg O_2/l)**					
BOD (mg O_2/l)		**10%**	**25%**	**50%**	**75%**	**90%**	**99%**
1975-1980 (average of annual means)	575	1.40	1.96	3.04	4.77	7.54	26.8
1992-1996 (average of annual means)	1159	1.40	1.82	2.35	1.43	5.14	17.5
1975-1980 (average of annual maxima)	557	2.52	3.83	6.2	10.0	19.0	98.6
1992-1996 (average of annual maxima)	1407	2.50	3.24	4.75	7.40	11.2	39.1

Note: This table includes all representative river sites as reported by national authorities.
Source: Compiled by ETC/IW from multiple sources (EEA, 1998)

2.1.5 2.2.3 Nitrate

About 80 per cent of the nitrogen in rivers is present as nitrate (EEA, 1995) which, as well as being a nutrient, can have implications for human health if it is present in drinking water at high concentrations (section 5.4.5). In pristine rivers the average level of nitrate has been reported to be around 0.1 mg N/l (Meybeck, 1982) but, due to high atmospheric nitrogen deposition, the nitrogen levels of relatively unpolluted European rivers ranges from 0.1-0.5 mg N/l (EEA, 1995).

In a recent assessment of nitrate concentrations in European rivers 70 per cent of sites in the Nordic countries were reported to have concentrations below 0.3 mg N/l, 68 per cent of the sites in all European rivers were reported to have annual average nitrate concentrations exceeding 1 mg N/l in the period 1992-1996 (Table 2.4; EEA, 1998). Peak concentrations exceeding 7.5 mg N/l are observed in about 15 per cent of the sites. The highest concentrations appear to be found in the northern part of western Europe, reflecting the intensive agriculture in these regions, although precipitation also greatly affects nitrate leaching (Figure 2.4). High concentrations also occurred in eastern Europe - most rivers in Belarus are reported to be contaminated, (Ministry of Natural Resources and Environmental Protection of Belarus, 1998), whilst southern European countries generally have lower concentrations. For many rivers in the former USSR, especially in basins of the Atlantic Ocean, Caspian and Aral Seas, concentrations of nitrates exceed natural concentrations (Tsirkunov *et al.*, 1998).

Table 2.4 Descriptive statistics for averages of annual mean and maximum nitrate nitrogen concentrations in European rivers 1975-1980 and 1992-1996. Data from 30 countries.

	Number of stations	**Percentage of river stations with concentrations not exceeding (mg N-NO_3/l)**					
		10%	**25%**	**50%**	**75%**	**90%**	**99%**
1975-1980 (average of annual means)	697	0.193	0.700	1.54	3.19	6.05	11.8
1992-1996 (average of annual means)	1525	0.193	.720	1.73	3.53	5.89	9.78
1975-1980 (average of annual maxima)	685	0.392	1.23	3.12	5.66	11.4	24.4
1992-1996 (average of annual maxima)	1352	.341	1.31	2.74	5.37	9.36	18.5

Note: This table includes all representative river sites as reported by national authorities. *Source:* Compiled by ETC/IW from multiple sources (EEA, 1998)

2.1.6 2.2.4 Phosphorus

Total phosphorus levels in undisturbed rivers are generally less than 25 µg/l, although natural minerals can contribute to higher concentrations. Concentrations greater than 50 µg P/l are attributed to human activities, and contamination resulting in levels higher than 100 µg P/l may give rise to excessive growths of algae. The extent of the influence of human activities on the phosphorus content in surface waters is demonstrated in a recent assessment of approximately 1000 European river sites showing that only 10 per cent of these rivers have mean total phosphorus concentrations of lower than 50 µg/l (Table 2.5).

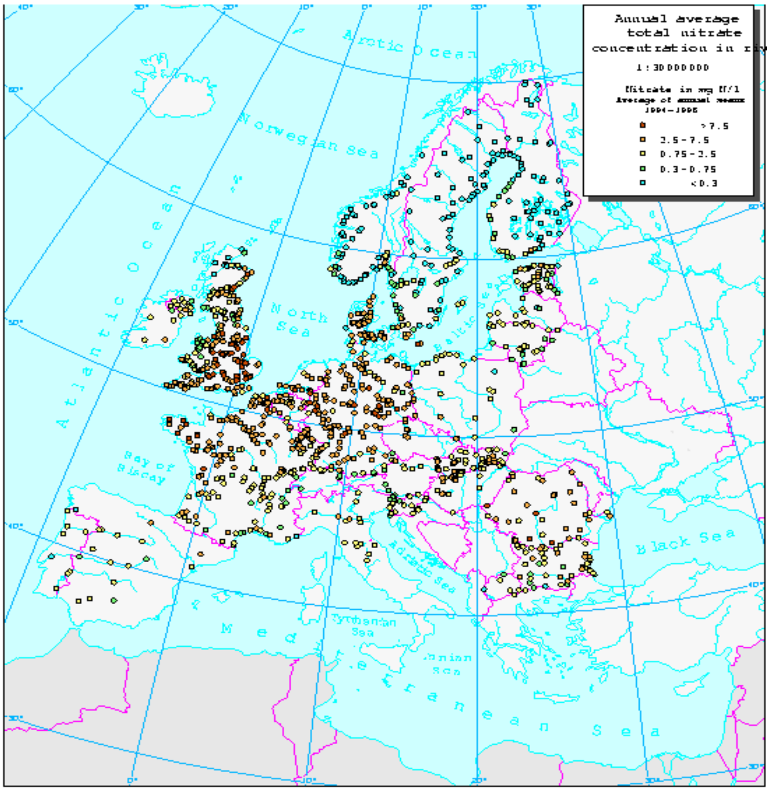

Figure 2.4 Nitrate in European rivers 1994-1996.

Source: Compiled by ETC/IW from multiple sources (EEA 1998)

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2.1.7

Table 2.5 Descriptive statistics for averages of annual mean dissolved (25 countries) and total phosphorus (24 countries) concentrations in European rivers 1975-1980 and 1992-1996.

		Number of stations	Percentage of river stations with concentrations not exceeding (µg P/l)					
			10%	25%	50%	75%	90%	99%
1975-1980	Total phosphorus	105	86	150	317	683	1020	2834
1975-1980	Dissolved phosphorus	657	7	32	91	276	811	2832
1992-1996	Total phosphorus	546	50	100	172	290	576	2219
1992-1996	Dissolved phosphorus	1404	4	27	60	132	383	1603

Note: This table includes all representative river sites as reported by national authorities.

Source: Compiled by ETC/IW from multiple sources.

Phosphorus concentrations are found to be lowest in the Nordic countries, where 91 per cent of sites have annual averages below 30 µg P/l, and 50 per cent below 4 µg P/l (Figure 2.5), (although rising concentrations have been observed) reflecting nutrient poor soils and bedrock, low population densities and high rainfall. High phosphorus concentrations are especially found in a band stretching from southern England across central Europe to Romania and Ukraine. Western and eastern countries exhibit very similar distribution patterns. Over the past two decades concentrations of phosphorus have increased to 0.2 mg/l in the Dubasari water basin in the Republic of Moldova causing eutrophication (Ministry of the Environment, Moldova, 1998).

Since the mid-1980s emissions of phosphorus from industrial regions of Denmark and the Netherlands have fallen by up to 90 per cent (EEA, 1998). As a result of the overall reductions in Europe, phosphorus concentrations in many rivers in the east and west of Europe generally decreased significantly between the periods 1987-1991 and 1992-1996 and the annual averages and maxima of total phosphorus and dissolved phosphorus exhibit the same patterns. The overall reduction in phosphorus emissions is likely to be due, in particular, to improved wastewater treatment and reduced use of phosphorus in detergents. The reduced pollution from point sources, however, means that contamination originating from diffuse sources, such as agriculture, is now relatively more significant. However, the trend in maximum values suggest that excessive concentrations may be recorded even in generally improving sites.

In Belarus the amount of wastewater discharged from point sources has reported to have declined by around 40 per cent and the amount of inadequately treated water discharged to rivers declined by 75 per cent between 1991 and 1995 (Ministry of Natural Resources and Environmental Protection of Belarus, 1998). In the Ukraine industrial wastewater discharges declined from 9813.49 million m^3 in 1992 to 7381 million m^3 in 1996 (Ministry of Natural Resources and Environmental Protection of Belarus, 1998).

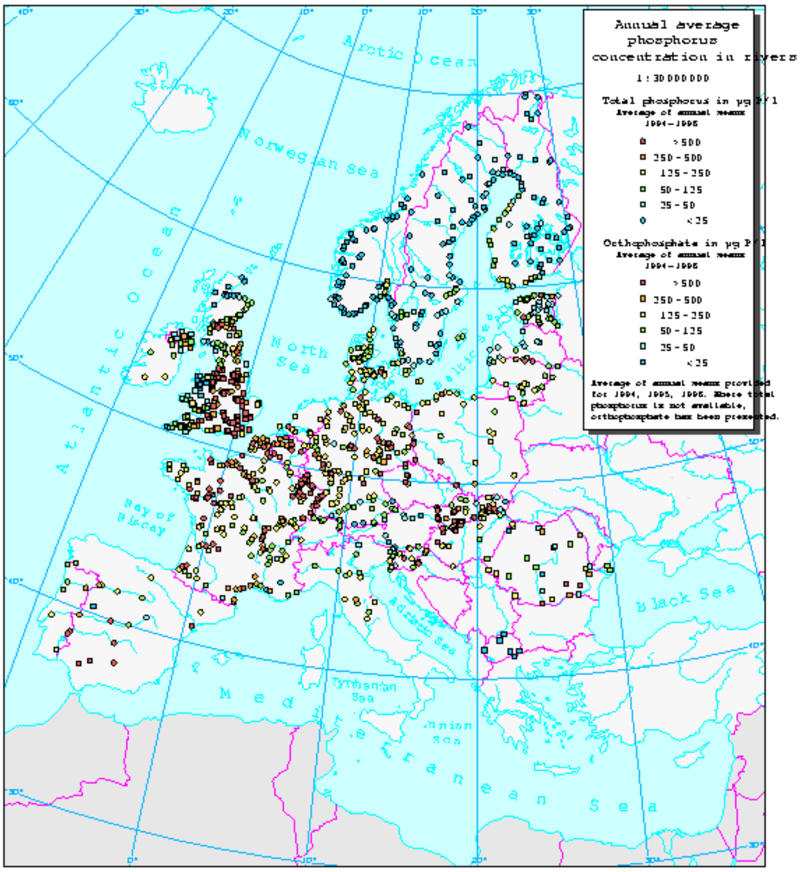


Figure 2.5 Phosphorus in European rivers 1994-96.
Source: Compiled by ETC/IW from multiple sources (EEA 1998)
Disclaimer: The designations and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organisation concerning the legal status of any country, territory, city or area or its authorities or concerning the delimitation of its frontiers or boundaries.

2.3. Lakes and Reservoirs

There are approximately 500 000 still water bodies of over 1 hectare in Europe (EEA, 1995). These comprise both natural lakes and man-made reservoirs. Limnicity (the total freshwater surface area in relation to a country's size) is nearly always related to the density of lakes in the 10-100 km² range. Limnicity ranges from over 9 per cent in countries such as Sweden (Bernes and Grundsten, 1992) to approximately 1 per cent in the UK and less than 0.5 per cent in Greece (Koussouris *et al.*, 1989) (all cited in EEA, 1999).

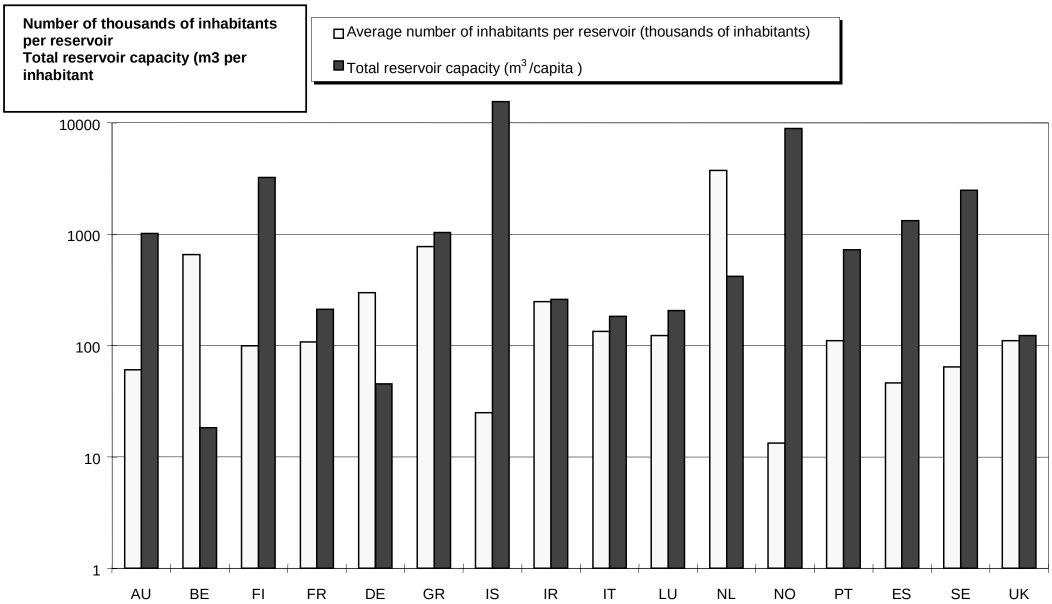
2.3.1 Lakes

Natural lakes are found in most countries but their distribution is very uneven, with a large proportion concentrated in Norway, Sweden, Finland and parts of the Russian Federation. In the former USSR, there were about 2,854,200 lakes - the total surface area, including the Caspian Sea, being 892,850 Km^2 and occupying 4 per cent of the territory (Shiklomanov *et al.*, 1998). Significant numbers of natural lakes exist in Iceland, Ireland and Scotland, but most of the largest European lakes are located in the Nordic countries and in the Alpine regions. In Albania lakes occupy a surface area of 1150 km^2. Geological processes such as fluvial damming, volcanic activity and glacial events form natural lakes.

2.1.8 2.3.2 Reservoirs

Man-made reservoirs, usually formed by damming rivers, are constructed for a number of purposes, the most obvious being to compensate for spatial or temporal deficiencies in the natural water resource in relation to water demand. Reservoirs are constructed to provide water for irrigation, public supply and industrial use. Dams may also be built for the purposes of fisheries, hydroelectricity generation, flood control, low flow enhancement, transport, recreation and spoil storage (EEA, 1999). The importance of the quality of the dammed water varies depending on the intended reservoir use, and is of extreme importance in reservoirs used for public supply, some industrial uses (such as food production), fisheries and recreation (EEA, 1999). Many reservoirs are, in practice, multi-purpose, which can lead to conflicting priorities for different water uses. A comparison of population and total reservoir capacity is presented in Figure 2.6.

In absolute terms, Spain has the largest total major reservoir capacity (the 849 major reservoirs in the EEA's **E**uropean **L**akes, **D**ams and **Re**servoirs **D**atabase; ELDRED) representing over 50 000 million m^3 of gross capacity, which is more than twice the total capacity in any other country except Norway. In terms of gross capacity per inhabitant, Spain has just over 1 000 m^3/capita. This compares directly with an annual average renewable resource which is also estimated at just over 1 000 m^3/capita.



Data sources: National Focal Points, ICOLD 1984/1988 and UN population statistics 1990, updated November 1997, Note that useful storage data instead of total reservoir capacity data has been used for Norway.

Figure 2.6 Reservoir capacity in relation to country's population for selected European countries

From EEA (1999b)

The UK and Spain have the largest number of reservoirs used for public water supply (approximately 400 and 300 respectively) and consequently may suffer problems of evaporation. Considerable numbers also exist in France, Germany and Italy. Approximately 180 other major European reservoirs have public water supply as a secondary (or lower priority) purpose (Figure 2.8). Problems exist to identify geological and geographical conditions suitable for sustainable water management - while in many countries farming or agricultural activities create major quality problems, in southern European countries problems exist because of high evaporation. The total capacity of European reservoirs used for public water supply (as their primary or lower priority purpose) is about 32 000 million m^3, representing approximately 20 per cent of total European reservoir capacity (ICOLD 1984, 1988; EEA, 1999). It should be noted that many important public water supply reservoirs in Europe are relatively shallow (<10 m) and will not, therefore, have been selected for the 'major reservoir' data-set contained in ELDRED; this may influence the apparent distribution of these reservoirs (EEA, 1999).

(Insert Plate II Birmingham water supply. Reservoir Elan Valley, Wales, UK)

2.1.9 Increasing reservoir capacity

The use of storage reservoirs overcomes the uneven distribution of natural water resources over time. Run-off in seasons of high rainfall can be held back to be used in drier seasons (seasonal regulation), and water available in wet years can be stored and used in dry years (inter-annual regulation). Increasing reservoir capacity is, therefore, a potential tool for meeting demand.

The reservoirs of Europe serve many functions other than the provision of drinking water, such as hydroelectric power production, irrigation, flood defence, recreation, navigation, fish farming and industrial supply (Figure 2.7). Consequently, there are already large storage capacities in a number of European countries.

The greatest increases in total reservoir capacity in Europe occurred between 1955 and 1985. The potential for the construction of further storage reservoirs in Europe is not likely to be large, since most economic dam sites have already been selected and reservoir schemes implemented. Consequently, future dams will face higher economic and environmental costs (EEA, 1999).

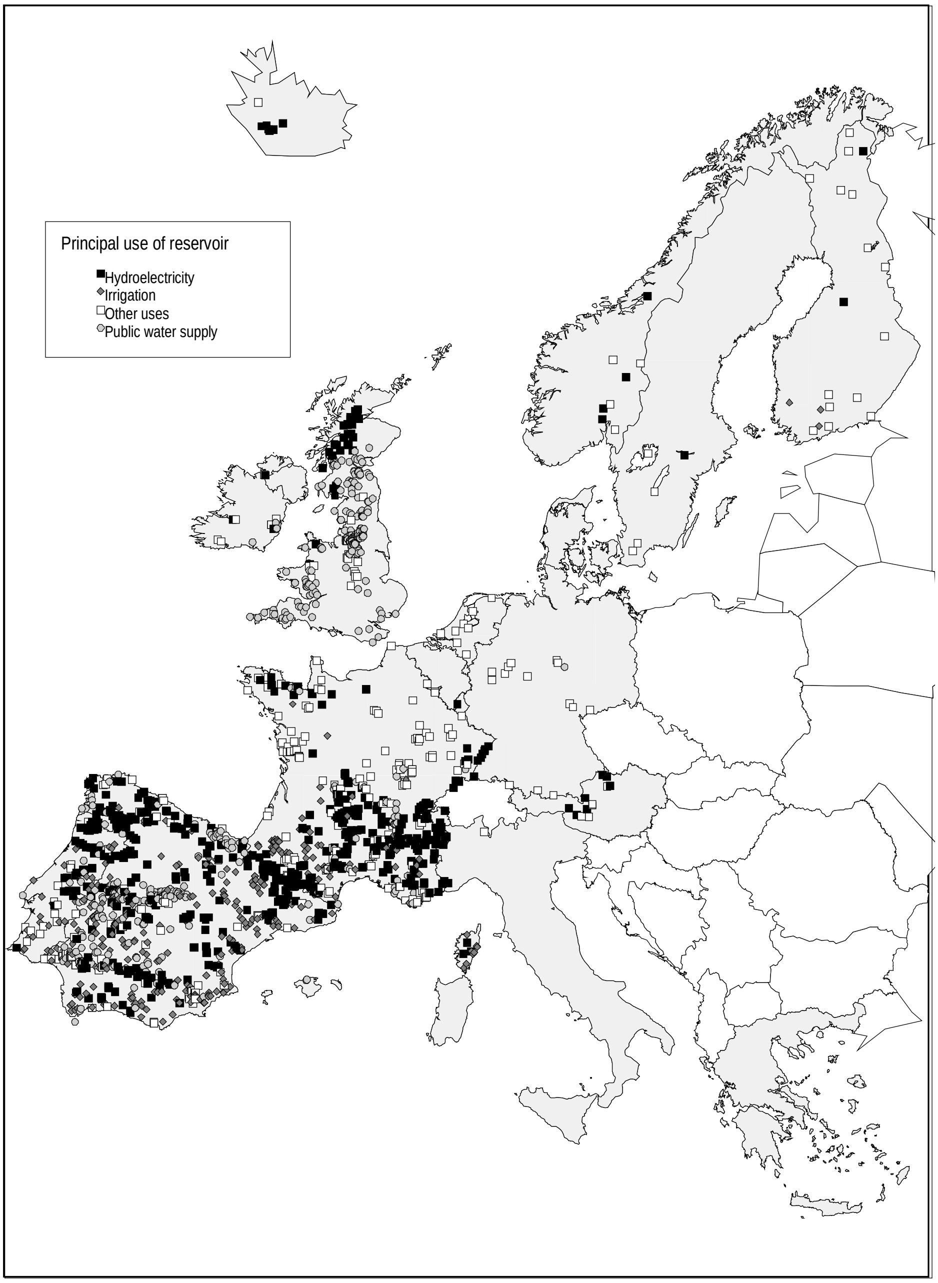


Figure 2.7 Principal use of major reservoirs in European Lakes, Dams and Reservoirs Database (ELDRED)

Data Source: ELDRED, 11/97

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2.1.10 2.3.3 Water quality

Water quality is a prime consideration in lakes and reservoirs used for public water supply. Such water bodies are often more vulnerable and sensitive to pollution than running waters or marine waters, since water volumes are not frequently renewed and lake morphology tends to lead to accumulation of pollution. Acidification, resulting from atmospheric deposition, and eutrophication, due to excessive nutrient loading, are the main problems affecting the quality of European lakes (Box 2.2). Only in sparsely populated areas or mountainous regions, where lakes are situated away from populated areas and fed by unaffected rivers, are low nutrient levels found. In densely populated areas such as Western and Central Europe, a large proportion of lakes have elevated phosphorus levels as a result of human activities (Figure 2.9). Lakes and reservoirs situated in lowland regions are most likely to be subject to higher nutrient loads. Such reservoirs are often used for irrigation or public supply, and are particularly sensitive to eutrophication (EEA, 1998b).

The release of nutrients (particularly nitrogen and phosphorus) which predominantly originate from agriculture and domestic sewage can have significant effects on the balance of the aquatic ecology and often produce a bloom of algae throughout the water body and at the surface. The resultant cloudy water requires additional treatment to make it fit for consumption, and algal by-products interfere with water treatment. As the algae die and fall to the bottom of the lake or river, their decay exerts an oxygen demand that can deplete the dissolved oxygen in the water column (Box 2.2). Significant amounts of phosphorus can be contained in sediments and the release of this phosphorus can significantly influence the quality of the water body. . In addition, some species of cyanobacteria produce toxins (Chorus and Bartram, 1999).

Insert Plate III Application of liquid animal slurry on Dutch field

An increased oxygen demand often results from the pollution of surface waters by other organic matter. Much organic matter, such as that contained in domestic wastewater, is easily decomposed in the presence of oxygen. The oxygen required for BOD or complete decomposition by all processes (COD) are often used as measures of the contamination of water by organic matter. As well as de-oxygenation, the decomposition can release high concentrations of ammonia, which is toxic to aquatic life, and the microbial nitrification of ammonia exerts an additional oxygen demand.

Eutrophication has become a widespread and severe problem across the European region and there has been considerable interest in finding methods to remediate affected lakes, as well as in preventing further pollution by nutrients (Boxes 2.3 and 2.4). Although there have been some notable successes in improving water quality by nutrient-stripping, such as at the Wahnbach Talsperre near Berlin, successful remediation is not easy. The differences in the properties of lakes, and the changes in the ecosystems that result from eutrophication, preclude a generic approach that can be applied to all lakes.

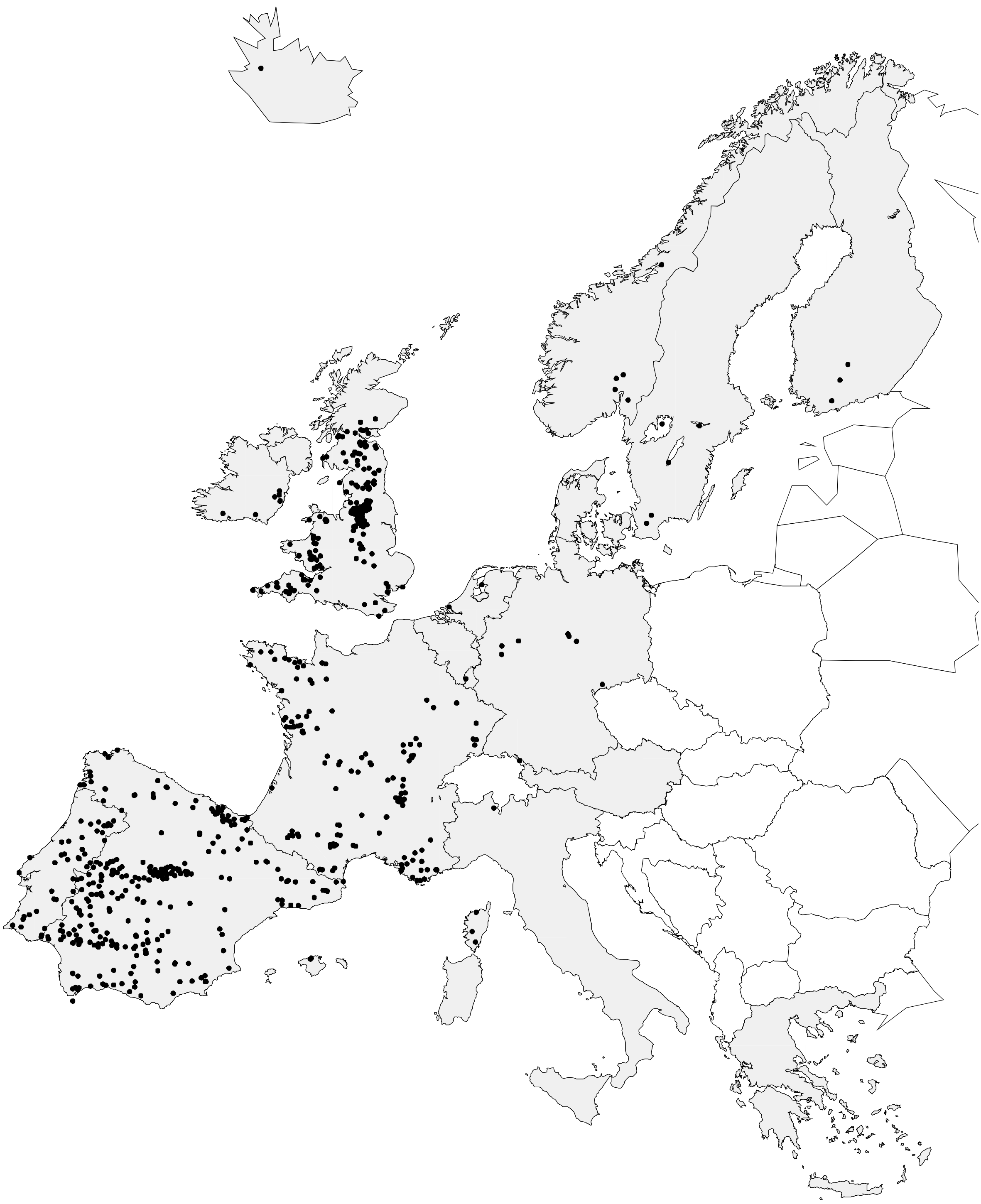

Figure 2.8 Reservoirs and lakes in ELDRED used for public water supply

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Box 2.2 Eutrophication

Excessive discharges of nutrients (phosphorus and nitrogen) to lakes and reservoirs causes an imbalance in the aquatic ecosystem. An N: P weight ratio of about 10:1 is considered to be ideal for algal growth. In freshwaters (N: P >10:1), phosphorus is naturally the limiting nutrient. Maximum permissible phosphate loads/surface area for different types of water bodies have been published. Phosphorus concentrations above 10-20 ųg/l result in algal blooms that cause a variety of problems in using those waters. In marine waters nitrogen is most often considered to be limiting (N: P <10:1) (Klein, 1989). Both nutrients can be limiting on a seasonal basis - nitrogen in summer and phosphorus in winter, although these nutrients are only truly limiting to algal growth at very low concentrations. The threshold concentration of nutrients above which eutrophication becomes a problem depends on the topography and the physical and chemical nature of the water. Limitations of phosphorus to surface waters is the only way to successfully control eutrophication.

Insert Plate IV Severe Eutrophication in Danish Lake

Increased algal standing crops reduce light penetration through the water column, thereby reducing the depth at which rooted higher plants can grow. Thus, lakes tend to be dominated either by rooted macrophytes (shallow or nutrient-poor lakes) or by algal growth in the water column (deep or nutrient-rich lakes). Raw water containing high levels of algae requires additional treatment if it is to be used for potable supply, due to the following:

- filter blockage
- filter penetration
- polysaccharide production (increases dissolved organic carbon levels and interferes with floc blanket stability)
- taste and odour generation
- toxin production

The high biological productivity in nutrient-enriched waters means that water column BOD and sediment oxygen demand is high as dead material is broken down, consequently oxygen can be stripped out of the water column if the water body is not well mixed. This can result in a series of ancillary raw water quality problems, such as high manganese, iron, ammonium and hydrogen sulphide concentrations, all of which are released from the sediment under reducing conditions.

Artificial mixing/aeration of lakes and reservoirs is widely used to prevent these ancillary problems, or in some cases reservoirs may be allowed to thermally stratify and bottom waters may be selectively removed from the reservoir - either by opening the scour valve at the base of the dam or by pumping the bottom waters over the dam. In deep lakes and reservoirs, artificial mixing may reduce algal levels by circulating algae from well-lit surface waters to a depth at which there is insufficient light for net photosynthesis.

An increased oxygen demand often results from the pollution of surface waters by other organic matter. Much organic matter, such as that contained in domestic wastewater, is easily decomposed in the presence of oxygen. The oxygen required for BOD or complete decomposition by all processes (COD) are often used as measures of the contamination of water by organic matter. As well as de-oxygenation, the decomposition can release high concentrations of ammonia, which is toxic to aquatic life, and the microbial nitrification of ammonia exerts an additional oxygen demand.

Map 9.9 Distribution of phosphorus concentration in European lakes and reservoirs by country.

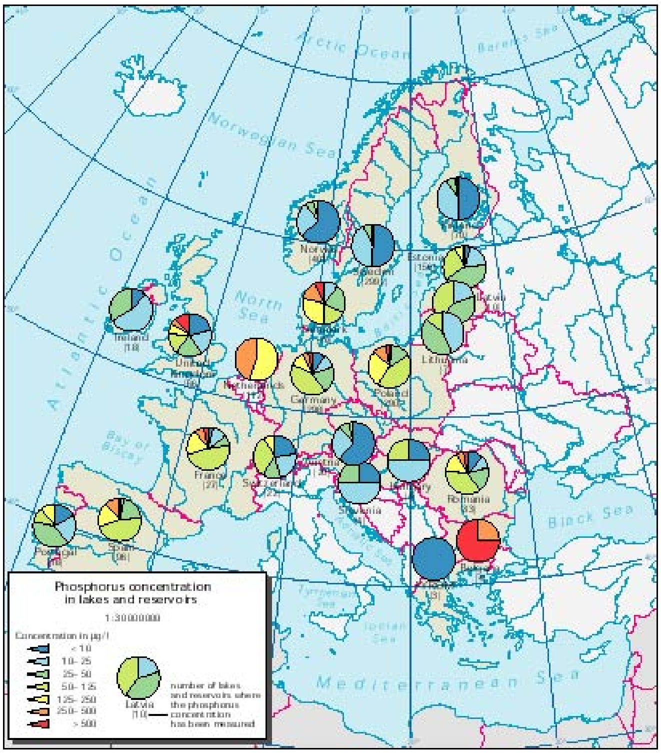

Figure 2.9 Distribution of phosphorus concentrations in European lakes and reservoirs by country.

Number of lakes per country: AT(26), BG(4), CH(22), DE(~300), DK(28), EE(156), ES(96), FI(70), FR(27), HU(4), IE(18), LT(7), LV(10), MK(3), NL(112), NO(401), PL(290), PT(18), RO(33), SE(2992), SL(4), UK(66).

Source: Compiled by ETC/IW from multiple sources Box.

From: (EEA,1998).

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Eutrophication has become a widespread and severe problem across the European region and there has been considerable interest in finding methods to remediate affected lakes, as well as in preventing further pollution by nutrients (Box 2.3 and 2.4). Although there have been some notable successes in improving water quality by nutrient-stripping, such as at the Wahnbach Talsperre near Berlin, successful remediation is not easy. The differences in the properties of lakes, and the changes in the ecosystems that result from eutrophication, preclude a generic approach that can be applied to all lakes.

Box 2.3 - Restoration of eutrophic lakes

Strategies to reduce the nutrient loading to lakes include measures to reduce nutrients entering the in-flowing streams. These might target diffuse sources by reducing fertiliser application rates or reducing animal stocking densities on farms. However, greater success has been achieved to date by tackling point sources, for example by installing nutrient stripping at sewage treatment works or by reducing the nutrient load to the works by reducing the phosphorus content of detergents. Alternative (but much less common) approaches include stripping nutrients from reservoir feeder streams before allowing the water to enter the lake, or circulating nutrient-rich reservoir water through a phosphorus stripping plant and returning the treated water to the reservoir. Metal salts, such as ferric sulphate, can be dosed to the lakes as flocculants, to precipitate the dissolved phosphorus, but the heavy metals build up in the sediment where they may have a toxic effect.

Unfortunately, an improvement in water quality and a restoration of the ecosystem is unlikely to be seen immediately after any of these measures are taken. Phosphorus stored in the sediments of lakes is released into the water column and high dissolved concentrations can result from this internal source. Even when this internal loading has stabilised to a lower rate, the ecological balance of the lake may have been altered so that, even if phosphorus concentrations are reduced to a third of their previous level, algal densities may show little change. To reduce the lag period caused by internal loading from sediments, many lake restoration schemes involve either sediment removal or sediment sealing/inactivation to prevent or inhibit phosphorus release.

Because of the changes in ecosystems that are induced by eutrophication, biomanipulation of the aquatic life in the lake may be necessary in addition to addressing the nutrient loading directly. This appears to be particularly the case for shallow lakes. Removal of the fish species that prey on zooplankton such as *Daphnia* is a commonly used strategy, thereby increasing the zooplankton standing crop and so increasing grazing pressure on the algal population.

There are numerous examples of lake/reservoir restoration schemes, such as Wahnbach Talsperre, Finjasjön and Lake Geneva (see Ryding and Rast 1989; Klapper 1991; Sas 1989). The success of different approaches and individual restoration programmes varies greatly. The economic and ecological impacts of eutrophication are high, either in terms of additional water treatment or restoration schemes; prevention is better than cure.

Box 2.4 Control of Eutrophication - case studies

Lake: **Finjasjön, Sweden**

Problem: Dominance by cyanobacterial blooms
Actions undertaken: Phosphorus removal introduced at a STW discharging into the lake in 1977. Dredging started in 1987, but stopped 5 years later when only 25 per cent had been dredged (cost 5 million ECU). Over 430 tonnes of fish removed 1992-94 (85 per cent of the fish in the lake) at a cost of 0.63 million ECU. A 30 ha artificial wetland was established to treat STW effluent (0.75 million ECU to build, annual running costs of 0.125 million ECU).
Results: Phosphorus removal at the STW lowered the external phosphorus load. However, massive internal loading from the nutrient-rich sediment meant that phosphorus levels in the lake water remained high. Dredged areas continued to release phosphorus at similar rates to undredged areas. Polished effluent from the artificial wetland contains low nutrient levels. Some signs of increasing Secchi depth and decreasing chlorophyll levels in 1994-95.
Lessons: Enormous costs involved. The costs of dredging would have been better spent on an earlier fishery management programme. The importance of chemical analysis of sediment core profiles to determine whether dredging will be of benefit is apparent.

Lake: **Lake Zurich Lower Basin, Switzerland**

Problem: Improvements to waste water treatment facilities were originally concentrated on reducing organic loadings. Nutrient enrichment was then considered a target for action, although Secchi depths were quite high at 3-11m.
Actions undertaken: Phosphorus removal has been progressively installed at STWs in the catchment since the 1970s. A national ban on phosphates in detergent was introduced in 1986.
Results: Little change in Secchi depth of phytoplankton levels despite substantial reductions in phosphorus levels.
Lessons: Reducing the in-lake phosphorus concentrations by a factor of about three from 1974 levels has had relatively little effect on algal standing crops.

Lake: **Wahnbach Talsperre, Germany**

Problem: The reservoir received strongly increased phosphate loadings in the 1960s and became eutrophic with blooms of cyanobacteria forming.
Actions undertaken: From 1969 the deep part of the lake received artificial aeration. A full restoration programme was started in 1977. This involved removing phosphorus from the in-flowing river by precipitation with iron (III) chloride and subsequent filtration of the precipitate.
Results: Nutrient removal of the feeder river achieved a high removal of incoming particulate phosphorus that is mainly of mineral composition, and would otherwise have significantly contributed to the fixation of phosphorus in the sediment. After about 5 years, measurements of chlorophyll concentration and opacity of the lake water indicated that the restoration has been successful in decreasing the algal population. Measurements of phosphorus concentrations confirm a successful reduction of nutrient concentrations.
Lessons: The principal populations of cyanobacteria decreased very rapidly after the onset of the phosphate-removal, but another, mobile, species was able to utilise the phosphorus in the upper layers of the sediment for about five years after the restoration started, until this phosphorus was depleted.

Sources: Klapper (1991); Ryding and Rast (1989); Sas (1989)

2.4 Groundwaters

The presence of groundwater resources depends largely on the geology of a country. The arrangement of permeable and impermeable layers of rocks, and impermeable glacial or glaciofluvial deposits, and the presence of underground caverns, determine the water storage capacity. Groundwaters are recharged primarily by percolation of water through the soil.

Groundwaters are generally of higher quality than surface water since they are, except in some karstic horizons, less vulnerable to anthropogenic contamination. Less treatment is therefore required to make them safe for use as drinking water. However, groundwaters are susceptible to contamination by certain chemicals, with particular problems occurring from nitrate, pesticides and volatile organic solvents. The virtual lack of any losses due to volatilisation, often minimal biodegradation and a long recharge time mean that groundwater sources are very slow to recover from contamination.

2.1.11 2.4.1 Abstraction from groundwater

Aquifers can be an efficient natural solution to seasonal water scarcity. Groundwaters act as a year-round resource and, providing recharge during wet periods is sufficient, can be used to supply water during times of low precipitation. Water quality is often good, and aquifers can provide quality reserves in areas where surface runoff in summer proves insufficient to maintain acceptable standards of water quality. The proportion of freshwater demand from groundwater abstractions varies from country to country. On average, in the EU, around 18 per cent of the total water abstraction is from groundwaters ranging from 91 per cent in Iceland to less than 10 per cent in Belgium. Groundwater abstractions account for 90 per cent of total freshwater demand in Georgia (Ministry of Environment of Georgia, 1998) whereas withdrawal from groundwater reserves constitute 57 per cent of total abstractions in Belarus (Ministry of Natural Resources and Environmental Protection of Belarus, 1998). The use of aquifers is dependent on annual recharge and requires effective management if sustainability is to be guaranteed. In countries with sufficient groundwater reserves (Austria, Denmark, Portugal, Iceland and Switzerland) more than 75 per cent of the water for public supply is abstracted from groundwaters. In other countries, with scarce groundwater reserves or with abundant, clean, surface water reserves, the proportion abstracted for drinking water falls to below 50 per cent.

2.1.12 2.4.2 Over-exploitation and saline intrusion

Aquifers vary in size and many of those exploited for abstraction contain large volumes of water. However, aquifer recharge is usually slow and current abstraction levels may, in some cases, not be sustainable. For many aquifers it is difficult to determine whether or not over-exploitation is occurring. Over-exploitation is often thought of as being the relatively straightforward balance between water taken out of the aquifer and water infiltrating back into it. Difficulties in estimating long-term recharge confound this simple approach.

Exploitation of groundwater sources beyond a sustainable level can have effects on the environment (loss of wetlands and effects on river ecosystems for example) as well as reducing the future availability of the resource. When aquifers near the coast are over-exploited, intrusion by saltwater is a possible consequence, reducing the quality of the groundwater. In some southern European coastal regions, in particular, aquifers have very limited annual recharge and over-exploitation, resulting in saline intrusion, has occurred (Figure 2.10; EEA, 1998) reducing the flexibility of water resources for required uses.. Over-exploitation (groundwater abstraction exceeding the recharge and leading to a lowering of the groundwater table) is most likely in arid or semi-arid regions, where the recharge is low. However, there are a number of overexploited aquifers in temperate climates (e.g. the rural aquifer north of Nottingham, UK is experiencing over exploitation causing drying out of wetlands). Irregular surface water resources and an increasing water demand from population, agriculture and tourism have led to a dependence on groundwater. Aquifers supplying Barcelona, Marseilles, Athens and the French Riviera coast, for example, are already stressed and expected to deteriorate further (Margat, 1992).

2.1.13 2.4.3 Aquifer recharge

Artificial recharge of aquifers, is used to avoid or rectify problems of over-exploitation. Surface waters and waste water are both potential sources of water for artificial recharge. Direct injection of water into the groundwater zone is one method of recharge, and can be used to create a barrier against saltwater intrusion in coastal areas. Surface-spreading, dune or bank filtration methods are more often used, as the percolation of the water through the soil or sand acts as a natural filter to remove particulate matter, some dissolved compounds and micro-organisms. Depending upon the soil characteristics and the extent and type of contamination of the water used for recharge, there is potential for the groundwater to become polluted. Where reclaimed wastewater is used for recharge, treatment may be necessary to eliminate micro-organisms.

In the Netherlands, where depletion of groundwater resources is recognised as a problem (Ministry of Transport and Public Works, 1996), a significant proportion of the water abstracted from surface sources is used to artificially recharge groundwater using methods such as dune filtration. Artificial recharge is also common in Germany, where water is treated (e.g. by coagulation) to reduce contamination by micro-organisms and organic compounds before it is used for recharge.

Bank filtered water may also be used for potable supply. In this case, water from a contaminated surface water source, usually a river, is allowed to filter into the groundwater zone through the riverbank and to travel through the aquifer to an extraction well some distance from the river. In some cases there is a very short residence time in the aquifer, perhaps as little as 20 to 30 days, and there is almost no dilution by natural groundwater (Crook *et al.*, 1992).

2.1.14 2.4.4 Nitrates

The natural level of nitrate in groundwater is generally below 10.0 mg NO_3/l. Elevated nitrate levels are caused particularly by the agricultural use of nitrogen fertilisers and manure in excess of plant requirements or application at the wrong time of year. Local pollution due to municipal or industrial sources can also be important. On site sanitation and leaky sewage pipes under urban areas may also contribute to increased nitrate levels. Certain types of aquifer, such as alluvial and shallow aquifers, are more vulnerable to nitrate pollution than others because of differences such as hydrogeology and land use. Deep or confined aquifers are generally better protected.

Nitrate moves relatively slowly through the ground, so there can be a significant time-lag between the polluting activity and the detection of the pollutant in groundwater (typically between 1 and 20 years). The general intensification of agriculture over the last 30 years was only relatively recently reflected in increasing groundwater nitrate concentrations. It is predicted that current polluting activities will continue to affect nitrate concentrations for several decades.

The WHO guideline value for nitrate in water intended for human consumption is 50 mg NO_3^-/l (WHO, 1998b). The EU Drinking Water Directive (80/778/EEC) permits the same concentrations. The results from groundwater monitoring programmes in 17 European countries showed high levels of nitrate (greater than 25 mg NO_3/l) in groundwaters in 50 per cent of the sampling sites in Slovenia (Figure 2.10). In eight countries this level was exceeded in about 25 per cent of the sites and in one country (Romania) 35 per cent exceeded 50 mg/l (EEA, 1998d). In Denmark, for example, about 2 per cent of all supply wells have been closed since 1986 because nitrate concentrations were above 50 mg NO_3/l. Figure 2.11 provides an overview of the regions in Europe where groundwater is affected by high nitrate concentrations.

High nitrate concentrations can be localised, largely depending upon land use. This is the case in Latvia, for example, where pollution of groundwaters from agricultural lands occurs regionally. At sites with intensified use of agrochemicals, an increase in nitrate concentrations was noted in 55 per cent of boreholes between 1988 and 1990. In the former USSR 20 per cent of groundwater sites are contaminated with agricultural contamination (Chernogaeva *et al.*, 1998). The Republic of Moldova report that half of the drinking water supplies from groundwater in the Prut basin have nitrate concentrations in excess of 45 mg/l (Ministry of the Environment of Moldova, 1998). High nitrate concentrations (in excess of 50 mg/l) are found in 15 per cent of sampling sites of Austria and in 28 per cent of sites more than 30 mg/l are found.

In many countries, groundwater nitrate concentrations have increased since the middle of the century, following the intensification of farming methods and an increase in area of arable farming. Nitrate levels are currently above maximum permissible levels in 76 per cent of wells in Belarus, with concentrations up to 300-600 mg/l (Ministry of Natural Resources and Environmental Protection of Belarus, 1998). In a number of eastern European countries, such as Hungary and Romania nitrate levels have shown reductions, probably related to decreased economic potential to purchase agrochemicals. Monitoring data show different trends in a number of western European countries even over a short time period in the 1990s. An increasing trend of nitrate concentrations in Denmark is implied for example. However, it is recognised that a much longer period of time is needed to establish meaningful trends and to eliminate the influence of short-term changes such as rainfall patterns. (Table 2.6). In some countries there appears to be no further increase in nitrate concentrations over this short time-period, possibly due to increased awareness and policies to decrease the use of nitrate fertilisers.

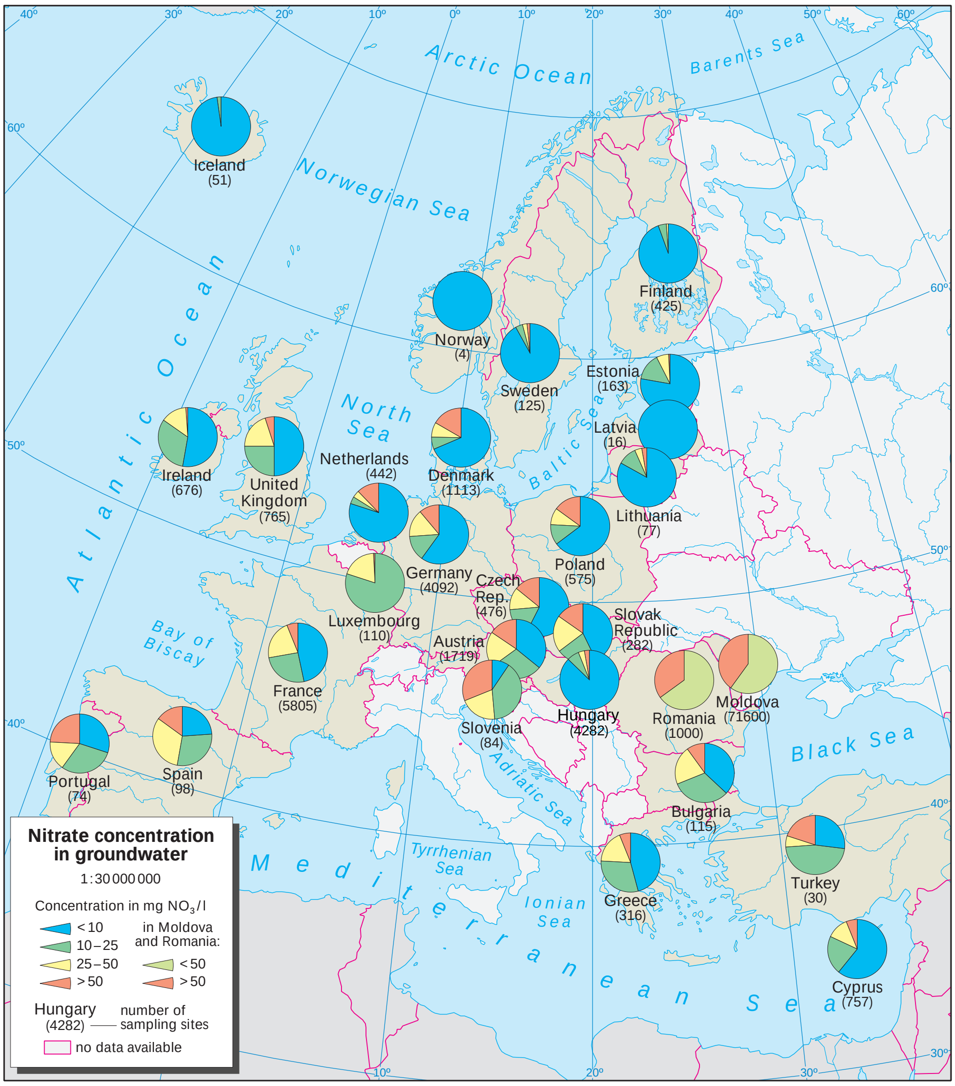

Figure 2.10 Nitrate concentration in groundwater from multiple sources.
Source: From: EEA, (1998)

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Figure 2.11 Regions affected by high nitrate concentrations in groundwater.
Source: Compiled by ETC/IW from multiple sources.
From: EEA (1998); based on national maps provided by NFPs of 16 countries.

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Table 2.6. Percentage of monitoring stations with increased, unchanged or decreased nitrate concentrations.

Country	Nitrate in groundwater, change from early 1990s to mid 1990s			
	Number of sites	Increased %	Unchanged %	Decreased %
Austria	979	13	72	15
Denmark	307	26	61	13
Finland	40	27	43	30
Germany	3741	15	70	15
United Kingdom	1025	8	80	12

Source: Compiled by ETC/IW from multiple sources.
From: EEA (1998)

2.1.15 2.4.5 Pesticides

Pesticides are a large and diverse group of chemicals with different physico-chemical properties and toxicity, and are used in a wide range of applications - in agriculture, horticulture and in public amenities, in public health in the control of vector-borne disease, and smaller volumes are used domestically. They can enter surface waters and groundwaters from point sources (disposal or spillage) and diffuse sources (used in agriculture and amenity use). The type and amount of pesticides found in raw water sources used for drinking water depends on factors such as the physico-chemical properties of the chemical (affecting the extent to which it binds to soil or leaches), its biodegradability, the soil type, the geological characteristics of the underlying rock, the weather (particularly precipitation and the soil moisture content) and the time of application (application before rain makes run-off more likely), but reflects mostly the quantities of the pesticides used in the catchment. Thus, commonly used herbicides such as the triazines (atrazine and simazine) and the urons (diuron, chlortoluron), that are used in relatively large quantities, are often reported as occurring in raw water sources. Breakdown products, such as desethylatrazine are also detected.

Insert Plate V Mixing of pesticides on the bank of a small stream

Agriculturally applied pesticides can infiltrate to groundwater under normal field conditions, although the crop, the method of application of the pesticide, the application rate and the equipment used may influence the infiltration rate. During application in the spring and subsequently through the summer months the moisture deficit within the soil profile restricts the vertical movement of pesticides through the soil profile. Adsorption onto organic carbon further retards movement through the profile and degradation by soil microbiological processes reduces the concentration of pesticides available for leaching. In wetter months water will start to migrate through the unsaturated zone. The solute will be subject to further biochemical decay as it moves through the aquifer matrix, moving slowly via intergranular flow paths. However where there is karstic (fissure flow) or high flux rates due to blind ditches or topography, groundwater recharge pathways tend to be highly developed and, under these conditions, pesticides have the potential to migrate through significant thickness of unsaturated material to infiltrate groundwater quickly. Infiltration of pesticides can occur year round following heavy rainfall, particularly where this follows soon after application.

Plate VI. Pesticide application on barley field

Because of the huge number of pesticides that exist (over 800 are approved for use in Europe), efficient monitoring of pesticide residues in the environment is complex and expensive. The most cost-effective basis for a monitoring programme is likely to be the targeting of analyses to the pesticides most likely to be used in the area. However, this approach makes the comparisons of data from different sites and countries and at different time points difficult, because of the variation in the number of pesticides for which analyses are undertaken and the different pesticides investigated. Differences in reporting the concentrations as exceeding a specific limit or being above the limit of detection also make comparisons difficult. In addition, monitoring may concentrate on sites that are suspected or known to be contaminated, therefore producing a non-representative sample of monitoring results. Table 2.7 shows an overview of selected pesticides at country and regional level and the percentage of sampling sites where the average annual pesticide concentration exceeds 0.1 µg/l.

Table 2.7 Percentage of sampling sites with average annual pesticide concentrations > 0.1 µg/l.

	EU-15 and EFTA								**PHARE**				**TACIS**	
	AT	**DK**	**FR**	**DE**	**ES**	**LU**	**NO**	**UK**	**CZ**	**RO**	**SK**	**SI**	**MD**	**Sum**
Atrazine	**16.3** (1666)	**0** (625)	●	**4.1** (11690)		●		●				**32.1** (84)		7
Simazine	**0.2** (1248)	**0.3** (625)	●	**0.9** (11630)		●						**4.8** (84)		6
Lindane			●	●	●				**0** (215)		**25** (8)			5
Atrazine-Desethyl	**24.5** (1666)			**7.1** (11690)								**47.6** (84)		3
Heptachlor			●		●						**0** (12)			3
Metolachlor	**1.1** (1248)					●						**4.8** (84)		3
Bentazone						●	**80** (5)							2
DDT									**0** (215)		**0** (12)			2
Dichlorprop		**0.6** (623)					**83.3** (6)							2
Methoxychlor									**0** (206)		**8.3** (12)			2
Atrazine-Desisopropyl	**1.3** (1666)													1
Bromacil				**3.5** (6650)										1

DDE,DDD,DDT													●	1
DDD (p,p'), DDT (p, p')					●									
Chlortoluron								●						1
Dichlorbenzamid		**13.7** (102)												1
Dieldrin			●											1
Diuron								●						1
Endosulfan I					●									1
Endosulfan sulphate					●									1
GCCG-a,b													●	1
HCH, α, β, δ					●									1
Hexachlorobenzene											**0** (10)			1
Hexazinon				●										1
Isoproturon								●						1
Linuron								●						1
MCPA							**100** (2)							1
Mecoprop (MCPP)		**0.2** (625)												1
Metalaxyl												●		1
Metazachlor						●								1
Parathion-methyl					●									1
Pentachlorophenol									**0** (207)					1
Phosphamid													●	1
Phozalon													●	1
Prometryn												**2.4** (84)		1
Propazine				**0.6** (10890)										1
Sum(HCH)										●				1
Sum(HCH+ DDT)										●				1

12.3 percentage of sampling sites > 0.1 µg/l
(625) number of sampling sites
● data available at the regional level only

From: EEA (1999a)

Much of the monitoring of pesticides in groundwater carried out in EU Member States has been purely in relation to compliance with the EU Drinking Water Directive (80/788/EEC). Current monitoring is not sufficient to establish the extent of contamination of groundwater with pesticides, or to establish any trend in concentrations (Fielding *et al.* 1998).

The pesticides that have been detected most frequently in groundwaters are the triazine herbicides, particularly atrazine and simazine, and their break-down products. These are broad spectrum herbicides that have been used extensively in both agricultural and non-agricultural situations. Because of their frequent appearance in groundwater, several countries have introduced bans or restrictions on the use of products containing these active ingredients, and a recent assessment (Fielding *et al.*, 1998) showed that there has been a statistically significant downward trend in the contamination of groundwater with atrazine and its metabolites in a number of countries such as Austria and Switzerland and in parts of Germany and France and Latvia. However, in the German State of Baden-Württemberg where atrazine concentrations in groundwater appear to be decreasing, concentrations of another triazine herbicide, hexazinon, show an upward trend (Fielding *et al.*, 1998).

There is only limited data available on pesticide contamination of surface waters. On the Danish Island of Funen for example, water samples taken in 1994 and 1995 from six streams showed 25 different substances in concentrations exceeding the detection limit. The highest concentrations were found in the spring, coinciding with pesticide application in the fields (EEA, 1998).

2.1.16 2.4.6 Hydrocarbons and chlorinated hydrocarbons

Hydrocarbons and chlorinated hydrocarbons are important contaminants of groundwaters in a number of European countries. Chlorinated hydrocarbons are widely distributed in groundwater in western Europe, where they have been extensively used as solvents. Because of their volatility, chlorinated solvents that are accidentally released to surface waters may rapidly be removed by evaporation and are not a significant pollution problem. In contrast, contamination of groundwaters is extremely persistent. A number of studies have investigated the extent of contamination of aquifers by chlorinated organic solvents, such as trichloroethene and PCE in western Europe. The picture that emerges is of widespread, low level contamination in aquifers under industrialised areas, with localised high levels of contamination (section 3.3).

Insert Plate VI Digging up of leaking gas tanks at a gas station

Groundwater contamination by hydrocarbons, gas stations, petrochemical plants and pipelines and military sites, in particular, is a problem throughout Europe. Pollution of groundwater by leakage from fuel tanks is reported in Estonia, for example (Mountain Unlimited, 1995).

2.6 Transboundary waters

Many countries share water resources, such as a river or lake that demarcates a country boundary or an underground aquifer, with a neighbouring country. Still more receive imported water in the downstream flow of rivers. Most of the major European river basins are transboundary with the river Danube basin, for example, 17 different countries have significant territory in the basin of the river Danube.

Some countries are highly dependent on transboundary flows and, it is apparent that, for some countries, water originating outside the country is essential to meet the needs of the population (Figure 2.12). The Netherlands, for example, extracts only 16 per cent of the total available resources, but this is equivalent to over 100 per cent of the water that originates within the country (Table 2.8). Over 95 per cent of the total freshwater resource in Hungary originate outside the country and over 80 per cent of the resources of Slovakia. These countries are therefore especially vulnerable to the effects of abstraction, impoundment and pollution by upstream countries.

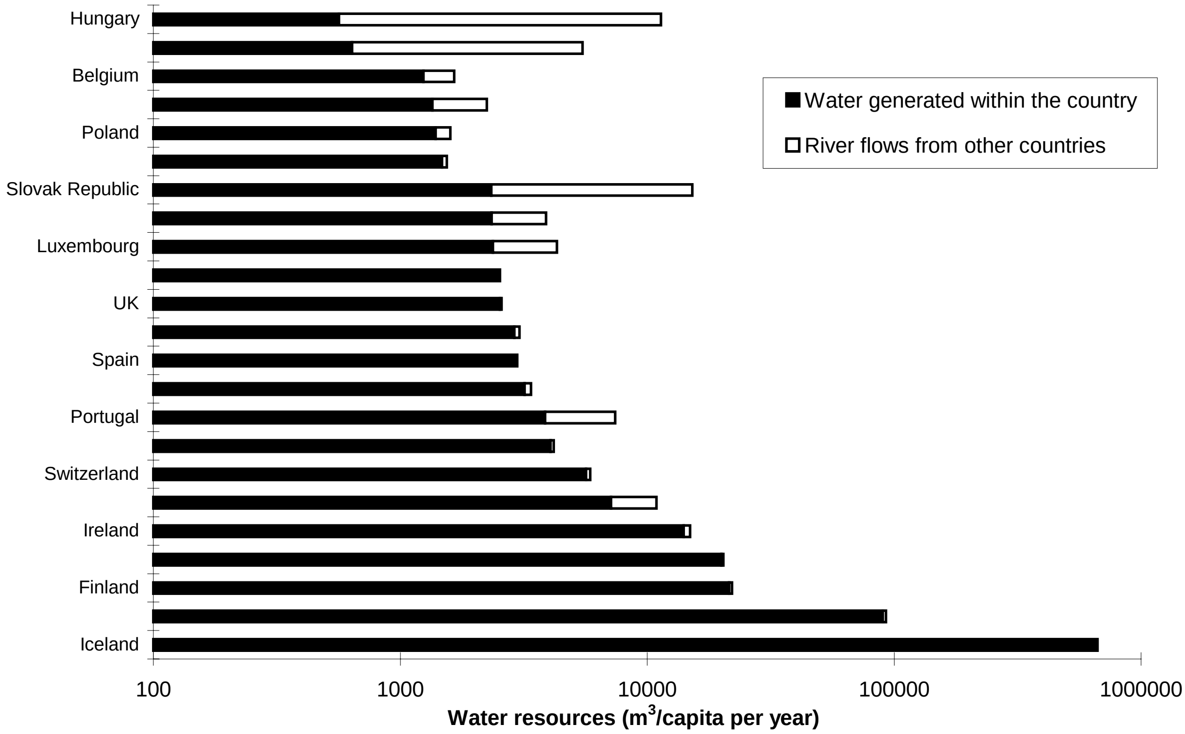

Figure 2.12 Freshwater availability in Europe
Source: Eurostat (1997a); OECD (1997).
From: EEA (1998)

Table 2.8 National water use intensity indicators

Country	**Water use indicator (per cent)**	
	Total available resources	**Internally generated water resources**
Belgium	72	91
Bulgaria	6	46 ->100
Lithuania	19	31
Hungary	5	96
Moldova	13	89
The Netherlands	16	136
Portugal	10	26
Romania	9	49

Note: Indicators are calculated as the country's water abstraction in percentage of (a) Total available resources and (b) internally generated water resources.
Source: EEA (1995)

There are a number of international agreements regarding the management of shared water resources in Europe. These include the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (box 2.5 and section 8.1) as well as a number of action plans and conventions relating to specific rivers and water bodies. Nonetheless, the potential for conflict of interests exists and there are problems relating to the contamination of international river catchments and aquifers. Important international monitoring programmes also exist for large lakes where International Commissions have been set up to co-ordinate action programmes. Notable examples include:

- Léman / Lake Généva - France/Switzerland (protection, navigation, monitoring and abstraction);
- Bodensee (Lake Constance) - Austria/Switzerland/Germany (protection and abstraction);
- Inari - Finland/Norway (regulation of hydropower);
- Lugano - Italy/Switzerland (convention) (EEA, 1998)
- GEMS/Water - an international programme on water quality monitoring and assessment, jointly implemented by WHO, World Meteorological Organisation, United Nations Environment Programme and the United Nations Educational, Scientific and Cultural Organisation. It aims to assist countries in establishing and strengthening their water quality monitoring operations and provides methodological and quality assurance support in order to support the sustainable management of freshwater resources.

Box 2.5 1992 Convention on the Protection and Use of Transboundary Watercourses and International lakes

Objectives	**Actions achieved**
• To prevent, control and reduce pollution of water causing or likely to cause transboundary impact • To ensure that transboundary waters are used with the aim of ecologically sound and rational water management, conservation of water resources and environmental protection • To ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact • To ensure conservation and where necessary restoration of ecosystems	• Measures required for prevention, control and reduction of water pollution • Ratified by 23 Parties (22 countries plus the EU) as of 30^{th} June 1998 • Convention came into force on 6 October 1996

2.5 Effects of climate change on the quality of water resources

As a result of sea level rise, saline intrusion into groundwater supplies may occur. Water quality will be most affected where salinity is already a problem due to over-exploitation of aquifers (McMichael *et al.,* 1996). Less obvious effects of a rising water table may occur such as the release of contaminants from septic systems and pollutants from underground waste disposal sites into waterways. However, coastal flooding is likely to be the most immediate and significant short-term effect, causing disruption of sanitation infrastructure and the potential sewage contamination of water courses.

The predicted increase in heavy rainfall events will result in increased contamination of surface waters by run-off, particularly by soil erosion, micro-organisms, pesticides and fertilisers from agricultural land (McMichael *et al.,* 1996). Areas with no vegetation cover are particularly vulnerable to run-off of soil and particulate matter during heavy rainfall.

The resultant poorer water quality will require more robust water treatment measures. However, the effectiveness of water treatment may also be compromised by some of the predicted changes. Heavy rainfall events and high winter river flows will result in source waters with lower dissolved salts and decreased alkalinity. Increased variability of river flows (increased winter flow but decreased summer flow, and increased variability between years) will make planning and design of appropriate facilities for treatment and distribution of drinking water more difficult.

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Box 2.6: Transboundary groundwater contamination.

As an activity of the UN-ECE Task Force on Monitoring and Assessment of Transboundary Waters development of Guidelines for Monitoring and Assessment of Transboundary Groundwaters was initiated in 1996. Although the guidelines will be similar to the guidelines for rivers, the strategy will be different because of the specific characteristics of the groundwaters.

The drafting of the guidelines is supported by five sub-projects:

- *Inventory of transboundary groundwaters in UN-ECE countries*

The main purpose of this sub-project is to highlight the location, extension and type of transboundary groundwaters, the monitoring activities, the pollution sources, the uses of groundwaters, problems and trends.

- *Case studies*

There are few case studies of transboundary groundwater pollution. Co-operation between neighbouring countries has been initiated in Austria, the Slovak Republic and Hungary; however, the achievements are very limited.

- *Problem-oriented approach and the use of indicators*

Identified problems are being analysed, information needs specified, and operational indicators will be developed.

- *Application of models*

Feasibility of the use of models to make predictions of impacts, to describe relations between groundwaters and surface waters is being undertaken. The results will be used to increase monitoring efficiency.

- *State of the art*

Recent literature and on-going activities are being reviewed to develop up-to-date recommendations for strategic aspects of monitoring and assessment of groundwater aquifers.

3. DRIVING FORCES AND PRESSURES ON WATER RESOURCES

The water resources of a country depend upon many factors including its climate, geography and geology. The pressures on these resources are determined by the population density and the agricultural, industrial and domestic practices of the population.

The water resources of Europe as a whole are sufficient to supply the requirements of the population and comparisons of total freshwater abstractions with the resources available suggest that most European countries have sufficient resources to meet the national needs (Figures 3.1 and 2.3). However, water resources are unevenly distributed and reported to be insufficient in the southern Ukraine, Republic of Moldova, middle and lower reaches of the River Volga, the Caspian lowland, southern parts of West Siberia, Kazakhstan and the Turkmenistan lowland (Chernogaeva *et al.*, 1998).

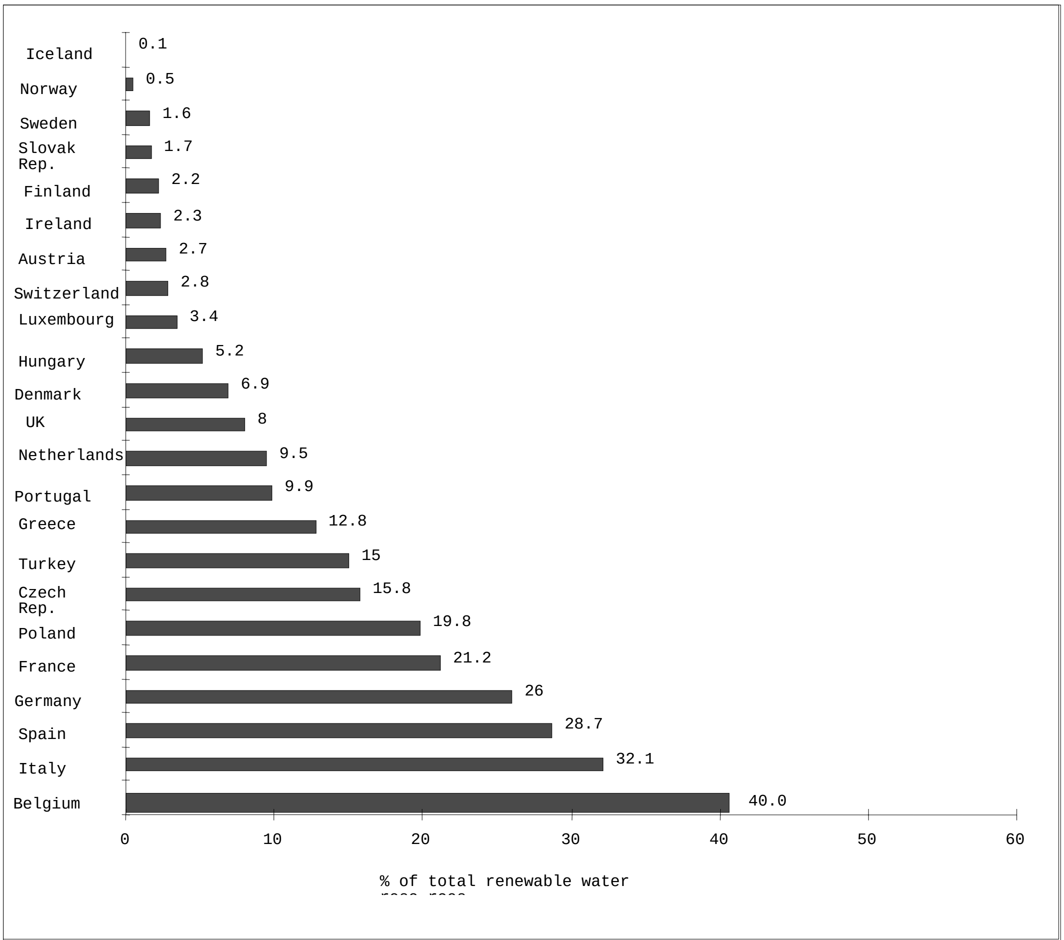


Figure 3.1 Freshwater abstractions in Europe
From: EEA (1999c)

Data relating to the relative demands exerted by different sectors on a country's water resources vary significantly, depending on the source of the data (EEA, 1999c). These differences are largely due to differing approaches towards data collection such as: inclusion of industries supplied by the public water networks in statistics on municipal water use; and the inclusion, or otherwise, of cooling water in power plants or water used for hydroelectric power production in the definition of industrial use. Nonetheless, it is clear that in many cases, particularly in the southern European countries (Greece, Italy, Portugal and Spain), agricultural water use, mainly for irrigation and livestock, is highly significant and can account for more than 60 per cent of total abstractions (Figure 3.2). In eastern Europe agricultural water demand has shown a decline since 1988 due to changes in land ownership (EEA, 1998). The Russian Federation showed an overall reduction of 0.7 per cent in abstraction for irrigation between 1993 and 1996 and a reduction in water used for irrigation was reported in Republic of Moldova between 1990 and 1994. However, an increase in water use for irrigation has been reported in Uzbekistan, Turkmenistan and Kazakhstan. In these regions approximately 50 per cent of total water demand is for irrigation (Chernogaeva *et al.*, 1998). Uncontrolled developments of irrigation can have severe effects on water resources. The Aral Sea is the most dramatic example of such consequences(Box 3.1).

Box 3.1 Uncontrolled development of irrigation in the Aral Sea

Irrigation is the main consumer of water resources in the Amu Darya basin, which occupies a wide delta region from the Tyamyun gorge to the Aral Sea - one of the largest inland water bodies in the world. From 1950-1985, the irrigated area in the basin increased four times and water intake from rivers increased by more than three times.

In the lower reaches of the Amu Darya water is lost by abstraction for irrigation and by evapotranspiration and infiltration. Between 1950 and 1988 there was a decrease in some grain crops planted and an increase in more water-consuming agricultural crops such as rice with a consequent increase in non-returnable water consumption volume for irrigated lands. The main water pollution source in the Amu Darya basin is the return drainage waters from irrigated lands, as well as industrial and municipal wastewaters. Inclusion of saline soils into irrigated farming lead to the formation of recurrent salty irrigation returns. The anthropogenic impact on the Aral Sea led to additional amounts of salt, of natural origin from the dry sea bed, to enter the atmosphere and some of this also reaches the Amu Darya.

By the beginning of the 1990s mean salinity increased to 30 parts per thousand and sedimentation of suphate salts began. At present 45 per cent of the Aral Sea has dried out. The Aral Sea volume has decreased by almost 70 per cent. The intensive salinisation of water and high concentrations of pesticides in water has led to the water in the lower parts of the Rivers Syr Darya and Amu Darya becoming unsuitable for drinking. The problem is exacerbated by the diversion of water for irrigation.

Source: Fedorov *et al.*, 1998

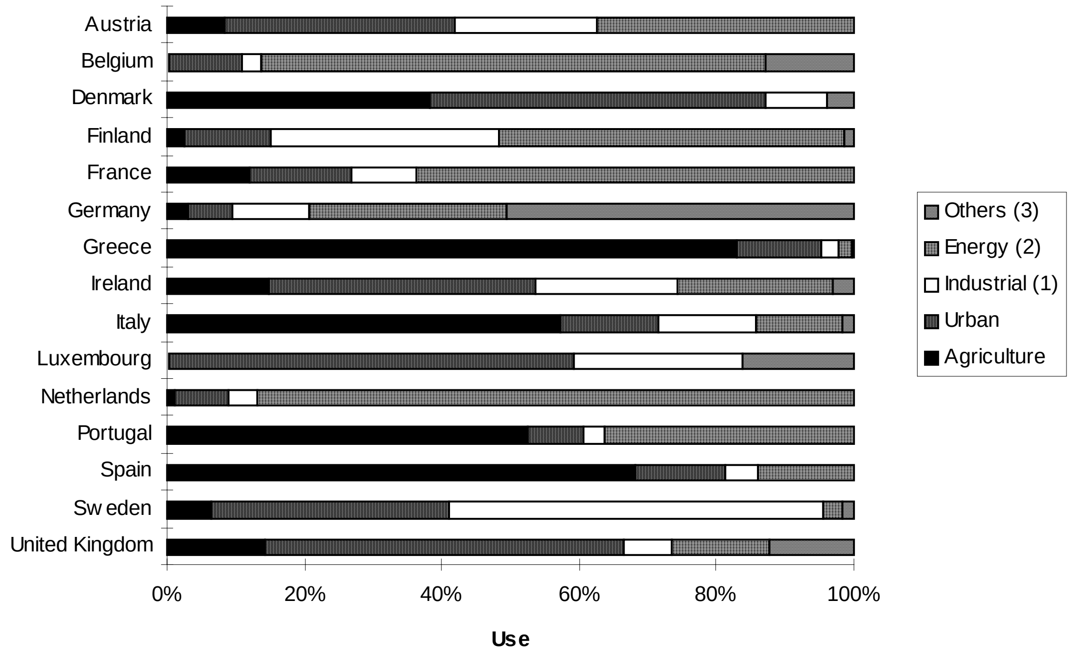


Figure 3.2 Sectoral use of water in selected countries of the European Union
From: EEA (1999c)

3.1 3.1 Population growth and urbanisation

Changes in population, population distribution and density are key factors influencing the demand for water resources. The population of the EU has increased by more than 72 million since 1960 with growth rates being positive in nearly all Member States. However, the current trend in the size of Europe's population is not entirely clear, with one long-range forecast based on France, Bulgaria, Greece, Hungary, Italy, the UK and the Netherlands predicting a decrease in population for the next 30 years (ICWS, 1996), other projections show that the population is expected to increase for the next 15 years, with the total population in EU countries reaching around 39 million by 2010 (Table 3.1; RIVM, 1998).

Table 3.1 Population in EU countries (thousands) (1995-2010)

Country	1995	2000	2005	2010
Austria	7968	8060	8141	8203
Belgium	10141	10304	10418	10496
Denmark	5225	5309	5349	5376
Finland	5115	5231	5321	5396
France	58251	59722	61230	62464
Germany	82400	84961	86458	86891
Greece	10480	10787	10977	11087
Ireland	3575	3633	3706	3781
Italy	56126	56345	56627	56769
Netherlands	15534	16109	16475	16765
Portugal	9915	10014	10100	10150
Spain	39238	39632	39970	40171
Sweden	8852	9111	9271	9364
United Kingdom	58204	58625	59066	59362
EU-14	371024	377845	383111	386276

Source: RIVM (1998)
From: EEA (1999)

The degree of urbanisation varies greatly between countries, (Figures 3.3;3.4). In Belgium, Luxembourg, Iceland and Malta over 90 per cent of the population lives in urban areas, while in Portugal and Tajikistan this figure is less than 40 per cent (Figure 3.3).

3.1.1 Demands on quantity

The requirement for water for drinking and domestic purposes is a significant proportion of the total water demand. The proportion varies between countries and it is not easy to make comparisons since the data available usually refer to public water supplies, which will include some industrial use but exclude private supplies used to supply individual or small groups of households. The proportion of water for urban use in total abstraction ranges from around 6.5 per cent in Germany to over 50 per cent in the UK (ETC/IW, 1998).

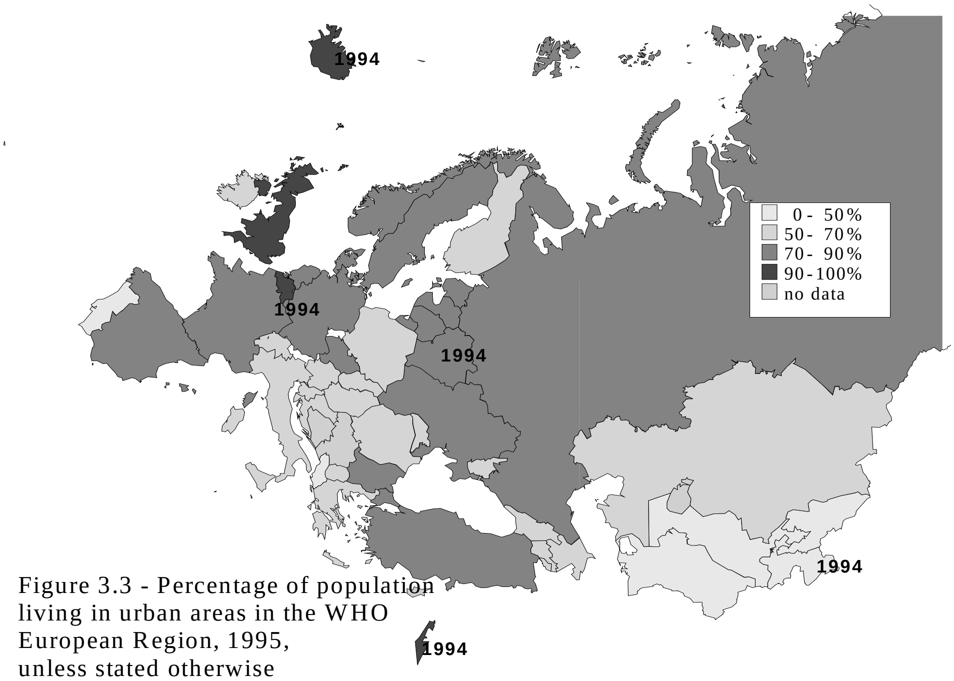


Figure 3.3 - Percentage of population living in urban areas in the WHO European Region, 1995, unless stated otherwise

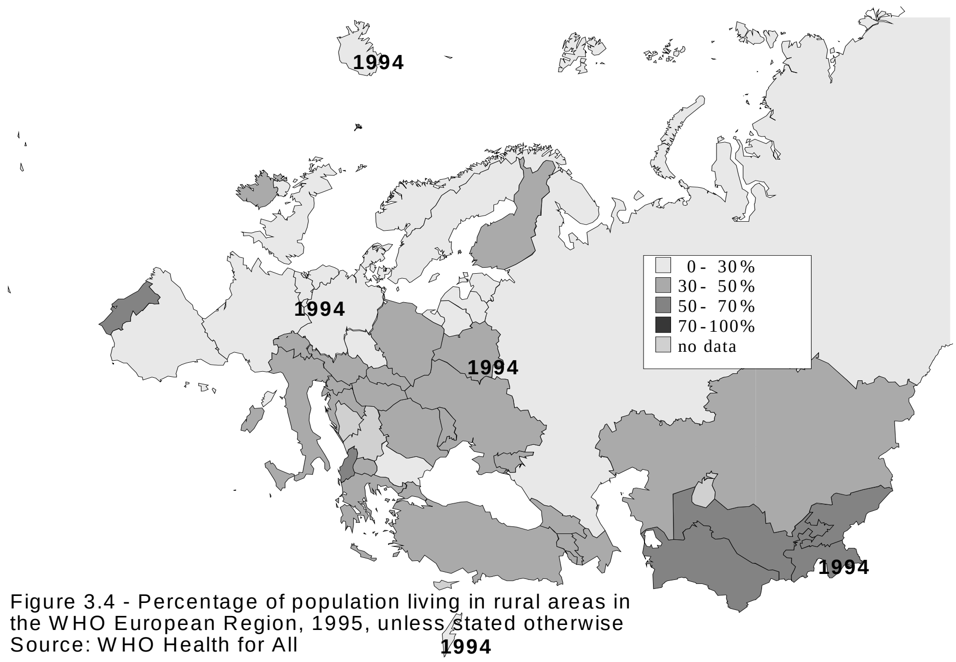


Figure 3.4 - Percentage of population living in rural areas in the WHO European Region, 1995, unless stated otherwise
Source: WHO Health for All

Increased urbanisation concentrates water demand and can lead to the overexploitation of local water resources (section 2.4.2.).

Insert Plate III 1 Abstraction of water for large cities - Paris

One consequence of increased urbanisation is a change in run-off patterns resulting from large areas being covered with an impermeable surface such as concrete, tarmac or roofs. Rainfall in cities largely enters a storm-drain system and is discharged, either directly or via a sewage treatment works, into surface waters. Thus, rainfall which in a rural area might have served to replenish groundwater supplies is, instead, directed to surface sources.

Urbanisation often, though not always, accompanies increased industrialisation and economic activity. The resultant rise in the standard of living is generally associated with an increased water demand, for example due to the use of water-consuming household appliances. However, urban water demand is expected to stabilise as a result of the development and use of appliances that are more water-efficient.

3.1.2 Threats to quality

In most European cities, human waste is removed from the house or latrine by a water-flush system. This wastewater enters a network of pipes along with other household wastewater. This wastewater may receive varying degrees of treatment to remove contaminants, or no treatment at all, depending on the country and location before discharge. Wastewater in public systems is treated at municipal treatment works which often receive wastewater from industrial discharges as well as domestic sewage.

Whilst the concentration of large numbers of people in close proximity simplifies the processes of water supply and wastewater collection, disposal of the large amounts of waste generated can compromise the water quality in the receiving water body. The release of untreated or partially-treated sewage to surface waters produces contamination by micro-organisms and nutrients and increases the BOD (sections 2.2.3 - 2.2.4). The conventional mechanical (primary) and biological (secondary) sewage treatment methods do not remove nutrients such as nitrogen and phosphorus or micro-organisms. Additional (tertiary) treatment to remove phosphorus has been common in Finland and Sweden since the middle of the 1970's and is becoming more common in other countries of western and northern Europe, but in much of Europe effluents discharged from wastewater treatment works contain nutrients which contribute to eutrophication (section 2.2.3).

Sewage effluents are the most significant contributors of phosphorus to surface waters and detergents add significantly to the phosphorus content of domestic sewage. Bans or voluntary agreements have been successful in reducing the use of phosphate-based detergents in a number of European countries.

There is also evidence to suggest that domestic sewage is a source of endocrine disrupting chemicals in the aquatic environment. Studies of sewage discharges to UK rivers have demonstrated the presence of natural and synthetic hormones used in the contraceptive pill (Desbrow *et al.,* 1996; section 3.3.2 and Box 3.6).

Poor personal hygiene, resulting in direct transfer of micro-organisms from person to person or transfer via contaminated food, is often a significant factor in the spread of disease. This route of infection becomes more likely where water supplies are inadequate or interrupted, and frequent washing is impractical. Poor sanitation and disposal of sewage is often associated with the spread of enteric diseases. In such circumstances faeces can contaminate the water sources that are used for potable supply, with the consequent spread of disease.

In some areas, particularly sparsely populated rural areas, the installation of a public sewerage network may involve excessive cost. In such cases, independent sewerage treatments such as sealed septic tanks were earlier considered an acceptable alternative. Other on-site sanitation systems such as pit latrines may protect the health of the local community by improving community hygiene. If they are however not properly designed or not adapted to the local conditions pathogens may be released and contaminate local water bodies or the environment. Figures 3.5, 3.6 and 3.7 show the extent of the European population connected to hygienic sewage disposal.

Even where wastewater is collected by a public sewage system, it may not receive adequate treatment, if any, before discharge into surface waters (Figure 3.8, Table 3.2 and Box 3.2).Advanced methods of sewage treatment are available and are used in some western and nordic contries. In some of these coutries, the majority of collected sewage receives at least secondary treatment, although there are exceptions (OECD, 1997). Significant proportions of collected sewage are discharged untreated by some southern European countries and this is also the case for some countries in the east of the region.

Wastewater treatment, as developed and practised in large parts of western Europe, is not designed for efficient removal of pathogens. Its primary purpose is to remove solids and reduce the BOD of the wastewater to prevent de-oxygenation and contamination of rivers when the effluent is discharged to water bodies. Nonetheless, 90-99 per cent of micro-organisms may be removed from the water phase during primary and secondary treatment and are concentrated in the sludge. Thus, although the microbiological content of effluent is lower than in the raw sewage, discharges from even quite advanced treatment works will be far from microbiologically pure. Life stages that do not readily settle, such as protozoan cysts, will also not be well removed by conventional sewage treatment (section 6.3.5; Merger *et al.*, 1995).

As the demands for water increases, wastewater reclamation and reuse may serve an important role in water resources management by providing a means to produce quality source water for irrigation, industrial and urban water requirements. In arid regions such as Israel, water reuse provides essential water source for agricultural production. Where untreated reclaimed wastewater is used for applications that have potential human exposure routes, the major acute health risks are associated with exposure to pathogens including bacterial pathogens and nematodes. Treatment of wastewater is a highly effective method of safeguarding public health (WHO, 1989).

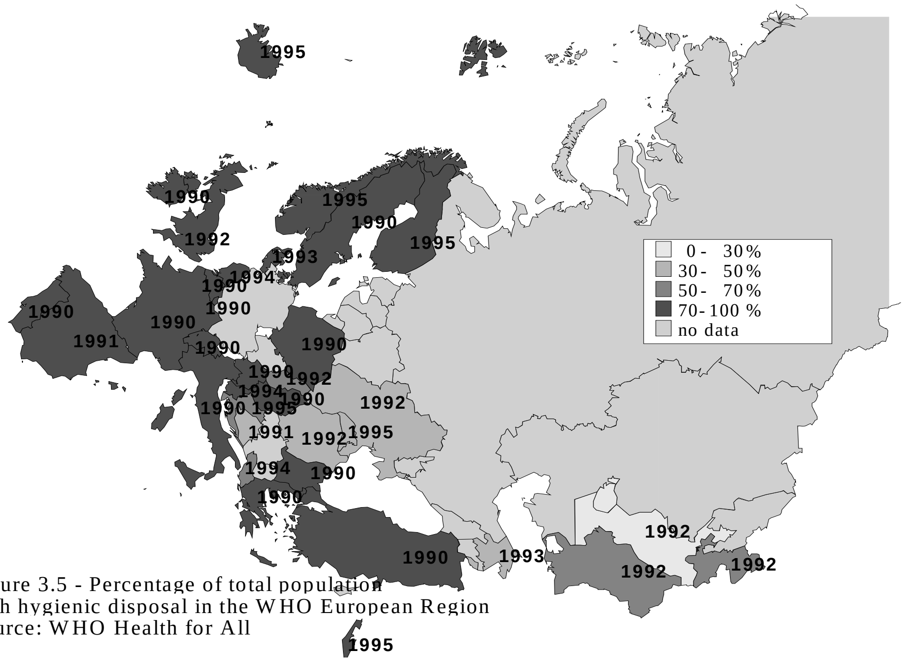


Figure 3.5 - Percentage of total population
with hygienic disposal in the WHO European Region
Source: WHO Health for All

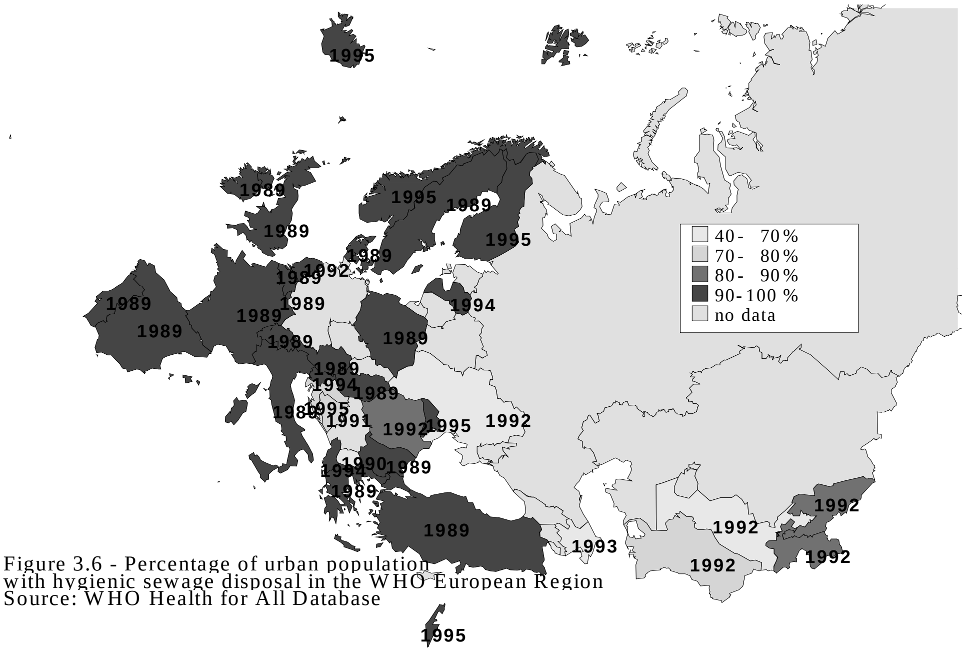


Figure 3.6 - Percentage of urban population
with hygienic sewage disposal in the WHO European Region
Source: WHO Health for All Database

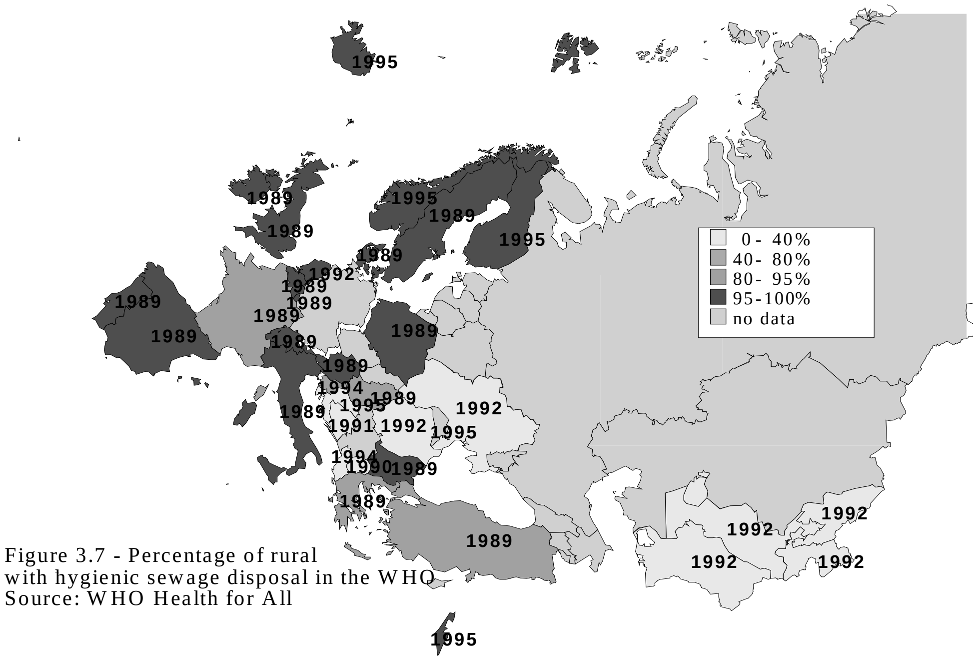


Figure 3.7 - Percentage of rural
with hygienic sewage disposal in the WHO
Source: WHO Health for All

Figure 3.8 Percentage of total populations connected to sewage collection and treatment systems in selected European countries, 1990

Notes: For Czech Republic and Slovakia: data on treatment received has been estimated based on 1990 data. Denmark: Data presented is from 1990. Data from OECD (1997) and the Danish NFP indicate that 99 per cent of all sewage is treated and receives at least secondary treatment. *Source:* OECD (1997)

Table 3.2 Sewage collection and treatment in selected countries of Europe

Country	Comments	Source
Albania	There are no wastewater treatment facilities to serve the wastewater collection systems in any of the municipalities. Collected wastewater is discharged, untreated, to inland surface waters or directly to the sea.	(1)
Bulgaria	Of the 237 towns, 79 per cent (187 towns) have a sewage network Only 5 per cent (92) of the villages have a sewage network.	(2)
Czech Republic	Total of 615.6 million m^3 of sewage waters are discharged to sewerage systems. Of this 90.3 per cent is treated. 70.3 per cent of inhabitants are connected to sewerage systems.	(3)
Estonia	In 1994, approximately 65 per cent of small sewage plants were not working. The poor rural population cannot pay for the maintenance and operation of sewage treatment plants and the network of institutions providing technical servicing of sewerage systems and sewage treatment plants has disintegrated.	(2)
Romania	Sewerage systems are found in 99.6 per cent of urban localities and 2.57 per cent of rural settlements. No adequate wastewater treatment plants have been developed in the localities.	(3)
Russian Federation	Around 77 per cent of the collected sewage undergo treatment, 72 per cent receives secondary treatment, and 10 per cent undergoes tertiary treatment.	(2)
Ukraine	Approximately 90 per cent of collected wastewater is treated, but parts of the treatment plants are often out of use because of problems with maintenance and lack of spare parts. There is no tertiary treatment. There are approximately 150,000 ha of sludge lagoons containing sludge that is too heavily contaminated with heavy metals to be spread on agricultural land.	(2)

Sources: (1) Mountain Unlimited (1997); (2) Mountain Unlimited (1995) (3) EEA/WHO questionnaire(1998)

Box 3.2 Wastewater disposal in Slovenia

The majority of drinking water supplies in Slovenia are derived from groundwater sources. One of the most important sources is in the Karats, an area of permeable limestone with many underground caves and streams, which covers 44 per cent of Slovenian territory. Because underground water flows in this region are very fast, contamination can spread rapidly and affect water sources some distance from its origin. Many surface waters in Slovenia are contaminated.

Only 44 per cent of the Slovenian population is connected to the public sewage system and only 36 per cent of the sewage water in the public sewage system receives treatment before it is discharged into streams, much of which enters the Karats underground caves and waters. The lack of sewage treatment extends even to the largest towns, including Mariner and the capital Ljubljana, despite a comprehensive and expensive plan implemented several years ago under which over 100 treatment plants were constructed. Unfortunately, the plants built incorporated inappropriate technology or were poorly maintained and, in general, only the primary mechanical treatment stage worked effectively.

Sewage discharges from domestic sources, public institutions such as schools and hospitals, and industrial and agricultural discharges are significant polluters in Slovenia, with intensive pig farms being notable point source polluters. It has been estimated that 5,000 sewage treatment works need constructing. Some of these would be very small and it has been suggested that reed bed treatments might be an effective and cheaper alternative for small towns and villages. *Source:* Pucelj (1996).

3.2 3.2 Agriculture and food production

A considerable proportion of Europe's surface area is devoted to food production. In 1989, agricultural land in Russia accounted for 37.3 per cent of the total land area in the former USSR, whereas in Kazakhstan it comprised 36.9 per cent, in Ukraine and the Republic of Republic of Moldova, 7.4 per cent; in Belarus and the Baltic Republics, 2.8 per cent (Chernogaeva *et al.*, 1998).

The proportion of agricultural land that is irrigated tends to be higher in southern European countries although this is not exclusively the case; a large proportion of agriculture in Denmark and the Netherlands makes use of irrigation (Figure 3.9). In western Europe currently around 2 per cent of the land area as a whole is irrigated (EEA, 1998).

3.2.1 Demands on quantity

The development and intensification of agriculture that has taken place over recent decades has brought with it implications for both the quantity and quality of water sources. Agricultural demand for water in Europe is dominated by its use for irrigation. Thus, over the past decades the trend of agricultural water use has, in general, been upwards, although. it seems that more recently in several countries, the rate of increase of the irrigated area has been diminishing. From 1990, the irrigated area tended to be stable in Austria, Denmark, Finland, Ireland, Netherlands and

Portugal; there has been a decreasing trend especially in the UK, Germany and Italy. However, there has been growth in France, Spain and Greece (Figure. 3.6).

Insert Plate III 2 Large scale irrigation project (Sicily)

Freshwater aquaculture makes less demands on the quantity of water, but can, if not carefully regulated and managed, cause severe impacts to water and ecological quality. Unlike agriculture where much of the irrigation water is lost to evapotranspiration or moved between compartments, water abstracted for aquaculture is returned to river shortly after abstraction, with very little loss in quantity (Mainstone *et al.* 1989). Some forms of freshwater aquaculture (caged fish farming) are undertaken in lakes and estuaries, where there is no need for abstraction, but a deterioration in quality may become apparent if the quantity of fish produced is not regulated.

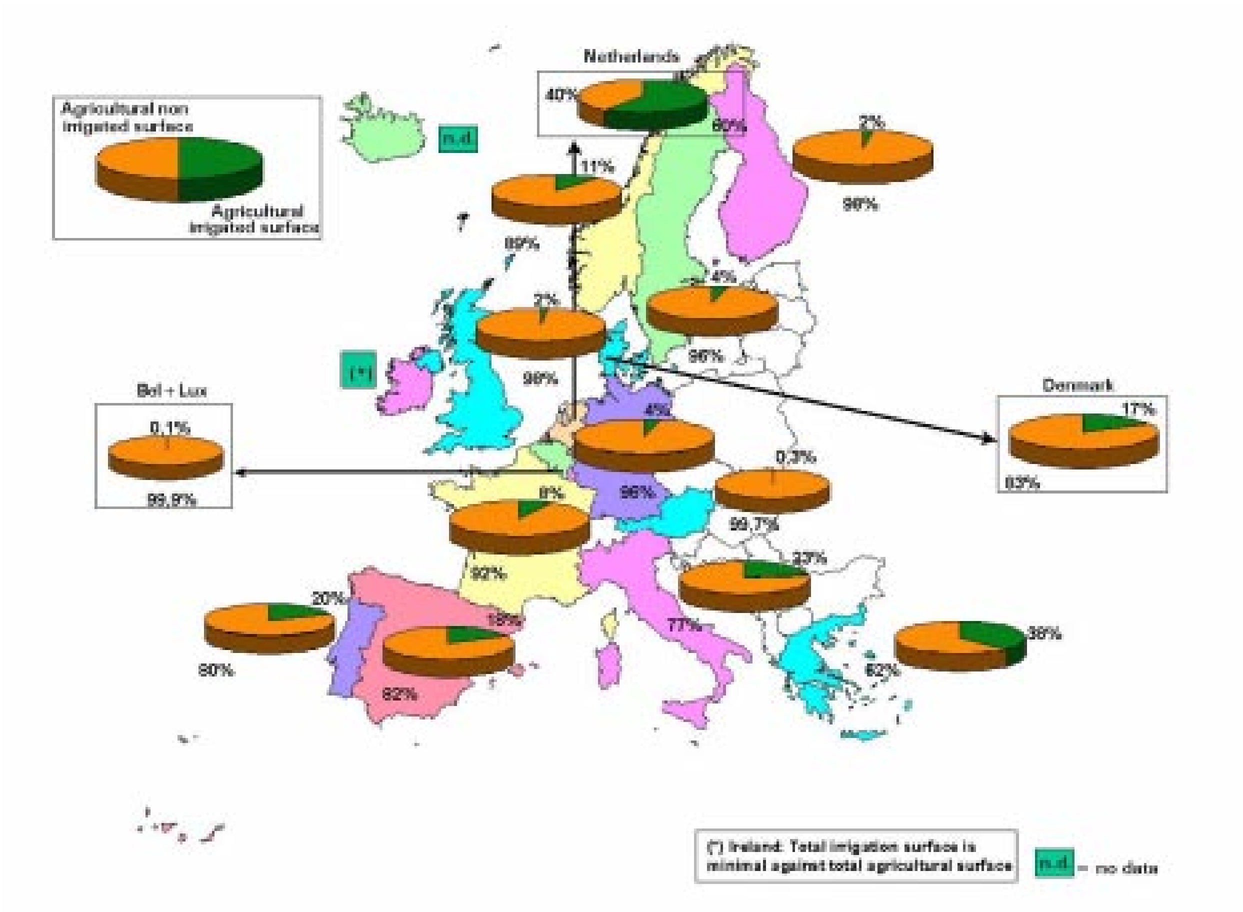


Figure 3.9 Irrigated versus non-irrigated agricultural area in selected European countries.
Source: EEA (1999c)

Disclaimer: The designations and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organisation concerning the legal status of any country, territory, city or area or its authorities or concerning the delimitation of its frontiers or boundaries.

Insert Plate III 3 Freshwater aquaculture, DK

The global aquaculture production statistics reported for 1984-1996 are noticeably higher than those between 1984 -1995. By 1996 Europe was the second largest contributor with 4.7 per cent of world production. The transition to a free economy adversely affected aquaculture development in the former USSR with total aquaculture production declining at an average rate of 21per cent per year in all countries between 1990 and 1996. Between 1990 and 1996 Armenia reported a 13 per cent decline in aquacultural output compared with 47 per cent in Tajakistan. Aquaculture production in the former USSR is dominated by the Russian Federation and Ukraine which between them accounted for 83 per cent of total production in 1996 (Rana and Immink, 1999).

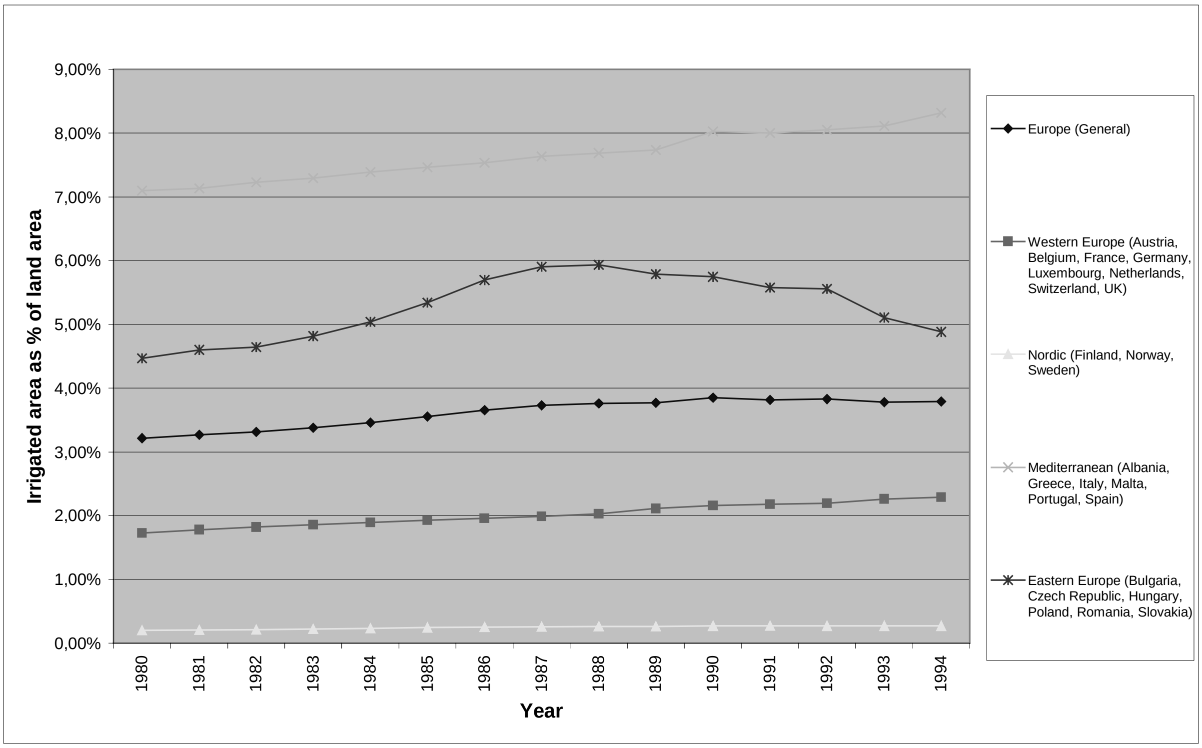


Figure 3.10 Change in percentage of irrigated area as a percentage of total land area in Europe 1980-1994
Source: FAO (1996)
From: EEA (1998)

3.2.2 Threats to quality

Concerns about the impact of agriculture on the quality of water resources are often related to the leaching and run-off of agrochemicals applied to crops and soil. Some agricultural contamination can originate from point sources, but the majority stems from diffuse sources. The use of agrochemicals depends upon the type of agriculture practised within a country and the market price of the crops grown. The economic conditions of the country and the agricultural subsidies available to farmers also strongly influence the extent of use. Contamination of water by nutrients and microbiological pathogens from farm wastes and animal slurries are also concerns.

Micro-organisms

Farmyard waste or run-off from fields on which animal manures have been spread can contain micro-organisms that are human pathogens. These include the bacterium *E. coli*, some strains of which are enteropathogenic, and the protozoan *Cryptosporidium*. Outbreaks of diseases caused by both of these pathogens, originating in agriculture, have occurred in the UK in recent times, with significant numbers of people affected. *Cryptosporidium* outbreaks have occurred following contamination of water sources used for abstraction for potable water (section 6.3.5), while diarrhoeal diseases caused by *E. coli* 0157, resulting in death in some cases, have been linked to consumption of infected meat or contact with contaminated mud.

Agricultural land has, for many years, been used as a recipient for sludge produced by sewage treatment, and this practice is increasing in some countries as disposal to the marine environment is being reduced and will be prohibited in the EU under the Directive 91/271/EEC, section 7.3.1). In other parts of the world where there has, historically, been more pressure on water resources than in Europe, domestic wastewater has also been used to irrigate crops. As well as providing water for irrigation, this also supplies nutrients to the crop and reduces the release of nutrients to surface waters in effluent. Within Europe the UK and Germany have practised wastewater reuse, and its use has been increasing in some countries.

Nutrients

One of the major threats to the quality of surface waters in Europe is eutrophication as a result of excessive nutrient loading (section 2.2.2 and 2.2.3). The intensification of agriculture in many areas has resulted in large quantities of inorganic fertiliser being applied to arable land resulting in eutrophication of lakes, rivers and coastal waters (Kauppi *et al.*, 1993). Intensification of livestock farming practices has also resulted in increased production of livestock waste, which is used as organic fertiliser (Sims, 1997).

Applications of organic fertilisers, such as animal manure, to arable land and run-off of slurries from farmyards may be another source of pollution by nutrients. Animal feeds are often high in nutrients, in order to encourage rapid growth of the livestock, and the excess is excreted.

Common inorganic fertiliser formulations contain nitrogen, phosphorus and potassium in varying proportions. Use of inorganic fertilisers varies between countries, depending on the economic situation and predominant agricultural practices (Figure. 3.11).

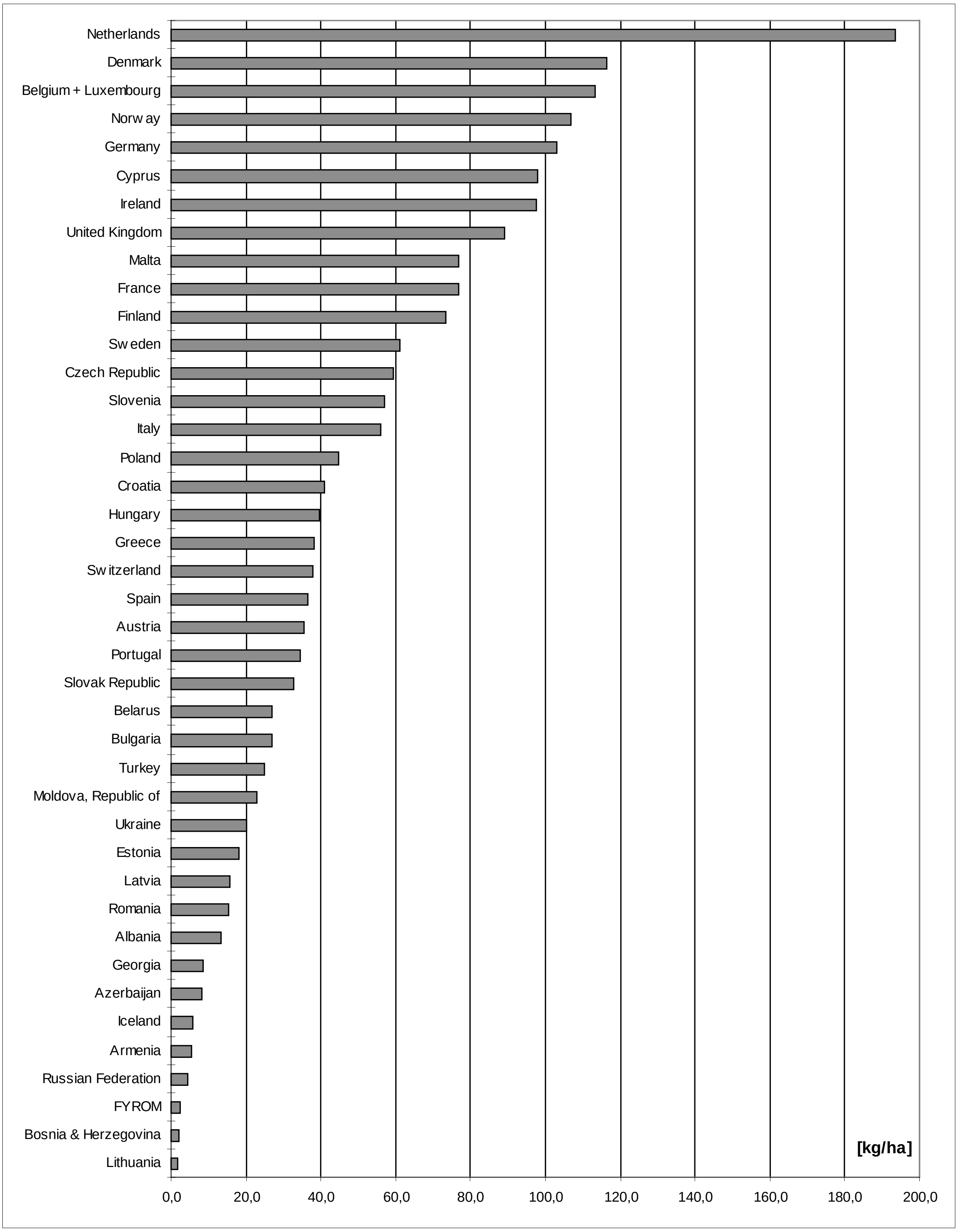


Figure 3.11 Nitrate-fertiliser consumption of commercial kg N-NO_3/ha agricultural area in 1994
Source: FAO (1996)

Although potassium applied in this manner rarely causes problems, in extreme cases it can reach very high levels in surface waters. For example, the effects of intensive horticultural practices on Guernsey (Channel Islands) mean that it is only by blending water from several different sources that the EU Drinking Water Directive (80/778(/EEC). standard for potassium can be met.

Insert Plate III 4 Application of fertiliser on a field

The system of subsidies operating in the EU under the CAP has encouraged the maximisation of crop yields and has often resulted in the application of fertiliser at supra-optimal rates. Nitrogen not taken up by the growing crop are then liable to leach into groundwater or run-off into surface waters, depending, amongst other things, on the precipitation pattern. It is this difference between the input of nitrogen to land and the output in crops (i.e. the nitrogen balance) that largely determines the potential for nitrogen leaching. Nitrogen balance studies in EU countries have shown that nitrogen surpluses are as high as 200 kg N/ha per year in the Netherlands, but less than 10 kg N/ha per year in Portugal, demonstrating the range and influence of different farming methods, even within the EU subsidies system (Figure. 3.12).

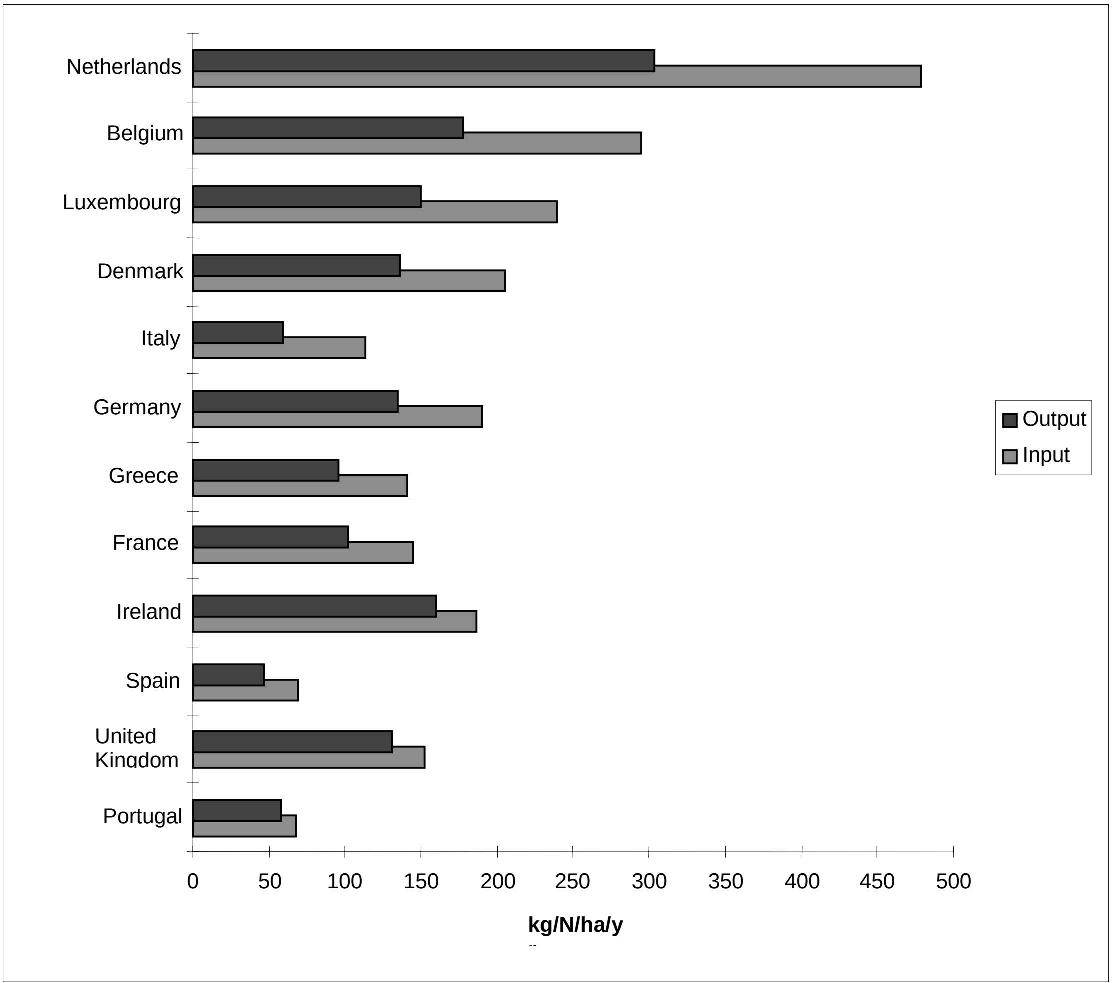


Figure 3.12 Soil surface nitrogen balances for agricultural land in EU12 countries 1993 (Countries ranked in terms of surplus of input over output)
Notes: Input includes fertiliser and manure. Output includes the harvest.
Source: Eurostat (1997b);
From EEA (1998)

Although point sources of pollution, such as sewage discharges, can contribute significantly to nitrogen pollution in some regions, diffuse sources such as agriculture are usually the major contributors and in some countries, such as the Netherlands, the proportion of water pollution due to diffuse sources is steadily increasing. Nitrogen is usually rate limiting for algal growth in marine waters, and leaching of nitrate fertilisers is a cause of marine eutrophication. It can also be rate limiting in fresh surface waters at certain times and, therefore, may also contribute to algal blooms in surface waters. Nitrate readily leaches into groundwaters, where it may cause health problems if water is abstracted for potable supply (Sims, 1997; refer to section 6.4.5).

Agriculture also contributes to the phosphorus loading to surface waters and, hence, to eutrophication and associated ecological problems. As with nitrogen, intensive farming methods produce a surplus of phosphorus in the soil, which has been estimated to be 13 kg P/ha per year in the EU (Sibbesen and Runge-Metzger, 1995). High surpluses have been reported in the Netherlands, Belgium, Luxembourg, Germany and Denmark. However, in densely populated areas this contribution has largely been insignificant in comparison with phosphorus from point sources, predominantly sewage discharges. As the control of pollution from urban wastewater improves, phosphorus from agricultural sources may become more significant.

Insert Plate III 5 Uncontrolled run-off of liquid

Aquaculture is another major source of nutrients in some lakes and rivers. Although reported nutrient export rates from fish farms can vary substantially, most values appear to be in the region of 20-100 kg P/tonne of salmonid fish (NCC, 1990; Foy and Rosell, 1991). It might be expected that the advent of low-phosphorus fish food would have lowered these export coefficients, but it is not known how widely these feeds have been adopted by farmers.

Pesticides

The use of pesticides in agriculture has become common place in the last half-century. In arable cropping, herbicides are used in the greatest quantities, and it is these that have been detected most frequently in European groundwater (section 2.4.5). Fungicides are used to prevent plant diseases, and insecticides are applied both to prevent direct damage by insects and their larvae and to prevent the spread of viral diseases for which insects are vectors. Modern animal husbandry also involves the use of veterinary products such as insecticides for use in animal houses and dips used to prevent infestation of the animals by ectoparasites.

As with fertilisers, pesticide use depends upon economic conditions, the market price for the crop being grown and the subsidies available, as well as accepted practice in the country concerned, and varies widely across Europe (Figure. 3.13).

Within the EU, there has been a decreasing trend in the quantity of pesticide active ingredients sold since 1985 (Figure 3.14). This may be due, in part, to changes in the pattern of use of established pesticides, but is also a reflection of the increased activity of recently introduced pesticides which enables them to be effective at lower application rates. Long-term monitoring of water bodies in Armenia, Georgia and

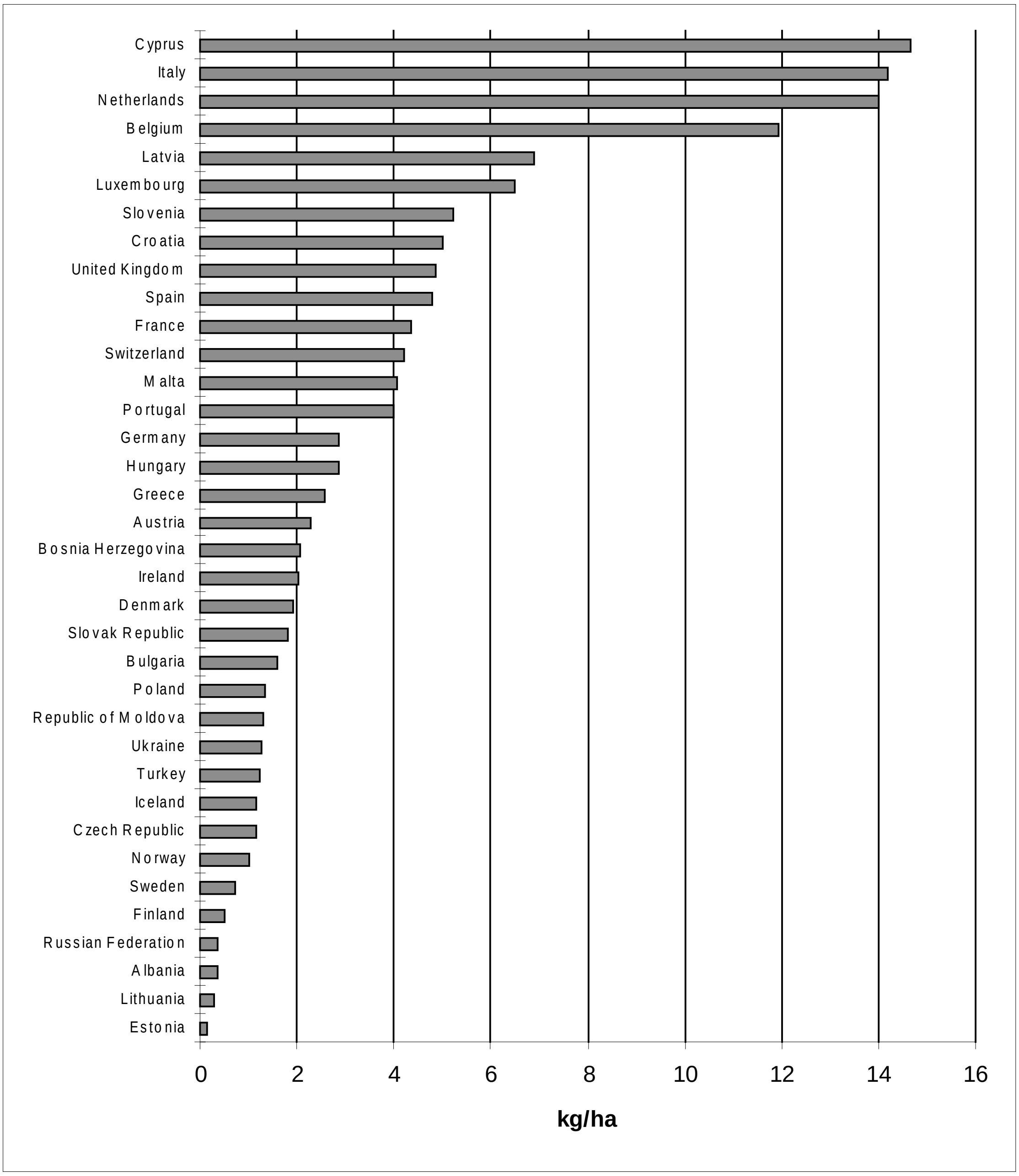


Figure 3.13 Pesticide consumption per arable land and permanent crop land (kg/ha)
Sources: FAO, EUROSTAT, OECD, ETC/IW questionnaire;
From: EEA (1999a)

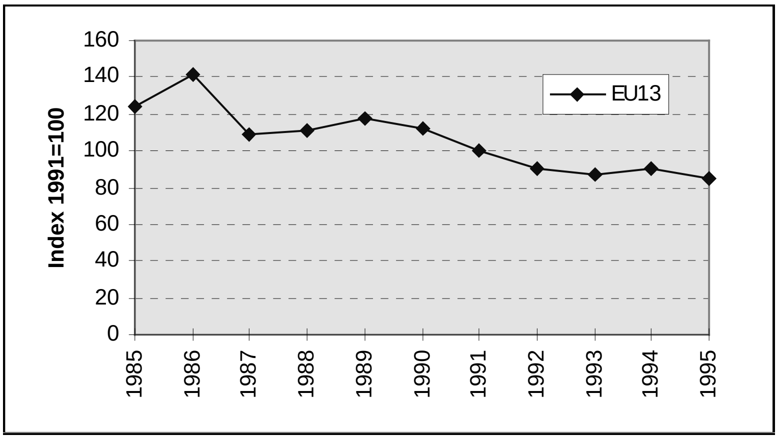


Figure 3.14 Total sales of pesticides in some EU countries 1985-1995
Source: ECPA (1996).
From: EEA (1999a)

Azerbaijan showed an overall trend of decreasing organochlorine pesticides since 1978 (Petrosyan *et al.*, 1998).

Groundwaters are usually regarded as being most vulnerable to pollution by pesticides, because of the long residence time and minimal degradation. However, pollution by pesticides can also affect surface waters (section 2.2.4) and toxic effects on aquatic life can occur. Lowland surface waters are particularly likely to contain pesticides, although some products, such as sheep dips, may find specific use in upland areas. Some pesticides, such as the sheep dip chemical cypermethrin, bind very strongly to sediment and this can act as a reservoir of the chemical that will slowly release the contaminant over a long time period.

As well as run-off or leaching from applied pesticides, pollution can result from the disposal of excess spray, tank washings and spent sheep dip (Box 3.3). Antibiotics, vaccines and other chemicals, such as malachite green (for the control of fungal infection), are widely used for the control of disease in fish farming. Most of these chemicals are administered as food additives, but chemicals utilised in the control of ectoparasites (e.g. acriflavine) are often administered as dip treatments. Pesticides have been implicated in various disorders and diseases including cancer, adverse reproductive disorders, impaired immune function, and allergic reactions, particularly of the skin (section 6.4.7).

Box 3.3 Disposal of spent sheep dip - UK

Until 1992, the dipping of sheep to control ectoparasites such as scab and blowfly was compulsory in the UK. Although farmers are no longer legally required to dip their sheep, good animal husbandry may require it. In recent years most dips have contained organophosphorus compounds such as propetamphos although there is an increasing tendency, largely because of concerns about operator health, towards synthetic pyrethroids such as flumethrin and cypermethrin.

Large volumes of spent dip are produced during each dipping operation, presenting the farmer with the problem of disposal. Older dipping tanks incorporated a drain plug which was removed when the dipping operation was over. The preferred disposal method for many years was a “soakaway”, a large pit backfilled with stones and sand or gravel. However, because intensive sheep farming is largely in upland areas with shallow soils and a high water table, these methods often resulted in the majority of the dip entering streams and rivers. On-site treatment of the dip using flocculation, settlement and filtration by gravel and GAC has been considered but was found to be unsuitable for the disposal of spent dip because of the high solids and lanolin content (Blackmore and Clark, 1994).

Disposal through an approved waste contractor is an option preferred by the UK regulatory authorities, but it will often be prohibitively expensive for many sheep farmers. As an alternative, guidelines the Environment Agency (1997) recommend spreading thinly onto grassland at an application rate of up to 5000 l/ha. Co-spreading with slurry is suggested as this may increase the rate at which the active ingredients are broken down. Spreading should not be carried out close to water courses or springs, nor if rain is forecast or if the soil water is already at field capacity, and level ground should be used. The guidelines stress that spreading should only be carried out if it will not affect the quality of ground or surface water. However, the concentration of sheep farming in hilly areas with thin soil and high rainfall are likely to preclude the implementation of these safeguards in many cases.

The leaching of sheep dip into aquifers is also a potential concern, although, the major aquifers in the UK are not those where sheep farming is practised most intensively. Nonetheless, sheep farming does exist, for example, in the South Downs, and percolation into the saturated and unsaturated layer has been demonstrated following the repeated spreading of spent dip from a mobile operation to land (Blackmore and Clark, 1994). Although the risk from sheep dip disposal to the quality of groundwater sources is not as great as that for surface waters, high concentrations in rivers and streams are seasonal, coinciding with sheep dipping operations. In contrast, contamination of an aquifer will lead to a more constant and persistent problem.

Suspended solids

Soil erosion is influenced by the degree of afforestation and the tillage regimes used in agriculture. Run-off containing high levels of particulate matter results in contamination of source waters by suspended solids, and heavy rainfall on fields without a crop root structure in place accentuates this. Thus, the type and timing of cultivations can influence water quality. Lee *et al.* (1995a,b) found for example in Britain that the increase in lowland erosion is due to the adoption of winter cereals and the consequent expansion of the area left bare in autumn and winter (Boardman and Robinson, 1985; Evans and Cook, 1986; Spiers and Frost, 1987). Other factors that are believed to have contributed to the increase include:

- arable farming on steep slopes
- the removal of field boundaries to create larger fields (Evans and Cook, 1986)
- inappropriate choice of crop on steep slopes and erodible soils
- working land up and down the line of maximum slope
- presence of vehicle wheel tracks which act as channels for runoff (Reed, 1986)
- rolling of seedbeds (Spiers and Frost, 1987).

Fish farming is also a source of relatively large amounts of suspended solids, consisting of uneaten food pellets, faecal particles (including gut bacteria), fish scales, mucus and other detritus. Estimates of dry pellet loss from trout and salmon tank and pond culture are commonly in the range 5-20 per cent, with feed losses from cage farms thought to be greater (NCC, 1990). The use of settlement ponds and other treatment methodologies, together with different sampling frequencies, system type, feeding methods and rates, fish size and type of diet used results in a wide range of suspended solids loads from fish farms. Values reviewed by NCC (1990) range from 110 to 2153 kg/tonne fish produced. This solids load has an associated oxygen demand, usually accounting for at least half of the total BOD load (particulate and dissolved) from salmonid fish farms. Fish farm effluents do not usually have a significant impact upon running water dissolved oxygen levels, but organic enrichment below caged fish farms in lakes is often detrimental to the sediment invertebrate community.

3.3 3.3 Industry and transport

Industrial demand and effects on water quality can directly impact on the water supplies of a large number of people where industry is co-located with urban areas of high population.

3.3.1 Demands on quantity

Some industries, particularly traditional heavy industries, require large amounts of water for cleaning or cooling and, therefore, compete for water resources. The amount of water abstracted for cooling usually far exceeds that used during industrial processes, but this is often regarded as a "non-consumptive" use as the water is returned to its source virtually unchanged except for an increase in temperature and, in some instances, the presence of a biocide. The amount of water required also depends on the type of process used; in general, more modern plant would be expected to incorporate more water-saving measures.

The amount of water used by industry and its significance as a proportion of total abstractions varies greatly between countries (Figure 3.2). Figures vary according to the different methods used to record specific uses (e.g. some countries include cooling water in the figure for industrial use, while others do not). There has been a trend of decreasing abstraction for industrial purposes in Europe since 1980, largely due to industrial recession in many countries of eastern Europe and changes in the predominant industries and industrial practices in northern and western Europe. In the latter countries there has been a decline in traditional industries such as textiles, iron and steel, coupled with technological improvements in water-using equipment and increased recycling.

3.3.2 Threats to quality

Industrial processes produce contaminated wastewaters that are, either directly or following treatment, released into fresh or marine surface waters. The range of chemical contamination that may be released is large, but much attention has been paid to substances that may accumulate in sediment or bioaccumulate and enter the food chain, such as some heavy metals and certain organic substances.

As well as controlled or intentional discharges, contamination can also occur as a result of spillages, poor handling, improper disposal methods and accidents. Acute incidents of source water pollution can occur, for example, following road accidents involving chemical tankers or a fire. On-going pollution may result from leaking oil pipelines or chemical tanks.

Insert Plate III 6 Industrial waste dumpsite - Slovakia

Often, pollution of water sources is a legacy of previous industrial practices. This is particularly the case with groundwaters, in which contamination persists for many decades, due to the lack of volatilisation and degradation and the slow recharge time. Leaching of industrial chemicals into groundwaters has also been the result of spillages and the historical disposal of chemicals onto land (Box 3.4).

In some cases, the discharge may continue even after the industry has ceased, such as the release of contaminated flood water from disused mines. However, discharges will, in general, change as the dominant industries change and industrial practices and disposal techniques improve.

Poor control of industrial pollution is recognised as a problem in many of the states that were formerly part of the USSR, and detrimental effects on health have been reported. In the Russian Federation, for example, illnesses have been linked with drinking water polluted by industry in the Perm-Krasnokamsk industrial zone, the cities of Kemerovo and Yurga and in residents near to the Ust-Ilminsk plant (Ministry of Environmental Protection and Natural Resources of the Russian Federation, 1994).

Heavy metals

Historically, heavy metals have been common contaminants, being released from a range of industries. Many are cumulative in the body and can persist in sediment, being released into the water column when the sediment is disturbed. However, measures undertaken in Nordic and western countries to reduce heavy metal emissions to inland waters and marine areas have been successful (Figure 3.15).

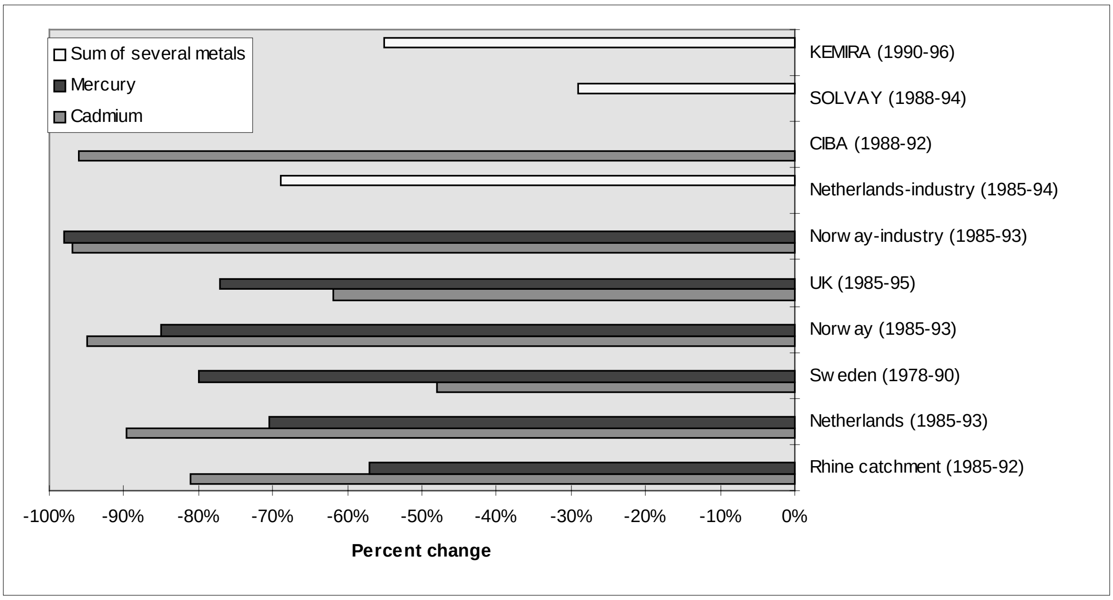


Figure 3.15 Change in emissions of heavy metals from various sources between ca. 1980 and ca. 1990

Sources: WWW homepages of industrial companies; IKSR, 1994; RIVM, 1995; Swedish EPA, 1993; SFT, 1996; DoE, 1997.

From: EEA (1998).

Petrochemicals and volatile organic compounds

Petrochemicals are amongst the most widely used of all industrial products because of their use in transport and power generation. Pollution incidents arising from spills from tanker disasters in the marine environment have, perhaps, been the most widely publicised incidents involving this industry. However, contamination of freshwater sources has occurred by leakage from petrochemical plants and pipelines, fuel tanks at filling stations and military sites (Box 3.5). Groundwaters are vulnerable and contamination by hydrocarbons is a particular problem in parts of eastern Europe. In the Czech Republic for example, approximately 50 per cent of accidental water pollution incidents involve petroleum (Czech Environmental Institute, 1996). Some regions of Estonia also report contamination of surface and groundwaters by phenols and petroleum products.

Contamination of aquifers with hydrocarbons may also influence the distribution of other contaminants within the aquifer. The Luton and Dunstable aquifer in the UK, for example (Box 3.5) was found to be contaminated with hydrocarbons as well as organic solvents. The hydrocarbons formed a layer at the top of the aquifer into which the solvents were preferentially dissolved (Longstaff *et al.*, 1992).

Box 3.4 Contamination of groundwater at military sites

Environmental damage caused by armed forces during peace has been observed in many parts of the world. In Hungary, for example, environmental impact assessment studies indicated serious environmental pollution at 18 Russian military bases, including airfields. The major problems related to the uncontrolled release of jet fuel just before landing, impacting directly on the soil and groundwater at the ends of the runway. This resulted in the serious contamination of the groundwater - a kerosene layer was observed floating on the top of the groundwater at several locations. Dispersion, diffusion and dissolution of components of this kerosene, particularly one-ring aromatic hydrocarbons, e.g., BTEX, in the groundwater and the migration by lateral flow into aquifers used for drinking water abstraction, created potential risk to the consumers. In addition to the "disposal" of jet fuel, other potential environmental hazards relate to the unsecured disposal of hazardous materials that are often unidentified. This may include toxic chemicals buried in the area of the military base.

A number of volatile chlorinated organic compounds are widely used in industry as solvents, degreasers and cleaning agents. These include compounds such as trichloroethene and PCE. Inappropriate handling procedures and disposal techniques, such as spreading on the ground, have resulted in groundwaters becoming contaminated through leaching. These compounds volatilise readily and therefore their release to surface waters has a lower impact on water quality.

Hormonally active chemicals

There has been much publicity in recent years regarding the presence in the aquatic environment of chemicals that mimic natural hormones, and concerns that they may be linked to reported increases in testicular and breast cancers and decreases in sperm counts. Some cases exist within Europe where adverse endocrine effects or reproductive toxicity, in birds and mammals coincide with high levels of anthropogenic chemicals which have been shown to have endocrine-disrupting properties (EC, 1996). Evidence for this association is limited, but some substances have been shown to cause feminisation of male fish, with the production of vitellogenin, an egg-yolk protein protein normally only found in sexually mature female fish, and oocytes (egg cells). A wide range of industrial chemicals has been shown to trigger this activity (Box 3.6).

Box 3.5 Industrial contamination of groundwater: Luton and Dunstable aquifer

The first in-depth study of contamination of groundwater sources in industrialised urban areas of Europe was carried out in Milan in the early 1980s (Cavellero *et al.*, 1985). Since then investigations of several aquifers in the UK, with different geologies, have repeated the findings of widespread contamination by industrial compounds, particularly chlorinated solvents (Baxter, 1985; Lerner and Tellam, 1992; Longstaff *et al.*, 1992; Rivett *et al.*, 1990).

The chalk aquifer, lying underneath the urban conurbation of Luton and Dunstable in Southern England, is the most widely exploited groundwater source in the UK. Industry in the area is dominated by the automobile industry which makes heavy use of chlorinated solvents as degreasing agents. The solvent traditionally used is TCE although this is now being replaced in some cases by 1,1,1-trichloroethane. A related solvent, PCE, has been widely used as a dry-cleaning fluid (Longstaff *et al.*, 1992).

Analyses of water from boreholes in the chalk aquifer showed a pattern of widespread low-level contamination by these solvents, with "hotspots" of higher concentrations. Much of the contamination is believed to be the legacy of historical industrial practices such as disposal by spreading on open ground to allow evaporation. However, although disposal methods have changed, studies have found that other handling practices have, in many factories, changed little over the last couple of decades. Casual use and indiscriminate disposal is still believed to be occurring. Solvents are frequently stored in drums in unbounded areas and spill prevention measures during decanting may be inadequate. Degreasing is often carried out in dip tanks, from which loss from leakage may go undetected because it is indistinguishable from loss by solvent evaporation. The assertion that the contamination is unlikely to be entirely a legacy from the past appears to be supported by the fact that 1,1,1-trichloroethane, which has only been widely in use since the 1970s, has been found in the aquifer (Rivett *et al.*, 1990; Longstaff *et al.*, 1992).

Chlorinated solvents have high specific densities and low viscosities and do not sorb to geological minerals. It is these properties that make them highly mobile in many soils, resulting in the contamination of groundwater. In addition, they are immiscible with water, and this, coupled with their density, may result in a liquid phase which is able to sink deep into the aquifer, producing widespread contamination. The solvents are chemically stable and have a high resistance to microbial degradation, making them persistent once they have entered groundwater.

Because of the elevated levels of chlorinated solvents detected in the Luton and Dunstable area, the Lee Valley Water Company installed air-stripping water treatment for water extracted from boreholes. This has been effective in reducing solvent concentrations by 95 per cent (Longstaff *et al.*, 1992).

Box 3.6 Oestrogenic substances and water

Concern has been expressed over the possible adverse environmental effects of hormone-like substances on man and other species such as fish. Research to date has mainly focused on the potential for compounds to inadvertently mimic the biological activities of the female endogenous hormone oestrogen, which can cause a feminising or "oestrogenic" effect. It has been postulated that exposure to such oestrogenic chemicals can cause adverse effects which include reduced reproductive function, increases in certain types of cancers in man, and a decline in wildlife populations.

Evidence exists that sewage effluents can contain substances causing oestrogenic effects. Generally, this has been demonstrated by the production of vitellogenin. However, male and immature females can also produce this protein in response to oestrogens. Vitellogenin production appears to be a very sensitive biomarker of oestrogenic activity, although a clear direct relationship between its production and effects on fertility has not been established. It remains unclear as to the extent to which these observations are associated with significant changes in population viability.

Numerous compounds have been shown to have weak oestrogenic activity e.g. alkylphenols, bisphenol A, PCBs and some pesticides. However, natural hormones appear to be predominantly responsible for the oestrogenic activity in domestic effluents (Desbrow *et al.,* 1996). For sewage treatment works that receive significant industrial inputs, some effluents can contain relatively high concentrations of other weak oestrogenically active compounds such as alkyl phenols and alkylphenol ethoxylates. In such cases, it is likely that these latter compounds contribute to the oestrogenic activity which could give rise to localised environmental impact.

Since river water is widely used for drinking water production, this has also raised concerns that drinking water might be a source of exposure to oestrogenic substances. However, in a study undertaken by (Harries *et al.,* 1995) no oestrogenic activity was detected at drinking water intakes or storage reservoirs and analyses using methods with appropriate limits of detection have provided no evidence for the presence of free natural hormones in drinking water sourced from rivers which receive sewage effluent (James *et al.,* 1998).

3.4 3.4 Tourism

Tourism is an important source of income in certain areas - including a number of Mediterranean countries, Austria, Ireland and Switzerland and Hungary (WHO, 1997f) - but the seasonal influx of large numbers of people can have significant impacts on water resources and greatly increase the volume of wastewater requiring treatment and disposal.

3.4.1 Demands on quantity

Domestic water use by tourists is often twice as high as for residents, and large volumes of water are also required for recreation facilities such as swimming pools, water parks and golf courses. Areas popular for tourism are often "good weather" areas, thus concentrating the demand in an area where water resources may already be limited (e.g. Mediterranean coast of Spain) and peak demand often occurs during periods of low water resource renewal. Localised shortages of water may therefore be common in areas used for tourism. Supplying sufficient water at the time of peak demand, often in the driest time of year, may require the construction of additional storage facilities such as reservoirs.

3.4.2 Threats to quality

A large, seasonal influx of tourists can produce challenges in the design and operation of water supply systems, wastewater collection and treatment facilities. Large variations in the quantity of wastewater to be treated make the design and operation of efficient sewage systems and treatment works difficult.

Some areas that attract tourism are in terrain that makes connection to conventional sewage collection and treatment systems difficult or inappropriate. For example, the Austrian and German Alpine Associations have more than 750 refuges and lodges in the Austrian Alps, attracting about 1 million overnight stays. This is in addition to the 1.5 million day-visitors and 2000 full-time staff, and the 300 lodges belonging to other organisations. Tourism in the Austrian Alps has been estimated to generate a total wastewater load equivalent to 430,000 people during the holiday season. This produces technical and financial difficulties associated with treating fluctuating discharges at low temperatures (EEA, 1998).

In summer mass tourism concentrates along coastal areas. The increase in visitors to coastal areas at specific times of the year creates demanding health problems. Discharged urban storm and wastewater are the main source of sea pollution affecting the quality of coastal sea water making it unsuitable for swimming and a threat to human health (section 5.6). Where municipal sewage constitutes a significant source of phosphorous pollution, removal of phosphorus at treatment plants is necessary. Heavy seasonal tourism increases the demand on the capacity of treatment plants and sewerage and also causes substantial fluctuations in the sewage load. Sewerage and treatment for fluctuating amounts of sewage present specific technical difficulties. Lake Balaton is an example of such a situation, where the number of tourists during July and August is twice that of the local population (Somlyody and van Straten, 1986).

If domestic wastewater is used in agriculture, health risks should be avoided by following the WHO guidelines for the use of wastewater in agriculture and aquaculture (Mara and Cairncross, 1989). Low population areas affected by tourism may need special consideration because the population may increase temporarily several fold and overload sewage treatment capacities. In temperate regions, the tourism season may coincide with the cyanobacterial growth season (Chorus and Bartram, 1999).

4. ACCESS TO SAFE WATER

A reliable supply of clean drinking water is essential to protect the health of individuals and communities. Both the quantity and the quality of supply are important. An adequate quantity of water is of primary importance in public health, since direct transfer of diseases from person to person or via contaminated food is higher when poor hygienic practices occur due to insufficient water. The potential consequences of microbial pollution are such that control of drinking water quality must never be compromised. A number of serious diseases can be spread via contaminated drinking water, such as cholera and typhoid fever, as well as common enteric diseases such as gastroenteritis (section 5.3). A supply containing high levels of chemical contaminants may also significantly affect the health of a whole community (section 5.4).

4.1 Coverage with drinking water supply

A reliable and adequate source of clean drinking water is considered to be a basic human right and is one of the highest priorities of any country. The means by which a country's inhabitants obtain their water will depend upon the natural and financial resources of a country and historical influences. The population density and pattern of habitation also influences the extent to which consumers are supplied by piped networks or rely on local sources for collection.

The residents of the towns and cities of Europe are generally well supplied with connections to water (Figures 4.1; 4.2; 4.3 Table 4.1). In many countries, 100 per cent of the urban population has a home connection to drinking water (Table 4.1) and, in most, this is true for over 90 per cent of urban inhabitants. However, there are some notable exceptions with a few countries (Uzbekistan, for example) having less than 75 per cent of the urban population connected.

The installation of a water network is a large capital project and, once installed, maintenance is required to ensure its continued efficient operation (Box 4.1). Financial restrictions may prevent the installation of a distribution system, or result in the deterioration of a network already in place.

Because of logistic difficulties, political priorities and relative cost, rural populations are less likely to have piped water and house connections than urban populations. However, the historical and current financial and organisational status of a country also strongly influences the extent of water infrastructure. For example, similar proportions of the populations of Finland and Croatia are rural (about 35 per cent) but whereas 87 per cent of the total Finnish population are connected to a public water supply (1996 data), this is true for only 70 per cent of the total inhabitants of Croatia (1997 data) (WHO/EEA questionnaire, 1997).

Table 4.1 Percentage populations (total, urban and rural) served by piped public water supply (1989)

Country	Population	Total population served by piped public water supply	Urban population served by house connection	Rural population served by house connection/ served by piped public water supply at home
Albania	3 million (1986)	92%	100%	88%
Austria	7 558,000 (1985)	80%	100%	70%
Belgium	9,863 374	97%	100%	90%
Bulgaria	8,942 976	98%	100%	94%
Czech Republic	15,503 426 (1985)	77.1%	89% - public network 11% - private network	86% - public network 24%-private installation
Denmark	5 million (1987)	88%	100%	99.98%
Finland	4.89 million (1984)	80%	96%	85%
France	55 173 000 (1985)	98%	100%	95%
Federal Republic of Germany	61 015 300 (1985)	97.8%	100%	97%
Greece	9 789 000 (1982)	86%	91%	73%
Hungary	10, 657 000 (1985)	84%	91.5%	74.3%
Iceland	242 000 (1985)	100%	100%	100%
Ireland	3.48 million (1982)	90.6%	98.7%	80.5%
Israel	4.2 million (1989)	99.9%	100%	98%

Italy	56 742 000 (1982)	98.8%	100%	96%
Luxembourg	366 000 (1981)	99%	100%	97.6%
Malta	331 997 (1984)	98%	100%	96%
Monaco	27 063 (1982)	100%	100%	NA
The Netherlands	14 453 833 (1985)	99.2%	99.8%	95%
Norway	4 159 335 (1986)	87%	100%	34.7% - public system 65.3% - private system
Poland	37 114 000 (1985)	79.9%	93.1%	55.8%
Portugal	9 833 014 (1984)	58%	97%	50%
Romania	22 724 836 (1986)	52.3%	91%	17%
Spain	39.3 million (1985)	80%	90%	50%
Sweden	8 331 000 (1983)	86%	100%	18%
Switzerland	6 423 000 (1982)	99%	100%	99%
Turkey	51 090 000 (1987)	69%	72.8%	66%
Former USSR	283 100 000 (1987)	No data	98%	86%
UK	56.3 million (1989)	99%	99.5%	91.5%

Source: WHO, 1989b

Box 4.1 Water distribution systems

The distribution of the treated water in large piped networked supplies requires an extensive and elaborate system of pumping stations, service reservoirs and pipework. The raw water resources and the treatment works are often some distance from the urban populations. Reservoirs of treated water within the distribution network allow treated water to be stored close to consumers, ensuring that there is sufficient to meet peak demand. They can also be used to mix water from different sources, to compensate for any variation in quality by diluting the contaminants. These reservoirs are usually constructed of concrete, although smaller ones may be made of steel. They must be watertight, both to prevent leakage and to prevent contamination of the stored water by leaching from the surrounding soil.

Trunk mains carry large volumes of water, often over long distances. The smaller distribution mains take water from the branched network of pipes supplying water to the individual houses. The distribution network usually consists of a ring main (a loop) from which the service pipes to the individual houses are supplied. However, in some cases a dead-end spur has to be installed because of the housing pattern. Water can sometimes remain in a long spur for considerable periods of time before it is utilised and this may have adverse effects on the water quality.

In sparsely populated areas of some countries, the provision of piped water supply may not be economically viable and rural populations are more likely to rely on small, private non-piped supplies. The proportion of the population connected to public water supplies can vary significantly between different areas of the same country. In Italy, for example, 77.9 per cent of the population in the north east of the country is connected to a public supply while this is true for only 27 per cent of the population of the Italian islands (WHO, 1995a). In some countries with a history of a good water infrastructure, all of the rural population is connected to a home water supply. This is the case, for example, in Iceland and Norway. In contrast, the homes of as few as 5 and 12 per cent of the rural populations of Turkmenistan and Ukraine are connected to water. In Romania, 84 per cent of the urban population is supplied by the centralised system whereas 32.3 per cent of the rural population has such supply (EEA/WHO questionnaire, 1997). The dichotomy between provision for urban and rural populations is perhaps best illustrated by the situation in Moldova, where 98 per cent of urban inhabitants have home connections to water while only 18 per cent of those in rural areas are connected (Figures 4.2; 4.3).

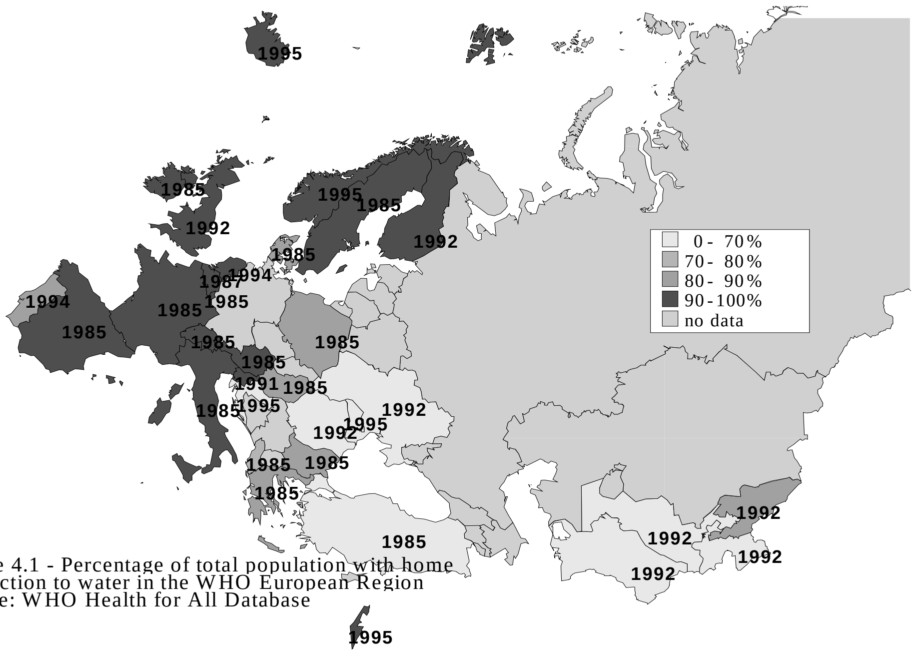


Figure 4.1 - Percentage of total population with home connection to water in the WHO European Region
Source: WHO Health for All Database

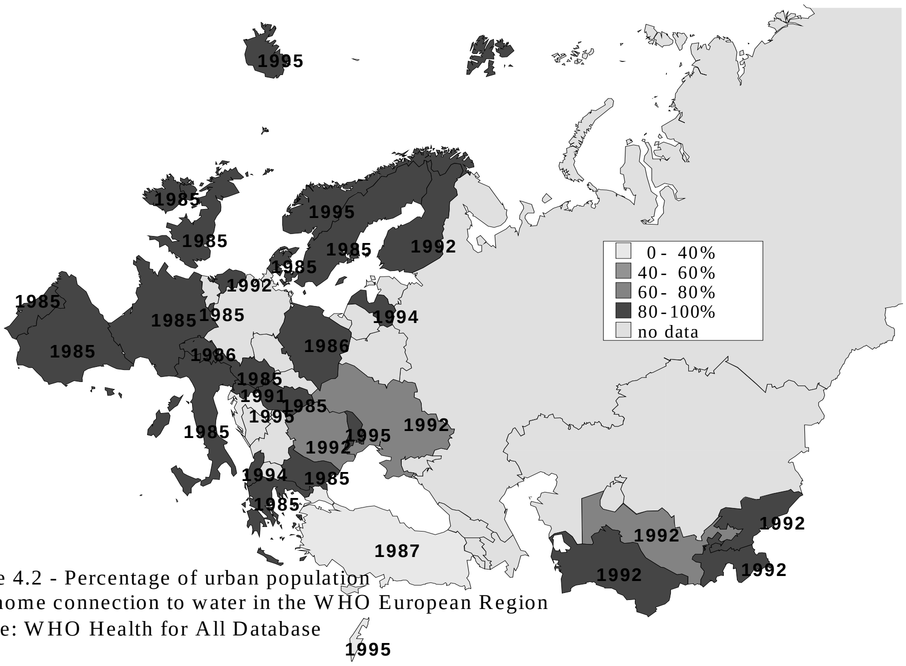


Figure 4.2 - Percentage of urban population
with home connection to water in the WHO European Region
Source: WHO Health for All Database

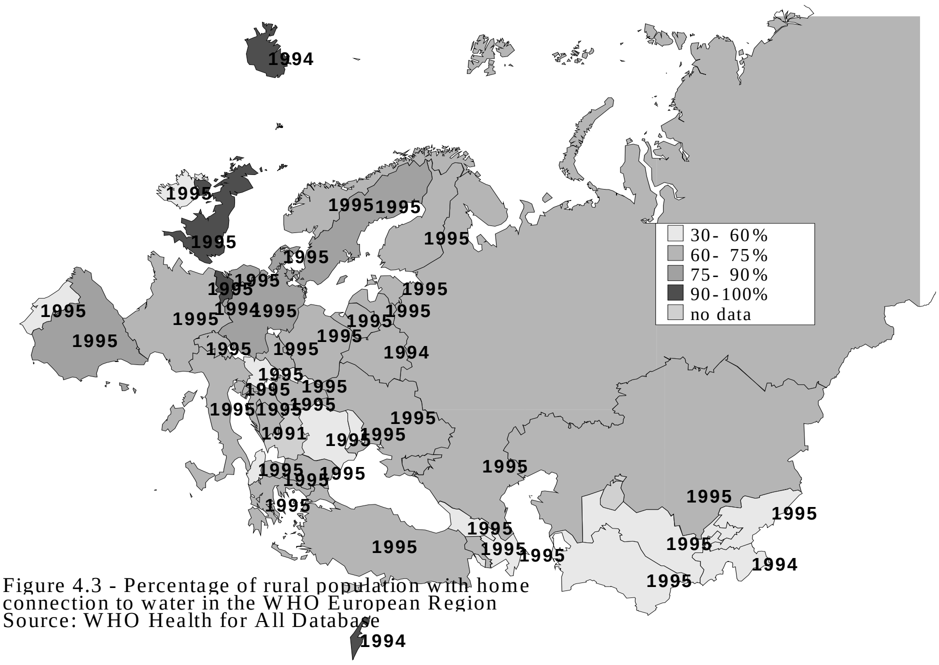


Figure 4.3 - Percentage of rural population with home
connection to water in the WHO European Region
Source: WHO Health for All Database

Community-managed (private) supplies are usually wells or boreholes supplying local residents with groundwater. However, the wells may be very shallow and, therefore, prone to contamination from the surrounding agricultural land and from excreta. In some countries, water supplies from shallow wells close to surface waters are commonly used. This rudimentary “bank filtration” may also be prone to contamination (section 5.2).

Because of the capital costs involved in water treatment, small community-managed supplies, particularly those supplying only a single household, often do not receive adequate treatment. More than 20 per cent of the population of Slovakia utilises drinking water from domestic wells and it is estimated that about 80-85 per cent of these do not comply with drinking water standards (Brtko *et al.,* 1997). Nitrate and phosphate concentrations in almost 17 per cent of Latvian wells, particularly the shallow ones, are reported to exceed 50 mg/l. This is primarily due to poor abstraction management and construction.

4.2 Continuity of drinking water

Access to a supply of drinking water goes beyond the presence of a well or a connection to a supply network. Most public water supplies within the EU and EFTA countries maintain a continuous supply of water. A number of Central and Eastern European countries, including some NIS, also provide continuous public water supplies. Nonetheless, there are areas within a number of European countries that do not receive a continuous supply of water. This may be for one of more reasons such as shortage of source (which may be seasonal); demand exceeding source or supply capacity; accidents and emergencies; leakage or misuse. Discontinuity in the supply may have implications for human health comparable to those experienced where there is inadequate water. This is made worse if the disruption is unpredictable or unannounced. Discontinuity is often due to poor design and conditions of the water works, inadequate water services operation, maintenance and management. Financial constraints may also be responsible for interrupted supply and may be linked to a discontinuous electricity supply that prevents the continuous pumping and treatment of water (Table 4.2). In Latvia poor infrastructure, no regular maintenance, financial constraints of collective farms that maintain the water pipes and on the responsible municipalities have resulted in an insufficient domestic water supply for rural populations (EEA/WHO questionnaire, 1997).

The quality of the water in supply may also be affected by discontinuous supply, as ingress of contaminants will occur through leaks in the network when the pressure drops (section 4.6). This is clearly illustrated in Armenia where faults in the network, during periods when the supply is switched off has been found to be associated with contamination of drinking water supply and outbreaks of waterborne disease (Box 4.2) (Mountain Unlimited, 1997). In the Russian Federation about 50 per cent of the population use water that does not meet quality standards. Water supply is frequently interrupted - particularly in regions of southern Russia where only a few hours per day may be on line. In Romania there are many regions where supply is discontinuous - up to 60 per cent of supply systems leading to water in distribution of at best dubious quality. Some interruptions exceed 12 hours per day. In Armenia 50 per cent of piped supplies do not meet sanitary standards. In the last five years more than 500 cases of dysentery and salmonellosis have been reported due to inadequate and poor quality water supply (WHO, 1997d).

Box 4.2 Case study: Influence of network integrity and discontinuous supply on outbreaks of waterborne disease in Albania

Since 1988 insufficient financial resources have existed to maintain drinking water quality and sanitation. There have been a number of known water-borne outbreaks of disease in Albania in recent years, and it is believed that water also contributes significantly to background rates of enteric diseases.

Although a number of aspects of water quality and supply need to be addressed, one of the principal problems is the poor state of the country's drinking water networks. High rates of water loss (up to 70 per cent) occur and this, as well as decreasing the amount of drinking water available, can also compromise its quality by allowing ingress of contaminants. Although 100 per cent of the urban population in Tirana for example has a networked supply, this figure is reduced to 72.7 per cent in peripheral areas. Public wells are used by 4.9 per cent, public fountains by 21.7 per cent and the local spring by 0.7 per cent (Palombi *et al.*, 1997).

Although Albania has high quality groundwater sources available, the cost of pumping this water prevents a continuous supply. In the peripheral areas of Tirana for example, 77.5 per cent of the population has water supplied for only 2-3 hours, 33 per cent of the population has water for 1 hour per day (Palombi *et al.*, 1997). The poor condition of the supply network is further compounded by intermittent distribution at low pressure, which results in microbiological contamination of the water in the supply system. High chlorine dosing is necessary to ensure that there is sufficient residual to secure a microbiologically safe supply. However, there is no chlorine residual in 54.3 per cent of samples in the peripheral areas of Tirana and 21 per cent of the population receive water without chlorine residual. This is attributed to financial restrictions and lack of specialised equipment. In addition, many of the raw water sources used are contaminated (coliforms are found in 34 per cent of water samples in Tirana) partly because treatment plants may not receive sufficient electricity for efficient functioning. WHO (1997a)

Table 4.2 Countries reporting discontinuity of drinking water supply

Country	Problems in achieving a continuous supply of drinking water	Source
Albania	Supplies provided intermittently for a number of hours each day (1-3 times per day or 1-3 h/day). Interruptions occur all year round and 100 per cent of the population is affected. Poor management, low levels of maintenance, limited funds for repairing defects, poor availability of equipment and increasing demand contributes to causes of discontinuity. It is often impossible to provide sufficient pressure.	(1,2)
Iceland	No major problems. Some regional problems possible.	(1)
Latvia	Discontinuous electricity supply (during emergencies) and poor availability of equipment	(1)
Republic of Moldova	Supply interruptions are very frequent, especially in rural areas, villages and small towns. Approximately 75 per cent of the population is affected. Problems include a discontinuous electricity supply, water shortages, financial considerations and poor availability of equipment.	(1)
Malta	Although all urban areas are provided with continuous supply (except during power failures) some new building developments have to use bowsers as they have not yet been connected to the drinking water network.	(1)
Romania	Urban development without adequate facilities; financial considerations; deficiencies in network systems; low capacity for storage. In 1993, 37 per cent of the total population connected to piped water received supply less than 8 hours per day. A further 11 per cent received the supply for between 8 and 12 hours of interruption per day and the supply to 6 per cent was interrupted for more than 12 hours per day. During 1990-1995 50 per cent of the population received water with intermittence in distribution, compared with 35 per cent of the population during the period 1985-1989.	(1, 4)
Slovenia	Almost 120 000 people suffer interruptions in supply. Interruptions are most frequent in the summer and in rural areas. Organisational difficulties and financial problems are the most common causes.	(1)
Turkey	Discontinuous supply in some areas is reported.	(1)
Turkmenistan (Dashkovuz Region)	Water distribution is intermittent, with three periods of delivery (of two hours each) scheduled each day.	(2)
Italy	An estimated 18 per cent of Italian families suffer from persistent discontinuies in the water supply. This varies from 8 per cent in the north east to 30 per cent in the islands.	(3)

Sources: (1) Responses to EEA/WHO questionnaire (1997)
(2) Mountain Unlimited (1997)
(3) WHO (1997c) (4) Iacob (1997)

Restrictions of supply can also be imposed in times of drought, as experienced in Romania and the UK, resulting in reduced access to water and, potentially, reduced quality caused by discontinuous supply.

4.3 Drinking water affordability

Charges made for supplied water reflect, to varying extents, the cost of abstracting, treating and supplying the water and maintaining the necessary installations, and the extent of subsidy by the state or municipality. Water prices across the region vary, with prices in western Europe varying from 53 ECU (or $66)/year in Rome to 286.6 ECU (or $287)/year in Brussels for a family in a house consuming 200 m^3/year. Water charges in central European cities are lower and vary from approximately 20 ECU ($25)/year in Bucharest and Bratislava to 59 ECU ($74)/year in Prague (IWSA, 1997). However, when these annual charges are compared with the Gross Domestic Product per capita, the proportional cost in Bucharest, Vilnius and Prague are found to be amongst the highest (Fig. 4.4).

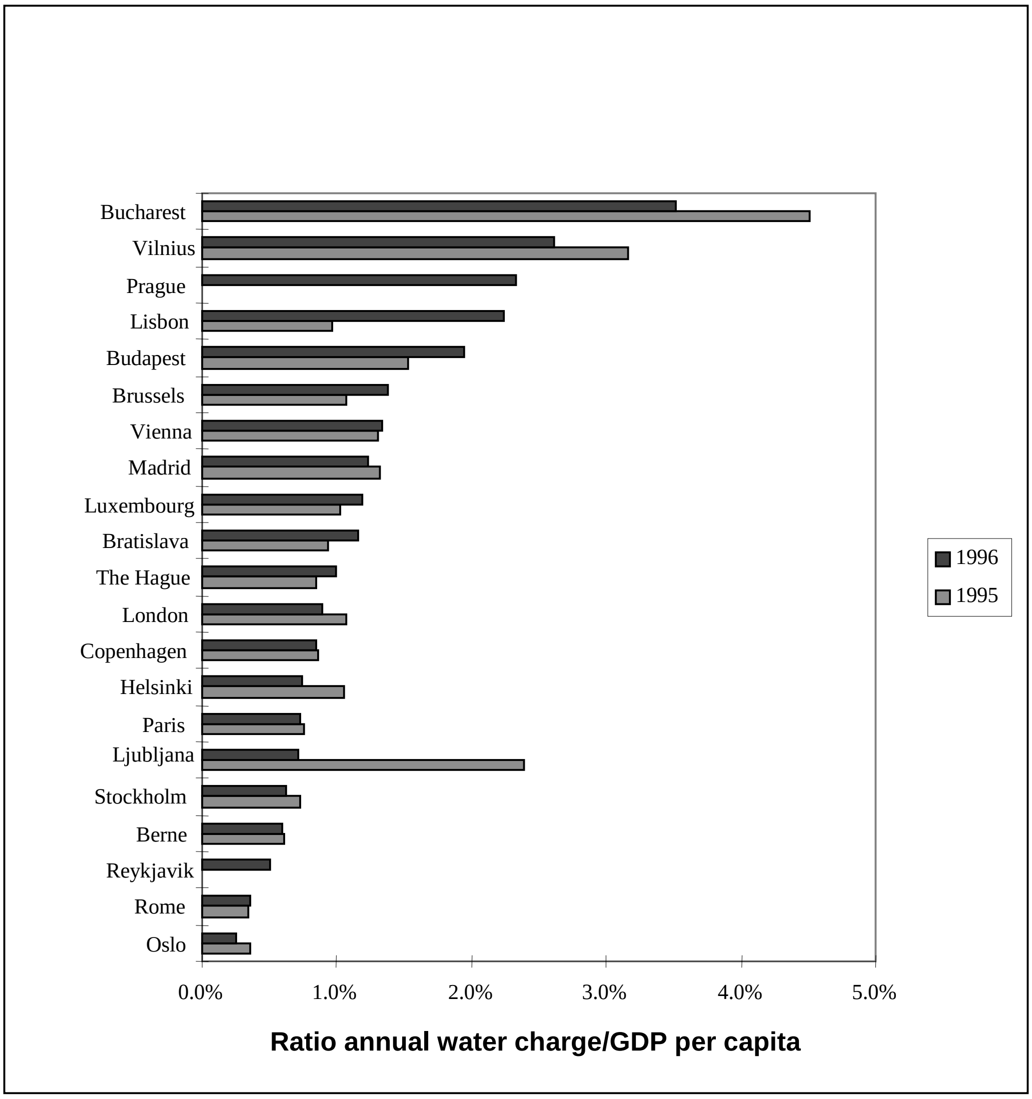


Figure 4.4 Annual water charges in some European cities in relation to Gross Domestic Product per capita.

Source: IWSA Congress (1997)
From: EEA (1999c)

The production and provision of clean water to consumers is expensive in terms of initial capital outlay and ongoing costs of maintenance, management and extension of services. However, the payment of services is an emotive issue. Water is a basic human right and for the long-term sustainability of water the costs must be recovered to avoid deterioration in infrastructure leading to a breakdown of system, absence of adequate water supply and an increased public health risk (section 5.1). The costs of treatment and disposal of return flows of wastewater should also be recovered (section 6).

In many countries of eastern Europe water prices have risen sharply since 1989 at a rate much higher than inflation, following the reduced state subsidies. Water impounding and distribution systems in East Germany and Hungary, for example, are now fully financed from charging revenues, with no subsidy from governments (with tariffs also including a portion for reconstruction and development of new schemes) (EEA, 1999c). Tariffs remain low in some countries such as Albania, where there is a fixed charge of 5 lek/m^3 (equivalent to approximately 0.03 ECU ($0.375) for domestic consumers, and Turkmenistan where no charge is made (Mountain Unlimited, 1997).

For all countries, cost containment should be an important objective of public utilities. Risk taking and deficit-spending measures, based on high technology and the assumption that at some future time consumers or the government will pay, cannot be afforded and should be discouraged (WHO, 1994).

4.4 Consumption of bottled water

In some countries of Europe, there is a tradition of the consumption of bottled water, particularly mineral waters (Table 4.3). In these countries there has been a trend of increasing consumption of bottled waters, and their market has widened to include other countries where bottled waters are not traditionally consumed in large quantities. In Austria, France, Germany, Italy, Spain and Switzerland, consumption of bottled waters increased by between 139 per cent and 248 per cent in the decade between 1983 and 1992 (GISEM-UNESEM, 1993, cited in WHO, 1997c).

Table 4.3 Consumption of bottled water in some European countries in 1992 (l/capita)

Ireland	6
United Kingdom	9.5
Netherlands	15
Portugal	29
Spain	44
Austria	76
Switzerland	76
France	80
Germany	93
Belgium	105
Italy	116

Source: GISEM-UNESEM (1993); cited in WHO (1997c).

The purchase of bottled waters is largely a market phenomenon governed by societal customs. It may also provide an indirect indication of poor availability or quality (or perceived poor quality) of the drinking water from other sources (WHO, 1995a). However, it is unlikely that the provision or purchase of bottled water is a cost-effective way of obtaining high quality drinking water. It is estimated that, for the individual consumer to drink bottled water raises his/her private expenses for buying water by a factor of between two and five; this money could be better spent in ensuring a safe piped water supply (WHO, 1995). The provision of bottled water may, however, be appropriate in certain situations. Emergency distribution in the case of serious contamination incidents affecting drinking water supplies are an obvious example and, in some circumstances, the provision of bottled water to households with infants and young children may be the most appropriate action in the case of supplies contaminated with high levels of nitrate, in order to prevent methaemoglobinemia (section 5.4.5).

4.5 Water quality

4.5.1 Sources and abstraction for drinking water

Freshwater is abstracted from ground and surface waters for a variety of purposes (Figure 3.2). The microbiological quality of water is of primary importance, and the least polluted available source is generally preferred for potable supply. Groundwater is generally of better microbiological and of more stable chemical quality than surface waters, although at a local level some substances that are naturally occurring in groundwater may be hazardous to human health such as fluoride and arsenic (section 5.4.1). Shallow wells, in particular, are vulnerable to contamination. Upland surface waters are generally less contaminated than lowland ones.

The availability of natural resources largely determines the proportions of a country's drinking water that is derived from surface and ground waters. The convenience and practicality of using the sources (distance from the centres of population) are also influential. In some countries (Albania and Turkmenistan, for example), almost all the drinking water supply is provided by groundwater (Mountain Unlimited, 1997), while in others a significant majority has to be abstracted from surface waters. In Denmark, and throughout most of Latvia over 50 per cent of the drinking water is derived from groundwater. About 50 per cent of the rural population of Latvia use shaft or frame shallow wells (no deeper than 10-15 m) although in recent years the number of wells for collective use has decreased. In contrast, approximately 72 per cent of the drinking water in the UK and 87 per cent of that in Norway are derived from surface water (Figure 4.5) In Sweden, the largest cities use surface waters, but nationally 50 per cent of the population connected to a municipal area is supplied by surface water, 25 per cent by surface water that has passed through gravel ridges and 25 per cent by groundwater. There are also approximately 400,000 private wells supplying permanent residents and 200,000-400,000 wells in 'recreation accommodation' (SOU, 1996). In Estonia, 60 per cent of drinking water is derived from surface waters or shallow wells and 40 per cent from deep groundwater sources (Raukas, 1996).

Some countries, such as the Netherlands and Moldova, have a policy of trying to reduce the proportion of drinking water supplied from aquifers. This may be to redress the over-exploitation of aquifers that has occurred in the past, such as in the Netherlands, or because of concern about contamination of groundwaters, as is the case in Moldova (WHO/UNDP, 1993).

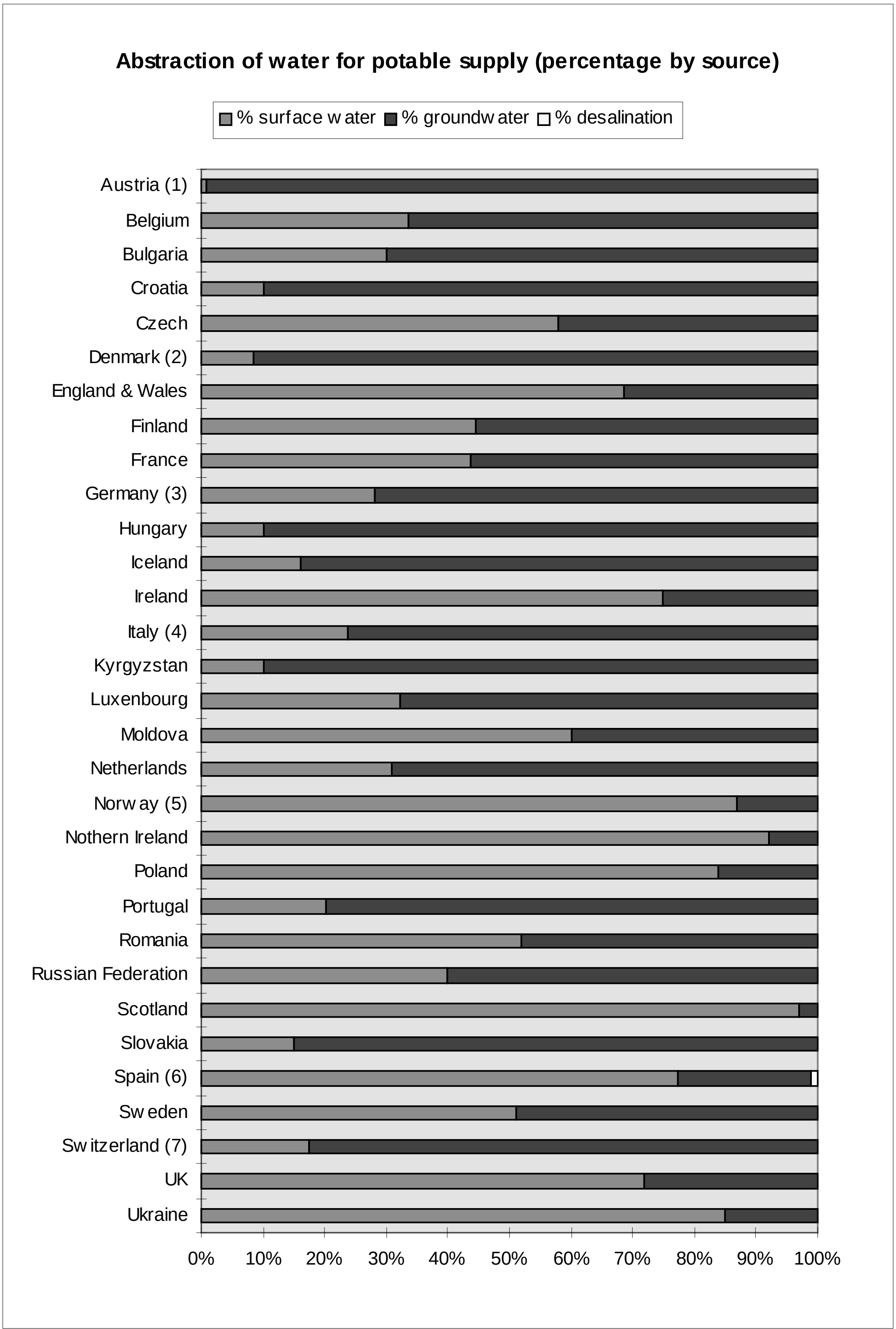


Figure 4.5 Proportion of drinking water derived from ground and surface waters and desalination in selected European countries

Notes: In some countries, "groundwater" may include spring water from shallow sources. Estimated proportions of drinking water derived from spring water: (1) Austria – 49 per cent (3) Germany – 7 per cent; (4) Italy – 37 per cent; (6) Spain – 4 per cent; (7) Switzerland – 46 per cent; In addition, in Norway (5) an estimated 6 per cent of groundwater is bank-filtered surface water.

Sources: Eurostat, 1997; Mountain Unlimited, 1995; WRc data.

4.5.2 Drinking water treatment

The type and degree of treatment required to make water wholesome differs depending on the quality of the raw water source. Good quality groundwaters often require no treatment other than aeration and disinfection before distribution. However, depending on the geology of the area, contamination may occur with iron, manganese, carbon dioxide, fluoride and arsenic and may be subjected to treatment and/or disinfection before use. Some groundwaters have been affected by human activities and may be contaminated, for example, by nitrates, pesticides, solvents or pathogens.

The level of treatment required to ensure poor quality sources are suitable for consumption is significant and costly. Consequently, private water supplies, particularly those supplying a single dwelling, may receive very limited, or no treatment. Prevention of pollution, rather than technological intervention to remove it is generally preferable. However, in many cases there is a legacy of historical pollution that has to be addressed, particularly as competing demands on water resources may result in poorer quality sources being utilised for drinking waters.

Satisfactory treatment of water for potable supply and maintenance of the distribution networks are compromised in many European countries because of financial limitations, or a shortage of human or technical resources. Such problems, along with organisational difficulties, are reported by many central and eastern European States and NIS. Unusually amongst the western and northern countries, authorities in Sweden report a personnel problem, in that human resources at waterworks have been reduced to a level of concern (Table 4.4). Financial constraints to small community water supply appear likely to be common.

Table 4.4 Countries reporting financial, human resource or organisational problems compromising the quality of drinking water

Country	Main difficulties experienced compromising water quality
Albania	Financial constraints. Organisational, technical and human resource problems reported. Old supply systems suffering corrosion and old, manual chlorination equipment are highlighted.
Belgium (Wallonia)	Financial constraints for water treatment (cost/m^3) in areas where small numbers of people are connected to many small sources.
Croatia	Financial constraints.
Czech Republic	Financial constraints prevent the use of the best available technology.
Estonia	Financial constraints.
France	Financial constraints particularly in small communities of less than 100 inhabitants.
Greece	Financial constraints.
Lithuania	Financial constraints. Unavailability of equipment and chemicals.
Malta	Financial constraints.
Moldova	Financial constraints and poor availability of equipment
Romania	Training of personnel. Financial considerations restrict improvement in equipment for water treatment and chlorination and to correct the overloading of water treatment capacities.
Slovenia	Organisational difficulties and lack of human resources. Financial constraints have resulted in a lack of sophisticated treatment plants.
Sweden	Human resources on waterworks have been reduced.

Source: Responses to EEA/WHO questionnaire (1997)

Many countries in Europe use bank-side filtration as an economic method of improving the quality of surface waters before abstraction for drinking water. This reduces the need for conventional treatment of the water by effecting a significant removal of particles, microbiological and chemical contamination. However, it is not practical in all cases, as it is dependent on suitable geology (Box 4.3).

One of the emerging concerns about the treatment of water is the production of disinfection by-products that have been shown to be carcinogenic in animal studies (Box 4.4). Most disinfectants are oxidising agents, and can react with natural compounds dissolved in the water to give products that are potentially of concern to human health. These by-products are more likely to be formed in surface waters, as these contain higher concentrations of organic matter such as humic and fulvic acids. However, the risks appear to be small and the over-riding priority in providing clean drinking water must be the microbiological quality, in order to prevent waterborne infectious diseases (WHO, 1996). It is therefore important to establish a balance between maintaining effective disinfection, and the need to reduce disinfection by-products to an acceptable level, which is clearly in favour of chemical disinfection.

Box 4.3 Bank-side filtration

Bank filtration is extensively used in a number of European countries, including Germany, the Netherlands and Hungary. In Hungary, for example, bank-filtered water provides 42 per cent of the total drinking water supply, and 100 per cent of Budapest’s drinking water. This water is of sufficient quality that Budapest’s water requires no further treatment, other than disinfection, before being put into supply (VITUKI, 1998).

Water from a surface water source, usually a river, is allowed to filter into the groundwater zone through the riverbank and to travel through the aquifer to an extraction well some distance from the river. In some cases there is a short residence time in the aquifer, perhaps as little as 20 to 30 days, and there is almost no dilution by natural groundwater (Crook *et al.*, 1992).

Bank-side filtration is often very effective in improving the microbiological quality of water, and also removes gross contamination such as suspended solids. Some chemical contaminants may also be removed by adsorption and complexation in the filtration medium, although the extent of removal will depend on the chemical involved and the geology of the area. However, there is also the potential for mobilisation of certain contaminants, resulting in an increased concentration. This is particularly so in agricultural areas where concentrations of pesticides and fertilisers may be high. Depending on the geology, elements such as iron and manganese may also be increased, particularly under anoxic conditions.

Bank-filtered water is often classified as groundwater, despite its recent origin in a surface source. This can produce problems in interpreting data regarding the relative quality of groundwater and surface water, since many of the assumptions regarding groundwater (eg low levels of contaminants, long recharge time) may not apply to some bank-filtered water, depending on the quality of the surface water, the geology of the area and the residence time before abstraction.

Box 4.4 Disinfection procedures and by-products

Chlorine is the most widely used drinking water disinfectant in Europe. The reaction of chlorine with water results in hypochlorous acid which dissociates, producing the hypochlorite ion. Alternatively, sodium hypochlorite can be added as a disinfectant. Chlorine reacts with natural organic chemicals dissolved in the water (humic and fulvic acids) to form chloroform (trichloromethane). In addition, hypochlorous acid oxidises bromide present in the water to form hypobromous acid, which also reacts with humic and fulvic compounds to produce bromoform. Mixed THMs (dibromochloromethane and bromodichloromethane) are also produced.

Animal studies using high doses of these compounds have indicated their carcinogenic potential, and many countries regulate their levels in drinking water. There is a number of other disinfection by-products, some of unknown toxicity, and the presence of THMs is considered to provide a broad indicator for these other chlorination by-products. Other by-products include chlorinated acetic acids, chloral hydrate, chloroacetones halogenated acetonitriles, cyanogen chloride and chloropicrin (WHO, 1996). Some other disinfection by-products produced, particularly chlorophenols impart an unpleasant taste and odour to the water.

Ozone is often used as an alternative where the natural waters contain substances that would produce adverse taste and odour if chlorine were used. It is a preferred method of disinfection in some countries (e.g. France and Germany) and has been shown to be effective against *Giardia* cysts and *Cryptosporidium*. However, it is expensive and there is no residual disinfection action within the water supply mains. Biological growth may subsequently occur within the piping. In order to prevent this, low level chlorination is often used after ozonation to impart a residual disinfectant action. A by-product of ozonation is bromate, formed by the oxidation of the bromide present in water, which has been shown to be carcinogenic in laboratory animals.

Chlorine dioxide is a further option, used in Belgium, France, Italy and Germany. Although the production of THMs is less with chlorine dioxide than with chlorine, concentrations of chlorite and chlorate may be higher in some waters. No adverse physiological effects of sodium chlorite on humans have been found, but methaemoglobinaemia, anuria, abdominal pain and renal failure are associated with chlorate poisoning. Chlorine dioxide is more effective than chlorine in inactivating *Giardia* cysts and *Cryptosporidium* oocysts but the residual is unstable (Hall, 1997).

Ultraviolet radiation is used to disinfect water supplies, alone or in conjunction with chemical disinfectants. As with ozone, the disadvantage is the lack of residual disinfection in the distribution and, therefore, chlorination may also be required. It is effective against bacteria and many viruses, but not against *Giardia* cysts and *Cryptosporidium* oocysts (Hall, 1997).

The prevailing treatment and disinfection methods in European countries are influenced by the quality of source waters, financial resources, available technology and historical practice. In the NIS, chlorine disinfection is most commonly used, often by a non-direct chlorine gas procedure (WHO, 1996a). Ultra-violet radiation is commonly applied in some countries of Europe, for example on groundwater from the alpine regions of Liechtenstein (where faecal contamination from cattle is a concern) and for the 6 per cent of the Icelandic population whose supplies are derived from surface waters.

A number of different approaches are normally used within the same country (Table 4.5). In Poland, chlorination is the main method of water disinfection in public water supply systems. In wells and individual water supply systems chloramine and chlorinated lime (containing up to 30 per cent of active chlorine) are commonly used. Chlorine dioxide is in wide use in France, Italy and Germany but ozone is preferred at some sites in France and Germany and is also common in the Netherlands.

Water quality may be threatened (through recontamination) where discontinuous chlorination occurs - Greece, Estonia, Romania, Armenia, Albania, Lithuania, Moldova, Turkmenistan and the Ukraine are amongst countries reporting such problems (EEA/WHO questionnaire, 1997; Mountain Unlimited, 1995; Mountain Unlimited, 1997). In many cases this is attributed to old, broken or manual equipment or a lack of chlorine (EEA/WHO questionnaire, 1997; WHO, 1997b). Automatic equipment for continuous chlorination using sodium hypochlorite has now been installed in a number of Albanian cities (EEA/WHO questionnaire, 1997).

Insufficiencies in the treatment of water, particularly disinfection, are a particular problem in small supplies. It has been reported that many small waterworks in Norway for example do not have sufficient disinfection and problems of microbiological contamination are reported in small supplies in the Wallonian region of Belgium due to discontinuous chlorination or no disinfection (EEA/WHO questionnaire, 1997). Achieving a high quality of drinking water (microbial and chemical) in small communities of less than 100 inhabitants, at a reasonable price, is also regarded as a problem in France (EEA/WHO questionnaire, 1997).

Table 4.5 Main types of treatment used for water for potable supply

	Main Treatment	
Country	**Ground (and spring) water**	**Surface water**
Belgium	Aeration and disinfection only Few GAC and nitrate removal units Some iron and manganese removal Some air-stripping for organics	Chemical coagulation (flocculation, rapid sand filtration, O_3/GAC filtration) and disinfection
Finland	Mostly alcalization. Iron and manganese removal and some disinfection. Some O_3/GAC treatments	Chemical coagulation, clarification, filtration and disinfection. Some O_3/GAC treatments
France	Disinfection only Some nitrate removal (ion exchange, biological denitrification)	Chemical coagulation, O_3+GAC (also some advanced oxidation processes e.g. O_3+GAC+O_3/H_2O_2) and disinfection Few works with membrane technology

		Some nitrate removal (mainly ion exchange)
Germany	Most groundwater not treated (some disinfection) except where pesticide, solvent or nitrate removal is required.	Bankside filtration commonly used. Activated carbon in common use. Recharged groundwater/bank filtration combined with coagulation, filtration, O_3+GAC, disaffection.
Iceland	No disaffection.	Filtration and uv radiation. No supplies are chlorinated.
Italy	Little or no treatment, mainly disinfection. Considerable use of GAC for pesticide, organic solvent removal Trend away from chlorine to chlorine dioxide for disinfection.	Traditional physical or physical/chemical treatment. Also complex treatment e.g. GAC and disinfection. Increasing use of chlorine dioxide.
Liechtenstein	Majority enters supply without treatment or disinfection. In Alpine regions, filtration or UV radiation is employed.	
Moldova	Groundwater is used for drinking water without treatment in about 50 towns.	
Netherlands	Aeration and multistage sand filtration	Extensive use of multistage treatment including: • dune infiltration • coagulation • activated carbon • disinfection with chlorine or ozone(trend away from chlorine use because of THM formation) Concern to maintain low AOC in distribution
Romania	Aeration and filtration (if water contains iron and manganese) and chlorination	Conventional physical/chemical treatment: coagulation, clarification, settling, rapid sand filtration and chlorination
Russian Federation	Disinfection (chlorination) only.	
Slovakia	75 per cent supplied following disinfection only (esp. in SW and Central Slovakia) Remainder treated for removal of Fe, Mn, NH_4, CO_2, oxidisability and methane.	The six largest plants use chemical coagulation and chlorination or chloramination. Stream abstractions often use sand filtration or slow sand filtration.
Spain	Minimal treatment, mainly	Most commonly chemical

	disinfection only. Filtration/chemical coagulation and GAC or O_3+GAC sometimes used.	coagulation with rapid filtration. GAC or O_3+GAC also relatively frequently used. Chlorine widely used and high doses are often required, leading to concern over THMs.
Sweden	None	Treatment and disinfection
Turkmenistan	Disinfection by chlorination only.	Disinfection by chlorination only.
UK	Disinfection only, using chlorine. Iron and manganese removal for some sources. Approximately 20 works with nitrate removal (all ion exchange). Removal of organics (pesticides/solvents) by O_3/GAC on 20 per cent of supplies.	Mostly chemical coagulation and disinfection. Some slow sand filtration. Removal of pesticides by GAC or O_3+GAC for one third of supplies.

Sources: Mountain Unlimited (1995; 1997)
Romania National Report (1997)
WHO (1995)
WRc Pers. Comm.
EEA/WHO questionnaire (1997)

Box 4.5 Drinking water problems in the Russian Federation

Providing drinking water in sufficient quantities and of sufficient quality has become an acute problem in many regions of the Russian Federation for various reasons including the pollution of surface waters, and sometimes groundwater. The greatest percentage of samples which fail to comply with standards are in Turkmenistan (18 per cent), Kyrgyzstan (per cent), Kazakhstan, Azerbaijan and Estonia. Drinking water has historically been abstracted mainly from surface resources. The worst affected areas in terms of tap water quality are in regions of Central Asia around the Aral Sea. Up to 60 per cent of the water samples from municipal water supply systems and approximately 38 per cent from rural supply systems in the Kayla Order region do not comply with standards. Established water quality standards are not always achieved due to the high degree of pollution, inadequate treatment processes and secondary bacteriological pollution in the water supply networks. Around one third of the population use water from local sources. These factors have contributed to an increase in outbreaks of acute digestive infections. In 1993 there was an increase in the number of water-related intestinal infections with 17 outbreaks, including 10 of dysentery. An outbreak of gastrointestinal infections and typhoid were also recorded in 1993 in the Roots Region, where 300 people were taken ill in Volgodonsk.

Source: State Committee of the Russian Federation on Environmental Protection, (1998); Abakumov and Talayeva, (1998)

4.6 Drinking water distribution

4.6.1 Effects of distribution on water quality

Microbial contamination

Micro-organisms found in drinking water in distribution systems may enter with the water through faulty source protection, treatment or disinfection; through recontamination in pipes and through back siphonage, or through re-growth. When the water pressure in the mains is not sufficient, for example where water supplies are discontinuous (section 5.1), ingress into the distribution system through leaks can occur and contaminate the water. This is most serious when mains pipes are laid alongside sewerage systems, with a high potential for contamination of the water supply with faecal pathogens. Losses of pressure may also result in back-siphonage of water through the plumbing system from connections, such as taps, into the distribution system. In Albania, the corrosion of old pipework is also cited as a contributory factor in the contamination of drinking water (EEA/WHO questionnaire, 1997).

The growth of bacteria in distribution, including in the bulk water and on surfaces, can result in discolouration, taste and odour, elevated numbers of micro-organisms and proliferation of higher organisms such as *Asellus aquaticus* (water louse). The growth of most bacteria is limited by the concentration of AOC in the water and/or the concentration and species of disinfectant residual. Even where disinfection is practised, biofilm slimes can harbour bacterial and protozoal pathogens that can be released into the distribution system when parts of the biofilm slough off. This can occur during, and after chlorination. Pathogens may also be protected from the action of chlorine (and other disinfectants) in the biofilm. The presence of biofilms may also initiate, and promote, corrosion in water distribution systems. This may be considered an indirect risk if the corrosion leads to a failure of the pipe system and ingress of material from the surrounding environment.

Conventional water treatment processes such as coagulation, sedimentation and filtration can reduce AOC but concentrations are increased by oxidants such as chlorine and ozone. To achieve the very low concentrations required to limit regrowth in the absence of a residual disinfectant, multi-stage treatment is required, including some form of biologically active process, such as slow-sand or GAC filtration with intermediate stages of oxidation (van der Heok, 1998).

Despite efforts to minimise carbon sources in supply, concentrations sufficient to allow regrowth of microbes in long distribution systems can still occur. Such problems are reported in Finland for example (EEA/WHO questionnaire, 1997).

Chemical contamination

The materials used in constructing distribution systems, the integrity of the systems and the maintenance of positive water pressure within the distribution can all affect the quality of the water in supply. Choice of pipes and materials depend on the size of the pipes and has changed with time. Large trunk mains have historically been constructed from iron, steel or asbestos cement. Asbestos cement has now largely been phased out and plastics such as uPVC and polyethylenes such as medium density polyethylene are supplementing the use of iron and steel. Nonetheless, there are concerns about the leaching of antioxidants, stabilisers and plasticisers from these products into water. Leaching tests may be carried out on materials to be used in contact with drinking water, to address this issue. Control of contamination is better directed against the materials rather than on the water quality.

Lead was favoured as the construction material for service pipes until the middle of this century in many countries. However, because of the recognised need to reduce the exposure of humans to lead and, in particular, concerns about the effects of dissolved lead on the development of the nervous system in children (section 5.4.1), lead piping is no longer installed in many countries, such as the UK and France, and is gradually being removed from the distribution system. Contamination of drinking water supplies with lead is reported from newly laid PVC pipes in which lead had been used as a stabiliser. However, this leaching appears to be short-term problem. The WHO guideline value for lead in drinking water is set at 0.01 mg/litre. However, it is recognised that most lead in drinking water arises from plumbing - the remedy consists mainly of removing the plumbing which is expensive and time-consuming and therefore it may take time for waters to meet the guideline. Corrosion control should be implemented where possible.

In the past, iron distribution pipes were often coated internally with coal tar, to reduce corrosion. Such linings contain relatively high levels of PAHs, a number of which are carcinogenic. The smaller, more water-soluble PAHs such as fluoranthene leach into the carried water. Although these PAHs are generally not regarded as carcinogenic, the use of new coal tar linings is now widely prohibited. Metal pipes now often receive an internal coating of bitumen, which contains very low levels of PAH, for the purpose of corrosion prevention.

4.6.2 Network efficiency - leakages

The efficiency of water transfer within supply networks has a direct effect on water demand. Leakage in water distribution networks may be significant, and can account for over 50 per cent of the water entering the network (Table 4.6). However, poor metering and monitoring in some countries makes accurate estimations difficult.

Table 4.6 Estimated losses from water networks

Country	**Estimated losses from water networks**	**Source**
Albania	Up to 75%	(3)
Armenia	50-55%	(2)
Czech Republic	33%	(8)

Bulgaria - Sofia	30-40%	(1)
Bulgaria - other than Sofia	More than 60%	(1)
Croatia	30-60%	(1)
France (national average, 1990)	30%	(4)
France (Paris)	15%	(4)
France (highly rural area)	32%	(4)
Germany (West Germany)	3.7 m3/km mains pipe per day 112 l/property per day	(4)
Hungary	30-40%	(1)
Italy (national average)	15%	(6)
Italy (Rome)	31%	(6)
Italy (Bari)	30%	(6)
Kyrgystan	20-35%	(1)
Moldova	40-60%	(1)
Romania	21-40%	(7)
Slovakia	27%	(8)
Spain (settlements of over 20,000)	20%	(5)
Spain (Madrid)	23%	(5)
Spain (Bilbao)	40%	(5)
Ukraine	Approximately 50%	(1)
UK (England and Wales)	8.4 m^3/km mains pipe per day 243 l/property per day	(4)

Sources: (1) Mountain Unlimited (1995)
(2) WHO (1997)
(3) Mountain Unlimited (1997)
(4) OFWAT (1997)
(5) AEAS (1997)
(6) IRSA (1996)
(7) EEA/WHO (1998)
(8) ETC/IW (1998)

Leakage may be reduced by a number of methods such as repair of visible leaks; establishment of leakage control zones; awareness, location and repair of leaks not visible from the surface; telemetry of zone flows; pressure reduction; mains replacement; subsidised/free detection and repair of domestic customer/business supply pipe leakage; repair of leakage through the structure of service reservoirs; minimisation of service reservoir overflow losses; trunk mains leakage detection and repair.

Recent studies in Spain seem to indicate distribution efficiency improving from 68 per cent in 1990 to 72 per cent in 1994 (AEAS, 1997). In Austria, water losses decreased from 47 to 15 million m^3 over a period of 17 years (Ambassade de France en Autriche, 1993). Similarly, estimates of future network efficiencies in France, range from 78 per cent in urban areas and 72 per cent in rural areas to 80 per cent for both. However, improvement is not the overall trend throughout Europe. There is currently an effort in many countries to decrease leakage rates, often encouraged by governmental concern. In the UK (England, the government has estimated that reducing leakage of supply pipes would save over 1,000 million litres of water per day (Announcement of the UK Deputy Prime Minister, July, 1997). UK water companies have been set statutory targets, with financial penalties, for leakage reduction and this has proved successful in some regions (Table 4.7).

Table 4.7 Leakage reduction in Yorkshire region (UK) (Yorkshire Water Services, 1997)

Leakage (Ml/d)	1994-95	1996-97
Total leakage	536	420
Supply pipe losses	101	98
Distribution losses	435	322

From: EEA (1998c)

Yorkshire Water Services, UK, considers that there is little scope for further reductions by repairing visible leaks and establishing leakage control zones, but other options such as telemetry of zone flows, pressure reduction, subsidised/free detection and repair of domestic customer/business supply pipe leakage, repair of leakage through the structure of service reservoirs and mains replacement could bring about further reduction (EEA, 1998c).

A potential conflict of interest has recently arisen in the UK, where reductions in mains pressure to reduce leakage has raised concerns from fire-fighting service that the pressure in some areas may now be insufficient to effectively fight large fires.

4.7 Re-use and recycling

The practice of wastewater re-use is increasing within EU countries, primarily to alleviate the lack of water resources in certain regions, such as in southern European countries. This is addressed in article 12 of the EU Urban Waste Water Treatment Directive (91/271/EEC) which specifies that treated water shall be re-used whenever appropriate (section 7.3.1).

4.7.1 Rural re-use (irrigation)

The largest application of direct wastewater re-use in Europe is for irrigation of crops, golf courses and sports fields, and concerns have been expressed that pathogens from the wastewater may be in contact with the public. Epidemiological studies have shown that crop irrigation with untreated wastewater causes a significant increase in intestinal nematode infections in crop consumers and field workers but that this is not the case when wastewater is adequately treated before being used for irrigation (WHO, 1989). Wastewater irrigation is successfully practised in parts of France, Germany, Spain, Portugal (WHO, 1989) and Poland. In Portugal it has been shown that the bacteriological quality of wastewater-irrigated lettuce is three orders of magnitude better than river water-irrigated lettuce (Vargas and Mara, 1989). It is common in other countries in Europe, which do not practice wastewater irrigation, to import produce and flowers that have been irrigated with wastewater.

Most European countries do not have specific regulations on wastewater re-use, although regulations and guidelines regarding uses of water may apply. WHO (1989) has developed quality guidelines for the use of treated wastewater in irrigation. These specify:

- Treated wastewater to be used for restricted irrigation (i.e. the irrigation of all crops except those eaten uncooked), should contain no more than 1 human intestinal nematode (human roundworm, whipworm and hookworms) egg per litre;

- Treated wastewater to be used for unrestricted irrigation (i.e. the irrigation of crops eaten uncooked), should contain no more than 1 human intestinal nematode (human roundworm, whipworm and hookworms) egg per litre and should contain no more than 1,000 faecal coliform bacteria per 100 ml.

Effluents complying with standards can be produced by treatment of wastewater in waste stabilisation ponds (Mara and Pearson, 1998). Conventional treatment processes, such as activated sludge, can achieve the nematological guideline due to the two periods of primary and secondary sedimentation, but a tertiary treatment process such as maturation ("polishing") ponds, UV or chemical disinfection is required to meet the faecal coliform guideline.

Spray irrigation using treated wastewater is not recommended, as it may constitute a risk to operators and adjacent communities by the inhalation of pathogens in aerosol droplets.

The potential for water re-use and recycling has not been fully exploited in many areas, and economic or regulatory incentives are likely to be required to encourage its use. There is, consequently, a lack of experience of water re-use in much of Europe. The limiting factor can, in many circumstances, be the quality of the water available, potential hazards for secondary users and public perception.

4.7.2 Desalination

The desalination of seawater presently costs approximately 0.7 ECU ($0.56) per m^3, including energy cost and depreciation and its contribution to the total water supply in Europe is very limited. In Spain and Monaco desalination contributes 0.33 per cent and 0.45 per cent of the water supply respectively. In Malta and the Balearic islands, characterised by a comparatively dry climate and relatively limited surface water resources, desalination supplies are of greater importance, contributing 46 per cent of the total water (1990 data) in Malta (1992 and 1991 data; Plan Bleu 1997; cited in EEA, 1998c) and one third of the total urban water supply (91,500 m^3/day) in the Balearics (Fayas *et al.* 1997 cited in EEA, 1998c).

The viability of desalination as a more widespread option for the future will depend on technological advances, the cost of energy and the cost of using alternative sources.

4.8 Water transfers

There are a number of large-scale, inter-basin water transfer schemes in Europe - the Rhône-Languedoc transfer and the Canal de Provence in France, with capacities of 75 and 40 m^3/s, respectively - are two of the largest. Smaller schemes exist in Belgium, Greece and the UK. In Spain, there are currently around 50 small inter-basin water transfers able to transfer about 1.5 km^3/year. For inter-basin transfers to be an efficient, cost-effective and acceptable means of satisfying water demand in regions with low water resources, the environmental sustainability and economic viability need to be carefully assessed (EEA, 1998c). Schemes to carry water from one catchment to another have encountered considerable resistance of local populations in some regions, particularly if there is evidence or suspicion of water shortage in the donor region.

The removal of large volumes of water from natural watercourses for water transfers may have detrimental environmental effects, and affect water availability in downstream regions. Such effects were experienced in Uzbekistan and Turkmenistan where water has been diverted from the two major rivers that feed the freshwater Aral Sea, in Central Asia, to areas that were being developed to allow intensive cotton production. These water transfers have had serious detrimental effects on water resources within the basin. The sea has shrunk significantly, and the quality of the rivers and groundwaters in the area has seriously deteriorated (Box 3.1).

5. HEALTH IMPACTS

5.1 Restricted access to drinking water

Access to a sufficient supply of safe water is essential in maintaining public health. In situations where there is inadequate water, direct and indirect effects on health are observed (Table 5.1). Poor hygiene enforced by the lack of water, results in the increased transmission of infectious diseases (Black *et al.* 1981). Where the sources of potable water is of poor quality or there is a lack of financing to maintain the distribution system, mortality rates attributable to infectious diseases (particularly intestinal diseases which provide an indication of the quality of potable water), availability of sanitation services and general hygiene, may increase.

As well as increasing the likelihood of person to person disease transmission, inadequate water supplies can compromise the effectiveness and efficiency of water-based sewage collection and treatment processes, posing an additional risk of disease.

In recent years the privatisation of water supplies in some countries has resulted in an increase in the number of households disconnected from water supplies. In the UK for example the number of domestic disconnections rose from 8,000 to over 21,000 between 1989 and 1992 following privatisation of the water industry. Water has become an increasingly expensive commodity and there is evidence that where water meters have been introduced low income groups restrict water use (McNeish, 1993). In a recent study, reductions in the flushing of toilets were reported by 54 per cent of households and reductions in the use of baths or showers in 73 per cent of households on low income in the UK (Lister, 1995). Few studies have looked at the social and health impacts of water disconnections or of low water use due to cost saving. One study showed a significant correlation between the number of disconnected households and the incidence of hepatitis A and shigellosis in some areas of the UK. Enforced reductions in water use due to economic deprivation was also implicated in this study as the cause of the increase in disease (Fewtrell *et al.*, 1994).

5.2 Drinking water quality

The quality of drinking water in supply depends upon many factors, including the quality of the raw water source, the extent and type of treatment and disinfection used, the materials and integrity of the distribution system and the maintenance of positive pressure within the network. Over abstraction and mineral excavation can also lead to contamination of groundwater supply as evidenced in Kyrgyzstan where saline intrusion and toxin contamination of the groundwater supply has occurred. Surface waters are of equally or even poorer quality in this country. Spring floods lead to annual outbreaks of hepatitis, typhoid and diarrhoeal disease (WHO, 1997d).

A number of chemical compounds are produced during disinfection of drinking waters some of which have been shown to be carcinogens in animal studies (section 4.5.2; 5.4). Standards and/or guidelines have been set for known by-products but the toxicity of by-products that have not yet been identified is also of potential concern. The microbiological safety of drinking water is the over-riding concern, and should not be compromised because of concern about possible risks to health from the presence of disinfection by-products.

Table 5.1 Incidence of diseases related to continuous and intermittent water supply in Romania

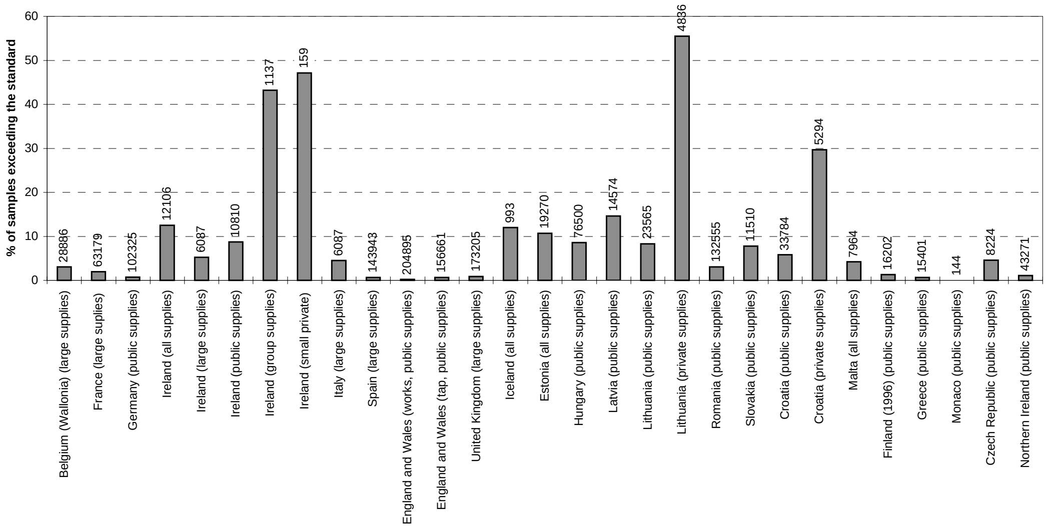
Incidence of disease 0/0000	Continuous water supply		Intermittence in water supply less than 8 hrs per day		Intermittence in water supply more than 8 hours per day	
	1990	**1991**	**1990**	**1991**	**1990**	**1991**
Typhoid	**0.06**	**0.04**	**0.13**	**0.15**	**0**	**0.08**
Bacillary dysentery	**133**	**182**	**58**	**191**	**106**	**89**
Hepatitis A	**183**	**45**	**333**	**107**	**311**	**163**
Acute diahorrea	**418**	**463**	**297**	**533**	**526**	**403**

(Source: Iacob *et al.,* 1997).

5.2.1 Microbiological quality

The provision of a microbiologically safe drinking water supply is the most important step that can be taken to improve the health of a community, by preventing the spread of waterborne disease (WHO, 1996). The monitoring of the microbiological quality of drinking water is therefore, aimed at verifying that it is free from such contamination. Whilst it is the pathogenic organisms directly responsible for the spread of disease that are of concern, their detection is difficult, expensive and time-consuming. Pathogen detection is therefore, not appropriate for routine monitoring. In addition not all pathogens have as yet been characterised and methods for detection of some others remain unavailable. Instead, water is examined for bacteria that are indicators of the presence of faecal contamination (WHO, 1996) (box 5.1).

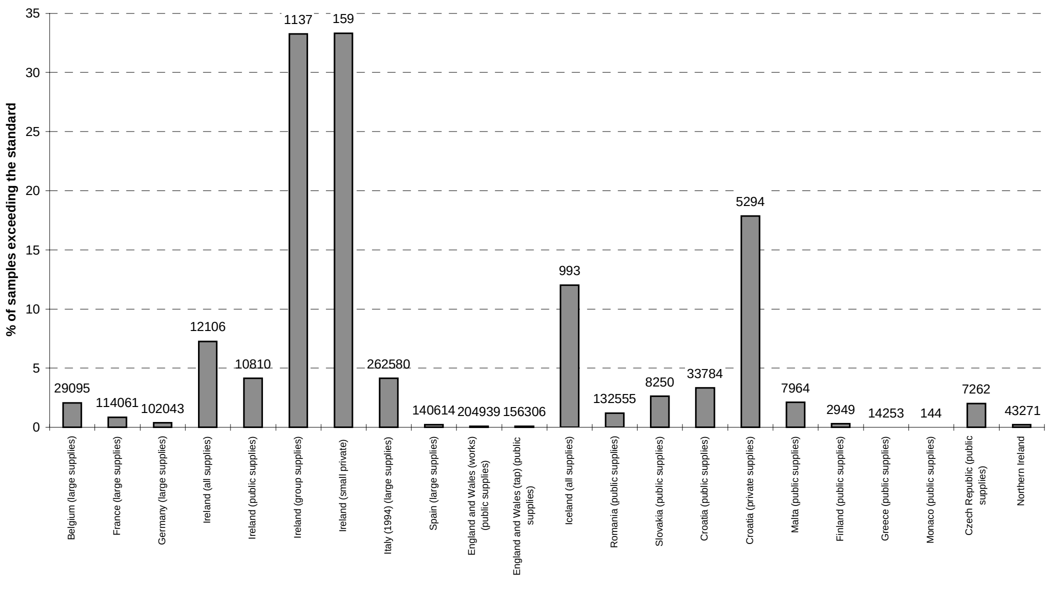
WHO guidelines for drinking water quality recommend that indicators of faecal contamination (*E. coli* or thermotolerant coliform bacteria) should not be detectable in any 100 ml sample of any water intended for drinking (WHO, 1996). In treated water entering the distribution system, neither faecal indicators nor total coliform bacteria should be detectable in any 100 ml sample. For water within the distribution system, the recommendation is again that no faecal indicators should be detectable in any 100 ml sample. The same applies to total coliforms, although the guideline indicates that in the case of large supplies where a large number of samples are examined, total coliforms should not be present in 95 per cent of samples taken throughout any 12-month period (WHO, 1996). Figures 5.1 and 5.2 show the percentage of drinking water samples exceeding national standards for total and faecal coliforms.



*Values on top of each bar are the number of samples analysed for total coliform.

Standards: Belgium, France, Germany, Ireland, Italy, England and Wales, UK, Romania, Crotia public and Malta **0/100ml**; Spain, Iceland, and Finland **<1/100ml;** Lithuania public **0.3/100ml;** Hungary **2/100ml;** Lithuania private **3/100ml;** Crot

Figure 5.1 Percentage of drinking water samples exceeding standard for total coliforms in 1995



Standards: Belgium, France, Germany, Ireland, Italy, England and Wales, Romania, Slovakia, Croatia, Malta, Greece, Monaco, Albania, Czech Republic 0/100ml; Spain, Iceland and Finland at <1/100ml
Values above the bar are the number of samples analysed for faecal coliforms

Figure 5.2 Percentage of drinking water samples exceeding standard for faecal coliforms in 1995

Box 5.1 Microbial indicators of faecal contamination

Indicators of faecal contamination should ideally be universally present in the faeces of humans and warm-blooded animals and should not grow in natural waters. They should be easy to detect and enumerate in water. Their persistence and removal during water treatment should similar to those of waterborne pathogens, so that they act not only as indicators of faecal contamination but also monitor the effectiveness of any water treatment measures in place in removing pathogens from the supply (WHO, 1996).

E. coli and the thermotolerant ('faecal') coliform bacteria are the most commonly used organisms as indicators of faecal contamination. Faecal streptococci are more persistent than *E. coli* and coliform bacteria. They are monitored regularly in fewer European countries than coliforms and may be used as a supplementary measure to investigate supplies where coliform measurements have indicated microbiological contamination. Faecal streptococci have been shown to be good indicators for microbiological contamination of a network system with discontinuities in water supply (Institute of Public Health, Bucharest).

Many European countries have standards for both total coliforms and faecal indicators of 0/100 ml. Although no countries permit the supply of water containing faecal indicators, a number of countries in central and eastern Europe (CCEE) and the NIS permit some evidence of microbiological contamination, as detected by total coliforms (standards of 0 - 3 /100 ml).

Community-managed supplies may not be subject to such stringent standards as public supplies and consequently the quality of communcity-managed supplies may be compromised. In Lithuania, for example, the standard for total coliforms in public supplies is 0.3/100 ml, while 1/100 ml is permitted in community-managed supplies. Microbiological contamination is reported as a particular problem in private wells (EEA/WHO questionnaire, 1997). Community-managed supplies may not be examined as part of a routine monitoring programme and only, as in Ireland, examined on an emergency basis in response to reported problems. Thus, samples will not be representative of the supplies as a whole and the reported proportion of excellencies of the standard will be higher than would be the case for random sampling.

Microbiological indicators are amongst the parameters found most frequently at levels of concern in the drinking water of many European countries. These include Germany, Sweden, Iceland, Liechtenstein, Norway, the Czech Republic, Estonia, Slovakia, Slovenia, Croatia, Malta, Turkey, Andorra, Greece (EEA/WHO questionnaire, 1997) Turkmenistan (Mountain Unlimited, 1997) and the Ukraine (Mountain Unlimited, 1995). In parts of Belgium and France microbiological parameters are reported as a particular concern in small supplies (EEA/WHO questionnaire, 1997).

The bacterial quality of drinking water will vary dependent upon a number of factors - the depth of the aquifer, the condition of the pipes in distribution, the efficiency of treatment and disinfection in particular. Diseases can also be contracted by exposure to microbiologically contaminated water during recreation (section 5.6) and potentially, as a result of the use of contaminated water for irrigation. Spray irrigation, in particular, is a potential hazard to agricultural workers, and there is a potential for the spread of disease via foodstuffs, particularly produce that is eaten uncooked, which have been irrigated by water containing pathogens.

Agricultural activities, often coupled with poor source protection, are widely regarded as contributing to microbiological contamination of the water source and this is reported as a factor in Liechtenstein (EEA/WHO questionnaire, 1997). Where the water source is open to animals or there is widely distributed rural housing, with widespread use of septic tanks, there is increased likelihood of contamination of the drinking water supplies (EPA, 1996).

Poor sewerage systems and the discharge of untreated sewage are likely to affect source water quality (Mountain Unlimited, 1997). Some organisms are more resistant to treatment than others - Cryprotosporidium oocytes for example (Maguire *et al.*, 1995) and can be discharged into surface waters in sewage effluent. Lack of chemical pre-treatment, improper backdating procedures, poor application of raw water to the filter and failure to monitor plant conditions have been implicated in outbreaks of waterborne giardiasis (Braidech and Karlin, 1985) and Cryptosporidiosis (Furtado, *et al.,* 1998; Karanis *et al.,* 1998).

Public supplies may be at risk if financial or technical constraints result in discontinuous chlorination. Financial and technical constraints have been reported to be a problem in providing a continuous supply of high quality drinking water in a number of countries including Estonia, Lithuania and the Republic of Moldova (EEA/WHO questionnaire, 1997).

Technical faults and faulty connections may result in wastewater infiltrating into the supply network, potentially contaminating the drinking water. Individual wells are vulnerable to contamination through adjacent ditches for sewage. This is considered to have caused between two and 10 outbreaks of disease in small communities each year in Sweden (SOU, 1996).

5.3 Infections

A number of serious infectious diseases, such as hepatitis A, cholera and typhoid fever can be spread via contaminated drinking water, as can more common intestinal diseases such as gastro-enteritis. Cholera (*Vibrio cholerae*), typhoid (*Salmonella typhi*), bacillary dysentery (*Shigella*), and *Campylobacter* are caused by bacteria. Others, such as hepatitis are viral. In addition, parasitic diseases are caused by protozoa.

Waterborne infectious diseases do not only cause preventable illness and death but also may have substantial economic consequences for the affected patients and their families and the society as a whole (e.g., expenses for health care, loss of productivity).

5.3.1 Surveillance

Available data on waterborne diseases or water borne disease outbreaks are often incomplete and inconsistent. The majority of diseases that can be spread by water are also spread through faecal contamination by other routes such as person-to-person contact and on contaminated food. Recorded cases of diseases could, therefore, have resulted from any of these routes of infection. Differences in recording (Table 5.2) and reporting procedures, classification of diseases, financial restrictions and variation in the legal basis between countries for reporting also often complicate the picture. For instance, in Spain, records of the incidence of diseases are based on the findings of microbiological laboratory investigations, while data on diseases transmitted in water are based on notification during outbreaks (EEA/WHO questionnaire, 1997). Some countries may record cases of gastro-enteritis, for example, while others maintain records of diseases caused by individual organisms. In the case of gastro-intestinal disturbances, the pathogen responsible for the disease is often not traced, and most records of these diseases do not associate the case with a cause. This is well illustrated by data from Albania, where 10-12 per cent of cases of gastro-enteritis are known to be caused by *Shigella* spp, 2 per cent by *Salmonella*, 20-25 per cent by *E.coli* and the remainder are of unknown origin (EEA/WHO questionnaire, 1997).

Different approaches to recording make immediate epidemiological follow-up difficult, and the exchange of information between central authorities, waterworks and local health authorities may be poor (EEA/WHO questionnaire, 1997). The reports of waterborne cases of a disease often exceed the total number of laboratory confirmed cases, leading to difficulties in interpreting the data and assessing the extent of the contribution of drinking water to the total disease incidence.

Visitors who contract diseases whilst on holiday contribute a significant proportion of cases of such illness in a number of European countries and tourists are particularly likely to contract enteric diseases, such as gastro-enteritis, from pathogens to which the resident population may be able to tolerate. Other factors such as trade and societal customs may also distort the picture of disease incidence. For example, a high incidence of bacillary dysentery in 1994 in Norway (approximately double the number of cases in the previous year) was traced to an outbreak caused by the import of contaminated lettuce (EEA/WHO questionnaire, 1997). Calculations of disease incidence based on the resident population can therefore be misleading. Statistics relating to the incidence of these diseases have to be interpreted with care.

Table 5.2 Countries indicating that they keep records of waterborne diseases

	Gastroenteritits		Ameobic dysentry		Bacillary dysentry		Cholera	
	Yes	No	Yes	No			Yes	No
Albania	√						√	
Andorra	√		√		√		√	
Austria		√	√		√		√	
Belgium (Flanders)	√*			√			√	
Belgium (Wallonia)		√		√			√	
Croatia	√			√	√		√	
Czech republic	√			√	√		√	
England and Wales	√		√		√		√	
Estonia	√		√		√		√	
Finland		√	√		√		√	
France				√			√	
Germany	√			√	√		√	
Greece	√		√			√	√	
Hungary		√	√		√		√	
Iceland		√		√				
Latvia	√				√			
Liechtenstein		√		√		√		√
Lithuania	√		√		√		√	
Luxembourg	√		√				√	
Malta			√		√			√
Monaco		√		√		√		√
Netherlands							√	
Northern Ireland	√		√				√	
Norway	√		√		√		√	
Poland	√**		√				√	
Republic of Moldova	√			√		√	√	
Romania	√			√	√		√	
Slovakia	√			√	√		√	
Spain			√				√	
Slovenia	√		√		√		√	
Sweden		√	√		√		√	
Turkey				√				

	Cryptosporidiosis		Giardiasis		Typhoid	
	Yes	No	Yes	No	Yes	No
Albania					√	
Andorra		√		√	√	
Austria		√		√	√	
Belgium (Flanders)	√		√		√	
Belgium (Wallonia)	√		√		√	
Croatia		√		√	√	
Czech republic	√		√	√	√	
England and Wales	√		√		√	
Estonia	√		√		√	
Finland	√		√		√	
France						
Germany		√		√	√	
Greece	√		√		√	
Hungary	√		√		√	
Iceland		√		√		
Latvia					√	
Liechtenstein		√		√		√
Lithuania	√		√		√	
Luxembourg		√		√	√	
Malta		√	√			
Monaco		√		√		√
Netherlands	√		√		√	
Northern Ireland	√		√		√	
Norway		√	√		√	
Poland						
Republic of Moldova		√		√		√
Romania		√	√***		√	
Slovakia	√		√		√	
Spain	√		√		√	
Slovenia	√		√		√	
Sweden		√	√		√	
Turkey		√		√		

Source: (WHO/EEA questionnaire, 1997);
*only epidemic cases; **gastroenteritis and colitis in infants from 4 weeks to 2 years old; ***Giardiasis is included in the intestinal parasitosis rate.

For the period 1986 to 1996, surveillance data from 17 countries of the European region reported a total of 2,567,210 cases of gastrointestinal disease; 52,304 (2.0 per cent) of these cases were linked to drinking water (Table 5.3). The average of 233,383 cases of gastrointestinal diseases per year for the 17 countries (estimated population, 220 million persons) is much lower than the estimated 6 to 80 million cases of foodborne diseases alone (to which, for example, the cases of waterborne and gastrointestinal diseases transmitted person-to-person must be added) for the United States of America (estimated population, 267 million persons) (Council for Agricultural Science and Technology, 1994; Helmick *et al.*, 1994). Thus, the data presented here (and in the following sections) most likely provides an underestimate of the true incidence of gastrointestinal diseases in the reporting countries. This conclusion is further supported by the results of recent surveys showing that foodborne diseases may be 300 to 350 times more frequent than reported cases tend to indicate (WHO, 1997); no such estimates are available for waterborne diseases.

For the 11-year period, a total of 710 waterborne disease outbreaks, i.e., an average of 3.8 outbreaks per year and country were reported (Table 5.4). For 208 outbreaks, details about the etiologic agent and the type of water system were available: For 142 (68.3 per cent) of the 208 water borne disease outbreaks, the etiologic agent could be identified; 86 (55.5 per cent) of 155 water borne disease outbreaks occurred in rural and 69 (44.5 per cent) in urban areas; 55 (35.7 per cent) of 154 outbreaks were associated with networked public water supplies, 27 (17.5 per cent) with individual water systems, 9 (5.8 per cent) with standpipe public supplies, and 63 (40.9 per cent) with unspecified supplies or recreational waters; 79 (65.8 per cent) of 120 outbreaks were associated with groundwater, 27 (22.5 per cent) with surface water, and 14 (11.7 per cent) with mixed source waters.

In each outbreak, for which such information was available, an average of 220 persons (range, 2-3500) were affected. The wide range of water borne disease outbreaks reported for the different countries is remarkable: during the 11-year period, no outbreaks were reported in Germany, Lithuania, and Norway, whereas from some countries more than 50 water borne disease outbreaks were reported: Spain (208 water borne disease outbreaks), Malta (162) and Sweden (53). These differences most likely do <u>not</u> only reflect true differences in the actual incidence of water borne disease outbreaks but also reflect differences in outbreak detection, investigation, and reporting in the different countries. For example, some countries do not have a surveillance system for water borne disease outbreaks and do not require reporting of waterborne diseases as such.

While it is possible to link a disease outbreak to a particular source (e.g., drinking water), normally it is impossible (or impracticable) to link a single case of (gastrointestinal) disease to a particular source. Thus, the data presented here most likely underestimate (in addition to the above mentioned under-reporting of gastrointestinal diseases in general) by far the true incidence of waterborne diseases in the reporting countries. In order to use the cases reported through surveillance systems for water borne disease outbreaks to estimate the magnitude of waterborne disease for a country or region it must be borne in mind that: (1) the data gathered through surveillance systems for water borne disease outbreaks probably do not reflect the true incidence of water borne disease outbreaks, because all water borne disease outbreaks may not be recognized, investigated, or reported; (2) the availability and utilization of laboratory services, the expertise of persons responsible for and resources allocated to surveillance activities may vary among countries; (3) recognition of water borne disease outbreaks is dependent on several other characteristics, e.g., severity of disease, relative size of the outbreak, and type of water system (Kramer *et al.*, 1996), and (4) the ratio of cases from waterborne disease outbreaks to "sporadic" cases of waterborne diseases is unknown and most likely varies among countries.

Hence, it is not possible to estimate the incidence of waterborne diseases in Europe from the data collected as part of the WHO/EEA questionnaire (1997). However, for the reasons outlined below it is possible to infer a large proportion of the reported gastrointestinal diseases in Europe is waterborne:

1. By analyzing data from waterborne diseases outbreaks it can be inferred that in general (depending also on the factors mentioned above) a high proportion of an affected population has to be affected before an outbreak is detected. For example, the 1993 Milwaukee water borne disease outbreak of cryptosporidiosis caused illness in more than 400,000 persons, but the outbreak was not detected before more than half of the affected persons already had become ill (MacKenzie *et al.,* 1994; Proctor *et al.,* 1998). During the investigation of an outbreak of cryptosporidiosis in AIDS-patients in Las Vegas in 1994, only a retrospective epidemiologic study showed that about nearly half of the employees of two randomly selected agencies had gastrointestinal illness during the outbreak period, indicating that this outbreak also affected persons in the general population of Las Vegas (Goldstein *et al.,* 1996; Roefer *et al.,* 1996), but no such outbreak was reported. These examples show that water borne disease outbreaks occur even in countries with sophisticated water treatment facilities and that even large water borne disease outbreaks may not be detected.

2. Improvements in source water protection and water treatment have resulted in a marked decrease of gastrointestinal diseases in developed countries over the last 100 years (Exner, 1995). However, studies and data from other parts of the world suggest that still a substantial part of gastrointestinal illness in Europe may also be waterborne. For example, epidemiologic studies from Canada, a country with a high standard of drinking water quality, indicate that up to 40 per cent of reported gastrointestinal diseases (depending on the type of source water, water treatment method, and distribution system) may be water-related (Payment *et al.,* 1991a, Payment *et al.,* 1997). In countries with less protected source waters, less sophisticated water treatment facilities, and less well-maintained water distribution systems, the proportion of water-related gastrointestinal diseases probably is even higher.

The data collected by the WHO/EEA questionnaire (1997) has a number of limitations (e.g., differences in surveillance activities and reporting, but also limitations in data collection) and therefore a meaningful estimate of the true magnitude of waterborne diseases in Europe is difficult to establish. There is a real need for the establishment of surveillance systems for water borne disease outbreaks as well as proper networks for regulation and command (for details see WHO 1998b) in those countries that do not yet have them, as well as the harmonization of systems and surveillance definitions used in different countries. The data gathered through surveillance systems for water borne disease outbreaks will be useful to identify the etiologic agents of water borne disease outbreaks, to determine why outbreaks occurred, to evaluate the adequacy of current water treatment technologies used in the different countries, and to characterize the epidemiology of water borne disease outbreaks (Kramer *et al.,* 1996). Further research is needed to be able to better estimate the burden of waterborne diseases not (obviously) related to outbreaks.

Table 5.3. Reported cases of gastrointestinal or other possibly waterborne diseases and cases of these diseases linked to drinking water—18 European countries,[1] 1986-1996

Etiologic agent/disease[2]	**Total no. of cases reported (per cent)**		**No. of cases linked to drinking water (per cent)**	
Bacterial etiology:				
Bacterial dysentery, cholera, typhoid fever, and *others*[3]	534,732	(20.8%)	15,167	(2.8%)
Viral etiology:				
Hepatitis A and *Norwalk like virus*	343,305	(13.4%)	6,869	(2.0%)
Parasitic etiology:				
Amoebic dysentery, amoebic meningoencephalitis, cryptosporidiosis, and giardiasis	220,581	(8.6%)	4,568	(2.1%)
Chemical etiology:				
Dental/skeletal fluorosis and methaemoglobinaemia	7,421	(0.3%)	2,802	(37.8%)
Unspecified etiology:				
Gastroenteritis and severe diarrhoea	1,461,171	(56.9%)	22,898	(1.6%)
Total	**2,576,210**	**(100%)**	**52,304**	**(2.0%)**

1 Andorra, Austria, Croatia, Czech Republic, England and Wales, Estonia, Germany, Hungary, Latvia, Lithuania, Malta, Moldavia, Norway, Romania, Slovak Republic, Slovenia, Sweden. On average, the countries had data available for 7/12 diseases (range, 3-10).

2 Categories/diseases in italics originally not provided in the questionnaire.

3 Others=*Aeromonas* sp., *Campylobacter* sp., *Salmonella* sp.

Source (WHO/EEA questionnaire, 1997)

Table 5.4. Reported waterborne disease outbreaks associated with drinking and recreational water in —19 countries of the European region, 1986-1996 (n=778)[1]

Country	Etiologic agent/disease (No. of outbreaks)	Total no. of outbreaks	No. of cases (No. of outbreaks for which details were available)[2]	
Albania	Amoebic dysentery (5), typhoid fever (5), cholera (4)	14	59	(3)
Croatia	Bacterial dysentery(14), gastroenteritis (6), hepatitis A (4), typhoid fever(4), cryptosporidiosis(1)	29[3]	1,931	(31[3])
Czech Republic	Gastroenteritis(15), bacterial dysentery(2), hepatitis A(1)	18[4]	76	(3)
England and Wales	Cryptosporidiosis(13), gastroenteritis (6), giardiasis(1)	20	2,810	(14)
Estonia	Bacterial dysentery(7), hepatitisA(5)	12	1,010	(12)
Germany	no outbreaks reported	0	0	
Greece	Bacterial dysentery(1), typhoid fever(1)	2	16	(1)
Hungary	Bacterial dysentery(17), gastroenteritis (6), salmonellosis(4)	27[5]	4,884	(27)
Iceland	Bacterial dysentery(1)	1	10	(1)
Latvia	Hepatitis A(1)	1	863	(1)
Lithuania	no outbreaks reported	0[6]	0	
Malta	Gastroenteritis(152), bacterial dysentery(4), hepatitis A(4), giardiasis(1), typhoid fever(1)	162	19	(6)
Norway	no outbreaks reported	0	0	
Romania	Bacterial dysentery(36), gastroenteritis(8), hepatitis A(8), cholera (3), typhoid fever(1), methaemoglobinaemia(1)	57	745	(1)
Slovak Republic	Bacterial dysentery(30), gastroenteritis(21), hepatitis A(8), typhoid fever(2),	61	5,173	(61)
Slovenia	Gastroenteritis(33), bacterial dysentery(8), hepatitis A(2), amoebic dysentery(1), giardiasis(1)	45	n.a.	
Spain	Gastroenteritis(97), bacterial dysentery(47), hepatitis A(28), typhoid fever(27), giardiasis(7), cryptosporidiosis (1), unspecified (1)	208	n.a.	
Sweden	Gastroenteritis (36), Cympylobacter sp.(8), Norwalk like virus(4), giardiasis(4), cryptosporidiosis(1), amoebic dysentery(1), Aeromonas sp.(1)	53[7]	27,074	(47)
Total	Gastroenteritis(410), bacterial dysentery(191), hepatitisA(71), typhoid fever(45), cryptosporidiosis(16), Giardiasis(14), Campylobacter sp.(8), amoebic dysentery(7), cholera (7), Norwalk like virus(4), salmonellosis(4), Aeromonas sp.(1), methaemoglobinaemia(1), unspecified(1)	778	54,782	(277)

1 For the 19 countries listed, information was available for a cumulative total of 198 surveillance years.
For the period of 1986-1996, Andorra, Austria, Belgium, Moldavia, Monaco, and Liechtenstein had no records of waterborne disease outbreaks; Switzerland did not provide data.
2 n.a.=not available.
3 Discrepant data were provided in the different sections of the questionnaire (see text for details).
4 One year of reporting only.

[5] Outbreaks associated with drinking water (n=12) and recreational water (n=15).
[6] Ten years of reporting only.
[7] In one outbreak, *Campylobacter* sp., *Cryptosporidium* sp., and *Giardia lamblia* were identified as the etiologic agents; in the column 'Etiologic agent,' all three are listed.

Source: WHO/EEA questionnaire, 1997

5.3.2 Non-specific gastro-enteritis

Gastro-enteritis is an intestinal disease that can be caused by a range of micro-organisms. Many countries keep records on gastro-enteritis (Table 5.2) but recording in different countries varies, with some recording any incident of severe diarrhoea as gastro-enteritis, with others including it in the definition of infectious intestinal diseases. Many cases of gastroenteritis are self-limiting and/or self treated and therefore not identified by some surveillance systems. This makes comparison of data difficult (section 5.3.1).

Few countries report links of cases of gastro-enteritis to drinking water and, where this is the case, they are generally a small proportion of the total incidence (Table 5.3). However, this may be related to the inefficiency of outbreak detection. Nonetheless, waterborne gastro-enteritis is regarded as a serious problem in a number of countries in the European Region including Spain and Albania (EEA/WHO questionnaire, 1997).

5.3.3 Amoebic dysentery

Ameobic dysentery is caused by the protozoa *Entamoeba histolytica.* It is a debilitating disease, whose symptoms include abdominal pain, diarrhoea alternating with constipation, or chronic dysentery with discharge of mucus or blood. Carriers of amoebic dysentery are now found worldwide. It is believed to be carried by only a small proportion of the population of Europe. Cysts of *E. histolytic*, like all protozoan cysts, tend not to settle in sewage treatment plants and there is therefore the potential for surface waters to be contaminated by sewage effluent (Gary, 1994).

The number of cases of amoebic dysentery reported from countries that maintain records is generally low (Table 5.2 and Figure 5.3) although between 1000 and 4000 cases were reported annually in Sweden in the early 1990s (an incidence of approximately 11 - 45 per 100 000 population). The only reported cases of amoebic dysentery known to be linked to drinking water were in Slovenia in 1991, when 39 out of a total 46 cases were believed to have resulted from contaminated drinking water (WHO/EEA questionnaire, 1997).

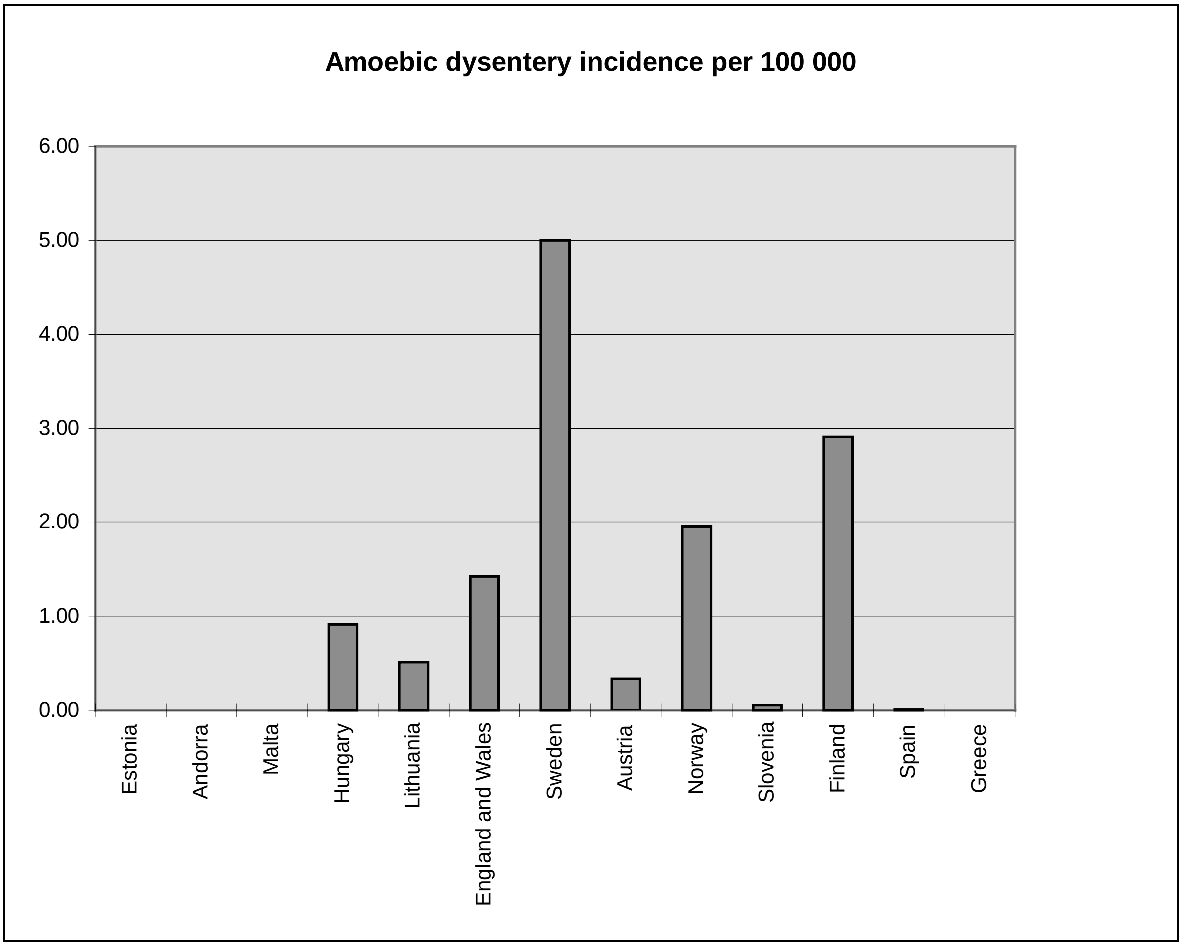


Figure 5.3 Reported incidence of amoebic dysentery, 1996
Notes: Most cases in Finland contracted abroad
Source: EEA/WHO questionnaire (1997)

5.3.4 Bacillary dysentery

Bacillary dysentery is an infectious intestinal disease, caused by *Shigella* spp. The disease is spread primarily by person to person contact as *Shigella* spp rarely infect animals and do not survive well in the environment. The infectious dose is low. However, poor quality drinking water contaminated by sewage has been the cause of disease outbreaks (Gray, 1994) although *Shigella* is readily destroyed by chlorination (WHO, 1996). Records of bacillary dysentery are kept by a number of European countries (Table 5.2). Outbreaks are regularly reported in many countries (Figure 5.4 and Table 5.3). In an epidemic of *Shigella sonnei* gastroenteritis in Israel, thought to be waterborne, 1216 people were affected within three weeks, 302 of them members of communal settlements, the kibbutzim. People at high risk within the kibbutzim were temporary visitors from Europe and the US, children aged 1 to 5 years, adult women, and children and their mothers in kibbutzim (Simchen *et al.*, 1991).

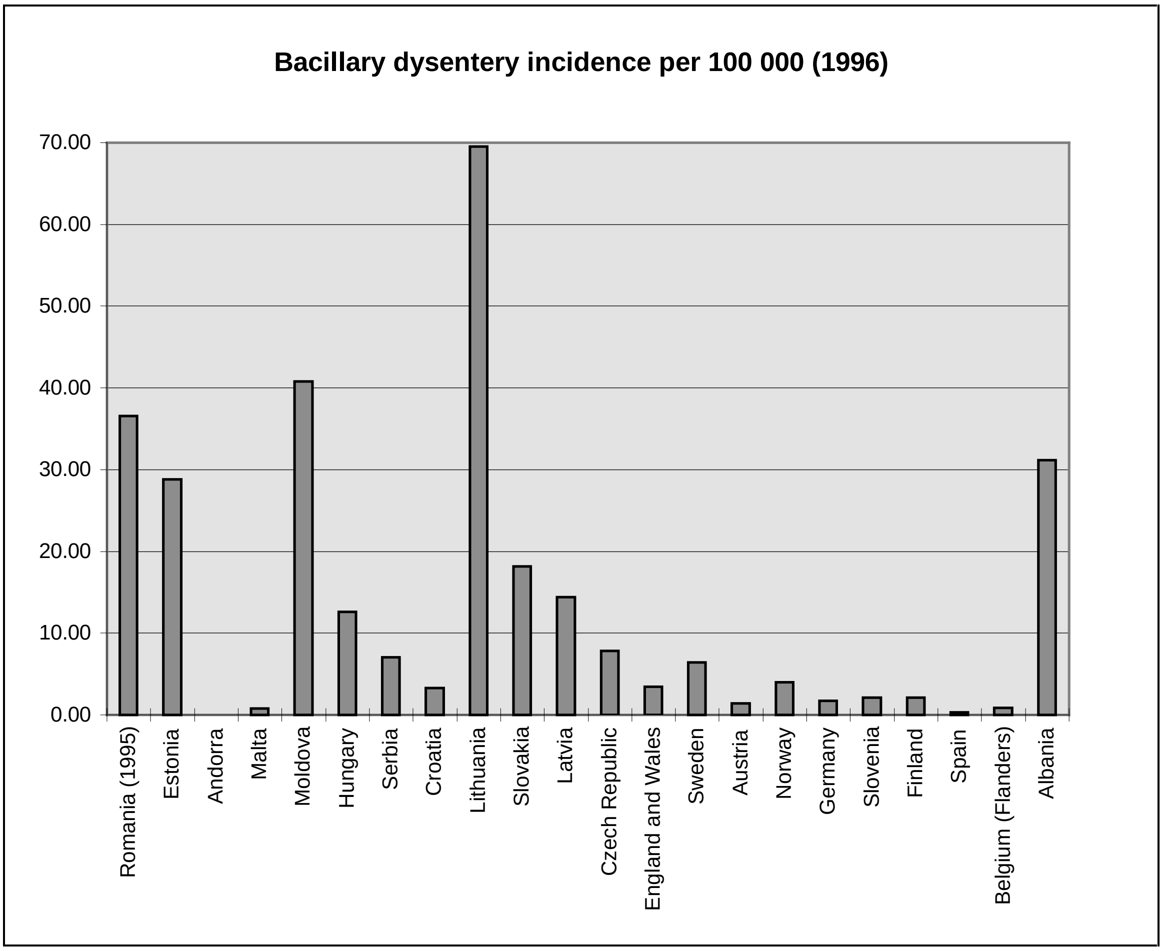


Figure 5.4 Reported incidence of bacillary dysentery
Source: EEA/WHO questionnaire (1997)

The contribution of known waterborne cases to the total morbidity varies between the countries for which data are available, and between years, but is significant in some cases. In Spain, a number of cases (between 83 and 1327) annually have been linked to drinking water between 1986 and 1995 (EEA/WHO questionnaire, 1997). In a number of countries, including Spain, Greece and Albania, it is regarded as one of the most serious waterborne disease problems (EEA/WHO questionnaire, 1997).

5.3.5 Campylobacteriosis

Campylobacter are spiral bacteria that cause severe acute diarrhoea. *Campylobacter* species have been isolated from surface waters contaminated by sewage, farm animals and wildlife, particularly birds, although *Campylobacter* is susceptible to chlorination (WHO, 1996). However, the most important reservoirs of the bacterium are meat and unpasturised milk. Household pets can also carry the disease. *Campylobacter* can remain viable for extended periods in the environment, particularly in lowish temperatures, and survival in excess of 12 months is possible at 4 ^{o}C (Gray, 1994; WHO 1996). Six waterborne outbreaks were recorded in Sweden between 1986 and 1996 (EEA/WHO questionnaire, 1997). *Campylobacter* has been reported to be widespread in the River Moskva and its tributaries in the former USSR (Abakumov and Talayeva, 1998).

5.3.6 Cholera

The symptoms of cholera are sudden diarrhoea with watery faeces, accompanied by vomiting, and the resultant dehydration and collapse is fatal in over half of untreated cases. The the main routes of transmission of cholera are waterborne or foodborne. Direct person to person contact is uncommon.

The epidemiology of cholera has been dominated by its tendancy to spread throughout the world in pandemics. The first of six pandemics began in Bangladesh. The seventh, started in 1961 in Indonesia and spread to the Indian subcontinent, the former USSR, Iran and Iraq during the 1960s. In the former USSR 10,723 cholera cases and carriers were reported between 1965 and 1989 from 11 republics. Since then the epidemiological situation in the USSR has been unstable - cases of cholera and virulent stains from surface waters are reported each year (Narkevich *et al.*, 1993). There has been a recrudescence of cholera epidemics since 1991, both in the continents where cholera is epidemic and in traditionally cholera-free areas (Grassi *et al.*, 1998). However, the number of reported cases in most European countries is low - cholera has basically have been controlled in Europe by improved water and sewage treatment and improved food hygiene - although *Vibrio cholerae* is not uncommon in European surface waters (Schiraldi, 1990). All pathogenic *Vibrio* spp. are halophilic and survive better in moderately saline waters. Temperatures of at least 10^{o}C for several consecutive weeks are also important for the survival of *V. cholerae* in the environment. The organism is highly susceptible to chlorine, and is readily destroyed by proper disinfection of water.

Tourism from Western Europe to the Far East and other areas is likely to have resulted in a significant increase in the proportion of the population that carries the organism. All cases reported in Andorra, England and Wales, Sweden, Finland and Greece between 1986 and 1996, were of individuals who had contracted the disease abroad and in Spain the majority of recorded cases are imported. However, a number of Central and Eastern states appear to have domestic cases (EEA/WHO questionnaire, 1997). In Romania, records on cholera as a notifiable disease have been kept since 1986. It is estimated that 286 cases of cholera were caused by drinking water between 1991-1993. These occurred in three outbreaks, one in each year, and all occurred within the Danube delta (EEA/WHO questionnaire, 1997). In Albania, 626 cases of cholera were reported in 1994, 25 of which were fatal. All of these were linked to drinking water, with four outbreaks of waterborne cholera reported in the year (EEA/WHO questionnaire, 1997). The incidence of cholera in the Republic of Moldova appears to have risen over recent years (1991: 1; 1993: 4; 1994: 9; 1995: 240) and, although none of the cases were reported linked to drinking water, cases were concentrated in particular areas (Slobozia, Stefan-Vode and Tiraspol districts; EEA/WHO questionnaire, 1997). A cholera epidemic in the Ukraine in 1994 and 1995 resulted in 32 fatalities among 1370 recorded cases. Environmental sources of the causative agent included sewage, sea and surface waters (Clark *et al.*, 1998).

5.3.7 Crytosporidiosis

Cryptosporidium is a coccidial protozoan parasite. About 20 species are now known, of which *C. parvum* is pathogenic for humans. Infection by the *Cryptosporidium* spp causes gastro-enteritis with stomach cramps, nausea, dehydration and headaches. The disease is usually self-limiting, lasting for up to two weeks, but can be fatal in the very young and very old and in individuals that are immunosuppressed, such as those suffering from AIDS (Gray, 1994). *Cryptosporidium* is widespread in nature and has a wide range of animal hosts as well as being a human pathogen. In its protected stage (the oocyst), *Cryptosporidium* is able to survive several months in water at 4^{o}C (Smith *et al.,* 1988). Treatments conventionally used to remove particulate matter and microbiological contamination from surface waters, such as coagulation and filtration, will remove a large proportion of the oocysts. However, because of their small size (4-7 µm in diameter) and their resistence to disinfection, oocysts are difficult to remove by water treatment (Maguire *et al.*, 1995). Exposure to a small number of oocysts is believed to be sufficient to cause an infection. A number of European countries keep records of detected cases of *Cryptosporidiosis* (Table 5.2).

Cryptosporidium parvum infection occurs worldwide in urban and rural populations (Crane *et al.*, 1998). Several thousand cases have been recorded in each of the last ten years in England and Wales (Table 5.5) (Crane *et al.*, 1998). Comprehensive records are not available for the proportion of these cases that were associated with contaminated drinking water, but some outbreaks have been investigated and are believed to have originated from this source (EEA/WHO questionnaire, 1997). For the period 1986-1996, thirteen outbreaks of waterborne *Cryptosporidiosis* were recorded in England and Wales. Around 4 per cent of all cases of *Cryptosporidiosis* reported in the UK were in people who had recently returned from abroad.

Table 5.5 Number of reported cases of *Cryptosporidiosis* in England and Wales

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
No of cases	3565	3277	2750	7768	4682	5165	5211	4832	4433	5684	3662

Source: EEA/WHO questionnaire (1997)

At least 500 cases of *Cryptosporidiosis* were confirmed in outbreaks in England and Wales between 1989 and 1995, with an additional 5000 people possibly being affected in the 1989 incident (EEA/WHO questionnaire, 1997). Although smaller numbers than this were involved in other possible waterborne outbreaks (20 - 477), these incidents demonstrate the potential for contaminated supplies to cause the disease in a significant number of people. All UK outbreaks detailed in the EEA/WHO questionnaire (1997) were in networked public supplies.

Cryptosporidium oocysts have been found to be widespread in British water resources, and they have been shown to be present at higher concentrations in lakes and rivers receiving wastewaters than in pristine streams (Gray, 1994). The source of environmental contamination can be both human sewage and animals. The majority of probable/possible waterborne outbreaks in England and Wales have been associated with supplies derived from surface water sources, as might be expected given their greater likelihood of contamination via run-off from agricultural land, by wildlife faeces and via sewage discharges. The seasonal presence of the organisms in the source water supplying the treatment plant involved in the 1989 incident was particularly associated with the grazing of young lambs, which often suffer scouring

(Gray, 1994). Nonetheless, at least three outbreaks have been linked to groundwater sources (EEA/WHO questionnaire, 1997).

Investigations into a number of waterborne outbreaks have established that the water supplied was free of indicators of faecal contamination. This emphasises the resilience of the oocysts to disinfection. Water suppliers face difficulties in detecting and efficiently removing *Cryptosporidium* (Richardson *et al.,* 1991; Gray, 1994; Maguire *et al.,* 1995). Recycling of filter backwash water has also been shown to contribute to the build up of oocysts in water treatment works. Proper treatment of washwaters before recycling may prevent such a build-up (Gray, 1994). Recreational water use, farm animal contact and old piping have also been identified as risk factors for cryptosporidiosis (Fewtrell and Delahunty, 1995; Duke *et al.,* 1996).

5.3.8 Giardiasis

Giardia lamblia is found in its free-living form in a wide range of host animals and its cysts can survive in unchlorinated water for long periods, particularly in cold weather. Symptoms of Giardiasis develop in the first few weeks after infection and include severe, watery foul-smelling diarrhoea, gas in the stomach or intestines, nausea and a loss of appetite. Water is probably not the primary mode of transmission of *Giardiasis* but it is a common transmitter (Gray, 1994; Karanis *et al.*, 1998).

The reported incidences of *Giardiasis* in European countries varies enormously (Figure 5.5), and it is likely that a significant proportion of cases in some countries are imported by people returning from travel abroad. One known incident in the UK involved a community-managed groundwater supply in a rural area, supplying 260 people. Of these, 31 (12 per cent) contracted the disease (EEA/WHO questionnaire, 1997).

In countries where Giardiasis has been known to be spread through water supplies, the contribution of waterborne infection to the total disease burden varies significantly between years. In Sweden, for example, 3500 waterborne cases were recorded in 1986. This was an exceptional outbreak caused by an overflow of sewage into the drinking water system at a ski resort (Ljungstrom and Castor, 1992). Between 1990 and 1996 over 23,000 cases were reported in Sweden. Known waterborne infections made up less than 1 per cent of infections in 1990 and 1996, while this figure was as high as 14 per cent in 1991, although no cases were linked to drinking water in most years of the last decade (EEA/WHO questionnaire, 1997).

A similar variation is reported in Slovenia, where the number of cases of Giardiasis reported annually has varied between 329 and 1299 in the last decade. In 1992 40 per cent of these cases linked to drinking water (520 out of a total of 1299) (EEA/WHO questionnaire, 1997). A number of cases in Spain have also been linked to drinking water (EEA/WHO questionnaire, 1997).

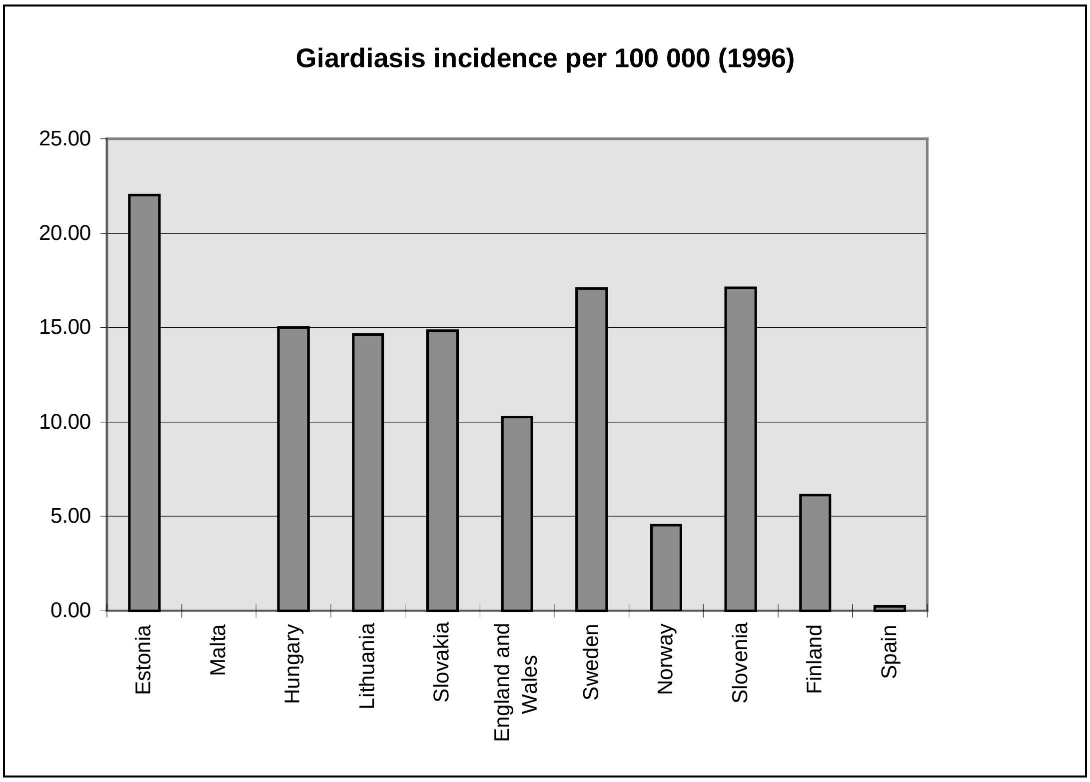


Figure 5.5 Reported incidence of *Giardiasis* in selected European countries 1996
Notes: Most cases in Norway, Finland, England and Wales imported from abroad
Source: EEA/WHO questionnaire (1997)

5.3.9 Helminthiases

The helminths, or parasitic worms, belong to two unrelated groups of organisms: roundworms and flatworms (flukes and tapeworms). Their distribution is limited geographically, and few of significance to human health are found in Europe. In sub-Saharan Africa drinking water is a primary mode of transmission only for the guinea worm (*Dracunculus medinensis*), a roundworm whose distribution is limited to certain countries. Other helminths may also be transmitted by drinking water, but this is unlikely to be the most important route of infection (WHO, 1996).

Schistosoma spp can affect the intestine, causing intestinal schistosomiasis, or the blood vessels around the bladder, causing urinary schistosomiasis. Organisms causing both forms of the disease occur in the Eastern Mediterranean Region but are not found in Europe. The infective larvae are able to penetrate the human skin or mucous membranes and are more of a hazard when contaminated water is used for washing, irrigation or recreation than from drinking water (WHO, 1996).

Other helminths that could potentially be transmitted through drinking water include *Fasciola* spp (flukes), which are parasites of farm and domestic animals. The eggs of the pork tapeworm (*Taenia solium*) may survive in the environment after they are excreted in faeces, and infect humans if ingested. The usual route of infection is from ingesting raw pork (WHO, 1996).

Infection by water-borne helminths is not a significant risk in most parts of the European region. However, it is a potential concern following the use of wastewater in agricultural irrigation. Epidemiological studies have shown that crop irrigation with untreated wastewater causes a significant increase in intestinal nematode infections in crop consumers and field workers but that this is not the case when wastewater is adequately treated before being used for irrigation. WHO guidelines for the microbiological quality of treated wastewater intended for crop irrigation recommend that the treated wastewater should contain <1 viable intestinal nematode egg per litre in order to protect the health of both field workers and consumers of crops. Wastewater complying with this guideline will contain few, if any, protozoan cysts, and no (or, exceptionally, very few) *Taenia solium* eggs, so consumers and field workers will also be protected from protozoan and tapeworm infections (Mara and Cairncross, 1989).

5.3.10 Infectious hepatitis

Viral hepatitis is an inflammation of the liver caused by one of several different viruses. Two of these viruses - hepatitis A and hepatitis E, have been regularly associated with waterborne outbreaks of disease. Hepatitis A is common throughout the world, and is very infectious. It causes nausea, vomiting, muscle ache and jaundice, and is spread by faecal contamination of food, drinking water or water used for bathing and swimming. Hepatitis E is less common than hepatitis A and is restricted to tropical and sub tropical countries.

Most countries keep records of reported cases of hepatitis A (Table 5.2). The number of cases varies enormously between countries, with the incidence in the CAS and the NIS being particularly high. Incidence in the EU and Norway and Iceland is much lower (Figure 5.6).

A proportion of cases have been linked to contaminated drinking water (Table 5.3),. The extent to which the origin of a case is traced is also likely to be very variable between countries. There were large fluctuations in the incidence of infections in England and Wales for example between 1986 and 1997 - the proportion considered to have been acquired abroad fluctuated and was estimated to be between 3 and 20 per cent for this period (WHO/EEA questionnaire, 1997).

5.3.11 Norwalk and Norwalk-like viruses

Norwalk virus causes severe diarrhoea and vomiting. A number of waterborne outbreaks caused by Norwalk or Norwalk-like virus have occurred in Norway and Sweden and it is regarded as a serious problem in both countries. In Sweden, four outbreaks occurred between 1994 and 1996, in which 325 people contracted the disease (EEA/WHO questionnaire, 1997). It is currently unclear whether Norwalk virus is effectively removed by normal chlorination practice (Gray, 1994; WHO, 1996).

5.3.12 Non gastro-intestinal disease -Typhoid

Typhoid (*Salmonella typhi)* and paratyphoid (*Salmonella paratyphi*) result from infection by *Salmonella spp*. The current incidence of typhoid is low in most

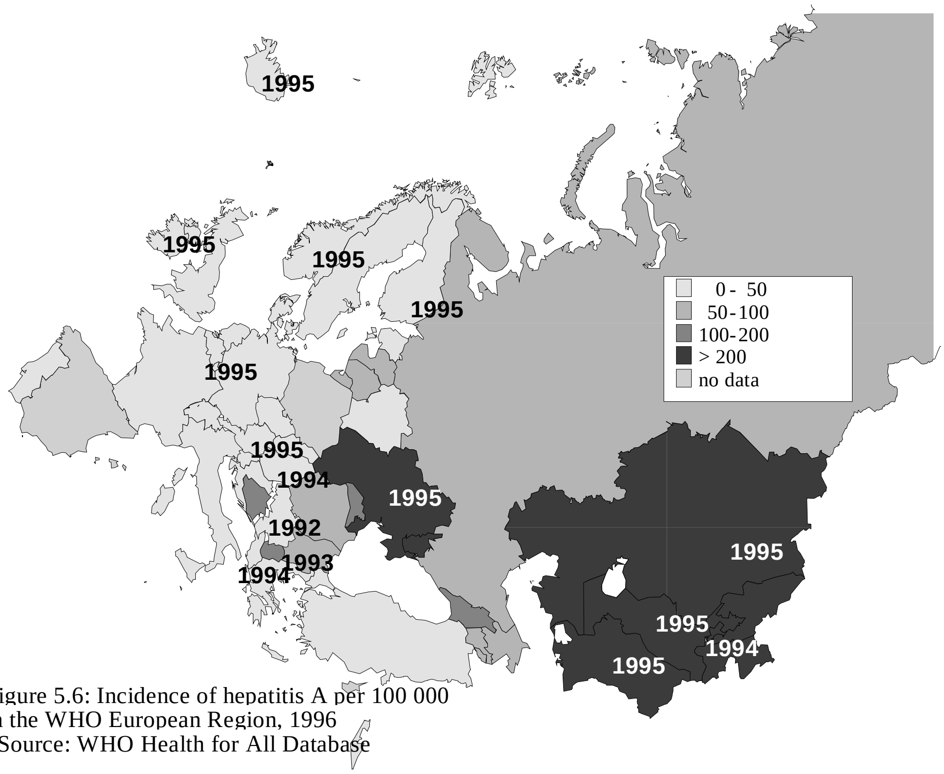


Figure 5.6: Incidence of hepatitis A per 100 000 in the WHO European Region, 1996
Source: WHO Health for All Database

European countries that hold records (Tables 5.2 and 5.4 and Figure 5.7) and, as with cholera, a significant proportion of cases recorded in many countries are likely to have been imported. All cases reported in Belgium (Flanders) in the last decade were contracted abroad, and this is also true of almost all of the cases reported in Sweden, Norway and Finland (EEA/WHO questionnaire, 1997). Approximately 90 per cent of reported cases in the UK were acquired outside the country.

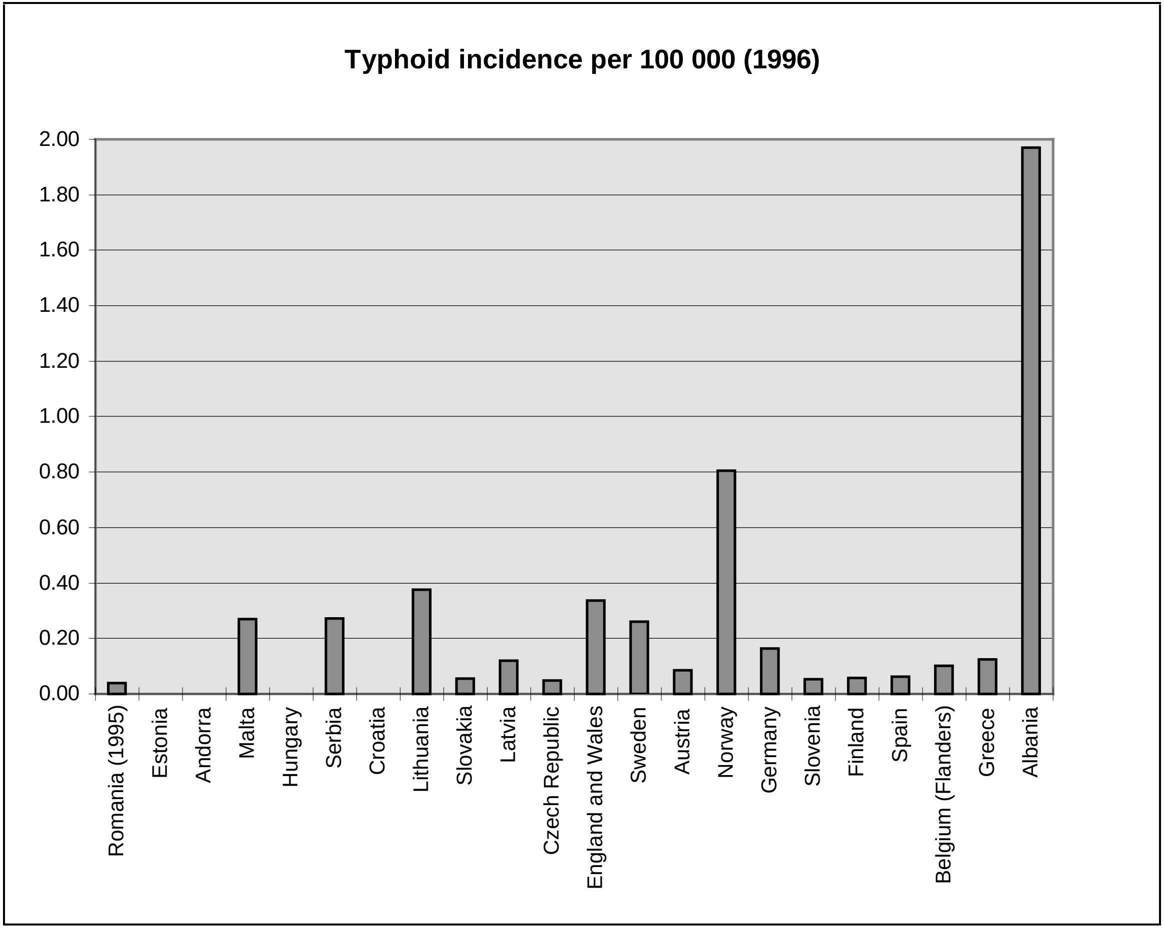


Figure 5.7 Reported incidence of typhoid in some European countries

Source: (EEA/WHO questionnaire, 1997)

Some countries (Romania, Estonia, Croatia, Albania, Greece, Spain and Slovakia), have linked recorded cases of typhoid to drinking water supplies during the last decade. In Romania, where the incidence of typhoid has dropped steadily over the last decade (from 0.3 per 100 000 population in 1986 to 0.04 per 100 000 population in 1995), only 9 cases have been linked to drinking water in this time.

In Tajikistan, an outbreak of typhoid fever (identification based on clinical observations) occurred in 1996. This was traced to heavy rainfall resulting in the overflow of water from the poorly maintained sewage systems, with the subsequent contamination of sources of drinking water. Nearly 4000 cases were reported between mid-May and the beginning of July 1996, with the outbreaks still continuing. Ten districts in two provinces were affected and a number of deaths occurred, mainly in the age range of 10-29 years; fatality rates of 1.2 per cent and 8.2 per cent in the two provinces were reported (WHO, 1996a).

5.4 Chemical parameters

5.4.1 Water-borne non-infectious diseases

Lead

Lead is a cumulative, general toxicant that can affect a large number of processes in the body. Impairment of the development of the nervous system of children, leading to an IQ deficit, has been reported following exposure to relatively low levels of lead, and is the effect of greatest concern at low level exposure. Effects on gestational age and foetal weight are also sensitive endpoints, as are blood pressure and some biochemical effects. Infants, children up to six years of age, the foetus and pregnant women are the most susceptible to the adverse health effects of lead. Endemic diseases of the nervous system, gingivitis and hypermenorrhea have been observed in the Debet river basin in Armenia where concentrations of lead in freshwater ecosystems of the area are 5-200 times higher than in the medial biogeochemical zone where conditions are taken as optimal (Zhulidov and Emetz, 1998).

Concerns about the potential health effects of dissolved lead have led to considerable efforts to reduce lead concentrations in water. Nonetheless lead piping is retained in some properties. It is this pipework, owned by and the responsibility of the householder, that is responsible for most of the failures of drinking water samples to meet the current standard of 50 µg/l set in the EU Drinking Water Directive (80/778/EEC) and the WHO guideline value of 0.01 mg/l. In the years 1990 - 1995, 2.7 - 3.4 percent of drinking water samples tested in England and Wales were above 50 ųg/l. A new standard of 10 µg/l is proposed in the current draft of the revised EU Drinking Water Directive and it is, therefore, likely that a greater proportion of samples will exceed this standard.

Orthophosphate dosing is used by a number of water suppliers in the UK, particularly those in soft water areas, to reduce the dissolution of lead (box 5.2).

Box 5.2 Treatment to reduce plumbo-solvency of drinking water supplies in the United Kingdom

Between 1994 and 1996, treatment has been installed in a number of areas of the UK to decrease the plumbo-solvency of the water in the supply, usually by dosing of orthophosphate or by adjusting the pH. In 1996 2.2 per cent of drinking water samples tested exceeded the standard in UK (UK (England and Wales)) compared with 2.7 per cent - 3.4 per cent between 1990 and 1995. Concentrations of lead in drinking water are also a concern in Scotland, where the predominant soft, acidic waters readily dissolve lead. There have been a number of educational drives to minimise the exposure to lead of children living in housing with lead piping, for example by advising householders to avoid using water that has been standing in the pipework overnight or for several hours.

Concern in Hungary has been caused by lead leaching out of newly laid PVC pipes in which it had been used as a stabiliser. However, this leaching appears to be only a short-term problem, with concentrations decreasing to below the standard of 50 µg/l a few weeks after the pipes are first used (WHO/EEA questionnaire, 1997).

Arsenic

Inorganic arsenic is a known human carcinogen and is classified by IARC in group 1. The WHO provisional guideline for arsenic is 0.01 mg/l (WHO, 1996) and this has been adopted as the standard in a number of European countries, although the standard in most remains at the previous WHO provisional guideline value of 0.05 mg/l, (WHO, 1984). The guideline value of 0.01 mg/l is provisional because of the lack of suitable testing methods. Based on health concerns alone it would be lower still. Data from Croatia, Slovakia, Belgium, Greece, Monaco and England, Wales and Northern Ireland indicate that arsenic does not generally occur in drinking water above their standard of 0.05 mg/l in these countries. In France only 0.06 per cent of samples tested in 1995 exceeded this standard, and the figure for the Czech Republic in 1996 was 0.25 per cent (EEA/WHO questionnaire, 1997).

Consumption of drinking water containing high levels of arsenic has been associated with increases in skin cancer and possibly internal cancers (WHO, 1996). Concentrations exceeding the WHO guideline value are found in areas of some central European states, particularly where there are natural sources of arsenic in minerals (Box 5.3). In the South-East of Hungary and in the adjoining areas of Romania, particularly in individual and public wells in districts Bihor and Arad, 3000 people have been exposed to levels exceeding the standard (Institute of Public Health Cluj-Napoca). In Bulgaria, high concentrations have been found in both surface and well waters near a copper smelter at Srednorgie. Locally, in the south-western parts of Poland natural high levels of arsenic can be observed although concentrations in drinking water do not generally exceed the standard.

Monitoring for arsenic is not routinely carried out in all countries. Sweden, for example does not carry out routine monitoring for arsenic, and 17 per cent of the samples taken during two surveys in 1986 were found to contain levels above the standard of 0.01 mg/l. These were in water from private wells. However the percentage of the country as a whole is much lower, 0.3-3 cases of cancer per year are estimated to be caused by arsenic (SOU, 1996). In Finland some areas have natural elevated arsenic concentrations in the groundwater. This concerns only some localised drilled wells serving less than 50 people and private single household drilled wells.

Box 5.3 Reductions in arsenic levels in drinking water in Hungary

In some areas of Hungary groundwaters naturally contain high concentrations of arsenic. This problem came to light in 1981 when a countrywide survey indicated that over 400 000 people were exposed to drinking water containing arsenic at levels above the standard of 0.05 mg/l. Measures were rapidly undertaken to address the high levels of arsenic in water and reduce the number of people exposed to concentrations above the health-based standard.

A number of different approaches have been used, depending on the size of the supply and the properties of the source waters. In some smaller villages and in a bigger plant (10 000 m^3 per day) serving two towns, co-precipitation technology was used to remove the arsenic. Trivalent arsenic, As (III), is oxidised to the pentavalent form, As (V), usually by chlorine. Iron (III) salts are dosed and the pH corrected using lime, to coagulate and precipitate the arsenic, and the water filtered to remove the precipitated salts. Where the water also contains humic material, a second oxidation and flocculation was undertaken using permanganate, and the water refiltered.

A simpler solution is possible where the natural concentration of arsenic is not much higher than the standard (e.g. 0.060 - 0.075 mg/l) and the water also has a natural iron content of 0.6 - 0.7 mg/l. Only a pre-oxidation using chlorination is required to induce co-precipitation prior to filtration, and this treatment has the added benefit of removing the iron content which would otherwise have required aeration and filtration. This procedure has been used in several Hungarian villages.

Where possible, such treatments are avoided by using an alternative water source to supply the population. New abstractions have been established to supply water from an alternative aquifer which is some distance from the settlements (about 20 - 50 km). A new regional waterworks has been established to supply water from this alternative source to about 20 settlements, including a large town of about 80 000 inhabitants. The majority of the older, contaminated, wells have remained in operation and, in the majority of cases, this water is mixed with the uncontaminated water to produce a final water containing a reduced level of arsenic.

These solutions were successful in reducing the concentrations of arsenic in drinking water supplies to below the old standard of 0.05 mg/l and the number of people estimated to be exposed to concentrations exceeding this level had been reduced from 400,000 to 20 000 by the end of 1995. However, Hungary has recently revised the standard for arsenic in drinking water to 0.01 mg/l, in line with the most recent WHO guideline (WHO, 1996) and the solutions currently used to reduce arsenic levels are not adequate to ensure that this level is adhered to. A new countrywide survey, begun in 1997, is underway to establish how many people may be exposed to concentrations higher than this. Preliminary results suggest that, although less than 0.5 per cent are exposed to arsenic concentrations higher than 0.05 mg/l, 10-12 per cent of the population may receive drinking water with a concentration higher than 0.01 mg/l (WHO, 1995)

Source: M. Csanady, Pers. comm.

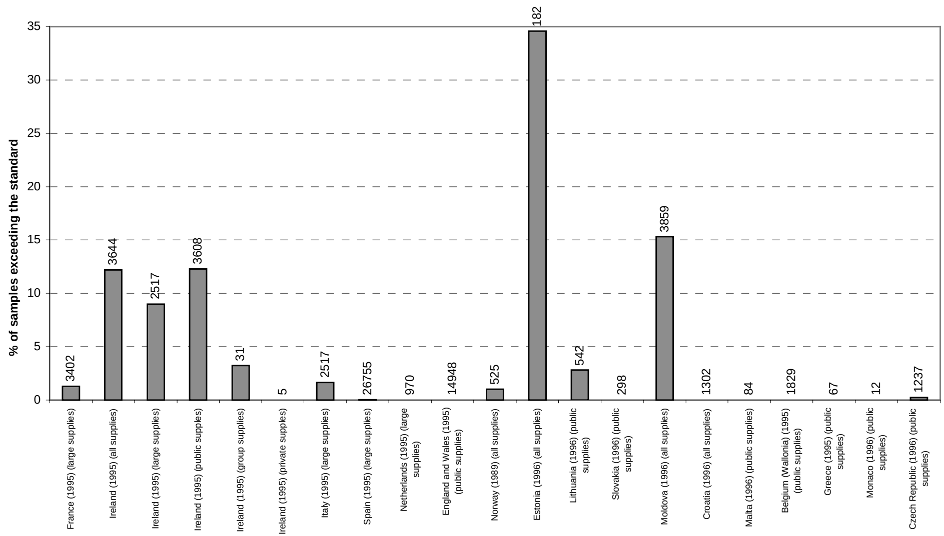
Fluorosis

Fluorides exist naturally in a number of minerals of which fluorspar, cryolite and fluorapatite are the most common (WHO, 1996). Where the geology is rich in such minerals, groundwater sources may contain high levels of fluoride, with levels of up to 10 mg/l in well waters (WHO, 1996). Fluoride can enter surface water as a result of industrial discharges, although the levels are usually lower than the highest that can be found in some groundwaters. In the river Meuse (France) for example, concentrations fluctuate between 0.2 and 1.3 mg/l as a result of variations in industrial processes (WHO, 1996). Following ingestion, high levels of fluoride can cause mottling of developing teeth. Dental fluorosis does not affect the strength of teeth and is often regarded as a cosmetic, rather than toxic, effect. The more serious toxic effect of excessive fluoride intake is skeletal fluorosis, in which the size of the bone mass increases. This restricts movement, both mechanically and because nerves that pass through bones are constricted. In severe cases, paralysis can result.

In moderate quantities fluoride is important in preventing dental decay, especially in children and in some countries and cities is added to drinking water at low levels in the interests of dental health. In these cases, a final concentration of about 1 mg/l is generally considered desirable. Populations in south east Slovenia, where the concentrations are <0.8 mg/l, report a high rate of dental caries. In Latvia, typically low concentrations of fluoride (0.4-0.5 mg/l) in groundwaters carries a risk of caries incidence in the population.

The WHO guideline value is 1.5 mg/l (WHO, 1996) and this value, or a similar figure (Ireland 1 mg/l, Netherlands 1.1 mg/l, Romania 1.2 mg/l, Sweden 1.3 mg/l, Italy 1.5 - 0.7 mg/l, Hungary 1.7 mg/l) has been adopted by the majority of European countries as the standard for fluoride in drinking waters. In Poland it is recommended that fluoride concentrations should not be lower than 0.3 mg/l. Fluorine is probably an essential element for humans. However, this has not been demonstrated unequivocally, and no data indicating the minimum nutritional requirements are available. Many epidemiological studies of possible adverse effects of the long-term ingestion of fluoride via drinking water have been carried out and clearly establish that fluoride primarily produces effects on skeletal tissue. However, low concentrations provide protection against dental caries, especially in children. This protective effect increases with concentrations up to about 2 mg of fluoride per litre of drinking water; the minimum concentration of fluoride in drinking water required to produce it is approximately 0.5 mg/l (WHO, 1996).

Most countries do not keep records of fluorosis. In France, 1.3 per cent of samples from supplies covering >5000 people exceeded the standard, but in all these cases the level was below 4.5 mg/l. In other countries, a significant proportion of drinking water samples contain fluoride at levels exceeding the standard, although the estimated population exposed may be relatively small (Figure 5.8). In Estonia, for example, 25-35 per cent of the drinking water samples analysed for fluoride since 1988 contained levels exceeding the standard, but the number of people exposed to these high levels is estimated to be 0.7 per cent of the total population and is localised depending on the geology of the area. Incidents of dental fluorosis in Sweden are scattered around the country, depending on the underlying geology and an estimated 2.4 per cent of the country are affected.



Standards: Ireland, Netherlands 1.1 mg/l; Moldova 1.2 mg/l; France, Spain, England, Norway, Estonia, Lithuania, Slovakia, Crotia, Malta, Belgium (Wallonia), Greece and Czech Reupublic; Monaco, 5 mg/l
Values on top of each bar are the number of samples analysed for fluoride

Figure 5.8 Percentage of drinking water samples in some European countries exceeding the standard for fluoride in the years specified

Approximately 50 000 wells are estimated to have levels of fluoride higher than 1.3 mg/l and 1200 exceed 6 mg/l (SOU, 1996). However, skeletal fluorosis is very rare, but a few cases have occurred near glassworks where wells have become contaminated with fluorine-based acid used for etching glass (EEA/WHO questionnaire, 1997). An estimated 35 per cent of the population of Republic of Moldova, is exposed to drinking water containing fluoride at concentrations above the standard (WHO/EEA questionnaire, 1997).

In the Czech Republic an estimated 1600 cases of dental fluorosis were reported annually between 1991 and 1993 in parts of Central and Northern Bohemia, of which 100 annually were linked to drinking water. The area receives water from the central Bohemian chalk table. Approximately 30 cases per year (1991-1993) of skeletal fluorosis were recorded. Although these were not directly linked to drinking water, they are concentrated in the same area (EEA/WHO questionnaire, 1997).

Fluoridation is widely practiced in Ireland. Exceedences of the standard for fluoride in Ireland are reported to be due to poor control of the addition of fluoride to public water supplies. No exceedences were found in samples from community-managed supplies in 1995 (only 5 samples taken) and exceedences in group supplies (3.23 per cent) were significantly lower than that in public supplies (12.30 per cent). The percentage of samples exceeding the standard for fluoride in Ireland has dropped from 15.9 per cent to 12.2 per cent (all supplies) due to efforts on the part of many authorities to address shortcomings in the handling of its addition during the water treatment process (EPA, 1996).

Cyanobacterial toxins

The eutrophication of surface waters often results in blooms of algae in the surface layers (section 2.3.3). As well as threatening the quality of drinking water due to physical effects on drinking water treatment equipment, some blooms of cyanobacteria ('blue-green algae') contain species that can produce toxins (Chorus and Bartram, 1999).

Blooms of toxin-producing algae are a particular hazard to users of recreational waters. The toxins are normally retained within the algal cells and normally present no immediate danger to drinking water supplies, since the algal scum is readily removed by filters. However, if the bloom begins to break down or the filters become blocked the toxin may be released directly into the water. Conventional coagulation treatment does not remove cyanobacterial toxins. Advanced treatments such as PAC or GAC, ozonation, potassium permanganate or nanofiltration can be effective in removing or breaking down cyanobacteria (Lahti and Hiisvirta, 1989; Hart and Stott, 1993; Fawell *et al.,* 1994; Chorus and Bartram, 1999).

A number of toxic compounds produced by these algae have been identified and characterised according to their effects. The most commonly encountered toxins are the hepatotoxins, the most potent is a cyclic septa-peptide termed microcystin-LR that has been shown to cause the death of laboratory animals on acute exposure due to massive hepatic haemorrhage. More than 40 variants of this toxin have been discovered and a related hepatotoxic cyclic peptide, nodularin, has also been identified. Microcystin-LR has not been adequately investigated as a chronic toxin but there is evidence that it can produce cellular changes that could promote tumour formation (Wroath and Fawell, 1995).

The principal neurotoxin identified is Anatoxin A which is up to two orders of magnitude more potent than nicotine. This appears to only be of concern as an acute toxin where it can induce paralysis of respiratory muscles. Saxitoxin and Anatoxin A(S) have also been identified and these inhibit nervous function. Anatoxin A(S) is unstable in water.

A third class of toxic compounds associated with some algal blooms have also been identified. Some lipopolysaccharides are capable of causing dermatological effects including irritation, rashes and weal's. Gastrointestinal effects have also been recorded.

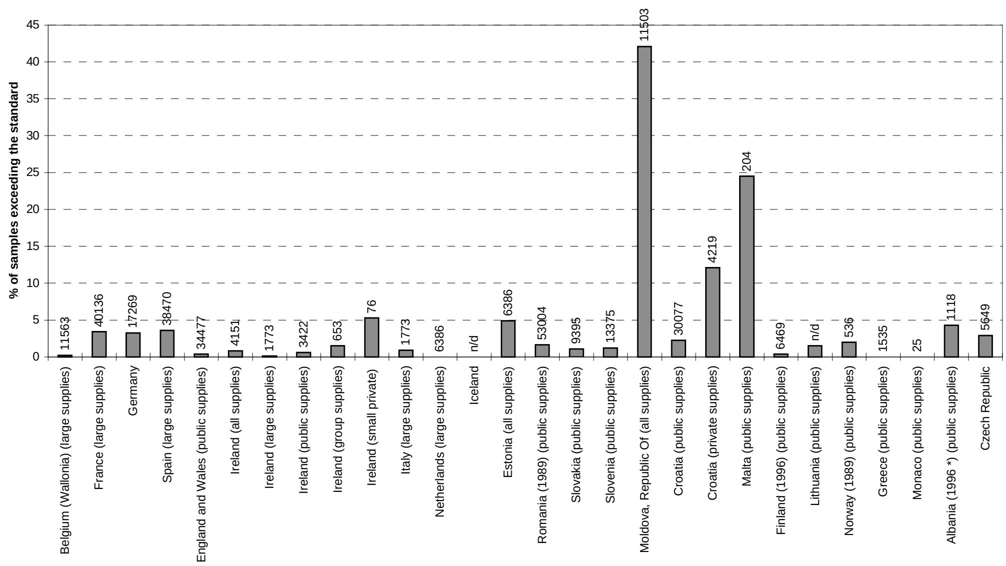
The presence of algal toxins in drinking water is currently regarded as particular concern by the Swedish authorities, as progressive eutrophication has allowed dense algal blooms to develop in surface waters on an almost annual basis (EEA/WHO questionnaire, 1997). Similar problems have been reported in a large number of countries world-wide (Falconer, 1994), including many European countries (Cronberg, 1982; Turner *et al.*, 1990; WHO, 1998).

Methaemoglobinaemia, nitrate and nitrite

Several European countries report high nitrate concentrations in drinking water including Austria, France, Slovenia Belgium, Germany, Turkey Croatia, Malta, Ukraine Czech Republic, Republic of Moldova, England and Wales, The Netherlands, Estonia, Slovakia. In France, it is estimated that 3.5 per cent of the population is exposed to concentrations of nitrate between 50 and 150 mg/l in their drinking water (EEA/WHO questionnaire, 1997; Mountain Unlimited, 1995). Figure 5.9 shows the percentage of drinking water samples exceeding the standard for nitrate in some European countries in 1995.

High concentrations of nitrate in drinking water are of concern because nitrate can be reduced to nitrite, causing methaemoglobinaemia. If the haemoglobin in red blood cells is oxidised, the resulting methaemoglobin is unable to carry oxygen. Thus, oxygen uptake in the lungs is decreased and there is insufficient oxygen in circulation around the body. The haemoglobin of young children is particularly susceptible to methaemoglobinaemia and this, coupled with the increased water consumption: bodyweight ratio makes infants particularly vulnerable to this disease. When methaemoglobin levels rise to about 10 per cent of the total haemoglobin, the so-called "blue-baby" syndrome develops. Progressive symptoms are stupor, coma and death in some cases.

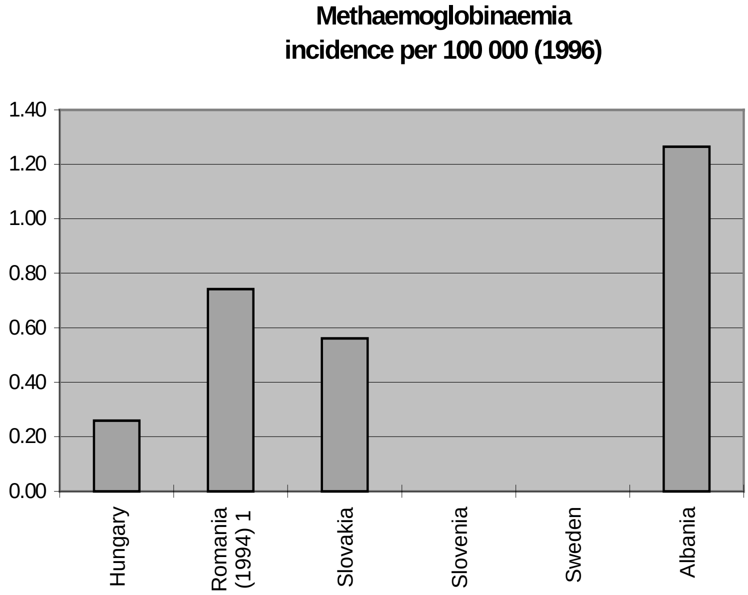
Methaemoglobinaemia is unusual in older children, even where nitrate levels are quite high. Infants fed on breast-milk are at not at risk unlike those infants bottle-fed on feed made up with nitrate-rich water. Nonetheless, there have been few, if any, cases of methaemoglobinemia in populations supplied by properly disinfected drinking water. An infant with a bacterial infection, such as gastro-enteritis, is more likely to



Standards: Belgium, France, Germany, Spain, UK, Ireland, Italy, Netherlands, Slovakia, Slovenia, Moldova, Malta, Lithuania, Norway, Greece, Monaco, Albania at 50 mg/l, Estonia, Romania, Crotia at 45mg/l, Iceland and Finland at 25 mg/l. ***Albania:** data for 5 districts only **Values on top of each bar** are the number of samples analysed for nitrate.

Figure 5.9 Percentage of drinking water samples exceeding the standard for nitrate in 1995

suffer from methaemoglobinaemia when exposed to high levels of nitrate than a healthy child. It is thought that this is because the enhanced bacterial activity associated with an infection increases the reduction of nitrate to nitrite. Few countries keep records of methaemoglobinaemia (Table 5.6) and incidents are low (Figure 5.10). Most reported cases of methaemoglobinaemia associated with drinking water



are caused by well water or community-managed water supplies of poor microbiological quality (WHO, 1996).

Figure 5.10 Incidence of methaemoglobinaemia in selected countries

Note 1 Records for methaemoglobinaemia in Romania are for cases related to well water only.

Table 5.6 Countries reported to be keeping records on methaemoglobinaemia

	Keep records	Do not keep records
Albania	√	
Andorra		√
Austria		√
Belgium		√
Croatia		√
Czech Republic		√
England and Wales		√
Estonia		√
Finland	√	
France		√
Germany		√
Hungary	√	
Latvia		√
Liechtenstein		√
Lithuania		√
Luxembourg		√
Malta		√
Monaco		√
Netherlands		√
Northern Ireland	√	
Norway		√
Republic of Moldova		√
Romania	√	
Slovakia	√	
Slovenia	√	
Sweden	√	

Source: EEA/WHO questionnaire (1997)

Groundwater sources, particularly those fed by percolation from intensively farmed agricultural land, are liable to contamination by nitrate. The vulnerability of infants receiving drinking water from shallow groundwater sources is emphasised by data from Hungary, where between 9 and 41 cases of methaemoglobinemia associated with drinking water are reported annually. All cases are related to individual private wells and almost the whole country is affected, apart from the south-eastern part where deep well water is used. A similar number of water-related incidents are recorded annually in Slovakia and, as in Hungary, the majority of these are associated with drinking water (EEA/WHO questionnaire, 1997). In both Slovakia and Hungary more than 80 per cent of the recorded cases of methamoglobinaemia are reported to be linked to drinking water. In Albania, all 43 reported cases in 1996 were linked to nitrate in drinking water (Bardhoshi, cited in EEA/WHO questionnaire, 1997).

The vulnerability of rural populations supplied by community-managed supplies to high concentrations of nitrates is illustrated by data from Romania (Box 5.4) and Lithuania (Figures 5.11 and 5.12). In the last decade less than 1.5 per cent of samples taken from public water supplies sourced from groundwater exceeded the standard for nitrate (50 mg/l). In contrast, nearly 50 per cent (in 1989) of samples from private water supplies sourced from groundwater contained concentrations of nitrate exceeding the standard. The consumers of some of these supplies were exposed to water containing nitrate concentrations of over 150 mg/l, considerably higher than the WHO guideline for nitrate in drinking water of 50 mg/l (WHO, 1996).

The vulnerability of private supplies is also illustrated by the situation in Sweden, where an estimated 35 000 people (0.4 per cent of the population), provided with drinking water from wells in the southern part of the country, have been exposed to nitrate above the standard of 50 mg/l. Data from Ireland also illustrate the increased nitrate levels in small, rural supplies compared with large public supplies (EEA/WHO questionnaire, 1997).

In contrast, Iceland has a stringent standard for nitrate in drinking water of 25 mg/l and the majority of samples tested containing less than 1 mg/l.

In Poland, an even stricter standard of 10 mg/l is set for nitrates in drinking waters. This is reported to be exceeded in some cases, primarily in water in rural areas, originating from wells. Results from the monitoring of 399 samples of well water from three communities located in the Krakow Province in 1988-1993 are shown in Table 5.7. Exposure to nitrates in water has shown to cause significant health problems. In a group of 8 infants with acute toxic methamoglobinamia treated in Krakow between 1980 and 1994, six were exposed to nitrates in well water, the remaining two to nitrates in carrot soup.

Surface waters can also be polluted by nitrate from agricultural run-off and sewage discharges. In a number of countries, a significant percentage of the drinking water samples tested contained concentrations higher than permitted under drinking water legislation (usually 45-50 mg/l). In Latvia, nitrate levels rarely exceed 20 mg/l although at sites of intensive agrochemical use, 55 per cent of boreholes are reported to show an increase compared with natural levels (EEA/WHO, 1998).

Table 5.7. Percentage of wells exceeding the standard for nitrates in three communities in Krakhow Province, Poland, 1988-1993.

Community	Percentage of wells exceeding the standard	
	Nitrates (>10 mg/l)	Nitrites (>0.1 mg/l)
Klaj	39	5
Drwina	56	10
Niepolomice	19	3

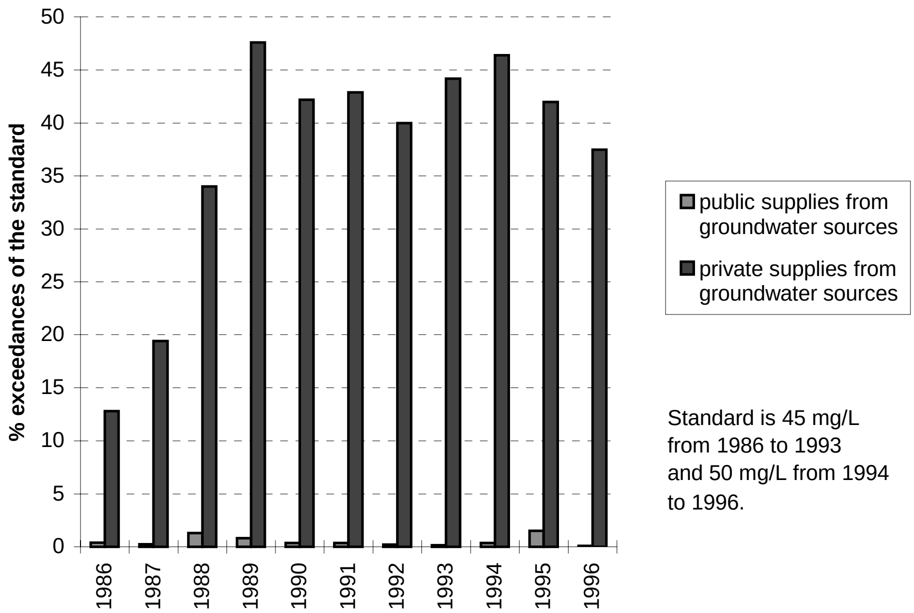


Figure 5.11. Comparison of nitrate exceedences in public and private supplies in Lithuania

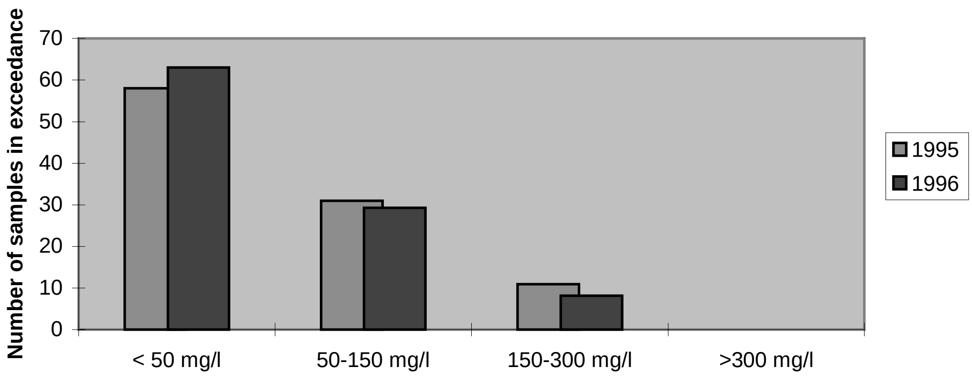


Figure 5.12 Concentration of nitrate in private groundwater supplies in Lithuania.

Box 5.4 Nitrate in Romanian wells and methaemoglobinaemia

Methaemoglobinemia has been recognised as a problem in rural areas of Romania since 1955, and records have been kept of cases related to well water since 1984. Between 1985 and 1996, 2913 cases were recorded, of which 102 were lethal. Analysis of the data on 954 cases of infantile methaemoglobinemia occurring between 1990 and 1993, of which 37 were fatal cases, indicated that 383 were bottle fed, 332 received both breast and bottle feeding and only 239 were breast fed. Methaemoglobinaemia was associated with acute diarrhoea in 196 cases. Of the 704 wells investigated (sources of drinking water for the infants) 17.7 per cent were found to be microbially polluted only, 6.3 per cent contained concentrations of nitrate between 50 and 1000 mg/l but were microbially acceptable, and 66 per cent were contaminated both microbially and by nitrate.

These findings illustrate clearly that infants receiving bottle fed drinking water are at greater risk than breast-fed infants. Shallow wells are particularly at risk from nitrate contamination. Of the wells investigated 45.9 per cent were below 10 m in depth, 28.9 per cent were between 10 and 20 m deep, and only 15.9 per cent were over 20 m in depth.

Sources: EEA/WHO questionnaire (1997); WHO (1995)

Radioactivity

Radioactivity is the name given to the release of ionising radiation in the form of energy or particles from a material, and chemicals which exhibit this effect are termed radionuclides. When ionising radiation passes through living tissue it can interact with the genetic material of the cell causing mutations which may ultimately lead to cancer. The rate at which the radiation is released from a radionuclide is termed the activity (measured in bequerels, Bq) and the manner in which it is released determines the type of radioactivity: alpha, beta or gamma. The different forms of radiation cause different degrees of biological damage (alpha and beta are most damaging) whilst different tissues have differing susceptibilities to radiological damage.

The contribution of drinking water to the annual average exposure to natural radiation is very small and is largely due to naturally occurring radionuclides in the uranium and thorium decay series, including radon. There may be local increases in natural radioactivity levels in water due to human activities but these are usually from regulated discharges.

Natural uranium isotopes (^{235}U and ^{238}U) are of low radiological activity. Uranium causes inflammation of the kidney in high concentrations, and this chemical toxicity will occur at levels lower than those at which there is a significant carcinogenic risk from uranium radiation. Thus, the radioactivity of uranium is of secondary importance, as a risk to human health, than its chemical toxicity. The WHO provisional guideline level for Uranium in drinking water is 0.002 mg/l (WHO, 1998b).

To take account of the spectrum of radionuclides which may be present, the different biological effectiveness of each type of radiation and the widely varying activity levels of radionuclides WHO recommend guideline activity concentrations of 0.1 Bq/l for gross alpha activity and 1.0 Bq/l for gross beta activity to screen water for radiological quality (WHO, 1996). If these levels are exceeded a more detailed analysis should be undertaken to determine which radionuclide(s) is (are) responsible and the risk assessed by appropriately qualified personnel. However, levels of radioactivity much higher than this would still be considered safe for short-term consumption and are preferable to cessation of supply. Volatile radionuclides such as radon will not be picked up by the method of detection used for gross alpha and beta emitters, while low energy beta emitters such as tritium, will not be detected by standard measurement techniques.

Radon-222 is produced as part of the uranium and thorium decay series and where these elements occur in the soil it is naturally released from the ground. Radon is an insoluble gas, readily released from surface waters which are usually low in radon concentrations. However, groundwaters can contain high levels of radon and this is particularly true for small private supplies which may utilise small aquifers unsuitable for public supply and very high in natural radionuclides. Groundwaters often undergo less treatment than surface waters so there is much less opportunity for degassing to occur before the water reaches the tap. The risk from drinking radon in water is considered low as radon gas and its decay progeny are very short lived. However, radon has been implicated as a carcinogen when inhaled because of the continual exposure. Theoretical calculations from Sweden suggest that 35-75 cases of cancer per year may be caused by radon in water. Between 10 and 20 of these are attributed to drinking the water and the remainder to the respiration of radon gas emitted by water (SOU, 1996). In July 1997 new standards were set in Sweden for radon in drinking water. These imposed a recommended upper limit of 100 Bq/l and classify water containing above 1000 Bq/l as unfit for human consumption. As many as 46 per cent of drinking water samples tested in Sweden contained levels of radon-derived radioactivity above 100 Bq/l and in 3 per cent of cases levels were higher than 1000 Bq/l.

The contribution of radon from drinking water to air concentrations within a house is difficult to determine because there are numerous confounding factors such as building construction, level of ventilation and local geology. A recent study by Auvenin *et al.* (1996) estimated that only 1 per cent of lung cancer in Finland could be attributed to indoor radon, despite a very high mean radon concentration compared with the rest of the world. In some local areas, exposure to radon via drinking water may, however, be significant and WHO recommend that total exposure via inhalation and ingestion is taken into account in each situation (WHO, 1996).

Pesticides

Analysis for pesticides is expensive, and there are likely to be wide variations in the extent of analyses, including the number of samples analysed and the type of pesticide looked for both, within and between countries (Tables 5.8 and 5.9). No method exists to analyse the 'total amount of pesticides'.

Countries of the EU are bound by the Drinking Water Directive (80/778/EEC) which sets limits for individual pesticides at 0.1 µg/l and for total pesticides at 0.5 µg/l. These standards do not take into account the individual toxicities of the pesticides, but are based more on the premise that these chemicals, which are by their nature designed to be toxic to organisms of one type or another, should not be present in drinking water. Thus, the Directive takes the precautionary approach to protecting human health in this instance.

Table 5.8 Countries reporting no problems in meeting pesticide standards

Country	**Comments**
Croatia	Concentrations of pesticides are reported to be generally below the gas chromatography detection limit (0.001 - 0.002 µg/l) and not to exceed standard.
Estonia	None of the drinking water samples tested exceeded the standard, and only trace levels of pesticides were detected.
Finland	Concentrations of pesticides analysed in drinking water samples are very low.
Spain	None of the drinking water samples from public supplies tested in 1995 exceeded the standard of 0.5 µg/l.
Sweden	National statistics are not available, but surveys over the last decade have indicated that levels of pesticides are low even in areas where pesticides are heavily used and with unfavourable water sources. Triazines detected most frequently.
Iceland	Routine monitoring is not carried out. However, analyses have been carried out at the larger waterworks and pesticides have never been detected in Icelandic drinking water.
Greece	No exceedences of standard for total pesticides in the limited number of samples analysed (41 in 1995).
Scotland*	In 1996 5 minor failures were reported relating to pollution incidents causing 3 supplies to exceed the limit for individual pesticides
Monaco	No exceedences reported.

Source: EEA/WHO questionnaire (1997) *The Scottish Office, 1997

Table 5.9 Countries considering contamination by pesticides to be among their major problems in drinking water quality

Country	Comments
Austria	None
Germany	Triazines frequently detected.
England and Wales	Of the drinking water samples tested in 1995, 3.2 per cent of samples exceeded the standard of 0.5 µg/l for total pesticides. This figure dropped to 0.3 per cent in 1996. Corresponding figures for the standard for individual pesticides are 0.8 per cent (1995) and 0.2 per cent (1996) (DWI, 1997). Triazines frequently detected.
Slovenia	None
Romania	Triazines frequently detected. Organochlorines also of concern.
Belgium (Wallonia)	Triazines and substituted ureas are the main problems. Percentage of samples exceeding the pesticides standard was 13.36 per cent in 1993 (651 samples), 7.35 per cent in 1994 (1224 samples) and 4.27 per cent in 1995 (1359 samples). However, these are not random samples and therefore have limited statistical importance.
Italy	Pollution of drinking water by herbicides is regarded as an important problem (WHO, 1995a). 0.13 per cent of samples failed to comply with pesticides standard (Drinking Water Directive Return).
France	1.46 per cent of samples failed to comply with pesticides standard (Drinking Water Directive Return). Atrazine, simazine, desethyl atrazine and diuron are the major problems.

Source: EEA/WHO questionnaire (1997)

Triazines are among the pesticides detected most frequently at levels exceeding the standards in Germany, Sweden, Belgium, France, England and Wales and Romania. In the UK, 1.56 per cent of drinking water samples tested for atrazine in 1995 exceeded the standard of 0.1 µg/l (Drinking Water Directive Return). In France (1995), 17 per cent of the 2401 samples tested contained more than 0.1 µg/l atrazine and 2.1 per cent of the 2756 samples tested for simazine exceeded the standard (EEA/WHO questionnaire, 1997). The population in Germany supplied with drinking water containing atrazine at a concentration above the standard is estimated to be over 16 500 people. Levels of up to 3 µg/l have been reported, thus exceeding the WHO guideline value of 2 µg/l. Investigation of triazines in Romanian wells found a range of concentrations of 0.016 - 24.41 µg/l, with a mean of 3.66 µg/l (EEA/WHO questionnaire, 1997).

In England and Wales the uron and chloroalkanoic acid herbicides have also been detected in drinking water samples - 12.26 per cent of drinking water samples tested in 1995 exceeded the standard for Isoproturon of 0.1 µg/l. However, the significance of these exceedences to human health is unclear. The WHO guideline value for Isoproturon is 9 µg/l (WHO, 1996). A high proportion (12.85 per cent) of the samples tested in the UK for TCA and 4.71 per cent of the samples tested for dalapon, also failed to comply with the standard. TCA and dalapon can both be by-products of chlorination. In Northern Ireland MCPA, Mecoprop, Isoproturon, Simazine and Atrazine are the pesticides found most frequently at levels exceeding the standard.

A number of studies have been carried out on the presence of organochlorine insecticides (α, β, γ-HCH, aldrin, dieldrin, heptachlor, DDT and DDE) in drinking water in Romania. Only 27 per cent of samples from 80 towns in the south of the country tested contained less than 0.1µg/l. Concentrations of 0.1-1 µg/l were reported in 6 per cent of the samples, while 37 per cent contained between 1 and 5 µg/l, 17 per cent 5-10 µg/l and 13 per cent over 10 µg/l. All of 16 samples from Bucharest contained concentrations exceeding the standard, with a range of 0.54 - 1.95 µg/l and a mean of 0.92 µg/l. Well waters are also contaminated: 64 per cent of samples contained organochlorines at levels above the standard with a mean of 0.74 µg/l (range 0.001-4.81 µg/l) (EEA/WHO questionnaire, 1997). For comparison, the WHO guidelines for aldrin/dieldrin are 0.03 µg/l and for DDT 2 µg/l.

The Netherlands report bentazon, atrazin, bromocil, Ampa, MCPA and diuron as pesticides most frequently detected at levels exceeding the EU standard.

In the Flanders region of Belgium, atrazine, simazine, diuron and isoproturon are reported as occurring frequently in raw surface waters. However, although pesticide pollution is regarded as a problem in achieving high quality drinking water, it is reported that pesticides are not found in drinking water due to the use of activated carbon treatment (EEA/WHO questionnaire, 1997).

Disinfection by-products

By-products of chlorination have been well investigated and include trihalomethanes and chloro-acetic acids. Although a number of disinfection by-products have been shown to be carcinogenic in animal studies, the over-riding priority in providing clean drinking water must be good microbiological quality, in order to prevent waterborne diseases. Disinfection is the most important step in the treatment of water for public supply. Microbiological quality should not be compromised in attempting to minimise the formation of disinfection by-products. The level of disinfection by-products can be reduced by optimising the treatment process. Removal of organic substances prior to disinfection reduces the formation of potentially harmful by-products. WHO guideline values are set for carcinogenic disinfectant by-products. Those of greater importance are those for chloramines (3 mg/l) and chlorine when used as a disinfectant (5 mg/l) ; bromoform (100 ųg/l), dibromochloromethane (100 ųg/l), bromodichloromethane (60 ųg/l), chloroform (200 ųg/l). Provisional guideline values have been set for chloral hydrate (10 ųg/l), chlorite (100 ųg/l), bromate (25 ųg/l), dichloroacetic acid (50 ųg/l) and trichloroacetic acid (100 ųg/l) (WHO, 1996).

The current EU Drinking Water Directive (80/778/EEC) does not contain specific standards for disinfection by-products and, as a result, standards vary significantly between countries. In Poland for example, chloroform concentration should not exceed 0.03 mg/l in drinking water. Standards in the proposed revised EU Drinking Water Directive include 100 µg/l for total trihalomethanes and 0.10 µg/l for epichlorohydrin.

In 1995, 3.56 per cent of samples in the UK contained total trihalomethanes at concentrations above the standard of 100 µg/l (Drinking Water Directive Returns). In the Wallonia region of Belgium the exceedence frequency was 3.5 per cent in 1993 (41 in 1171 samples), 9.77 per cent (212 in 2169 samples) (Drinking Water Directive Returns). In Italy, the standard for organohalogenated compounds is 30 µg/l, but an estimated 5 per cent of the Italian population is supplied with water to which a waiver allowing concentrations of up to 50 µg/l is applied (WHO, 1995a).

Solvents

Many countries do not have standards for solvents and monitoring is, therefore, unlikely to be carried out regularly. A number of countries (England and Wales, Hungary, Slovakia, Croatia) indicate that chlorinated solvents such as TCE and PCE may be occasionally detected in drinking water. However, they rarely, if ever, exceed the national standards significantly or reach levels considered to be a health concern. In the UK, only 0.06 per cent of samples tested for PCE in 1995 exceeded the standard of 10 µg/l and there were no recorded exceedences of TCE. In Hungary, some data indicate the presence of TCE and PCE, but at levels that are not considered a health hazard. Dichloroethane is present at the waterworks supplying one town but at levels below the WHO guideline value of 30 µg/l. In the UK the standard for tetrachloromethane is 3 µg/l but only 0.01 per cent of samples exceeded this value in 1995 (Drinking Water Directive Returns).

Aluminium

Aluminium has been implicated in the etiology of two neurodegenerative diseases - amyotrophic lateral sclerosis and parkinsonism dementia (Alzhiemer disease). Although not conclusive there is support for a positive relationship between the concentrations of aluminium in drinking water and the incidence of Alzheimer disease (Martyn *et al.,* 1989). No health-based guideline is derived but a concentration of aluminium of 0.2 mg/l in drinking water is recommended (WHO, 1996).

Aesthetic aspects

Iron and manganese can be found in groundwaters, depending on the local geology and, in addition, iron salts may be used as coagulants in drinking water treatment. The ions of both metals can be removed by correct pH adjustment of the coagulation procedure. However, this stage of treatment is often not applied to groundwaters that may contain naturally high levels. Where iron salts are used in coagulation, excessive dosing and poor control of the pH may be the cause of high concentrations in the finished water. The primary concern with excessive levels of these metals in water supplies is their detrimental effect on the aesthetic qualities of the water. Both cause “dirty water” problems, forming insoluble precipitates when they are oxidised.

Drinking water in some areas of Finland, Northern Ireland, the Netherlands, Latvia, Lithuania and Belgium are reported to contain naturally high concentrations of iron and manganese due to the local geology. In Latvia over half of the groundwater intakes are not equipped with filters for the removal of excess iron, thus up to 50 per cent of tested water samples do not meet the organoleptic requirements. In Sweden, Lithuania, Hungary and the Republic of Moldova poor water treatment or the unavailability of appropriate treatment technology contribute to elevated levels of iron and manganese in drinking water. High levels of aluminium and iron in drinking water in France are attributed to malfunctioning of treatment plants. In parts of Belgium, England and Wales, high levels are generally the result of dissolution of iron in the distribution system. Corrosion of metal piping is also a problem in Norwegian distribution systems. In the UK, 2.4 per cent of samples tested in 1995 exceeded the standard for iron of 0.2 mg/l and in Ireland 5.3 per cent exceeded (Drinking Water Directive Returns). Between 1994 and 1997 about 3 per cent of samples tested in the Slovakia exceeded the standard for iron of 0.3 mg/l. Manganese levels above the standard of 0.05 mg/l were found in 4.2 per cent of drinking water samples tested in Ireland in 1995 (Drinking Water Directive Return) and 3.4 per cent of samples tested in the Czech Republic in 1996 exceeded 0.1 mg/l (SZU, 1997).

High concentrations of other ions, such as sulphate and chloride, can also impart an unpleasant taste to drinking water. Measurements of the TDS or conductivity are commonly used in assessing the aesthetic quality of water supplies. Whilst a high level of dissolved solids does not, itself, pose a health hazard the risk occurs if water intake is substantially decreased because of its unpalatability (Box 3.2). Similarly, excessive quantities of iron and manganese, which also affect the aesthetic quality of the water, might be expected to have similar effects.

5. 5 Flooding, drought and disease

5.5.1 Floods

Much of the effect of flooding upon mortality and ill health may be attributed to the distress and the psychological effects of the event. Following flooding in Bristol, UK, a 50 per cent increase in mortality among those whose homes had been flooded was reported. In addition, primary care attendance rose by 53 per cent and referrals and admissions to hospitals more than doubled (Bennet, 1970). Similar psychological effects were found following floods in Brisbane in 1974 (Abrahams *et al.,* 1976). An increase in psychological symptoms and post-traumatic stress disorder including 50 flood-linked suicides were reported in the two months following the major floods in Poland in 1997 (IFRC, 1998).

During and following both catastrophic and non-catastrophic flooding, there is a risk to health if the floodwaters become contaminated with human or animal waste. Floods in Europe are associated with an increased risk of leptospirosis. An epidemic of leptospirosis was associated with floods in the Ukraine in 1997, flood-related outbreaks of epidemic nephropathy have also been reported (Kriz, 1998). Flooding in Lisbon, Portugal, in 1967 was linked with a small outbreak of Weil's disease; a total of 32 cases were estimated on the assumption that only a third of cases are reported (Simoes *et al.,* 1969). Analysis of surveillance data following the major floods in

1997 suggests that there was an increase in cases of leptospirosis in the Czech Republic (Kriz *et al.,* 1998).

A number of studies have established a link between dampness in the home, including occasional flooding, with a variety of respiratory symptoms. For example, flooding has been significantly linked to childhood experience of cough, wheeze, asthma, bronchitis, chest illness, upper respiratory symptoms, eye irritation and non-respiratory symptoms (Dales *et al.,* 1991). Very little is known about the occurrence of other diseases, such as skin diseases.

As a general rule in Europe, the floods that bring about the highest material losses are different from those, which claim the highest number of victims. Floods that are responsible for a high number of victims largely take place in open spaces in mountainous basins, where there is a short response time (in many cases less than three hours) and where the surprise factor is the main cause of death. However, these phenomena rarely cause major material losses. Floods in urban areas do not generally occur suddenly, and there is usually capacity for real time forecasting, so that the population can be alerted and evacuated in advance.

On the Spanish mainland an average of approximately five floods has occurred per year over the last five centuries. The average national material damage per year is estimated at 70 billion Pts per year (Estrela *et al.*, 1996). Recent devastating floods in central Europe affected Poland, Germany and the Czech Republic. More than 400 people were killed and many thousands were destitute (Saunders, 1998). In total, 160,000 were evacuated from their homes in Poland and a further 50,000 were evacuated in the Czech Republic (IFRC, 1998).

5.5.2 Droughts

Over the last 50 years in Europe there have been no deaths caused directly by a shortage of water. However severe restrictions may result in a lack of hygiene and the use of resources that are not subject to sanitation control. Not only is there a lack of statistics about this type of effect, but it is often also the case that the quality and quantity of the water are not considered in an holistic way. The absence of statistics is in part a result of the lack of a unified definition of drought and, unlike floods, it is difficult to evaluate or quantify a drought. There is a need for criteria that would clearly distinguish between and define drought, desertification, water shortage or scarcity.

5.6 Recreational water, health and disease

A diverse range of hazards to human health are encountered in recreational water environments - including factors associated with accidents (resulting in drowning and near drowning and spinal injuries), microbiological pollution, exposure to toxic algal products and occasional exposure to chemical pollution. Hazards exist even in unpolluted environments - eye infections occur in bathers probably as a result of a reduction in the eye's natural defences through contact with water (WHO/UNEP, 1994).

5.6.1 Drowning and physical injuries

Information concerning accidents is not systematically collected in all countries throughout Europe. Deaths through drowning are available from the WHO mortality database but in general the accidents related to bathing waters are not separately recorded (Table 5.10; WHO, 1996). Data suggest that males are more likely to drown than females (WHO, 1996; Figure 5.13).

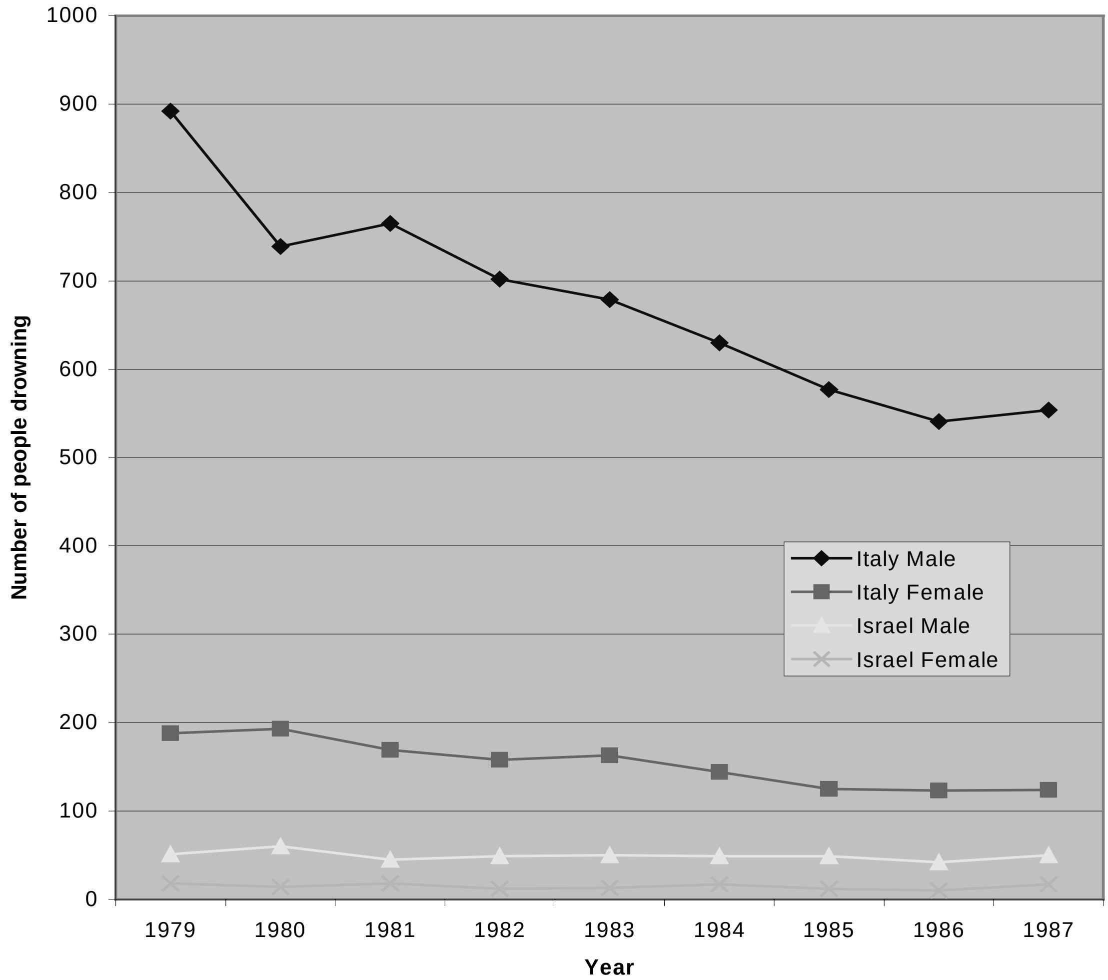


Figure 5.13 Comparison of number of males and females drowning

The higher consumption of alcohol by males is one contributing factor (CDC, 1999). However, heart attack, sea currents and surf also contribute to drowning accidents. Private pools, lakes and other freshwater bodies contribute significantly to drowning statistics, especially in children - in Denmark for example 63 per cent of all child (0-14 year olds) drowning occurred in these types of water bodies between 1989 and 1993. This trend is clearly illustrated by data from the UK where the greatest percentage of drownings occurs in such open water bodies (Table 5.11). In terms of all accidental deaths in the European Region, drowning account for less than 10 per cent of the 280,000 deaths due to accidents (WHO, 1996).

Permanent paralysis may occur as a result of diving into a shallow body of water or swimming pool. A spinal cord injury can result in paraplegia or quadriplegia, the latter being more common. The number of spinal injuries sustained as a result of swimming accidents does not appear to be widely available. Data available from the Czech Republic suggests that spinal injuries are more frequently sustained in open freshwater bathing areas compared with supervised swimming areas. However, the number of injuries sustained in freshwater areas in this country has declined from 38 in 1995 to 30 in 1997.

5.6.2 Microbiological aspects

Recreational waters may contain a mixture of pathogenic and non-pathogenic microbes from a variety of sources including: human sewage effluents; industrial processes; farming activities; wildlife; recreational water users. In addition to the above, other microbiological and biological hazards such as leptospires and algal blooms may present a risk. There is clear evidence that exposure to faecal pollution through contaminated recreational waters leads to detectable health effects (Pike, 1994; WHO, 1998). It has been estimated that microbiological contamination of bathing waters, primarily in the Mediterranean, is responsible for over two million cases of gastrointestinal diseases annually (EEA, 1995).

A number of studies have provided evidence of a dose-response relationship between enteric and non-enteric illnesses and faecal pollution (Fewtrell *et al.*, 1993; Pike, 1994). Enteric illness, such as self-limiting gastroenteritis, is the most frequently reported adverse health outcome investigated and evidence suggests a causal relationship between increasing recreational exposure to faecal contamination and frequency of gastroenteritis (WHO, 1998). Associations between ear infections and microbiological indicators of faecal pollution and bather load have been reported and increased rates of eye symptoms have been reported amongst bathers. Evidence also exists for more severe health outcomes. Although the probabilities of contracting acute febrile respiratory illness are generally lower compared with gastroenteritis a cause-effect relationship between faecal pollution and acute febrile respiratory illness is possible. There is reason to believe that other severe infectious diseases such as typhoid and viral diseases such as hepatitis A/E may be transmitted to susceptible bathers making recreational use of water polluted with the causative agents (WHO, 1998).

Bathing water quality monitoring in the European region is based on the definition of the bathing area as passing or failing a defined microbiological standard. This approach has severe limitations as an identified bathing area can vary widely in terms of spatial and temporal factors. Data on microbiological quality of recreational waters is collected principally for compliance assessment by regulatory agencies. Problems of analytical reproducibility, inter-laboratory comparability, the number of waters monitored, sampling frequencies and variations in temporal conditions make comparison between countries difficult.

There is a need for an improved approach to the regulation of recreational water which better reflects the health risk and provides enhanced scope for effective management intervention. EU Member States monitor designated bathing waters for compliance with the Directive on the quality of bathing waters (76/160/EEC) and some non-EU countries monitor routinely (Table 5.12). Published water quality data is always retrospective in nature due to the nature and frequency of analysis undertaken. An alternative approach to monitoring and assessment is to classify a beach based on health risk as opposed to the current pass/fail approach in place in the EU. This approach is more flexible than the pass/fail approach and allows managers to respond to sporadic events and upgrade a beach's classification. Such a scheme provides a more robust, accurate and feasible index of health risk, provided by a combination of a measure of a microbiological indicator of faecal contamination with an inspection-based assessment of the susceptibility of an area to direct influence from human faecal contamination (Bartram and Rees, 1999). The principle components of the scheme are a primary classification based upon the combination of evidence for the degree of influence of human faecal material together with counts of a suitable faecal indicator bacteria. There is the possibility of 'reclassifying' a beach to a 'better' class if effective management interventions are deployed to reduce human exposure at times or places of increased risk (Bartram and Rees, 1999).

There are currently considerably more coastal designated bathing sites than freshwater within EU Member States, despite the common use of freshwater sites for recreational activities (Figure 5.14). The quality of freshwater sites designated for bathing is considerably worse than that of coastal sites in the EU although the overall quality trend for both coastal and freshwater sites appears to be improving (Figure 5.15).

Data on other parameters concerning recreational water quality across Europe are available sporadically. Physico-chemical, aesthetic and other biological parameters are not routinely monitored and international comparability is not possible.

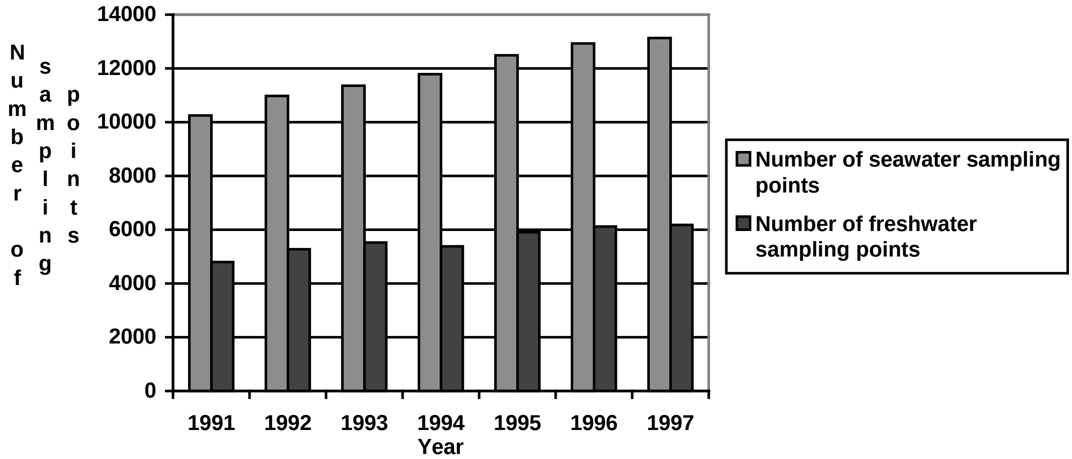


Figure 5.14. Total number of sampling points from Member States in the European Union 1991-1997*).*
Source: EC (1998).

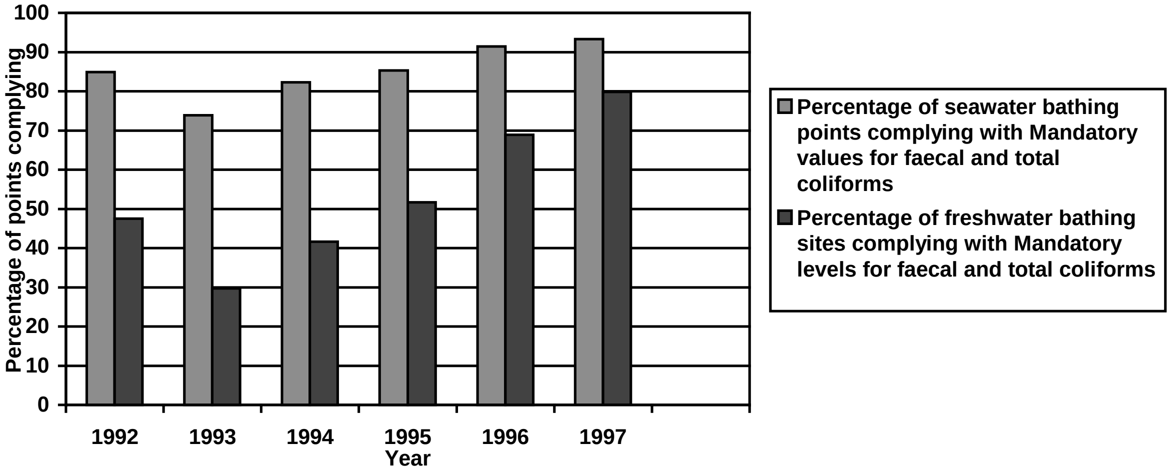


Figure 5.15. Percentage of sea and freshwater sampling points throughout the EU complying with the Mandatory levels for total and faecal coliforms (1992-1997).
Source: EC (1998).

Table 5.10. Number of bathing sites and percentage compliance with national standards in selected non-EU Member States.

Country	Number of recognised bathing sites		Percentage of (a) coastal; (b) freshwater and (c) all sites complying with microbiological standards			
	Freshwater	Coastal	1994	1995	1996	1997
Lithuania	149	10	(a) no data (b) no data (c) 55.9	(a) no data (b) no data (c) 58.5	(a) no data (b) no data (c) 70	(a) no data (b) no data (c) 61.3
Croatia	158	831	(a) 91.9 (b) 95.8 (c) no data	(a) 93.5 (b) 96.5 (c) no data	(a) 93.6 (b) 97.7 (c) no data	(a) 96.7 (b) 96.8 (c) no data
Republic of Moldova	42	0	(a) no data (b) 63.7 (c) no data	(a) no data (b) 41.1 (c) no data	(a) no data (b) 63.8 (c) no data	(a) no data (b) 60 (c) no data
Finland	360	94	(a) no data (b) no data (c) no data	(a) no data (b) no data (c) 98.2	(a) no data (b) no data (c) 99.7	(a) no data (b) no data (c) 98.5
Czech Republic	276 (open areas) 237 (public pools) 549 (seasonal)	None	84-86%			

Table 5.11 Mortality rates from accidental drowning and submersion throughout the European Region 1994 (unless stated otherwise). Rates per 10,000 population

Source: WHO (1996)

Country	Males	Females
Albania (1993)	0.49	0.18
Armenia (1992)	0.24	0.05
Austria	0.27	0.08
Belarus (1993)	1.34	0.24
Belgium (1992)	0.15	0.06
Bulgaria	0.56	0.07
Croatia	0.47	0.08
Czech Republic (1993)	0.44	0.13
Denmark (1993)	0.12	0.03
Estonia	2.87	0.49
Finland	0.54	0.06
France	0.17	0.04
Germany	0.10	0.05
Greece	0.41	0.12
Hungary	0.55	0.09
Ireland	0.42	0.04
Israel	0.14	0.06
Italy (1993)	0.16	0.03
Kazakstan	1.30	0.29
Kyrgystan	1.44	0.39
Latvia	3.77	0.71
Lithuania	3.73	0.55
Netherlands	0.11	0.03
Norway	0.29	0.06
Poland	0.78	0.15
Portugal	0.12	0.04
Republic of Moldova	1.79	0.38
Romania	1.16	0.29
Russian Federation	2.13	0.34
Slovenia	0.43	0.12
Spain	0.29	0.06
Sweden	0.21	0.03
Switzerland	0.18	0.08
Tajikstan (1992)	0.57	0.24
Turkmenistan	1.12	0.39
Ukraine (1992)	1.62	0.27
UK	0.08	0.02
Uzbekistan (1993)	0.73	0.34

Table 5.12. Percentage of drownings in the UK occurring in specified water bodies.
Source: RoSPA, UK, (1998)

	1991	1992	1993	1994	1995	1996	1997
Rivers, Streams	36	39	38	37	32	32	30
Docks, Harbours	5	4	5	6	5	3	5
Lakes, Reservoirs	16	12	10	17	15	18	18
Swimming Pools	4	4	6	3	3	2	5
Garden Ponds, pits, tanks	2	3	4	2	2	2	2
Home Baths	9	7	8	6	8	9	6
Coastal	17	21	18	22	27	28	24
Canals	9	9	8	6	7	7	8
Other	1	1	2	1	0.2	1	2

5.6.3 Cyanobacteria

In coastal marine environments many toxic species of dinoflagellates, diatoms, nanoflagellates and cyanobacteria occur and several forms of human health impacts have been reported in association with them mainly after consumption of shellfish and fish. The evidence documenting the health effects for recreational water users from marine toxic phytoplanktonic blooms are primarily from the Black Sea, the Baltic Sea, the North Sea and parts of the Mediterranean and Adriatic. Observations of human deaths through cyanobacterial toxins have been limited to exposure through renal dialysis (Jochimesen *et al.*, 1998 cited in WHO, 1998) but the health implications are known from anectodal reports of irritations of the skin and/or mucous membranes. Marine cyanobacterial dermatitis may occur after swimming in seas containing blooms of certain species of marine cyanobacteria (Grauer and Arnold, 1961 cited in WHO, 1998). Inhalation of sea spray aerosol containing fragments of marine dinoflagellate cells and/or toxins released into the surf by lysed algae can be harmful to man (Baden *et al.*, 1984; Scoging, 1991). Due to the limited evidence of risks to human health associated with the occurrence of marine toxic algae or cyanobacteria during recreational activities there are currently no guidelines values (WHO, 1998).

5.6.4 Shellfish

The main types of human exposure to pathogenic micro-organisms in the marine environment are through direct contact with polluted seawater, sand or sediment, and through consumption of contaminated seafood. The potential health risks arising from consumption of shellfish relate to the quality of the waters in which the shellfish are grown or harvested, and the quality of the shellfish when they reach the market. The link between shellfish water quality and health effects on humans as the final consumer is more complex than that applying to bathing water. The extent of faecal contamination that can be tolerated in the growing waters is complex and there is no satisfactory correlation either between bacterial indicator levels in shellfish and those in the growing waters, or between the indicators and pathogens in the shellfish themselves (UNEP/WHO, 1996). Overall morbidity statistics are insufficient as practically all diseases caused by pathogens are capable of being contracted through media other than the marine environment. For example, in 1974, a large outbreak of cholera affected several areas of Portugal. There were 2467 bacteriologically confirmed cases who were hospitalised and 48 deaths. The most significant risk factor for the national outbreak was the consumption of raw or semi-cooked shellfish. However, epidemiological investigations in Lisbon showed that visitors to the local spa had a much higher attack rate (Blake *et al.*, 1977).

Artificial purification of mussels is widely practised throughout Europe. One method involves the use of chlorine to disinfect the seawater (which must then be dechlorinated before it can be used to depurate contaminated shellfish). Although this method is relatively expensive, it is used widely in Spain and France. Disinfection by ozone is now the depuration method of choice in large shellfish-cleaning stations in France but a considerable amount of shellfish throughout Europe are still not subject to strict depuration procedures or proper control of storage after harvest (WHO/UNEP, 1995).

5.7 Vector-borne diseases

5.7.1 Malaria

Malaria is by far the most important water-related, vector-borne disease, in terms of both numbers of sufferers and of directly attributable deaths. The causative gaents in humans are four species of *Plasmodium* protozoa. Of these *P. falciparum* accounts for the majority of infections and is the most lethal.

The geographical area affected by malaria has shrunk considerably over the past 50 years, but control is becoming more difficult. Increased risk of the disease is linked with changes in land use linked to activities such as road building, mining, logging and agricultural and irrigation projects. Other causes of its spread include global climate change, disintegration of health services, armed conflicts and mass movements of refugees. Due to the increase in travel malaria is re-emerging in areas where it was previously eradicated, such as Central Asian republics of Tajikistan and Azerbaijan. In the UK 2364 cases of malaria were registered in 1997, all imported by travellers. Malaria is now endemic in 4 countries of the WHO European region.

4. 6. PRESENT POLICIES

To achieve sustainable water management both the quantity and quality of water need to be considered. A balance has to be achieved between the abstractive uses of water, the in-stream uses (e.g. recreation, ecosystem maintenance), the discharge of effluents and the impact of diffuse sources of pollution. Surface water systems are now often highly regulated in efforts to control water availability, whether for direct use in irrigation, hydropower generation, or drinking water availability or to protect against the consequences of floods or droughts. Changes in the nature and scale of human activities have consequences both for the qualitative and quantitative properties of water resources. The change in development of society from rural and agricultural to urban and industrial water uses is reflected in the water demands and water pollution. It is unclear whether this shift in water demand will continue in the future - there are increasing demands upon irrigated agriculture, a process which already accounts for around 70 per cent of water demand world-wide. Many industries have successfully developed processes with substantial water economy measures. Development of lower consumption appliances and control of losses from water mains may therefore stabilise or even reduce total demand for water in the future (Chorus and Bartram, 1999).

6.1 Quantity management

High levels of water consumption have occurred in past decades under the perception that water was abundant and cheap. In the light of growing water pollution, droughts or water stress and increasing water prices, this perception is changing. In many countries, the enforcement of EU or national legislation and the rising cost of water are leading municipalities and industries to reduce water use and is encouraging investment in water saving processes and equipment.

The two main approaches to increasing the efficiency of the supply and use of water are demand side management, which includes economic incentives to reduce use and increased efficiency of use, and infrastructure changes. These latter may take the form of improvements to the network, increasing storage capacity, improving industrial efficiency, the use of low consumption devices, the use of new sources, recycling or water transfer.

6.1.1 Use of available resources

The European Community’s Fifth Environmental Action Programme “Towards Sustainability” published in 1992 (COM 1992) encourages Member States to employ environmental taxes and charges to achieve a more cost-effective environmental policy. This has led to an increase in the application of a wide range of different charging or taxation policies in the Member States, including charges for water abstraction and use.

Abstraction charges

A system of licensing has traditionally been applied to try to achieve the required balance between the different demands on the water environment, the so-called "command and control approach". However, economic instruments are increasingly being applied to complement the licensing system, as water resources of adequate quality become more scarce and the public interest in the aquatic environment in terms of minimum flow, quality and aesthetic appearance increases.

To be effective in decreasing demand, charges made for abstracting water must be set at a rate which influences the extent of the abstraction without causing undesirable economic or social effects, such as reduced competitiveness of industry or decreasing standards of hygiene in poor households.

The purpose and the design of the charging schemes for water abstractions vary widely in different countries, reflecting different institutional arrangements and geographic conditions (Table 6.1; Buckland and Zabel 1996).

Table 6.1 Purpose of water abstraction charge in selected countries

Country	Cost recovery	Revenue raising	Incentive	Replacement of taxation
France		Yes	Yes	
Germany	Yes		Yes[1]	
Netherlands		Yes[2]	(Yes)[3]	Yes[4]
UK	Yes			

Notes:
1 Depends on the charging scheme in the individual Länder
2 Provincial tax for water abstraction, groundwater only
3 The charge is for groundwater only
4 Introduced in 1995 for general tax raising purposes, i.e. green fiscal reform
Source: Buckland and Zabel (1996)

The use of the funds raised varies in the different countries, from providing funds for water resource infrastructures to subsidies for water supply systems. The range of charges applied in selected EU Member States is given in Table 6.2.

Table 6.2 Range of abstraction charges applied in selected EU Member States

	ECU/m^3
France	0.01 - 0.02
Germany	0.02 - 0.53
Netherlands:	
- National	0.15
- Provincial	0.08
UK	0.006 - 0.021

From: EEA (1999c)

Variation in the charges made for abstractions from different types of water source or for different uses can be an additional tool in demand management and can encourage changes in the pattern of water abstraction (Table 6.3). In Germany, for example, higher charges are generally applied to groundwater abstractions than those from surface waters, especially for uses other than for potable supply; in some Länder charges are only made for groundwater abstractions. Charges may also be varied according to the availability of the water, the season of abstraction and how much of the abstracted water is returned to the source, as is the case in UK, while in France the charges vary according to the quality and vulnerability of the source (EEA, 1999c).

Table 6.3 Abstraction charges in selected EU states and regions

Country	Variations in charges	Comments
Germany	Higher charges for groundwater abstractions, especially for uses other than potable supply.	
Germany (Hamburg)	Charges only applied to groundwater abstractions.	Charging scheme resulted in significant return of unused water rights.
Germany (Hessen)	Charges only applied to groundwater abstractions.	11% reduction in water consumption achieved (but may be due, in part, to the influence of the economy).
Netherlands	Charges only applied to groundwater abstractions.	Two charges made: (1) Provincial: to finance research for groundwater resource development and water planning (2) Central: part of a reform of the national tax system to shift the burden of taxation from income tax towards consumption.
England and Wales	Annual charge based on licensed volume taking into account: • Source and region • season • loss factor	Charges levied are usually low and are based on cost recovery (to cover regulatory authority administration cost)
France	Charges are based on: • volume abstracted • scarcity of water resources • loss factor • Charges for groundwater tend to be higher. • Charges higher for waters	Financial charges are collected at a catchment level by the 6 Water Agencies. Funds are reallocated to improve water management.

	taken from upper reaches of rivers.	

Source: EEA (1999c)

Where the abstraction charges are relatively low compared to the price of drinking water as in Germany, France, the Netherlands and England and Wales, the incentive to reduce the volume of water used is low. Current water abstraction charging schemes are best described as financial instruments to raise revenue, in order to cover costs or to fund specified activities, rather than as economic instruments to change the behaviour of water users. None of the charging schemes attempts to set the charges based on the site specific true value of the water resource.

Although water abstracted for irrigation is increasingly becoming a major issue (section 3.2.1), charges for water used for irrigation tend to be very low, much lower than the charges for other users, and charges do not represent the true value of water especially as irrigation tends to be practised in the summer when water resources are under greatest threat (EEA, 1999c).

Water pricing and metering

Charging for water can undoubtedly influence the volume of water used. It has been shown that where water charges have been raised, water consumption decreases. In East Germany the consumer price index increased approximately 14 per cent from 1985 to 1992 for households and 9 per cent for consumers other than households. Water consumption dropped 10 per cent per annum between 1980 and 1991. Between 1990 and 1995 water consumption per person declined by 9 per cent in the whole of Germany and the observed drop in water consumption is influenced by changes in consumer behaviour as well as changes in water prices (EEA, 1998c). In Croatia, the average consumption has decreased from 266 l/capita per day to 150 litres/person/day because of the introduction of higher tariffs (Mountain Unlimited, 1995). In contrast, in Albania, water tariffs are very low, and this has been identified as a factor in the increasing demand for water (Mountain Unlimited, 1997). In some cases where water prices have risen populations may use alternative water supplies that may be of poorer quality compromising the health of the population (Box 6.1).

A balance needs to be kept between having prices high enough to reduce excessive demand and wastage and ensuring that the health of the population is not compromised because low-income families cannot afford to pay their bills (section 4.3). The cost of supplying water and sanitation services to small communities in rural areas or where the provision of safe water is difficult is high, and in some countries such populations account for a considerable proportion of the population (section 4.1). A rigid policy that a fixed proportion of the total costs must be met by the community is unfair and unrealistic (WHO, 1994).

Charges for water generally reflect, to a varying degree, the cost of abstracting and treating water and supplying it to the consumer. The costs of constructing resource/source protection are rarely incorporated. However, charges can also influence the use of water, by discouraging waste and encouraging the use of water-efficient appliances. Several studies have demonstrated that rising water prices have a positive affect on both indoor and outdoor water conservation efforts (use of low-flow toilets, taps and showerheads for example) (Agthe and Billings, 1996; ICWS, 1996).

Box 6.1 Water charges and consumption in Hungarian towns
An analysis of the relation between water price and water consumption has been performed for three different towns in Hungary: Budapest (characteristically a large city with a heavy concentration of industries and vast suburban areas with housing and gardens), Miskolc (the second largest town also with a heavy concentration of industries) and Fejer county (characterised by high living standards and few industries). From 1987 to 1992, water price went up by a factor of 10 in Budapest and by a factor of more than 20 in the other towns. In parallel, water consumption decreased by between five and 28 per cent for households and 20 to 30 per cent for industries, depending on the level of price before the increase. A secondary, unwanted effect was an increase in the use of private wells, often of unacceptable quality. The pattern of reductions in water use suggest that a price increase might have a much greater impact on consumption in countries and areas where the price of water had previously been low than in those where water had always been relatively expensive. *Source:* EEA (1998c)

Domestic metering is widespread in many countries (e.g. Denmark, France, Germany, Netherlands, Portugal), but less common in others, for example in the UK (NRA, 1995) and non-EU countries. The use of metering allows charges to be based on the volume of water actually used and therefore the charge can be related to the cost. There are incentives to avoid wastage of water and this seems to be borne out in the UK, where the use of water in metered households is estimated to be 10 per cent lower than in households without a meter. However, the capital costs of water supply are significantly increased. Metering requires efficient administrative procedures and a sophisticated maintenance procedure to avoid technical problems with meters. Table 6.4 shows some of the advantages and disadvantages of metering.

Table 6.4 Advantages and disadvantages of metering water

Advantages	Disadvantages
Increase in revenue Equity Reduction in misuse and wastage Conservation of the resource More accurate economic costing and pricing Differential tariff structures according to volume consumed Better technical control of water-supply systems	Cost Irregular income High levels of under-registration and other technical problems Logistic difficulties related to inspection and reading High level of accuracy required before computerisation Billing system not adapted to equity objectives

Source: WHO (1994)

6.1.2 Improving efficiency of use

In most countries the instinctive response to water stress is to consider supply augmentation. Most authorities respond to water scarcity by non-pricing devices, such as rationing, prohibiting uses or cutting off supplies (FAO, 1995). Reforming public behaviour towards water is a difficult task with political and administrative costs. Efficacy is related to the criterion of acceptability and in many cases a combination of measures might be most effective. The acceptability of responsibility by users and involvement of all stakeholders in policy formulation and implementation are crucial.

Urban water use

The conservation of water in urban areas can be facilitated in a number of ways:

- Infrastructure programmes: improvements in the distribution system in order to reduce losses (e.g. improvement of network, repair of weak points, installation of measurement devices).

- Programmes to improve efficiency: reduction of water consumption by means of technical modifications of installations (e.g. better sanitary equipment, design of public and private gardens in a way that allows water demand to be reduced).
- Substitution programmes: using alternative sources of water (e.g. re-use) for non-potable uses, rather than using drinking water from the public supply network.
- Water saving programmes: reduction of water consumption through user education, public awareness, tariff systems, information campaigns.
- Management programmes: municipal regulations, tariff systems, commercial incentives and discounts for economic water use, hydraulic audits, loans and subsidies for improvement measures (EEA, 1999c).

A combination of these measures have been used in various countries (e.g. Box 6.2) and contribute to the expectation that water demand in much of the European region will stabilise or decline.

Agricultural water use

The main use of water for agriculture is for irrigation in the European region and this is a significant proportion of the total demand in some countries (section 3.2.1). Some irrigation systems are small-scale, belonging to, and managed by, an individual farm. The groundwater demand may be reduced in these cases by the construction of individual reservoirs for the storage of winter rainfall, which can then be used for irrigation during summer periods of water storage. Farmers in the south-east of England are increasingly following this approach.

Large scale irrigation systems may include storage reservoirs and major canal distribution networks, and their administration often involves public bodies. There are large differences in the efficiency of water use between irrigation systems with earth canals and gravity irrigation, and systems with concrete lined canals and pipe distribution systems. There is scope for improvement both in the distribution system and in the efficiency of use at farm level. Targeting the irrigation where it is most required, levelling fields, improving drainage and choosing the most appropriate irrigation system are local measures which will increase the efficiency of water use (EEA, 1999c).

Box 6.2 Urban demand management, Brittany, France

After facing several years of difficulties in providing drinking water (because of limited quantities and poor quality, especially from nitrates and pesticides), a new scheme for water supply and management was initiated in Brittany, France in 1990. Initial pilot action plans undertaken in several towns led to the reduction in public water consumption of 76 per cent in 15 years (with a stable population size) obtained by the installation of low-flow toilets, watering equipment for public gardens, saving appliances in swimming pools and schools. The predicted development of peri-urban zones and the associated increase in water use led the regional and municipal authorities to launch new pilot action programmes to reduce domestic water use. In seven towns, the installation of water saving appliances (tap, shower, and toilets) has reduced the annual water consumption by 31 m^3/flat. In addition, the use of new watering systems has led to the reduction of 60 per cent of water during summer time. In some towns the reduction in water consumption has been reduced by 50 per cent after 10 months. This pilot action has also increased the awareness of the population in an area where water quality is frequently one of the major problems.

Co-financed by the Agence de l'Eaux and Environment Ministry, it is intended that the operation will be extended beyond the region to make the population and professionals (plumbers) more sensitive to water use and saving equipment, including testing of existing appliances, installation of new saving equipment in households, identification/ diagnosis of waterworks losses and improvement of the efficiency of water consumption. Such action programmes have also been conducted in several industries and in the field of agriculture (irrigation, water for animals).

From: EEA (1999c)

Organisational and management changes such as improvement of knowledge about water losses, establishment of information systems, improving the determination of crop demand and adjustment of water allocations, optimisation of timing and tariff systems can all contribute to irrigation water demand management (EEA, 1999c).

The potential for using secondary water effluents after adequate treatment might also open considerable possibilities for substantial water savings with secondary benefits for water resource quality.

Industrial water use

Mechanisms to reduce demand in the industrial sector are similar to those that apply to urban water supply, thus infrastructure improvements and reduction in consumption by increased efficiency and tariffs can be beneficial. Recycling and re-use of water are important in saving water in industry (section 4.7).

Legal and regulatory frameworks and economic incentives are the measures that are likely to achieve the most success in reducing industrial water demand. In addition, programmes aiming at the promotion of water re-utilisation and recycling promise the possibility of major savings. Rationalisation of production in larger units also tends to reduce the consumption of water per product unit (EEA, 1999c).

6.2 Quality management

6.2.1 Water pollution control

In order to ensure that high quality drinking water can be supplied, the contamination of source waters should be prevented. Source protection is often cheaper and more reliable than treatment and universally relevant to the provision of safe drinking water. In other areas, where advanced treatment is a possibility, the cost of the provision of drinking water will, nonetheless, be reduced if the raw source is of good quality.

Poor protection of source waters from contamination by agricultural activities and industrial or domestic discharges, resulting in microbial or chemical contamination, is identified by many countries in the European region (section 5.2.1). Both surface and groundwaters are regarded as having been poorly protected in Sweden while in Hungary, shallow aquifers and bank filtered supplies are considered particularly vulnerable (EEA/WHO questionnaire 1997).

Various measures can be used to prevent microbiological and chemical pollution of the water resource from both diffuse and point sources, but economic or regulatory incentives may be a necessary complement to ensure their implementation.

Agricultural pollution

Agriculture is carried out over much of Europe’s land-mass, and agricultural land constitutes an extensive area that is a potential diffuse source of chemical and microbiological pollution. The intensification of agriculture that occurred in the middle years of the twentieth century was encouraged in EU countries by the CAP that continues to give subsidies for production and led to a substantial increase in agricultural production in the EU.

The CAP was revised in 1992 and replaced production-based subsidies with direct grants related, for example, to cultivated area, and payments for land to be taken out of production as “set-aside” were also introduced as incentives to reduce the intensiveness of agriculture. In addition, a number of other EU agri-environment schemes, such as NSAs and the Water-Fringe Habitat Schemes are specific incentives to prevent the pollution of water bodies.

The cost and the economic situation of the country are major determinants of cost-effectiveness and extent of the use of agrochemical inputs. Taxation or levies on the purchase of pesticides and inorganic fertiliser are another potential management tool. Payments for conversion to organic agriculture are available in some European countries. The economic balance of biological or organic farms is frequently good because of reduced expenditure for agrochemical and, in some cases, better prices for the product. Co-operation between water supply agencies and farmers in Germany has supported this development (Chorus and Bartram, 1999).

A change of attitude and community awareness for quality criteria and the ecological impacts of products are important in pollution control. There are a wide array of measures that can be used by governments to encourage this, such as training and advice to farmers, eco-audits on products, subsidies for setting land aside from use, subsidies or tax exemptions during periods of transition to organic farming methods, pollutiontaxes and legislation to enforce water protection (Chorus and Bartram, 1999).

Pesticides
Avoiding direct overspray of water bodies is a basic precaution in avoiding pesticide contamination. Except for those that are used to control aquatic weeds or insects, pesticides should not be used in a way that makes contamination of water likely. The conditions of use for some pesticides approved in the EU impose a minimum distance between spraying operations and water. Establishing protection zones around the water source and regulating practices allowed or prohibited within these zones will reduce the likelihood of contamination. In the Netherlands it is predicted that this method along with measures to reduce atmospheric deposition and leaching will reduce pollution by pesticides in water by 70-90 per cent (EEA/WHO, questionnaire, 1997).

Reduced pesticide use will result in a lower potential for run-off and leaching. Lower application rates, without compromising efficacy, can sometimes be obtained through improved application methods such as low volume spraying and placement applications.

The use of IPM allows the control of pests with reduced chemical inputs, by integrating a number of pest control techniques. IPM methods include the use of crop varieties that are resistant to pests and encouraging populations of beneficial insects that prey on crop pests. Cultivation methods that reduce the need for pesticides, such as the use of reduced sowing rates to give a lower incidence of fungal diseases, are also used.

Fertilisers

Codes of good agricultural practice have been developed in many countries, and most include recommendations designed to reduce the potential for leaching of nutrients from fertilisers. Recommended measures include:

- timing fertiliser applications to avoid high-risk times such as autumn, winter and before heavy rainfall
- applying fertilisers when uptake by the crop is greatest
- measuring the nutrient balance for the field to allow an informed assessment of the fertiliser requirement
- using cover crops during winter months to fix soil nitrogen and cover bare soil
- use of straw fertilisation during the winter, (carbon-rich substances in the straw tend to immobilise the soluble soil nitrogen)
- limits on irrigation during high risk periods
- appropriate methods and timing of tillage
- crop rotation
- observing buffer zones alongside water courses, preferably planted or overgrown so that there is uptake of nutrients, to reduce surface water contamination (EEA 1998a)

Animal husbandry

As with agrochemicals, spreading of animal wastes as fertiliser onto land should be timed to minimise the likelihood of run-off and leaching of nutrients and micro-organisms. Using lower stocking regimes ("extensive" farming) alongside water courses is a measure designed to reduce the contamination of surface waters by animal faeces.

Many animal feeds contain concentrations of nutrients that are higher than required by the animals and the excess, rather than being assimilated, is excreted. Optimising the nutrient content of feeds is an approach that may contribute to successful reduction of nutrients reaching surface waters and causing problems of eutrophication.

6.2.2 Economic instruments

Agriculture

Several countries have introduced policies involving the introduction of tariffs and incentives to encourage the use of farming methods that reduce the potential for contamination of water sources by agrochemicals or animal wastes (Boxes 6.3 and 6.4). Prosecutions in the case of contamination and incentive schemes to encourage less intensive or organic farming are some examples.

Box 6.3 Case study: Legal instruments and state subsidies to encourage decreased agrochemical inputs in Swiss farming

Agriculture in Switzerland is undergoing considerable changes, characterised by a move towards integrated farming with minimisation of the use of chemical products. In order to encourage this change, legislation was introduced in 1993, providing for payments to farmers who use ecologically-friendly farming methods. To qualify for these payments, farmers must comply with strict requirements on reducing agrochemical inputs to the land by demonstrating adherence to farm according to the requirements of IP or BP (equivalent to organic farming practices).

The requirements of IP focus on extensification of farming with minimal usage of fertilisers and pesticides, and safeguarding or increasing natural biodiversity on agricultural land. For example, no preventative pesticide application is permitted and for cereal production no fungicides, pesticides or growth regulators are allowed, although some use of herbicides is permitted. For both the IP and BP schemes codes of practice have been produced and there are strict controls (inspections, spot checks and analyses) to verify a farmer's qualification for payments. In general, compliance with official requirements and professional codes of practice is considered high (Dr Suter, Union Suisse des Paysans, pers. comm.).

Participation in these schemes is voluntary but the financial incentives to participate are considerable. As a result, the agricultural area farmed according to the principles of IP increased from 17 per cent in 1993 to 33 per cent in 1995, and is expected to rise to 85 per cent by 2001. Participation in BP schemes has increased from 2.0 per cent of the agricultural area in 1993 to 2.6 per cent in 1995, an estimated 4.7 per cent in 1996, and is expected to rise to 10 per cent by 2001 (Olivier Roux, Office Fédérale de l'Agriculture, pers. comm.).

The reduction of agrochemical inputs under these "extenso-production" schemes means that crop yields are lower but, because costs are also reduced, profits are maintained. The reduced use of chemical fertilisers can lead to reduced infestation of the crop by pests and diseases and, traditionally, organic farmers have also used lower seeding rates to reduce the incidence of disease. However, Swiss farmers have been sowing mixed varieties of cereals which also helps to reduce disease without the use of fungicides. Mixed crops are far less susceptible to the rapid spread of a disease than a monoculture, as the susceptibilities of the different varieties to any given disease will be different. The success of the mixed-variety approach is underlined by its use elsewhere: Denmark has grown more than 60 000 ha of spring barley as mixtures since 1979 and more than 80 000 ha of barley variety mixtures is grown annually in Poland.

Box 6.4 Case study: German agricultural policies to protect groundwater sources

German Federal Policy on agriculture encourages extensification of agriculture, minimal use of chemical products, integrated plant protection control, and organic farming. Legislation and official advice is based on integrated production principles, i.e. maximum use of biological defence mechanisms, minimising pesticide usage and application of the damage threshold principle (use of pesticide, only if the cost of damage exceeds the cost of pesticide application).

Protection of groundwater

Environmental protection and protection of groundwater in particular (which provides about 85 per cent of the drinking water supply in Germany) is characterised by a precautionary approach. The basic expectation is the maintenance of water in its natural state, allowing it to be used as a drinking water supply without requiring any treatment (groundwater) or minimal treatment only (surface water). It is in the interest of the water companies, as well as the consumer, that abstracted water is of high quality, as this will remove the requirement for expensive, advanced water treatment.

In order to protect groundwater sources used for potable supply, water protection zones around abstraction points have been widely established in Germany. In Zone 1 (10m radius around an abstraction borehole) the application of pesticides is banned. In Zone 2 (catchment defined by 50 days travel time for the water to reach the abstraction well) application of pesticides which are considered a threat to groundwater (listed in a Federal regulation applying to the whole of Germany) must not be used. These are minimum requirements and must be adopted by all the Länder, although individual Länder may impose stricter requirements for the various zones.

On a national basis, there has been a move towards protection of all groundwater, rather than focusing on protection zones in the catchments of drinking water abstraction wells. In particular, authorisation of new pesticides and the review of previously approved pesticides involve a strict assessment in terms of the potential to contaminate groundwater.

Compensation payments and voluntary agreements

In some Länder, payments are made to compensate farmers for reduced income due to the restrictions in the use of agrochemicals in water protection zones, for example the so-called "water penny" first introduced in Baden-Württemberg. In this scheme, water suppliers pay a charge to authorities that then use the money to provide standard compensation payments to farmers affected by water protection zones.

In other Länder, compensation payments are made to farmers for complying with strict environmental criteria including fertiliser and pesticide usage reductions. Special payments are made in sensitive areas for adherence to stricter criteria, such as extensive farming with no fertiliser or pesticide usage.

Other schemes to reduce the risk of non-compliance with the pesticides parameter in drinking water are also in operation. These include voluntary co-operation between farmers and water suppliers to ensure appropriate active ingredient management and some water suppliers employ agricultural engineers to advise farmers on the management necessary to protect water sources. In some cases, compensation payments for reduced yields (or increased costs for alternative pesticides) may be made on an individual basis after assessment of applications for payments.

The Munich Water Company (Stadtwerke München, SWM) pays farmers interim compensation payments during a three year transition period to organic farming . The Mangfall valley south-east of Munich was designated as a target area for conversion to organic farming in 1992-3, to halt the trend of increasing levels of pesticides and nitrate fertilisers in groundwater, and by 1996 70 per cent of the agricultural land in the area was farmed organically. The high uptake of the scheme is encouraged by the financial support and advice available, but an awareness, amongst the younger generation of farmers, in particular, of the importance of ecological soil protection is also an important factor (Mr Höllein, Stadwerke München, pers. comm. 1997). A co-operative has been formed to market the organic produce, using promotional slogans such as “one litre of Bio milk contributes to the protection of 4,000 litres of Munich’s drinking water”.

Since the start of the scheme, nitrate levels in groundwater, formerly 14 mg/l, have decreased by about 14 per cent and pesticides are not detected at levels that would breach the drinking water regulations.

Industrial contamination

Regulatory powers and economic incentives are required in order to reduce the contamination of water resources by industrial activities. Many countries make charges for the discharge of industrial effluent both to sewers and to surface waters and, in EU countries, the discharge of industrial waste water to surface waters requires consents to be obtained from a regulatory body. Consents take into account the amount and toxicity of the contaminants contained in the wastewater. However, the charges levied may not always reflect these factors, and the effluent charging schemes applied in the different EU Member States vary widely (Table 6.5).

Table 6.5 Effluent charges in selected EU states

Country	Basis of charges	Comments
Germany	A national unit charge is applied, independent of the capacity of the receiving water. Charges are reduced by 75 per cent once the limit values laid down in Federal Regulations for the specific industrial sector have been achieved. If the consent is breached the reduction in charges no longer applies.	Charges can be regarded as an incentive system. The money raised is used to fund research and infrastructures for pollution abatement. The success of the scheme in pollution prevention is probably because of the relatively high charges and the incentive element built into the scheme.
Netherlands	A unit charge is applied, independent of the capacity of the receiving water.	Charges are relatively high and their impact in improving the environment has therefore been significant. The money raised is used to fund research and infrastructures for pollution abatement.
England and Wales	Charges reflect monitoring costs which are related to: • the contents of the discharge (e.g.: monitoring costs are higher for the more difficult to analyse organic hazardous compounds) • the type of receiving water (effluents discharged to vulnerable receiving waters require more frequent monitoring)	Charges are designed to recover the administration cost of the regulatory authority (Environment Agency) for its pollution control function. Charges are low compared to those in Germany and the Netherlands and their impact has been relatively low.
France	Charges are based on quantity of pollution produced in a “normal” day during the maximum discharge month. The physic-chemical and biological/microbiological elements that are taken into account are defined by each Water Agency Basin Committee. These usually include: • suspended solids • oxidisable matter • toxics • phosphorus • nitrogen Charges take into account the vulnerability of the receiving water and the impact of the effluent	These charges implement the “polluter pays” principle but are lower than in Germany and the Netherlands and their impact has therefore been relatively low. The money raised is used to fund research and infrastructures for pollution abatement.

Source: EEA (1999c)

6.3 Local management

Whilst in most countries, responsibilities for the operation and management of water supply lies at local (municipal) level, in a few countries the water industry is run wholly or in part through private companies with government controls to enforce standards, notably England and Wales and France. Due to the increasing need for investment in water services (sewerage and water supply), not only in central and eastern European countries but also in EU, and other countries, there is a general trend towards private sector participation, though only relatively large utilities can usually attract private investment. Where international funding agencies provide significant contributions to investment, there is also pressure to manage the services more effectively and impose realistic charges on the users, thereby opening the way to private investment and operation of the utilities.

The only example of a wholly privatised water industry exists in England and Wales, where water supply and sewerage services are run by water service companies covering entire river basin catchments and some smaller water companies operating within these catchments. These companies wholly own the facilities. Whilst local authorities have some involvement in the supervision of the service and dealing with consumer complaints, the main supervision is centralised (section 7.3), with the Drinking Water Inspectorate at the Department of Environment, Transport and the Regions, UK overseeing compliance with quality standards. The companies carry out their own water quality analyses (self-monitoring) but the Drinking Water Inspectorate (inspection, quality systems) strictly supervises this.

In France 50 per cent of sewage treatment plants are privately operated, and private water companies supply 60 per cent of consumers. With the exception of the Paris water supply company and sewerage services, which are wholly owned and managed by the municipal authority, the remainder are numerous, mainly small community services managed directly by local councils or unions of several municipalities and, in rural areas, there are still many individual private supplies. However, the approach is significantly different from England and Wales. In France, ownership of the facilities remains with the municipality (or joint syndicates of several municipalities) and the ultimate responsibility remains with the local Mayor, whilst time-limited management contracts are issued to private companies for provision of the services. Overall supervision of water quality, technical and administrative matters, on behalf of the State, are the responsibility of the Departmental Prefects (95 Departmental Directorates) who also carry out or delegate the tasks of water quality monitoring.

In most other countries, water services are predominantly organised and managed by local, town or district administrations. There are a variety of approaches ranging from direct operation and management by local authorities, to economic enterprises governed separately by public administrations, or public corporations managed by several municipalities linked together, and in some countries increasingly a trend towards delegation of duties to a private company whilst maintaining public control.

In addition, in rural areas, there are still large numbers of very small community or private, individual household supplies with little or no treatment and often minimum supervision of quality.

Whilst the services in central and eastern European countries are now run predominantly by local administrations, major issues still to be addressed are often much more basic than in EU and other European countries; i.e. the provision of continuous supplies of adequate microbiological quality (section 5). Pressure for private sector participation is increasing, particularly the water supply utilities in large towns and cities.

Supervision of water quality is carried out in a variety of ways. Self-monitoring as practised in England and Wales and the Netherlands is relatively rare; the function is more typically carried out by government health laboratories, or other government appointed laboratories. These laboratories are not always the best equipped or resourced to deal with the considerable technical demands of the full range of water quality analyses, for example the low concentrations of organic contaminants prescribed in the EU Drinking Water Directive or recommended in the WHO Guidelines for Drinking Water Quality (WHO, 1998b). In addition, they are often poorly equipped to assess, interpret and report on issues related to access and continuity. These problems have been recognised in some instances, and for example in Germany, some laboratories of water suppliers have been certified by the administration to carry out compliance analyses on their behalf, but are only permitted to carry out compliance monitoring of other water suppliers, not their own.

The organisational arrangements aimed at ensuring compliance with the requirements of legislation, standards or codes of practice must provide for surveillance to be shared between the water-supply agency and a separate, preferably independent, surveillance agency. The former is responsible for the quality and safety of the water it produces. The water supply agency carries out routine testing and monitoring (water-quality control) and the surveillance agency separate checking and testing. Both water control testing and testing by the surveillance agency should be applied to all types of water available to the community.

The surveillance agency should be established with national support and operate at central, regional and local levels. It should be concerned with the public health aspects of drinking-water supplies, and have overall responsibility for ensuring that all such supplies under its jurisdiction are free from health hazards. To this end periodic sanitary inspections and analyses of water samples should be carried out to ensure the suppliers are fulfilling their responsibilities.

6.4 Costs and benefits

Many economic consequences follow from the quality of water and sanitation facilities available in a country. Improvements in the level of service will lead to improvements in health but also involve a cost (funds devoted to water and sanitation improvements are not available for other purposes). Costs can be viewed from many perspectives - the sufferer, the family, the health care system or society generally.

Reductions in disease produce benefits, primarily though not exclusively, through the avoidance of these costs. Water supply and sanitation services also accrue non-health related costs and benefits such as convenience and time saved and increased employment.

Whether, to what level and how rapidly interventions to improve water supply and sanitation conditions should be pursued depends upon both the costs of such interventions and the consequent benefits as well as the importance society gives to averting avoidable health impacts and to the convenience provided by high quality services. Ignorance of the ways in which inadequate water supply and sanitation systems lead to health and other costs increases the risk of inadequate investment. The balance of costs and benefits will differ according to local conditions. One consequence of programmes to control and prevent water related disease across the WHO European Region could be a narrowing of the gap between western and eastern states. A significant burden of disease, however, remains in western European states[1] and this should not be ignored.

Substantial problems exist in terms of the availability and reliability of data and estimates of costs and benefits are necessarily broad approximations. For the purposes of analysing the issues the region can be split into two broad areas - West and East. The East being composed on the Baltic's, Danube countries, Balkans, the Russian Federation, Black Sea countries and the Central Asian Republics.

Cost models were developed to predict the annualised cost of improving water and sanitation service provision to levels consistent with those in the more developed parts of the region.[2] Annualised costs in the region of 30 to 50 ECU ($38 - 62.5) per capita of the Eastern WHO European region are estimated. In all regions except the Central Asian States these costs are a small proportion of GDP (1 per cent to 2 per cent).

From an economic perspective it is net costs (costs net of any subsequent benefits) which are important[3]. The quantifiable benefits include reductions in the burden of disease to individuals and society. From a social perspective the health benefits need

[1] In Sweden 90 water related outbreaks mainly associated with *campylobacter* leading to 50,000 cases of sickness and two deaths were reported between 1980 and 1995 (Andersson et al (1997)). In the UK the leaching of lead from supply pipes is a significant problem. Lead exposure induces hypertension related disease and affects the cognitive development of children. A recent study by WRc and OXERA quantified the benefits of reduced exposure from both causes as between 1.7bn ECU and £4bn ECU for England and Wales.

[2] Costs were estimated on the basis of 1) the existing level of coverage as reported in data on the percentage of the population with "home water supply" and "hygienic sanitation", 2) the proportion of existing services that might need to be upgraded, 3) the demographic characteristics of the population (degree of urbanisation), and 4) the characteristics of the investment needed - level of treatment etc. These calculations are necessarily coarse approximations and are likely to overestimate actual costs because 1) they are engineering based calculations which ignore more cost effective local solutions, 2) they are supply side costs and ignore what can be achieved from more effective management of water resources and or improved health education, and 3) they are "blanket" measures which ignore cost savings which may be achieved through targeting.

[3] The above gross costs overestimate the actual social costs of the interventions in a number of ways. Firstly, from a social perspective the costs are only relevant if they reflect opportunity costs. The degree of under-utilisation of resources in the region (particularly labour) means the opportunity costs will be lower. Secondly, there are benefits (some of which can be quantified) which offset the estimated costs.

to be valued at what society is willing to pay to secure them (generally measured as the sum of individual willingness to pay). In the absence of primary research on the value attached by society to a reduction in the level of water related disease experienced less accurate methods need to be employed. The most common form of assessment is the cost of illness (CoI) approach. This method attempts to assess the economic implications of disease morbidity and mortality in terms of the costs of the resources lost or required to deal with the disease. A literature compiled information from over 25 studies of the economic burden associated with common water related diseases. These are summarised in Table 6.5.

Table. 6.6 Costs of illness (morbidity) of water related diseases (ECU)

Disease	Value[1] and coverage[2]		Comment
Hepatitis A			
Severo *et al* (1995)	1,432 (0.079)	1,2	Propylaxis for military, hospital workers and tourists
Sander *et al* (1975)	9,765 (0.354)	1,2	German study of Hepatitis outbreak
Arnal *et al* (1994)	909 (0.072)	1	Spanish study of vaccination efficacy
Verma & Srivatava (1990)	31 (0.095)	1,2	Water related ineffective hepatitis in Indian rural populations
Dermichelli *et al* (1996)	7,109 (0.423)	1,2	Analysis of an Italian outbreak mainly affecting children
Lucioni *et al* (1998)	3,735 (0.217)	1,2,3, 4	Study of a seafood based outbreak in Italy
Chossegross *et al* (1994)	1,779 (0.090)	1,2	Study of hospital recorded cases in France
Smith *et al* (1997)	7,310 (0.290)	1,2	US study of health care workers
Behrens and Roberts (1994)	16,170 (1.316)	1,2,3, 4	Study on travel prophylaxis in UK
Dalton *et al* (1996)	1,577 (0.082)	1,2,3, 4	Foodborne outbreak in US
Van Doorslaer (1994)	4,362 (0.343)	1,2	Travel propylaxis study in the UK
Typhoid			
Sridhar *et al* (1995)	22 (0.067)	1	
Shandera *et al* (1985)	4,479 (0.244)	1,2,4	Foodborne outbreak of Typhoid in the US
Behrens and Roberts (1994)	9,397 (0.807)	1,2,3, 4	Study on travel prophylaxis in UK
Diarrhoea			
Archer and Kvernberg (1985)	2,138 (0.091)	1,2	Foodborne diarrhoeal disease in the US
Thompson and Booth	19 (0.002)	1,2	Travellers diarrhoeal in UK

(1991)			
Verma & Srivatava (1990)	10 (0.031)	1,2	Water related acute diarrhoeal disease in Indian rural pop
Danzon *et al* (1988)	379 (0.020)	1	Efficacy of treatment for French children NSA diarrhoea
Skirrow (1990)	980 (0.083)	1,2	UK study of cost of diarrhoea (salmenelosis)
Gastro-enteritis			
Baker *et al* (1979)	94 (0.002)	1,2,4	Waterborne outbreak in US
Hopkins *et al* (1986)	87 (0.005)	1,2,4	Waterborne non bacterial outbreak in US
Liddle et al (1997)	896 (0.050)	1,3,4	Rotovirus affecting children in Australia
Laursen (1995)	104 (0.005)	2	Water related outbreak in Denmark
Camphylobacterosis			
Sockett and Pearson (1988)	850 (0.096)	1,3,4	Outbreak of diarrhoeal associated with camphylobacter in UK
Andersson *et al* (1997)	221 (0.009)	1,2,3, 4	Study of a waterborne outbreak in Sweden
Cholera			
Cvjetanovic (1971)	39 (0.030)	1	Cost benefit of sanitation intervention in Yugoslavia
Cookson *et al* (1997)	761 (0.297)	1	Study of cases in rural Argentina
Enteric Fever			
Verma & Srivatava (1990)	10 (0.030)	1,2	Study of water related in Indian rural populations
Giardiasis			
Harrington	5,297 (0.230)	1,2,3, 4	US study of waterborne outbreak.
Conjunctivitis			
Verma & Srivatava (1990)	10 (0.031)	1,2	Study of water related in Indian rural populations
Scabies			
Verma & Srivatava (1990)	22 (0.068)	1,2	Study of water related in Indian rural populations
Cryptosporidiosis			
Shaffer *et al*	76 (0.004)	1	Waterborne outbreak in the US

Notes: (1) Costs are shown in absolute levels (ECU) for 1995 and in parenthesis the proportion of per capita GDP in the study country that this represents. (2)Costs included: 1 = medical expenses for patient and society, 2 = direct productivity loss from sufferers 3: = indirect productivity loss (familial care etc provided to sufferers) and 4 = other costs - frequently defensive expenditures such as purchase of bottled water.

The studies vary widely in their perspectives, many being based on the evaluation of immunisation efficacy or on post outbreak evaluations of resource costs. Few of the studies are based directly on collated information on costs from individuals experiencing the disease. The studies differ substantially on the costs examined - many are restricted to medical costs and few treat non-marketed labour in a satisfactory manner.

Despite the deficiencies associated with many of the studies, however, they do indicate the relative burden of the morbidity associated with water related disease. For the more severe diseases (hepatitis A, typhoid, cholera) costs are high - generally in the region of 10 to 40 per cent of per capita GDP. For less severe diseases - diarrhoea, gastro-enteritis etc the costs are much lower - generally less than 5 per cent of GDP per capita.

Data on the incidence of water-related disease have been compiled from questionnaires completed by the Member States (WHO/EEA questionnaire 1997). Under reporting is a significant problem because of poor surveillance systems and, for the less acute diseases, the high number of cases that do not involve medical attention and hence go unreported. This data, adjusted to reflect the latter has been used in combination with the estimates of the percentage of cases that are considered avoidable through water and sanitation improvements[4], to provide estimates of the number of avoidable cases in each of the eastern regions.

This data indicates that over 30 million cases of water related disease could be avoided annually through water and sanitation interventions. On the basis of the cost of illness calculations the economic burden is estimated at approximately 25 ECU per capita of the Eastern region. These are the benefits associated with a small sub-set of all water related disease and ignore benefits associated with a number of other important water related diseases including, the hygiene related diseases such as scabies, pediculosis, conjunctivitis; skin infections, dermatophytes etc.; and from chemical contaminants such as nitrate, arsenic and lead[5].

Avoided costs of illness are, however, only one aspect of the health benefits of water supply and sanitation interventions. Estimated costs of illness ignore the social factors associated with the disease. In addition improvements in the health status of the general population are likely to positively alter economic conditions at the macro-economic level for example by improving educational attendance and future human capital, savings and investment rates and attracting tourism and investment[6].

Investing in water supply and sanitation will produce benefits over and above those associated directly with health. Individuals also value improvements to the conditions and quality of the water supplied (e.g. the added convenience of a home water connection, fewer restrictions on water use through a more continuous supply etc).

[4] Estimates of the excess disease associated with poor water supply and sanitation conditions must recognise the multiple pathways associated with water related disease occurrence. Given the multiple infection pathways it is estimated that between 60% and 80% of disease is avoidable through water and sanitation improvements.

[5] A recent study in Moldova estimated that the annual costs from premature mortality and from lost work days at 60ECU to 114ECU suggesting health benefits from reduced nitrate pollution alone of between 15 and 25 ECU per capita.

[6] Specific disease outbreaks can have important macro-economic impacts. The Peru cholera epidemic for example estimated the losses from trade and tourism at 34% of the total costs.

Improvements to sanitation will generate environmental benefits through a cleaner environment - raising the quality of the conditions under which the water is used for non drinking water applications - aquaculture, recreation, industrial abstraction, irrigation etc.

The benefits of improving water supply and sanitation conditions in the east of the region are, therefore, likely to be immense. Although gross costs are also high, given the importance of the benefits not estimated and the likely overestimation of costs, on balance such investments are likely to produce substantial net benefits. The benefits are likely to increase where well targeted and locally effective strategies are pursued.

7. INTERNATIONAL, ADMINISTRATIVE AND LEGAL INITIATIVES

7.1 Draft Protocol on Water and Health to the 1992 Convention on the Protection and use of Transboundary Watercourses and International Lakes

WHO/EURO and UN/ECE with the involvement of UNEP and the EC has developed the Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

The protocol is based on the aims of universal access to drinking water and sanitation protective of human health and the environment and of sustainable use of water resources. The aims of the protocol are:

- Universal access to drinking water;
- Provision of sanitation for everyone; and
- Sustainable use of water resources.

In order to achieve these aims, countries should establish, publish and periodically revise national or local targets, ensuring public participation, and taking account of relevant recommendations of international bodies; national and local capacities and resources; and available knowledge related to priorities for the improvement of public health and the protection of the environment, concerning:

- The quality of the drinking water supplied;
- The area of their territory, or the size or proportion of the population, which should be served by collective systems for the supply of drinking water, or where the supply of drinking water by other means should be improved;
- The area of their territory, or the size or proportion of the population, which should be served by collective systems of sanitation, or where sanitation by other means should be improved;
- The standards of performance to be achieved by these systems and by other means of water supply and sanitation;
- The application of recognised good practice to the management of water supply and sanitation;
- The quality of discharges of wastewater to waters within the scope of the Protocol from waste-water collection systems and wastewater treatment installations;
- The disposal or reuse of sewage sludge from collective systems of sanitation or other sanitation installations;
- The quality of waters used as a source of drinking water or for bathing, irrigation, the production of fish by aquaculture and the production or harvesting of shellfish;

- The application of recognised good practice to the management of enclosed waters generally available for bathing;
- The performance of systems for the management and protection of water resources, including the application of recognised good practice to the control of pollution from sources of all kind;

International co-operation will be necessary in many cases, and parties to the protocol will be required to assist each other in implementing national and local plans. Unexpected events may influence the quality and quantity of water and precautionary measures and emergency responses should be considered. These may be:

- Improved security of water supply by abstraction from different water bodies if possible
- Connections to alternative water supply systems if possible
- Availability of equipment for water purification and for the transport of drinking water from unaffected areas
- Availability of equipment to assess drinking water quality
- Storage of bottled water in households.

7.2 National frameworks

National legislation and institutional frameworks vary across the Region, and in some countries have undergone significant change in the last decade.

7.2.1 Member States of the European Union

The ultimate responsibility for legislation and enforcement of the legislation concerning water resources and supply lies at national, ministerial level in most countries, often with the Ministry of Environment or Ministry of Health (or ministries with similar functions); or there may be shared responsibilities between two ministries, each covering different aspects of water supply. For example, water resources (quality and quantity), licences for abstraction and discharge consents may be under the Ministry of Environment, whilst drinking water, bathing water and irrigation water and quality may be under the Ministry of Health or Foods. However, in some Federal Nations, responsibilities are divided between Federal level and individual Federal State level, as for example in Germany. In practice, the supervision of compliance is often fragmented with much of the responsibilities divulged to regional level and more frequently to local level.

There are some exceptions, however, notably England and Wales, Ireland and the Netherlands where centralised controls relating to water supply and quality are in place. For England and Wales where the water industry is fully privatised, the Drinking Water Inspectorate supervises quality compliance of all water companies centrally, whilst OFWAT is in charge of the economic/financial aspects and consumer interests, and the Department for Environment Transport and the Regions and

Environment Agency (with regional offices based on catchment areas) is responsible for abstraction and discharge consents. Similar provisions have recently been put in place in Ireland to supervise publicly owned water suppliers. Similarly in the Netherlands, though somewhat less centralised in practice, Regional Public Health Inspectors supervise all water service utilities in their respective Regions, whilst one of the Inspectors acts as national co-ordinator to ensure consistency of approach throughout the Regions.

The EU Drinking Water Directive (80/778/EEC recently revised and replaced by Directive 98/83/EC) provides the framework for drinking water quality standards across Member States**.** The first Directive was issued in 1980 and transposal by Member States was required by 1986. Issues of the quality of water resources are covered by a variety of Directives (and corresponding national legislation). Some of these will be incorporated into the Water Policy Framework Directive which aims to establish a framework for the protection and management of water resources.

Although transposal of Directives into national legislation and subsequent implementation, the organisation of drinking water supply, and the institutional mechanisms to control compliance with the standards, varies considerably in the different States, there is a common goal to achieve certain standards. The WHO Guidelines for Drinking Water Quality WHO 1998b are used as the 'scientific point of departure' in setting individual standards.

All current EU Members have transposed the Drinking Water Directive into national legislation, some with considerable delay and others, relatively new Members of the EU are still adjusting to EU requirements (e.g. Austria). On the whole, the EU standards have been adopted with minor variations and some additional or stricter national standards that are in place in some countries. Many countries still experience problems in fully complying with certain parameters, and/or are still not fully complying with monitoring requirements and reporting of data.

Whilst the system of compliance monitoring and enforcement in England and Wales has proved effective in raising compliance with drinking water quality standards, the EU Commission has recently challenged the legality (and started court action) in respect of the approach taken by the DWI in cases where water companies breach standards without compromising public health. The approach involves the use of legally binding 'Undertakings', i.e. improvement programmes agreed between DWI and water companies, with clear targets and time limits for achieving these. Many EU Member States take similar, though less formalised approaches to enforcement or they have, in the past, issued legislation permitting temporary exceedance of standards (e.g. France, Italy); the latter clearly in contravention of the EU Directive. A very similar approach to DWI's enforcement practice is taken in the Netherlands where, with the exception of one private operator, water services are directly under public control; compliance controls are also carried out through self-monitoring and the approach to enforcement action taken by Public Health Inspectors is on a much more informal basis, but equally successful in achieving improved compliance. Ironically, a similar approach, to that currently practised in England and Wales and in the Netherlands, has now been sanctioned by the revised EU Drinking Water Directive 98/83/EC.

Effectiveness and needs

Attempts to gather and collate information on compliance with the EU Drinking water Directive are difficult since there are only a limited number of countries that publish detailed, national, annual reports of drinking water quality. Even where reports are produced or data are otherwise available, it is difficult to make precise comparisons of compliance, due to differences in data presentation; for example data may be presented in terms of percentage of samples analysed, population or volume of water supplied, supply regions, compliance for individual parameters or all parameters measured.

On the whole, supply is maintained on a continuous basis in the EU region, with the exception of certain localised, seasonal problems due to drought conditions. Concerning water quality, the most frequently reported compliance problems relate to microbiological parameters, nitrate, pesticides, and sometimes toxic metals. Similar, but more severe problems are encountered in central and, particularly, in eastern European countries where supply is still frequently interrupted (section 5.1).

France is also facing EU court action, in this case over non-compliance with the nitrate standard. In addition, French consumers have successfully fought court actions and have been awarded compensation payments from water suppliers for breaches of water quality standards. Moreover, France's own public audit office, the Court de Comptes, in a report in 1997 on French water service management, has criticised municipalities, utility companies and the relevant state agencies of a lack of transparency, insufficient competition between private operators, inadequate information for consumers, and a lack of monitoring of delegated public services.

However, when considering compliance with drinking water quality standards, it must be remembered that, unlike the WHO Guideline values, some parameters of the Directive are not based on health considerations; notably the limits for pesticides of $0.1 \mu g\ l^{-1}$ for individual pesticides, and $0.5\ \mu g\ l^{-1}$ for total pesticides. The enforcement has exerted significant pressure on implementation of environmental measures, such as stricter controls on pesticide application and designation of water protection zones. Whilst this approach has undoubtedly lead to environmental improvements in the EU region, considerable expense is associated with these measures. In addition, expensive treatment technology has frequently to be employed to remove traces of pesticides from drinking water at great expense to consumers, whilst conferring dubious benefits in terms of health effects. The fairness of this approach in terms of violation of the 'polluter pays' principle has often been criticised.

Such debate is particularly pertinent in countries (e.g. many Eastern European countries) where continuity of supply and microbiological quality is the prime concerns. Considerable care should be exercised in prioritising investment, primarily to secure continuous, safe supplies whilst, in the short term, avoiding undue emphasis and pressure on compliance with parameters which have little health significance.

Dealing with pollution of water sources may in time be affected by the new European Water Framework Directive, but in the short-term, costly treatment options and investment in distribution facilities, as well as putting in place effective controls, are widely needed to provide a safe and uninterrupted drinking water supply.

This results in pressures to attract investment through privatisation, which in turn re-enforces the need for effective controls to adequately supervise such private operators, i.e. strong legislation and institutional mechanisms backed by staff training and adequate resources to allow effective monitoring of drinking water quality and enforcement of compliance with quality standards. At the same time, overuse of legislation and resorting to prosecution of water suppliers for breaches of standards can be very costly, ultimately having to be paid for by the consumer, whilst it is likely to provide little or no benefits in terms of public health.

7.2.2 Other western European countries

Western European countries that are not members of the EU, such as Switzerland and Norway, have similar national frameworks and legislation in place, with drinking water quality standards based on a combination of EU limits and WHO Guideline values. As these countries are not subject to the legal requirements of the EU, the approach tends to be more pragmatic and focusing on health based criteria. Switzerland, for example, has two sets of standards: mandatory health based limits and non-health based guide or target values which are less strictly enforced, but ultimately to be aimed at.

7.2.3 Central and eastern European countries

Central and eastern European countries have experienced many changes with the recent break-up of the former Soviet Union. Previous Soviet legislation contained numerous, strict standards for drinking water quality but these were often poorly enforced due to lack of institutional mechanisms and resources in most countries (apart from a few exceptions, most notably the Czech Republic). For most parameters, methods of analyses were inadequate and there was no clear distinction between those responsible for provision of services and those responsible for supervision of standards and law enforcement. Moreover, drinking water quality was often severely compromised through intensive industrial activity without any concerns for the environment, and, consequently, inadequate protection of water resources. A lack of investment in treatment and distribution facilities also contributed to significant problems.

Many of these countries are preparing or have recently introduced new legislation closely linked to the WHO Guidelines and/or the EU Drinking Water Directive, particularly those expecting to join the EU in the near future. However, whilst some countries, for example the Czech Republic, formerly had a relatively sound system of legislation and enforcement, including publication of drinking water quality reports, it has delayed adoption of its revised draft legislation, whilst waiting for completion of the revision of the Drinking Water Directive and for progress with the Water Framework Directive. Meanwhile, there are concerns that there is a gap in the legislation and enforcement mechanisms that could be exploited, particularly by newly emerging, inexperienced private water service operators.

Similar to the EU Member States, overall responsibilities for water supply lie at ministerial level. Whilst the preparation of suitable legislation and to some extent, the allocation of responsibilities, is taking shape in most countries, resources and experience are often lacking to enforce the standards effectively. It is clear that in many countries considerable investment is needed to improve the infrastructure.

7.3 Legislation and Guidelines

Despite legislation in place in all Member States on safe water quality as well as basic rules on water resource management there is still an incredible lack of implementation due to the inconsistencies of legal systems. Successfully conducted case studies on water resource management have shown that space for manoeuvring within the regulations are key requisites for achieving standards above the minimum legal requirements without increasing costs above those which consumers are willing to pay for.

7.3.1 EU Directives

Nitrates from agricultural source (91/676/EEC)

Member States are required, under this directive, to identify waters that may be affected by pollution from nitrate (Nitrate Vulnerable Zones) and to establish action programmes to prevent pollution in these areas. The directive is intended both to safeguard drinking water supplies and to prevent ecological damage by reducing or preventing the pollution of water caused by the application and storage of inorganic fertilisers and manure on farmland.

Waters covered by the Directive include surface freshwaters (in particular those used for the abstraction of drinking water), groundwaters actually or potentially containing more than 50 mg/l nitrate, and water bodies, (lakes, other freshwater bodies, estuaries, coastal water and marine waters) which are, or may become, eutrophic. Action programmes must include periods when the application of certain fertilisers is prohibited, limits on the quantities of fertilisers applied, a limit on the application of livestock manure, conditions relating to the available storage capacity on farms for livestock manure and a code of good agricultural practice.

Dangerous Substances Directive (76/464/EEC)

This directive sets a framework for the elimination or reduction of pollution of inland, coastal and territorial waters by particularly dangerous substances. The regulation of specific substances is promulgated in daughter directives.

The directive requires Member States to eliminate or reduce pollution of water bodies by certain substances contained in an annex to the directive and to set standards for their occurrence in water. The dangerous substances to be controlled are contained in two lists, List I (the “Black List”) of priority chemicals and List II (the “Grey List”). Discharges to water of substances on either list must be authorised prior to release.

Procedures for determining acceptable levels of release differ between the two lists. List I chemicals are controlled by community-wide emission standards specified in Daughter Directives, whereas it is the responsibility of individual Member States to set standards for those List II substances which require control.

Groundwater Directive (80/68/EEC)

Directive 80/68/EEC aims to protect exploitable groundwater sources by prohibiting or regulating direct and indirect discharges of dangerous substances. The dangerous substances covered by the directive are those controlled by the Dangerous Substances Directive (76/464/EEC). Member States are required to prevent the introduction of List I substances into groundwater and to limit the introduction of List II substances, so as to avoid pollution.

Bathing Water Directive (76/160/EEC)

Directive 76/160/EEC sets out the quality requirements for identified bathing waters in each member Country to 'reduce the pollution of bathing water and to protect such water against further deterioration'. The standards were set in order 'to protect the environment and public health'. The Directive specifies minimum sampling frequencies - fortnightly for most parameters. However, the current Imperative and Guideline standards of microbiological determinants set in the Directive were published before many of the major epidemiological studies had been carried out. The water quality standards of the bathing water Directive are currently being revised after a considerable period of consultation**.**

Urban Waste Water Treatment Directive (91/271/EEC)

The Urban Waste Water Treatment Directive (91/271/EEC) sets minimum standards for the collection, treatment and discharge of urban waste water, with the aim of reducing the pollution of raw waters by domestic sewage, industrial waste water and rainwater run-off. It introduces controls over the disposal of sewage sludge and ends the practice of dumping sewage sludge at sea.

Under directive 91/271/EEC, all towns and villages with a population equivalent or greater than 2000 are required to have sewage collection systems. The wastewater is subject to treatment requirements; a minimum of secondary treatment is normally required. Tertiary treatment is required for discharges to particularly sensitive areas (as designated by Member States), including waters subject to eutrophication and surface waters intended for abstraction for drinking water with high nitrate levels. Exceptions and derogation's are made for specific circumstances; for example, septic tanks giving the same degree of protection as sewage collection may be used where the installation of sewerage systems involves "excessive cost".

The directive requires that all discharges of industrial waste water into collecting systems and treatment plants is subject to regulation or specific authorisation and will be implemented progressively from 1998 to 2005.

7.3.2 Drinking water supply

In the EU, minimum standards are set for drinking water quality, supported by monitoring and legal enforcement, and regulations also govern the quality of surface waters abstracted for potable supply and the extent of treatment required.

Such regulations would appear to be necessary to ensure that water in potable supply is of acceptable quality, and that suitable sources of water are used and sufficient treatment applied. However, the disadvantage of this type of legislation, and financial penalties for supply companies that breach the quality requirements, is that it is ultimately the consumer, not the polluter, that pays for the treatment to remove the pollution.

Drinking Water Directive (80/778/EEC)

Directive 80/778/EEC specifies quality standards for water intended for drinking and use in food or drink production. Standards are set for six different categories of parameters: organoleptic parameters (e.g. colour, odour taste); physicochemical parameters (e.g. pH, conductivity); parameters concerning substances undesirable in excessive amounts (e.g. nitrates, nitrites); toxic substances (e.g. mercury, lead, pesticides); microbiological parameters (e.g. coliforms, faecal streptococci) and minimum required concentrations for softened water intended for human consumption (e.g. hardness, alkalinity). The directive sets MAC and MRL for most parameters, which must be incorporated into the laws of Member States, and includes guidelines for others. The standards are backed up by monitoring and legal enforcement, and regulations also govern the quality of surface water abstracted for potable supply and the extent of treatment required.

The directive is currently being reviewed and updated, and a number of changes will be included in the Directive that is ratified. The number of parameters to be regulated will be reduced, with only parameters considered to indicate a significant risk to human health being specified. The MACs for a number of parameters are also likely to differ from those in the current directive.

Surface water for drinking Directive (75/440/EEC)

Directive 75/440/EEC is intended to ensure that surface water abstracted for use as drinking water reaches certain standards and receives adequate treatment before being put into public supply. It requires the classification of rivers based on quality (A1, A2, or A3) and corresponding to the degree of treatment required to render the surface water fit for supply. Physical, chemical and microbiological characteristics are used to define the quality of the water. The forty-six parameters include temperature, BOD_5, nitrates, lead and faecal coliforms. Sampling at abstraction points must demonstrate a high degree of compliance with the values required.

The directive prohibits the use of surface water of a quality worse than A3 for drinking water except in exceptional circumstances, and requires a plan of action for the improvement of surface water quality, especially A3 water.

7.4 WHO Guidelines

WHO/UNEP Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture

These guidelines have been developed to protect the health of both workers and consumers. They specify that waste water should be treated to attain certain microbiological standards before use (section 4.7.1), and differentiate between the more stringent quality required for restricted use (on edible crops, sports fields and public parks) and that acceptable for unrestricted use (irrigation of trees, fodder and industrial crops, fruit trees and pasture). Excreta that have not received sufficient treatment to remove the risk of infection should only be applied by subsurface injection or in covered trenches before the start of the growing season. Where wastes are used as a nutrient in aquaculture, measures to reduce the risk of consumers of fish should be implemented. These include keeping fish in clean water for at least 2 to 3 weeks before harvest (WHO, 1989). Plans are in development for the updating of these Guidelines.

WHO Guidelines for safe recreational-water environments

WHO are currently developing guidelines for safe recreational water-use environments with the primary aim of the protection of public health. The Guidelines are in two volumes - volume 1 concerned with coastal and freshwaters (WHO, 1998) and volume 2 concerned with swimming pools, spas and similar recreational water environments (in preparation). Faecal pollution of recreational waters is one of the major hazards facing users, although microbiological contamination from other sources, and chemical and physical aspects, also affect the suitability of water for recreation. The guidelines do not provide mandatory limits but measures the safety of a recreational water environment and promotes the adoption of a risk-benefit approach. This approach can then lead to the adoption of measurable standards which can be implemented and enforced, for example to deal with water quality.

WHO Guidelines for drinking water quality

The WHO has derived guideline values for a large number of drinking water parameters (WHO, 1998b). These include measures of microbiological and chemical contamination and also organoleptic parameters. A guideline value for a chemical parameter represents the concentration of a constituent that does not result in any significant risk to the health of the consumer over a lifetime of consumption. The guidelines are intended set achievable goals that can be used as a basis for the development of national standards that will ensure the safety of drinking water supplies. They are not intended to be mandatory and should be considered in the context of local or national environmental, social, economic and cultural conditions. The guidelines are reconsidered periodically in the light of new evidence, and may be revised if necessary. The achievability of the recommended levels is taken into account when setting guidelines.

The guidelines emphasise the over-riding importance of ensuring that drinking water supplies are protected from microbiological contamination. The potential consequences of microbial contamination of water supplies are severe (section 5.2), with the potential for the simultaneous infection of a high proportion of the community, particularly affecting infants and young children, the elderly and those already debilitated by illness. Because chemical contamination is not normally associated with acute effects (except in cases of massive accidental contamination of supplies) it can be argued that chemical standards for drinking water are of secondary consideration in a supply subject to severe microbial contamination. Similarly, it should be noted that the risks to health from disinfection by-products are extremely small in comparison with those associated with inadequate disinfection of microbially contaminated supplies (WHO, 1996a).

The WHO Guidelines are supported by a series of documents relating to good practice and generally orientated towards specific health hazards or management issues. These documents include a guide to monitoring bathing waters (Bartram and Rees, 1999); and an authoritative review concerning cyanobacteria (Chorus and Bartram, 1998).

4.2 7.5 International organisations, initiatives and responses

4.2.1 7.5.1 WHO

The WHO has undertaken several initiatives to improve the health of the population of Europe and to contribute to ensuring that drinking and recreational water is of sufficient quality. These include the global Guidelines described in section 7.4 and Health for All strategies.

Health for All

The WHO's Health for All movement began with the International Conference on Primary Health Care at Alma-Ata in Kazakstan in 1978. The Member States of the WHO European Region adopted the first set of European targets for health in 1984, and these were updated by the Regional Committee in 1991. The targets include all aspects of health, from achieving environments and lifestyles that are conducive to good health to providing health care.

Target 20 is specific to water quality: "*By the year 2000, all people should have access to adequate supplies of safe drinking-water and the pollution of groundwater sources, rivers, lakes and seas should no longer pose a threat to health*." It was proposed that: "*This target is achievable if water conservation strategies are implemented to meet evolving environmental health problems and needs".*

Achievement of these strategies requires:

- providing access to adequate and continuous supplies of safe drinking water that meet WHO drinking water quality guidelines;
- ensuring effective wastewater disposal, sanitation and protection of drinking water resources;
- taking appropriate intersectoral action to prevent contamination of water sources by agricultural and industrial pollution.

The problems highlighted in the Health for All policy for Europe (poor servicing of some rural areas by drinking water connections, periodic interruptions of supplies, losses of water of drinking quality through leakage, the lagging behind of appropriate sewage collection and treatment facilities compared with the provision of drinking water and the discharge of untreated domestic and industrial discharges into the aquatic environment) are still very much present in some areas of the region.

Although it must be recognised that improvements have been made in some aspects and some countries, many of the suggested solutions are applicable today as they were in 1991. These include: focusing more attention on supplies in rural areas; placing emphasis on the proper treatment of wastewater; prevention of pollution of groundwater by toxic materials; charging both consumers and polluters to recover the costs of providing good quality drinking water; effective national strategies for supplying safe drinking water to the whole population; research into specific pollutants; and a common, region-wide strategy.

The WHO Regional Director for Europe noted in 1993 that the central and eastern countries of the WHO European Region faced the most dramatic challenges in achieving Health for All, and considered that adopting the WHO Health for All targets as national policies would be the most effective measure in creating a cohesive framework for development (WHO, 1993).

4.2.2 7.5.2 EU

European Community Policy addressed environmental and health issues related to water at a time when such issues were not yet laid down as Community policy in the Treaty establishing the European Community. Thus already in 1973 the First Environmental Action programme was adopted by the Community, to be followed by others. The 1976 Bathing Water Quality Directive directly addressed an issue important for human health, i.e. setting criteria for bathing waters and obliging Member States to take the necessary action where those criteria are not yet met. The 1980 Drinking Water Directive for the first time established health-related criteria for drinking water at the tap, thus providing security for the consumer and a basis for technical and financial planning for the water suppliers. This legislation has been complemented by emission-orientated legislation addressing pollution at the source, such as the legislation on urban waste water 1991; nitrates pollution from agriculture 1991; and pollution from large industries 1996. However, European water policy and water legislation still lacked an overall coherent way also contributing to the protection of human health.

Following an initiative taken by the European Commission, a major process of restructuring European water policy is underway, the issue to be addressed by the Water Framework Directive (COM (97) 49). The new policy and legislation will have as its main objectives:

- expanding the scope of water protection to all waters, surface waters and groundwaters, freshwaters, estuaries and marine waters;

- achieving 'good status' for all waters by a certain deadline

- water management based on river basins, by applying the combined approach of limit values and environmental quality standards to the control of discharges and by controlling water abstractions from both surface waters and groundwaters. River Basin Authorities must be designated by Member States to administer and implement the directive, and transboundary co-operation will be required in many instances.
- A 'combined approach' of emission limit values and quality standards
- getting the prices right
- getting the citizen involved more closely
- streamlining legislation

The Water Framework Directive aims to provide an overall framework for the management of water, in terms of both quality and quantity, thus enabling an integrated approach to be taken to achieve the objective of sustainable water management.(Table 7.1). It aims to reconcile all human activities within a catchment, using command and control measures, planning and economic instruments.

The Directive will incorporate the requirements of a number of current directives, including the Groundwater and Surface Water Directives and the Dangerous Substances Directive, which are likely to be repealed. Some other directives, such as the Urban Waste Water Treatment Directive, Nitrates from Agriculture, Bathing Water and the Integrated Pollution Prevention Control (IPPC) Directives are likely to remain in force and will provide some of the tools required to implement the Water Framework Directive. The progress on negotiating the future European water legislation seems to indicate a final adoption in 1999.

Currently, legislation concerned with the water sector is often fragmented and inconsistent. The pursuance of an integrated water resource and quality management policy is essential. Sustainable improvements in the protection of human health can only be achieved if policies on drinking water quality take account of wider issues of pollution control, water resource management and social planning.

There is a need for developing and expanding local management at appropriate level, with effective communication at the policy-making level. There is a need for intersectoral co-operation in planning, infrastructures, agricultural practices and pollution control. (WHO, 1997f).

Management of surface waters and wastewater quality is of increasing importance to protect human health. Management tools such as guidelines, quality objectives, discharge permits and cost recovery options must be developed in an appropriate institutional framework.

Table 7.1 Requirements of existing directives and the Water Framework Directive by source

Operational	Sources			
Indicator	Industry		Domestic-UWWT	Agriculture
	IPPC	Non IPPC		
Ecological status				
Nutrients	IPPC		UWWT	Nitrates (N only)
	Freshwater Fisheries nitrites and P			
	Surface Waters total N, nitrate and phosphate			
Organic matter - all waters	IPPC	UWWT	UWWT	
- special protection areas	Bathing waters DO			
	Shellfish waters, DO, pH			
	Freshwater Fisheries, BOD, DO, pH, nitrites and P			
	Surface Waters, NH3, BOD, DO, N, inorganic anions including nitrate and phosphate, metals and organic substances			
Ammonia	IPPC		UWWT (only tot-N)	Nitrates (N only)
	Freshwater Fisheries, ammonium			
	Surface Waters, NH3			
Biological structure				
Water flow and level				
	Habitats			
Physical habitat				
	Habitats			
Chemical status				
Dangerous substances	IPPC	DSD	DSD	
- groundwaters	Groundwater; List I, List II substances			
- special protection areas	Bathing waters hydrocarbons, phenols and surfactants			
	Shellfish waters hydrocarbons, organohalogens and metals			
	Freshwater Fisheries, hydrocarbons phenols and metals			
	Surface Waters, metals and organic substances			
Pesticides	IPPC	DSD	DSD	
	Surface Waters, pesticides			
Nitrates (groundwater only)	IPPC			Nitrates
Groundwater quantity				
Groundwater level				
Saltwater intrusion				
Impact on surface water (dry rivers)				
Impact on wetlands				
	Habitats			

Notes: [shaded box] Indicates areas not covered by existing directives

References

Abakumov, V.A. Talayeva, Y.G. 1998. Microbial pollution. In *A water quality assessment of the former Soviet Union.* Eds V. Kimstach, M. Meybeck and E. Baroudy. E & FN Spon. 267-292.

Abrahams, M.J., Price, J., Whitlock, F.A. and Williams, G. 1976. The Brisbane floods, January 1974: their impact on health. *Med. J. Aust.,* **2,** 936-939.

AEAS (Asociación Española de Abastecimientos de Agua y Saneamiento) 1997. *Suministro de Agua Potable y Saneamiento en España (1994).*

Agthe, D.E. and R.B. Billings 1996. Water price effect on residential and apartment low flow fixtures, *Journal of Water Resources Planning and Management.* January, February.

Andersson Y., De-Jong B., Studahl A. 1997. Waterborne Campylobacter in Sweden: The cost of an outbreak. *Water Science and Technology,* **35(11-12).** 11-14. ISSN: 0273-1223

Anon 1992 The economic impact of the cholera epidemic, Peru. *Epidemiology Bulletin,* **13**(3).

Archer D.L., Kvenberg J.E., 1985 Incidence and cost of foodborne diarrhoeal disease in the United States. *Journal of Food Protection* **48 (10),** 887-894.

Arnal-J-M, Frisas-O, Garuz-R, Antonanzas-F 1997. Cost effectiveness of hepatitis A virus immunisation in Spain. *Pharmacoeconomics,* **12,(3),** Sept., pp 361-373 ISSN: 1170-7690.

Arnell, N.W. and Reynard, N.S. 1996. The effects of climate change due to global warming on river flows in Great Britain. *Journal of Hydrology,* **183 (3-4),** 397-424.

Auvinin, A., Makelainen, I., Hakama, M., Castren, O., Pukkala, E., Reisbacka, H. and Rytomaa, T. 1996. Indoor radon exposure and risk of lung cancer: a nested case control study in Finland. *Journal of the National Cancer Institute,* **88,** 966-972.

Baden D.G., Mende, T.J., Poli, M.A. Block, R.E. 1984. Toxins from Florida's red tide dinoflagellates, Ptychodiscus brevis. In: EP Regelis (Ed), *Seafood Toxins*. American Chemical Society Washington DC. 359-367.

Baker E.L. Jnr. *et al.* 1979 Economic impact of a community wide waterborne outbreak of gastrointestinal illness. *American Journal of Public Health* **69(5),** 501-502.

Bartram, J., Rees, G (Eds) (1999). Approaches to microbiological monitoring. In*: Monitoring bathing waters*. E & FN Spon, London. In Press.

Baxter, K.M. 1985. The effects of a hazardous and a domestic waste landfill on the trace organic quality of chalk groundwater at a site in East Anglia. *Science of the Total Environment,* **47,** 93-98.

Behrens, R.H. and Roberts. J.A. 1994. Is Travel Prophylaxis worth while? Economic appraisal of prophylactic measures. *British Medical Journal,* **309(6959),** 918-22.

Beniston M., Rebetez M., Giorgi F., Marinucci MR., 1994: An analysis of regional climate change in Switzerland. *Theoretical And Applied Climatology*, **49**, 135-159.

Bennet, G. 1970. Bristol floods 1968: controlled survey of effects of health on local community disaster. *British Medical Journal,* **3,** 454-458.

Bennet, G. 1970. Bristol flods 1968: controlled survey of effects of health on local community disaster. *British Medical Journal,* **3;** 454-458.

Bernes, C. and Grundsten, C. 1992. *The Environment*. Published by the National Atlas of Sweden. Theme manager: The National Environmental Protection Agency, Stockholm.

Black, R.E., Dykes, A.C., Anderson, K.E., Wells, J.G., Sinclair, S.P., Gary, W.G., Hatch, M.H. and Gangarosa, E.J. 1981. Handwashing to prevent diarrhoea in day-care centres. *American Journal of Epidemiology,* **113,** 445-451.

Blackmore, J. and Clark, L. 1994. *The disposal of sheep dip waste: effects on water quality.* WRc report. Published by NRA, Bristol.

Blake, PA., Rosenburg, ML., Costa, JB., Ferreira, PS., Guimaraes, CL and Gangarosa, EJ 1977. Cholera in Portugal, 1974, I. Modes of transmission. *American Journal of Epidemiology,* **105**; 337-343.

Boardman, J. and Robinson, D.A. 1985. Soil erosion, climate vagarity and agricultural change on the Downs around Lewes and Brighton, autumn 1982, *Applied Geography*, **5**, 243-258.

Braidech, T.E., Karlin, R.J 1985. Causes of a waterborne giardiasis outbreak.. *Journal of the American Water Works Association,* **77(2),** 48-51.

Brazdil, R., M. Budikova, I.Auer, R. Bohm, T. Cegnar, P. Fasko, M.Lapin, M. Gajiccapka, K. Zaninovic, E. Koleva, T. Niedzwiedz, Z. Ustrnul, S. Scalai, R.O. Weber, 1996, Trends in minimum and maximum daily temperatures in central and southeastern Europe. *International Journal of Climatology,* **16(7),** 765-782.

Brtko, J., Büchlerova, E. and Zajicova, H. 1997. *National Report, Slovak Republic*. Published on the occasion of the World IWSA Congress, Madrid, September 1997 by Water Research Institute, Bratislava. p. 9.

Buckland, J. and Zabel, T. 1996. *Economic Instruments of Water Management and Financing of Infrastructure.* EUROWATER, Horizontal Report, UK Environment Agency R&D Technical Report E10, 1996. p. 86

Cavellero, A., Corradi, C., De Felice, G. and Grassi, P. 1985. Underground water pollution in Milan by industrial chlorinated organic compounds. In: *Effects of land use upon Fresh Waters* Eds: J. F. de L.G. Solbe. Ellis Harwood, Chichester, 65-84.

CDC 1999. Surveillance for waterborne-disease outbreaks - United States, 1995-1996. *Surveillance Summaries,* **December 11 1998/47(SS-5);** 1-34.

Chernogaeva, G.M., Lvov, A.P. & Georgievsky, V.Y. 1998. Water use and the influence of anthropogenic activity. Pp 69-94. In*: A water quality assessment of the former Soviet Union.* Eds: V. Kimstach, M. Maybeck & E. Baroudy. E & FN Spon, London. 611pp.

Chorus, I. and Bartram, J. (Eds).1999. *Toxic cyanobacteria in water*. E & FN Spon, London.

Chossegros-P, *et al*, 1994. Cost of acute hepatitis A in adults in France. Presse-Med 12 Mar 26 VOL/ISS: 23 P 561--4 ISSN: 0755-4982.

Clark, C.G., Kravetz, A.N., Alekseenko, V.V., Krendelev, Yu, D. & Johnson, W.M. 1998. Microbiological and epidemiological investigation of cholera epidemic in Ukraine during 1994 and 1995. *Epidemiology and Infection,* **121(1);** 1-13.

Cookson, S.T. *et al.* 1997. A cost Benefit Analysis of Programmatic Use of CVD 103-HgR live Oral cholera vaccine in a high risk population. *International Journal of Epidemiology*, **26(1);** 212-219.

Cooper, D.M., Wilkinson, W.B. and Arnell, N.W. 1995. The effects of climate changes on aquifer storage and river baseflow. *Hydrological Sciences Journal,* **40 (5);** 615-631.

Council for Agricultural Science and Technology. Foodborne pathogens: risks and consequences. (Task force report no. 122). Council for Agricultural Science and Technology, Ames, Iowa, USA**,** 1994.

Craun, GF., Hubbs, SA., Frost, F., Calderon, RL and Via, SH 1998. Waterborne outbreaks of cryptosporidiosis. *Journal of American Water Works Association*, **90 (9);** 81-91.

Cronberg, G. 1982. Phytoplankton changes in Lake Trummen induced by restoration. Folia Limnologica Scandinavica, **18;** 119.

Crook, J., Ammerman, D.K., Okun, D.A. and Matthew, R.L. 1992. *Guidelines for Water Reuse.* Camp Dresser & McKee Inc, Massachusetts. p. 254

Cross, H. T., Harley, N. H. and Hofmann, W. 1985. Health effects and risks from ^{222}Rn in drinking water. *Health Physics*, **48;** 649-670.

Cvjetanovic B. 1979. Sanitation versus immunization in the control of enteric and diarrhoeal diseases. *Progress in Water Technology.* **11 (1);** 81-87.

Czech Environmental Institute (Ed.), 1996. *Statistical Environmental Yearbook of the Czech Republic 1996.* The Ministry of the Environment of the Czech Republic.

Dai A., Fung I.Y. and Del Genio, A.D. 1997. Surface observed global land precipitation variation during 1900-88. *Journal of Climate,* **10;** 2943-2962.

Dales, R.E., Burnett, R. and Zwanenburg, H. 1991. Adverse health effects among adults exposed to home dampness and molds. *Am. Rev. Respir. Dis*. **143;** 505-509.

Dalton, C.B. *et al.* 1996. The cost of a food-borne outbreak of Hepatitis A in Denver, Colorado. *Arch ntern Med*., **156(9);** 1013-6.

Danzon A., *et al.* 1987. Care of infants with non severe acute diarrhoea: A socio-economic perspective. *REV-EPIDEMIOL-SANTE-PUBL*, **35 (6)**; pp 451-457. ISSN: 0398-7620.

Demicheli-V, Rivetti-D, Jefferson-T-O. 1996. Economic aspects of a small epidemic of hepatitis A in a religious community in Northern Italy. *Journal of Infection* **33(2),** Sept, pp 87-90. ISSN:0163-4453

Desbrow C., Routledge E., Sheehan D., Waldock, M. and Sumpter, J. 1996*. The identification and assessment of oestrogenic substances in sewage treatment effluents.* Environment Agency Report P2-i490/7, UK. p. 65

DoE, 1997. *The Environment in your Pocket 1997.* Department of the Environment, Transport and the Regions. London.

Duke, LA., Breathnach, AS., Jenkins, DR., Harkis, BA and Codd, AW 1996. A mixed outbreak of cryptosporidium and campylobacter infection associated with a private water supply. *Journal of Epidemiology and Infection*, **116**(3). 303-308.

DWI, 1997. *Drinking Water 1996.* A report by the Chief Inspector, Drinking Water Inspectorate, UK. p. 200

EC 1996. *European Workshop on the impact of endocrine disrupters on human health and wildlife.* Report of Proceedings. 2-4 December 1996, Weybridge, UK.

EC 1998. *Quality of bathing water (1997 bathing season).* May 1998-EUR 18166.325pp.

Environment Agency 1997. *Sheep dipping: pollution prevention guidelines.* PPG12. Environment Agency, Bristol, UK. p. 4

EPA 1996. *The Quality of Drinking Water in Ireland. A report for the year 1995 with a reviews of the period 1993-1995.* Environmental Protection Agency, Wexford, Ireland. p. 381

Estrela, T., Marcuello, C., Inglesias, A. 1996. Water resources problems in southern Europe. An overview report. European Environment Agency, Copenhagen.

Esrey, S. *et al.* 1985. Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. *Bull WHO,* **63**(4), 757-772.

European Environment Agency (EEA), 1995. *Europe's Environment, The Dobrís Assessment*. Eds: D. Stanners, & P. Bourdeau. European Environment Agency, Copenhagen. 676 pp.

European Environment Agency (EEA), 1998. *Europe's Environment, The Second Assessment.* European Environment Agency, Copenhagen/Elsevier. 293 pages

European Environment Agency (EEA), 1999. *Lakes and Reservoirs in the EEA Area*. European Environment Agency, Copenhagen. 110 pages.

European Environment Agency (EEA), 1999a. *Groundwater Quality and Quantity.* European Environment Agency, Copenhagen.

European Environment Agency (EEA), 1999c. *Sustainable Water Use in Europe: Part 1: Sectoral use of water.* European Environment Agency, Copenhagen. 102 pages.

European Environment Agency (EEA). 1999b. *Environment in the European Union 1998.* European Environment Agency, Copenhagen/Elsevier. 293 pages.

European Topic Centre on Inland Waters (ETC/IW) 1996. *Review of Water Use Efficiency in Europe* (unpublished but incorporated into EEA 1998c).

European Topic Centre on Inland Waters (ETC/IW) 1997. "Questionnaire to NFPs".

Evans, R. and Cook, S. 1986. Soil erosion in Britain, *SEESOIL*, **3**, 28-58.

Exner M. 1995. *Infectious diseases from the hygienic viewpoint with special reference of infectious diseases from the environment—a retrospective and prospective view*. Zbl Hyg;197.134-161.

Falconer, I.R 1994. Health problems from exposure to Cyanobacteria and proposed safety guidelines for drinking and recreational water, 3-30. In: G.A Codd., T.M. Jeffries, C.W Keevil, E. Potter (Eds), *Detection Methods for Cyanobacterial Toxins*. The Royal Society of Chemistry. ISBN 0-85186-961-0. 191pp.

FAO 1995. Water sector policy review and strategy formulation. A general framework. *FAO Land and Water Bulletin,* **3.**

FAO 1996. *Current World Fertiliser Situation and Outlook 1994/95 + 2000/2001*. World Wide Web, http://www.fao.org/waicent/faoinfo/agricult/agl/agin/cwfso9494.htm.

FAO 1997. Food and Agriculture Organisation. Agrostat Homebase.

FAO, Home Page. http://www.fao.org

Fawell, J.K., James, C.C.P. and James, H.J. 1994. *Toxins from blue-green algae: Toxicological assessment of microcystin-LR and a method for its determination in water.* WRc . Foundation for Water Research Report FR 0359/ DoE 3358/2. p. 46

Federov, YA., Kulmatov, RA and Rubinova, FE. The Amu Darya. *In A water quality assessment of the former USSR.* Eds V. Kimstach, M. Maybeck & E. Baroudy. E & FN Spon, London. 611pp.

Fewtrell, L. and Delahunty, A. 1995. The incidence of crytosporidiosis in comparison with other gastro-intestinal illnesses in Blackpool, Wyre and Fylde. *Journal of the Chartered Instution of Water and Environmental Management,* **9(6);** 598-601.

Fewtrell, L., Jones, F., Kay, D., Godfree, A.F., and Merrett, H. 1993. *Pathogens in surface temperate waters.* Samara Press, UK. 262pp.

Fewtrell, L., Kay, D., Dunlop, J., O'Neill, G. and Wyer, M. 1994. Infectious diseases and water-supply disconnections. *Lancet*, **343**, 1370.

Fielding, M., Mole, N., Horth, H., Gendebien, A. and Van Dijk, P. 1998. *Pesticides in Groundwater. Final Report to European Crop Protection Association.* WRc Ref: CO 4395. WRc, MedmenhamUK. p. 69

Fleisher, J.M., Kay, D., Salmon, R.L., Jones, F., Wyer, M.D.,and Morano, R. 1996. Marine waters contaminated with domestic sewage: nonenteric illnesses associated with bather exposure in the United Kingdom. *American Journal of Public Health,* **86 (9),** 1228-1234.

Food and Agricultural Organisation of the United Nations (FAO) 1996. FAOSTAT Statistics database (Agriculture - Irrigation), FAO, Rome, Italy, October 1996.

Foy, R.H. and Rosell, R. 1991. Loadings of nitrogen and phosphorus from a Northern Ireland fish farm, *Aquaculture*, **96 (1)**, 17-30.

Furtado, C., Adak, G.K., Stuart, J.M., Wall, P.G., Evans, H.S., Casemore, D.P 1998. Outbreaks of waterborne infectious disease in England and Wales, 1992-95. *Epidemiology and Infection,* **121(1),** 109-119.

GISEM-UNESEM 1993. Dix ans de croissance pour l'industrie europeenne des eaux minerales naturelles. Madrid.

Gleick, P.H. 1993. "An introduction to global fresh water issues". In *Water in Crisis - A Guide to the World's Fresh Water Resources.* Ed: P.H. Gleick, Pacific Institute for Studies in Development, Environment and Security - Stockholm Environment Institute. p 473.

Goldstein ST, Juranek DD, Ravenholt O, et al. 1996. Cryptosporidiosis: an outbreak associated with drinking water despite state-of-the-art water treatment. *Ann Intern Med;***124;** 459-468.

Grassi, E., Petrollp, M., Guidi, E., Angelini, L., Raspadori, F., Gregorio, P. 1998. The control of cholera epidemics: continuity or discordance in the health interventions. *Igiene Moderna*,**109(5)**; 541-556.

Gray, N.F. ed. 1994. *Drinking Water Quality: Problems and solutions.* John Wiley and Sons. Chichester 315 pp.

Hall, T. [Ed.] 1997. *Water Treatment Processes and Practices.* Second Edition. WRc, Swindon, UK. p. 234.

Harries J.E., Jobling S., Matthiessen P., Sheahan D.A. and Sumpter J.P. 1995. *Effects of trace organics on fish - Phase 2.* Foundation for Water Research FR/D 0022. Marlow, UK.

Harrington W., *et al.* 1989 The economic losses of a waterborne disease outbreak. *Journal of Urban Economics,* **25 (l)** 116-138.

Hart, J. and Stott, P. 1993. *Microcystin-LR removal from water.* Foundation for Water Research Report FR 0367. Marlow, UK 77 p.

Helmick CG, Griffin PM, Addiss DG, Tauxe RV, Juranek DD. 1994. *Infectious Diarrheas*. In: Everhart JE, ed. Digestive diseases in the United States: epidemiology and impact. Publication No. 94-1447:85-120. National Institutes of Health, Bethesda, Maryland, USA.

Hoermann, G., Ebrecht C., Herbst M., Geffers K. Kluge W., Reiche E.-W., Widmoser P., 1995: Auswirkungen einer Temperaturerhoehung auf den Wasserhaushalt der Bornhoeveder Seenkette. *EcoSys*, **5,** 27-49.

Hopkins R.S., *et al.,* 1986. Gastroenteritis: case study of a Colorado outbreak. *Journal of American Water Works Association,* **78 (1)** 40-44.

Horth H., and Casillas, J. (1998*) Review on the Approaches to Water Quality Monitoring and Assessment in Europe*. WHO Substantiation Document - Report to DWI/DETR, WRc Medmenham, Marlow, SL7 2HD, England.

Iacob, I. 1997. *A decade of drinking water surveillance in Romania*, Proceedings of the XXXII-the International 70th Anniversary Conference of the Institute of Public Health Bucharest, Romania. May **8-9,** 1997. pp122-123.

ICOLD 1984/1988. *World Register of Dams.* The International Commission on Large Dams, (ICOLD), Paris. Complete register published in 1984, revision volume published in 1988.

ICWS 1996. *Long range study on water supply and demand in Europe - Level A – France.* France, p. 119

IFRC 1998 *World Disaster Report 1997.* New York. Oxford University Press.

IKSR 1994. *Aktionsprogramm Rhein - Bestandsaufnahme der punktuellen Einleitungen prioritärer Stoffe 1992.* Internationale Kommission zum Schutze des Rheins. Koblenz.

Institute of Public Health Bucharest, Romania 1997. *Annual National Report on Drinking Water Quality in Urban Areas.* Institute of Public Health, Bucharest, Romania 1986 - 1996. p 2-5.

IPCC, 1996. Climate Change 1995: Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 3, Nicholls N., G.V. Gruza , J. Jouzel, TR Karl, LA Ogallo, DE Parker. *Observed climate variability and change*, pp.133-192

Istituto di Ricerca sulle Acque (IRSA) 1996. *Evoluzione dei Fabbisogni Idrici Civili ed Industriali*. Editoriale Bios, 126 pp.

IWSA 1997. *International Statistics for Water Supply,* IWSA (International Water Supply Association) Congress 1997, Madrid. 11pp.

James, H.A., Fielding, M., Franklin, O., Williams, D. and Lunt, D. 1998. *Steroid concentrations in treated sewage effluents and water courses - implications for water supplies.* WRc report for UKWIR. Report No. 98 TX011. p. 38

Jefferson, T., Demicheli, V. and Wright, D. 1994) An economic evaluation of the introduction of vaccination against hepatitis in a peacekeeping operation. *International Journal of Technology Assessment Health Care,* **10(3),** 490-7.

Karanis, P., Schoenen, D, Seitz, H.M 1998. Distribution and removal of Giardia and Crptosporidium in water supplies in Germany. *Water Science and Technology,* **37 (2),** 9-18.

Kauppi, L., Pietilainen, O.P. and Knuuttila, S. (1993). Impacts of agricultural nutrient loading on Finnish watercourses. *Water Science and Technology,* **28 (3-5),** 461-471.

Klapper, H. 1991. *Control of Eutrophication in Inland Waters.* Ellis Horwood: p. 337.

Klein, G. 1989. Application of the OECD eutrphication model in the process of ogliotrophication in eutrophied waters. *Vom Wasser,* **73;** 365-373.

Knezevic, T. 1997. *Water and sanitation in Yugoslavia*. Federal Institute of Public Health, Environment and Health Department, Belgrade, Yugoslavia.

Kovats, S., McMichael, A., Bertollini, R. and Menne, B. 1999. *The early health effects of climate change in Europe.* WHO monograph in preparation.

Koussouris, T.S., Photis, G.D., Diapoulis, A.C. and Bertahas, I.T. 1989. Water quality evaluation in lakes of Greece. In *Watershed 89. Proceedings of the IAWPRC conference.* Guildford, UK 17-20 April 1989. 119-128.

Kramer MH, Herwaldt BL, Craun GF, Calderon RL, Juranek DD. 1996. Waterborne disease: 1993-1994. *Journal of American Water Works Association*; **88(3),** 66-80.

Kriz, B. 1998. Infectious disease consequences of the massive 1997 summer floods in the Czech Republic. Working Group Paper. EHRO 020502/12.

Lahti, K. and Hiisvirta, L. 1989. Removal of cyanobacterial toxins in water treatment processes; Review of studies conducted in Finland. *Water Supply,* **7,** 149-154, Barcelona.

Lee, E.M., Clark, A.R., Doornkamp, J.C., Boardman, J., Hooke, J., Lewin, J., Pethick, J., Brunsden, D., Jones, D. and Newson, M. 1995a. *The occurrence and significance of erosion, deposition and flooding in Great Britain.* HMSO, London. pp178.

Lee, E.M., Clark, A.R., Freeman, A.S., Newson, M., Doornkamp, J.C., Brunsden, D. and Pethick, J. 1995b. *The investigation and management of erosion, deposition and flooding in Great Britain.* HMSO, London. pp 208.

Lerner, D.N. and Tellam, J.H. 1992. The protection of urban groundwater from pollution. *Journal of the Institute of Water and Environmental Management,* **6,** 28-37.

Liddle J.L. *et al.* 1997. Rotavirus gastroenteritis: impact on young children, their families and the health care system. *Med-J-Aust* 6 Sept, **15 (167)** p 304-7 ISSN: 0025-729X.

Longstaff, S.L., Aldous, P.J., Clark, L., Flavin, R.J. and Partington, J. 1992. Contamination of the chalk aquifer by chlorinated solvents: A case study of the Luton and Dunstable area. *Journal of the Institute of Water and Environmental Management,* **6,** 541-550.

Lucioni-C, *et al* 1998. *Cost of an outbreak of hepatitis A in Puglia,* Italy.

MacKenzie WR, Hoxie NJ, Proctor ME *et al.* 1994. A massive outbreak in Milwaukee of cryptosporidium infection transmitted through the public water supply**.** *New England Journal of Medicine;* **331**: 161-167.

Madgwick, J. and Phillips, G. 1996. *A Guide to the Restoration of Nutrient-enriched shallow lakes.* Environment Agency and Broads Authority. 180pp.

Maguire, H.C., Holmes, E., Hollyer, J., Strangeways, J.E.M., Foster, P., Holliman, R.E. Stanwell-Smith, R. 1995. An outbreak of cyrptosporidiosis in South London - what value the P value. *Epidemiology and Infection*, **115(2),** 279-287.

Mainstone, C., Lambton, S., Gulson, J. and Seager, J. 1989. *The environmental impact of fish farming - a review.* WRc report No. PRS 2243-M. Medmenham. 90 pp

Mara, D. and Cairncross, S. 189. *Guidelines for the Safe Use of Wastewater in Agriculture and Aquaculture: Measures for Public Health Protection.* Geneva: World Health Organisation.

Mara, D.D. and Pearson, H.W. 1998. *Design Manual for Waste Stabilisation Ponds in Mediterranean Countries.* Leeds: Lagoon Technology International, for the European Investment Bank, Luxembourg.

Margat, J.1992. *L'eau dans le bassin Méditerranéen. Situation et prospective.* Les Fascicules du Plan Bleu 6. Paris: Economica. 91pp.

Martyn, C.N. *et al.,* 1989. Geographical relation between Alzheimer's disease and aluminium in dinking-water. *Lancet,* **1;** 59-62.

McMichael AJ , Haines A, Sloof R., Kovats S 1996 :Climate change and human health, WHO/EHG/96.7

McMichael, A.J., Haines, A., Sloof, R. and Kovats, S. eds. 1996. *Climate Change and Human Health.* An assessment prepared by a Task Group on behalf of the World Health Organisation, the World Meteorological Organisation and the United Nations Environment Programme. WHO, Geneva. p. 297.

McNeish, D. 1993. *Liquid Gold. The cost of water in the 90's.* Ilford: Barnardos.

Meybeck, M. 1982. Carbon, nitrogen and phosphorus transport by world rivers. *American Journal of Science*, **282**, 402-450.

Middleston, J.D., Saunders, P. and Corson, J. 1994. Water disconnection and disease. *Lancet,* **344,** 62.

Ministry of Environment of Georgia (1998). State of the Environment: Country Overview - Georgia. Brief report for the European Union's TACIS Programme.

Ministry of Environmental Protection and Natural Resources of the Russian Federation 1994. *State of the Environment of the Russian Federation. 1993 National Report.* Moscow 1994. pp. 97-99.

Ministry of Natural Resources and Environmental Protection of Belarus 1988. State of the Environment: Country overview - Belarus. Brief report for the European Union's TACIS Programme.

Ministry of Environment of Moldova (1998). State of the Environment: Country Overview - Modova. Brief report for the European Union's TACIS Programme.

Ministry of the Environment of Ukraine 1998. State of the Environment: Country overview: Ukraine. Brief report for the European Union's TACIS Programme.

Ministry of Transport and Public Works 1996. *Report on the Dutch Aquatic Outlook: Future for Water.* Directorate-General of Public Works and Water Management. The Hague. p47

Mountain Unlimited 1995. *Water Supply and Sanitation in Central and East European Countries, New Independent States and Mongolia.* Final Report. Mountain Unlimited, Society of Development and Cooperation. Water Supply and Sanitation Collaborative Council. Vienna, 176 pp.

Mountain Unlimited 1997. *Water Supply and Sanitation in Central and East European Countries, New Independent States and Mongolia*. Vol. II, Draft Version. Mountain Unlimited, Society of Development and Cooperation. Water Supply and Sanitation Collaborative Council. Vienna, 58 pp.

MŻP-ĊR 1997. Vodohospodářský sbornik (SVP ČR 1995-II dil). Publ. SVP č. 44, 1-1804.

Narkevich, M.I., Onischenko, G.G., Lomov, J.M., Moskvitninia, E.A., Podosinnikova, L.S. and Medinsky, G.M 1993. The seventh pandemic of cholera in the USSR, 1961-1989. *Bulletin of the World Health Organisation,* **71(2),** 189-196.

Nathwani D, Davey P.G., 1995. The socioeconomic impact and management of adult diarrhoea in primary care: Is there variation? A personal viewpoint. *Infectious Diseases in Clinical Practice.* **4(5) Sept-Oct**. pp 380-386 ISSN: 1056-9103.

National Environmental Action Plan 1998. Moldova.

NCC 1990. *Fish farming and the Scottish freshwater environment.* Report prepared for the Nature Conservancy Council by the Institute of Aquaculture (Stirling University), Institute of Freshwater Ecology and the Institute of Terrestrial Ecology. 285 pages

OFWAT 1997. *International comparison of the demand for water: a comparison of the demand for water in three European countries: England and Wales, France and Germany.* UK

Onate JJ, A.Pou, 1996. Temperature variations in Spain since 1901: A preliminary analysis. Int. *Journal of Climatology,* **16(7),** 805-816

Organisation for Economic Co-operation and Development (OECD) 1997. *OECD Environmental Data Compendium 1997* (DRAFT), OECD, Paris.

Palombi, L., Buonomo, E., Rakotomanojy, H., Cenko, F. & Siniari, V. 1997. *Tirana survey on water facilities.* Community of S. Edido, Tirano.

Payment P, et al. 1991a. A prospective epidemiological study of drinking water related gastrointestinal illnesses. *Water Science and Technology,* **24(2),** 27-28

Payment P, Richardson L, Siemiatycki J, Dewar R, Edwards M, Franco E. 1991b. A randomized trial to evaluate the risk of gastrointestinal disease due to consumption of drinking water meeting current microbiological standards. *American Journal of Public Health*; **81**:703-708.

Payment P, Siemiatycki J, Richardson L, Renaud G, Franco E, Prévost M. 1997. A prospective epidemiological study of gastrointestinal health effects due to the consumption of drinking water. *Intl J Environ Health Research*;**7**: 5-31.

Perera, J. 1993. A sea turns to dust. *New Scientist,* **23 October 1993** 24-27.

Petrosyan, V.S., Vinnikov, Y.Y., Kimstach, V.A.., Boeva, L.V Sergeeva, T.A. 1998 Organic pollutants. In: *A water quality assessment of the former Soviet Union.* Eds V. Kimstach, M. Meybeck and E. Baroudy. E & FN Spon.2211-240.

Pike, E.B. 1994. *Health effects of sea bathing* (WMI 9021) - Phase III: Final report to the Department of the Environment. Report No. DoE 3412/2. Water Research Centre plc, Medmenham, UK, 1-38.

Plan Bleu 1997. *Workshop Water Demands Management*, Frejus, 12-13 September, 1997 (Plan Bleu - Mediterranean Action Plan-, UNEP). France, 46 pp.

Pourriot, R. and Meybeck, M. eds 1995. *Limnologie Générale.* Masson, Paris.

Proctor ME, Blair KA, Davis JP. Surveillance data for waterborne illness detection: an assessment following a massive waterborne outbreak of Cryptosporidium infection. *Epidemiol Infect* 1998;**120:**43-54.

Pruss, A. 1998. A review of epidemiological studies from exposure to recreational water. *International Journal of Epidemiology*, **27,** 1-9.

Pucelj, G. 1996. Will less technology solve sewage problems? *Danube Watch,* **2 (4),** Environmental Programme for the Danube River Basin. pp. 10-11

Rana, K. and Immink, A. 1999. Trends in global aquaculture production:1984-1996. FAO Fisheries Department. 6pp.

Raukas, A. 1996. *Estonian Environment: Past, Present and Future.* Ministry of the Environment of Estonia Environment Information Centre, Tallinn. pp. 166-167

Reed, A.H. 1986. Soil loss from tractor wheelings, *Soil and Water*, **14**, 12-14.

Rees, H.G., Croker, K.M., Reynard, N.S. and Gustard, A. 1997. Estimating the renewable water resource. In: Rees, H.G. and Cole, G.A. (Eds.) *Estimation of renewable water resources in the European Union.* Institute of Hydrology, Wallingford, UK. Final Report to Eurostat (SUP-COM95, 95/5-441931EN). 92 pp.

Richardson, AJ., Frankenberg, RA., Buck, AC., Selkon, JB., Colbourne, JS., Parsons, JW and Mayonwhite, RT. 1991. An outbreak of waterborne cryptosporidiosis in Swindon and Oxfordshire. *Epidemiology and Infection*, **107(3);** 485-495.

Rivett, M.O., Lerner, D.N. and Lloyd, J.W. 1990. Chlorinated solvents in UK aquifers. *Journal of the Institute of Water and Environmental Management,* **4,** 242-250.

RIVM, 1995. *Milieubalans 95*. National Institute of Public Health and Environmental Protection. Bilthoven, The Netherlands. pp.314.

Roefer PA, Monscvitz JT, Rexing DJ. 1996. The Las Vegas cryptosporidiosis outbreak. *Journal of American Water Works Association*;**88(9):**95-106.

Romania National Report Concerning the Water Supply Situation in Romania, April 1997.

Ryding, S-O, and Rast, W. 1989. *The Control of Eutrophication of Lakes and Reservoirs.* The Parthenon Publishing Group/UNESCO. 314 pp.

Sander G. *et al. 1978 Problem of cost demonstration in communicable diseases.* Z-Arztl-Fortbild (Jena) . Feb 15, 72 (4), p. 194-200, ISSN: 0044-2178.

Sas, H. 1989. *Lake Restoration by Reduction of Nutrient Loading: Expectations, Experiences, Extrapolations.* Academia Verlag. 497pp.

Saunders, M.A. 1998. *Central and Eastern European Floods of July 1997*. London, Benfield Grieg Hazard Research Centre, University College, London.

Schiraldi, 1990. Tourist health and enteric infections - cholera. In: *Tourist Health*. Pasini, W (Ed). Proceedings of the second international conference on tourist health. Rimini 15-18 March 1989. 95-97.

Schoenwiese, C-D., J. Rapp, T. Fuchs, and M. Denhard, 1993, *Klimatrend Atlas Europa 1891-1990.* ZUF Verlag, Frankfurt, Germany, 210 pp.

Schuurmans, CJE, 1996, Climate Variability in Europe. In*: Climate Variability and climate change-vulnerability and adaptation.* Proceedings of the Regional Climate Change Workshop, September 1996. Prague Czech Republic, pp.25-33.

Scoging, AC. 1991. Illness associated with seafood. *Communicable Disease Report, England and Wales;* **1, Review No. 11 October,** 117-122-

Severo C-A, Fagnani-F, and Lafuma-A, 1995 Cost effectiveness of hepatitis A prevention in France. Pharmacoeconomics . V8, N1, JUL, pp 46-61. ISSN: 1170-7690.

SFT 1996. *Pollution in Norway*. Norwegian Pollution Control Authority. Oslo.

Shaffer P.A. *et al.* 1996. The impact of a community-wide waterborne outbreak of cryptosporidiosis on local health-care resources (abstract). AHSR-FHSR-Annual Meeting Abstract Book, 13, p 99.

Shandera, W.Z. *et al.* 1985 An analysis of the economic costs associated with an outbreak of typhoid fever. *American Journal of Public Heath*, **75(1),** 71-73.

Shiklomanov, I.A. 1991. The World's Water Resources. In *International Symposium to commemorate the 25 years of IHD/IHP*. UNESCO, Paris, 1991. 93-126.

Sibbesen, E. and Runge-Metzger, 1995. Phosphorus balance in European agriculture - Status and policy options. *SCOPE*, **54,** 43-60.

Simchen, E., Jeeraphat, S., Shihab, S. and Fattal, B. 1991. An epidemic of waterborne Shigella gastroenteritis in Kibbutzim of Western Galilee in Israel. *International Journal of Epidemiology,* **20 (4).** 1081-1087.

Simoes, J. 1969. Some aspects of Weils disease epidemiology based on a recent epidemic after a flood in Lisbon (1967). An. Esc. Nacl, Saude,. *Publica. Med. Trop. Lisb.*, **3,** 19-32.

Sims, J.T. (1997). Agricultural and environmental issues in the management of poultry wastes: Recent innovations and long-term challenges. *ACS Symposium Series*, **668,** 72-90.

Smith, H.V. *et al.*, 1988. The effect of free chlorine on the viability of *Cryptosporidium spp* oocysts. Medmenham. Water Research Centre, Report PRU 2023-M.

SOU 1996. Environment for Sustainable Health development - an Action Plan for Sweden. Report on the proposals presented by the commission on environmental health. Stockholm.

Spiers, R.B. and Frost, C.A. 1987. Soil water erosion on arable land in the United Kingdom, *Research and Development in Agriculture*, **4**, 1-11.

Sridhar C.B., Kulkarni R.D. 1995 Reassessment of frequency of occurrence of typhoid fever and cost efficacy analysis of antibiotic therapy. *Journal of the Association of Physicians-India.* **Oct. 43 (10)** p. 679-684 ISSN: 0004-5772.

State Committee of the Russian Federation on Environmental Protection, 1998. State of the Environment. Country Overview - Russia. A report for the European Union's TACIS Programme.17-20.

Swedish EPA, 1993. *Metals and the environment.* Swedish Environmental Protection Agency. Stockholm.

SZU 1996 Project II. Health effect and risks from quality of drinking water. SZU Praha, Ustredi monitoringu zdravotniho stavu, 1-101.

SZU 1997. *Drinking Water Supply Distribution Network from 01/01/96 to 31/12/96.* National Institute of Public Health, Prague, Czech Republic. p. 4.

Thomson M.A., Booth I.W. 1996. Treatment of traveller's diarrhoea. Economic aspects. *Pharmaceonomics,* **9 (5)**; p382-391. ISSN: 1170-7690.

Tsirkunov, V.V 1998. Water quality monitoring systems Pp 95-112. In*: A water quality assessment of the former Soviet Union.* Eds V. Kimstach, M. Maybeck & E. Baroudy. E & FN Spon, London. 611pp.

Turner, P.C., Gammie, A.J., Hollinrake, K. Codd, G.A 1990. Pneumonia associated with cyanobacteria. *British Medical Journal***, 200,** 1440-1441.

UNEP/WHO 1996. *Assessment of the state of microbiological pollution of the Mediterranean Sea*. UNEP(OCA)/MED WG. 104/Inf.9.

van der Heok 1998. *Production of drinking water without chlorine: Disinfection By-products, the way forward,* RSC/SCI/CIWEM conference, *In Press.*

Van Doorslaer, E. *et al.* 1994. Cost effectiveness analysis of vaccination against hepatitis A in Travellers. *Journal of Medical Virology*, **44(4),** 463-9.

Vargas, S.M.V. da C. and Mara, D.D. 1987. "The bacterial quality of lettuce and alfalfa spray-irrigated with trickling filter effluent". In *Implementing Water Re-use (Water Re-use Symposium IV*) Denver, CO:AWWA Research Foundation. pp 793-802.

Vasilescu, M. 1996. *Oganochlorinated insecticide level in the Danube River: A source of drinking water.* Proceedings from the Third International Symposium on Environmental Contamination in Central and Eastern Europe, Warsaw, 1996. pp 853-855.

Verma B.L., Srivastava R.N. 1990. Measurement of the personal cost of illness due to some major water-related diseases in an Indian rural population. *International Journal of Epidemiology,***19 (1)** pp169-176. ISSN: 0300-5771.

WHO 1984. *Guidelines for drinking-water quality.* First edition. Volume 1. World Health Organisation. Geneva.

WHO 1989. *Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture.* Technical Report Series No. 778: World Health Organisation. Geneva.

WHO 1989b *Water and sanitation services in Europe 19881-1990.* World Health Organisation Regional Office for Europe, Copenhagen.

WHO 1993. *Health for all targets: The health policy for Europe.* Updated edition September 1991. World Health Organisation Regional Office for Europe, Copenhagen. p. 228.

WHO 1994. *Financial management of water supply and sanitation. A handbook.* World Health Organisation, Geneva.83pp.

WHO 1995. *Joint WHO/German Regional Seminar on Drinking-Water Quality*. Report on a WHO Seminar, Bad Elster, Germany. 10-14 October, 1994. p. 25.

WHO 1995a. *Environment and Health in Italy.* Preliminary Report for the Ministry of Environment. Executive Summary. World Health Organization, European Centre for Environment and Health, Rome Division. June 1995. p. 34.

WHO 1996. *Guidelines for drinking water quality.* Second Edition. Volume 2. Health criteria and supporting information. WHO, Geneva. 973pp.

WHO 1996a. *Outbreak of typhoid fever in Tajikistan.* Report of a WHO expert team visit to Tajikistan, **1-9** July 1996.

WHO 1997. *World Health Statistics Quarterly,* **50, N1/2**. World Health Organization, Geneva, Switzerland.

WHO 1997a. *Epidemiological aspects of investigation of outbreaks of communicable diseases and surveillance and control of water quality.* Report on a WHO workshop in Tsahkhadzor, Armenia, 15-21 September 1996. WHO Regional Office for Europe, Copenhagen. p. 16.

WHO 1997b. *Policy aspects of water-related issues.* Report on a WHO Consensus Meeting. Yerevan, Armenia. 9-11 April 1997. WHO Regional Office for Europe, Copenhagen. p. 13.

WHO 1997c *Ambiente e salute in Italia,* Eds: R. Bertollini, M. Faberi, and N. di Tanno. World Health Organization, European Centre for Environment and Health , Rome Division. p. 590.

WHO 1997d. *Joint UNECE/WHO Consultation on the eradication of water-related diseases. Kiev, Ukraine,* 20-22 March 1997.

WHO 1997e. *Expert consultation on health impacts of recreational water and bathing beach quality,* Bad Elster, Germany, 20-22 June 1996. EUR/ICP/EHPM 07 02 02, WHO EURO Copenhagen.

WHO 1997f *Concern for Europe's Tomorrow.* Published on behalf of WHO European Centre for Environment and Health by Wissenschaftliche Verlagsgesellschaft mbH. 537pp.

WHO 1998. *Guidelines for safe recreational water environments - Volume 1: Coastal and Fresh Waters.* Draft for Consultation. WHO/EOS/98.14.

WHO 1998a. *Preliminary draft of a (European) protocol on water and health.*

WHO 1998b. *Guidelines for drinking water quality.* Second edition. Addendum to Volume 2. Health criteria and supporting information. World Health Organisation, Geneva. 283pp.

WHO/UNDP 1993. *Danube Programme Co-ordination Unit. Workshop on Drinking Water Related Environmental Health aspects in the Catchment Area of the River Danube.* Bratislava, the Slovak Republic, 16-19 December 1993. Volume II Country Reports. Institutional Development Project Environmental Programme for the Danube River Basin. Funded by the Global Environmental Facility. Workshop organised by: World Health Organisation Regional Office for Europe European Centre for Environment and Health and the United Nations Development Programme. 195pp.

WHO/UNEP 1994. *Microbiological quality of coastal recreational water*. MED POL Phase II, Report on a joint WHO/UNEP meeting, 9-12 June 1993, Athens, Greece. WHO Regional Office for Europe, 1994.

WHO/UNEP 1995. *Health risks from marine pollution in the Mediterranean. Part II - review of hazards and health risks.* Document EUR/ICP/EHAZ 94 01/MTO1(2). WHO Regional Office for Europe, Copehagen.

Wolf, J. 1997. Chlorination disinfection project combats Aral Sea crisis. *Water and Wastewater International,* **12 (5)** 6-9.

WRc 1997. *Cost Benefit Analysis of Reducing Lead in Drinking Water*. Report to the Department of the Environment. DoE/DWI 4304 April 1997 UK.

Wroath, A. and Fawell, J.K. 1995. *The Toxicity and Significance of Toxins from Blue-Green Algae.* WRc for UKWIR, UK. p. 20.

Zhulidov, A.V. Emetz, V.M 1998. Heavy metals, natural variability and anthropogenic impacts. In *A water quality assessment of the former Soviet Union.* Eds V. Kimstach, M. Meybeck and E. Baroudy. E & FN Spon. 179-202.